Aggregate Resource Evaluation of the Proposed Tansem SNA, Clay County, Minnesota

Minnesota Department of Natural Resources
Division of Lands and Minerals
William C. Brice, Director

Project 334-12
August 2000

Aggregate Resource Evaluation of the Proposed Tansem SNA, Clay County, Minnesota

Glenn D. Melchert
August 2000

Minnesota Department of Natural Resources
Division of Lands and Minerals
William C. Brice, Director
500 Lafayette Road
St. Paul, MN 55155-4045

Project 334-12

ACKNOWLEDGMENTS

This report is the culmination of cooperative efforts by numerous individuals. Several individuals from DNR Division of Lands and Minerals (LAM) played key roles in the field work and sample processing. They are Mike Ellet, Al Dzuck, Ricco Riihiluoma, Pat Geiselman, and Mike Lubotina and their work is greatly appreciated. A special thanks goes to Dan Steinbrink who spent a good share of his time the past two weeks prompting me through the Techbase modeling. Thanks also to anyone else that I inadvertently omitted here.

Executive Summary

This report summarizes the results of an aggregate evaluation of approximately 306 acres of land owned by Mr. Ed Gilbertson. The property is located in Sections 11 and 14 of T. 137 N, R. 44 W (Tansem Township), Clay County, Minnesota. The Minnesota Department of Natural Resources (DNR) proposes to purchase this land to create a Scientific and Natural Area (SNA). An appraisal which includes the value of the aggregate is necessary before this land can be purchased. The DNR requested DNR Division of Lands and Minerals (LAM) to complete an aggregate evaluation of this property so that the aggregate could be appraised.

The evaluation began in April 2000 with a review of existing information for the area. A week of reconnaissance level drilling with the pickup-mounted Giddings probe was also completed in April. Sixty-eight holes, with an average depth of about 9 feet were drilled. In May, the large drill truck from the Minnesota Department of Transportation (MnDOT) was used to drill 102 holes covering nearly all of the property. These holes ranged in depth from 20 to 50 feet. This rig had a 10-inch auger which, when retrieved from the hole, indicated the geology beneath and allowed for the collection of gravel samples for gradation and quality analyses. After drilling, a geophysical survey using electrical resistivity techniques was conducted over a portion of the property to obtain additional information to verify the depth and lateral continuity of the gravel deposits.

Based on the evaluation, the property was divided into 7 tracts (see Figure 3) to help explain the distribution of the gravel. The results are summarized below.

- a relatively thick layer of glacial outwash deposits (sands and gravels) occurs on the property which were substantiated by the geophysical lines
- water table was not encountered during drilling

TRACTS 1 and 2

- 2.45 million cubic yards of gravel over 89 acres
- average gravel content is 38% (range 22 - 57%)
- gravel quality is high - meets specifications for concrete
- weighted average gravel thickness is 17.2 feet (range 3 - 47 feet)
- weighted average overburden thickness is 2.7 feet (range 0.1 - 10 feet)

TRACT 3

- 2.05 million cubic yards of gravel over 98 acres
- average gravel content is 32% (range 19 - 49%)
- gravel quality was not tested but may be similar to tracts 1 and 2
- weighted average gravel thickness is 13.1 feet (range 4 - 30.8 ft)
- weighted average overburden thickness is 3.0 feet (range 0.1 - 11 ft)

TRACTS 4 and 5

- 0.55 million cubic yards of gravel over 108 acres
- average gravel content is 39%
- the occurrences of gravel usually are not contiguous from hole to hole
- gravel quality was not tested
- weighted average gravel thickness is 4.2 feet (range 0 - 17)
- weighted average overburden thickness is 7.3 feet (range 0.2 - 20)

TRACTS 6 and 7

- 0.05 million cubic yards of gravel over 14 acres
- gravel usually is not contiguous from hole to hole
- weighted average gravel thickness is 5.5 feet (range 3 - 8.7 feet)
- weighted average overburden thickness is 7.5 feet (range 1.3 - 15.5 feet)

Our recommendation, based upon current established economics of mining, is that a total of 5.1 million cubic yards should be considered for appraisal. This total is comprised of 4.5 million cubic yards of gravel (tracts 1 through 3) that appears to be of high quality. The remaining 0.6 million cubic yards of gravel (tracts 4 through 7) is estimated to be of good to high quality, but may be of less value due to the inconsistent distribution of the gravel in these tracts.

Introduction

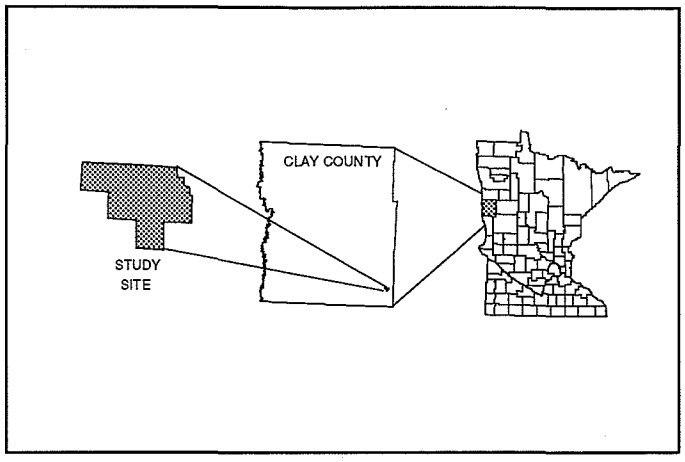


Figure 1. Index map showing the location of the study area.

This report summarizes the results of an aggregate evaluation of approximately 306 acres of land owned by Mr. Ed Gilbertson. The property is located in Sections 11 and 14 of T. 137 N, R. 44 W (Tansem Township) in southeastern Clay County, Minnesota (Figure 1). The Minnesota Department of Natural Resources (DNR) proposes to purchase this land to create a Scientific and Natural Area (SNA). This site contains an upland prairie community classified as a Sand-Gravel Subtype of a Dry Prairie. This property is the second largest tract with this prairie type remaining in Minnesota (Peter Buesseler, personal communication, 2000). Mr Gilbertson proposed opening a gravel pit on this property. Purchasing this property would preserve this prairie community. Mr. Gilbertson requested consideration for the aggregate contained on this land as part of the purchase agreement. The DNR then requested the Division of Lands and Minerals to complete an aggregate evaluation of this property so they could proceed with the proposed purchase.

Purpose–The purpose of this project was to perform an aggregate evaluation of the Gilbertson property. An appraiser could then take this report and develop an appraisal for the property that considers the value of the aggregate.

Geologic Setting

Around 11,000 years ago, glaciers occupied the area now known as the Red River Valley. The eastern edge of these glaciers was situated roughly in the vicinity of the study area. As these glaciers periodically melted, rivers flowed off the ice. These rivers carried sediments ranging from cobbles to silt and mud. Some of these rivers flowed over the Gilbertson property, depositing sand and gravel. Large pieces of ice were buried under the sand and gravel deposits in several places. When the buried ice melted years later, closed basins were created. Several of these basins are now watering holes on the Gilbertson property. The geologic term for this type of terrain is collapsed outwash.

Methods

Previous work– The evaluation began in April 2000 with a review of existing geologic information for the area. The Gilbertson property is within an area previously designated as having 'high aggregate potential' (Lehr, 1997). Mr. Gilbertson had a gravel operator dig

numerous test pits on the property with a backhoe. Mr. Gilbertson stated that the operator found areas with gravel that they would mine and other areas that contained gravel that was less desirable or was covered with too much overburden–around 10 feet.

Map interpretation– Color infrared aerial photos (NAPP 3088-37 through 40 flown 4/19/91) and U. S. Geological Survey (USGS) 7.5 minute Quadrangle maps (Rollag, MN) were analyzed for geological interpretations and the identification of landforms on the property. Additional geologic information was obtained from the Clay County Aggregate Resources map (Lehr, 1997).

Auger drilling– A week of reconnaissance-level drilling with the pickup-mounted Giddings probe was also completed in April. Sixty-eight holes, with an average depth of about 9 feet (range 5 to 18 feet) were drilled. These holes are indicated as an open circle in Figure 2 and labeled 1 through 68.

In May, the large drill truck from MnDOT (Minnesota Department of Transportation) was used to drill 102 holes covering essentially all of the property. These holes are indicated by a filled circle and labeled 69 through 170 (Figure 2). The holes ranged in depth from 20 to 50 feet, with an average depth of 26 feet. Holes were drilled at a spacing of about 300 feet in tracts 1 and 2 (Figure 3). Mr. Gilbertson had indicated, and drilling with the Giddings probe confirmed these two tracts contained substantial quantities of gravel. Drill holes in these two tracts ranged in depth from 20 to 50 feet. The distance between drill holes in the remaining central portion of the property (tracts 3, 4, and 5) was increased to about a 450 foot grid due to time constraints. Within these tracts, most of the holes were not drilled deeper than 20 feet.

The MnDOT rig has a boom that accommodates a 10-inch auger that is 20 feet long. Drilling deeper than 20 feet required the addition of additional augers at 5-foot increments. Capacity of the rig was 50 feet When the auger was pulled from the hole, the subsurface geology was represented on the auger flights. Detailed geologic logs are presented in Appendix A. Gravel samples for gradation and quality analyses were collected from the auger flights.

All drill holes were located by a Global Positioning System (GPS). Nearly all of the drill holes in tracts 1 and 2 were surveyed by traditional methods for location and ground elevation.

Geophysical study– After drilling, a geophysical survey using electrical resistivity techniques was conducted over a portion of the property to obtain an indication of the depth and lateral continuity of the gravel deposits (Figure 2). Three lines were run on the western deposit (tract 1). Additional lines were planned but not run due to several days of stormy weather and malfunctioning equipment.

The surveys were run and interpreted by personnel from the DNR Division of Waters. The lines were located by GPS.

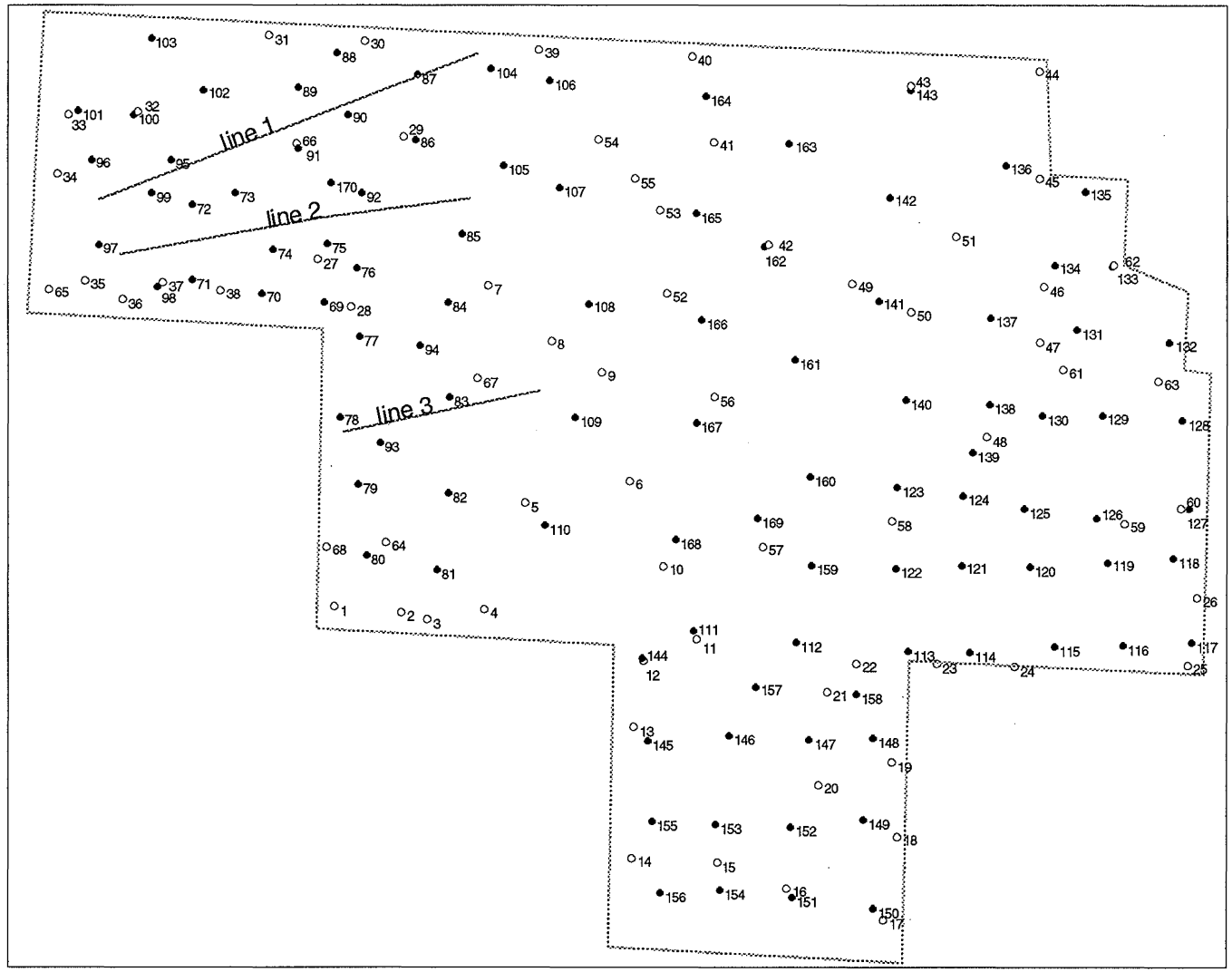


Figure 2. Site map showing drill hole locations and geophysical lines. The open circles represent holes drilled with the Giddings probe. The filled circles represent holes drilled with the MnDOT rig with 10-inch auger.

Gradations and quality analysis– One hundred nine gravel samples of about 30 pounds each were collected from 79 holes. These samples came from drill holes located in tracts 1, 2, 3, 4, and 5. Two or three samples often were collected at different depths from the same hole when the gravel deposit was more than about 20 feet thick. This was necessary to verify field observations that the gravel usually became more fine, more sandy, and less silty below an upper layer of gravel in the upper 3 to 15 feet. This stratification was most apparent in tract 1. Gradations were done following MnDOT protocol by DNR personnel at the Hibbing office.

Splits were taken from the gravel samples from the holes in tract 1 and combined into one composite sample representing an overall average of the deposit. The same was done for tract 2. Appendix B lists which samples were composited for quality testing. These samples were sent to Braun Intertec for the following quality tests: shale, soft iron oxide, total spall, clay lumps, flat and elongated particles, specific gravity and absorption (coarse and fine). An additional split from tract 1 was sent to American Petrographic Services, Inc. for a lithologic analysis according to ASTM C295 for concrete. This test was not run for tract 2 because the cost of the analysis is relatively high for the quantity of gravel in that tract.

Computer analysis– Prior to modeling, it was necessary to determine what was or was not gravel. The depth intervals represented by samples that were sieved in the lab (gradation results) that had a gravel content of 19 percent (%, by weight) or greater were considered gravel for modeling purposes. In addition, all intervals from holes without gradation results were considered gravel if the field estimate of percent gravel was 15 % or higher. The definition of gravel used in this report is the total of all the particles retained on the #10 mesh (2 mm) sieve and larger sieves. In other words, gravel is everything larger than 2 mm. Appendix C lists the data that were used for modeling.

Software from Techbase, Inc was used to generate a computer model that generated estimates of gravel volumes for the tracts depicted in Figure 3. A polygonal algorithm was used to compute a zone of influence or polygon around each drill hole. The size or area of the polygon is dependent on the distance to the nearest drill holes in each direction and is drawn as the mid point between adjacent drill holes. The model then calculates the volume of gravel in each polygon by multiplying the thickness of gravel in the drill hole by the area of the polygon. The volumes for the polygons or portions of polygons contained within each tract depicted in Figure 3 are then summed to obtain a volume for each tract. Drill holes with less than 5 feet of gravel were not included in the calculations. Holes with 10 or more feet of overburden were also omitted from the volumetric calculations. This did not affect any holes in tract 2, but did affect 1 hole in tract 1 (#72) and tract 3 (#159). These two holes were retained in the calculations because the quantity of gravel in these holes or their location within the deposit made it likely they could be mined. This criterion did affect some holes in tracts 4, 5, and 7. Overburden is waste material such as soil, silt, and sand that must be stripped off the land before the underlying gravel can be mined.

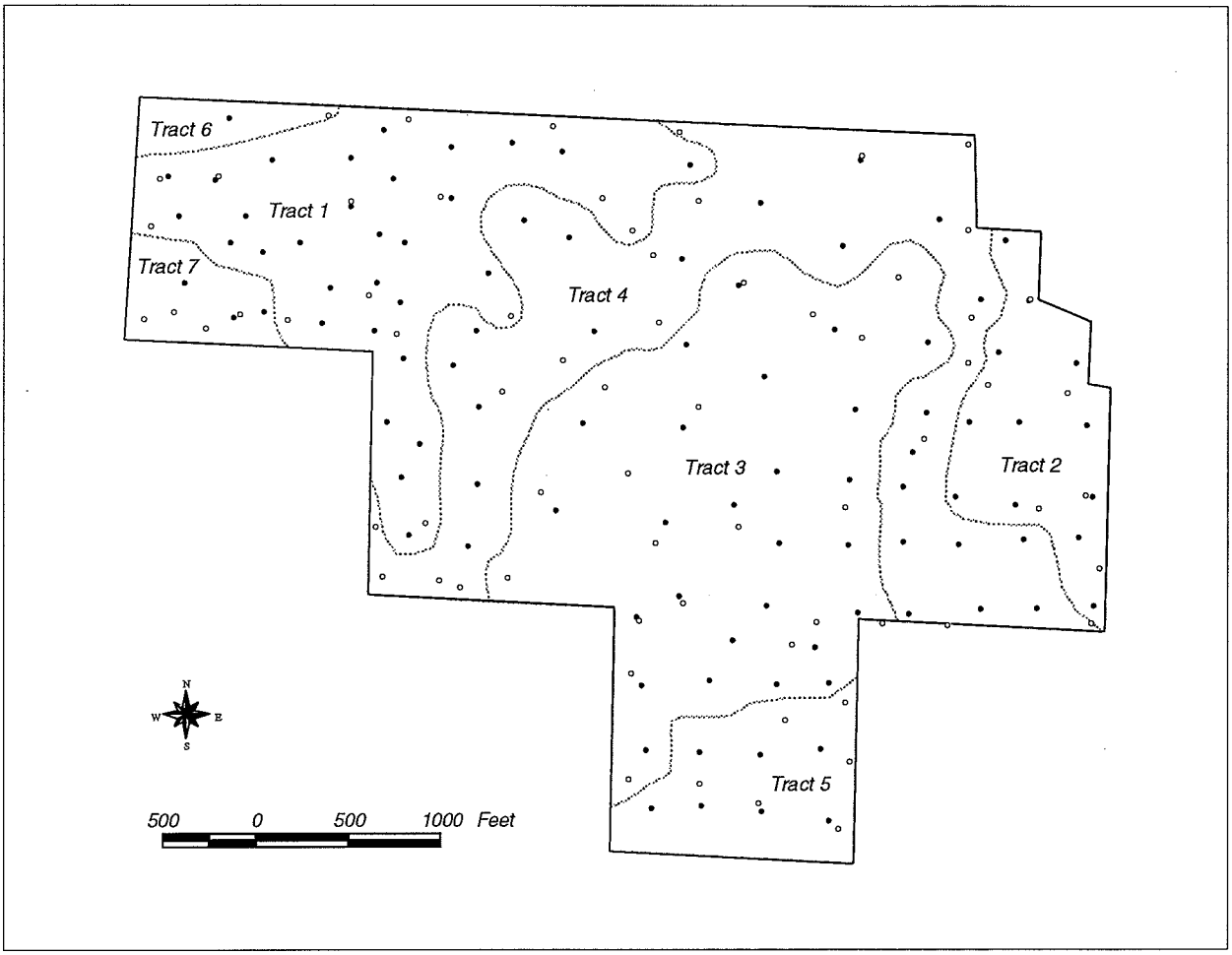


Figure 3. This illustration shows the Gilbertson property divided into 5 tracts along with the drill holes. The open circles represent holes drilled with the Giddings probe. The filled circles represent holes drilled with the MnDOT rig with 10-inch auger. Details about the size and volumes of gravel associated with each tract are presented in Table 1.

Results

Drilling– Drilling provided depth-related information about the sediments below the surface of the land. The following results are based on drilling observations.

- A thick layer of mixed sand and gravel occurs over the entire property
- A black topsoil layer is as thin as 0.1 feet on hills and as thick as 5.5 feet in some low areas
- Overburden is 0 to 4 feet thick over most of the gravel deposits, but does exceed 20 feet in places that are somewhat randomly distributed. Average thickness of overburden over the entire study area is 4.1 feet.
- A thick, relatively contiguous gravel deposit occurs in tracts 1, 2, and 3

- The water table was not encountered in any of the drill holes. The watering holes appear to be perched over a layer of silt and clay which in turn overlies sand or gravel.

Volume– Volumes of gravel estimated by computer modeling are reported for each tract in Table 1. These volumes are based on factual drill hole information only.

Table 1. Gravel volumes estimated by computer modeling were rounded off to the nearest 50,000 yards and listed below. Volumes are reported as in-place cubic yards. The estimate of error is the potential error of the gravel volumes and based on professional judgement. It is based on the uncertainty of whether gravel occurs at all and how much it may vary in thickness between drill holes within a tract.

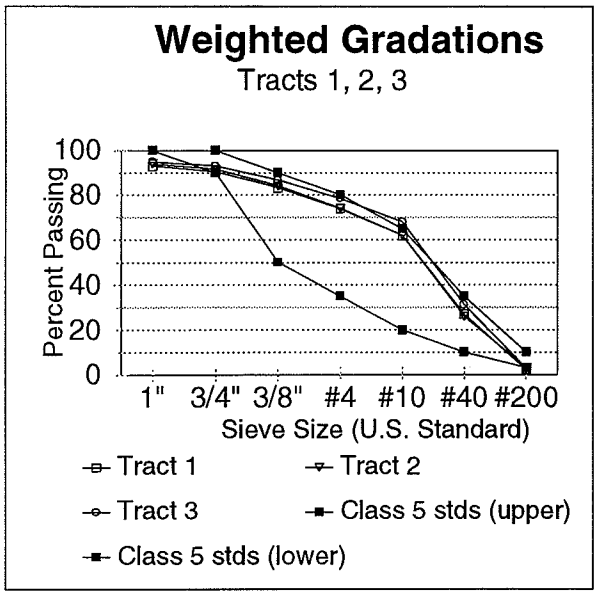
Tract #	ACRES	VOLUME 1 (gravel >= 5 ft; overburden >= 0)	VOLUME 2 (gravel >= 5 ft; overburden < 10 ft	ESTIMATE OF ERROR (percent)
1	64	1,750,000	1,750,000	25
2	25	700,000	700,000	30
3	98	2,050,000	2,050,000	35
4	86	450,000	350,000	35
5	22	250,000	200,000	35
6	5	0	0	NA
7	9	50,000	50,000	NA
TOTAL	307	5,250,000	5,100,000	

The yards under the heading 'VOLUME 1' above represents all the gravel equal to or thicker than 5 feet. The 5-foot threshold is reasonable based on economics. An additional economic threshold occurs when the overburden is too thick to strip economically. Ten feet of overburden was used as the cut off. The values under 'VOLUME 2' represent gravel that is 5 feet or thicker and covered by less than 10 feet of overburden. The values listed under 'VOLUME 2' has a current market value.

Gradations and quality– Weighted average gradations for the gravel in tracts 1, 2, 3, 4, and 5 are presented in Table 2. These gradations are compared graphically to MnDOT's class 5 specifications in Figure 4. The gradation distributions from all 5 tracts are very close to or fall within the allowable range for class 5 aggregate. The gravel in tract 1 is slightly low in silt (material passing #200 sieve) compared to class 5 specifications. Tract 3 has a slightly high sand content (material passing #10 sieve) compared to class 5 specifications. The gradations for each sample are presented in Appendix D.

Table 2. Weighted average gradations for each tract. This is the traditional method of presenting gradation results. The sieve sizes get progressively smaller moving to the right in the table. The cutoff for gravel is the #10 sieve. For tract 1 for example, 62% of the sample passed through the #10 sieve. This means that tract 1 has an average of 38% (100 - 62 = 38) gravel.

	Percent passing respective sieve (coarse gradations)												Percent passing respective sieve (fine gradations)							
Tract	4" (100mm)	3" (75mm)	2.5" (63mm)	2" (50mm)	1.5" (37.5mm)	1.25" (31.5mm)	1" (25mm)	3/4" (19mm)	5/8" (16mm)	½" (12.5mm)	3/8" (9.5mm)	#4 (4.75mm)	#8 (2.36mm)	#10 (2.0mm)	#16 (1.18mm)	#30 (0.600mm)	#40 (0.425mm)	#50 (0.300mm)	#100 (0.150mm)	#200 (0.075mm)
1	100	100	100	99	96	95	93	91	89	86	83	74	65	62	53	38	27	17	5	2.3
2	100	100	100	99	97	96	94	92	90	88	84	74	65	62	52	36	26	17	6	3.0
3	100	100	100	99	97	96	95	93	92	90	87	78	70	68	58	42	31	20	6	2.9
4	100	100	100	99	97	96	95	92	90	88	84	75	65	62	51	33	23	16	7	3.7
5	100	100	100	98	96	95	93	90	88	86	82	71	62	60	51	37	29	20	7	3.3
class 5 stds (upper)							100	100			90	80		65			35			10.0
class 5 stds (lower)							100	90			50	35		20			10			3.0



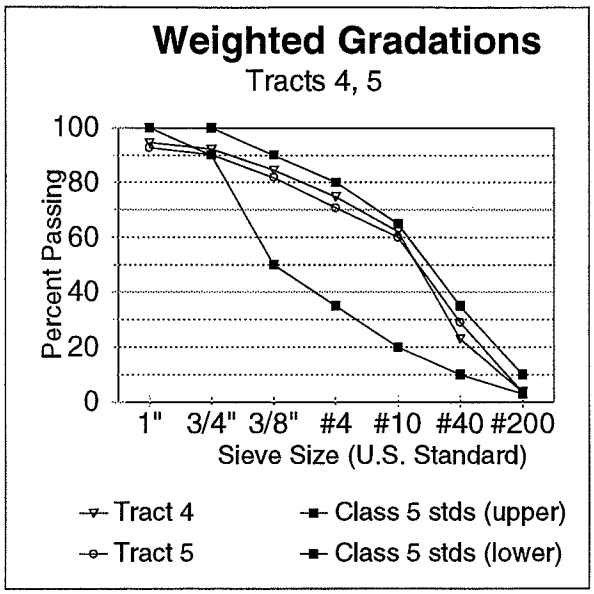


Figure 4. These graphics compare the gradation of the composited samples from each tract to the specifications for class 5 aggregate. Values that plot between the upper and lower limits meet specifications. These graphs are intended to provide a point of reference to a familiar gravel product (class 5). Percent passing refers to the proportion of the sample that passes through a particular sieve size. Particles larger than 3/4 inch are normally crushed.

Quality tests from independent labs indicate the aggregate from tracts 1 and 2 meet MnDOT specifications for concrete aggregate (Table 3, Appendix E). Aggregate from tract 2 also meet specifications for concrete structures. Quality tests were not done on gravel from any of the other tracts. Given that the gradations from all 5 tracts are fairly similar, the quality of gravel from tracts 3, 4, and 5 may be similar to that from tracts 1 and 2.

Table 3. Results of quality tests of composited aggregate samples from tract 1 and tract 2.

	Tract 1	Tract 2	MnDOT Specifications	
			Concrete	Structures
% shale +1/2"	0	0		
% shale +#4	0.3	0	<0.7	<0.3
% soft iron oxide	0.3	0		
% total spall +1/2	0.1	0.2		
% total spall +#4	0.7	0.1	<1.0	<0.3
% soft particles	0	0		
% clay balls and lumps	0.1	0		
% total spall	0.9	0.3	<3.5	<3.0
% slate	0	0		
% flat and elongated particles	0.1	0.1		
% passing #200	4.7	5.3		
Specific gravity +#4 (coarse)	2.658	2.653		
Specific gravity -#4 (fine)	2.602	2.579		
Specific gravity average	2.617	2.599		
% absorption +#4 (coarse)	1.34	1.16		
% absorption -#4 (fine)	1.38	1.64		
% absorption average	1.369	1.510		

A petrographic examination of the coarse portion from tract 1 found the particles were mostly equidimensional, well rounded, and relatively free of secondary coatings. The majority of the particles consisted of carbonate, granite, gneiss, quartzite, and greywacke. These rock types are generally considered hard, sound, and durable. The sample did contain some deleterious materials including weathered granite, shale, soft carbonates, and lesser amounts of iron oxides and mud balls (Appendix F).

Geophysics– The geophysical surveys show a difference between silts or clays and sand or gravel. The lines show a thin, roughly 3 foot layer of silt overlies the sand and gravel over most of the land covered by the lines with an occasional pocket of thick silts here and there. A resistivity value of around 400 ohm meters was used to draw the line on the figures which separates the sand and gravel layer from silts and clays (see Plate 1). Lines 1 and 2 also give an indication that glacial till (clay silt) lies beneath the sand and gravel layer at a depth in the range of 75 to 100 feet.

References Cited

Lehr, J. D., 1997, Aggregate Resources, Eastern Clay County, Minnesota Map Series, Minnesota Department of Natural Resources, Division of Minerals.

NAPP, 1991, National Aerial Photography Program, Stereoscopic Color Infer Red Aerial Photographs.

Appendix A: Detailed descriptions for each drill hole

Appendix B: Samples composited for quality testing or petrographic analysis

Appendix C: Drill holes with respective data used for Techbase modeling

Appendix D: Complete gradation data

Appendix E: Aggregate quality testing report

Appendix F: Petrographic analysis of aggregate report

Appendix A: Detailed descriptions for each drill hole. Abbreviations used in 'color' column: lt = light, dk = dark, gry = gray, blk = black, brn = brown, yel = yellow, org = orange. Abbreviations used in 'layer' column: grvl = gravel, sd = sand, slty = silty, vf = very fine, f = fine, m = medium, c = coarse.

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
1	0	1	black	top soil	2	
1	1	5	black	silt	2	
1	5	7	yellow brn	sandy grvl	15	rock at 6.25 ft
1	7	8	org brn	grvl	30	Iron stain at 7.5 ft
1	8	8.5	gry brn	grvly silt	15	possibly till
2	0	0.7	black	top soil		
2	0.7	2	dk brn	silt	2	firm, few pebbles, gleyed gray at 2 ft
2	2	4.5	olive gray brn	clay silt	3	maybe till
2	4.5	6	brn	f grvl	30	layers of pea gravel
2	6	9	lt brn	f-m sand	2	bright orange at 6.5 ft. grind on rock at 9 ft
3	0	5.5	black	top soil	0	lower 1 ft is moist
3	5.5	8	brn gray	silt	0	orange brown at 7-8 ft and wet
3	8	9.5	org brn	grvl	35	
3	9.5	13.5	brn	grvl	45	grvl is nearly dry, subrounded pebbles of limestone, basalt and granite
3	13.5	18	lt brn	f sand	0	dry
4	0	0.7	black	top soil	2	loam
4	0.7	4	brn gray	rocky silt		till?
4	4	6	brn	sandy grvl	20	some thin gray fine sd layers
4	6	10	brn	grvl	30	high f-m sd content
5	0	0.1	black	top soil		grvly loam
5	0.1	1.5	dk brn	grvl	40	good gradation
5	1.5	10	lt gry brn	sandy grvl	15	clean, less grvl with depth, possible f sd below 8 ft due to poor recovery
6	0	0.3	black	top soil	20	
6	0.3	2	dk brn	grvl	45	good gradation
6	2	5.5	lt brn	f sand	5	little silt
6	5.5	8	lt brn	sandy grvl	15	dry, good gradation
6	8	9	white gry	f sand	0	
7	0	0.5	black	top soil		
7	0.5	1.5	dk brn	grvl	45	good gradation
7	1.5	2	gry brn	sandy grvl	20	
7	2	4	brn	grvl	40	good gradation
7	4	6.5	gry brn	sandy grvl	15	some clean (no silt) white medium sand layers
7	6.5	10	brn	grvl	35	good gradation, occ. white sand layers
8	0	3.5	black	top soil	0	sandy loam

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
8	3.5	9	dk brn	f-m sand	0	
8	9	10	lt brn	vf sand	0	no silt
9	0	0.5	black	top soil	0	sandy loam
9	0.5	3.5	brn	f-m sand	0	
9	3.5	7.5	brn	sandy grvl	20	more grvl in lower, good gradation
9	7.5	8	gry white	sand	5	
9	8	10	brn	grvl	35	
9	10	12	brn	grvl	45	good gradation
10	0	0.3	black	top soil	5	grvly loam
10	0.3	5.25	brn	grvl	40	subrounded pebbles, lower 1/2 ft has lt gray white clay in gravel
10	5.25	6.25	gry brn	sand	2	
10	6.25	8	brn	grvl	30	more f-m sand than grvl above
10	8	10	white brn	sandy grvl	15	
11	0	0.3	black	top soil		grvly loam
11	0.3	2	brn	sandy grvl	20	
11	2	3.75	brn	grvl	35	good gradation
11	3.75	7	gry white	sand	5	silty 6-7 ft
11	7	12	brn	grvl	30	
11	12	14	gry brn	sand	10	poor recovery
12	0	1.5	black	top soil	2	sandy loam
12	1.5	2.5	dk brn	grvly slt	15	
12	2.5	5.5	brn	grvl	38	4" cobbles at 4.5-5 ft, refusal on rock at 5.5 ft
13	0	1.5	black	top soil		loam
13	1.5	2.5	dk brn	silt		
13	2.5	6	brn	grvl	45	good gradation, refusal on rock at 6 ft
14	0	0.2	black	top soil		sandy loam
14	0.2	1	brn	sand		
14	1	4	brn	grvl	30	graded sand
14	4	7	white brn	sandy grvl	20	occasional white sand layers
14	7	10	brn	grvl	30	good gradation
15	0	1.5	black	top soil		loam
15	1.5	2.5	dk brn	silt	2	rare pebble
15	2.5	6	brn	slty grvl	30	subrounded pebbles, good gradation, pea grvl at 4-6 ft
15	6	9.5	brn	sandy grvl	20	well graded sand, less grvl with depth
15	9.5	10	white gry	f sand	0	
16	0	0.3	black	top soil		grvly loam
16	0.3	2	dk brn	slty sd		
16	2	3.5	brn	sandy grvl	20	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
16	3.5	4	gry brn	sandy grvl	15	mostly clean sand
16	4	10	brn	grvl	40	good gradation
17	0	0.3	black	top soil	2	loam
17	0.3	2	dk brn	sandy slt	2	
17	2	3.5	brn	grvl	40	
17	3.5	5	gry brn	vf sand	0	no silt
17	5	8	lt brn	sand	12	occasional grvl layers
17	8	10	brn	sandy grvl	20	
18	0	1.5	black	top soil		clay loam
18	1.5	2.2	dk brn	silt	2	
19	2.2	5.5	brn	grvl	40	
19	5.5	6	lt brn	sandy grvl	15	clean, well graded sand
19	6	10	lt brn	vf sand	0	firm
20	0	0.2	black	top soil		sandy loam
20	0.2	3	brn	sandy grvl	15	pea grvl
20	3	4	lt brn	f-m sand	0	clean
20	4	8	brn	sand	10	iron stains at 5 ft, ½" gray shale at 5 ft
21	0	1	black	top soil		silt loam
21	1	3	dk brn	silt	5	rock from 2-4 ft
21	3	5	lt brn	f-m sand	2	no silt, mostly f sand
21	5	10	lt brn	f sand	0	no silt, gets finer with depth
22	0	1.8	black	top soil	2	loam
22	1.8	3	dk brn	grvl	40	good gradation
22	3	5.5	lt brn	f-m sand	5	iron stain at 4 ft
22	5.5	10	brn	grvl	30	
23	0	0.1	black	top soil		sandy loam
23	0.1	6	brn	grvl	35	iron stain at 3-4 ft, sandy at 2-3 ft, rocks at 3-4 ft
23	6	10	lt brn	sandy grvl	22	less silt and grvl than above
24	0	1.2	black	top soil		
24	1.2	2	dk brn	silt		
24	2	4	brn	grvl	35	poor gradation--too much f-m sand
24	4	8	brn	grvl	50	still sandy but lots of pebbles
25	0	1	black	top soil	0	
25	1	4	dk brn	silt	2	thin sand layers at 3-4 ft
25	4	7.5	brn	grvl	45	moist, good gradation
25	7.5	8	gry brn	f sand	0	
25	8	10	lt brn	f-m sand		
26	0	1	black	top soil		grvly silt
26	1	2	brn	grvl	30	
26	2	10	lt brn	sandy grvl	15	poor gradation

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
27	0	1.5	brn	grvl	35	
27	1.5	4	lt brn	f-m sand	0	
27	4	6	lt brn	grvl	25	sandy
27	6	10	brn	grvl	35	more grvl with depth
28	0	1	black	top soil		
28	1	2	dk brn	clay silt	10	
28	2	4	brn	grvl	40	lots of 1-2" pebbles
28	4	6.5	olive brn	slty sandy grvl	15	some clods
28	6.5	10	brn	slty grvl	35	friable clods
29	0	8	brn	grvl	45	good gradation, silty top 2 ft
30	0	1.5	black	top soil		
30	1.5	3	dk brn	silt		
30	3	4	dk brn	slty sd		
30	4	10	brn	sandy grvl	22	more grvl with depth, good silt content
31	0	0.8	black	top soil		
31	0.8	2.5	dk brn	slty f sd		
31	2.5	5		sand	5	
31	5	8		sandy grvl	15	
31	8	10		f-m sand	5	
32	0	0.1	black	top soil		sandy loam
32	0.1	1.5	brn	sandy grvl	20	
32	1.5	5	brn	grvl	40	good gradation, iron stains at 3.5-4 ft
32	5	7	brn	sandy grvl	20	rock at 7 ft
32	7	10	brn	grvl	35	good gradation, cobbles
33	0	0.2	black	top soil		grvly loam
33	0.2	3	dk brn	grvl	50	good gradation
33	3	10	brn	grvl	32	more sand than above
34	0	3.5	black	top soil	0	clay loam
34	3.5	4.5	dk brn	slty sd	5	
34	4.5	7	lt brn	sandy grvl	15	
34	7	8	brn	grvl	40	good gradation
34	8	10	brn	grvl	30	
35	0	1.5	black	top soil		
35	1.5	2.5	dk brn	silt		
35	2.5	4	lt brn	f-m sand	8	
35	4	6	lt brn	f sand	0	clean
35	6	8	lt brn	m sand	3	coarser with depth
35	8	10	lt brn	sand	5	
36	0	2	dk brn	silt	0	
36	2	5.5	org brn	m sand	0	
36	5.5	6	brn	grvl	35	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
36	6	10	lt brn	sandy grvl	15	occasional 1" pebble
37	0	2	dk brn	slty sd	3	occasional pebble
37	2	6	brn	f-m sand	5	some silt
37	6	8.5	brn	slty sd	3	refusal on rock at 8.5ft
38	0	0.4	black	top soil	0	
38	0.4	2	gry brn	silt	0	
38	2	3.5	gry brn	sandy slt	5	occasional pebble
38	3.5	4	brn	grvl	35	
38	4	6	brn	sandy grvl	20	some silt
38	6	8	brn	grvl	35	good gradation
38	8	9.5	brn	grvl	40	good gradation, refusal on rock at 9.5 ft
39	0	1.3	black	top soil	20	grvly loam
39	1.3	4	brn	grvl	30	cobbles at 3-3.5 ft
39	4	5.5	brn	grvl	40	refusal on rock at 5.5ft
40	0	1	dk brn	top soil	8	grvly loam
40	1	2	dk brn	slty grvl	25	
40	2	5	lt brn	slty grvl	25	some sandy layers
40	5	6	gry brn	f-m sand	3	
40	6	9	lt brn	sand	8	
40	9	11	lt brn	sandy grvl	20	medium sand matrix
41	0	3	brn	grvl	35	good gradation
41	3	6	lt brn	sand	5	clean
41	6	10	lt brn	sand	5	
42	0	0.5	dk brn	top soil	20	grvly sandy loam
42	0.5	2.5	brn	slty grvl	35	
42	2.5	5	lt brn	sand	7	clean
42	5	10	brn	grvl	30	good gradation
43	0	0.2	black	top soil	25	grvly loam
43	0.2	2	brn	slty grvl	30	
43	2	6	lt brn	sandy grvl	20	poor gradation
43	6	10	lt brn	f-m sand	10	
44	0	1	black	top soil	0	
44	1	2.5	dk brn	sandy slt	0	
44	2.5	6	lt yel brn	vf sand	0	coarser with depth
44	6	10	white brn	f-m sand	1	clean, very rare granules
45	0	2	black	top soil	0	
45	2	2.5	dk brn	sandy grvl	20	
45	2.5	10	lt yel brn	f-m sand	2	occ. vf sand layers at 6-8 ft, occ v thin f grvl layers
46	0	0.7	black	top soil	15	grvly loam
46	0.7	2	dk brn	slty sandy grvl	20	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
46	2	3	lt brn	f-m sand	5	
46	3	4	brn	sandy grvl	20	
46	4	5	gry brn	f sand	2	
46	5	6	gry brn	f-m sand	10	
46	6	8	brn	sandy grvl	15	rock at 7.5 ft
46	8	10	lt brn	sand	7	
47	0	2	black	top soil	0	
47	2	8	olive gray	clay silt	0	
48	0	1	black	top soil	25	grvly loam
48	1	3	dk brn	grvl	40	
48	3	5	lt brn	sandy grvl	17	sandy, poor gradation
48	5	7	brn	grvl	40	grinding at 5 and 7 ft
48	7	9	lt brn	f-m sand	5	
48	9	10	brn	grvl	25	
49	0	0.8	black	top soil	2	
49	0.8	2.5	dk brn	sandy slt	2	
49	2.5	6	brn	grvl	25	good gradation, rocks at 5 and 7.5 ft
49	6	10	brn	sandy grvl	20	less grvl in lower
50	0	1	black	top soil	25	grvly loam
50	1	2.5	brn	grvl	35	good gradation
50	2.5	6.5	brn	sandy grvl	20	#10 sieve indicates 25-30% grvl
50	6.5	8	brn	grvl	25	
50	8	10	brn	grvl	35	
51	0	0.7	black	top soil	3	sandy loam
51	0.7	2	dk brn	silt	5	
51	2	3	brn	sand	5	
51	3	10	brn	grvl	45	good gradation
52	0	0.2	black	top soil	5	sandy loam
52	0.2	1.5	dk brn	sandy slt	5	
52	1.5	3	brn	sand	13	occ. f grvl
52	3	10	lt brn	f-m sand	5	clean, lots of quartz sand
53	0	0.5	dk brn	top soil	8	grvly silt
53	0.5	3	lt brn	f-m sand	2	
53	3	6	lt brn	sand	8	mostly medium sand
53	6	8	lt brn	sandy grvl	20	
53	8	10	lt brn	sand	10	
54	0	0.3	black	top soil	2	sandy loam
54	0.3	2.5	dk brn	f sand	2	
54	2.5	3.8	lt brn	f-m sand	10	
54	3.8	10	brn	grvl	35	good gradation, rocks at 4.5, 5.5, 8 ft, finer 8-10 ft

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
55	0	1.2	black	top soil	2	sandy loam
55	1.2	2	org brn	slty sand	2	
55	2	3.5	dk brn	slty vf sand	0	
55	3.5	6	lt brn	grvl	25	some clean sand layers
55	6	9	lt brn	c sand	10	
55	9	10	brn	grvl	30	
55	10	14	brn	sandy grvl	20	
56	0	0.7	dk brn	top soil	10	grvly loam
56	0.7	2	org brn	grvl	30	
56	2	5	lt brn	sand	10	
56	5	6	brn	grvl	25	
56	6	8	brn	grvl	30	
56	8	10	lt brn	sandy grvl	15	
57	0	0.2	black	top soil	3	sandy loam
57	0.2	1	dk brn	slty sand	3	
57	1	4.5	lt brn	m sand	8	
57	4.5	5.5	brn	sandy grvl	20	
57	5.5	6	brn	grvl	30	
57	6	8	lt brn	grvl	25	one 6" layer of clean m sand
57	8	10	lt brn	sandy grvl	20	
58	0	0.1	black	top soil		cobbles
58	0.1	3	lt brn	sandy grvl	20	
58	3	5	brn	grvl	30	
58	5	7	lt brn	sandy grvl	20	medium sand matrix
58	7	10	brn	grvl	30	fairly good gradation
59	0	1.5	brn black	top soil	20	grvly silty sand
59	1.5	3.5	dk brn	grvl	35	
59	3.5	4.5	dk brn	slty sandy grvl	20	clods
59	4.5	7	dk brn	slty grvl	30	
59	7	10	lt gray	vf sand	0	clean
60	0	1	brn	sandy grvl	20	
60	1	4	brn	grvl	50	good gradation
60	4	10	brn	grvl	35	good gradation
61	0	0.1	black	top soil		
61	0.1	4	brn	grvl	35	good gradation
61	4	7	lt brn	grvl	30	minimal silt
61	7	8	lt brn	m sand	10	
61	8	10	brn	grvl	30	good gradation
62	0	2.5	black	top soil	0	
62	2.5	3.5	dk brn	silt	0	
62	3.5	7	lt brn	m sand	2	rare pebble and granules, occ c. sand

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
62	7	9	lt brn	grvly c sd	15	minimal silt
62	9	14	brn	grvl	30	good gradation, more grvl in lower
63	0	0.3	black	top soil	20	grvly loam
63	0.3	4	dk brn	slty grvl	40	lots of 3/4 - 1" pebbles
63	4	6	lt brn	grvl	30	minor silt
63	6	8	lt brn	sandy grvl	20	mostly medium sand
64	0	1	black	top soil	0	sandy loam
64	1	2	dk brn	slty sand	3	
64	2	3	gry brn	sandy grvl	15	
64	3	5	brn	grvl	25	
64	5	5.5	brn	grvl	40	good
64	5.5	6	white gry	f-m sand	0	
64	6	11	gry brn	sandy grvl	15	
65	0	0.5	black	top soil	0	
65	0.5	1.3	dk brn	slty sand	5	
65	1.3	5.5	lt brn	sandy grvl	15	
65	5.5	10	brn	grvl	25	slightly sandy, rocks at 5.5, 6, 7, 8, 9 ft
66	0	0.8	black	top soil		sandy loam
66	0.8	1.5	dk brn	grvly silt	25	
66	1.5	5	brn	slty grvl	40	good gradation, cobbly
67	0	1	black	top soil	15	grvly loam
67	1	2	brn gray	grvly silt	15	
67	2	4.5	yellow brn	v slty grvly sd	15	some of this looks like sandy till, but frost action likely
67	4.5	6	yellow brn	slty grvl	25	rocks at 5-6 ft, good gradation
67	6	8	brn	slty grvl	35	excess m sand
67	8	10	lt brn	sandy grvl	20	rock at 8 ft
68	0	1	black	top soil	10	
68	1	2.5	org brn	v slty f sd	10	
68	2.5	4	yellow brn	slty grvl	25	
68	4	7	yellow brn	v slty grvly sd	15	looks like till, refusal on rock at 7 ft
69	0	1	black	top soil	20	cobbly silt
69	1	3	lt brn	grvly silt	15	
69	3	4	brn	grvl	25	
69	4	7	brn	c grvl	50	cobbles in upper part
69	7	9	white	f-m sand	0	clean
69	9	12	brn	grvl	35	
69	12	13.5	lt brn	m sand	5	pretty clean, possible cross beds
69	13.5	20	brn	grvl	35	thin sand layer at 18 ft
69	20	25	lt brn	m sand	2	
69	25	30	brn	sandy grvl	20	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
69	30	36	brn	sand	5	
69	36	41	dk red brn	sandy grvl	20	some iron staining, moist, lower 2 ft is pea grvl
69	41	50	lt brn	f-m sand	5	
70	0	1	black	top soil	0	
70	1	3	gry brn	silt	5	more grvl with depth
70	3	4.5	brn	grvl	45	good gradation
70	4.5	7.5	brn	grvl	30	variable layers of 10-40% grvl
70	7.5	10.5	white brn	f-m sand	1	very clean, some iron streaks
70	10.5	19	brn	grvl	35	variable layers, some rusty layers, cobbles
70	19	20	dk brn	slty sand		
70	20	29.5	brn	grvl	25	little silt
70	29.5	31	gry brn	f-m sand	0	
70	31	45	brn	sandy grvl	20	v sandy
70	45	47	brn	grvl	45	good gradation
70	47	50	brn	sandy grvl	20	
71	0	3	black	top soil		
71	3	5	red brn	silt	10	
71	5	6.5	red brn	slty grvl	30	more grvl with depth
71	6.5	10	dk brn	slty sand	10	varied layers
71	10	15	brn	sand	5	
71	15	15.5	lt brn	clay silt	0	wet, no water
71	15.5	20	brn	sand	10	one ft of pea grvl at 18 ft
72	0	2	black	top soil	0	
72	2	3	dk brn	silt	5	
72	3	5	brn	v slty sd	10	
72	5	7.5	brn	sand	5	
72	7.5	10	olive brn	silt	5	looks like soft till
72	10	12	brn	slty grvl	30	
72	12	14	white brn	sand	2	
72	14	19	brn	grvl	40	
72	19	33	brn	sandy grvl	22	varied layers, occ. cobble
72	33	36	white brn	sand	3	
72	36	47	brn	grvl	25	little silt
72	47	50	white	sand	0	
73	0	0.5	black	top soil	20	grvly loam
73	0.5	3	brn	grvl	40	
73	3	11.5	lt brn	sand	10	10% grvl on #10 sieve
73	11.5	13	brn	grvl	40	
73	13	20	lt brn	grvl	25	clean
73	20	22	brn	sand	10	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
73	22	33	brn white	sand	5	v clean, finest sand at top
73	33	36	lt brn	f sand	0	
73	36	50	brn white	f-m sand	3	occ 4" thick pea layers
74	0	1	black	top soil	0	
74	1	2	dk brn	silt	3	occ. cobble
74	2	5	olive brn	silt	0	
74	5	6	white brn	sand	10	
74	6	8	lt brn	vf sand	0	
74	8	10	org brn	silt	0	slightly clayey, moist, lt. gray mottles
74	10	13	org brn	grvl	30	good gradation
74	13	17.5	lt brn	vf sand	3	occ. thin grvl layer
74	17.5	20	org brn	sandy grvl	20	
75	0	0.5	black	top soil	10	grvly loam
75	0.5	2	dk brn	grvly slt	15	
75	2	3	brn	slty sandy grvl	20	
75	3	6	brn	grvl	35	
75	6	7	white brn	m sand	5	
75	7	24	brn	grvl	35	3 layers of 6" thick white sand
75	24	39	white brn	sand	8	
75	39	50	white brn	f sand	0	
76	0	9.5	dk brn	slty grvl	50	numerous 2-4" cobbles
76	9.5	10.5	lt brn	f-m sand	0	
76	10.5	24	brn	grvl	30	varied layers from good grvl to sand, some silt, grvl decrease with depth
76	24	26	lt brn	sand	5	
76	26	34	brn	sandy grvl	20	some silt
76	34	40	white	m sand	0	
76	40	45	lt brn	sand	5	
77	0	1	black	top soil		occ. cobble
77	1	2	olive brn	silt		
77	2	12	brn	grvl	35	two 1 ft layers of white sand, 50% of cobbles are limestone
77	12	14	white brn	m sand	2	
77	14	22	brn	grvl	25	occ. cobble in lower 3 ft
77	22	43	lt brn	sand	12	some 1-2 ft white sand layers
77	43	50	white	f-m sand	0	
78	0	1	black	top soil		cobbly loam
78	1	1.5	olive brn	slty sand		cobbles
78	1.5	2	brn	grvl	45	
78	2	4	lt org brn	m sand	0	
78	4	15	brn	grvl	35	numerous cobbles

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
78	15	19	lt brn	grvl	25	clean
78	19	25	white	sand	8	clean
79	0	1	black	top soil		
79	1	2	olive brn	silt		
79	2	3	lt brn	f-m sand	10	
79	3	11	brn	grvl	35	some cobbles, some f sand layers
79	11	13	yellow brn	f-m sand	0	
79	13	20	lt brn	sand	10	clean, good cobble layer in top 6"
80	0	1	black	top soil		
80	1	2	olive brn	silt		
80	2	8	gry brn	silt	10	pebbles to 3" big, possibly till
80	8	11	gry brn	v slty grvl	30	
80	11	20	red brn	grvl	35	size decreases downward, good gradation
80	20	23	white brn	sandy grvl	15	
80	23	27	brn white	f-m sand	1	
80	27	30	brn	grvl	30	
80	30	40	brn white	sand	5	tough drilling
81	0	1	black	top soil		pebbly loam
81	1	7	olive brn	clay silt	5	possibly till, pebbles to 4"
81	7	7.5	red brn	grvl	45	
81	7.5	10	olive brn	clay silt	0	
81	10	13	lt brn	sand	10	clean
81	13	18	lt brn	slit/f sand	0	iron streaks
81	18	20	red brn	sandy grvl	20	
82	0	1	black	top soil	5	
82	1	2.5	olive gray	pebbly silt	5	
82	2.5	10	lt brn	sand	10	little silt
82	10	12	olive brn	vf sand	0	
82	12	20	lt brn	grvl	35	
83	0	1	black	top soil	0	
83	1	3	dk brn	silt	5	
83	3	3.75	brn	slty grvl	45	cobble layer
83	3.75	4	yellow	vf sand	0	
83	4	7	olive brn	pebbly silt	5	possibly till
83	7	7.5	red brn	grvl	30	
83	7.5	12	lt brn	sand	1	
83	12	15	olive brn	vf sand	0	
83	15	18	brn white	f sand	0	
83	18	20	brn white	sand	3	
84	0	0.5	black	top soil	0	sandy loam
84	0.5	1.5	red brn	slty sand	2	rare pebbles

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
84	1.5	8	yellow brn	vf/m sand	2	various layers
84	8	20	brn white	f-m sand	1	v clean sand, one 6" pea grvl layer at 11 ft
85	0	0.5	black	top soil		sandy loam
85	0.5	3.5	brn	grvl	40	good
85	3.5	5	white brn	f-m sand	0	clean
85	5	6	brn	grvl	45	clean, cobbly
85	6	10	white brn	f-m sand	0	
85	10	13	lt brn	grvl	35	little silt
85	13	20	lt brn	sand	10	
86	0	0.5	black	top soil		sandy loam
86	0.5	1.5	brn	m sand		
86	1.5	7	brn	grvl	25	
86	7	8.5	white brn	f sand	0	
86	8.5	13	brn	grvl	25	3 inch cobbles at 12-13 ft in m sand matrix
86	13	15	lt brn	m sand	0	
86	15	17	brn	sandy grvl	20	no silt
86	17	20	lt brn	sand	10	some grvl at base
87	0	0.5	black	top soil	2	sandy loam
87	0.5	1.5	lt brn	m sand	5	
87	1.5	6	brn	grvl	30	clean, good gradation
87	6	8	white brn	m sand	0	
87	8	10	lt brn	sandy grvl	20	clean
87	10	15	brn	grvl	30	minor silt
87	15	20	lt brn	sand	3	
88	0	0.5	black	top soil	10	grvly loam
88	0.5	1.5	dk brn	silt	10	
88	1.5	6	brn	slty grvl	35	good gradation
88	6	10	brn	slty sandy grvl	15	
88	10	20	brn	grvl	35	some silt, good gradation
88	20	34	brn	sandy grvl	20	varying grvl layers, minor silt
88	34	40	brn white	m sand	12	occ pebbles in clean sand
89	0	0.5	black	top soil	5	
89	0.5	1.5	yellow brn	slty sandy grvl	15	
89	1.5	4	red brn	slty grvl	40	
89	4	8	lt brn	grvl	25	sandier in lower part
89	8	18	lt brn	grvl	25	variable grvl, better at 12-16 ft
89	18	20	lt white brn	grvly c sd	15	
89	20	27	brn	grvl	35	varies from c sand to grvl
89	27	30	white	m sand	5	
90	0	0.5	black	top soil		
90	0.5	1.5	brn	silt	10	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
90	1.5	3	lt brn	sandy grvl	20	
90	3	6	lt brn	sandy grvl	20	
90	6	10	lt brn	grvl	25	clean, one cobble layer at 6 ft
90	10	17	lt brn	sandy grvl	20	
90	17	19	red brn	grvl	50	cobbly
90	19	22	lt brn	sandy grvl	20	
90	22	26	white	m sand	5	
90	26	30	lt brn	sandy grvl	20	
91	0	0.5	black	top soil		grvly loam
91	0.5	1	olive brn	grvly silt		
91	1	3.5	red brn	slty grvl	40	
91	3.5	9	brn	grvl	50	good
91	9	12	lt brn	grvl	25	minimal silt
91	12	20	white brn	sand	8	lots of med sand, occ grvl layers
92	0	0.5	black	top soil		grvly loam
92	0.5	4	lt brn	grvl	30	
92	4	6	lt brn	sand	10	
92	6	8.5	brn	grvl	35	
92	8.5	11	white	sand	5	v clean, occ 1" pebble
92	11	21	lt brn	grvl	25	little silt, good gradation
92	21	25	brn white	m sand	2	
92	25	32	brn	sand	10	
92	32	40	brn white	m sand	5	occ pebble
93	0	0.75	black	top soil		
93	0.75	1.5	yellow gry	silt	5	
93	1.5	4	brn	grvl	40	siltier in upper
93	4	6.5	lt brn	m sand	5	clean
93	6.5	15	lt brn	grvl	25	
93	15	18	lt brn	vf sand	0	
93	18	21	lt brn	grvl	25	
93	21	30	brn white	sand	10	
94	0	1.5	black	top soil	20	cobbles, one limestone slab
94	1.5	6	lt yel brn	m sand	0	
94	6	20	white brn	m sand	0	
95	0	0.5	black	top soil	10	grvly loam
95	0.5	1.5	red brn	silt	10	
95	1.5	5	lt yel brn	sand	2	
95	5	8	gry brn	grvly silt	15	maybe till, friable
95	8	13	brn	grvl	35	good gradation
95	13	19	white brn	sand	10	clean
95	19	20	brn white	f sand	0	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
96	0	0.5	black	top soil	0	
96	0.5	1.5	red brn	silt		grvly in lower
96	1.5	3	brn	slty sandy grvl	20	
96	3	6	brn	sand	5	
96	6	9	lt brn	sandy grvl	15	
96	9	16	white brn	m sand	5	occ. pea layer
96	16	18	olive gray	vf sand	0	clean
96	18	20	lt brn	sand	10	thin pea layer at top
97	0	0.75	black	top soil		clay loam
97	0.75	1.5	red brn	clay silt	5	
97	1.5	9	olive brn	silt	10	till?
97	9	14	lt white brn	sand	10	washed sand
97	14	15.5	brn red	c grvl	75	well rounded pebbles and cobbles
97	15.5	17	brn white	m sand	2	
97	17	20	lt brn	sandy grvl	20	washed sand
98	0	1	black	top soil	1	
98	1	3	dk red brn	silt	1	
98	3	4	lt brn	grvly silt	20	
98	4	5.5	brn	grvl	35	good gradation, rocks at 4-5 ft
98	5.5	11	lt brn	f-m sand	2	occ vf sand layers
98	11	15	red brn	slty grvl	40	
98	15	20	lt brn	sand	8	less grvl in lower
99	0	2	black	top soil	0	silt
99	2	4	org brn	silt	1	
99	4	5.5	brn	sandy grvl	20	cobble layer at 4 ft
99	5.5	10	lt brn	sandy grvl	15	
99	10	23	lt brn	sandy grvl	20	little silt
99	23	30	white brn	sand	5	varies from c sand to f sand
100	0	0.3	black	top soil	10	
100	0.3	9	brn	grvl	30	red brown at 5 ft, good gradation and binder, less grvl with depth
100	9	11	lt brn	sand	10	
100	11	25	brn	grvl	30	less silt than above, cobble (3-6") layer at 20-25 ft
100	25	30	white	f-m sand	0	v clean
101	0	0.3	black	top soil	10	
101	0.3	2	red brn	grvl	35	
101	2	2.3	brn white	vf sand	0	
101	2.3	5	lt brn	f-m sand	10	
101	5	6	white	f-m sand	3	
101	6	11	lt brn	sandy grvl	20	washed pea grvl

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
101	11	15	lt brn white	m sand	2	
101	15	22	lt brn	sandy grvl	20	
101	22	30	brn white	m sand	5	
102	0	1	black	top soil	0	sandy loam
102	1	3	dk brn	sandy slt	2	
102	3	7	lt brn	grvl	25	low silt, lots of limestone pebbles
102	7	8	gry green	sandy slt	5	soft till? with limestone pebbles
102	8	16	red brn	grvl	25	rock at 16 ft
102	16	17	lt brn	m sand	5	
102	17	20	green gry	clay silt	5	till?
102	20	21.5	red brn	grvl	45	
102	21.5	23.5	lt brn	vf sand	0	
102	23.5	26	lt brn	sandy grvl	20	
102	26	35	white	f sand	0	dry, v clean
103	0	4	black	top soil	0	sandy silt
103	4	6	gry brn	slty sand	0	wet, sticky
103	6	12.5	brn	slty sand	5	wet, sticky
103	12.5	15.5	olive brn	vf sand	0	moist
103	15.5	20	lt brn	grvl	25	dry, less grvl in lower
104	0	1	black	top soil	0	sandy loam
104	1	5.5	dk yel brn	v slty sd	8	
104	5.5	10	brn	f grvl	30	mostly pea grvl, some binder
104	10	10.5	brn white	m sand	2	
104	10.5	18	lt brn	f grvl	25	cobbles at 18 ft
104	18	20	brn	c grvl	50	cobbly layer
104	20	30	lt brn	f grvl	30	pea grvl
104	30	41	lt brn	sandy grvl	25	less grvl, variable layers
104	41	45				hard drilling, no recovery
105	0	1	black	top soil	2	sandy loam
105	1	4	dk org brn	slty sand	3	
105	4	5	brn	grvl	30	
105	5	7	dk olive brn	vf sand	0	
105	7	8.5	lt brn	sand	10	
105	8.5	14.5	brn	grvl	25	varied
105	14.5	20	lt brn	sand	10	clean, poor graded, layered
106	0	1	black	top soil	0	sandy silt
106	1	2	dk org brn	sandy slt	2	
106	2	3.5	brn	grvl	30	occ cobble
106	3.5	6	lt brn	sand	10	
106	6	10.5	brn	grvl	40	dry, no binder
106	10.5	12	olive brn	vf sand	0	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
106	12	16	brn white	m sand	5	clean
106	16	20	lt brn	grvl	30	few cobbles
107	0	0.75	black	top soil	0	
107	0.75	1.5	dk org brn	sandy slt	2	
107	1.5	2.5	brn	sandy grvl	20	
107	2.5	12	lt brn	m sand	5	clean, dry, layered from f sand to one pea grvl 6" thick
107	12	14.5	lt brn	grvl	45	
107	14.5	18	lt brn	sand	5	varied
107	18	20	brn	grvl	25	cobble at 19 ft
108	0	0.3	black	top soil		sandy loam
108	0.3	3	dk olive brn	vf sand	5	
108	3	6	lt brn	m sand	5	
108	6	8	olive brn	vf sand	0	
108	8	20	lt brn	f sand	0	occ 1 ft layers of vf sand
109	0	0.25	black	top soil		sandy loam
109	0.25	5	lt brn	grvl	25	
109	5	7	brn	grvly c sd	15	
109	7	10	lt brn	grvl	25	grinding rock at 7 ft
109	10	26	brn	grvl	30	grinding rock at 12, 17-19, cobble layer at 18-25 ft
109	26	30	white brn	f-m sand	8	
109	30	34	lt brn	sandy grvl	15	tough drilling
109	34	35	white	m sand	0	
110	0	0.5	black	top soil	5	
110	0.5	2.5	gry brn	clay silt	10	
110	2.5	4.5	brn	slty sandy grvl	20	
110	4.5	8	red brn	grvl	40	ground up a 1 ft diameter limestone slab at 4-6 ft
110	8	20	brn white	vf sand	2	tough drilling 15-20 ft, occ 1 ft layers of m sand with 5% grvl
111	0	0.5	black	top soil	3	sandy loam
111	0.5	1	dk org brn	sandy slt	5	
111	1	2	brn	sandy grvl	20	
111	2	6	lt olive brn	vf sand	0	
111	6	9.5	lt brn	sandy grvl	20	low silt
111	9.5	14	lt brn	sandy grvl	20	
111	14	18	brn white	f-m sand	5	occ pebble
111	18	20	brn	grvl	25	
112	0	0.25	black	top soil	10	sandy loam
112	0.25	11	brn	grvl	32	has thin layers of white sand

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
112	11	15	brn white	m sand	12	
112	15	20	lt brn	grvl	30	
112	20	31	lt brn	sandy grvl	20	varied layers
112	31	35	brn white	m sand	5	
113	0	1.5	black	top soil	2	sandy loam
113	1.5	2	dk red brn	silt	2	
113	2	7.5	brn	grvl	30	silty in upper 6"
113	7.5	16	lt brn	sandy grvl	20	sieved 20% grvl
113	16	26	brn white	m sand	10	layered
113	26	29.5	brn	grvl	30	cobble layer at 28 ft
113	29.5	30	lt olive brn	vf sand	0	
114	0	0.25	black	top soil	10	
114	0.25	4	lt brn	grvl	25	
114	4	5.5	white	m sand	2	
114	5.5	8	lt brn	sandy grvl	20	
114	8	20	white	m sand	10	clean, occ 1" pebbles, 6" pea layer at 18 ft
115	0	0.5	black	top soil		
115	0.5	1	dk red brn	silt	5	
115	1	9	brn	grvl	40	grinding rock at 5-9 ft, good gradation, good binder
115	9	20	lt brn	sand	10	three 6" layers of pea grvl amongst clean white sand
116	0	1.5	black	top soil	5	sandy loam
116	1.5	4	dk red brn	silt	5	
116	4	11	brn	sandy grvl	23	low silt
116	11	12	lt olive brn	vf sand	0	
116	12	14	red brn	grvl	40	pebble layer with silt
116	14	20	brn white	f-m sand	10	dry, clean, occ pea layer
117	0	2	black	top soil	0	clay silt
117	2	4	dk yel brn	clay silt	0	
117	4	5.5	gry brn	clay silt	5	has orange spots
117	5.5	9.5	red brn	grvl	35	
117	9.5	10	brn white	f sand	0	
117	10	12	lt brn	sand	10	
117	12	14	red brn	slty grvl	45	cobbly
117	14	17.5	olive brn	vf/m sand	5	
117	17.5	19.5	red brn	slty grvl	25	
118	0	0.25	black	top soil	5	sandy loam
118	0.25	14	brn	grvl	25	less grvl at 5-10 ft, occ soft iron oxide balls (1/2")
118	14	17	brn white	f-m sand	5	clean

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
118	17	26	brn	sandy grvl	22	varied layers, less grvl with depth
118	26	32	brn white	f sand	0	clean
118	32	35	brn white	m sand	5	clean
119	0	2	black	top soil	5	sandy loam
119	2	5	dk red brn	sandy slt	5	
119	5	6.5	brn	sandy grvl	20	
119	6.5	9.5	gry blk	sandy slt	5	sticky
119	9.5	10	brn	sandy grvl	20	
119	10	14	gry blk	sandy slt	5	sticky
119	14	20	red org brn	sandy slt	5	layers of orangish brn sand near bottom
120	0	1.5	black	top soil	2	sandy silt
120	1.5	3	dk brn	sandy slt	2	
120	3	5	org brn	v slty sd	5	
120	5	8	brn	sandy grvl	23	good gradation
120	8	10	lt yel brn	f sand	0	
120	10	12	brn	grvl	25	
120	12	17	brn white	m sand	5	
120	17	20	brn	grvl	35	
121	0	2.5	black	top soil	0	sandy loam
121	2.5	5	dk yel brn	sandy slt	0	
121	5	6	brn	grvl	30	
121	6	11	lt brn	sand	5	
121	11	16	lt brn	sandy grvl	22	low silt
121	16	20	lt brn	m sand	10	layered
122	0	0.3	black	top soil	5	sandy loam
122	0.3	16	lt brn	sandy grvl	22	rock at 8 ft
122	16	20	brn white	m sand	10	layered
123	0	0.5	black	top soil	10	
123	0.5	5.5	lt brn	sandy grvl	20	soft iron oxide clods at 4 ft
123	5.5	14	brn white	vf/m sand	8	layered sands 0-20% grvl, 2 ft of vf sand,
123	14	14.5	brn	c grvl	70	cobble layer
123	14.5	20	brn white	vf/m sand	10	clean, occ pea layer, 2.5 ft of vf sd with 0 grvl
124	0	0.5	black	top soil	0	sandy loam
124	0.5	2	dk red brn	slty sand	0	
124	2	14	lt brn	sand	3	clea, one 6" layer of pea grvl
124	14	20	lt brn	sandy grvl	20	low silt
125	0	0.5	black	top soil	10	sandy loam
125	0.5	1	dk brn	sand	10	
125	1	7	brn	sandy grvl	22	good gradation
125	7	18.5	brn white	f-m sand	2	one or two 3" pea grvl layer at 16-17 ft

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
125	18.5	20	red brn	grvl	35	pea grvl, good gradation
126	0	0.5	black	top soil	15	grvly loam
126	0.5	1.5	dk brn	slty grvl	35	
126	1.5	5	lt brn	f-m sand	0	
126	5	10	red brn	grvl	40	
126	10	12	brn white	f-m sand	0	
126	12	20	white brn	sand	13	clean, occ pebbles, occ pea layers
127	0	0.3	black	top soil	20	
127	0.3	13.5	brn	grvl	40	mostly pea grvl
127	13.5	19	lt brn	f-m sand	0	
127	19	20	brn	sand	10	
128	0	0.5	black	top soil	5	
128	0.5	1	dk brn	grvly slt	15	
128	1	7	brn	slty grvl	35	good gradation and binder
128	7	10	lt brn	sandy grvl	20	less silt
128	10	20	lt brn	sand	10	occ pea grvl layer, rare pebbles
129	0	0.5	black	top soil	0	sandy loam
129	0.5	4.5	org brn	m sand	2	some silt
129	4.5	8.5	org brn	grvl	35	
129	8.5	11	lt white brn	f-m sand	0	
129	11	25	lt brn	grvl	25	varied layers, rock at 14 ft
129	25	35	brn white	sand	5	one ft of grvl at 30 ft
130	0	0.5	black	grvl	30	
130	0.5	1	dk brn	slty c grvl	55	
130	1	5	brn	c grvl	55	good gradation and binder
130	5	7.5	brn	f grvl	30	one v silty layer
130	7.5	20	lt white brn	f-m sand	0	clean
131	0	3	brn	slty grvl	40	
131	3	5	lt brn	sand	8	
131	5	11.5	brn	grvl	35	good gradation, 1" shale pebble at 6 ft
131	11.5	20	lt white brn	sandy grvl	20	less grvl and thicker sand layers with depth
132	0	3	black	top soil	0	sandy silt
132	3	4.5	dk red brn	sandy slt	2	
132	4.5	6	brn	grvl	35	
132	6	10	lt brn	sandy grvl	20	layers of sand and grvl
132	10	12	lt olive	vf sand	0	
132	12	26	brn	slty grvl	40	finer and less grvl at 15-20 ft
132	26	30	lt brn	grvly c sd	15	
133	0	2	black	top soil	0	
133	2	3.5	dk brn	silt	0	
133	3.5	6.5	lt brn	m sand	2	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
133	6.5	10	lt brn	grvly c sd	18	clean
133	10	18	brn	grvl	45	pea grvl
133	18	20	lt brn	f-m sand	0	
133	20	28	white brn	grvl	35	good gradation, clean
133	28	30	lt brn	grvly c sd	20	
133	30	38	lt white brn	grvl	35	pea grvl
133	38	42	brn white	f-m sand	2	clean
133	42	44	lt brn	sandy grvl	15	alternating layers of pea grvl and white sand, refusal on rock at 44 ft
134	0	0.5	black	top soil	2	silty sand
134	0.5	14	org brn	f-m sand	5	occasional thin grvl layers
134	14	20	lt olive brn	f sand	2	
135	0	1.5	black	top soil		
135	1.5	2	dk org brn	silt	0	
135	2	4	brn	sand	3	
135	4	6	org brn	sand	10	occ grvl
135	6	12.5	brn	slty grvl	45	good gradation, good binder
135	12.5	15	white	m sand	2	
135	15	20	brn	f grvl	30	minor silt
135	20	31	brn	slty grvl	35	good binder
135	31	32.5	lt olive	f sand	0	
135	32.5	42	brn	grvl	35	coarser and siltier in lower 3 ft
135	42	43	lt brn	m sand	5	
135	43	44	brn	grvl	35	
135	44	50	white brn	sand	10	washed sand, occ f grvl, white m sand in lower 2 ft
136	0	0.5	black	top soil	2	silty sand
136	0.5	4	dk yel brn	m sand	5	
136	4	5	lt brn	m sand	5	
136	5	9.5	olive brn	vf sand	0	
136	9.5	20	white	f-m sand	0	occasional change in grain size
137	0	0.2	black	top soil		
137	0.2	1.5	dk red brn	sandy slt	5	
137	1.5	7	brn	grvl	40	good binder
137	7	8.5	brn	sandy grvl	20	alternating layers of m sand and grvl
137	8.5	10.5	brn white	m sand	5	
137	10.5	14.5	lt brn	sandy grvl	17	grvl layers, no silt
137	14.5	20	white	f-m sand	0	clean
138	0	0.5	black	top soil	0	sandy loam
138	0.5	2	dk brn	slty sand	5	
138	2	5	org brn	sandy grvl	22	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
138	5	12	lt brn	f-m sand	5	occ grvl, clean
138	12	16	lt olive brn	vf sand	0	
138	16	20	brn white	f-m sand	5	traces of grvl, appears to be 3 coarsening up sequences from 20-12 ft
139	0	1.5	black	top soil		
139	1.5	4	dk red brn	sandy slt	5	
139	4	5.5	brn	m sand	5	
139	5.5	10	lt olive brn	f-m sand	0	
139	10	20	lt olive brn	vf sand	0	tough drilling 10-20 ft
140	0	0.5	black	top soil	0	
140	0.5	1	dk org brn	silt	0	
140	1	2.5	org brn	sand	10	
140	2.5	6	org brn	sandy grvl	20	
140	6	11	lt gry brn	m sand	10	clean
140	11	15		grvl	35	pea grvl
140	15	16.5	lt brn	sand	10	clean
140	16.5	20	lt olive brn	f-m sand	0	
141	0	0.5	black	top soil	2	sandy loam
141	0.5	1.5	dk org brn	silt	10	
141	1.5	16	org brn	sandy grvl	20	varied layers of % grvl, good grvl at 8 ft
141	16	20	lt brn	sand	5	
142	0	0.5	black	top soil		sandy loam
142	0.5	1.5	lt brn	sand	10	
142	1.5	5.5	brn	grvl	30	mostly pea grvl, some silt
142	5.5	10	lt brn	f-m sand	0	finer in lower 2 ft
142	10	15	lt brn	f sand	0	
142	15	16	brn	grvl	40	pea grvl, little silt
142	16	17	lt brn	m sand	5	
142	17	20	brn	grvl	40	pea grvl, little silt
143	0	0.5	black	top soil		
143	0.5	4.5	brn	grvl	25	
143	4.5	13	lt brn	m sand	5	clean, some f sand layers with 0 grvl, rare 3" grvl layers
143	13	20	brn white	f-m sand	0	clean
144	0	0.5	black	top soil	1	
144	0.5	1	dk brn	silt	5	
144	1	5	brn	grvl	40	good rock gradation, lower has m sand matrix
144	5	8	lt brn	vf sand	0	very well sorted
144	8	9	brn	grvl	35	good rock gradation
144	9	10		sand	0	iron stains at 9 ft

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
144	10	12	red brn	grvl	35	good rock gradation
144	12	13.5	gry brn	vf sand	0	
144	13.5	20	lt brn	sand	10	varies with depth
145	0	0.5	black	top soil	2	sandy loam
145	0.5	1.5	dk org brn	silty sd	5	
145	1.5	7	brn	slty grvl	30	pretty good
145	7	20	lt brn	sandy grvl	15	varies with depth from m sd with 0 grvl to 30% pea grvl
146	0	2	black	top soil	2	sandy loam
146	2	3.5	dk org brn	slty sand	2	
146	3.5	5	dk brn	sand	2	
146	5	6	brn	grvl	40	good gradation
146	6	8.5	lt brn	sand	4	variable
146	8.5	13.5	lt brn	sandy grvl	18	
146	13.5	17	brn	f-m sand	1	some silt
146	17	20	lt brn	sand	12	
147	0	1.5	black	top soil	0	
147	1.5	3	dk brn	silt	2	
147	3	5	lt brn	grvl	25	
147	5	22	lt brn	sandy grvl	20	variable, low silt
147	22	40	lt brn	sand	15	clean
148	0	0.25	black	top soil	5	sandy loam
148	0.25	4	brn	grvl	35	
148	4	7.5	lt brn	sandy grvl	20	low silt
148	7.5	13	lt brn	sandy grvl	17	clean
148	13	17	lt white brn	f-m sand	5	
148	17	20	lt brn	sandy grvl	20	
149	0	0.3	black	top soil	2	sandy loam
149	0.3	10	lt brn	grvl	35	sandy, low silt, lower 3 ft is sand with 1" pebbles
149	10	20	white brn	vf sand	0	
150	0	0.75	black	top soil	0	
150	0.75	2.5	dk brn	sandy slt		
150	2.5	3.5	brn	slty grvl	35	pebble lag at top
150	3.5	11	lt brn	f-m sand	5	clean, slightly calcareous
150	11	28	org brn	grvl	25	iron stains at 11-12 ft, alt layers of grvl and sand
150	28	30	lt brn	sand	5	
151	0	0.5	black	top soil	10	grvly loam
151	0.5	8.5	org brn	grvl	35	cobbly and silty at 1, 4, 6 ft, pea grvl below 7 ft

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
151	8.5	10	lt brn	m sand	5	
151	10	14	brn	grvl	30	cobbles and silt at 10-11 ft, pea grvl below
151	14	20	lt brn	sand	10	
152	0	0.5	black	top soil	0	sandy loam
152	0.5	2	dk brn	f-m sand	0	
152	2	13.5	lt brn	grvl	35	lower 4 ft seems to coarsen upwards
152	13.5	17.5	lt brn	sand	10	
152	17.5	20	olive brn	vf sand	0	
153	0	1	black	top soil	0	sandy loam
153	1	4	dk brn	sandy slt	5	
153	4	7.5	brn	slty sand	5	moist
153	7.5	11	org brn	grvl	25	
153	11	12.5	lt olive brn	f sand	0	
153	12.5	20	lt brn	m sand	10	6" thick pebble layer at 12.5 and 17 ft, otherwise mostly clean m sand
154	0	1	black	top soil	0	
154	1	3	dk brn	silty sd	5	
154	3	4	lt brn	grvl	40	top 6" is silty with cobbles, clean below
154	4	10	lt brn	sandy grvl	15	
154	10	13.5	org brn	slty grvl	35	good gradation
154	13.5	20	white brn	f sand	0	
155	0	0.75	black	top soil	0	
155	0.75	2.5	dk org brn	silt	5	
155	2.5	5	org brn	silty sd	5	
155	5	7	org brn	grvl	40	about 50% of the limestone pebbles are angular
155	7	11	lt brn	sand	5	
155	11	20	brn	grvl	25	variable layers
155	20	30	lt brn	grvl	25	low silt
155	30	35	lt brn	sand	7	
156	0	0.5	black	top soil	0	
156	0.5	1	dk brn	silt	5	
156	1	5	brn	grvl	25	slightly silty, high % of m sand, iron stains at 5 ft
156	5	10	lt brn	sand	8	
156	10	14	lt brn	sand	2	washed sand, tough drilling 11-20 ft
156	14	20	white brn	f-m sand	0	v well sorted
157	0	0.5	black	top soil	2	sandy loam
157	0.5	3.5	brn	grvl	40	pebble layer at 2-3 ft
157	3.5	5	lt brn	sand	3	
157	5	10.5	lt brn	sandy grvl	20	pea grvl

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
157	10.5	12	white brn	f-m sand	0	
157	12	23.5	brn	grvl	28	
157	23.5	30	lt brn	sand	10	
158	0	3	black	silt	0	
158	3	4.5	dk brn	sandy slt	0	
158	4.5	5	org brn	grvl	35	cobbles
158	5	7.5	lt brn	sandy grvl	20	
158	7.5	10	lt olive brn	vf sand	0	
158	10	14	lt brn	m sand	2	
158	14	29	brn	grvl	25	cobble layer at top
158	29	35	white brn	f-m sand	0	v well sorted
159	0	1.5	black	top soil	0	sandy silt
159	1.5	4	dk org brn	silty sd	2	
159	4	11	lt brn	sand	8	two 6" pea grvl layers among clean sand, 1" clay ball at 4.5 ft
159	11	19	lt brn	grvl	30	low silt
159	19	20	white brn	sand	5	
160	0	0.75	black	top soil	2	silty sand
160	0.75	2	dk org brn	silty sd	2	
160	2	3		sand	12	pebbles at top
160	3	7	lt org brn	grvl	30	good silty pebble layer at 6-7 ft
160	7	10	white brn	f-m sand	3	well sorted
160	10	15	lt brn	grvl	25	
160	15	20	white brn	sand	12	clean
161	0	0.5	black	top soil	2	sandy loam
161	0.5	4.5	dk brn	silty sd	8	
161	4.5	17	gry brn	grvl	25	cobbles mostly blue green basalt, pebble layer at 15 ft
161	17	20	lt brn	sand	5	
161	20	30	lt brn	grvl	25	low silt, variable layers
161	30	40	lt brn	c sand	12	
162	0	0.7	black	top soil	0	silt
162	0.7	2	dk brn	silty c sand	10	iron stains and thin cobble layer at 2 ft
162	2	6	lt yel brn	sand	3	
162	6	7.5	brn	grvl	40	
162	7.5	10	lt brn	sand	8	washed sand
162	10	20	lt brn	sandy grvl	20	layered, good 1 ft thick pea grvl at 15 ft
163	0	1	black	top soil	0	
163	1	2	dk org brn	sandy slt	0	
163	2	6	lt org brn	sand	10	
163	6	10	lt olive brn	vf-m sand	2	sand coarsens upwards

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
163	10	20	lt white brn	vf-m sand	0	
164	0	1.5	black	top soil	0	
164	1.5	3.5	dk brn	silt	0	
164	3.5	4	dk brn	grvly silt	30	cobbles in silt
164	4	14	brn	sandy grvl	20	
164	14	28	brn	grvl	30	rare cobbles, excellent pea and ½" grvl from 15-25 ft
165	0	1.5	black	top soil	0	
165	1.5	2.5	dk org brn	silt	2	
165	2.5	6	lt brn	m sand	2	
165	6	11	lt brn	m sand	12	pea grvl at 7.5-8.5 ft
165	11	14.5	lt olive brn	vf sand	0	firm
165	14.5	16	white brn	grvl	25	lots of 1" pebbles in f-m sand matrix
165	16	20	brn	grvl	40	good gradation
166	0	1	black	top soil	0	silty sand
166	1	2.5	dk org brn	silty sd	5	
166	2.5	5	lt org brn	sand	12	
166	5	15	lt brn	sandy grvl	15	clean
166	15	20	white brn	sand	5	varies from vf to c sand
167	0	2	black	top soil		sandy loam
167	2	4.5	dk org brn	silt		
167	4.5	8	lt org brn	slty sand	2	
167	8	10	org brn	sandy grvl	22	pea grvl
167	10	12	org brn	grvl	40	cobble layer at 11 ft
167	12	20	lt brn	f-m sand	5	one pea grvl layer at 16 ft
168	0	0.7	black	top soil	0	sandy loam
168	0.7	2.5	org brn	slty f sd	0	
168	2.5	5	brn	grvl	45	pea grvl
168	5	10	lt brn	sandy grvl	17	alternating layers of washed sand and pea grvl
168	10	15	lt org brn	sand	5	
168	15	17.5	brn	grvl	35	
168	17.5	20	lt brn	sand	10	varied layers
169	0	0.5	black	top soil	2	sandy loam
169	0.5	1	dk brn	silty sd	5	
169	1	4	lt org brn	sand	5	
169	4	5	lt brn	sandy grvl	20	
169	5	9.5	lt brn	sand	8	rare thin pea grvl layers in clean sand
169	9.5	30	lt brn	grvl	25	less grvl at 20-30 ft
170	0	0.5	black	top soil	0	sandy loam
170	0.5	1	dk org brn	silt	2	

Hole	From	To	Color	Layer	%Gravel (visual estimate)	Comments
170	1	1.5	org brn	grvl	40	platy limestone slab at top, cobbles at top
170	1.5	5	lt brn	grvl	25	low silt
170	5	15	red brn	grvl	30	good gradation, mostly pea grvl
170	15	17.5		sandy grvl	20	
170	17.5	20	white brn	f-m sand	2	
170	20	29		sandy grvl	20	sample climbed about 12 ft on auger
170	29	33	lt brn	sand	10	
170	33	40	white brn	f-m sand	5	occ thin pea layers
171	0	0.5	black	top soil	2	
171	0.5	1	dk org brn	silty sd	2	
171	1	5	lt org brn	sand	5	
171	5	10	lt yel brn	sand	2	
171	10	20	lt brn	vf sand	0	

Appendix B. Samples that were composited for quality testing or petrographic analysis. Separate quality tests were run for tracts 1 and 2. The petrographic analysis was done on samples from tract 1 only. A 'yes' under a particular column means a portion of that sample was composited with representative portions of the other samples from the same tract with a 'yes' to make a single sample for testing. No tests were run on the samples for tracts 3 through 7. Samples from tracts 1 and 2 that were not included in the tests either were too sandy and therefore not part of the gravel deposit or from holes that were initially excluded from the gravel deposit, but included after gradations were completed.

Sample #	Drill Hole	Tract #	From (ft)	To (ft)	Quality test?	Petrographic Analysis?
69001	69	1	3	20	yes	yes
69002	69	1	25	40		
70003	70	1	3	19	yes	yes
70004	70	1	19	29.5	yes	yes
70005	70	1	29.5	50		
72007	72	1	10	19	yes	yes
72008	72	1	19	47	yes	yes
73009	73	1	0.5	3	yes	yes
73010	73	1	3	11.5		
73011	73	1	11.5	20	yes	yes
74012	74	1	10	13	yes	yes
75013	75	1	2	24	yes	yes
75014	75	1	24	39		
75015	76	1	0	9.5	yes	yes
76016	76	1	9.5	24	yes	yes
76017	76	1	24	34		
77018	77	1	2	12	yes	yes
77019	77	1	12	22	yes	yes
78020	78	1	1.5	19	yes	yes
79021	79	1	3	11	yes	yes
80022	80	1	8	20	yes	yes
85024	85	1	0.5	6	yes	yes
86025	86	1	1.5	13	yes	yes
87026	87	1	1.5	6	yes	yes
87027	87	1	6	15	yes	yes
88028	88	1	1.5	6	yes	yes
88029	88	1	6	20	yes	yes
88030	88	1	20	34		
89031	89	1	1.5	27	yes	yes
90032	90	1	1.5	22	yes	yes
91033	91	1	1	12	yes	yes
92034	92	1	0.5	21	yes	yes
93035	93	1	1.5	15	yes	yes
95036	95	1	8	13	yes	yes

Sample #	Drill Hole	Tract #	From (ft)	To (ft)	Quality test?	Petrographic Analysis?
99037	99	1	4	23		
100038	100	1	0.3	25	yes	yes
101039	101	1	0.3	11		
101040	101	1	11	22		
102041	102	1	3	16	yes	yes
104042	104	1	5.5	30	yes	yes
104043	104	1	30	41	yes	yes
106045	106	1	2	10.5	yes	yes
164118	164	1	4	28		
170125	170	1	1	17.5	yes	yes
170126	170	1	17.5	29		
117059	117	2	5.5	14		
118060	118	2	0.25	14	yes	
118061	118	2	14	26		
125068	125	2	1	7		
126069	126	2	5	10	yes	
126070	126	2	12	20		
127071	127	2	0.3	13.5	yes	
128072	128	2	1	10	yes	
129073	129	2	4.5	8.5	yes	
129074	129	2	11	25	yes	
130075	130	2	0.5	7.5	yes	
131076	131	2	0	11.5	yes	
131077	131	2	11.5	20	yes	
132078	132	2	4.5	6	yes	
132079	132	2	6	12	yes	
132080	132	2	12	26	yes	
133081	133	2	6.5	18	yes	
133082	133	2	18	38	yes	
135083	135	2	6	12.5	yes	
135084	135	2	12.5	44	yes	
109046	109	3	0.25	10		
109047	109	3	10	26		
110048	110	3	2.5	8		
111049	111	3	6	14		
112050	112	3	0.25	11		
112053	112	3	11	31		
113054	113	3	2	16		
122065	122	3	0.3	16		
123066	123	3	0.5	5.5		
137085	137	3	1.5	8.5		
137086	137	3	8.5	14.5		

Sample #	Drill Hole	Tract #	From (ft)	To (ft)	Quality test?	Petrographic Analysis?
140088	140	3	2.5	6		
140088	140	3	11	15		
141090	141	3	1.5	16		
144093	144	3	1	5		
144094	144	3	8	12		
145094	145	3	1.5	7		
145095	145	3	7	20		
146096	146	3	5	13.5		
147097	147	3	3	22		
147098	147	3	22	40		
148099	148	3	0.25	13		
155107	155	3	5	30		
157111	157	3	0.5	23.5		
158112	158	3	4.5	7.5		
158113	158	3	14	29		
160115	160	3	3	15		
161116	161	3	4.5	17		
161117	161	3	17	30		
162117	162	3	6	20		
166120	166	3	2.5	15		
168122	168	3	2.5	10		
169124	169	3	9.5	30		
82023	82	4	12	20		
105044	105	4	8.5	14.5		
115057	115	4	1	9		
116058	116	4	4	14		
120062	120	4	5	12		
138087	138	4	2	5		
149101	149	5	0.3	10		
150102	150	5	11	28		
151103	151	5	0.5	14		
152104	152	5	2	13.5		
154106	154	5	3	13.5		
71006	71	7	5	6.5		

Appendix C. Drill holes with respective data used for Techbase modeling. Abbreviations used: ob = overburden, grvl = gravel.

Drill hole	from (ft)	to (ft)	layer
1	0	5	ob
1	5	8	grvl
1	8	8.5	silt
2	0	4.5	ob
2	4.5	6	grvl
2	6	9	sand
3	0	8	ob
3	8	13.5	grvl
3	13.5	18	sand
4	0	4	ob
4	4	10	grvl
5	0	0.1	ob
5	0.1	10	grvl
6	0	0.3	ob
6	0.3	8	grvl
6	8	9	sand
7	0	0.5	ob
7	0.5	10	grvl
8	0	10	ob
9	0	3.5	ob
9	3.5	12	grvl
10	0	0.3	ob
10	0.3	10	grvl
11	0	0.3	ob
11	0.3	12	grvl
11	12	14	sand
14	0	1	ob
14	1	10	grvl
15	0	2.5	ob
15	2.5	9.5	grvl
15	9.5	10	sand
17	0	2	ob
17	2	10	grvl
18	0	2.2	ob
18	2.2	6	grvl
18	6	10	sand
19	0	0.2	ob
19	0.2	3	grvl
19	3	8	sand
20	0	10	ob
23	0	0.1	ob
23	0.1	10	grvl
24	0	2	ob

Drill hole	from (ft)	to (ft)	layer
24	2	8	grvl
25	0	4	ob
25	4	7.5	grvl
25	7.5	10	sand
26	0	1	ob
26	1	10	grvl
31	0	5	ob
31	5	8	grvl
31	8	10	sand
34	0	4.5	ob
34	4.5	10	grvl
35	0	10	ob
36	0	5.5	ob
36	5.5	10	grvl
40	0	1	ob
40	1	5	grvl
40	5	11	sand
41	0	3	grvl
41	3	10	sand
44	0	10	ob
45	0	2	ob
45	2	2.5	grvl
45	2.5	10	sand
46	0	0.7	ob
46	0.7	4	grvl
46	4	10	sand
47	0	8	ob
48	0	1	ob
48	1	10	grvl
51	0	3	ob
51	3	10	grvl
52	0	10	ob
53	0	6	ob
53	6	8	grvl
53	8	10	sand
54	0	3.8	ob
54	3.8	10	grvl
55	0	3.5	ob
55	3.5	14	grvl
56	0	0.7	ob
56	0.7	10	grvl
58	0	0.1	ob
58	0.1	10	grvl
61	0	0.1	ob
61	0.1	10	grvl
65	0	1.3	ob

Drill hole	from (ft)	to (ft)	layer
65	1.3	10	grvl
67	0	4.5	ob
67	4.5	10	grvl
68	0	2.5	ob
68	2.5	4	grvl
68	4	7	sdy till
69	0	3	ob
69	3	41	grvl
69	41	50	sand
70	0	3	ob
70	3	50	grvl
71	0	5	ob
71	5	6.5	grvl
71	6.5	20	sand
72	0	10	ob
72	10	47	grvl
72	47	50	sand
73	0	0.5	ob
73	0.5	20	grvl
73	20	50	sand
74	0	10	ob
74	10	13	grvl
74	13	20	sand
75	0	2	ob
75	2	24	grvl
75	24	50	sand
76	0	34	grvl
76	34	45	sand
77	0	2	ob
77	2	22	grvl
77	22	50	sand
78	0	1.5	ob
78	1.5	19	grvl
78	19	25	sand
79	0	3	ob
79	3	11	grvl
79	11	20	sand
80	0	8	ob
80	8	23	grvl
80	23	40	sand
81	0	7	ob
81	7	7.5	grvl
81	7.5	20	sand
82	0	12	ob
82	12	20	grvl
83	0	3	ob

Drill hole	from (ft)	to (ft)	layer
83	3	3.8	grvl
83	3.8	20	sand
84	0	20	ob
85	0	0.5	ob
85	0.5	13	grvl
85	13	20	sand
86	0	1.5	ob
86	1.5	13	grvl
86	13	20	sand
87	0	1.5	ob
87	1.5	15	grvl
87	15	20	sand
88	0	1.5	ob
88	1.5	34	grvl
88	34	40	sand
89	0	1.5	ob
89	1.5	27	grvl
89	27	30	sand
90	0	1.5	ob
90	1.5	22	grvl
90	22	30	sand
91	0	1	ob
91	1	12	grvl
91	12	20	sand
92	0	0.5	ob
92	0.5	21	grvl
92	21	40	sand
93	0	1.5	ob
93	1.5	15	grvl
93	15	30	sand
94	0	20	ob
95	0	8	ob
95	8	13	grvl
95	13	20	sand
96	0	1.5	ob
96	1.5	9	grvl
96	9	20	sand
97	0	14	ob
97	14	20	grvl
98	0	4	ob
98	4	5.5	grvl
98	5.5	20	sand
99	0	4	ob
99	4	23	grvl
99	23	30	sand
100	0	0.3	ob

Drill hole	from (ft)	to (ft)	layer
100	0.3	25	grvl
100	25	50	sand
101	0	0.3	ob
101	0.3	22	grvl
101	22	30	sand
102	0	3	ob
102	3	16	grvl
102	16	35	sand
103	0	15.5	ob
103	15.5	20	grvl
104	0	5.5	ob
104	5.5	41	grvl
105	0	8.5	ob
105	8.5	14.5	grvl
105	14.5	20	sand
106	0	2	ob
106	2	10.5	grvl
106	10.5	20	sand
107	0	12	ob
107	12	20	grvl
108	0	20	ob
109	0	0.3	ob
109	0.3	26	grvl
109	26	35	sand
110	0	2.5	ob
110	2.5	8	grvl
110	8	20	sand
111	0	6	ob
111	6	14	grvl
111	14	20	sand
112	0	0.3	ob
112	0.3	31	grvl
112	31	35	sand
113	0	2	ob
113	2	16	grvl
113	16	30	sand
114	0	0.3	ob
114	0.3	8	grvl
114	8	20	sand
115	0	1	ob
115	1	9	grvl
115	9	20	sand
116	0	4	ob
116	4	14	grvl
116	14	20	sand
117	0	5.5	ob

Drill hole	from (ft)	to (ft)	layer
117	5.5	14	grvl
117	14	20	sand
118	0	0.3	ob
118	0.3	26	grvl
118	26	35	sand
119	0	5	ob
119	5	6.5	grvl
119	6.5	20	sand
120	0	5	ob
120	5	12	grvl
120	12	20	sand
121	0	11	ob
121	11	16	grvl
121	16	20	sand
122	0	0.3	ob
122	0.3	16	grvl
122	16	20	sand
123	0	0.5	ob
123	0.5	5.5	grvl
123	5.5	20	sand
124	0	14	ob
124	14	20	grvl
125	0	1	ob
125	1	7	grvl
125	7	20	sand
126	0	0.5	ob
126	0.5	10	grvl
126	10	20	sand
127	0	0.3	ob
127	0.3	13.5	grvl
127	13.5	20	sand
128	0	1	ob
128	1	10	grvl
128	10	20	sand
129	0	4.5	ob
129	4.5	25	grvl
129	25	35	sand
130	0	0.5	ob
130	0.5	7.5	grvl
130	7.5	20	sand
131	0	20	grvl
132	0	4.5	ob
132	4.5	30	grvl
133	0	6.5	ob
133	6.5	38	grvl
133	38	44	sand

Drill hole	from (ft)	to (ft)	layer
134	0	20	ob
135	0	6	ob
135	6	44	grvl
135	44	50	sand
136	0	20	ob
137	0	1.5	ob
137	1.5	14.5	grvl
137	14.5	20	sand
138	0	2	ob
138	2	5	grvl
138	5	20	sand
139	0	20	ob
140	0	2.5	ob
140	2.5	15	grvl
140	15	20	sand
141	0	1.5	ob
141	1.5	16	grvl
141	16	20	sand
142	0	1.5	ob
142	1.5	5.5	grvl
142	5.5	20	sand
143	0	0.5	ob
143	0.5	4.5	grvl
143	4.5	20	sand
144	0	1	ob
144	1	12	grvl
144	12	20	sand
145	0	1.5	ob
145	1.5	20	grvl
146	0	5	ob
146	5	13.5	grvl
146	13.5	20	sand
147	0	3	ob
147	3	22	grvl
147	22	40	sand
148	0	0.3	ob
148	0.3	13	grvl
148	13	20	sand
149	0	0.3	ob
149	0.3	10	grvl
149	10	20	sand
150	0	11	ob
150	11	28	grvl
150	28	30	sand
151	0	0.5	ob
151	0.5	14	grvl

Drill hole	from (ft)	to (ft)	layer
151	14	20	sand
152	0	2	ob
152	2	13.5	grvl
152	13.5	20	sand
153	0	7.5	ob
153	7.5	11	grvl
153	11	20	sand
154	0	3	ob
154	3	13.5	grvl
154	13.5	20	sand
155	0	5	ob
155	5	30	grvl
155	30	35	sand
156	0	1	ob
156	1	5	grvl
156	5	20	sand
157	0	0.5	ob
157	0.5	23.5	grvl
157	23.5	30	sand
158	0	4.5	ob
158	4.5	29	grvl
158	29	35	sand
159	0	11	ob
159	11	19	grvl
159	19	20	sand
160	0	3	ob
160	3	15	grvl
160	15	20	sand
161	0	4.5	ob
161	4.5	30	grvl
161	30	40	sand
162	0	6	ob
162	6	20	grvl
163	0	20	ob
164	0	4	ob
164	4	28	grvl
164	28	35	sand
165	0	14.5	ob
165	14.5	20	grvl
166	0	2.5	ob
166	2.5	15	grvl
166	15	20	sand
167	0	8	ob
167	8	12	grvl
167	12	20	sand
168	0	2.5	ob

Drill hole	from (ft)	to (ft)	layer
168	2.5	10	grvl
168	10	20	sand
169	0	9.5	ob
169	9.5	30	grvl
170	0	1	ob
170	1	29	grvl
170	29	40	sand

Appendix D. Complete gradation data for each sample sieved.

Sample	Drill	Tract	From	To	feet	Percent passing respective sieve (coarse fraction)												Percent passing respective sieve (fine fraction)							
#	hole				grvl	4"	3"	2.5"	2"	1.5"	1.25"	1"	3/4"	5/8"	1/2"	3/8"	#4	#8	#10	#16	#30	#40	#50	#100	#200
69001	69	1	3	20	17	100	100	100	100	86	83	80	76	73	71	67	59	52	50	44	33	25	18	4	2.4
69002	69	1	25	40	15	100	100	100	100	100	100	100	99	98	95	93	82	72	70	58	41	29	18	5	1.7
70003	70	1	3	19	16	100	100	100	100	94	90	87	83	81	79	75	65	55	53	45	31	22	14	3	1.5
70004	70	1	19	29.5	10.5	100	100	100	100	100	98	94	90	88	87	84	77	72	70	63	49	37	23	5	1.6
70005	70	1	29.5	50	20.5	100	100	100	100	99	97	94	92	91	90	88	81	74	72	63	46	30	17	4	1.0
72007	72	1	10	19	9	100	100	100	94	92	88	83	79	77	73	68	59	50	48	39	27	20	13	4	2.4
72008	72	1	19	47	28	100	100	100	99	96	94	91	90	88	86	83	75	68	66	58	41	29	18	4	1.9
73009	73	1	0.5	3	2.5	100	100	100	100	95	95	90	86	82	79	75	66	54	51	39	22	15	9	3	1.8
73010	73	1	3	11.5	8.5	100	100	100	100	100	99	99	99	98	97	95	91	86	84	74	51	33	16	2	0.8
73011	73	1	11.5	20	8.5	100	100	100	100	100	100	96	92	91	88	84	74	62	60	50	34	24	12	2	1.0
74012	74	1	10	13	3	100	100	100	100	100	97	97	94	91	89	86	77	67	64	53	35	23	13	4	1.8
75013	75	1	2	24	22	100	100	100	100	97	95	94	92	90	88	84	76	66	63	53	38	28	18	6	2.6
75014	75	1	24	39	15	100	100	100	100	99	99	99	99	99	98	97	93	89	87	81	67	51	33	10	3.9
75015	76	1	0	9.5	9.5	100	100	100	100	83	80	78	74	71	67	63	52	45	43	35	25	19	14	7	3.9
76016	76	1	9.5	24	14.5	100	100	100	100	99	97	95	93	92	90	86	78	66	64	54	39	27	16	3	2.1
76017	76	1	24	34	10	100	100	100	100	100	99	99	98	98	96	94	86	79	76	66	50	37	19	2	0.8
77018	77	1	2	12	10	100	100	100	100	98	96	95	92	90	88	84	73	53	49	39	28	21	15	7	3.9
77019	77	1	12	22	10	100	100	100	100	98	98	96	94	92	90	87	76	67	64	54	39	30	22	9	4.4
78020	78	1	1.5	19	17.5	100	100	100	100	91	88	86	83	81	78	75	65	54	51	43	31	22	13	3	1.9
79021	79	1	3	11	8	100	100	100	98	97	94	91	88	86	84	80	69	59	57	46	32	24	18	6	2.8
80022	80	1	8	20	12	100	100	100	100	100	98	97	94	92	89	85	75	64	61	48	31	23	16	6	3.9
85024	85	1	0.5	6	5.5	100	100	100	96	94	90	89	87	85	84	80	71	60	57	48	37	31	22	5	2.0

Sample	Drill	Tract	From	To	feet	Percent passing respective sieve (coarse fraction)												Percent passing respective sieve (fine fraction)							
#	hole				grvl	4"	3"	2.5"	2"	1.5"	1.25"	1"	3/4"	5/8"	1/2"	3/8"	#4	#8	#10	#16	#30	#40	#50	#100	#200
86025	86	1	1.5	13	11.5	100	100	100	100	93	91	90	87	86	84	81	71	59	57	47	31	22	14	5	2.7
87026	87	1	1.5	6	4.5	100	100	100	100	98	94	93	89	86	83	79	69	61	59	52	37	26	15	3	1.1
87027	87	1	6	15	9	100	100	100	100	100	98	96	93	90	87	82	69	61	59	52	39	29	18	4	1.6
88028	88	1	1.5	6	4.5	100	100	100	100	98	97	95	93	90	87	84	75	67	65	57	40	29	19	5	1.6
88029	88	1	6	20	14	100	100	100	98	97	96	95	93	92	89	85	74	66	63	53	37	28	19	7	3.2
88030	88	1	20	34	14	100	100	100	100	100	98	98	96	94	91	87	75	61	57	44	28	19	11	3	1.4
89031	89	1	1.5	27	25.5	100	100	100	99	97	97	95	91	89	86	81	69	59	57	47	33	26	18	6	2.6
90032	90	1	1.5	22	20.5	100	100	100	96	95	94	93	91	89	87	83	77	70	68	61	47	37	27	9	4.2
91033	91	1	1	12	11	100	100	100	98	93	89	87	82	78	74	69	57	50	48	40	28	22	20	8	4.4
92034	92	1	0.5	21	20.5	100	100	100	97	96	95	93	91	90	88	84	75	62	58	45	30	21	12	4	1.9
93035	93	1	1.5	15	13.5	100	100	100	100	97	96	94	92	90	88	84	75	67	65	55	36	25	16	5	2.8
95036	95	1	8	13	5	100	100	100	98	96	95	93	89	86	83	79	67	58	55	47	33	24	16	5	2.8
99037	99	1	4	23	19	100	100	100	100	100	99	99	97	95	94	91	81	71	68	56	37	26	15	4	1.9
100038	100	1	0.3	25	24.7	100	100	96	93	89	86	83	80	78	76	72	63	56	53	45	33	25	17	5	2.2
101039	101	1	0.3	11	10.7	100	100	100	100	100	97	95	94	93	91	88	82	72	70	61	46	33	21	6	3.3
101040	101	1	11	22	11	100	100	100	100	100	100	98	97	96	94	91	83	73	70	58	54	49	30	6	2.1
102041	102	1	3	16	13	100	100	100	100	99	98	97	96	95	92	88	78	68	65	56	41	31	21	7	3.4
104042	104	1	5.5	30	24.5	100	100	100	97	95	94	92	90	89	86	82	72	62	59	47	29	18	10	3	1.6
104043	104	1	30	41	11	100	100	100	100	100	99	99	97	96	95	93	86	79	77	67	49	36	21	3	1.0
106045	106	1	2	10.5	8.5	100	100	100	100	96	95	90	87	85	82	78	68	57	54	45	30	22	15	5	1.8
164118	164	1	4	28	24	100	100	100	100	97	95	93	90	89	86	83	71	61	59	49	33	23	15	4	1.9
170125	170	1	1	17.5	16.5	100	100	100	100	98	97	95	93	92	90	88	81	72	69	59	39	27	15	3	1.4
170126	170	1	17.5	29	11.5	100	100	100	100	99	99	98	97	96	94	92	85	78	76	67	48	33	18	4	1.9

Sample	Drill	Tract	From	To	feet	Percent passing respective sieve (coarse fraction)												Percent passing respective sieve (fine fraction)							
#	hole				grvl	4"	3"	2.5"	2"	1.5"	1.25"	1"	3/4"	5/8"	1/2"	3/8"	#4	#8	#10	#16	#30	#40	#50	#100	#200
117059	117	2	5.5	14	8.5	100	100	100	97	95	95	93	91	89	86	83	71	61	59	50	35	26	16	5	2.2
118060	118	2	0.25	14	13.75	100	100	100	100	99	98	96	94	92	90	87	78	68	66	57	42	32	22	7	3.2
118061	118	2	14	26	12	100	100	100	100	98	97	96	93	91	89	86	80	73	71	65	51	41	28	7	1.8
125068	125	2	1	7	6	100	100	100	100	98	97	96	95	94	93	91	85	80	78	70	48	32	17	3	1.2
126069	126	2	5	10	5	100	100	100	100	97	96	96	92	89	86	81	67	54	51	40	25	18	13	6	3.3
126070	126	2	12	20	8	100	100	100	100	100	99	97	96	94	93	91	87	83	81	73	48	30	17	5	1.7
127071	127	2	0.3	13.5	13.2	100	100	100	100	100	98	96	93	91	89	84	72	62	59	47	31	22	14	4	1.9
128072	128	2	1	10	9	100	100	100	100	92	87	85	85	82	80	77	70	63	61	52	32	21	11	3	1.4
129073	129	2	4.5	8.5	4	100	100	100	100	100	100	100	98	96	93	89	77	63	59	44	28	20	13	5	2.4
129074	129	2	11	25	14	100	100	100	100	99	96	94	94	92	90	87	79	72	69	60	41	29	18	5	2.4
130075	130	2	0.5	7.5	7	100	100	100	90	80	76	74	72	70	68	65	56	46	43	32	21	16	11	4	2.0
131076	131	2	0	11.5	11.5	100	100	100	100	99	97	95	92	91	89	86	76	66	64	51	31	20	11	3	1.2
131077	131	2	11.5	20	8.5	100	100	100	100	100	99	98	97	95	94	92	84	76	74	66	53	43	32	10	3.8
132078	132	2	4.5	6	1.5	100	100	100	100	100	98	96	92	88	84	79	68	59	56	48	38	31	23	9	4.0
132079	132	2	6	12	6	100	100	100	100	97	96	95	92	92	90	88	82	74	72	69	63	57	50	31	22.1
132080	132	2	12	26	14	100	100	100	96	92	89	85	82	79	75	70	58	48	45	37	24	18	13	7	4.1
133081	133	2	6.5	18	11.5	100	100	100	100	100	99	97	95	93	91	87	73	61	58	46	27	18	11	3	1.8
133082	133	2	18	38	20	100	100	100	100	100	99	98	97	96	94	90	78	65	62	49	30	21	12	3	1.4
135083	135	2	6	12.5	6.5	100	100	100	100	100	100	95	88	84	78	71	56	42	39	32	24	21	17	9	3.8
135084	135	2	12.5	44	31.5	100	100	100	97	96	96	94	92	90	88	84	74	66	63	52	35	26	17	7	3.4
109046	109	3	0.25	10	9.75	100	100	100	100	99	97	94	91	89	87	84	77	70	68	59	43	33	17	4	2.4
109047	109	3	10	26	16	100	100	97	97	96	94	92	91	89	87	83	73	62	59	47	26	16	10	3	1.8
110048	110	3	2.5	8	5.5	100	100	100	96	93	92	89	87	85	83	79	67	54	51	40	26	19	12	5	2.5

Sample	Drill	Tract	From	To	feet	Percent passing respective sieve (coarse fraction)												Percent passing respective sieve (fine fraction)							
#	hole				grvl	4"	3"	2.5"	2"	1.5"	1.25"	1"	3/4"	5/8"	1/2"	3/8"	#4	#8	#10	#16	#30	#40	#50	#100	#200
111049	111	3	6	14	8	100	100	100	100	98	96	96	95	94	92	90	82	77	75	67	41	30	21	8	5.2
112050	112	3	0.25	11	10.75	100	100	100	98	97	96	94	92	90	87	84	75	67	65	59	46	36	24	7	2.6
112053	112	3	11	31	20	100	100	100	100	99	98	97	94	93	91	87	79	67	64	53	39	30	20	5	2.4
113054	113	3	2	16	14	100	100	100	98	98	95	94	91	90	87	84	73	66	64	55	35	26	15	4	2.0
122065	122	3	0.3	16	15.7	100	100	100	100	98	97	96	95	93	91	88	79	71	69	60	45	34	23	5	1.6
123066	123	3	0.5	5.5	5	100	100	100	100	100	100	99	99	98	97	95	86	79	77	68	51	39	27	8	3.4
137085	137	3	1.5	8.5	7	100	100	100	100	93	92	90	87	84	80	74	61	51	49	40	25	18	13	7	4.2
137086	137	3	8.5	14.5	6	100	100	100	92	92	92	90	89	88	87	86	81	75	73	67	53	40	25	5	1.9
140088	140	3	2.5	6	3.5	100	100	100	100	100	99	99	97	96	94	91	82	71	68	56	39	30	21	6	2.1
140088	140	3	11	15	4	100	100	100	100	100	99	99	97	96	94	91	82	71	68	56	39	30	21	6	2.1
141090	141	3	1.5	16	14.5	100	100	100	100	100	100	98	96	95	93	90	83	72	70	63	37	33	27	6	2.0
144093	144	3	1	5	4	100	100	100	100	93	89	85	81	78	75	71	59	52	50	43	33	26	18	6	3.1
144094	144	3	8	12	4	100	100	100	96	96	93	89	85	82	79	75	65	58	56	49	38	29	21	7	3.1
145094	145	3	1.5	7	5.5	100	100	92	89	81	80	76	72	69	66	63	57	50	48	40	31	25	19	10	4.8
145095	145	3	7	20	13	100	100	100	100	100	100	98	97	96	94	92	85	81	79	72	59	48	33	12	5.7
146096	146	3	5	13.5	8.5	100	100	100	97	96	96	95	94	92	91	89	80	68	64	52	38	30	20	9	6.0
147097	147	3	3	22	19	100	100	100	99	98	96	95	92	91	89	87	80	72	70	59	47	33	18	7	3.0
147098	147	3	22	40	18	100	100	100	100	100	100	100	99	98	97	96	90	85	83	75	56	40	23	5	1.5
148099	148	3	0.25	13	12.75	100	100	100	100	99	98	96	95	94	92	89	81	75	72	62	42	28	17	5	2.3
155107	155	3	5	30	25	100	100	100	97	96	95	93	92	90	88	85	76	66	64	54	37	27	17	6	4.4
157111	157	3	0.5	23.5	23	100	100	100	100	96	94	94	92	91	89	86	78	72	70	61	42	27	16	5	2.6
158112	158	3	4.5	7.5	3	100	100	100	100	99	95	95	91	89	86	85	72	66	64	57	45	36	23	8	5.1

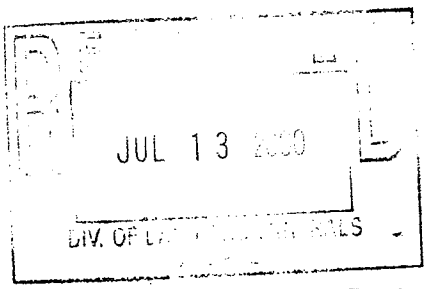
Sample	Drill	Tract	From	To	feet	Percent passing respective sieve (coarse fraction)												Percent passing respective sieve (fine fraction)							
#	hole				grvl	4"	3"	2.5"	2"	1.5"	1.25"	1"	3/4"	5/8"	1/2"	3/8"	#4	#8	#10	#16	#30	#40	#50	#100	#200
158113	158	3	14	29	15	100	100	100	98	96	96	93	91	89	86	82	73	63	59	48	32	22	13	5	2.6
160115	160	3	3	15	12	100	100	100	100	99	99	97	95	94	92	90	82	73	71	62	46	34	23	6	2.1
161116	161	3	4.5	17	12.5	100	100	100	100	97	97	95	93	90	87	83	72	66	64	55	38	26	18	7	3.8
161117	161	3	17	30	13	100	100	100	99	95	95	93	92	91	89	87	80	74	72	64	47	36	25	9	3.5
162117	162	3	6	20	14	100	100	100	98	96	95	94	93	92	90	88	81	67	64	54	37	26	16	4	2.3
166120	166	3	2.5	15	12.5	100	100	100	100	100	99	99	98	97	97	95	91	83	81	73	60	50	37	13	4.7
168122	168	3	2.5	10	7.5	100	100	100	100	100	100	97	96	95	93	88	76	70	68	61	48	37	23	4	2.0
169124	169	3	9.5	30	20.5	100	100	100	100	100	100	99	97	95	94	90	82	74	71	63	48	37	26	6	2.3
82023	82	4	12	20	8	100	100	100	100	97	96	94	89	87	84	80	71	60	57	46	26	17	10	3	1.8
105044	105	4	8.5	14.5	6	100	100	100	100	98	97	95	92	90	86	83	73	66	63	54	38	26	16	4	2.4
115057	115	4	1	9	8	100	100	100	100	97	95	94	91	89	87	83	71	63	60	49	29	18	11	5	2.7
116058	116	4	4	14	10	100	100	100	100	98	96	95	93	91	88	85	75	60	57	43	26	19	14	8	4.4
120062	120	4	5	12	7	100	100	100	95	95	95	94	93	92	90	88	80	74	72	63	47	38	29	13	7.8
138087	138	4	2	5	3	100	100	100	100	100	100	99	98	98	96	93	84	72	69	57	38	26	16	4	2.4
149101	149	5	0.3	10	9.7	100	100	100	98	97	96	94	91	89	87	83	73	67	64	56	41	31	21	6	2.9
150102	150	5	11	28	17	100	100	100	98	96	94	91	88	85	82	78	65	54	52	43	31	24	19	9	3.7
151103	151	5	0.5	14	13.5	100	100	100	99	97	97	95	92	90	87	83	71	62	60	52	39	32	24	9	4.3
152104	152	5	2	13.5	11.5	100	100	100	97	94	94	91	89	87	85	81	70	60	58	49	35	25	14	4	2.1
154106	154	5	3	13.5	10.5	100	100	100	98	97	95	94	92	90	88	85	78	71	69	60	46	35	25	7	3.2
71006	71	7	5	6.5	1.5	100	100	100	100	98	98	98	97	97	95	94	91	89	88	81	65	53	38	8	2.1

Appendix E. Aggregate Quality Testing Report

BRAUNSM
INTERTEC

Braun Intertec Corporation
6801 Washington Avenue South
Minneapolis, Minnesota 55439
612-941-5600 Fax: 941-4151

Engineers and Scientists Serving the Built and Natural Environments



Coarse Concrete Aggregate

Date : 7/11/00 **Project Number :** BADX-00-1200

Client : Dennis Martin
Department of Natural Resources,
Div. of Lands & Minerals
Box 45, 500 Lafayette Road
St. Paul MN 55155

Project : Aggregate Quality Testing
Braun Intertec Laboratory
Minneapolis MN

Background Information

Lab ID : 3368
Sample Number : 3341200128
Date Sampled : 5/15/00
Date Submitted : 6/21/00
Date Tested : 6/29/00
Sample Location : TRACT 1

Specification : Project
Classification :
Test Method : MnDOT
Class Designation :
Sampled by : Client
Source : Not Given

Properties	Test Results	Spec's
Shale MnDOT 1209		
+1/2"	0.0	
+#4 Total	0.3	
Soft Iron Oxide MnDOT 1209	0.3	
Total Spall Excluding Soft Part's & Clay Balls		
+1/2" MnDOT 1209	0.1	
+#4 Total	0.7	
Soft Particles MnDOT 1209	0.0	
Clay Balls and Lumps MnDOT	0.1	
Sum of Spall, Soft particles ,Clay balls	0.9	
Slate MnDOT 1209	0.0	
Flat and Elongated MnDOT ASTM D4791	0.1	
Passing # 200 MnDOT 1202-1203	4.7	
Los Angeles Abrasion MnDOT 1210		
Magnesium Soundness Loss MnDOT 1219		
16-Cycle Freeze/Thaw MnDOT 1220		
Specific Gravity MnDOT 1204		
Bulk Oven Dry	2.658	
Bulk Saturated Surface Dry	2.693	
Absorption	1.34	
Carbonate Content MnDOT 1209		
Fineness Modulus		
Unit Weight MnDOT 1211		
Voids MnDOT 1211		

Sieve Analysis
(MnDOT 1202-1203)

	% Passing	Spec's
3" (75mm)	100	
2" (50mm)	99	
1.5" (37.5mm)	96	
1.25"(31.5mm)		
1" (25mm)	94	
3/4" (19mm)	91	
5/8" (16mm)		
1/2" (12.5mm)	85	
3/8" (9.5mm)	82	
#4 (4.75mm)	72	
#8 (2.36mm)	60	
#16 (1.18mm)	50	
#30 (.60mm)	38	
#50 (.30mm)	17	

Remarks : Specific Gravity is +4 only on this report.

CC:

Sincerely,
Braun Intertec Corporation
Timothy J. Mueller
Timothy J. Mueller
Bituminous & Aggregate Supervisor

BRAUN[SM]
INTERTEC

Braun Intertec Corporation
6801 Washington Avenue South
Minneapolis, Minnesota 55439
612-941-5600 Fax: 941-4151

Engineers and Scientists Serving the Built and Natural Environments

Aggregate Testing

Date : 7/11/00

Project Number : BADX-00-1200

Client : Dennis Martin
Department of Natural Resources,
Div. of Lands & Minerals
Box 45, 500 Lafayette Road
St. Paul MN 55155

Project : Aggregate Quality Testing
Braun Intertec Laboratory
Minneapolis MN

Background Information

Lab ID :	3368	Classification :	
Sample Number :	3341200128	Test Method :	MnDOT
Date Tested :	6/29/00	Sampled by :	Client
Sample Desc:		Source :	Not Given

Test Results

Sieve Analysis MnDOT 1202-1203

1.5" (37.5mm)	96
1" (25mm)	94
3/4" (19mm)	91
1/2" (12.5mm)	85
3/8" (9.5mm)	82
#4 (4.75mm)	72
#8 (2.36mm)	60
#16 (1.18mm)	50
#30 (.60mm)	38
#50 (.30mm)	17
#100(.15mm)	7
#200(.075mm)	4.7

Soundness Loss MnDOT 1219

Insoluble Residue MnDOT 1221

+ #200	
- #200	
Total Insoluble	

Specific Gravity MnDOT 1204/1205	Sample Average	Coarse	Fine
Bulk Oven Dry	2.617	2.658	2.602
Bulk Saturated Surface Dry	2.653	2.693	2.638
Apparent Oven Dry	2.714	2.755	2.699
% Absorption	1.369	1.34	1.38

CC:

Sincerely,
Braun Intertec Corporation

Timothy J. Mueller
Bituminous & Aggregate Supervisor

BRAUNSM
INTERTEC

Braun Intertec Corporation
6801 Washington Avenue South
Minneapolis, Minnesota 55439
612-941-5600 Fax: 941-4151

Engineers and Scientists Serving the Built and Natural Environments

Coarse Concrete Aggregate

Date : 7/11/00 **Project Number :** BADX-00-1200

Client : Dennis Martin
Department of Natural Resources,
Div. of Lands & Minerals
Box 45, 500 Lafayette Road
St. Paul MN 55155

Project : Aggregate Quality Testing
Braun Intertec Laboratory
Minneapolis MN

Background Information

Lab ID : 3367
Sample Number : 3341200127
Date Sampled : 5/15/00
Date Submitted : 6/21/00
Date Tested : 6/29/00
Sample Location : TRACT 2

Specification : Project
Classification :
Test Method : MnDOT
Class Designation :
Sampled by : Client
Source : Not Given

Properties	Test Results	Spec's
Shale MnDOT 1209		
+1/2"	0.0	
+#4 Total	0.0	
Soft Iron Oxide MnDOT 1209	0.0	
Total Spall Excluding Soft Part's & Clay Balls		
+1/2" MnDOT 1209	0.2	
+#4 Total	0.1	
Soft Particles MnDOT 1209	0.0	
Clay Balls and Lumps MnDOT	0.0	
Sum of Spall, Soft particles ,Clay balls	0.3	
Slate MnDOT 1209	0.0	
Flat and Elongated MnDOT ASTM D4791	0.1	
Passing # 200 MnDOT 1202-1203	5.3	
Los Angeles Abrasion MnDOT 1210		
Magnesium Soundness Loss MnDOT 1219		
16-Cycle Freeze/Thaw MnDOT 1220		
Specific Gravity MnDOT 1204		
Bulk Oven Dry	2.653	
Bulk Saturated Surface Dry	2.684	
Absorption	1.16	
Carbonate Content MnDOT 1209		
Fineness Modulus		
Unit Weight MnDOT 1211		
Voids MnDOT 1211		

Sieve Analysis
(MnDOT 1202-1203)

		% Passing	Spec's
3"	(75mm)	100	
2"	(50mm)	98	
1.5"	(37.5mm)	98	
1.25"	(31.5mm)		
1"	(25mm)	95	
3/4"	(19mm)	92	
5/8"	(16mm)		
1/2"	(12.5mm)	88	
3/8"	(9.5mm)	83	
#4	(4.75mm)	73	
#8	(2.36mm)	63	
#16	(1.18mm)	52	
#30	(.60mm)	39	
#50	(.30mm)	18	

Remarks : Specific Gravity is +4 only on this report.

CC:

Sincerely,
Braun Intertec Corporation
Timothy J. Mueller
Timothy J. Mueller
Bituminous & Aggregate Supervisor

BRAUN[SM]
INTERTEC

Braun Intertec Corporation
6801 Washington Avenue South
Minneapolis, Minnesota 55439
612-941-5600 Fax: 941-4151

Engineers and Scientists Serving the Built and Natural Environments

Aggregate Testing

Date : 7/11/00

Project Number : BADX-00-1200

Client : Dennis Martin
Department of Natural Resources,
Div. of Lands & Minerals
Box 45, 500 Lafayette Road
St. Paul MN 55155

Project : Aggregate Quality Testing
Braun Intertec Laboratory
Minneapolis MN

Background Information

Lab ID :	3367	Classification :	
Sample Number :	3341200127	Test Method :	MnDOT
Date Tested :	6/29/00	Sampled by :	Client
Sample Desc:		Source :	Not Given

Test Results

Sieve Analysis MnDOT 1202-1203

1.5" (37.5mm)	98
1" (25mm)	95
3/4" (19mm)	92
1/2" (12.5mm)	88
3/8" (9.5mm)	83
#4 (4.75mm)	73
#8 (2.36mm)	63
#16 (1.18mm)	52
#30 (.60mm)	39
#50 (.30mm)	18
#100(.15mm)	8
#200(.075mm)	5.3

Soundness Loss MnDOT 1219

Insoluble Residue MnDOT 1221

+ #200

- #200

Total Insoluble

Specific Gravity MnDOT 1204/1205		Coarse	Fine
Bulk Oven Dry	2.599	2.653	2.579
Bulk Saturated Surface Dry	2.638	2.684	2.621
Apparent Oven Dry	2.705	2.737	2.693
% Absorption	1.510	1.16	1.64

CC:

Sincerely,
Braun Intertec Corporation

Timothy J. Mueller
Bituminous & Aggregate Supervisor

Appendix F. Petrographic Analysis of Aggregate Report

AMERICAN
PETROGRAPHIC
SERVICES, INC.

PETROGRAPHIC ANALYSIS OF AGGREGATE

PROJECT:

MN-DNR MINERALS #33412
TANSEM SNA
PO# R291000062100

REPORTED TO:

DEPARTMENT of NATURAL RESOURCES
DIVISION of LANDS & MINERALS
BOX 45, 500 LAFAYETTE ROAD
ST. PAUL, MN 55155

ATTN: DENNIS MARTIN

APS JOB NO: 10-01110

DATE: JULY 24, 2000

INTRODUCTION

This report presents the results of laboratory work performed by our firm on one sample of gravel submitted to us by Mr. Dennis Martin of the Department of Natural Resources Division of Lands & Minerals on June 22, 2000. The scope of our work was limited to performing petrographic analysis testing on the aggregate sample to provide a geological description of the material as well as identify any potentially deleterious properties when it is used as concrete aggregate.

SAMPLE IDENTIFICATION

Sample Identification:	3341200129, West Litho, Tansem SNA TRACT 1
Sample Type:	Natural Gravel
Original Sample size, lbs:	9.9

TEST RESULTS

Our complete petrographic analysis test results appear on the attached data sheets. A summary of our analysis and opinions are as follows:

1. The aggregate particles were mostly equidimensional and well rounded. The material was relatively free of secondary coatings, although some loose $CaCO_3$ scale was observed in the finer fractions.

2. The great majority of the particles consisted of the lithologies: carbonate, granite, gneiss, quartzite, and greywacke. When present in Minnesota glacial gravel, these particles are generally considered hard, sound, and durable.

3. Particles considered deleterious or potentially deleterious include: friable weathered granites (1.46%), soft carbonates (1.18%), friable sandstone (0.01%), shale (1.45%), iron ore/oxides (0.15%), "mud balls" (0.41%).

4. The shales within the aggregate are known to produce alkali-silica reaction (ASR) when in concrete. The ASR generally manifests itself as an aesthetic problem, producing small "popouts" visible on smooth finished flatwork or precast panels.

DISCUSSION

The deposit from which the material was mined was most likely a glacial and/or fluvial (river) deposit consisting of predominantly Des Moines Lobe outwash. The gravel contains lithologies ranging from the shales of west central Manitoba to the granites of north western Minnesota. Des Moines Lobe gravel deposits are generally considered to be of fair to good quality for concrete aggregate. Deleterious, reactive shales are present in varying quantities. Also, some carbonates and soft cherts, which are not durable in freeze-thaw, are usually present.

TEST PROCEDURES

Laboratory testing was performed on June 30, 2000 and subsequent dates. The petrographic analysis was performed on representative hand samples and in thin section. A total of six thin sections were produced. Observations were made using an Olympus polarizing-light microscope with magnification up to 1000x and an Olympus stereozoom microscope with magnification up to 130x. Testing was performed in accordance with APS Standard Operating Procedure 00 LAB 004, "Petrographic Examination of Aggregates for Concrete, ASTM:C295".

The test procedure included conducting a gradation on the submitted sample. The percent retained was determined for each of the sieve sizes #200, # 100, #50, #30, #16, #8, #4, 3/8, ½, 3/4, 1", and 1½". At least 150 particles were split from the material retained on each sieve, when available, and each particle identified lithologically. The weight percent of each lithology by sieve size in the entire sample was calculated by multiplying the lithologic percentage for a particular size fraction by the percent retained on that sieve.

Photographs are included to illustrate our work and conclusions.

REMARKS

The test sample will be retained for a period of at least thirty days from the date of this report. Unless further instructions are received by that time, the sample may be discarded. Potential reactivity testing can be performed in our laboratories. The geologic services for this project have been conducted in a manner consistent with that level of care and skill exercised by members of the profession currently practicing in this area under similar budget and time constraints. No warranty, expressed or implied, is made.

If we can be of further assistance to you, please contact Gerard Moulzolf at (651) 659-1346 or Scott Wolter at (651) 659-1345.

Report Prepared By:

Gerard Moulzolf, PG
Vice President/Geologist/Petrographer
MN License #30023

Report Reviewed by:

Scott F. Wolter, PG
President
MN License #30024

Percent of Rock Type Retained in Each Sieve Size

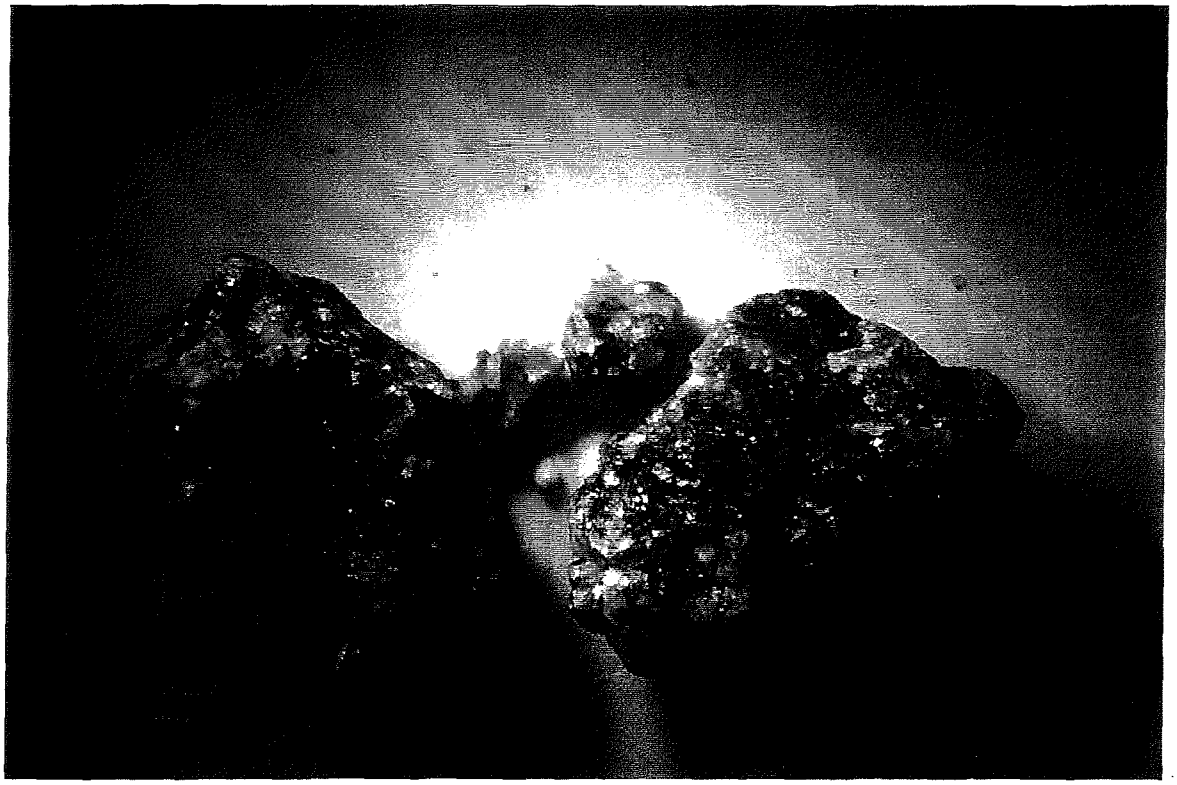
Lithology	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
Igneous												
Granitic	0.0	6.7	29.1	17.9	15.4	19.1	27.0	51.8	36.9	11.6	5.5	3.0
Granitic, weathered, friable	0.0	6.7	0.0	1.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Basalt	0.0	0.0	8.3	8.3	1.9	3.8	3.1	1.3	0.6	0.0	0.0	0.0
Gabbro	0.0	0.0	0.0	1.5	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Felsite	0.0	6.7	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metamorphic												
Quartzite	0.0	26.5	4.2	9.0	4.9	6.4	9.8	8.6	21.3	11.6	7.3	10.3
Gneiss	0.0	6.7	8.3	13.5	16.0	14.0	11.0	2.0	0.0	0.0	0.0	0.0
Schist	0.0	0.0	0.0	2.3	1.9	0.6	0.6	1.3	3.1	0.0	0.0	0.0
Sedimentary												
Carbonate	0.0	40.0	33.4	36.0	53.1	42.7	33.1	8.6	10.6	9.1	6.7	9.1
Carbonate, soft	0.0	6.7	0.0	0.0	0.6	0.0	0.0	2.0	1.3	0.0	0.0	0.0
Carbonate, iron oxide weathering rind	0.0	0.0	4.2	0.8	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Carbonate, sandy	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.6	0.0	0.0
Calcium carbonate scale	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	3.1	1.8	0.0	0.0
Greywacke	100.0	0.0	12.5	2.3	2.5	6.4	3.1	0.0	0.0	1.2	1.2	0.0
Sandstone	0.0	0.0	0.0	3.0	0.6	1.9	1.2	2.0	2.5	2.4	0.0	0.0
Sandstone, friable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.3	0.0	0.0	0.0
Shale	0.0	0.0	0.0	0.0	0.6	3.2	4.3	13.2	13.1	6.7	5.5	6.7
Iron Ore/Oxide	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.3	0.0	0.0	0.0	0.0
Chert, hard	0.0	0.0	0.0	0.8	1.9	0.0	0.0	0.0	0.0	0.6	0.6	0.6
Chalcedony	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mud ball	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0
Mineral												
Quartz	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	38.5	59.8	51.6
Feldspar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.6	11.6	7.9	14.5
Mica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.7	3.1	3.0
Amphibole	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.6
Magnetite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0
Heavy Mineral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Calculated Percentage in Entire Sample

Lithology	1 ½"	1	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200	-#200	TOTAL
Igneous														
Granitic	0.0000	1.0988	2.6772	3.4905	1.8172	6.0738	0.9990	0.2072	0.1476	0.0580	0.0220	0.0180		16.6093
Granitic, weathered, friable	0.0000	1.0988	0.0000	0.2925	0.0708	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		1.4621
Basalt	0.0000	0.0000	0.7636	1.6185	0.2242	1.2084	0.1147	0.0052	0.0024	0.0000	0.0000	0.0000		3.9370
Gabbro	0.0000	0.0000	0.0000	0.2925	0.0000	0.1908	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.4833
Felsite	0.0000	1.0988	0.0000	0.4485	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		1.5473
Metamorphic														
Quartzite	0.0000	4.3460	0.3864	1.7550	0.5782	2.0352	0.3626	0.0344	0.0852	0.0580	0.0292	0.0618		9.7320
Gneiss	0.0000	1.0988	0.7636	2.6325	1.8880	4.4520	0.4070	0.0080	0.0000	0.0000	0.0000	0.0000		11.2499
Schist	0.0000	0.0000	0.0000	0.4485	0.2242	0.1908	0.0222	0.0052	0.0124	0.0000	0.0000	0.0000		0.9033
Sedimentary														
Carbonate	0.0000	6.5600	3.0728	7.0200	6.2658	13.5786	1.2247	0.0344	0.0424	0.0455	0.0268	0.0546		37.9256
Carbonate, soft	0.0000	1.0988	0.0000	0.0000	0.0708	0.0000	0.0000	0.0080	0.0052	0.0000	0.0000	0.0000		1.1828
Carbonate, iron oxide weathering rind	0.0000	0.0000	0.3864	0.1560	0.0000	0.0000	0.0222	0.0000	0.0000	0.0000	0.0000	0.0000		0.5646
Carbonate, sandy	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0925	0.0000	0.0000	0.0030	0.0000	0.0000		0.0955
Calcium carbonate scale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0156	0.0124	0.0090	0.0000	0.0000		0.0370
Greywacke	5.1000	0.0000	1.1500	0.4485	0.2950	2.0352	0.1147	0.0000	0.0000	0.0060	0.0048	0.0000		9.1542
Sandstone	0.0000	0.0000	0.0000	0.5850	0.0708	0.6042	0.0444	0.0080	0.0100	0.0120	0.0000	0.0000		1.3344
Sandstone, friable	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0052	0.0052	0.0000	0.0000	0.0000		0.0104
Shale	0.0000	0.0000	0.0000	0.0000	0.0708	1.0176	0.1591	0.0528	0.0524	0.0335	0.0220	0.0402		1.4484
Iron Ore/Oxide	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1369	0.0132	0.0000	0.0000	0.0000	0.0000		0.1501
Chert, hard	0.0000	0.0000	0.0000	0.1560	0.2242	0.0000	0.0000	0.0000	0.0000	0.0030	0.0024	0.0036		0.3892
Chalcedony	0.0000	0.0000	0.0000	0.1560	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.1560
Mud ball	0.0000	0.0000	0.0000	0.0000	0.0000	0.4134	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.4134
Mineral														
Quartz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0152	0.1925	0.2392	0.3096		0.7565
Feldspar	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0028	0.0024	0.0580	0.0316	0.0870		0.1818
Mica	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0072	0.0185	0.0124	0.0180		0.0561
Amphibole	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0048	0.0036		0.0084
Magnetite	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0048	0.0000		0.0048
Heavy Mineral	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0030	0.0000	0.0036		0.0066
Total	5.1	16.4	9.2	19.5	11.8	31.8	3.7	0.4	0.4	0.5	0.4	0.6		99.8000
% Retained	5.1	16.4	9.2	19.5	11.8	31.8	3.7	0.4	0.4	0.5	0.4	0.6	0.2*	99.8

*0.2% of the sample passed through a #200 sieve

APS# 10-01110 DATE: JULY 24, 2000
PROJECT: MN-DNR MINERALS #33412
TANSEM SNA



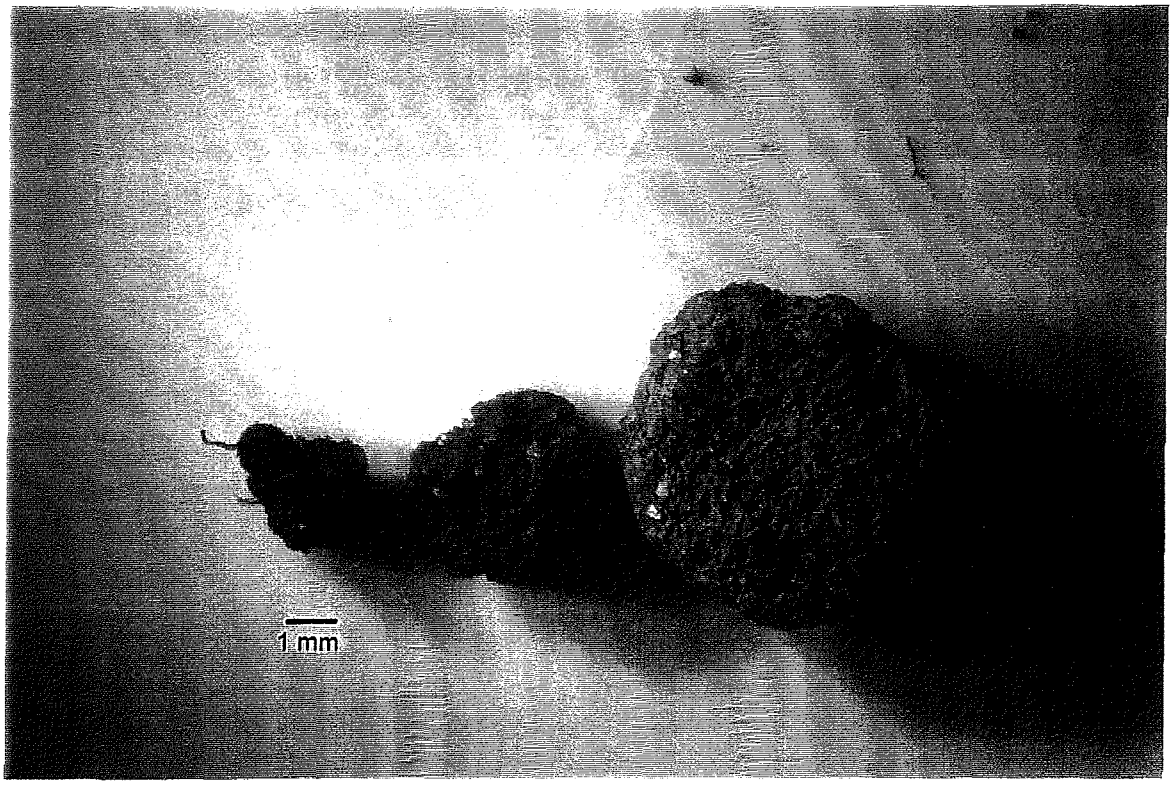
SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Weathered, friable granitic particles; from material retained on the 1/2" sieve.

MAGNIFICATION: 3.75x

SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Hard and durable cherts; from material retained on the 3/8" sieve.

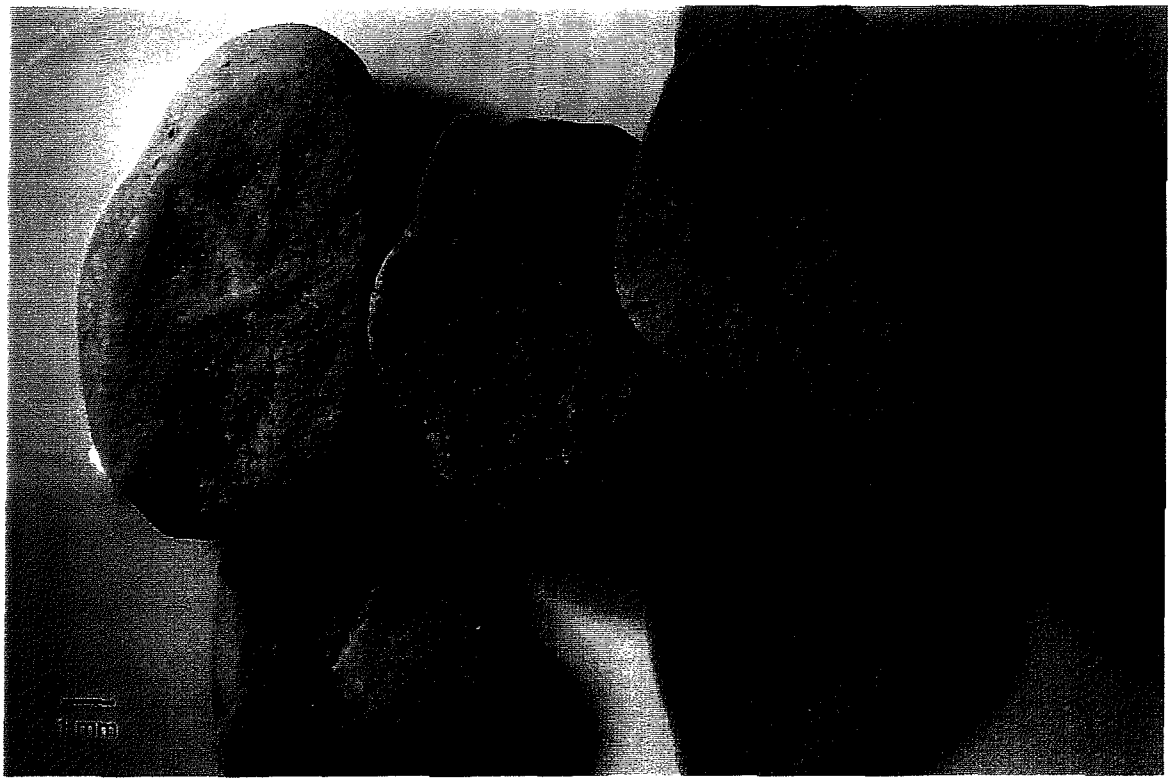
MAGNIFICATION: 3.75x

APS# 10-01110 DATE: JULY 24, 2000
PROJECT: MN-DNR MINERALS #33412
TANSEM SNA



SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Soft and friable "mudballs"; from material retained on the #4 sieve.

MAGNIFICATION: 7.5x



SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Soft, deleterious shales; from material retained on the #4 sieve.

MAGNIFICATION: 7.5x

APS# 10-01110 DATE: JULY 24, 2000
PROJECT: MN-DNR MINERALS #33412
TANSEM SNA

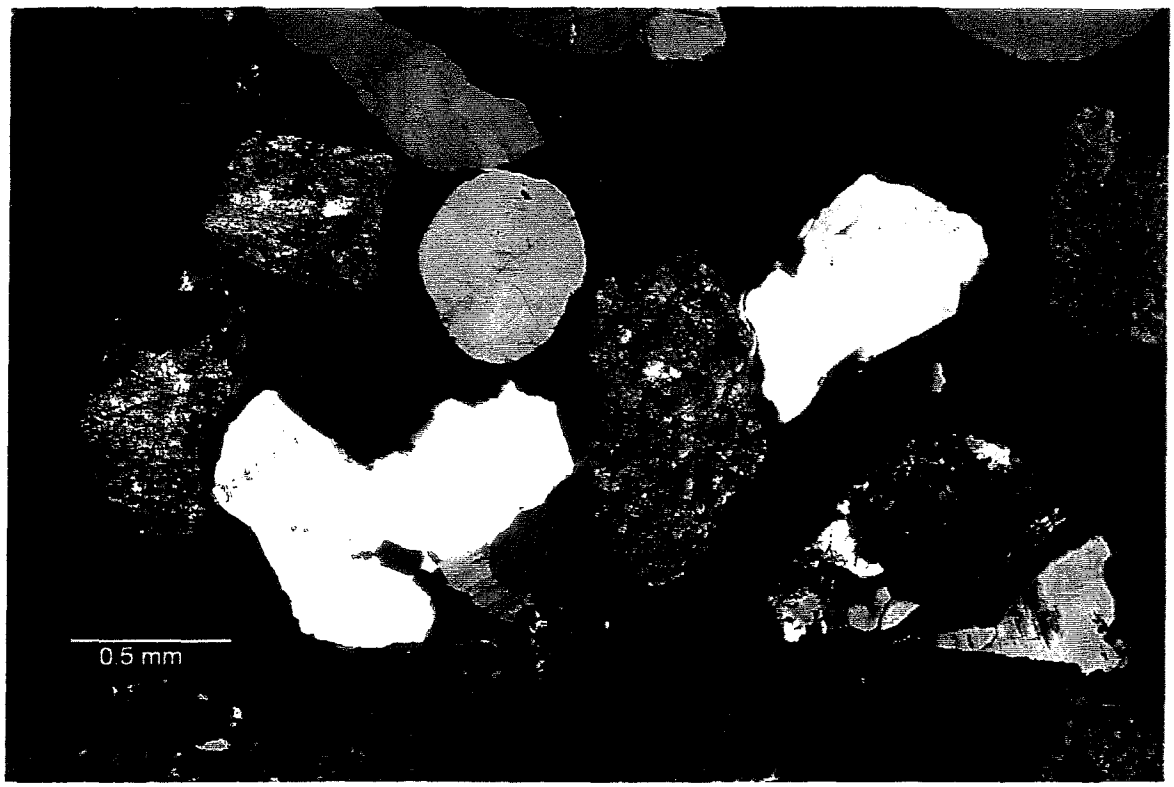
SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Deleterious iron ores/oxides; from material retained on the #8 sieve.

MAGNIFICATION: 7.5x

SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Soft, deleterious shales; from material retained on the #8 sieve.

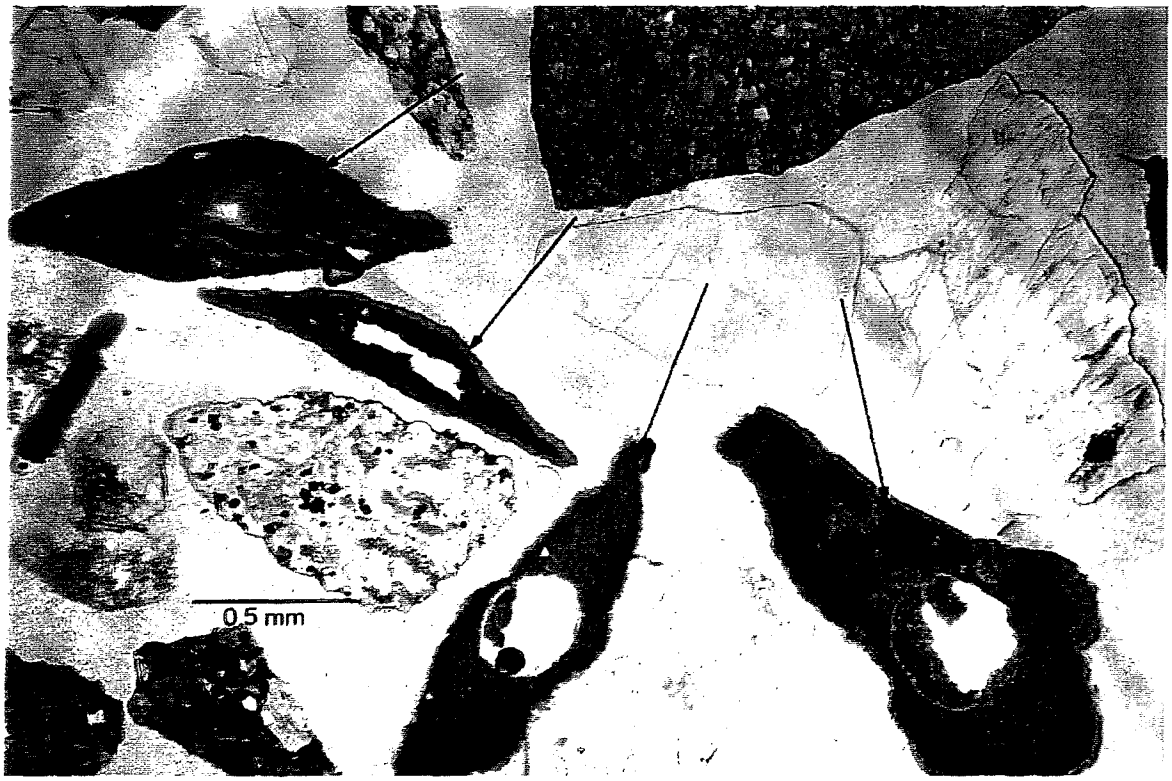
MAGNIFICATION: 7.5x

APS# 10-01110 DATE: JULY 24, 2000
PROJECT: MN-DNR MINERALS #33412
TANSEM SNA



SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Overall view of quartz, twinned feldspars, and brightly colored carbonates in material retained on the #30 sieve; in thin section under cross polarized light.

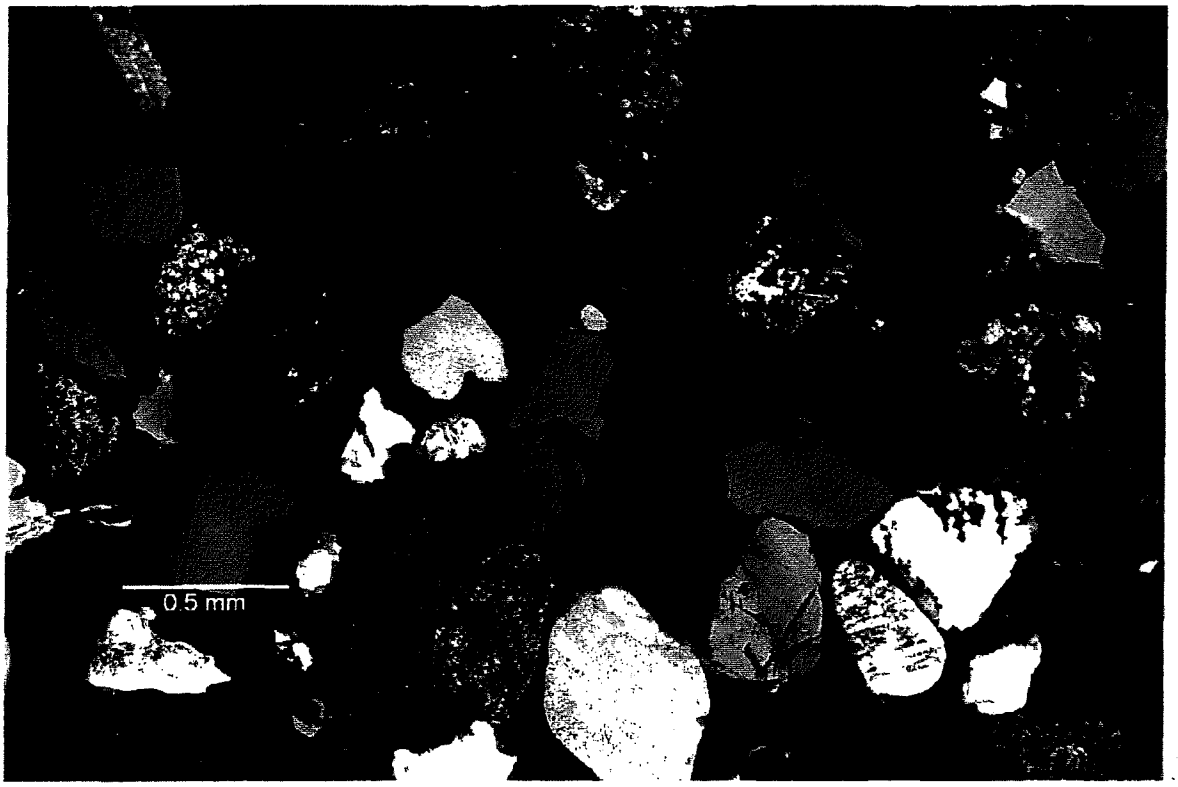
MAGNIFICATION: 40x



SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Deleterious shales from material retained on the #30 sieve; in thin section under plane polarized light.

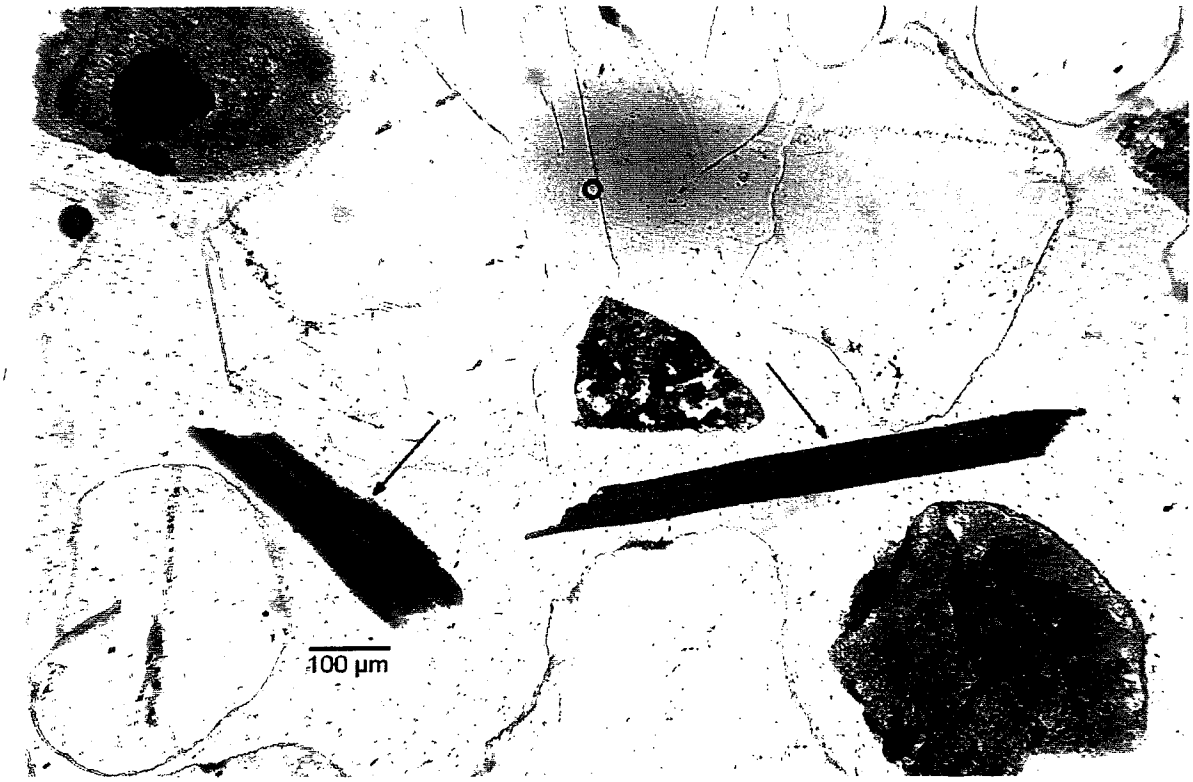
MAGNIFICATION: 40x

APS# 10-01110 DATE: JULY 24, 2000
PROJECT: MN-DNR MINERALS #33412
TANSEM SNA



SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Overall view of quartz, twinned feldspars, and brightly colored carbonates in material retained on the #50 sieve; in thin section under cross polarized light.

MAGNIFICATION: 40x

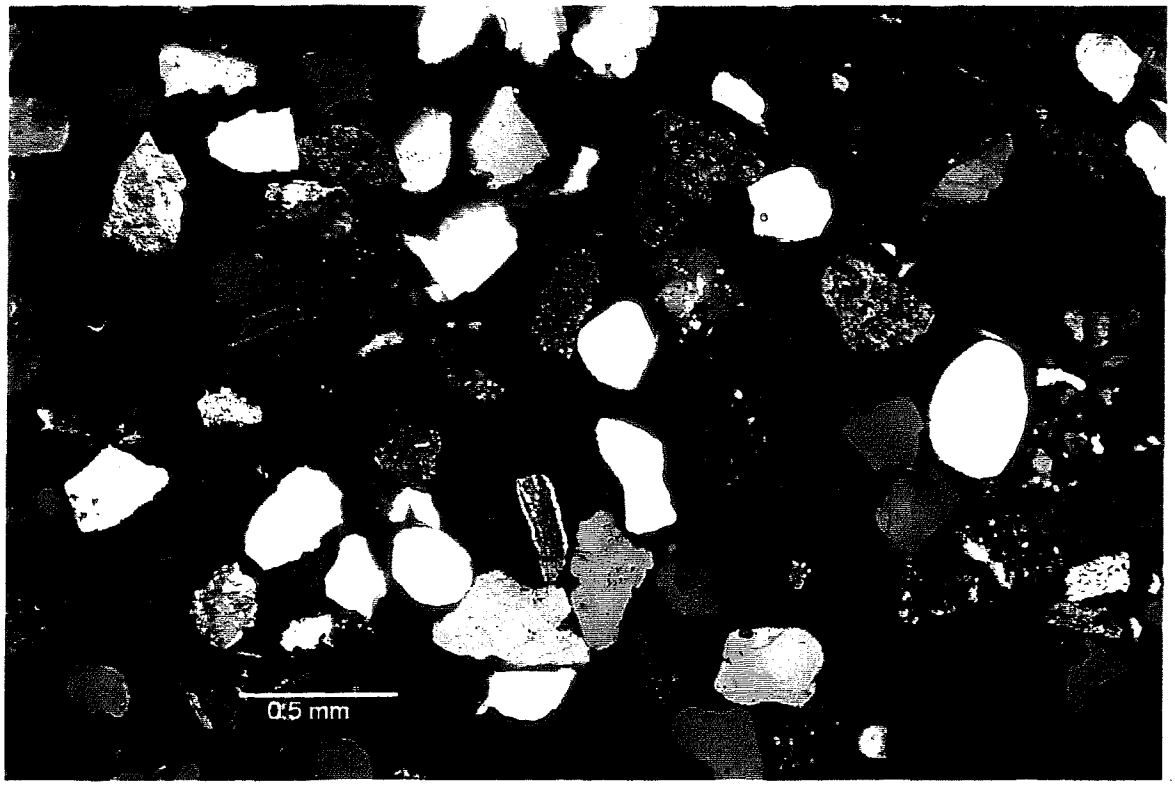


SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Platy mica particles from material retained on the #50 sieve; in thin section under plane polarized light.

MAGNIFICATION: 100x

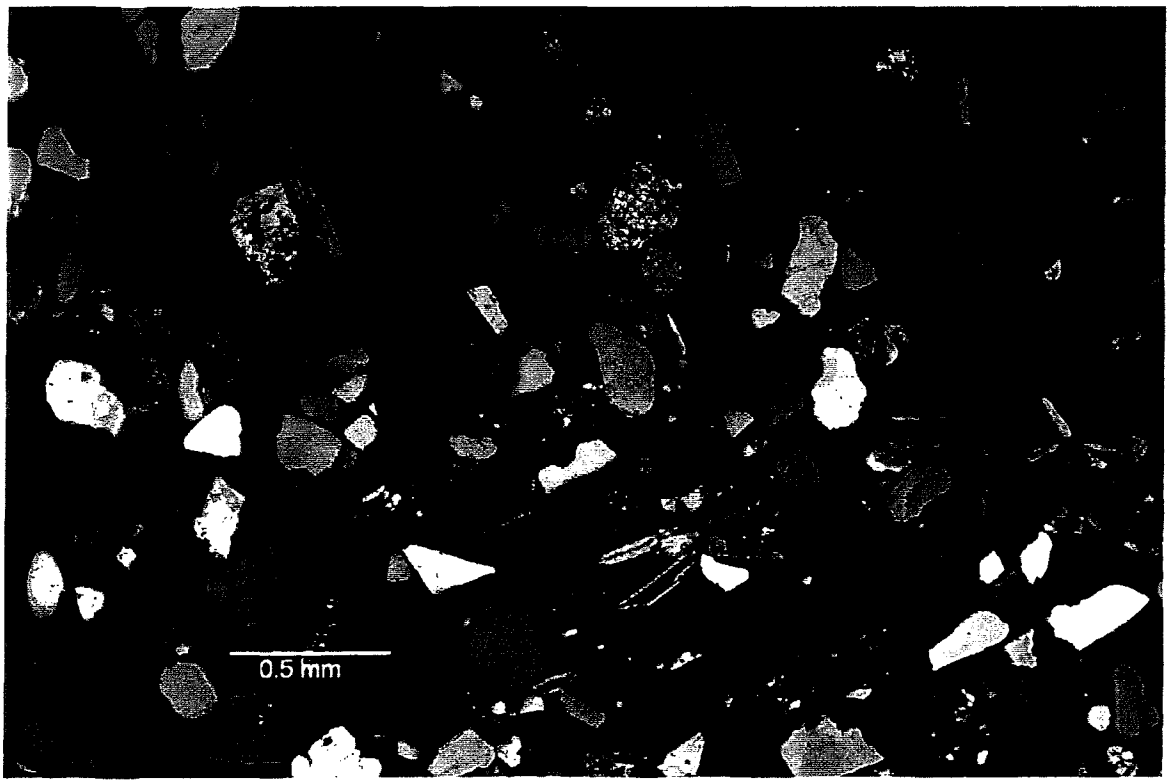
APS# 10-01110 DATE: JULY 24, 2000

PROJECT: MN-DNR MINERALS #33412
TANSEM SNA



SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Overall view of quartz, twinned feldspars, and brightly colored carbonates in material retained on the #100 sieve; in thin section under cross polarized light.

MAGNIFICATION: 40x



SAMPLE IDENTIFICATION: 3341200129 SAMPLE DESCRIPTION: Overall view of quartz, twinned feldspars, platy micas, and brightly colored carbonates in material retained on the #200 sieve; in thin section under cross polarized light.

MAGNIFICATION: 40x