South Dakota
Geological and Natural History Survey

Freeman Ward, State Geologist

CIRCULAR 21

SAND AND GRAVEL DEPOSITS
of
YANKTON COUNTY

By

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Tests by R. V. Newcomb

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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.

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INTRODUCTION

FOREWORD

Yankton has been an important commercial center since early territorial days. As a consequence, the travel routes along the Missouri valley all passed through there. The same is still true of the major lines of travel but the old trails and wagon roads have been supplanted by the railroads and the much traveled State Highway 50. North and south travel has been so heavy that State Highway 21 was built and with the change from a ferry to a bridge crossing on the Missouri River, this traffic has been greatly increased. Four marked trails pass through Yankton: the Meridian Highway, which follows State Highway 21 to the northern edge of the county; the Washington Highway, which follows State Highway 50 across the county; the Sunshine Highway, which follows State Highway 50 westward to a point three miles west of Yankton, whence it follows county roads toward the northwest through Utica and Lesterville; and the Corn Belt Highway, which connects Irene with the Meridian Highway. The traffic on these roads is heavy and their construction and maintenance have drawn attention to the gravels available in Yankton County.

The present survey was carried on to ascertain the location of sand and gravel deposits in the county, their adaptability to use as materials for road, concrete or other purposes, and the amount of these materials the county can furnish.

LOCATION AND AREA

Yankton County lies near the southeastern corner of South Dakota, the Missouri River forming its southern boundary. (See index map, Figure 1.) This survey covers the entire county with the exception of that part which lies on the Missouri bottoms. The character of the materials in the bottoms is such that the chances of finding sand and gravel deposits which could be commerically exploited are very remote.

Twelve entire townships and parts of two others were covered, making a total of 464 square miles.

METHOD OF WORK

The field work for this report was done during the summer of 1924. Locations were made from known section corners and distances measured, in most cases, with an odometer. The results were plotted on a county map on the scale of one mile to the inch. Locations, therefore, are accurate to within a few hundred feet only. The positions of the deposits, however, are given with as much accuracy as is necessary for locating them in the field.

The estimates of the amounts of gravels and sands are of necessity very rough. There is in nearly every case an uncertainty

as to the correct depth and the character of the surface on which the deposits lie. The shapes of the deposits are such, in most cases, that it would be impossible to get an accurate figure for the volume without spending more time than the purpose of this survey justified. The estimates are intended merely to give an idea of the size of the deposits.

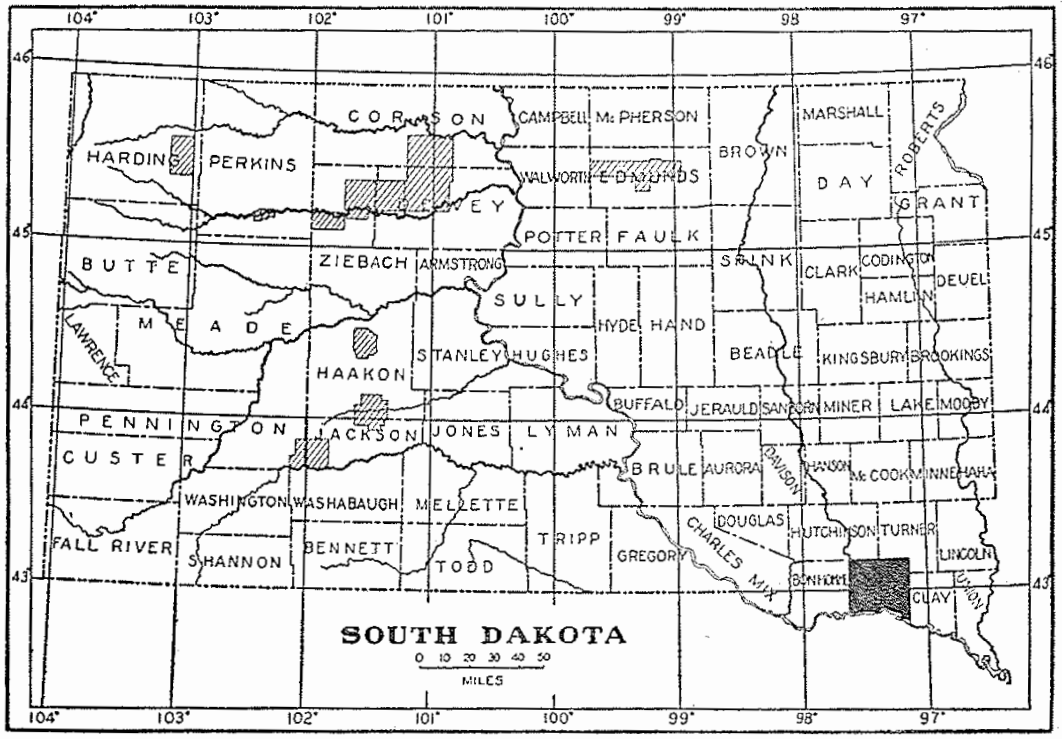


Figure 1. Index Map

Black portion shows area covered by this report.
Shaded portions give locations for the reports already published.

The field work, including the geology, location and mapping of deposits, the estimation of volume and collecting of samples is the work of the senior author. The testing of materials and determination of their suitability for the various purposes were done by the junior author in the laboratories of the Department of Highway Engineering at the University of South Dakota.

ACKNOWLEDGMENTS

The courtesy of the citizens of Yankton County in giving information and other assistance is greatly appreciated. The authors also wish to express their appreciation of the work of Messrs. Sidney Halverson and O. A. Reiners, students in the School of Engineering, University of South Dakota, who faithfully and efficiently conducted many of the laboratory tests.

GENERAL STATEMENT

AMOUNT AND DISTRIBUTION

It is estimated that there are about ten million cubic yards of sands and gravels in the deposits of Yankton County. Most of this material is of such a character that it should be classed as gravel but a few deposits, aggregating about a million cubic yards, are composed of more than 50 per cent sand, separated into streaks of such thickness that it is possible to work it without screening. No deposits of pure sand were found. Some, however, contain only occasional thin streaks of fine gravel and could produce sand with only a little screening.

There are only a few places where large amounts of these materials may be found. About 95 per cent occurs in or near the valleys of the larger streams, James River, Beaver Creek and Turkey Creek, the largest deposits being near Volin, just east of Yankton, in the lower Beaver Valley, and in the James Valley near the mouth of Mud Creek. The remaining deposits are small in comparison but are widely scattered over the county. The localizing of the big deposits, however, has made the smaller ones more important, for they can furnish materials for small projects far from the big deposits.

ORIGIN

The gravels and sands of this county are all of glacial origin. A brief description of the method of their formation has been given in a previous report[1] and therefore will not be repeated here. Suffice it to say that the deposits occur in certain well defined physiographic forms, each of which has a different origin and in most cases a distinctive type of material. The following definitions will explain the terms as used in this report:

Terraces.—Deposits found on valley walls, usually long and narrow, the long dimension paralleling the valley. In typical terraces tops are quite flat. Materials vary from very coarse gravels to fine sands.

Eskers.—Long gravel ridges with notably steep sides and an undulating crest. Made of very coarse gravels, in most cases too coarse to be used without crushing.

Kames—Beehive shaped gravel hills which in most cases occur in groups of two or more. Made of coarse or fine materials, in Yankton County medium to fine gravels.

COUNTY DIVISIONS

For convenience in describing the deposits the county has been divided into six regions, all but the last of which are characterized by some prominent physiographic feature. The divisions are as follows (See Figure 2):

[1]Rothrock, E. P., Sand and Gravel Deposits in Eastern South Dakota: Circular 15, February, 1924.

1. Turkey Ridge Division—Includes deposits found on Turkey Ridge, which occupies the northeastern quarter of the county.

2. Mud Creek Valley Division—Includes the deposits of Mud Creek Valley, which lies just west of Turkey Ridge.

3. James Valley Division—Includes deposits found in the valley of the James River.

4. Lower Beaver Valley—Terrace deposits found in the valley of Beaver Creek below the end of James Ridge.

5. James Ridge Division—Includes deposits found on James Ridge, a prominent ridge in the central part of the county just west of the James Valley.

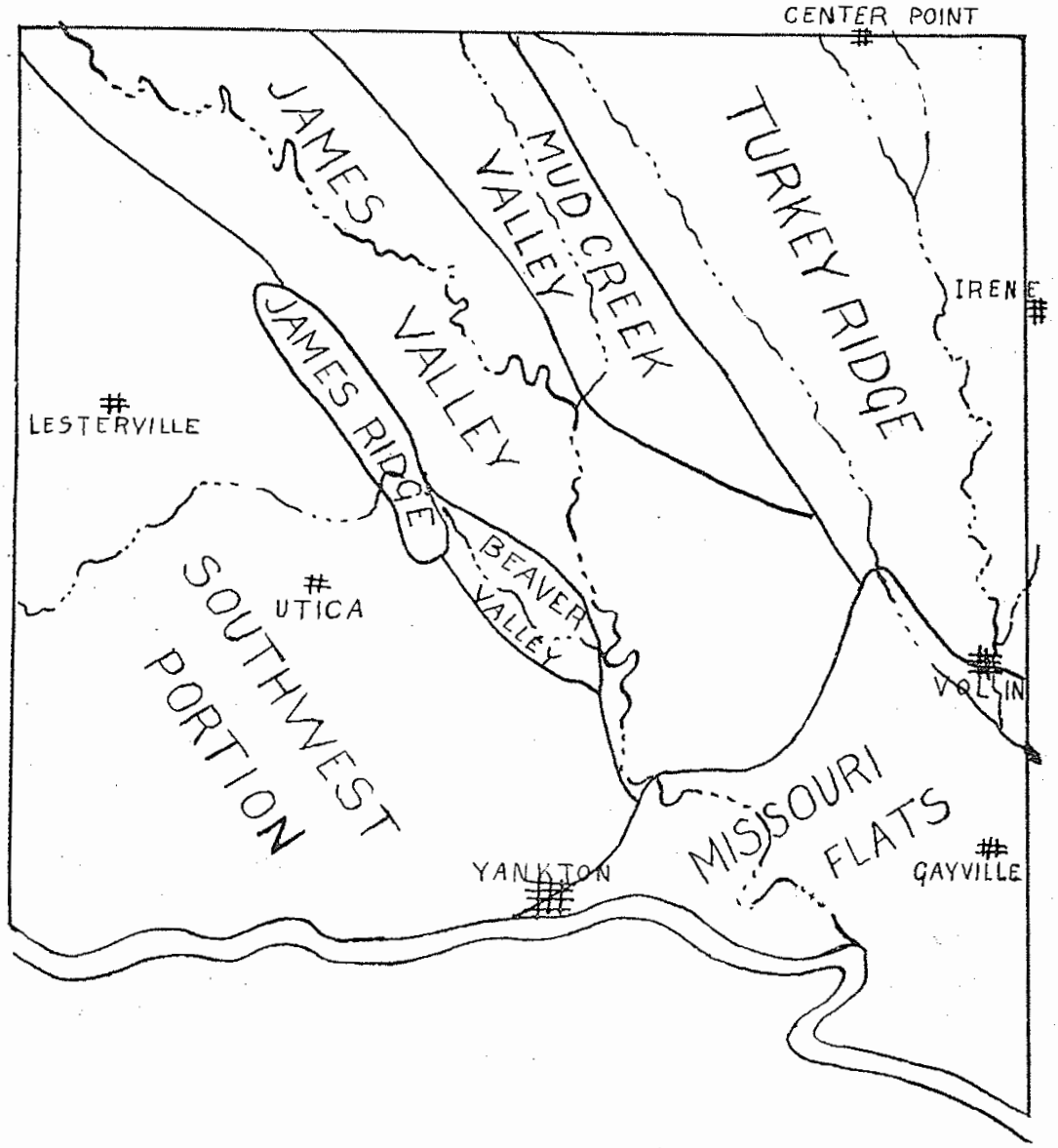


Figure 2. County Divisions

6. Southwestern Portion of the County—This includes deposits scattered over nearly a third of the county which lies west of the James Valley, James Ridge and Lower Beaver Valley divisions.

The Missouri Flats are not included in the above divisions because no deposits are described from this region.

DETAILED DESCRIPTION

TURKEY RIDGE DEPOSITS

The deposits of this region may be divided into five groups on a basis of location and character of material: (1) Gravels of the Lower Turkey Creek Valley; (2) the "white sands" in the vicinity of Irene; (3) the gravel terraces of the Upper Turkey Creek Valley; (4) the kame field gravels; and (5) the esker gravels in the northern part of Turkey Ridge. The locations of these deposits are given on the folded map at the end of the circular.

1. Lower Turkey Creek Valley.—These deposits include the Volin terraces and the Gorset gravel deposit.

Volin Terraces.—In the lower Turkey Creek Valley there is a series of terraces extending up the valley for two miles from its mouth. Most of these are small, but there are at least three that are large enough to be exploited commercially. The largest of the three lies on the east side of the valley and extends upstream from its mouth for a half mile. At its southern end it is separated into two distinct terraces, the top of the upper one being 20 feet above that of the lower. About a quarter of a mile to the north these two terraces merge into one. These terraces have been cut by stream valleys so that the gravels occur in a series of shoulders which protrude from the valley bluffs.

The estimated volume of this terrace is 500,000 cubic yards. The gravels are nowhere very deep because they were banked against a gently sloping valley wall. The maximum depth that can be expected is 10 to 15 feet, while the average will be from 5 to 7 feet. The cover is very thin and very little stripping has been necessary in the operations thus far carried on.

Pits, known as the Volin pits, have been opened at the southern end and considerable material excavated for use on the roads. As exposed in the pits the materials are only fairly well sorted, and are composed of a heterogeneous mixture of sands and gravels. Between 20 and 30 per cent of the material is oversize. From the standpoint of durability, however, this oversize is the best material in the deposit, as it is made of the more resistant rocks like granite and quartzite. The pieces in the oversize vary from the size of cobbles to small boulders one to two feet in diameter.

An average sample from these pits gave the following analysis (See Fig. 3) :—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
102	2.51	35	68	55	38	9	5	7½	201	19	36	45

Figure 3

FAVORABLE QUALITIES

Good weight.
Low per cent of voids.
Within limits (60 to 80 percent passing ½ inch.) for road gravels.
Sand passes tensile strength (7 day).

UNFAVORABLE QUALITIES

Amount of soft material.
Per cent of silt.

USES

The best use for this gravel would be as road surfacing material. It is recommended that the oversize be crushed and mixed in with the gravel instead of being screened out and wasted. This would result in a more durable surface.

The objection to the use of this pit-run gravel in concrete is the amount of chalk rock and shale that it contains. Chalk rock and shale have a tendency to spall when used in concrete. Any amount is objectionable but about 10 per cent is usually the allowable maximum.

The sand could be screened out and used with good crushed stone. This would result in passable concrete, according to the mix.

DEFINITIONS

The following definitions apply to the terms used in all the analyses in this report:

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

Specific Gravity—Weight of a unit volume of the sample divided by the weight of an equal volume of water.

Voids—Percentage of pore space in sample.

Per cent passing ½ inch—Screen with ½ inch openings. Used to determine adaptibility of sample for road gravel. 60 to 80 per cent should pass through this screen to make a fair road gravel.

Sand—Everything coarser than silt which passes a quarter inch screen.

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

Per cent Silt—Percentage of fine material (below about 200 mesh) in the sample.

Seven Day Tensile Test—The tensile strength of a mortar made from the 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.

Character of the Material Retained on ¼ inch Screen—The character of the coarse material.

Soft—Crumbly rock such as shale, chalk, and some chert.
Medium Hard—Fairly tough rocks like limestone and some cherts.
Hard—Very resistant rocks such as granites, basalt, quartzite, etc.

A second large terrace lies less than a mile north of Volin on the west side of the valley in the N. W. ¼ of section 13. It is roughly bounded by the north-south road on the west and the Great Northern railroad tracks on the east. Its length is about 1,200 feet and its average width about 600 feet. The depth of the gravels at the eastern edge, which should be the maximum, is 15 feet. These figures would give a maximum of about 400,000 cubic yards.

The gravels in this terrace are covered with a silt which varies in depth in different places. The maximum, however, did not exceed three feet in any of the places observed.

This deposit has never been opened, but gravels were exposed in a road cut and in the railroad cuts. The material exposed showed that the deposit is made of poorly sorted materials varying from coarse gravels, made of cobbles, down to fine sands and even silts. At least one silt pocket was exposed in one of the railroad cuts. This material is of the same character as that of the first terrace described and would have to be used in much the same manner.

The third terrace lies a mile north and a half mile east of the terrace just described on the east side of Turkey Creek Valley. Its northern end is near the north ¼ corner of section 12, and from this point its long axis trends southeast. Its length is 1,000 to 1,200 feet and its width 500 feet. The maximum depth of gravels is about 10 feet. The total volume of the gravels would be in the neighborhood of 400,000 cubic yards. The terrace has never been opened but the exposures of gravel in the railroad cuts indicate that it is about the same in character as that from the Volin pits. In the small exposures the coarse material seemed to be less abundant than in the terraces farther down stream, but that may be due to the location of the cuts. The deposit is covered with a silt, but no observations were made on its thickness. It is certain that it is not of great depth.

Gorset Gravel.—While not as large as the terraces just described this deposit is important because of the quality of its gravel and because of its location. It lies two miles north of Volin in the S. E. ¼ of section 2 on the north side of a little valley which is tributary to Turkey Creek. A pit was opened in it about twenty-five years ago and has been operated off and on ever since. No figures are available but from the size of the pit is is estimated that about 10,000 cubic yards of gravel have been removed.

A pit has been opened in a shoulder which protrudes from the north side of the valley, but gravel is indicated in another shoulder to the east and along the same side of the valley for at least 1,000 feet westward. In the latter place three feet of cover was drilled which was so powdery that it was impossible to drill the hole deeper. The dry condition of this cover when the surrounding subsoil was wet indicates that it is underlaid with gravels which drain out the water. It is difficult to get a very good estimate of the amount of gravel in this deposit, because the bottom of the gravels has not been reached in the pit, because the topography gives no information as to its extent, and because of the nature of the cover.

The cover over a considerable part of the deposit is till (boulder clay). As exposed in the pit, its thickness varies considerably. At the back of the pit where the gravels are deepest the cover is less than a foot thick, but at other places in the pit it reaches a maximum of 10 feet. The cover has not been a serious obstacle in the operation of the pit thus far and could doubtless be handled with ease if the pit were used for large scale operations.

The chief advantage of this deposit over the Volin terraces is the uniformity of the materials throughout the deposit and the medium size of the gravel. There is very little oversize and not much variation in the size of the materials in the entire 15 feet exposed in the pit.

An analysis of an average sample taken from this pit showed (Fig. 4) :—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
93	2.71	45	58	32	12	10	9	16	278	11	28	61

Figure 4

FAVORABLE QUALITIES

High specific gravity.
Small per cent of soft material.
Coarse material.
Sand passes tensile strength (7 day)).

UNFAVORABLE QUALITIES

Large amount of silt.

USES

This is a good road surfacing material.

Pit run gravel may be used in concrete, using care with regard to the per cent of silt contained (should be washed if extensive amount were to be used), also with regard to the per cent of soft material. Mix by volume could be about one part cement to six parts pit run gravel.

2. "White Sands."—Terrace deposits of medium to coarse sands with occasional streaks of fine gravels occur in the valleys of Turkey Creek and its tributaries and in the nameless valley in which Irene is located. These are characterized by their color, which is a light gray to white. They all occur in the northeastern portion of T. 95 N., R. 54 W. There is a large deposit in the valley of Turkey Creek in the western part of section 3 and two smaller ones in sections 10 and 12, but the greatest amounts occur in the nameless valley in which Irene is situated. Only two deposits were located in this last valley in Yankton County, but at least two more good sized deposits are known just east of the county line in Clay County, two miles south of Irene.

Will Jonason Deposit.—The first mentioned deposit is situated largely on the Will Jonason farm. It forms a ridge about 500 feet in length trending S. 50 E. and paralleling a small tributary of Turkey Creek. The western end is near the W. ¼ corner of section 3 and the eastern end terminates abruptly 500 feet away at the junction of two little valleys.

A pit was opened in the western end of the ridge just east of the road in the hope of obtaining gravel for road use, but sand was encountered instead and the pit abandoned. The material exposed in the pit is medium grained, white to gray sand with streaks of fine gravel running through it. The gravel streaks are more numerous and coarser toward the top with pebbles averaging ¼ to ½ inch in diameter.

A cover of 1½ to 2 feet of silt was found over the entire deposit. This material is very easily stripped and not so thick that it would be a hindrance in working the deposit. The total volume of materials is estimated at 5,500 cubic yards.

An average sample from the pit gave the following analysis (Fig. 5) :—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
88	2.55	44½	97	94	86	32	5	3½	180	51	18	31

Figure 5

[1]This sample may not truly represent the deposit, for the pit was small and the walls had slumped, making it difficult to obtain a good sample.

UNFAVORABLE QUALITIES

Too much soft material.
Sand too fine.
Low weight.
Did not pass mortar test.

USES

From this sample it would seem that the deposit is too fine for concrete purposes. Could not be used as a plaster sand on account of soft material.
Could be used to make a sand-clay road surface.

Dutton Deposit.—The northern-most of the two small deposits in Turkey Creek Valley is found under the gravels in the Henry Dutton pit, N. E. corner section 10, T. 95 N., R. 54 W. Materials here are very nearly like those described from the Jonason pit. They lie under the gravels and therefore their size and character could not be determined very well. A four foot hole was drilled in them without finding bottom and it is reported that ten feet have been penetrated. This deposit at best can not be very large; perhaps 1,000 loads would be a maximum volume. The sands would have to be worked with the gravels which overlie them or the stripping would be excessive. The deposit is very accessible and this might offset some of the difficulties in working it.

A sample from the top 4 feet of sand gave the following (Fig. 6):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
93	2.62	43	98	95	72	13	2	2½	204	1	2	97

Figure 6

FAVORABLE QUALITIES

A clean sand (free from silt).
A hard sand (free from soft material).

UNFAVORABLE QUALITIES

A rather fine sand (not coarse).

USES

A good sand for use in concrete.
It is adaptable to plaster work because it is practically free from soft material such as chalk rock or shale.

N. E. ¼ of Sec. 14.—The other deposit in the valley of Turkey Creek occurs high up on the bluff of the east side of the valley near the N. E. corner of section 14, T. 95 N., R. 54 W. This is a small deposit from which sand is occasionally taken but which is to be noticed chiefly as a slumped place in the hillside. This deposit is too small for commercial exploitation, but might be used locally. Probably 500 loads could be collected but that would be an optimistic maximum.

Sandburg Deposits.—The two sand deposits in the valley in which Irene is situated are two miles south of that city, one on the east bluff and one on the west bluff of the valley some 50 to 60 feet above the valley bottom. A pit has been opened in the one on the east side at the N. E. corner of section 13 which is known as the Sandburg pit. This is the smaller of the two deposits, containing about 1,000 cubic yards.

The second deposit lies on the opposite bluff at about the same elevation and is found in a series of three spurs lying just north of the road in the S. W. ½ of the S. E. ¼ of section 12. This is the largest of the sand deposits so far described and probably the largest of any in the region. No pits were opened to get accurate information on the depth of the sands but from the surface indications it appears that about 30,000 cubic yards could be excavated. There is little or no cover except a sod which has formed and which is only a few inches thick, probably nowhere exceeding a foot.

The materials exposed in the Sandburg pit are the same as those in the pits heretofore described. The deposit is primarily a coarse white sand with streaks of fine gravel running through it. The largest pebbles in the gravels do not exceed an inch and the average size is ¼ inch or less.

The following is an analysis of an average sample from the Sandburg pit. (Fig. 7):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
97	2.62	41	99	97	71	18	2	2	150	3	6	91

Figure 7

FAVORABLE QUALITIES

A clean sand (free from silt).
A hard sand (free from soft materials).

UNFAVORABLE QUALITIES

Too fine.
This one sample did not pass tensile test (1 to 3 mortar)

USES

For use in concrete.
For use as plaster sand.

(This sand would be of much greater value if it had a higher percentage of the coarser particles.)

Deposits of the same sort of sand can be found on the east bluffs of the valley in Clay County for two miles south of Irene. Their extent was not carefully studied but at a rough estimate there should be from 30,000 to 60,000 cubic yards or possibly more. If the sands of this valley were to be exploited on a large scale, these in Clay County should be given careful consideration, for they make a major portion of the total.

The white sands, while not in one large deposit, in the aggregate would furnish sand enough for something more than a purely local industry. The total of the estimates given would make 87,000 cubic yards for Yankton County, and if those in Clay County be added the total for the region should be not far from 150,000 cubic yards.

3. Upper Turkey Creek Valley.—There are no large deposits of gravel in this region, but, because of the scarcity, the deposits which occur are much more important than they would be under other conditions. The workable deposits of gravel lie in sections 2 and 10 of T. 95 N., R. 54 W., about two miles southwest of Irene, and in section 27 T. 96 N., 54 W., two and a half miles northwest of Irene. These are all composed of medium to fine gravels and considerable sand but there is no such uniformity in their character as there is in the white sands.

Middle of Section 10.—The southern-most deposit is found in a tributary of Turkey Creek near the center of section 10, T. 95 N., R. 54 W. The gravel occurs on the north side of a little valley and stands out as a slight shoulder. North of the shoulder about 500 feet there is a dome-like hill which also contains gravels. The two physiographic features are so close together that it really comprises a continuous deposit of gravel.

A pit has been opened in the southern end but abandoned. It had slumped so that it was impossible to get much of an idea of the composition. In general, it runs to fine gravels and sands. A sample which was as near average as could be obtained gave the following (Fig. 8):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
93	2.53	41	97	93	71	11	3	8	221	30	19	51

Figure 8

FAVORABLE QUALITIES

Sand passes tensile test (1 to 3 mortar).

UNFAVORABLE QUALITIES

Large per cent of soft material.
Percent of silt.

USES

For use as road surfacing material, the material is too fine to stand up well. The treatment here might be to add enough clay to make a good sand-clay type of surface.

The sand could be screened out and used with good crushed stone as a concrete material.

The per cent of silt would have to be carefully watched.

The deposit should yield about 18,000 cubic yards which, while not a great volume, would be valuable because of its location and the scarcity of gravels in the vicinity. It has so little cover that the gravel is thrown out by the plow and in gopher holes on the slopes. Three feet will probably be the maximum stripping required.

Dutton Deposits.—The next deposit is a half to three quarters of a mile to the north of the one just described and consists of six or seven little shoulders high up on the bluffs of Turkey Creek Valley and a tributary of that valley which enters in from the west. These shoulders vary in size but average about 100 feet long, 50 to 75 feet in width and 15 to 25 feet in height. The shoulders are located in the N. E. ¼ of section 10 and the S. E. ¼ of section 3, most of them being in the first section. Only one shoulder has been opened, the pit being on the Henry Dutton farm in the N. E. corner of section 10. A fifteen foot face here shows rather poorly sorted sands and medium grained gravels. At the top there is a three foot layer of cobbles ranging up to 6 inches in diameter; below that sands and medium gravels in beds less than a foot thick and with occasional cobbles scattered through it; and below this comes the white sand described above (p. 13).

The maximum volume for all these together is estimated at 32,000 cubic yards. This figure is probably more than could actually be counted on in operating these deposits, as it would mean getting all the gravel in the deposits.

There is no cover that would have to be stripped except possibly at the back of the deposits where clay may have washed over the gravels. This, however, would hardly be a feature that would hinder to any degree the exploitation of the gravels.

A sample from the Dutton pit gave the following (Fig. 9):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
96	2.56	40	75	66	53	11	3	8	219	6	41	53

Figure 9

FAVORABLE QUALITIES

Fair weight.
Fair amount retained on ½ in. mesh.
Well graded sand.
Low amount of soft material.

UNFAVORABLE QUALITIES

Rather high silt content for use in concrete.

USES

By installing a small portable crusher at this pit to crush the oversize, an excellent road material would result.

This material could be used in making concrete because of fairly low amount of soft material. The amount of silt should be watched, however. For pit run, the following mix (by volume) is suggested; one part cement to 4¼ parts pit run.

Dolrup Deposit.—A little less than a mile northeast of the Dutton pit there is a deposit which has been opened on the Chris Dolrup farm. It lies in a little valley less than a quarter of a mile from the valley of Turkey Creek, near the center of section 2, T. 95 N., R. 54 W. The deposit lies under a small rounded knoll whose top is very nearly the same elevation as the top of the valley walls.

A pit has been opened in it and a great deal removed, but it is estimated that the deposit could be worked for 100 feet east of the present (1924) face of the pit. It would be safe to estimate that between 6,000 and 7,000 cubic yards of material could still be excavated.

The materials consist of sands and gravels which are pretty well separated, so that it has been possible to excavate them separately without screening. The sands occupy the lower and western part of the deposit and are medium to fine grained with a few small streaks and patches of pebbles scattered through it. It is composed chiefly of quartz but some portions have a considerable amount of chalk. This chalk however does not exceed 5 or 10 per cent and would not be injurious for most uses. A sample of the sand gave the following analysis (Fig. 10):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ¼ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
88	2.56	45	99	96	66	4	1	5½	220	41	34	25

Figure 10

FAVORABLE QUALITIES

Well graded sand.
Fairly low per cent of silt.
Passes tensile test (1 to 3 mortar)

UNFAVORABLE QUALITIES

Large per cent of soft material (chalk rock and shale).

USES

Could be used in concrete if sand was screened and mixed with a good coarse aggregate.

The sand has been pretty largely used and there is not enough left for commercial exploitation but there is still sufficient for local use.

Gravels make up the main part of the deposit. As exposed in the pit they are quite uniform in size and composition over the entire face. On top there is a streak of sand which varies from 0 to 3 or 4 feet in thickness. Under this comes a one to four foot layer of coarse gravel and cobbles. The rest of the 20 feet exposed was composed of medium gravels with considerable sand mixed in.

An average sample of this gravel gave the following (Fig. 11):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
86	2.51	46	85	72	33	6	1	12	200	47	17	36

Figure 11

FAVORABLE QUALITIES

Has a fairly well graded sand—passes tensile test.

UNFAVORABLE QUALITIES

Large per cent of chalk rock and shale.
Large silt contest for use in concrete.
Low weight.

USES

As a road material it would have a tendency to dust and ravel because of large amount of soft material. Could be improved by crushing oversize, (in case oversize runs mostly hard material,) otherwise might be treated somewhat similar as sand-clay road.

Sec. 27 *T.* 96 *N., R.* 54 *W.*—A small isolated terrace occurs near the center of section 27, T. 96 N., R. 54 W. This occurs as a small terrace on the east side of the valley of Turkey Creek about 15 feet above the bottom of the valley. The total volume of the deposit was between 6,000 and 8,000 cubic yards but about two thirds of of this has been removed.

The pit had been abandoned (1924) and had fallen in, but from the few exposures and character of the slumped material it was ascertained that the material was predominantly fine gravel, the maximum size of the pebbles being ¼ to ½ inch with the average size of about one-eighth of an inch. Patches of cobbles and small boulders are scattered through the deposit but are so well segregated that little or no screening was necessary to remove them. These patches make 5 to 10 per cent of the deposit. This material is a little too fine for road material but could be made to serve if needed. It is better sized for concrete work.

Small Unusable Deposits.—Gravels show at several places along Turkey Creek just above the chalk outcrops but the deposits are not sufficiently large to be considered. Such gravels show in T. 95 N., R. 54 W. On the east bluff of Turkey Creek Valley in the N. E. ¼ of section 14, and on the road ascending the bluff at the S. ¼ corner of the same section and also along the road at the S. E. corner of the section. They were also noted near the S. ¼ corner of section 13. Some of these showings seem to indicate abundant gravels on first sight but more careful observation showed that they were only small patches on the hillside.

4. Kame Deposits:—

Peter Jonason Deposits.—There is just one kame field on Turkey Ridge and that is not far from the gravels last described. It lies in the S. E. ¼ of section 33 T. 96 N., R. 54 W., three miles due west of Irene, on the Peter Jonason Farm. The deposit consits of two

rows of little kames in a rough north-south alignment lying on the south side of a broad valley tributary to Turkey Creek. There are at least ten little kames in the group but only three of them are large enough to be worth consideration from a commercial standpoint. One of these has been opened. It is a low, rounded hill about 100 by 150 feet in width and 8 or 10 feet high. The bottom of the gravels in this hill has not been reached but it is probable that they will not extend much beyond 10 feet or 15 feet. This hill should furnish between 2,800 and 3,000 cubic yards of material.

The second workable kame is a ridge which lies a few hundred feet east of the first kame and trends in a northwest-southeasterly direction. This ridge is about 400 feet long by 50 feet high and stands about 8 feet high. The volume of this hill is estimated at about 3,000 cubic yards.

The only other hill apparently worth opening is a few hundred feet due north of the one with the pit in it. A fence line runs across the top of it. It is a dome-shaped hill about two-thirds the size of the one which contains the pit and therefore could be counted on for about 2,000 cubic yards of gravel.

In none of these kames is there more cover than a sod or a few inches of silt, so that they require very little stripping.

The material exposed in the pit will give a good idea of what may be expected from all the kames in this field. It is not well sorted nor very uniform through the pit but consists of coarse and fine gravels mixed. A few boulders are scattered over the surface of the kame but none were found in the pit. The average size of the coarser gravels is two inches and from this size the materials grade down to sands. There are also a few streaks of silt exposed.

The average sample from this pit yielded the following tests (Fig. 12) :—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
92	2.51	41	87	73	48	15	4	7	173	22	28	50

Figure 12

UNFAVORABLE QUALITIES

Fairly large amount of soft material.
Sand did not pass 7 day mortar test.

USES

Can be used for road surfacing material. It would help the sizing and make a better road to crush and use oversize rather than screen them out. The sample as obtained has too much sand in proportion to the coarser material.

5. **Esker Gravels.**—Strings of boulders and ridges of very coarse gravel and boulders occur in the valleys of both forks of Turkey Creek in T. 96 N., R. 54 W. and in the nameless valley at the eastern edge of this township. The materials in these deposits are too coarse to be used by the ordinary methods but they will be described here in order that they may be available if it is found possible to crush them profitably.. At many places in these valleys small eskers and boulder strings occur but there are only four that are large enough to be worthy of consideration. Three of the four are in the main valley of Turkey Creek. For convenience these may be called the north esker, middle esker and south esker. The fourth lies in the valley at the eastern edge of the township about two miles north of Irene.

The North Esker.—This esker occurs in the bottom of the valley within a few feet of the channel of the stream three quarters of a mile west of the village of Center Point in the N. W. ¼ of section 5. Its northern end lies about 1,000 feet east of the northwest corner of the section. From this point it trends southwest for a distance of about 1,400 feet. It rises as a sharp ridge 10 to 15 feet in height. About 1,000 feet from the northern end there is a sag 50 to 100 feet long, which cuts the esker in two parts, the northern part being the longer (1,000 feet) while the southern part is only about 300 feet in length.

The materials in this esker are typical of this form of deposit, being made chiefly of coarse gravels and cobbles with some finer streaks mixed in. A little sand was also exposed in one of the road cuts. All material exposed is much oxidized and therefore very red in color, due to the iron contained. This, however, is no detriment to its use as road gravel. It is too coarse to use profitably even with screening but might be crushed to usable size. If such preparation were possible, the esker should be made to yield about 33,000 cubic yards of material. About 25,000 cubic yards of this would come from the northern section and 8,000 from the southern.

Middle Esker.—This is a rather large deposit which lies along the west bank of the creek, running south from the N. ¼ corner of section 16, two miles south and half mile east of the village of Center Point. It forms a ridge 1,000 feet long, its east side sloping very abruptly to the stream of Turkey Creek, while its west side slopes gently away into the west side of the valley. It rises some 20 feet above the stream at its highest point.

The materials have been exposed in a fifteen foot face, partly by the action of the stream and partly by a pit which was dug, apparently, in search of gravel. This exposure shows that the major part of the deposit is made of extremely coarse materials. Boulders one to two feet in diameter form 50 to 70 per cent of the deposit. There are, however, pockets of gravel and also sand mixed in with the boulders and it was one of these pockets that led to prospecting

the esker for gravel. None of the pockets exposed, however, were over 5 or 6 feet deep and so could not be depended on as a source of gravels. There were also a few small patches of silt. The hole was very much oxidized so that the prevailing color was red or dark brown. So much iron was present that it cemented the finer gravels and sands in places.

The volume of this deposit is estimated at from 18,000 to 20,000 cubic yards. The great preponderance of boulders, however, will prevent its exploitation unless it can be crushed and sized profitably.

The South Esker.—This esker lies on the east side of the Turkey Creek, just below the junction of the east and west forks of that stream, at the western edge of the S. E. ¼ of section 22, two and a half miles east and two miles north of Irene. It is a prominent ridge, rising some 20 feet above the stream, which is composed of two parts separated from each other by about 400 feet. The southern section is 250 feet long and the northern 500 feet.

This esker has not been opened except where the road cuts through it, at which place there is a large deposit of silt. The boulders strewn over the surface and the gravel thrown up in badger holes show that most of the esker is composed of the typical coarse material A poor sorting of materials may be expected so that crushing and screening would have to be resorted to in order to use it.

The total volume of this esker is estimated at 15,000 cubic yards.

Irene Esker.—Only the extreme northern tip of this esker is in Yankton County but it wil be described here because it lies just east of the county line in Turner County and because it belongs with the Yankton County eskers by reason of its origin and proximity. The southern end is a mile and a half due north of Irene, about 300 feet east of the W. ¼ corner of section 30, T. 96 N., R. 53 W. From this point it follows the nameless valley in which Irene is situated due north, except for winding back and forth across the valley for a mile and three quarters, ending in the S. E. ¼ of section 13, T. 96 N., R. 54 W.

The esker is not one continuous ridge but is made of seven elongate mounds lying end to end. They rise conspicuously out of the valley floor to heights varying from 8 to 30 feet. There are two large mounds, one at the southern end and one near the northern. They are about 400 feet long and from 25 to 30 feet in height. The other mounds are all smaller, rising only five to eight feet.

This esker contains the characteristic coarse materials and could not be used for gravels without considerable preparation, either screening or crushing or both. It was opened only in a road cut near the N. W. corner of section 19. About a five foot face was exposed, which showed that about 30 per cent of the material there

was made up of boulders up to a foot and a half in diameter, the average running six to eight inches, 40 per cent of gravel with pebbles averaging one inch in diameters, and 30 per cent coarse to medium sand. This material was poorly sorted, though there were some pockets of sand which had been worked a little for road material. A redeeming feature, however, is the resistance of the rocks making up a large portion of the cobbles and boulders. A large percentage of them is quartzite, while there is a generous amount of schist, gneiss, and granites and limestone. All of these, with the exception of some of the granites which are much weathered, will make excellent road material if crushed.

The total volume of the esker is about 30,000 cubic yards. Some 8,000 cubic yards are contained in each of the large mounds, while the total volume of the five smaller mounds is about 14,000 cubic yards. Distributed over such a length of territory as it is, and considering the amount of preparation necessary before the materials could be used, this does not offer as promising a deposit as many others in the county.

6. A Stray Sand Deposit.—On the west wall of the little tributary to Clay Creek near the S. ¼ corner of section 36, T. 96 N., R. 55 W. a bank of well sorted, medium grained sand is exposed. It is white to gray with reddish portions, especially near the top. The exposed face varied from 5 to 15 feet in height but no estimate of the volume of the deposit can be given because the sand was overlaid by till (boulder clay) and there was no hint of its extent in the topography. The face can be followed along the road for two or three hundred feet and outcrops for about 500 feet north of the road.

This is a very good sand but cannot be recommended for large operations because of the uncertainty of its volume and because of the thickness of the till cover. However, it could be used to advantage locally for smaller operations.

MUD CREEK VALLEY DEPOSITS

Mud Creek flows parallel to the James River a few miles east of it and enters that stream near the middle of the county in section 17, T. 95 N., R. 55 W. At the southern end of the valley gravel terraces occur which are sufficiently large to be worthy of attention. A field of small kames containing inferior gravels and lying just north of the terraces should be added to the list of deposits in this valley.

1. Terraces.—South of the Corn Belt Highway (the north line of T. 95 N., R. 55 W.) Mud Creek has incised itself in a sharp little valley and in the process has left gravel-capped shoulders projecting from the bluffs. The tops of these shoulders are about 25 feet above the bottom of the valley floor but gravels occur only in the upper few feet. The lower part of the terraces is made of till (boulder clay). The depth of the gravel caps varies from about

three feet to ten or fifteen, the deeper deposits being near the mouth of the valley.

Erickson Deposit.—With the exception of one a mile south of the Corn Belt Highway and one or two near the mouth of the valley, these terraces do not contain enough gravel to be worthy of consideration for commercial exploitation. The first mentioned deposit lies in the fork where a small tributary joins Mud Creek in the S. E. ¼ of section 5, T. 95 N., R. 55 W. A pit has been opened in its southern end which is known as the Erickson pit.

The terrace lies on the west side of Mud Creek Valley extending north for about 1,000 feet from the section line road. For the first 500 feet it occupies the entire space between the valley of Mud Creek and that of the tributary stream mentioned above. At the pit 9 feet of gravel is exposed. At a conservative estimate this terrace should contain 20,000 cubic yards of material.

In the pit the gravels are covered by a foot of silt. Further north, however, this cover increases in depth to three feet. This cover would not prove a serious obstacle to operating the gravels, since it is a light clay and not very thick.

The gravels are fairly well sorted, medium grained, with not more than a half of one per cent oversize. These materials are fairly well sorted into separate beds of sand and gravel but the beds are too thin to allow working them separately. The sand beds do not exceed two or three feet at most and the gravels run about the same.

An average sample from this pit showed the following (Fig. 13):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
99	2.58	38½	61	45	20	7	2	6	98	7	29	64

Figure 13

FAVORABLE QUALITIES

Good weight.
Small amount of soft material.
Good percentage of material retained on ½ in. mesh.

UNFAVORABLE QUALITIES

In the sand—not enough material passing 20 mesh.

USES

A good road material. Oversize could be economically crushed and mixed in.

As a concrete material the sand does not contain enough fine particles, that is, material between 20 and 50 mesh. Perhaps other sand deposits in the terrace run finer, so that a good aggregate could be had by proper manipulation. There is very little soft material, which is a very favorable condition for use in concrete.

Mouth of Mud Creek.—There is a group of terraces at the mouth of the valley and in the James Valley near by which contains large

amounts of gravel. One is located about a half mile from the mouth on the north bluff of the valley in the N. E. ¼ of section 17, T. 95-55, and a second across from it on the south bluffs which can be traced down to the mouth of the valley and into the James Valley. These have not been opened, so there is little chance of telling much about the quality or amount of gravels in them. A continuation of these terraces in the James Valley, a quarter of a mile north of the mouth of Mud Creek, showed 15 feet of gravel. Assuming that this represents about the thickness of the gravels in these terraces, there should be from 100,000 to 200,000 cubic yards in the two terraces.

The character of these gravels is similar to that of the M. T. Johnson pits a quarter of a mile north, as near as can be judged from the small amount exposed in gullies. If so the deposits would be composed of fine gravels and sands with some coarser streaks, the oversize not exceeding 5 per cent. Because of the volume and the character of the gravels this deposit can be recommended as a possibility for exploitation for road projects or similar uses.

2. Kames.—An area containing numerous small gravel and sand deposits lies on the west side of Mud Creek Valley in the southwest corner of T. 96 N., R. 55 W. It is impossible to draw the exact limits of this field with the present information, but most of it lies in the S. W. ¼ of section 30 and portions of the northern half of section 31. The most conspicuous feature of the field is a S. W. trending ridge about 1,000 feet long, which lies on the A. E. Hotter farm near the S. W. ¼ of section 30. This ridge is divided into three parts of about equal size by two sags, which make it look like three short ridges. Each of these portions stands up sharply from its surroundings to a height of about fifteen feet.

This ridge has never been opened and the only information as to the character of the materials came from two shallow test holes made with a four foot post hole digger; one at the northern end and one at the southern end of the ridge. At the northern end three feet of a silt containing scattered pebbles overlaid a brown sand which was at least a foot in thickness. Farther south, on the ridge, however, water worn pebbles and cobbles were scattered over the surface, showing that the cover of silt was either lacking or quite thin. From the little information thus gained it may be assumed that the material is finer than is usually found in esker-like ridges of this type and is probably quite poorly sorted.

The total volume of this ridge cannot exceed 15,000 cubic yards of material. The fineness of much of that exposed and its uneven distribution make it certain that it would be impossible to excavate any such amount of material suitable, whether for road purposes or concrete work.

The gravels in the rest of the field are contained in little dome-like hills 50 to 100 feet across and 4 to 8 feet high and in low ridges of about the same height 100 to 150 feet long. Several of

these were tested with a post hole digger and some were found to be made of till (boulder clay), but most of them contained gravels and sands. One of them lying just north of the road three-tenths of a mile west of the S. E. corner of section 30 has been opened and is known as the Nuni pit. This pit shows a depth of six feet of coarse, poorly sorted materials. About half of it is coarse gravel with pebbles over two inches in diameter. The maximum size of pebbles in the over-size is eight inches. The other half is composed of medium to fine gravels, some sand and considerable clay.

It is not probable that more than 3,000 cubic yards could be excavated from all the kames in the field. The small volume and the character of the materials do not make them very promising for large scale exploitation. If their volume be added to that of the esker ridge just described, sufficient volume could be obtained to make it worth while but the character of the materials is such as to make their value quite doubtful. If the field should be considered, careful prospecting should be done before excavation is begun.

JAMES VALLEY DEPOSITS

About twenty-three miles of the James River Valley lies in Yankton County. Though this valley might seem a logical place to find gravels they are surprisingly scarce. There are a few large deposits but these are separated by long stretches in which gravels are found only in small patches or as little showings scattered over the bluffs. These deposits have been divided into four groups:—(1) the terrace gravels, which form perhaps the most important type; (2) the deposits of sand and gravels at Johnston's Bridge; (3) Johnston's esker; and (4) miscellaneous deposits, which include some gravel pockets and stray sand deposit. For convenience in location, these features, with the exception of the pocket gravels, will be described in order, starting from the northern end of the valley.

1. The Terrace Gravels:—

T. 96 *N.*, *R.* 57 *W.*—Gravel terraces are to be found on the east bluff of the valley in the township, in sections 10, 11 and 12. The first one worthy of note occurs just east of the school house in the N. W. ¼ of section 10 and is a little shoulder one or two hundred feet long. To the east of it in the N. W. ¼ of the same section occurs another at the same elevation. This is about 1,000 feet long and one to two hundred feet in width. East of this last near the E. ¼ corner of section 11 occurs another small terrace not over 400 feet each way. A church is located on top of this terrace at the junction of the bluff road and a road leading northward. A little gravel spot on top of an isolated hill between the James Valley and a tributary valley near the center of section 11, and an extensive terrace in which the Hauck pit has been opened in the S. W. ¼ of section 12 complete the list. These terraces are all about

the same level and are found about 60 feet above the floor of the James Valley.

Though they appear rather extensive as mapped, they are small deposits, for in none of them is the gravel more than a few feet deep.

The few exposures in gullies and road cuts indicate that the character of the gravels in the smaller terraces is much like that of the gravels in the Hauck pit described below.

Hauck Deposits.—This terrace contains the largest amount of gravel in this township. It lies in the S. W. ¼ of section 12, on the east side of the James Valley, 70 feet above the valley floor. The terrace is 1,200 feet long and averages 100 feet in width. The gravels covering the terrace average 5 feet in depth. The total volume of gravels in this deposit, therefore, would be about 22,000 cubic yards. The cover is very thin, reaching not more than 2 or 3 feet as a maximum.

Two pits have been opened about the middle of the terrace and are known as the Hauck pits. Both these pits showed medium to fine gravels, quite uniform in all parts of the pits. The oversize did not exceed two per cent. An average sample gave the following analysis (Fig. 14):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
89	2.51	43	82	71	34	7	6	5	156	22	40	38

Figure 14

UNFAVORABLE QUALITIES

Lots of shale in sand (held on 10 mesh, passing ¼ in.)
Soft material.
Did not pass mortar test.

USES

The best use for this material would be for road surfacing purposes. Because of the large percent of sand and soft material, the treatment here might be the same as for a sand-clay road.

T. 96 *N.*, *R.* 56 *W.*—There are no gravel terraces on the west bluff of the James Valley in this township. Occasional little patches of gravel may be found on the hillsides and in one or two instances small pits have been opened in them. These pits, however, proved to be only tiny pockets and were abandoned. The only material which might prove of interest is a sand deposit in a little tributary valley in section 30. In the bottom of this valley there is a deposit of sands which might be worked to advantage for some purposes. The channel of the stream has cut into this deposit so that it stands as terraces not over 100 feet wide on both sides of the stream channel 8 to 10 feet above its bottom. This deposit can be traced for about 2,500 feet from the mouth of the valley.

It is composed primarily of medium to fine white sand, with spots and streaks of gravel. The gravel makes only 10 to 20 per cent of the deposit.

Near the stream channel there is very little cover but this increases toward the sides of the valley, due to wash from the bluffs. An average of two to four feet might be expected.

The character of the bottom of the sand deposit being unknown, it is not possible to make more than a very rough estimate of the volume. It is thought, however, that 60,000 cubic yards would be all that the most optimistic could expect.

The Jamesville Ridge.—This is the largest single deposit on the east bluffs in this township and is located in the S. W. ¼ of section 28, just east of the site of the Jamesville colony.

The gravel lies on a ridge whose top is 60 feet above the bottom of the valley. The ridge is broken by two small valleys which divide it into three parts, the west end being a small portion about 200 feet long, the middle section 800 feet, and the western section 200 feet in length. The average width of the ridge is about 50 feet. The depth of the gravels varies from a very few feet to 8 or 10 feet, with an average of about 6 feet. The total volume of gravels that might be expected from this deposit is about 13,000 cubic yards. It is very accessible, however, as the Bluff Road runs at the base of the ridge and little or no stripping would be necessary.

A pit was opened in the little section at the extreme western end of the ridge, probably for use in making the buildings for the colony, but it has fallen in and gives a poor idea of the character of the material. The following analysis (Fig. 15) was made on a sample taken from this pit and while it is not certain that this represents an average of the deposit, the analysis gives a pretty fair idea of the sort of material to be expected.

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
90	2.53	43	84	79	25	9	4	3	188	11	45	44

Figure 15

FAVORABLE QUALITIES

Low per cent of silt.
Fairly low per cent of chalk rock.

UNFAVORABLE QUALITIES

Too fine to make a good road gravel.
As a sand, too much material held on 10 mesh and pass ¼ in.
But did not pass mortar test.

USES

Its best use would be for road surfacing. Because of large percentage of sand this material would probably be best handled in the same manner as for a sand-clay road.

Nelson and Peterson Deposits.—East of the Jamesville Ridge, in sections 28 and 27, some small shoulders containing some gravel may be found at about the same height above the bottom of the valley. They are all small, however, the largest having a volume of from 200 to 700 cubic yards each. The largest and most abundant of these deposits occurs in and about the mouth of a small tributary which flows along the western side of section 26. There are about six fair sized shoulders of gravel here. Two of them have been opened, one at the mouth, on the Nels Nelson farm in the N. E. corner of section 34, and another, known as the Peterson pit, a mile north near the N. W. corner of section 26.

The materials exposed in the Nelson pit were medium to fine gravels, which should make very good road material. The Peterson pit, however, was opened for road graveling but proved to be too fine and was abandoned. There should be a considerable amount of materials for road or other purposes in these shoulders but they should be carefully tested before starting any large scale operations on them. The volume of the entire lot would not be great, however, perhaps 1,500 to 3,000 cubic yards is all that might be expected.

T. 95 *N.*, *R.* 56 *W.*—Only three miles of the James Valley lies in this township. Gravel terraces occur on both sides of the valley near the north line of the township and some pockets of gravel occur a mile to the south on the east bluffs. While none of these are large deposits, there is more gravel in the short portion of the valley in this township than in the entire length of the two townships farther north.

Sigel Gravel Deposits.—These occur in a large terrace on the west bluff of the valley near the east ¼ corner of section 3 and in two or more little terraces southeast of the large one in the S. W. ¼ of section 2. These terraces lie about 60 feet above the floor of the James Valley. The first one mentioned is 550 feet long and varies from 400 to 200 feet in width in the wider parts. A pit opened in the southern end of this terrace exposes 10 feet of gravel without reaching the underlying clay. That, however, is about the average depth of the gravels. The other terraces are much smaller but might make a supplement to the large one, being not over two hundred feet across.

The large terrace should yield about 40,000 cubic yards of material. The smaller ones might yield 1,000 cubic yards apiece.

The material exposed in the pit showed quite clean, fine gravel, fairly uniform from top to bottom of the pit. There is a little zone of coarser gravel near the top but very little oversize in any part of the deposit. An average sample from the pit gave the following analysis (Fig. 16):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
90	2.55	43	96	90	26	2	0	4½	133	24	36	40

Figure 16

UNFAVORABLE QUALITIES

Amount of soft material.
Too much sand for road gravel.
Sand has too much material retained on 10 mesh and pass ¼ in.

USES

As road surfacing material. Add clay and treat as sand-clay road. The cover varies from 1 to 2 feet and is a silt which can be easily removed. The thin cover, the amount of gravel and the uniformity of the materials should make this a profitable deposit to exploit.

Terrace on East Bluff.—This deposit is located in the N. W. ¼ of section 1. The largest part of it occurs in a terrace about the same height above the valley floor as the Sigel terraces. A small tributary valley lies behind the terrace, making it stand out as more or less of a ridge. On the west side of this little valley there are shoulders of gravel. Two little shoulders north of the big ridge belong to this deposit.

The big terrace is about a quarter of a mile long and 150 to 200 feet wide. Its coat of gravel, however, is not very thick, probably not averaging over 5 feet. Even with as thin a coat it would be possible to strip off 20,000 to 25,000 cubic yards of material if it were all taken. The gravels on the small terraces are deeper and could probably be worked more easily. They could hardly be expected to furnish more than 5,000 cubic yards, however.

As no pits were opened, an idea of the character of the materials must be gained from shallow borings and the material on the surface. These indicate that it is made primarily of medium gravels with patches of coarser materials here and there. The coarse materials ranged up to small boulders but apparently made a small proportion of the deposit.

T. 95 *N.*, *R.* 55 *W.*—The portion of the valley in the township includes a five mile section north from the Johnson bridge. In this strip are located the largest deposits in the James Valley. These deposits are all terrace gravels and may be found on both sides of the valley. The largest single deposit occurs as a terrace on the west side of the valley in the western half of section 27.

Small shoulders occur near the Meridian Highway, some of which have been used for road work; large amounts occur about the mouth of Mud Creek, and a big terrace occurs southwest of these last.

Small Shoulders.—These shoulders occur on the east bluffs of the valley in section 7 and on the west side in section 18. On the

east bluff there are at least two little shoulders about 100 feet long by 50 feet wide and 10 feet high in the N. W. ¼ of section 7. One of these nearest the road has been opened and exposes fresh gravels of medium size pebbles. There is little sorting into separate beds of sand and gravel, these materials being quite uniformly mixed. A sample from this pit showed (Fig. 17):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
96	2.56	40	84	55	9	2	2	7	196	7	40	53

Figure 17

FAVORABLE QUALITIES

Fair weight.
Low amount of soft material.

UNFAVORABLE QUALITIES

In sand, too much material retained on 20 mesh and passing ¼ in.

USES

This is a good road gravel.
To use this pit run for concrete purposes, the sand runs too coarse. However, the sand in the pit probably varies in this respect and by manipulation a fair result may be obtained. If pit run material were to be used a mix of one part cement to 4.75 parts pit (by volume) should result in a fair concrete.

The two deposits together could not furnish over 2,000 cubic yards. Therefore this deposit, while useful for road work or concrete, cannot be profitably exploited for more than local operations such as road repair work or small concrete structures.

On the west bluff there is a series of shoulders which are somewhat larger than those just described. A pit was opened in one near the N. W. corner of the N. W. ¼ of section 18 known as the Schram pit. The gravels have been nearly exhausted from this shoulder leaving a hole about 125x100x30 feet, or about 14,000 cubic yards of material. There are three other shoulders which might be worked between the pit and the Meridian Highway but they are small and could hardly be expected to contain over 1,000 cubic yards apiece.

The materials exposed in the Schram pit consisted of fine to medium gravels. There was a little oversize but not more than one or two per cent of the deposit. An average sample from this pit showed (Fig. 18):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
97	2.56	36	89	75	11	3	1	8	241	13	34	53

Figure 18

FAVORABLE QUALITIES

Fair weight.
Low per cent of voids.
Sand passes 1 to 3 mortar tensile test.

UNFAVORABLE QUALITIES

Too much material passing ½ in. screen to make ideal material.
In sand, too much material retained on 10 mesh and pass ¼ in.

USES

As an ideal road material, grading runs too fine. More material around ½ in. and ¼ in. would help a great deal. Low percentage of soft material is a good point in its favor.

For use in concrete, both the amount of silt and amount of soft material would have to be watched. If these factors were within the limits, a good concrete could be obtained with a one to four mix (by volume) pit run.

On the whole these gravel shoulders do not offer a very encouraging field for prospecting. Their character is good but there is too small an amount of them. For such purposes as road repair or maintenance they will serve very well, as they are located near the highway and contain sufficient material for such purposes for some time.

Near the Mouth of Mud Creek.—For a stretch of a mile and a half along the east bluff of Mud Creek remnants of gravel terraces occur. The northern-most, large enough amount to be noted, occurred at the N. ¼ corner of section 17, nearly a mile north of the mouth of Mud Creek. This shoulder is about 100 feet long and 30 feet wide and stands about 60 feet above the floor of the James Valley. About 500 feet east of this occurs a larger terrace which is some 200 feet long and 50 feet wide. Near the center of the section a fairly large terrace occurs, from which flows a big spring and south of this point the gravels are nearly continuous to the mouth of Mud Creek. The continuity of this last section, however, is broken by stream valleys into three distinct parts, the one with the spring, the next one east with the M. T. Johnson pit, and the third one, the largest part of the terrace, at the north of Mud Creek. The first two parts are but a few hundred feet long but the third has a length of at least 1,000 feet.

A terrace at the mouth of Mud Creek on the south side has been described with the deposits of Mud Creek. (See p. 23.)

About a half a mile south of the mouth of the creek in the northern part of the S. W. ¼ of section 21, occurs a terrace at the same height above the valley floor as those just described. It is smaller than some of them, being about 500 feet in length by 200 feet wide.

The volume of gravels which may be expected from these terraces may be tabulated thus:—

Northern-most shoulder	800	cubic yards
Shoulder 500 feet south	2,500	cubic yards
Large terrace from spring to mouth of Mud Creek	40,000 plus	yards
Schoolhouse terrace	35,000	cubic yards
Total	78,300	cubic yards

If to this figure is added the volume of the gravels described in Mud Creek Valley near its mouth, the total would amount to something over 200,000 cubic yards.

M. T. Johnson Pit.—There is but one pit opened in all these terraces and this is about 1,000 feet north of the mouth of Mud Creek Valley on the M. T. Johnson farm. The materials of this pit probably represent about the average character of all the gravels in this vicinity. Ten feet of gravels were exposed, the upper part being of medium to coarse gravel and cobbles. Only about 5 per cent is over 2 inches in diameter. Below this zone was a zone of about three feet of fine gravel and sand. Below this lies four feet of medium gravels. An average sample from this pit gave the following (Fig. 19):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
101	2.56	37	69	52	23	2	0	5½	207	23	19	58

Figure 19

FAVORABLE QUALITIES

Good weight.
Low per cent of voids.
For road gravels, good percentage passing ½ in. screen.
Sand passed 7 day mortar test.

UNFAVORABLE QUALITIES

Large per cent of soft materials.

USES

The best use for this material would be for road surfacing purposes. The grading is very good.

As a concrete material, the large per cent of soft material is a serious drawback. If this shale and chalk could be partly removed, a good concrete would result from the following mix, 1 to 4.75 (by volume).

Voll Pit and Terrace.—This deposit is one of the two largest continuous deposits in the county. The terrace lies on the west bluff of the valley in the western half of section 29. It is a mile and a third long and averages 800 feet in width. Its top lies about 60 feet above the floor of the James Valley. It is capped with gravels which vary from 10 feet in thickness at the northern end to 20 feet near the southern. This terrace is estimated to contain 1,500,000 cubic yards of gravels, which makes it one of the largest deposits in the county. The cover is not over two feet, except at the back of the terrace, which adds materially to the ease with which it could be excavated.

The materials vary in different parts of the deposit, apparently grading more or less roughly from north to south. A road cut at the northern end exposes very coarse materials with small boulders up to 1½ feet in diameter overlain by a thin zone of fine gravels and sands. At the southern end the material appears to

be finer, two to six inch streaks of sand and fine gravels making most of the deposit at the extreme southern end. The materials found in shallow tests and thrown up from the badger holes indicate a medium sized gravel and it is thought that material of this size makes most of the deposit.

The only pit opened in this deposit is on a remnant of this terrace which has been left just south of a tributary valley. It is on the Voll farm in the S. W. corner of section 29. The following analysis (Fig. 20) from a sample taken from this pit will give an idea of the character of the deposit:—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
94	2.56	41	84	68	46	12	1	3½	98	10	56	34

Figure 20

FAVORABLE QUALITIES

Low per cent of silt.

UNFAVORABLE QUALITIES

Sand did not pass one to three mortar test.
Not a very large per cent of hard materials.
Runs a little fine for a well graded road material.

USES

Because of the extent of this deposit it may well be expected that qualities will vary. From this sample as taken, the following recommendations are made:

As a road material this gravel runs a little fine.

Because of the extent of the pit and probable oversize that will be encountered, it is suggested that a small portable crushing plant be established and all oversize be crushed and mixed in with the gravel. As most of the larger material is of limestone nature, a good road material would result.

As material for making concrete, further investigations should be made. The sand obtained in this sample did not meet requirements for 1 to 3 mortar on 7 day test. A strength of 200 is necessary, while this one showed only half that amount. Apparently the reason is because of poor grading of particles. By proper manipulation with a little coarser sand, a good material would result. The percentage of soft material is fairly low, which is a factor in its favor.

2. Deposits at Johnson's Bridge.—Some very large deposits of sand and gravels which cannot be classed with the terrace gravels occur on the east and west bluffs of the James Valley at Johnson's Bridge. Those on the east side lie in the S. W. ¼ of section 33, T. 95 N., R. 55 W. and extend south in the N. W. ¼ of section 4, T. 94 N., R. 55 W. Those on the west bluffs lie for the most part in the S. E. ¼ of section 31 of the first township and extend southward into the N. W. ¼ of section 5 of the second.

They occur as shoulders projecting into the valley. At their northern end they occur almost at the top of the valley but lie lower down toward the south. The lowest parts of the deposits are 30 to 60 feet above the bottom of the valley.

These shoulders are particularly noticeable in the middle and late summer because of the brown and dry character of the vegetation. Instead of the plants commonly found in the neighboring regions, these sand and gravel shoulders are covered with yucca cactus, sage and the hardier grasses.

It is difficult to estimate the amount of sand and gravel which these deposits contain, because there has been considerable slumping in the main and tributary valleys which has made the depth of the material uncertain. It is probable, however, that those on the east bluff will supply more than 100,000 cubic yards and those on the west bluff 150,000 cubic yards. This makes a total of 250,000 cubic yards for this region.

The materials of the deposits are exposed in slumped faces here and there, and in a few shallow pits which have been opened, but these are not placed so that it is possible to get more than some general ideas on their average character. Medium size gravels, fine gravels and sands form almost the entire bulk of the deposits. A few boulders are scattered over the hills and probably occur scattered through the body of the sands and gravels but they form so small a proportion of the materials that they can be ignored. The sands are to a large extent red or brown but considerable clean, gray sand is to be found also. It averages about 30 mesh and in most places is quite clean and uniformly sized. Medium size gravels are very abundant, making up perhaps half of the deposit.

These materials occur in large streaks or pockets. Ten or fifteen foot faces of sand occur in several places and equal thicknesses of gravels can be counted on. This makes it possible to work these deposits separately for sand or gravel without resorting to screening or other mechanical separation. It is impossible to predict the amount of material which might be excavated at any one place in this way but it is certain that a careful testing of the deposit will reveal that it is attractive for commercial exploitation if properly handled.

3. The Johnson Esker.—This is a short esker at the junction of the valleys of the James River and Beaver Creek. It projects from the point of the bluffs on the north side of the Beaver Valley near the middle of section 17 into the James Valley, trending S. 30 E, for a distance of 1,700 feet. It rises sharply out of the valley to a height of 15 feet at its southern end and 25 feet at its northern end.

The total volume is about 55,000 cubic yards. It is doubtful, however, whether that much usable gravel could be excavated. In the first place the materials in the southern quarter of the esker are very coarse, boulders from one to three feet in diameter being common. In the second place, the northern end runs up over the boulder clay of the valley bluff and the exact depth of the gravels there is not certain. Fully half of the esker, however, is composed

of medium gravel with very little oversize. A pit opened near the middle of the esker exposed a ten foot face of gravel which tested as follows (Fig. 21):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
118	2.54	26	88	79	31	6	2	4	272	7	18	75

Figure 21

FAVORABLE QUALITIES

Good weight.
Low per cent of voids.
Low silt content.
Low per cent of soft material.
High 1 to 3 mortar test.

USES

This material could well be used in concrete because of its low per cent of voids and low per cent of soft material.

As a road material it would be better to mix a little of the coarser material in with the material such as was sampled.

Because of the variable size of the material in this deposit, it would be economical to install a small portable jaw crusher if exploitation on a large scale was demanded.

4. Miscellaneous:—

Gravel Pockets.—Gravel pockets in the till (boulder clay) of sufficient size to have attracted attention have been exposed in the bluffs of the James Valley at two localities. The northern one is on the east bluff at the bend of the valley in sections 1 and 12 of T. 95 N., R. 56 W. Gravel is strewn over the road and in rather large patches over the hillside at the bend and for half a mile east. Some small pits have been opened in these gravels but apparently abandoned before much material was removed. A fresh road cut up the hill at the bend and some stream cuts to the east showed conclusively that these gravels were simply large pockets in the boulder clay. The largest pocket exposed was 6 by 10 feet. It is estimated that all the pockets in this vicinity would not supply more than 1,000 loads, which would not be worth working commercially because of the difficulty of excavating and the character of the gravels.

Some of the pockets contain first class medium gravels fairly well sorted but in most of them the gravel was poorly sorted, coarse and fine mixed with sand and clay streaks. Most of the pockets contained medium gravels; there was also a considerable amount of materials too coarse for the ordinary uses of gravel.

Olson Pit and Neighboring Pockets:—The southern area of gravel pockets is on the east bluff of the James Valley very near its mouth. It lies in the N. W. ¼ of section 27 and the N. E. ¼ of section 28 T. 94 N., R. 55 W. Gravel is strewn over the hills here in much the same fashion as in the area just described. Several

pits have been opened and each one has turned out to be simply a pocket of gravel. The largest are 8 by 5 feet. The materials vary from clays and fine sands to coarse gravels and small boulders. They are not well sorted in most pits so that it is not possible to excavate large amounts of any sized material without screening. A pit which was recently (1924) opened showed fairly uniform medium gravels. An average sample from this pit showed (Fig. 22) :—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
91	2.51	42	78	65	43	9	3	5½		13	37	50

Figure 22

FAVORABLE QUALITIES

Passes 1 to 3 mortar test.
Fairly low percentage of soft materials.

UNFAVORABLE QUALITIES

Low weight.

USES

Because of smallness of deposit, could be used as maintenance pit for any near-by gravel road.
Could be used in small concrete jobs. Use mix about one part cement to 4½ parts pit run ((by volume).

There is no way of estimating the amount of gravel contained in this area because it is impossible to predict the size of the pockets which are exposed. It is safe to assume, however, that the total volume would lie somewhere between a few hundred and a thousand cubic yards.

These gravel pockets cannot be recommended for road construction or similiar large projects but might be useful for small concrete jobs or road maintainance.

Till Covered Deposits.—South of the mouth of the Beaver Valley are some small scattered deposits of sand and gravels which do not fall in the above classification. On the west side for a distance of two miles along the bluff road little patches of sand and some gravel are exposed under the boulder clay of the high bluffs. A similiar body of sand occurs under the till on the east side of the valley at the S. E. corner of section 21, T. 94 N., R. 55 W. These deposits are not workable commercially because they have a great thickness of till cover and they are too small to be worth excavating except for local purposes.

5. Summary.—By way of summarizing the James Valley deposits it may be said that the terrace gravel about the mouth of Mud Creek and across the valley north of the Voll pit, and the deposits at Johnson's Bridge are the most inviting for commercial exploitation. They present the largest volumes of gravel and it is of a fair quality. Next in importance would come the ter-

races in the far northwestern end of the county and the Jamesville Ridge for the northern end of the valley; the Sigel terraces and those opposite them on the east bluff of the valley. Though these deposits are not so large as the first mentioned, they occur in regions where gravels are not abundant and are therefore worth careful consideration. The Johnson esker is the only large deposit south of the Johnson Bridge and would be very important were it not for the proximity of other large deposits. It contains a large volume of gravels of good quality. Smaller deposits occur as shoulders on the bluffs and in the southern part of the valley under the bluffs near the road. None of these however, are large enough to work profitably for large operations.

LOWER BEAVER VALLEY DEPOSITS

In the lower four miles of the Beaver Creek Valley there are a number of terraces which will yield gravels in such abundance and of such quality as to make this one of the most important gravel regions in the county. The gravels occur in two sets of terraces, a lower set which is near the bottom of the valley and an upper set which is 50 to 65 feet above the bottom.

1. Lower Terraces.—The lower terraces are the most important of the two sets because they contain by far the most of the gravels. There are six of them, the largest being the farthest upstream and the remaining five being scattered on both sides of the valley farther downstream.

Big Terrace.—This terrace lies on the western side of the valley in section 12, T. 94 N., R. 56 W. It is nearly a mile long, and averages about 500 feet in width. Its northern end is but 8 or 10 feet above the stream bed and at this place it appears more like the bottom of the valley than a terrace. At its southern end, however, it is a true terrace 15 or 20 feet above the valley bottom.

This deposit has never been opened but gravels are exposed in some small gullies near its outer edge and in undercut banks of Beaver Creek. The deepest cut shows nine feet of gravel but does not reach the bottom. Using a depth of 9 feet as an average, the volume of this terrace should be 900,000 cubic yards. This figure is probably too low and an estimate of 1,000,000 cubic yards would probably be nearer the correct figure.

The information available shows that the materials are, in the main, medium to coarse gravels but there is not an abundance of oversize. It should average about like that in the Frick gravel pit described in the following paragraphs. There is a silt cover over almost the entire terrace but, as it is only one to three feet in depth, it will not form a serious obstacle in working the gravels. The indications are that this terrace can produce a very large amount of good gravel.

Frick Gravel Deposit.—This is the next terrace down stream and is opposite the southern end of the big terrace just described. It

lies on the east bluff of the valley near the S. E. corner of section 12, T. 94 N., R. 56 W. The Meridian Highway crosses its eastern end and the Frick pit has been open on the west side of the road. It is the smallest of the terraces, being about 250 by 400 feet across. A twenty foot face was exposed in the pit without reaching the bottom of the gravels. The volume of the terrace was in the neighborhood of 75,000 cubic yards, but from a third to a half has been removed and used for graveling the Meridian Highway.

The deposit is composed of fine to medium gravel. There is a little oversize which does not exceed three or four per cent. The material is fairly well sorted, so that little screening was necessary to prepare it for road use. The oversize consisted of cobbles and small boulders up to 1 or 2 feet in diameter and were made of the more resistant rocks such as quartzite and granite. Analyses run on an average sample from the pit gave the following (Fig. 23) :—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
101	2.66	39	66	53	23	4	2	7	201	7	44	49

Figure 23

FAVORABLE QUALITIES

High weight.
High specific gravity.
Low per cent of soft material.
Passed 1 to 3 mortar test.

UNFAVORABLE QUALITIES

Silt content.
Should have more materials from ½ in. to 1 in. for road material.

USES

As a road material it is good because of low per cent of soft material but it could be bettered by crushing all material over 1 in. and mixing it with general run. This would prevent probable raveling under heavier traffic.

Can be used for concrete purposes but per cent of silt should be watched very carefully. For pit run material use mix of 1 to 4¾ (by volume)).

Frick Sand Deposit.—The next terrace to the east is on the same side of the valley as the one just described and less than half a mile downstream. This terrace lies in the N. W. ¼ of the N. W. ¼ of section 18, T. 94 N., R. 55 W. It is about 1,000 feet long and 300 feet in width and contains gravels and sands to a depth of 20 feet. This should yield 225,000 cubic yards of materials. There is a cover of 1 to 2 feet of soil over the gravels.

A small pit has been opened in the eastern end of the terrace. The deposit here is composed of sand and fine gravels, with a small proportion (1 per cent or less) of cobbles and boulders. An analysis of an average sample from this pit gave the following (Fig. 24) :—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
93	2.46	40	89	79	53	10	2	4	176	31	21	48

Figure 24

UNFAVORABLE QUALITIES

Low weight.
High percentage of soft material.
Mortar did not pass 7 day test.

USES

This sample showed the pit to contain too large an amount of soft material to work all in a concrete mix.

As a road material, the material runs quite fine and the treatment should be similar to that for a sandy-clay road.

Other Terraces.—Two large terraces occur farther downstream on the south side of the valley. The larger one lies in section 18, T. 94 N., R. 55 W., with its eastern end at the east ¼ corner of that section and the smaller one about half a mile east in the N. W. ¼ of the S. E. ¼ of section 17. The first terrace is the largest of any in this valley except the Big Terrace described above. Its length is about 1,500 feet and its width 500 feet. The depth of gravel is about the same as for the other deposits. The second terrace has about a third the area of the first but the depth of gravels is about the same. The estimated volume of the larger pit is 550,000 cubic yards and that of the smaller 150,000 cubic yards.

No pits have been opened in these terraces large enough to give an accurate idea of the materials of which they are composed. The indication from gullies and road cuts is that they are much the same as those in the pits upstream. Medium to fine gravels and sands make up the major portion of these deposits.

2. Upper Terraces.—The upper set of terraces will never be an important source of gravels and sands because of their small amount of gravel compared with the lower terraces. Some pits have been opened in them, however, and there might be a use for them as supplements for the larger deposits.

They are particularly conspicuous in T. 94 N., R. 56 W., from the James Ridge to the Meridian Highway and can be traced even farther down the valley but become so small that they are little more than a mile from the Highway. The largest amounts of material are found in little tributary valleys on the east bluffs of the Beaver in sections 2 and 1, T. 94 N., R. 56 W. Gravels and sands are exposed in two of them in the N. W. ¼ of section 2 T. 94 N., R. 56 W. The tops of these deposits are about 50 feet above the floor of the Beaver Valley but the materials have slumped till it is not possible to get an adequate idea of their true thickness. The thick-

est section exposed was 10 feet. It is probable, however, that several feet could be added to this.

The materials here are rather well sorted. Medium grained sands and gravels make the bulk of the deposit, though there are streaks and patches of coarser material such as cobbles and small boulders. Much of it is oxidized, giving it a red or brown color. In some spots there is so much iron that it has cemented the sands and gravels into solid rock.

A quarter of a mile from these terraces in a tributary valley in the N. W. ¼ of section 1 there is another deposit less well pronounced. Several pits have been opened exposing coarse and medium sands and gravels. There is very little oversize and in this respect these materials differ from those in the other two tributaries. The whole is much oxidized, giving it a brown color.

The amount of gravel in these terraces is not as large as might appear because the slumping has spread the gravels over the valley slopes. A thousand cubic yards apiece for each tributary would be a most liberal estimate and the probabilities are that it would fall considerably below that figure.

Other small shoulders of gravel found scattered along the valley in sections 1 and 12 of this township can be located easily in mid and late summer by the dead and dried character of vegetation. None of them, however, is large enough to claim much attention. Pits have been opened in some of them for local uses but none has been worked on any large scale. The most that can be expected of them is a hundred loads each. Below the Meridian Highway they are too small to be worth investigating.

The materials exposed in them are medium to coarse gravels with little oversize. The material is fairly uniform and would make very usable gravels if the deposits were not so small.

JAMES RIDGE DEPOSITS

James Ridge is a conspicuous ridge that lies about five miles west of the James Valley and roughly parallels it. Its northern end is in the southeast corner of T. 96 N., R. 57 W., from which point it trends southeast for about seven miles. It rises abruptly 150 feet or more above the surrounding country. The Beaver Valley, which has cut through it near its southern end in sections 27 and 28, T. 95 N., R. 56 W., separates a conspicuous portion a mile and a half long from the main ridge, which is known as Mt. Pisgah.

Gravels and sands have been deposited on the sides of the ridge well up near the top. At the time of their formation, they were continuous along the east side of the ridge, around the northern end, and in Beaver Gap. Since that time, however, most of the material has been removed by erosion or slumped down toward the bottom of the ridge, so that large deposits are to be found only in two places, though small shoulders are scattered all along the east side of the ridge.

The materials of these deposits are patchy. Sands and gravels occur well sorted and in large masses but there is no regularity in their distribution. Boulders are common in some parts of the deposits but make a very small part of the whole. They are primarily of finer materials, sands probably being the most abundant. Gravels are plentiful enough, however, to make the deposits worth considering as gravel projects.

1. Mt. Pisgah Deposits.—Mt. Pisgah rises to a conspicuous peak with its highest point in the northern part of the S. E. ¼ of section 34, T. 95 N., R. 56 W. Around this peak there is a large deposit of sands and gravels. With the exception of a small patch just west of the top, most of the west and south sides are barren of gravels and sands, but on the remaining sides, facing the Beaver Valley, these materials are to be found in great abundance. They resemble the deposits at Johnson's Bridge in the James Valley in that they occur on a series of long spurs or shoulders which project from the peak and there is no definite level for their tops. They occur within 3 feet of the top of the peak and can be found to within 30 feet of the bottom of the valley. Most of the spurs, however, are at a rather high elevation.

There are four major shoulders and some minor ones. Each of these contains sand and gravels on top. The same materials can also be found in the gullies between them. The material has slumped so much that an estimate of the volume is little more than a guess. There should be about 100,000 cubic yards on and about each shoulder. That would bring the total to 400,000 or 500,000 cubic yards.

This is essentially a sand deposit with streaks and patches of gravel. Most of the faces exposed by slumping show sand and in the few shallow pits which have been opened sand and fine gravels form the major portion of the material. The tops of the hills, however, are strewn with gravel. This may be due in part to the washing out of the finer material. The sorting is good in most places and in some places excellent, so that it is possible to work these deposits for sand with little or no screening. In a gully on the north side of the southern-most shoulder is a thick "vein" of medium size (about 20 mesh) grit as clean as it could be made by washing mechanically. The gravels exposed are not so well sorted. They are medium to fine grained but considerable sand is mixed with them. It is probable that some parts of the deposit can be worked for gravels without screening but most of them would be improved by such separation.

There is a great volume of material here but it is impossible at present to recommend any one place as better than another to work for either gravels or sands because there is apparently no order in the deposition of these materials. If sand is wanted, a sufficient body of sand can be found without much search, but it

will require careful prospecting to locate large enough masses of suitable gravel for commercial purposes.

2. North of Beaver Creek:—

Lloyd Deposit.—This deposit is near the center of section 28. It is on a shoulder which projects from the western side of James Ridge into Beaver Valley. The shoulder is about 500 feet long and 200 feet wide. Sands and gravels occur on its top to a depth of about 20 feet.

From these figures it is safe to make an estimate of 30,000 to 35,000 cubic yards of materials.

Small pits have been opened in several places and these all show that the deposit is primarily of fine to medium buff sand. Patches of gravel which are thick enough to be worked occur in places. The sorting in some parts is fairly good while in others it is poor. There is no considerable amount of oversize. An average sample from the pits opened gave the following analysis (Fig. 25):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
91	2.65	45	89	87	81	15	3	3½	134	53	13	34

Figure 25

UNFAVORABLE QUALITIES

High per cent of soft material.
Sand failed to pass 7 day mortar test.
In the sand, too much material passing the 20 mesh.
Low weight.

FAVORABLE QUALITIES

Low silt content.

USES

There is too much sand in pit run to make a good road material. Treatment should be similar to that for a sand-clay road.

Material will not do for concrete purposes because of large per cent of soft material.

Terraces of Section 21.—No deposits except the Lloyd deposits are known to occur in the Beaver Valley, the next ones north being the small shoulders on the eastern side of the ridge just north of the Beaver in the S. W. ¼ of section 21. None are large, a few hundred cubic yards being the maximum content that can be expected of any of them. These will contain a higher percentage of gravels than the larger deposits and will run low in oversize, so that for small enterprises they would be more desirable than the large deposits.

School Section Hill Deposit.—School Section Hill is the name applied to the hill where the Lesterville road ascends the eastern side of James Ridge at the south ¼ corner of section 16. About half way up the hill the road has been cut through a sand and gravel deposit and these materials have been excavated from the roadside

for local use. This pit is at the southern end of a ridge of sand and gravel nearly a half a mile long and fifty feet wide. Two other spurs behind this ridge contain considerable amounts of sands and gravels. Pits have been opened in each of these but abandoned without removing much material.

This is one of the three largest deposits on James Ridge. It is estimated that the deposit which contains the School Section pit could yield some 65,000 cubic yards of material, the southern of the two spurs about 40,000 and the northern one about 30,000. The total volume is about 130,000 cubic yards.

The materials in this deposit are similar to those of the Lloyd pit, sands making the largest proportion, with a minor amount of gravels. The face at the roadside pit showed the following section:—

5 feet Boulders and coarse gravels, very red and partly cemented with iron.

40 feet Sand, medium to fine with streaks and patches of fine gravels through it. Some red with iron but largely gray.

3 feet Coarse red gravels.

An average sample taken from this pit will give an idea of the character of the entire deposit (Fig. 26):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
91	2.62	44½	98	92	70	21	2	4	192	57	12	31

Figure 26

UNFAVORABLE QUALITIES

Low weight.
High percentage of soft material.
Mortar fails to pass 7 day test.
Sand too fine, too much material passing 20 mesh.

USES

This sample showed the sand was unfit for concrete uses. However, it is possible that the pit may vary in quality and by proper manipulation, a usable concrete sand obtained.

Deposits North of School Section Hill.—There are no more large deposits on the east side of the ridge but a series of small shoulders occur here and there along the entire remaining length. In the S. E. ¼ of section 8, two shoulders of gravel occur which have a volume of not more than 4,000 cubic yards each. These shoulders show gravel float in the surface but much sand below, and probably average much like the larger deposits except for a little higher percentage of gravel.

More small shoulders occur on the ridge from about the N. W. corner of section 8 northward for half a mile. There are three or

possibly four shoulders in this group containing not more than 1,500 to 2,000 cubic yards each. The material in them is much like that of the preceding deposits, largely sand but with considerable gravel.

The Northern Sand Pile.—On the north end of the ridge, at its highest part, is a deposit of sand and gravel which lies just south of the N. W. corner of section 6, T. 95 N., R. 56 W. About half of it lies in the N. W. ¼ of that section and the other half in the N. E. ¼ of section 1, T. 95 N., R. 57 W. It is difficult to find the limits of this pile accurately but it is about 800 feet long and 200 feet wide. The gravel and sand at the deepest part are probably about 20 feet. The estimated volume of this deposit is 40,000 to 50,000 cubic yards.

Two pits have been opened in this deposit but apparently abandoned after removing only a little material. The exposures indicate that this hill is chiefly a sand pile with here and there streaks of fairly good gravel. The sand is medium to fine and brown in color, due to oxidized iron. There is very little oversize. A dozen or two small boulders are strewn over the surface but very few cobbles and no boulders were observed in the pits.

The following analysis (Fig. 27) is from a sample which was made as representative as possible. As there were no large exposures, however, the proportions in the analysis may hold only in a general way for the entire deposit.

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
93	2.62	43	93	82	11	4	2	7	168	35	27	38

Figure 27

UNFAVORABLE QUALITIES

Too much soft material.
Sand did not pass 7 day mortar test.

USES

Its best possible use would be for road material. Treatment would be the same as for a sand-clay road.

As a concrete sand this sample showed the lack of finer particles. By manipulation with other sand pockets in the pit a usable sand might be obtained.

West Side of James Ridge.—The only deposit on the west side of the James Ridge is a tiny shoulder found near the W. ¼ corner of section 17. This is a rather isolated, rounded hill about half way up on the side of the ridge, 90 feet above its base. It is about 75 feet in diameter and 10 feet of gravels are exposed near the middle. This makes a total of some 600 cubic yards.

This is a gravel deposit, the materials varying from fine to coarse gravels. They are not well sorted, however, and are also quite "dirty." Near the top is a layer of coarse material composed

of small boulders and cobbles and beneath that the ill sorted streaks of coarser or finer gravels.

SOUTHWESTERN PORTION OF COUNTY, SCATTERED DEPOSITS

The remaining area includes the southwestern third of the county. In this area there are very few gravel deposits and the few there are, are scattered widely. None of them are large except perhaps those in the vicinity of Yankton, but their isolated position makes them important especially for local use. For convenience in locating they will be grouped for description according to their nearest towns.

1. Deposits near Yankton:—

Kame Gravels.—There is a strip of gravel hills and pockets two miles long and about a quarter of a mile wide which follows the Meridian Highway from the north side of the city of Yankton to the State Hospital. These deposits are found on and at the base of a rather conspicuous, sharp ridge which lies on the east side of the highway throughout the larger part of its length. The city cemetery is situated on top of this ridge near its middle point.

The gravel and sands occur as pockets and kames. Near the southern end large pockets of gravel are the most common forms and several of them have been worked out. They range in size up to about 200 feet across and 20 feet deep. These have apparently been the source of the sand used for local concrete and similar projects in Yankton. Kame hills are to be found along the crest of the ridge and also on the western side. There is at least one large kame in the cemetery, several smaller ones to the south and quite a group in the half mile north of the cemetery. One has been opened near the S. W. corner of section 31, T. 94 N., R. 55 W. The northern-most is a little hill on the State Hospital grounds about a quarter of a mile north of the southeast corner of the grounds. The only conspicuous kames opened west of the Meridian Highway are in the N. E. ¼ of section 12 of T. 93 N., R. 56 W., directly southwest of the Yankton cemetery. Not many of these kames have been opened, there being only two pits now in operation. One of these is the Heins pit, which is just west of the highway in the N. E. corner of section 12, T. 93 N., R. 56 W., and the other 300 feet east and 200 feet north of the S.W. corner of section 31, T. 94 N., R. 55 W., opposite the State Hospital. Gravels are also to be found at the base of the ridge on the west side but their location is not indicated by any physiographic feature. A pit was opened for use in building the State Hospital near the E. ¼ corner of section 1, T. 93 N., R. 55 W., in which a considerable depth of the gravels was encountered.

The amount of sand and gravel obtainable from these kames and pockets is largely a matter of guess, because it is not possible to locate the kames and pockets accurately without more careful prospecting than was possible on this survey. It is reasonably safe

to estimate the volume of the kames at about 30,000 to 50,000 cubic yards each, but there is no way of telling the amount in the pockets or in the slope at the western base of the ridge. A conservative estimate would place the total available materials at 125,000 to 200,000 cubic yards.

The material in these kames is finer than is commonly found in such deposits. Medium to fine gravels and coarse to medium sands are the rule. The material exposed in different parts of the area is very much alike.

Heins Pit.—In the Heins pit the gravels were opened to a depth of about 20 feet, where the water prevented further excavation. The materials are fine to medium gravels and sands. These are quite well sorted and lie in streaks three or four feet thick. Thus it has been possible to excavate either sands or gravels with little or no screening. Samples from this pit average (Fig 28):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
102	2.58	36½	87	77	52	9	3	7	207	4	12	84

Figure 28

FAVORABLE QUALITIES

Low per cent of soft material.
High weight.
Low voids.

UNFAVORABLE QUALITIES

Too fine for road gravel.

USES

All right for use as concrete material.
For road use treatment should be same as for sand-clay roads.

The pit in the S. W. corner of section 31, T. 94 N., R. 54 W., showed medium gravels to coarse sand with little oversize. An average sample gave the following (Fig. 29):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
91	2.56	43	74	60	37	7	3	5½	120	22	23	55

Figure 29

UNFAVORABLE QUALITIES

Large per cent of soft material.
Did not pass 1 to 3 mortar test.

USES

All right for use as road material, only big objection being too large percentage of soft material.

For use in concrete pit run should not be used on account of soft material contained.

The cover on these deposits varies. On some hills the gravels are at the surface, while in others there is a cover of boulder clay. In the Heins pit part of the gravel is covered with 5 feet of boulder clay and in the pit in the S. W. corner of section 31, the entire hill had been covered with from 4 to 8 feet of it. This cover makes it impossible to tell which of the hills contain gravel and which do not, without rather deep test holes. In most of the hills, however, the cover is lacking or so thin that it is no obstacle to prospecting and little or none to operating pits.

Golf Links Gravels.—About a mile north of the kame area is a small deposit in a little valley. It lies but a few hundred feet from the Yankton Country Club's golf links. It occurs as a shoulder near the top of the valley. As the total volume will not exceed about 1,500 cubic yards and as there are no other deposits near to supplement it, this can hardly be considered sufficient for more than local uses.

The deposit is composed largely of coarse sand and fine gravel. There is a two foot layer of coarser gravel over the top, in which the pebbles run one to four inches in diameter. An average sample from this pit showed (Fig. 30):—

Weight per Cu. Ft.	Specific Gravity	% Volds	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
87	2.56	45½	98	94	61	5	2	2		15	65	20

Figure 30

FAVORABLE QUALITIES

Low per cent of silt.

UNFAVORABLE QUALITIES

Rather high per cent of soft material.
Low weight.

USES

It could be used as concrete sand with a good coarse aggregate.
Should contain more particles between 1 in. and ¼ in. for use as road material.

Channel Deposit.—Just east of Yankton, between it and the James Valley is a broad, shallow depression which is filled with sands and gravels. Its northern end is in the S. E. ¼ of the N. W. ¼ of section 4, T. 93 N., R. 55 W., on the bluffs of the James Valley. It extends southwest for a little over a mile and merges with the valley of the Missouri. At its northern end it is less than an eighth of a mile across but it widens rapidly to the south till it is nearly three-fourths of a mile in width in the middle of section 8, where it crosses Highway 50.

The materials of this deposit were exposed at three places; (1) the Hansen pit, near the north end near the N. W. corner of section 4; (2) the Donaldson pit, about the middle of the deposit

near the S. ¼ corner of section 5; and (3) in the road cuts and wells near the south end of the deposit, about a school and farm house in the N. E. ¼ of the S. W. ¼ of section 8. In general there seems to be a gradation of materials from north to south. At the Hanson pit gravels occur, but only fine gravels and sand at the Donaldson pit, while only sands with stray pebbles are exposed at the schoolhouse in section 8.

Hansen Pit.—The materials in this pit are fine to medium gravels with pebbles averaging a half to one inch in diameter. There is very little oversize, probably not more than 3 to 5 per cent. There is also a considerable quantity of coarse sand. These materials, however, are fairly well sorted but not into beds of sufficient thickness to permit their extraction without mechanical sorting. An analysis of an average sample from this pit gave (Fig 31):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
94	2.50	39½	82	73	50	22	8	5		19	54	27

Figure 31

UNFAVORABLE QUALITIES

Large per cent of soft material.
Did not pass mortar test.

USES

Its best probable use would be for road surfacing material.
This one sample would show too large an amount of fine material.
It might be necessary to add a litle clay to more closely follow a sand-clay type of road.

Donaldson Pit.—This pit had been abandoned after the removal of quite a large quantity of material and so badly fallen in that it was possible only to get a very general idea of the sort of materials it had produced. In the main they were fine gravels and sands. No piles of oversize were in evidence and none seen in the gravel faces in the pit. The best sample obtainable showed (Fig. 32):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
95	2.58	41½	94	88	50	20	14	8½	157	10	17	73

Figure 32

FAVORABLE QUALITIES

Rather low per cent of soft materials.

UNFAVORABLE QUALITIES

Material too fine.
Per cent silt content.
Did not pass mortar test.

USES

For use as concrete sand, must be washed in order to remove silt and fine particles of sand.

There is a cover of silt over the entire deposit. At the northern end, over the Hansen pit, it averages 2 to 3 feet, and at the Donaldson pit it runs 4 to 5 feet. The road cuts at the extreme southern end along Highway 50 do not cut through this cover. At the schoolhouse above mentioned, however, the sand is within a foot or so of the surface. The average thickness of the cover will probably be from 4 to 6 feet.

It is not possible to make more than a general estimate of the volume of materials because the depth of the sands and gravels is unknown and the shape of the under surface is also unknown. At the Hansen pit 10 feet of gravels are exposed but the bottom was not reached and 6 or 7 feet occur in the Donaldson pit. If there is an average depth of 10 feet over the entire area covered by the deposit, the volume would be about 15,000,000 cubic yards. This is too large because it is certain that the sands and gravels feather out on the east and west margins and half that figure would be a more conservative estimate. At least 7,000,000 cubic yards would be within the limit that could be counted on with confidence. Though this deposit is one of the largest single deposits in the county it is not as good as a source of gravel as some of those previously described because the gravel runs rather fine and at least the southern half is largely a sand deposit.

2. Deposits near Lesterville:—

Kame Deposits.—These deposits are found at three places, the first one a mile south and a mile and a quarter east of Lesterville, the second two miles south and three miles east, and the third a half mile south of the second. All these would fall very near a straight line between Lesterville and Utica. They are not large deposits but their isolation and the character of the gravels make them important.

The Vaith Kames.—These are the northern-most deposits mentioned above and lie in the N. E. ¼ of the N. W. ¼ of section 27, T. 95 N., R. 57 W. There are two kames here, one near the road in which the Vaith pit has been opened, and the other about a thousand feet southeast of it, which has not been opened. These hills are about 300 feet in diameter at the base and 15 feet in height and rise conspicuously above their surroundings. They have a volume of about 15,000 cubic yards each. About two thirds of the first kame has been removed for road graveling.

The kame which contains the pit has a three to four foot cover over all faces. On the east side this cover is a soil with pebbles in

it but on the west side, which comprises over half the exposed area, there is a boulder clay which varies in depth from two to four feet. It is probable that the same cover will be found over most of the other kame.

The materials are, for the most part, fine gravels and coarse sands. The pit as a whole runs quite uniform. An average sample from this pit showed (Fig. 33):—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
94	2.56	41	89	82	43	11	5	1½		9	18	73

Figure 33

FAVORABLE QUALITIES

Low per cent of silt.
Passes mortar test.
Fairly low per cent of soft material.

UNFAVORABLE QUALITIES

Too fine for good road material.

USES

Sand may be screened out and used as concrete sand.
For use as road material treatment would be the same as for sand-clay road.

Middle Kames—On top of the bluffs on the south side of the Beaver Valley near the S. E. corner of section 26 T. 95 N., R. 57 W. are two kame shaped hills, which stand up conspicuously from their surroundings. They are apparently till covered but their shape and position suggest very strongly that they are both gravel cored hills. If such should be the case material much like that of the Vaith kames could be expected. These hills are fully as large and possibly a little larger than the northern Vaith kames which would add 40,000 to 50,000 cubic yards to the supply available. It was not possible to examine these hills carefully during this survey and therefore they can be recommended for commercial exploitation only after a more careful examination of them has been made.

Southern Kame.—This is a single pit in a gravel hill or shoulder on the north bluff of a small tributary of the Beaver near the W. ¼ corner of section 36, T. 95 N., R. 57 W. This pit has exposed some 10 feet of medium gravels fairly well sorted. There should be between 5,000 and 10,000 cubic yards of material in this deposit.

East of Lesterville.—Just west of the northern end of James Ridge is a string of lakes which lie in a marked depression between the ridge and a low country to the west. Though this should be a place to expect gravels, no large deposits are to be found. Careful search, however, will doubtless reveal several small deposits. Only one deposit is known in this vicinity and that is a short gravel ridge which lies one fourth of a mile west of the N. E. corner of section

13, T. 95 N., R. 57 W., three and a fourth miles east and one mile north of Lesterville. The length of the ridge is about 300 feet, its width 50 feet. It rises to about 10 feet in height. Its volume is about 2,500 cubic yards.

The material is similiar to that found in typical eskers, coarse and fine jumbled together. There is some sorting into thin, short beds but not enough to enable the various sizes to be excavated without mechanical sorting. The largest pieces are cobbles 6 to 8 inches across and small boulders. From this size it grades down to fine silts. The silts occur in chunks or pockets about 3 feet across. The average material is medium gravel. The oversize makes up about 20 per cent of the deposit and the silt about 10 per cent, leaving 70 per cent for sands and gravels. The percentage of these materials found in an average sample was found by analysis to be as follows (Fig. 34) :—

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
91	2.58	43½	66	59	29	8	5	3		11	30	59

Figure 34

FAVORABLE QUALITIES

A coarse sand.
Low silt content.

USES

This deposit would make a good road surfacing material. Because of being a small deposit it might be a question whether or not it would pay to crush the oversize as screened out.

Could be used as concrete material. The suggested mix (by volume) for pit run material would be one part cement to 4¾ parts pit run.

Karlovitch Deposit.—This is small deposit on the bluffs of the Beaver Creek Valley in the western side of the county. It occurs near the E. ¼ corner of section 7, T. 94 N., R. 57 W., six miles west and half a mile south of Utica. It lies as a skin of gravels or remnant of terrace gravels at the bend of the valley about 30 feet above the valley floor. It is about 300 feet long and 50 feet wide but only five or six feet deep. A total volume of 2,000 cubic yards would be a liberal estimate.

Dirty gravels compose the desposit. There is a little oversize but it is not more than three or four per cent. An analysis of a representative sample from the several shallow pits that have been opened in the gravels showed (Fig. 35) :—

3. Deposits near the Missouri Valley Bluffs.—Deposits primarily of sand are to be found in the valleys of the tributaries of the Missouri in T. 93 N., R. 57 W. None of them is large enough to attract more than passing attention and none are recommended for

commercial exploitation. The largest contains the Nevded pit, which is in the N. W. ¼ of section 2. In some deposits, especially those in the western part of the same township, the sands are white to gray but in others they are brownish, due to oxidation. Some deposits contain a fair percentage of gravel. No attempt was made to map these deposits.

Weight per Cu. Ft.	Specific Gravity	% Voids	% Passing ½ in. Mesh	% Sand	Material Passing ¼ in. (Sand)					Character of Material Retained on ¼ in.		
					% Pass'g 20 Mesh	% Pass'g 50 Mesh	% Pass'g 100 Mesh	% Silt	7 Day Tensile	% Soft	% Med.	% Hard
89	2.58	45	77	61	25	8	5	4		7	48	45

Figure 35

FAVORABLE QUALITIES

Low per cent of soft materials.
Low silt content.

UNFAVORABLE QUALITIES

Low weight.

USES

The best use for this material would be for a road gravel. Oversize should be crushed.

May be used in concrete, the suggested mix by volume for pit run material would be one part cement to 5 parts pit run.

SUMMARY

Locations and Volumes.—Three localities stand out conspicuously as containing largest amounts of materials: (1) the James Valley, near the mouth of Mud Creek; (2) the lower Beaver Valley; and (3) the valley of Turkey Creek, near Volin. The first contains about 1,700,000 cubic yards of gravel, the second 2,000,000 cubic yards and the third 1,300,000 cubic yards. The only other large deposit in the county is the channel deposit just east of Yankton, which is the largest single deposit in the county according to the best estimate available. The fineness of the materials exposed over most of the channel, however, indicates that most of the deposit should be classed as sand. The four areas named contain 75 to 80 per cent of all the sands and gravels of the county. Most of the remaining 20 to 25 per cent is distributed along the James Valley, the valley of Turkey Creek, and on James Ridge.

Character of Deposits.—The character of the materials varies with each deposit. It is possible, however, to divide them roughly into three divisions on the basis of composition. The first group is composed of deposits composed primarily of gravels. This group includes all the James Valley deposits except those at Johnson's Bridge, all those in the lower Beaver Valley, most of those on Turkey Ridge, and the scattered deposits in the southwestern portion of the county. The coarsest are the esker deposits of Turkey Ridge, which are composed largely of boulders, and from this size they grade down to fine gravels. As a whole they run a little too fine

for ideal road gravels. Ideal road gravel should have 60 to 80 per cent passing a half inch screen but these gravels average about 87 per cent passing. The content of soft material (chalk and shale) is also rather high for ideal road work. There is, in most deposits, however, considerable oversize, which is made of the most resistant rocks, limestones, quartzites, and granites. Where it is possible to crush this oversize and add it to the gravels a very usable gravel can be made.

The high percentage of soft material makes the use of the gravels for concrete work somewhat of a problem. The soft pebbles of chalk and shale are apt to spall out, leaving holes in the surface of the concrete. If it were possible to remove this objectionable matter, these would make good concrete materials.

The second group of deposits consists of those which are composed primarily of sand but which contain abundant streaks or patches of gravel. In this group are included the deposits at Johnson's Bridge and those on James Ridge. In general they are quite well sorted and in many places is is possible to work the two materials separately with little or no screening.

The material varies greatly from place to place. Most of it, however, is quite well sorted. Bands and pockets of the cleanest sand and grits can be found and spots of dirty gravels occur in another part of the same deposit. Analyses of the samples that were collected showed that the sands run rather fine but are fairly free from silt. The weight is a little lower than the average for this sort of sand but this is probably due to the high per cent of voids, which is characteristic of finer sands.

The third group includes deposits of sand. There are no deposits of pure sand in the county but the white sands of Turkey Ridge and probably the southern half of the channel deposit northeast of Yankton come as near it as any. There are some streaks of coarse sand and fine gravel in the white sands but they are as uniformly sized as can be expected in glacial sands. Seventy-two per cent passes a 20 mesh screen, and pebbles over a quarter inch are scarce. The material is a clean sand made largely of quartz. The sizing is a little fine for some purposes but otherwise it is an excellent material.

Adequate samples of the sands of the channel deposit were not available. This will doubtless be less uniformly sorted and will carry a higher content of silts and clay than the white sands.

The following tables attempt to summarize the important facts about the deposits that have been described:—

TABLE I

Table of Totals

LOCATION	Character and Amount of Materials			
	Sand and Gravels			
	Predom. Gravel	Predom. Sand	Sand	Total
Turkey Ridge	1,056,000	.....	582,000	1,638,500
Mud Creek	138,000	.....	.....	138,000
James Valley	1,720,000	310,000	.....	2,030,000
James Ridge	600	602,000	.....	602,600
Beaver Valley	2,003,000	.....	.....	2,003,000
Southwestern Section..	3,500,000	.....	.....	3,500,000
	8,417,600	912,000	582,500	9,912,100

TABLE II

Detailed Table

NAME OF DEPOSIT	Location Sec., T., R.	Amount and Character Cubic Yards			Cover in feet
		Sands & Gravels		Sand	
		Predom. Gravel	Predom. Sand		
TURKEY RIDGE DEPOSITS					
Volin Terrace Deposits					
Terrace No. 1	13, 94, 54	400,000			0–2
Terrace No. 2	13, 94, 54	400,000			0–2
Terrace No. 3	12, 94, 54	500,000			
Gorset Deposit	2, 94, 54	20,000			0–10
Turkey Creek White Sands					
Will Jonason Deposit	3, 95, 54			550,000	1–2
Dutton Deposit	10, 95, 54			1,000	
N. E. Corn. Sec. 14	14, 95, 54			500	0
Sandburg Pit	13, 95, 54			1,000	0
Sandburg Deposit	13, 95, 54			30,000	0–4
Upper Turkey Creek Gravels					
Section 10 Deposit	10, 95, 54	18,000			0–3
Dutton Deposit	34, 10; 95, 54	32,000			0–3
Dolrup Pit	2, 95, 54	7,000			0–4
Turkey Ridge Kame Field					
(Peter Jonason Pit)	33, 96, 54	3,000			0
Turkey Creek Eskers					
North Esker	5, 96, 54	33,000			0
Middle Esker	16, 96, 54	18,000			0
Southern Esker	22, 96, 54	15,000			
Irene Esker	19, 30, 31; 96, 53	30,000			0
MUD CREEK DEPOSITS					
Erickson Deposit	5, 95, 55	20,000			1–3
Mouth of Mud Creek	17, 95, 55	100,000			1–2
Kame Field	30, 31; 96, 55	18,000			0–3
JAMES VALLEY DEPOSITS					
Terrace Deposits					
Northern Terraces	10, 96, 57	100,000			0–3
Hauck Terrace	12, 96, 57	300,000			0–2
Sand Terrace	30, 96, 56			60,000	0–2
Jamesville Ridge	28, 96, 56	13,000			0
Nelson and Peterson Dep.	26, 34; 96, 56	3,000			0–2
Sigel Deposits	2, 3; 95, 56	42,000			0–2
E. Bluff opp. Sigel Dep.	1, 95, 56	25,000			0–2
Small Shoulders	95, 55	2,000			0
Near Mouth of Mud Creek	17, 20; 95, 55	78,000			0–3
Voll Terrace	29, 95, 55	1,500,000			0–3
Johnson's Bridge	N. line sec. 5, 94, 55		250,000		0
Johnson"s Esker	17, 94, 55	55,000			
Miscellaneous					
Northern Pockets	12, 95, 56	1,000			
Olson Pits	27, 94, 55	1,000			

TABLE II—(Continued)
Detailed Table

NAME OF DEPOSIT	Location Sec., T., R.	Amount and Character Cubic Yards			Cover in feet
		Sands & Gravels		Sand	
		Predom. Gravel	Predom. Sand		
JAMES RIDGE DEPOSITS					
Around Mt. Pisgah	34, 35; 95, 56		400,000		0
North of Beaver Creek					
Lloyd Deposit	28, 95, 56		30,000		0–3
Section 21	21, 95, 56		*		
School Section Hill	16, 95, 56		130,000		0–3
North of School Sec. Hill	5, 6, 8; 95, 56		2,000		0
Northern Sand Pile	6, 95, 56		40,000		0–2
W. side of James Ridge	17, 95, 56	600			0–3
BEAVER VALLEY DEPOSITS					
Lower Terraces					
Big Terrace	12, 94, 56	1,000,000			1–3
Frick Gravel Pit	12, 94, 56	75,000			0–3
Frick Sand Pit	18, 94, 55	225,000			0–3
Other Terraces	18, 94, 55	550,000			
	17, 94, 55	150,000			0–3
Upper Terraces	1, 2; 94, 56	3,000			0–1
SOUTHWESTERN SECTION					
Deposits near Yankton					
Kame Gravels	6, 93, 55	125,000			0–8
Golf Links Gravels	25, 94, 56	1,500			0–2
Channel Dep. Hanson Pit	4, 5, 8; 93, 55	3,500,000			2–8
Donaldson Pit					
Deposits Near Lesterville Kames					
(1) Vaith Kames	27, 95, 57	30,000			3–4
(2) Middle Kames	26, 95, 57	40,000			3–6
(3) Southern Kames	36, 95, 57	5,000			0–3
East of Lesterville	13, 95, 57	2,500			0
Karlovitch Deposits	7, 94, 57	2,000			0

*Few hundred.

TABLE III

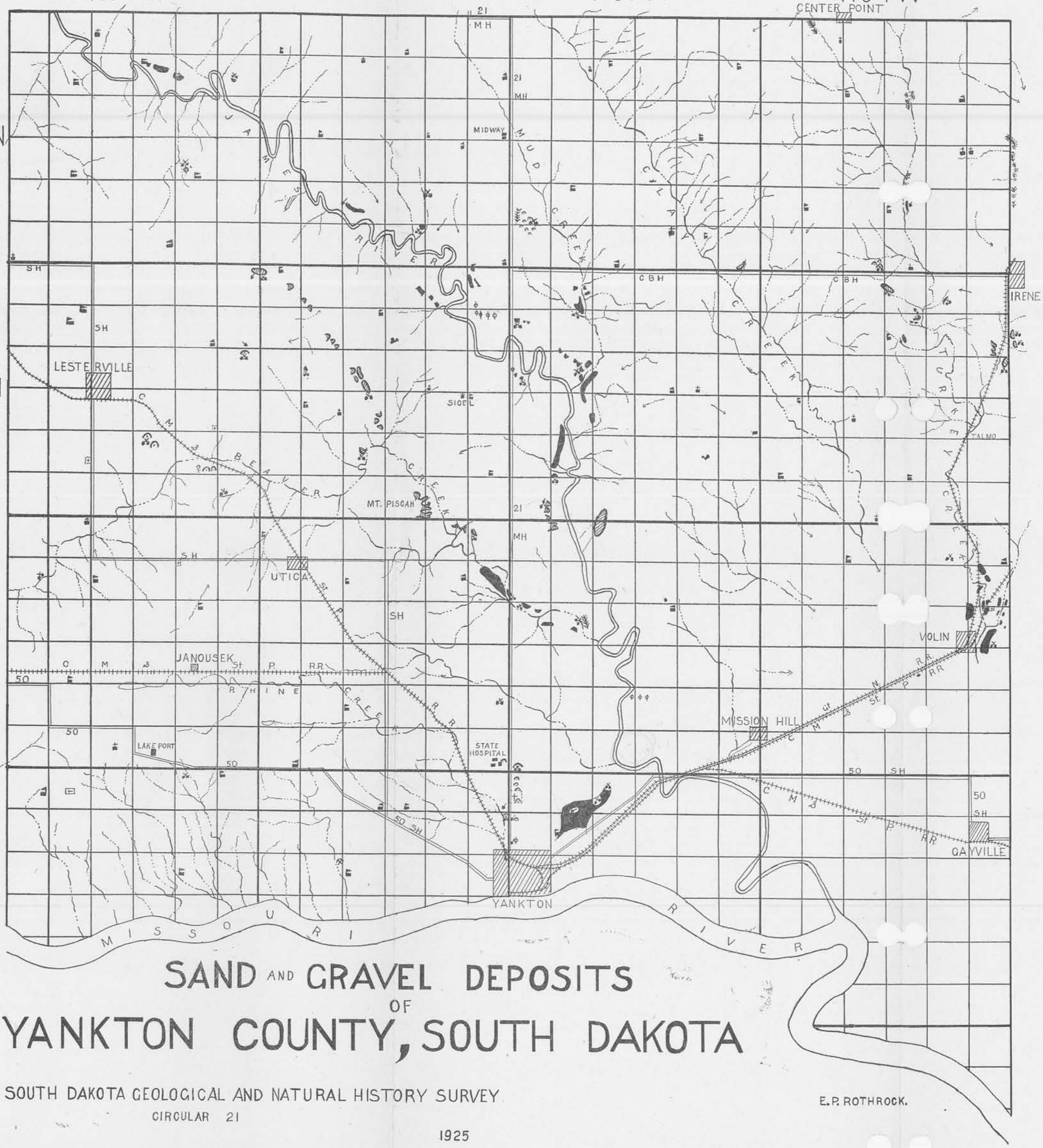
Index of Deposits

(arranged according to surveyed divisions)

Township and Range	Sections	Name of Pits	Material	Pages
93–54	.....	No deposits ..	.....	.....
93–55	4, 5, 8	.....	gravels and sands ..	47, 48
	6, 7	.....	gravels	45
93–56	1, 2	Heins Pit	gravel	45
93–57	2	Nundi	sand	52
94–54	2	Gorsett	gravel	11
	12	.....	gravels	11
	13	Volin	gravels	9, 10
94–55	4, 5	Johnson's Bridge	sand and gravels ...	33
	17	Johnson's Esker	gravel	34
	17, 18	Frick	gravel	38, 39
	27, 28	Olson	gravels	35
94–56	1, 2	.....	gravels	39
	12	Frick	gravels	37
	25	Golf Links ...	gravels	47
94–57	7	Karlovitch ...	gravels	51
95–53	7	.....	white sand	12
95–54	2	Dolrup	gravel	17
	3	Jonason	sand	12
	10	.....	gravel	15
	10	Dutton	gravels and white sands	13, 16
	12, 13	Sanburg	white sands	14
95–55	5	Erickson	gravel	23
	7	.....	gravel	29, 30
	17	M. T. Johnson	gravel	32
	17, 20	.....	gravel	31
	18	Schram	gravel	30
	29	Voll	gravel	33
	30, 33	Johnson's Bridge	sand and gravel	33
95–56	1	.....	gravel	29, 35
	2, 3	Sigel	gravel	28
	6, 8	.....	sand and gravel	43, 44
	12	.....	gravel	35
	16	School sec. hill	sand and gravel	42
	17	.....	sand and gravel	44
	21	School sec. hill	sand and gravel	42
	.....	.....	sand and gravel	43
	28	Lloyd	sand and gravel	42
	34, 35	Mt. Pisgah ...	sand and gravel	41
95–57	1	.....	sands and gravels ..	44
	13	.....	gravel	50
	26	.....	gravel	50
	27	Vaith	gravel	49
	36	.....	gravel	50
96–53	18, 19, 30	.....	coarse gravel	21
96–54	5	.....	gravel	20
	10, 14	.....	gravel	20
	22	.....	gravel	21
	27	.....	gravel	18
	33	Jonason	gravel	18
96–55	30, 31	.....	gravel	24
	36	.....	sand	22
96–56	26	Peterson	gravel	28
	28	.....	gravel	27
	30	.....	sand	26
	34	Nelson	gravel	28
96–57	10, 11	.....	gravel	25
	12	Hauck	gravel	26

R57W R56W R55W R54W

T96N T95N T94N T93N



SAND AND GRAVEL DEPOSITS OF YANKTON COUNTY, SOUTH DAKOTA

SOUTH DAKOTA GEOLOGICAL AND NATURAL HISTORY SURVEY

CIRCULAR 21

1925

E. P. ROTHROCK.

LEGEND

SAND AND GRAVEL SYMBOLS

- Gravel Deposits with Minor Amounts of Sand
- Sand Deposits with Minor Amounts of Gravel
- Kame Deposits (Largely Gravel)
- Esker Deposits (Coarse Gravel)
- Gravel Pockets

CULTURE

- Sand or Gravel Pit
- Abandoned Pit
- Quarry
- Towns
- School House
- Church
- Cemetery
- Railroad
- 21 / 50 State Highways
- Marked Trails
- MH. Meridian Highway
- SH Sunshine Highway
- CBH Corn Belt Highway

WATER

- Rivers
- Creeks and Smaller Drainage Lines

SCALE

1 2 3 4 5 6 miles

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36