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September 18, 2017

City of Vermillion
25 Center Street
Vermillion, South Dakota 57069

Attn: José Dominguez, PE

Subj: Geotechnical Exploration
Proposed Street Improvements
Jefferson Street & Clark Street
Vermillion, South Dakota
GeoTek #17-873

This correspondence presents our written report of the geotechnical exploration program for the referenced project. Our work was performed in accordance with the authorization of John Prescott with the City of Vermillion. We are transmitting an electronic copy of our report for your use. An additional copy is also being sent as noted below.

We thank you for the opportunity of providing our services on this project and look forward to continued participation during the design and construction phases. If you have any questions regarding this report, please contact our office at (605) 335-5512.

Respectfully Submitted,
GeoTek Engineering & Testing Services, Inc.

Brennen Ahlers

Brennen Ahlers, PE
Project Manager

Cc: Banner Associates, Inc. Attn: Rich Uckert, PE

TABLE OF CONTENTS

INTRODUCTION **4**
PROJECT INFORMATION 4
SCOPE OF SERVICES 4
SITE & SUBSURFACE CONDITIONS **5**
PROJECT AREAS & DESCRIPTION 5
GROUND SURFACE ELEVATIONS & TEST BORING LOCATIONS 5
EXISTING PAVEMENT CONDITIONS 5
SUBSURFACE CONDITIONS 5
WATER LEVELS 6
ENGINEERING REVIEW & RECOMMENDATIONS **6**
PROJECT DESIGN DATA 6
UTILITY EXCAVATIONS 7
Subgrade Soils *7*
Water Control *7*
OSHA Requirements *8*
Trench Backfill *8*
SUBGRADE SOILS & PAVEMENT SECTION 9
Subgrade Soils *9*
Stripping & Removals *9*
Filling *9*
Subgrade Reinforcement *10*
Cement Stabilization *10*
Asphalt & Concrete Pavement Section Thicknesses *11*
CONSTRUCTION CONSIDERATIONS **12**
GROUNDWATER & SURFACE WATER 12
DISTURBANCE OF SOILS 12
COLD WEATHER PRECAUTIONS 13
EXCAVATION SIDESLOPES 13
OBSERVATIONS & TESTING 13
Excavation *14*
Testing *14*
SUBSURFACE EXPLORATION PROCEDURES **14**
TEST BORINGS 14
SOIL CLASSIFICATION 15
WATER LEVEL MEASUREMENTS 15
LABORATORY TESTS 15
LIMITATIONS **16**
STANDARD OF CARE **16**

APPENDIX A

FIGURE 1 – TEST BORING LOCATION MAP (TEST BORINGS 1 & 2)
FIGURE 2 – TEST BORING LOCATION MAP (TEST BORINGS 3 & 4)
FIGURE 3 – TEST BORING LOCATION MAP (TEST BORINGS 5-7)
BORING LOGS
SOIL CLASSIFICATION SHEET
SYMBOLS & DESCRIPTIVE TERMINOLOGY
PROCTOR DATA SHEETS

GEOTECHNICAL EXPLORATION
PROPOSED STREET IMPROVEMENTS
JEFFERSON STREET & CLARK STREET
VERMILLION, SOUTH DAKOTA
GEOTEK #17-873

INTRODUCTION

Project Information

This report presents the results of the recent geotechnical exploration program for the proposed street improvements for Jefferson Street and Clark Street in Vermillion, South Dakota.

Scope of Services

Our work was performed in accordance with the authorization of John Prescott with the City of Vermillion. The scope of work as presented in this report is limited to the following:

1. To perform seven (7) standard penetration test (SPT) borings to gather data on the subsurface conditions at the project areas.

2. To perform laboratory tests that include moisture content, dry density and standard Proctor.

3. To prepare an engineering report that includes the results of the field and laboratory tests as well as our geotechnical engineering opinions and recommendations regarding the following:

    - Existing pavement section;
    - Subgrade strength and potential corrective measures;
    - Pavement section thicknesses;
    - Special geotechnical conditions that may impact the constructability and final performance of the project;
    - Quality control observation and testing.

The scope of our work was intended for geotechnical purposes only. This scope of work did not include determining the presence or extent of environmental contamination at the project areas or to characterize the project areas relative to wetlands status.

SITE & SUBSURFACE CONDITIONS

Project Areas & Description

The project areas are located on Jefferson Street between Duke Street and Clark Street and on Clark Street between Jefferson Street and Anderson Street in Vermillion, South Dakota. The existing streets are asphalt surfaced with curb and gutter. A concrete section exists at some of the intersections.

Ground Surface Elevations & Test Boring Locations

We did not determine the ground surface elevations at the test boring locations. The test borings were performed within the streets. Three (3) test boring location maps are attached showing the relative location of the test borings.

Existing Pavement Conditions

Table 1 summarizes the thickness of the existing asphalt pavement and gravel base encountered at the respective test boring locations.

Table 1. Thickness of the Existing Asphalt Pavement & Gravel Base

Test Boring	Street	Asphalt Thickness, in	Gravel Base Thickness, in
1	Jefferson Street	5	2
2	Jefferson Street	5	5 ½
3	Jefferson Street	6	6
4	Jefferson Street	6	6 ½
5	Jefferson Street	5	6 ½
6	Jefferson Street	5 ½	6
7	Clark Street	6	10

Subsurface Conditions

Seven (7) test borings were performed on July 26, 2017. The subsurface conditions encountered at the test boring locations are illustrated by means of the boring logs included in Appendix A.

The subsurface profile at the test boring locations consisted of the following layers: existing fill materials and fine alluvium soils.

The existing fill materials consisted of lean clay soils and lean clay with sand soils. The fine alluvium soils consisted of lean clay soils.

The consistency or relative density of the soils is indicated by the standard penetration resistance ("N") values as shown on the boring logs. A description of the soil consistency or relative density based on the "N" values can be found on the attached Soil Boring Symbols and Descriptive Terminology data sheet.

We wish to point out that the subsurface conditions at other times and locations at the sites may differ from those found at our test boring locations. If different conditions are encountered during construction, then it is important that you contact us so that our recommendations can be reviewed.

Water Levels

Measurements to record the groundwater levels were made at the test boring locations. The time and level of the groundwater readings are recorded on the boring logs. Groundwater did not enter the boreholes at the test boring locations at the time of our measurements.

The water levels indicated on the boring logs may or may not be an accurate indication of the depth or lack of subsurface groundwater. The limited length of observation restricts the accuracy of the measurements. Long term groundwater monitoring was not included in our scope of work.

ENGINEERING REVIEW & RECOMMENDATIONS

Project Design Data

We understand that the project will consist of street improvements on Jefferson Street between Duke Street and Clark Street and on Clark Street between Jefferson Street and Anderson Street in Vermillion, South Dakota. The street improvements will consist of a new pavement section. These streets are considered part of a truck route. No major utility improvements are expected

for the project; however, minor storm sewer improvements are will occur. Grade changes are expected to be minimal.

The information/assumptions detailed in the project design data section of the report are important factors in our review and recommendations. If there are any corrections or additions to the information detailed in this section, then it is important that you contact us so that we can review our recommendations with regards to the revised plans.

Utility Excavations

Subgrade Soils

We understand that the utilities that will be installed for the project will be shallow. With that said, the subgrade soils anticipated at the invert depths for the underground utilities will consist of fine alluvium soils. Where clay soils having moderate moisture and density values are encountered at the bottom of the trench excavations, it is our opinion that the soils are considered suitable for support of the proposed utilities, provided they are adequately dewatered, and are not disturbed by construction traffic. Localized areas of wet or soft soils may be encountered at the bottom of the trench excavations. These areas will require subexcavation and trench stabilization methods and materials. Appropriate bedding materials should be used for the utility pipes.

Water Control

Water may enter the utility trench excavations as a result of subsurface water, precipitation or surface run off. Dewatering procedures may be required in order to control and remove water during the excavation for the various utilities. Where clay soils are encountered, it may be possible to remove and control water entering the excavations using normal sump pumping techniques. However, if waterbearing soils are encountered, then extensive dewatering techniques will likely be required due to the potentially large volumes of water. It should be noted that waterbearing sand soils were not encountered at the time the test borings were performed. The contractor should provide appropriate dewatering methods and equipment. Water may also enter the excavations as a result of precipitation or surface run off. Any water that accumulates at the bottom of the excavations should be immediately removed and surface drainage away from the excavations should be provided during construction.

OSHA Requirements

All excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, "Excavations and Trenches". This document states that the excavation safety is the responsibility of the contractor. Reference to this OSHA requirement should be included in the project specifications. It should be noted that the ability of the trench sidewalls to maintain a limited backslope face will be greatly reduced if waterbearing sand is encountered.

Trench Backfill

We recommend that the trench backfill soils be placed and compacted in uniform thin lifts (6-inch maximum lifts). The trench backfill should be compacted to a minimum of 95 percent of standard Proctor density (ASTM:D698). The moisture content of the trench backfill soils should be adjusted to a moisture level that is within plus or minus 2 percent of the optimum moisture content as determined by standard Proctor (ASTM:D698). We anticipate that some moisture adjustment (drying) will be needed with the fine alluvium soils in order to adjust the moisture content of the soils to a level that is within the recommended range.

A portion of the on-site soils encountered in the utility trench excavations may not be suitable for use as trench backfill. These unsuitable soils would consist of organic soils as well as soils having high moisture content levels such that the specified compaction level cannot be reasonably achieved. Organic materials should be replaced with suitable material available at the project site or with suitable off-site borrow soils. The wet soils will require significant drying in order to adjust the moisture content of the soils to a level that will facilitate the specified compaction requirement. Alternatively, the wet soils could be replaced with suitable material available at the project site or with suitable off-site borrow soils. If off-site borrow materials are used, then we recommend that the off-site borrow materials consist of a non-organic clay having a liquid limit less than 45. Scrutiny on the clay material's moisture content should be made prior to the acceptance and use. If the subgrade material and the material used to backfill trenches are not similar, then differential frost movement could occur within the pavement.

Subgrade Soils & Pavement Section

Subgrade Soils

The upper portions of the subgrade soils encountered at the test boring locations consisted of existing fill materials and fine alluvium soils. These subgrade soils have a Unified Soils Classification System symbol of CL and AASHTO classifications of A-6 and A-7.

In our opinion, poor subgrade conditions were encountered at the majority of the test boring locations. We estimate California Bearing Ratio (CBR) values of 1.0 to 1.5 for the majority of the subgrade soils. CBR values of 1.0 to 1.5 are considered very low to low CBR values. In order to provide a stable and uniform subgrade condition throughout the areas of the project, it is our opinion that subgrade reinforcement or cement stabilization will be needed. The subgrade reinforcement should consist of coarse granular subbase overlying a geotextile fabric.

Stripping & Removals

We recommend removing the existing pavement section in order to achieve the design elevations. Low-ground-pressure construction equipment or excavators with smooth-edged buckets should be used for the stripping and removals in areas where soft/wet soils are present. Based on the in-situ moisture content levels, we expect that low-ground-pressure equipment will be needed.

Filling

Limited grade changes are expected; however, if filling is required to achieve the design subgrade elevations, then the fill materials should consist of non-organic lean clay or sandy lean clay soils having a liquid limit less than 45 and a plasticity index between 15 and 35. The moisture content of the fill soils should be 1 percent to 4 percent below the optimum moisture content. The fill soils should be placed in compacted lifts having a maximum thickness of 6 inches. We recommend a minimum compaction specification of 95 percent of standard Proctor (ASTM:D698) for the fill soils.

Subgrade Reinforcement

The subgrade reinforcement should consist of granular subbase overlying a geotextile fabric. The geotextile fabric should consist of Mirafi HP 370, Propex Geotex 3x3 HF, Huesker Comtrac P 45/45 or approved alternative. The granular subbase should consist of crushed quartzite, recycled concrete or a crushed pit-run material meeting the gradation specifications shown in Table 2. The granular subbase should be compacted to a minimum of 97 percent of standard Proctor density (ASTM:D698). It should be noted that compaction testing may not be practical for the granular subbase due to the large aggregate.

Table 2. Granular Subbase Gradation Specifications

Sieve Size	Percent Passing
4-inch	100
1-inch	40 – 80
#4	10 – 50
#40	5 – 20
#200	0 – 5

Cement Stabilization

The cement stabilization should consist of blending the subgrade soils with cement to a minimum depth of 12 inches. The percentage of cement used typically ranges from 4 percent to 6 percent and should be based on a site specific mix design. For bidding purposes, the percentage of cement used should be 5 percent (example: if the in-place dry density equals 100 pounds per cubic foot (pcf), then 5 pounds of cement should be applied to the subgrade, per square foot). We recommend that the percentage of cement used during the blending process be determined by the mix design that should be performed when the subgrade soils are exposed.

Once the percentage of cement is determined, the cement should be placed uniformly over the subgrade surface at the specified percentage with a truck-mounted cement spreader. In addition to the cement being placed uniformly, the truck-mounted spreader will help control the spread of cement dust. Then, a self-propelled pulvimixer/reclaimer should be used to reclaim the upper 12

inches of the subgrade along with the cement. Within 30 minutes, the reclaimed mixture of soil and cement should be initially compacted with a large (minimum of 72-inch diameter) vibratory sheepsfoot roller to a minimum of 95 percent of the maximum dry density as determined by Moisture-Density Relations of Soil-Cement Mixtures (ASTM:D558). The moisture content of the material should be adjusted to a moisture level that is within 3 percent below to 3 percent above the optimum moisture content determined by Moisture-Density Relations of Soil-Cement Mixtures (ASTM:D558). After initial compaction, the subgrade should be graded to design elevations, rolled with a pneumatic tire roller and watered with a commercial water truck. Construction traffic should not be allowed on the subgrade for 48 hours after the final watering. This delay allows for the cement to properly hydrate without being disturbed. If at any time during or after the cement stabilization process it is determined that the subgrade is not performing as expected, then the problem should be assessed to determine the best course of action. This may include an additional application of cement.

Asphalt & Concrete Pavement Section Thicknesses

We were not provided a traffic volume for the streets. However, we understand that the project areas are part of a truck route. We assume that the daily truck traffic counts are low. The traffic will consist of trucks and automobiles. Tables 3 and 4 summarize the recommended asphalt and concrete pavement section thicknesses.

Table 3. Asphalt Pavement Section Thicknesses

Asphalt Pavement Thickness, in	Aggregate Base Course Thickness, in	Granular Subbase Thickness, in	Subgrade Reinforcement	Cement Stabilization
5	6	12	Geotextile Fabric	-
5	6	-	-	Yes

Table 4. Concrete Pavement Section Thicknesses

Concrete Pavement Thickness, in	Aggregate Base Course Thickness, in	Granular Subbase Thickness, in	Subgrade Reinforcement	Cement Stabilization
7	6	12	Geotextile Fabric	-
7	6	-	-	Yes

The asphalt pavement should meet the requirements of sections 320 and 321 for Class G. We recommend that the aggregate base course materials meet the requirements of Sections 260 and 882 of the SDDOT Standard Specifications. We recommend that the concrete pavement meet the requirements of Section 380 of the SDDOT Standard Specifications.

Reclaiming of the existing asphalt pavement and gravel base for use as aggregate base course material could be considered, but reclaiming may be difficult in some areas due to the existing thickness of aggregate base course. The reclaimed materials may need to be blended with additional aggregate base course material in order to meet the requirements of Sections 260 and 882 of the SDDOT Standard Specifications. Samples of the reclaimed material should be collected for analysis during construction in order to approve the material for use as aggregate base course material. The aggregate base course material should be compacted to a minimum of 97 percent of standard Proctor (ASTM:D698).

We recommend that routine maintenance such as crack filling, localized patching and seal coating be performed. The design sections could be reduced if the owner is willing to assume additional maintenance costs or potentially shorter pavement life.

CONSTRUCTION CONSIDERATIONS

Groundwater & Surface Water

Water may enter the excavations due to subsurface water, precipitation or surface run off. Any water that accumulates in the bottom of the excavations should be immediately removed and surface drainage away from the excavations should be provided during construction.

Disturbance of Soils

The soils encountered at the test boring locations are susceptible to disturbance and can experience strength loss caused by construction traffic and/or additional moisture. Precautions will be required during earthwork activities in order to reduce the risk of soil disturbance. Where soft/wet soils are encountered, the excavations should be performed with low-ground-pressure construction equipment or an excavator (backhoe) having a smooth cutting edge on the bucket.

Cold Weather Precautions

If site preparation and construction is anticipated during cold weather, we recommend all subgrades, slabs and other improvements that may be affected by frost movements be insulated from frost penetration during freezing temperatures. If filling is performed during freezing temperatures, all frozen soils, snow and ice should be removed from the areas to be filled prior to placing the new fill. The new fill should not be allowed to freeze during transit, placement and compaction. Concrete and asphalt should not be placed on frozen subgrades. If subgrades freeze, we recommend that the frozen soils be removed and replaced, or completely thawed. The subgrade soils will likely require reworking and recompacting due to the loss of density caused by the freeze/thaw process.

Excavation Sideslopes

All excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, "Excavations and Trenches". This document states that the excavation safety is the responsibility of the contractor. Reference to this OSHA requirement should be included in the project specifications.

Observations & Testing

This report was prepared using a limited amount of information for the project and a number of assumptions were necessary to help us develop our conclusions and recommendations. It is recommended that our firm be retained to review the geotechnical aspects of the final design plans and specifications to check that our recommendations have been properly incorporated into the design documents.

The recommendations submitted in this report have been made based on the subsurface conditions encountered at the test boring locations. It is possible that there are subsurface conditions at the site that are different from those represented by the test borings. As a result, on-site observation during construction is considered integral to the successful implementation of the recommendations. We believe that qualified field personnel need to be on-site at the following times to observe the site conditions and effectiveness of the construction.

Excavation

We recommend that a geotechnical engineer or geotechnical engineering technician working under the direct supervision of a geotechnical engineer observe all excavations for utilities, slabs and pavements. These observations are recommended to determine if the exposed soils are similar to those encountered at the test boring locations, if unsuitable soils have been adequately removed and if the exposed soils are suitable for support of the proposed construction.

Testing

After the subgrade is observed by a geotechnical engineer/technician and approved, we recommend a representative number of compaction tests be taken during the placement of the backfill placed below slabs and pavements. The tests should be performed to determine if the required compaction has been achieved. As a general guideline, we recommend at least one (1) test be taken for every 10,000 square feet of embankment fill placed, at least one (1) test for every 500 feet in trench fill, and for every 2-foot thickness of fill or backfill placed. The actual number of tests should be left to the discretion of the geotechnical engineer. Samples of proposed fill and backfill materials should be submitted to our laboratory for testing to determine their compliance with our recommendations and project specifications.

SUBSURFACE EXPLORATION PROCEDURES

Test Borings

We drilled seven (7) SPT borings on July 26, 2017 with a truck rig equipped with hollow-stem auger. Soil sampling was performed in accordance with the procedures described in ASTM:D1586. Using this procedure, a 2-inch O.D. split barrel sampler is driven into the soil by a 140-pound weight falling 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as the penetration resistance, or “N” value. The “N” value is an index of the relative density of cohesionless soils and the consistency of cohesive soils. In addition, thin walled tube samples were obtained according to ASTM:D1587, where indicated by the appropriate symbol on the boring logs.

The test borings were backfilled with on-site materials and some settlement of these materials can be expected to occur. Final closure of the holes is the responsibility of the client or property owner.

Soil Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief according to ASTM:D2488. Representative portions of all samples were then sealed and returned to the laboratory for further examination and for verification of the field classification. In addition, select samples were then submitted to a program of laboratory tests. Where laboratory classification tests (sieve analysis and Atterberg limits) have been performed, classifications according to ASTM:D2487 are possible. Logs of the test borings indicating the depth and identification of the various strata, the "N" value, the laboratory test data, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are also attached in Appendix A. Charts illustrating the soil classification procedures, the descriptive terminology and the symbols used on the boring logs are also attached in Appendix A.

Water Level Measurements

Subsurface groundwater levels should be expected to fluctuate seasonally and yearly from the groundwater readings recorded at the test borings. Fluctuations occur due to varying seasonal and yearly rainfall amounts and snowmelt, as well as other factors. It is possible that the subsurface groundwater levels during or after construction could be significantly different than the time the test borings were performed.

Laboratory Tests

We performed laboratory tests on select samples to aid in determining the index properties of the soils. The tests consisted of moisture content, dry density and standard Proctor. The laboratory tests were performed in accordance with the appropriate ASTM procedures. The results of the laboratory tests are shown on the boring logs opposite the samples upon which the tests were performed or on the data sheets included in the Appendix or on the attached data sheet.

LIMITATIONS

The recommendations and professional opinions submitted in this report were based upon the data obtained through the sampling and testing program at the test boring locations. We wish to point out that because no exploration program can totally reveal the exact subsurface conditions for the entire site, conditions between test borings and between samples and at other times may differ from those described in our report. Our exploration program identified subsurface conditions only at those points where samples were retrieved or where water was observed. It is not standard engineering practice to continuously retrieve samples for the full depth of the test borings. Therefore, strata boundaries and thicknesses must be inferred to some extent. Additionally, some soils layers present in the ground may not be observed between sampling intervals. If the subsurface conditions encountered at the time of construction differ from those represented by our test borings, it is necessary to contact us so that our recommendations can be reviewed. The variations may result in altering our conclusions or recommendations regarding site preparation or construction procedures, thus, potentially affecting construction costs.

This report is for the exclusive use of the addressee and its representatives for use in design of the proposed project described herein and preparation of construction documents. Without written approval, we assume no responsibility to other parties regarding this report. Our conclusions, opinions and recommendations may not be appropriate for other parties or projects.

STANDARD OF CARE

The recommendations submitted in this report represent our professional opinions. Our services for your project were performed in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering profession currently practicing at this time and area.

This report was prepared by:
GeoTek Engineering & Testing Services, Inc.

Brennen Ahlers, PE
Project Manager

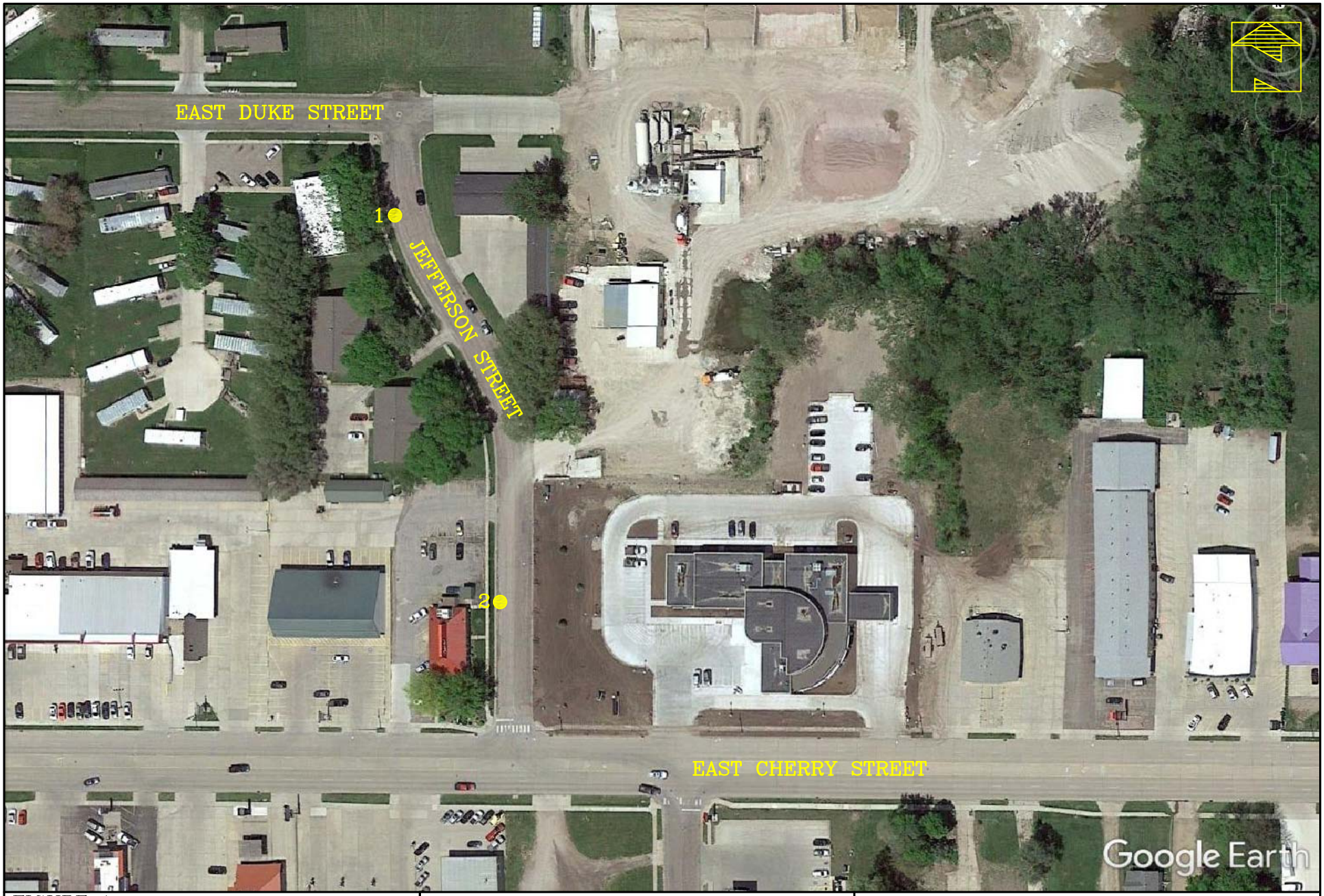

FIGURE 1
TEST BORING LOCATION MAP
PROPOSED JEFFERSON IMPROVEMENTS
VERMILLION, SD
ACAD\GEOTEK\BRENNEN\17-873

PROJECT#: 17-873

DRAWN BY: CDW CHECKED BY:

GEOTEK ENGINEERING & TESTING SERVICES, INC.

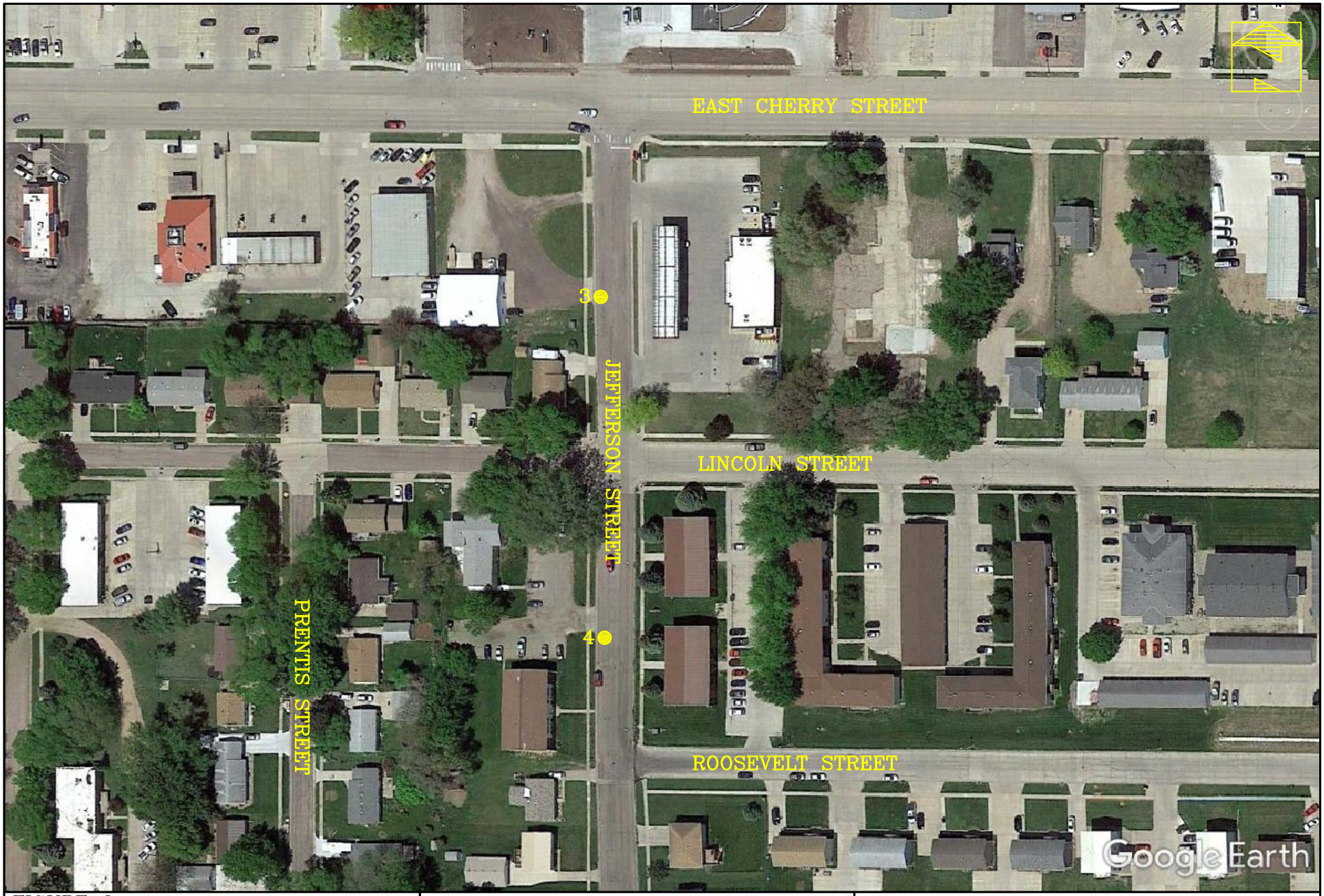

FIGURE 2
TEST BORING LOCATION MAP
PROPOSED JEFFERSON IMPROVEMENTS
VERMILLION, SD
ACAD\GEOTEK\BRENNEN\17-873

PROJECT#: 17-873

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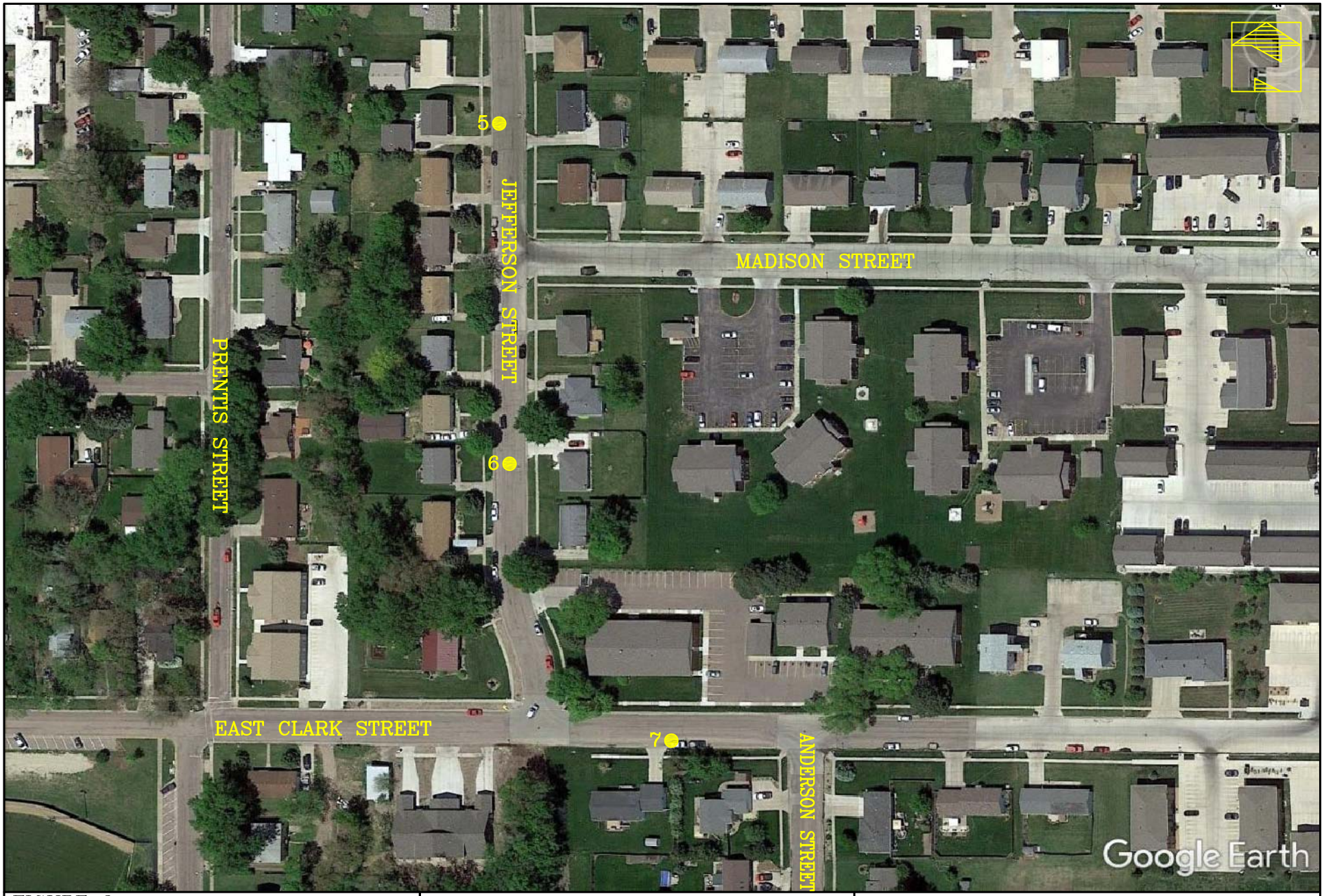

FIGURE 3
TEST BORING LOCATION MAP
PROPOSED JEFFERSON IMPROVEMENTS
VERMILLION, SD
ACAD\GEOTEK\BRENNEN\17-873

PROJECT#: 17-873

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-873** BORING NO. **1 (1 of 1)**

PROJECT **Proposed Jefferson Street Improvements, Vermillion, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION TOA ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LAB WC	LAB D	LAB LL	LAB PL	LAB QU
	FILL, MOSTLY LEAN CLAY: a little gravel, brown and black, moist, a 5" layer of asphalt at the surface and 2" of gravel	FILL	7		1	SPT	20	105			
2	**LEAN CLAY**: brown, moist to wet, soft, (CL)	FINE ALLUVIUM	4		2	SPT	27	94			
					3	BAG					
4½	**LEAN CLAY**: brown and gray, wet, soft, (CL)	FINE ALLUVIUM	2		4	SPT	30				
6	Bottom of borehole at 6 feet.										
	TOA = Top of Asphalt										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-26-17	9:55 am	6	--	4	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 7-26-17 COMPLETE 7-26-17 9:55 am

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 17-873.GPJ GEOTEKENG.GDT 8/23/17

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-873** BORING NO. **2 (1 of 1)**

PROJECT **Proposed Jefferson Street Improvements, Vermillion, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION TOA ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LAB WC	LAB D	LAB LL	LAB PL	LAB QU
	FILL, MOSTLY LEAN CLAY: a little gravel, brown and black, moist to wet, a 5" layer of asphalt at the surface and 5.5" of gravel	FILL	6		1	SPT	25				
2	**LEAN CLAY**: brown, wet, soft, (CL)	FINE ALLUVIUM	3		2	SPT	26				
4½	**LEAN CLAY**: brown and gray, wet, soft, (CL)	FINE ALLUVIUM	2		3	SPT	26				
6	Bottom of borehole at 6 feet.										
	TOA = Top of Asphalt										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-26-17	10:15 am	6	--	4	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 7-26-17 COMPLETE 7-26-17 10:15 am

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 17-873.GPJ GEOTEKENG.GDT 8/23/17

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-873** BORING NO. **3 (1 of 1)**

PROJECT **Proposed Jefferson Street Improvements, Vermillion, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL SURFACE ELEVATION TOA ft	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and black, moist to wet, a 6" layer of asphalt at the surface and 6" of gravel	FILL	7		1	SPT	19	108			
			3		2	SPT	25	98			
					3	BAG					
			2		4	SPT	25				
6	Bottom of borehole at 6 feet. TOA = Top of Asphalt										

WATER LEVEL MEASUREMENTS

START 7-26-17 COMPLETE 7-26-17 10:30 am

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-26-17	10:30 am	6	--	4	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 17-873.GPJ GEOTEKENG.GDT 8/23/17

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E. 50th St. N.
Sioux Falls SD 57104
605-335-5512 Fax 605-335-0773
www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-873** BORING NO. **4 (1 of 1)**

PROJECT **Proposed Jefferson Street Improvements, Vermillion, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION TOA ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LAB WC	LAB D	LAB LL	LAB PL	LAB QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and black, moist, a 6" layer of asphalt at the surface and 6.5" of gravel	FILL	6		1	SPT	21	105			
2	**LEAN CLAY**: brown, moist to wet, soft, (CL)	FINE ALLUVIUM	4		2	SPT	25				
3½	**LEAN CLAY**: brown and gray, wet, soft, (CL)	FINE ALLUVIUM	2		3	SPT	29				
6	Bottom of borehole at 6 feet.										
	TOA = Top of Asphalt										

WATER LEVEL MEASUREMENTS

START 7-26-17 COMPLETE 7-26-17 10:45 am

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-26-17	10:45 am	6	--	4	none
--	--	--	--	--	--
--	--	--	--	--	--
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METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 17-873.GPJ GEOTEKENG.GDT 8/23/17

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-873** BORING NO. **5 (1 of 1)**

PROJECT **Proposed Jefferson Street Improvements, Vermillion, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION TOA ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LAB WC	LAB D	LAB LL	LAB PL	LAB QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and black, moist to wet, a 5" layer of asphalt at the surface and 6.5" of gravel	FILL	7		1	SPT	28	96			
2	**LEAN CLAY**: brown, moist, soft, (CL)	FINE ALLUVIUM	3		2	SPT	23				
4½	**LEAN CLAY**: brown and gray, wet, soft, (CL)	FINE ALLUVIUM	2		3	SPT	24				
6	Bottom of borehole at 6 feet.										
	TOA = Top of Asphalt										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-26-17	11:05 am	6	--	4	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 7-26-17 COMPLETE 7-26-17 11:05 am

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 17-873.GPJ GEOTEKENG.GDT 8/23/17

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-873** BORING NO. **6 (1 of 1)**

PROJECT **Proposed Jefferson Street Improvements, Vermillion, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION TOA ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LAB WC	LAB D	LAB LL	LAB PL	LAB QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and black, moist, a 5.5" layer of asphalt at the surface and 6" of gravel	FILL	8		1	SPT	23	101			
2	**LEAN CLAY**: brown and gray, wet, soft, (CL)	FINE ALLUVIUM	3		2	SPT	24	99			
					3	BAG					
			2		4	SPT	29				
6	Bottom of borehole at 6 feet.										
	TOA = Top of Asphalt										

WATER LEVEL MEASUREMENTS

START 7-26-17 COMPLETE 7-26-17 11:25 am

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-26-17	11:25 am	6	--	4	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 17-873.GPJ GEOTEKENG.GDT 8/23/17

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **17-873** BORING NO. **7 (1 of 1)**

PROJECT **Proposed Jefferson Street Improvements, Vermillion, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION TOA ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LAB WC	LAB D	LAB LL	LAB PL	LAB QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and black, moist, a 6" layer of asphalt at the surface and 10" of gravel	FILL	8		1	SPT	18	111			
			7		2	SPT	20	106			
4½	**LEAN CLAY**: brown and gray, moist, soft, (CL)	FINE ALLUVIUM	3		3	SPT	22				
6	Bottom of borehole at 6 feet.										
	TOA = Top of Asphalt										

WATER LEVEL MEASUREMENTS

START 7-26-17 COMPLETE 7-26-17 11:35 am

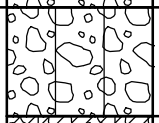
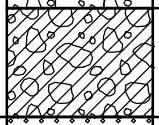
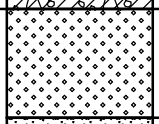
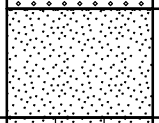
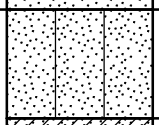
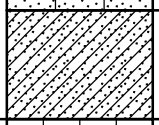
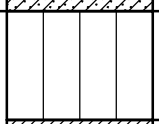
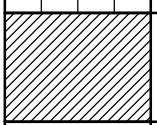
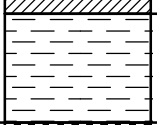
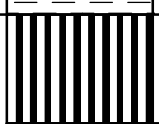
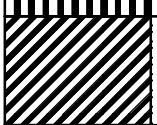
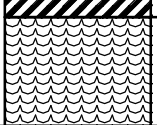
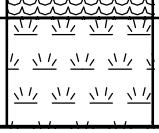
DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
7-26-17	11:35 am	6	--	4	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

METHOD
6" Flight Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 17-873.GPJ GEOTEKENG.GDT 8/23/17

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

BORING LOG SYMBOLS AND DESCRIPTIVE TERMINOLOGY

SYMBOLS FOR DRILLING AND SAMPLING

Symbol	Definition
Bag	Bag sample
CS	Continuous split-spoon sampling
DM	Drilling mud
FA	Flight auger; number indicates outside diameter in inches
HA	Hand auger; number indicates outside diameter in inches
HSA	Hollow stem auger; number indicates inside diameter in inches
LS	Liner sample; number indicates outside diameter of liner sample
N	Standard penetration resistance (N-value) in blows per foot
NMR	No water level measurement recorded, primarily due to presence of drilling fluid
NSR	No sample retrieved; classification is based on action of drilling equipment and/or material noted in drilling fluid or on sampling bit
SH	Shelby tube sample; 3-inch outside diameter
SPT	Standard penetration test (N-value) using standard split-spoon sampler
SS	Split-spoon sample; 2-inch outside diameter unless otherwise noted
WL	Water level directly measured in boring
▼	Water level symbol

SYMBOLS FOR LABORATORY TESTS

Symbol	Definition
WC	Water content, percent of dry weight; ASTM:D2216
D	Dry density, pounds per cubic foot
LL	Liquid limit; ASTM:D4318
PL	Plastic limit; ASTM:D4318
QU	Unconfined compressive strength, pounds per square foot; ASTM:D2166

DENSITY/CONSISTENCY TERMINOLOGY

Density		Consistency
Term	N-Value	Term
Very Loose	0-4	Soft
Loose	5-8	Firm
Medium Dense	9-15	Stiff
Dense	16-30	Very Stiff
Very Dense	Over 30	Hard

PARTICLE SIZES

Term	Particle Size
Boulder	Over 12”
Cobble	3” – 12”
Gravel	#4 – 3”
Coarse Sand	#10 – #4
Medium Sand	#40 – #10
Fine Sand	#200 – #40
Silt and Clay	passes #200 sieve

DESCRIPTIVE TERMINOLOGY

Term	Definition
Dry	Absence of moisture, powdery
Frozen	Frozen soil
Moist	Damp, below saturation
Waterbearing	Pervious soil below water
Wet	Saturated, above liquid limit
Lamination	Up to ½” thick stratum
Layer	½” to 6” thick stratum
Lens	½” to 6” discontinuous stratum

GRAVEL PERCENTAGES

Term	Range
A trace of gravel	2-4%
A little gravel	5-15%
With gravel	16-50%

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MOISTURE - DENSITY TEST REPORT

REPORTED TO:

City of Vermillion
Jose Dominguez
25 Center Street
Vermillion, SD 57069

PROJECT: 17-873

Proposed Jefferson Street Improvements
Vermillion, SD

COPIES TO:

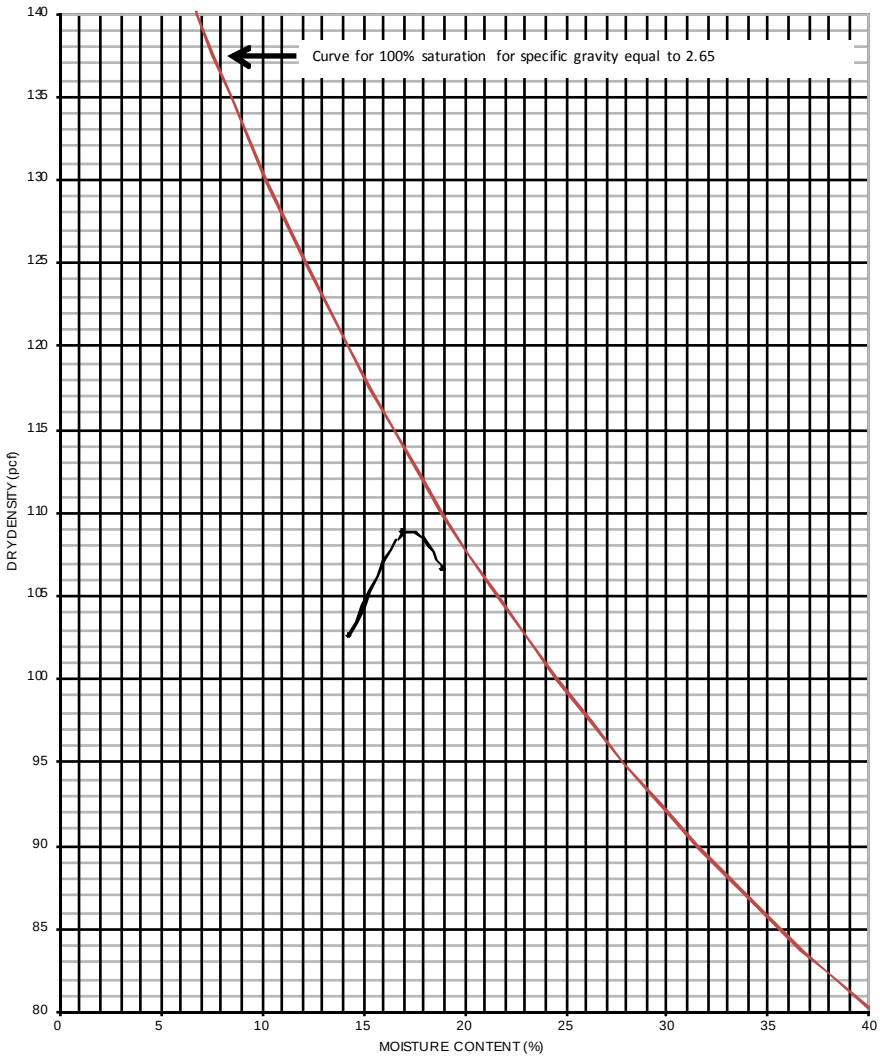
DATE REPORTED: 8/2/2017

SAMPLE DATA

Sample No.: 1
ASTM Test Method: D698B
Soil Classification: Lean Clay with Sand, Brown (CL) - 1
Remarks: SB 3, 4, 5 & 7 (1' to 4')

Date Received: 7/27/2017
Date Tested: 7/28/2017

TEST DATA



Maximum Density, pcf: 108.8
Optimum Moisture, %: 17.0

Percent Passing, %:
3/4": 100
3/8": 100
#4: 100
#200: 77

Atterberg Limits (ASTM: D4318):
Liquid Limit:
Plastic Limit:
Plasticity Index:

Matthew Thompson, P.E.: Project Manager

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MOISTURE - DENSITY TEST REPORT

REPORTED TO:

City of Vermillion
Jose Dominguez
25 Center Street
Vermillion, SD 57069

PROJECT: 17-873

Proposed Jefferson Street Improvements
Vermillion, SD

COPIES TO:

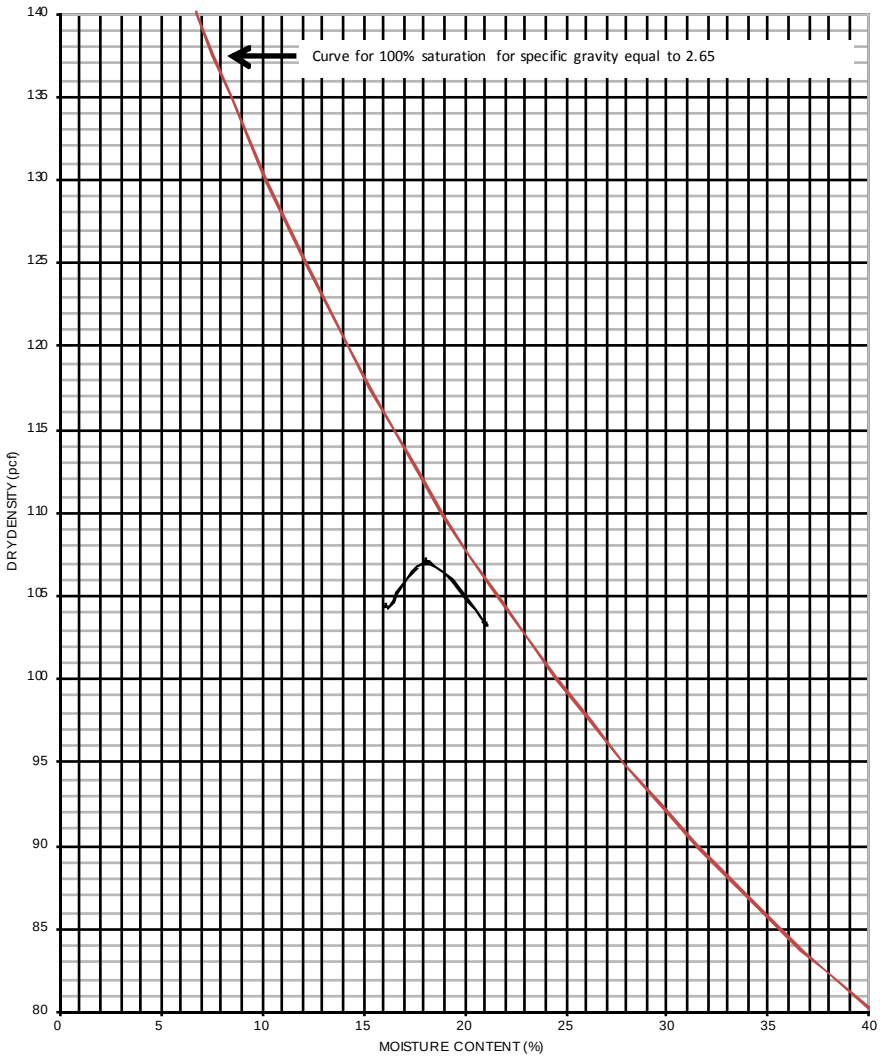
DATE REPORTED: 8/2/2017

SAMPLE DATA

Sample No.: 2
ASTM Test Method: D698B
Soil Classification: Lean Clay, Dark Brown (CL) - 2
Remarks: SB 6 (2' to 4 1/2')

Date Received: 7/26/2017
Date Tested: 7/27/2017

TEST DATA



Maximum Density, pcf: 107.1
Optimum Moisture, %: 18.2

Percent Passing, %:
3/4": 100
3/8": 100
#4: 100
#200: 90

Atterberg Limits (ASTM: D4318):
Liquid Limit:
Plastic Limit:
Plasticity Index:

Matthew Thompson, P.E.: Project Manager