BANNER ASSOCIATES, INC.
BROOKINGS, SOUTH DAKOTA

#443-0026

GEOTECHNICAL EXPLORATION PROGRAM
PROPOSED WATER TREATMENT PLANT SITE
LEWIS AND CLARK RURAL WATER SYSTEM
NEAR VERMILLION, SOUTH DAKOTA

November 19, 2003

MAXIM
TECHNOLOGIES INC®

MAXIM
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November 19, 2003

Mr. Timothy R. Conner, PE
Banner Associates, Inc.
402 22nd Avenue South
P.O. Box 298
Brookings, South Dakota 57006-0298

Dear Mr. Conner:

Subj: Geotechnical Exploration Program
Proposed Water Treatment Plant Site
Lewis and Clark Rural Water System
Near Vermillion, South Dakota
#443-0026

We are pleased to submit the results of our geotechnical exploration program for the referenced project. The geotechnical work was performed in accordance with the written authorization of our proposal dated October 8, 2003. Three copies of this report are enclosed for your use.

Representative samples of the soils obtained during our field operations will be retained for a period of one month and will then be discarded. Please advise us in writing if you wish to have the samples retained for a longer period.

Thank you for the opportunity to perform these services for you on this project. If you have any questions regarding the contents of this report or if we can be of further assistance to you in any way, please feel free to contact us at (605) 332-5371.

Sincerely,

Bruce W. Card, PE
Branch Manager

G:data\wpfiles\soils\2003\443-0026-Lewis and Clark Water Treatment Plant

IMPORTANT INFORMATION
ABOUT YOUR
GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/ The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting geotechnical engineer indicates otherwise, *your geotechnical engineering report should not be used*:

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership, or
- for application to an adjacent site.

Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their report's development have changed.

MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no geotechnical engineer, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their geotechnical consultants through the construction stage*, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time.* Speak with the geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

EXECUTIVE SUMMARY

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The following is a general summary of the recommendations contained in this report. This summary is for your convenience only, and we recommend you read the entire contents of this report for specific recommendations in all regards.

* **Foundation type:** Spread footings (ref. pages 7 & 11)

* **Allowable soil bearing pressure:** Slab-on-grade structures - 2000 psf (ref. page 11)
Below grade structures – 3000 psf (ref. page 11)

* **Estimated settlement:** Less than 1" total and ½" differential (ref. page 12)

* **Footing excavation depths and elevations:**
  - **Slab-on-grade structures** Excavate existing topsoil and clay alluvium at least 12" below footing (ref. page 8)
  - **Below grade structures** Excavate to depths indicated in Table 2 (ref. page 9)

* **Water level measurements:** 8.6' to 29.0' below existing grade (ref. page 3)

* **Type of engineered fill below footings:** (ref. Pages 10 & 11)
  - -In dry excavated areas: Granular or lean clay soils
  - -Within 6" of floor slab: Free draining granular

* **Percent compaction of engineered fill:** (ref. pages 11, 14, 17 & 18)
  - -Below footings: 95% of the Standard Proctor density (ASTM:D698)
  - -Below floor slab: 95% of the Standard Proctor density (ASTM:D698)
  - -Exterior backfill:
    - -Structural areas - 95% of the Standard Proctor density (ASTM:D698)
    - -Nonstructural areas - 90% of the Standard Proctor density (ASTM:D698)
  - -Pavement section:
    - -Subgrade fill – 95% of the Standard Proctor density (ASTM:D698)
    - -Base course & subbase – 100% of the Standard Proctor density (ASTM:D698)

* **Minimum frost depth of footings:** (ref. page 12)
  - -Heated areas: 4'
  - -Unheated areas: 5'

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1.0 INTRODUCTION

1.1 Project Information

We understand the project will consist of the construction of a water treatment plant located north of Vermillion, South Dakota.

1.2 Scope of Services

In accordance with the written authorization received from Mr. Timothy Conner, we have conducted a geotechnical exploration program for the proposed project. The scope of our work under this authorization is limited to the following:

1. To perform seven (7) soil borings to explore the subsurface soil and groundwater conditions.
2. To perform nominal laboratory testing to aid in judging soil properties.
3. To provide an engineering report including results of the field and laboratory tests as well as engineering opinions and recommendations for the following:
    - a. Site preparation and excavation oversize requirements.
    - b. Possible foundation types and depths, allowable bearing capabilities and estimated potential settlement.
    - c. Floor slab support.
    - d. Exterior backfill.
    - e. Suitability of the on-site soils for liner construction.

f. Soils corrosion properties.

g. Construction and post-construction groundwater control.

h. Construction considerations.

i. Construction observations and testing.

1.3 Purpose of Report

The purpose of this report is to present the results of our field and laboratory tests as well as our geotechnical engineering review and recommendations for the project. It should be noted that our work is intended for geotechnical purposes only and not to document the presence or extent of any contamination at the site.

2.0 EXPLORATION PROGRAM RESULTS

2.1 Scope of Exploration

Seven soil borings were performed at the site on October 29 and 30 and November 3, 2003. The borings were advanced at the locations staked in the field by Banner Associates, Inc. (Banner) and as shown on the sketch included in Appendix A. The surface elevations of the test borings were also furnished by Banner. Some settlement of the soils used to fill the open bore holes should be anticipated and final closure of the holes is the responsibility of the client or property owner.

2.2 Site Surface Conditions

The area of the proposed construction is located in the southeast quarter of Section 35, Township 93 North, Range 52 West in Clay County, South Dakota. The site has been utilized for agricultural purposes and soybeans were recently harvested on the site. The general topography of the site slopes toward the east. The surface elevations at the boring locations ranged from 1200.15' to 1210.15' based on the elevations provided by Banner.

2.3 Site Subsurface Conditions

A review of the soil boring logs suggests a soil profile consisting of 1.0' to 1.5' of clay topsoil overlying clay alluvium (water deposited) soils underlain by clay till (glacial deposited) soils extending to the termination depth of the borings at 51' below existing surface elevations. An exception to this soil profile was noted in boring #6 where sand soils were encountered from 45' below existing grade to the termination depth of the boring.

The clay alluvium and till soils encountered at the site exhibited a consistency of medium to stiff. A density of medium dense was noted in the sand soils encountered at the site. The consistency and density of the soils are estimated by the "N" values (penetration resistance) shown on the boring logs in Appendix A.

The subsurface conditions encountered at each test boring location are illustrated on the logs included in Appendix A. We wish to point out that the subsurface conditions at other times and locations on this site may differ from those found at our test locations. If different subsurface conditions are encountered during construction, it is necessary that you contact us so that our recommendations can be reviewed. The test boring logs also indicate the possible geologic origin of the materials encountered.

2.4 Water Levels

Observations for subsurface groundwater were made at the boring locations during our drilling operations. The time and level of the groundwater readings are shown on the boring logs. Groundwater was encountered in the majority of the borings at depths ranging from 8.6' to 29' below existing grade during our drilling operations.

It should be noted that observations over a long period of time are usually required in order to accurately determine the static groundwater level. Such periods of observation are normally not available in a typical soil boring program. Seasonal and annual fluctuations of groundwater levels can be expected to occur.

2.5 Laboratory Test Program

2.5.1 Index Properties

Soil samples were selected for laboratory tests to determine the engineering and index properties. These tests consisted of the determination of moisture content, dry density, Atterberg limits and unconfined compressive strength.

The tests were performed in accordance with the American Society for Testing and Materials (ASTM) procedures. The test results are shown on the boring logs opposite the samples upon which the tests were made.

2.5.2 Proctor Tests

The maximum density and optimum moisture content were determined for a composite soil sample obtained from each of the seven borings. The maximum density and optimum moisture content were determined in accordance with the Standard Proctor method (ASTM:D698). The results of the proctor tests are attached in Appendix A and are titled "Report of Moisture-Density Relations".

2.5.3 Permeability Tests

Upon the determination of the maximum density and optimum moisture content for each boring, the samples were submitted to the laboratory for permeability testing. The permeability tests were performed on the proctor test specimens, which were remolded to 95% of the maximum density at a moisture content near the optimum moisture content.

The remolded test specimens were tested for permeability using the falling head procedure. The permeability tests were performed in chambers similar to a tri-axial chamber whereby an effective confining fluid pressure of 2.0 pounds per square inch (psi) is applied and accurately maintained throughout the test to completely seal off the interface between the specimen and the membrane. A maximum head differential of 5' was utilized for the test. The specimens were allowed to saturate after which readings were taken over a period of several days. The test results present an average of the latter, fairly constant readings. The permeability test results are indicated on the data sheets attached in Appendix A.

2.5.4 Soil Corrosivity Testing

Representative soil samples from each boring were submitted to our laboratory for a series of tests to help judge the corrosivity of the soils encountered at the site. The tests included the pH, chloride content, sulfate content and resistivity. The results of the tests are shown in Table 1 and are included in Appendix A.

TABLE 1

SUMMARY OF SOIL CORROSIVITY TESTING

Boring Number	Depth of Sample	pH	Chloride (mg/kg)	Sulfate (mg/kg)	Resistivity (ohm-cm)
1	6' to 10'	7.57	<6.0	290	1201
1	15' to 25'	7.08	<6.0	220	749
2	6' to 10'	7.59	12	310	1329
2	15' to 25'	7.10	<6.0	190	806
3	6' to 10'	7.53	<6.0	430	1596
3	15' to 25'	7.01	<6.0	49	800
4	6' to 10'	7.52	<6.0	7400	616
4	15' to 25'	7.37	<6.0	1500	542
5	6' to 10'	7.46	25	6900	665
5	15' to 25'	7.08	<6.0	100	716
6	6' to 10'	7.65	<6.0	1400	640
7	6' to 10'	7.65	<6.0	1900	893

3.0 ENGINEERING REVIEW

3.1 Project Data

The engineering recommendations provided in this report are based on our understanding of the project as described in the following paragraphs. The recommendations are valid for a specific set of project conditions. If the characteristics of the project change from those indicated in this section, it is necessary that we be notified so that we can determine whether the new conditions affect our recommendations.

We understand that the project will consist of the construction of a water treatment plant complex which will include a series of buildings to house various process components, maintenance functions, administrative building and pump stations. The plant site will also include clearwell reservoirs and various other water containing structures and basins. Sludge storage lagoons will be required to store and dewater the gravity thickened sludge generated by the plant operation. Final disposal of the dewatered sludge from the plant is planned for on-site disposal in a monofill.

Actual details regarding the construction were not available at the time of this report. We assume that the plant would be constructed within several feet of the existing grade at the site. We also assume that column loads will be less than 200 kips and wall loadings will be in the range of 4 to 9 kips per foot for the structures at the site. Floor slab loadings of less than 250 pounds per square foot (psf) are assumed to be exerted on the underlying soils.

Our design assumptions also include a minimum theoretical safety factor of three or more with respect to shearing or base failure of the foundations. In addition, we assume allowable total settlement and differential settlement of up to 1" and ½", respectively.

3.2 Discussion

In our opinion, the subsurface soil conditions encountered at the site are suitable for support of the proposed structures on spread footing foundations. As noted previously, the soils encountered at the site generally consist of 1.0' to 1.5' of clay topsoil overlying clay alluvium soils underlain by clay till soils which extended to the termination depth of the borings. The existing topsoil should not be relied upon for footing or floor slab support for any of the structures.

Due to the relatively weak condition of the upper clay soils encountered at this site, we recommend that the site grades not be raised more than 5'. If they are raised more than 5', a sufficient amount of time is required between the placement of the engineered fill and any construction on the site. We anticipate 3 to 6 months may be required to consolidate the underlying clay soils due to the weight of the overburden soils.

Based on the soil testing performed to judge the corrosive potential of the soils, it is our opinion that some potentially corrosive soils are present on this site. High sulfate contents were present in the area of borings #4, #5, #6 and #7. Sulfate attack on concrete should be considered severe in the areas represented by these borings. Some sulfate attack on concrete may occur at other areas as well. We recommend that a Type II cement be used for construction on this site. The resistivity results also indicate a corrosive environment. We recommend some form of protection for all piping that will be in contact with soils on this site.

We wish to note that the clay soils encountered at the site are sensitive to disturbance and potential strength loss under construction traffic and/or excessive moisture. This is especially true with the clay mixed or fine alluvium soils, which were found to be substantially above optimum moisture content for these soils. These soils can lose strength with the combination of additional moisture and construction traffic. Disturbance of these soils should be prohibited. Water should not be allowed to pond on these soils for any length of time. Some challenges with stability of the soils should be anticipated for the parking and drive areas of the project.

We recommend that additional soils borings be performed on this site once construction plans have been finalized. We also recommend that we be allowed to review our preliminary soils report as it relates to the proposed construction once grading and construction plans have been finalized.

3.3 Site Preparations

3.3.1 Slab-On-Grade Structures

For structures supported on shallow spread footing foundations, we recommend that site preparations for the footings and floor slabs consist of excavating the clay topsoil and clay alluvium soils to a depth to allow for the placement of a minimum of 12” of granular engineered fill below the footings and floor slabs. The purpose of the granular fill is to provide a working surface for the placement of concrete due to the presence of relatively soft and moist clay soils at this site.

If there are any large tanks supported at-grade, an excavate/refill program to a greater depth than referenced above will likely be required to maintain acceptable settlements. The final excavation depths should be observed in the field by a geotechnical engineer to judge the suitability of the exposed soils for support of the proposed structures.

3.3.2 Below Grade Structures

We recommend that consideration be given to supporting any below grade structures on an engineered fill system placed from the level of the clay till soils encountered at the site. Table 2 identifies the recommended depth of excavation at each of the boring locations. We wish to note that the depth of excavation required at other locations may vary considerably from those identified in Table 2. The final excavation depths should be observed in the field by a geotechnical engineer to judge the suitability of the exposed soils for support of the proposed structures.

TABLE 2

BORING NUMBER	SURFACE ELEVATION (FT)	EXCAVATION DEPTH (FT)	ESTIMATED ELEVATION OF BOTTOM OF EXCAVATION (FT)
1	1207.6	8.0	1199.6
2	1208.8	7.0	1201.8
3	1206.2	12.0	1194.2
4	1209.3	7.0	1202.3
5	1210.2	7.0	1203.2
6	1201.3	11.0	1190.3
7	1200.2	10.0	1190.2

Depending upon the actual bottom elevations of the structures at the site, groundwater may be encountered in the excavations. To help control any groundwater encountered, we recommend that the excavations extend at least 12" below the bottom of the proposed structures. A 12" layer of crushed or washed rock should then be placed below the structures to provide a working surface for the placement of concrete. The rock should have a maximum size of 1".

3.3.3 General Recommendations

Where engineered fill is required below footings at the site, we recommend the excavation be oversized 2' plus 1' laterally for each foot of fill placed beneath the footings. A schematic drawing illustrating excavation oversize requirements is included in Appendix B.

Engineered fill placed in dry excavations for support of the foundations or floor slabs can consist of either a granular or clay material. However, based on the sensitive nature of the clay soils encountered at this site, it is our opinion that a granular engineered fill would be much easier to work with and to obtain the desired compaction. The granular fill can consist of a pit run or processed sand or gravel having a maximum size of 3". If clay fill soils are used, they should consist of a non-organic and non-expansive lean clay having a liquid limit of 45 or less.

In our opinion, the potential for groundwater entering the deeper excavations is likely. It should be possible to control most groundwater with normal sump pumping procedures. However, if water becomes pooled in the excavation and cannot be completely removed, the placement of a select engineered fill may be required from the bottom of the excavation to a level approximately 2' above the static groundwater level. The select fill should consist of a medium to coarse grained sand having a maximum of 40% of the material passing the #40 sieve and less than 5% of the material passing the #200 sieve by weight. After placement of the select fill, the above recommended pit run sand or gravel engineered fill could be placed to reach the elevation of the bottom of the footings and the floor slab.

In the floor slab area, the final 6" of fill placed directly beneath the floor slab should consist of a relatively free-draining granular soil having a maximum size of 1" with less than 10% fine material passing the #200 sieve by weight. The purpose of the sand cushion is to provide a working surface for the placement of concrete and to serve as a capillary barrier. If desired, a polyethylene vapor membrane may be added beneath the floor slab, especially if moisture/sensitive floor coverings are planned. The membrane should be placed at least 2" beneath the surface of the granular layer to minimize the potential for curling of the concrete floor slab.

All engineered fill placed below the footings and floor slabs should receive a compaction of at least 95% of the Standard Proctor density (ASTM: D698). Granular fill compacted with heavy, self-propelled compaction equipment should be placed in loose lifts of 12" or less. Granular fill compacted with hand-operated compaction equipment should be placed in loose lifts of 6" or less. Clay fill soils should be placed in maximum loose lifts of 8" using either self-propelled or hand-operated compaction equipment and should be placed at a moisture content ranging from -3% to +2% of the optimum moisture content as determined by the Standard Proctor. Vibratory compaction equipment should be used for compaction of granular engineered fill soils.

3.4 Foundation Recommendations

As noted previously, the proposed structures can be supported on spread footing foundations. It is our opinion that the footings can be designed using an allowable soil bearing pressure of up to 2000 psf for the slab-on-grade structures and up to 3000 psf for the structures supported from the level of the clay till soils at the site. These allowable bearing capacities are based on the site being prepared as recommended above. The allowable soil bearing pressure is based on our judgment of the soil conditions at the boring locations along with the penetration resistance values ("N" values), laboratory test results, recommended compaction levels and our experience with similar soil conditions.

It is our opinion that our recommendations should provide a theoretical safety factor of at least three against localized shear failure. It is our opinion that total long-term settlements will be less than 1" with long-term differential settlements less than ½".

We recommend that all perimeter footings and any unheated interior footings be placed at a sufficient depth for frost protection. For heated structures in this area, we recommend a minimum frost depth of 4' be used. For unheated structures and canopies, or footings not artificially protected from frost during construction, a minimum frost depth of 5' should be used. For perimeter footings, the depth of embedment should be measured from the finished exterior grade to the bottom of the footings. For interior footings, the depth should be measured from the interior finished grade to the bottom of the interior footings.

3.5 Lagoon Construction

3.5.1 Dikes

It is our opinion that the on-site clay alluvium and clay till soils are suitable material for dike construction. The existing clay topsoil and any sand alluvium soils encountered should not be used for dike construction. We recommend the existing topsoil be removed from the base areas of the proposed dikes to expose the clay alluvium or clay till soils. Prior to constructing the dikes, if there are stability problems, we recommend scarifying, drying and recompacting the soils or mixing a stabilizing agent such as fly ash into the top 6" of soil and re-compacting the soil to at least 95% of the Standard Proctor density (ASTM:D698).

Following the scarifying operations, the dikes could be constructed using the on-site clay alluvium or till soils. The dikes should be constructed with a maximum loose layer soil thickness of 8" and be compacted to at least 95% of the Standard Proctor density. The dike soils should be placed at a moisture content ranging from 2% below to 3% above the optimum moisture content as determined by the Standard Proctor. If the on-site clay alluvium soils are used for dike construction, some drying will likely be required prior to compacting.

We recommend that the interior and exterior slopes of the dikes be restricted to a maximum of 3' horizontal to 1' vertical. The width of the top of the dikes should be at least 10' if maintenance vehicles will be utilizing the dikes.

3.5.2 Liners

Based on the review of the boring logs as well as the results of the laboratory tests, it is our opinion that sufficient quantities of clay alluvium and clay till soils are present at the site for use as lagoon liner material. Based on our review of these soils, they should satisfy the recommended seepage rate criteria if placed at the recommended compaction and moisture specifications listed below.

We recommend a minimum liner thickness of 12" be used for the proposed lagoon cells. The excavations for the cell floors should extend through the topsoil and into the clay alluvium or clay till soils a depth of 6" below the design floor elevations. The excavations should then be followed by scarifying, stabilizing, and re-compacting a minimum of 6" of the exposed **clay alluvium or till** soils followed by the placement of an additional 6" of **clay alluvium or till soils**.

If sand soils are encountered at the bottom of the excavation, we recommend a liner thickness of 18" be used or the complete excavation of the sand soils and replacement of the sand soils with clay engineered fill.

The clay liner soils should be compacted to at least 98% of the Standard Proctor density (ASTM:D698). The clay liner soils should be placed at a moisture content ranging from optimum to 3% over optimum moisture content as determined by the Standard Proctor.

During construction and once the liners have been completed, they should not be allowed to dry out. Drying of the liners will cause cracking, which would be very difficult to repair, and may result in seepage rates above the desired rate. Therefore, once the liners have been completed, we recommend that compaction tests along with a representative number of permeability tests be performed as soon as possible so that the cells can be flooded. It may be advisable to place a layer of soil over the compacted liners to reduce the drying effects.

3.6 Exterior Backfill

The non-organic and non-expansive on-site clay soils are suitable for exterior backfill material for the proposed structures. Organic soils should not be used for exterior backfill except for cover material. The exterior backfill soils should be placed in maximum 8" loose lifts. The clay exterior backfill soils should be placed at a moisture content ranging from $\pm$3% of the optimum moisture content as determined by the Standard Proctor. The backfill material should be free of frost and should not be placed on frozen soils. Please refer to the Cold Weather Precautions attached in Appendix B.

Exterior backfill soils placed along the foundation walls, in utility trenches and in structural areas, such as beneath sidewalks or light traffic areas, should be compacted to at least 95% of the Standard Proctor density (ASTM: D698). Other exterior backfill soils placed in nonstructural areas, such as beneath lawns and landscaping, should receive a compaction of at least 90% of the Standard Proctor density.

Proper drainage should be maintained during and after construction. General site grading should not allow water to pond in the building area or in the excavation. Any ponded water should be removed as soon as possible. Finished grades around the perimeter of the structure should also be sloped away from the structure with a minimum slope of 1" per foot for at least 10' beyond the excavation line.

3.7 Lateral Earth Pressures

Assuming that any portion of the structures that will experience lateral earth pressures will be rigid and no deflection can take place during or following backfilling, we recommend an at rest equivalent fluid pressure of 60 pounds per cubic foot (pcf) be used above the groundwater level for the on-site clay soils or new granular engineered fill soils above the groundwater level. For submerged conditions, we recommend that an at rest equivalent fluid pressure of 100 pcf or an active equivalent fluid pressure of 90 pcf be used for the on-site clay or sand soils or new granular engineered fill soils.

The values calculated for the above parameters would provide ultimate values. We recommend a minimum safety factor of at least 1.5 be applied to the calculated lateral values. The above noted equivalent fluid pressures assume the backfill soils adjacent to the walls will be compacted to a range of about 90% to 100% of the Standard Proctor density.

3.8 Drain Tile

Groundwater was encountered at the majority of the boring locations; therefore, we recommend installing a drain tile system below any below-grade structures. The tile lines should be connected to a suitable outfall or adequate sump pump system. Also, we recommend that all below-grade walls be adequately waterproofed.

Depending upon the floor elevation of the structures and future groundwater table elevations, groundwater may exist above the floor of the structures. Therefore, we recommend that consideration be given to providing the below grade structures with check valves (hydrostatic relief plugs), which allow groundwater or other perched water into the structures if they have been drained, thus eliminating the hydrostatic pressure surrounding the structures.

3.9 Site Drainage

Proper drainage should be maintained during and after construction. General site grading should not allow water to pond in the building areas or in the excavations. Any ponded water should be removed as soon as possible.

Finished grades around the perimeter of the structures should also be sloped away from the buildings. The slope should be a minimum 1" per foot for at least 10' beyond the excavation line. A system to collect and channel roof run-off water away from the structure is recommended. The roof run-off water should be controlled by a system of downspouts and gutters with proper extensions to remove the run-off water away from the structure. The gutters and downspouts, as well as splash pads and extensions should be maintained so that leakage does not occur adjacent to the structure.

3.10 Pavement Construction

We recommend that site preparation for the proposed parking lot and driveway areas consist of the excavation (subcutting) of the existing topsoil to a depth that would provide for the placement of the recommended pavement sections listed in the following table. At a minimum, the top 8" of the existing topsoil should be excavated before placement of any new subgrade or base materials. The purpose of the excavation of the top 8" is to remove the majority of the higher organic material that is likely to exist at the surface of the soils. In addition, we recommend that the top 6" of the existing clay soils be scarified and recompacted to a minimum of 95% of the Standard Proctor density. Final excavation depths should be determined in the field by a geotechnical engineer. Adequate stability of the subgrade soils must exist before the placement of the pavement section.

Based on the present moisture content and dry density of the clay alluvium soils encountered beneath the topsoil at the site, it is our opinion that some problems with stability with these soils is likely. Heavy wheeled construction equipment such as scrapers will likely have difficulty when working with the clay fine alluvium soils at the site. The soils will likely require some drying before adequate compaction can be achieved.

Depending upon the moisture content of the clay alluvium soils at the time of construction, consideration could be given to stabilizing these soils with fly ash or lime. If lime is used, it should consist of 4% to 5% of a hydrated lime mixed with the top 6" to 8" of soil at the site. If fly ash is used, it will likely require about 20% fly ash mixed with the top 6" to 8" of soil at the site.

If additional subgrade fill is required to meet design elevations of the proposed parking lot and driveway areas, we recommend a granular subgrade material be used. Alternatively, but less desirable, a non-organic lean clay having a liquid limit of 45 or less could possibly be used. The subgrade fill soils should be placed in maximum 8" loose lifts and be compacted to 95% of the Standard Proctor density.

Following the site preparation, we recommend the placement of one of the following pavement sections.

TABLE 3

Pavement Description	Pavement Surfacing	Aggregate Base Course	Granular Subbase
Standard Duty Pavement (cars and light trucks) Asphalt: Concrete:	 3" 5"	 8" 6"	 None* None*
Heavy Duty Pavement (heavy trucks-forklift) Asphalt: Concrete:	 5" 7"	 8" 8"	 6"* None*

*If wet soil conditions exist at the time of construction, additional subbase material and/or geotextile fabric may be needed in some areas to stabilize existing subgrade soil conditions.

The aggregate base course and granular subbase materials along with the bituminous asphalt used for the pavement sections should meet the specifications outlined in the South Dakota Department of Transportation Standard Specifications. Aggregate base course and granular subbase material should be compacted to at least 100% of the Standard Proctor density.

The concrete paving products should also be composed of a quality mix. The mix should have a proven success or a mix design should be established for proper proportions of aggregate, cement, water and any admixtures. The concrete should be handled, placed and cured according to current ACI Guidelines and Specifications for Exterior Concrete. The concrete should have a minimum compressive strength of 4000 psi, be placed with a maximum slump of 3", and have air entrainment between 5% and 7%.

Relative to saw joints, a maximum width in the longitudinal and transverse directions should be provided as per ACI guidelines. All saw joints should be made within 24 hours of casting or as soon as the surface is sufficiently hard to support equipment. All joints should be adequately sealed with proper joint sealer.

In addition, if the exposed soils are sensitive to disturbance, scarifying and re-compacting them may be detrimental for subgrade support of the proposed pavement section. If areas of sensitive soils are encountered, we recommend a geotechnical engineer observe these soil conditions and make further recommendations to stabilize the soil for support of the pavement sections. As noted above, adequate stability of the subgrade soils is necessary for support of the pavement section.

We recommend that extra care be taken in the design and construction process to insure that adequate subgrade and surface drainage is maintained throughout the parking lot and driveway areas. The subgrade surface should be uniformly sloped to facilitate drainage of the base material within the pavement system and to avoid any ponding of water beneath the pavement. The purpose of the drainage is to minimize saturation of the subgrade soils and to minimize potential distress due to frost movement of the underlying soils. We wish to note that routine maintenance such as crack filling, seal coats and localized patching should be expected for all pavements in our recommendations.

4.0 CONSTRUCTION CONSIDERATIONS (CONSTRUCTABILITY)

4.1 Site Excavation

The clay soils encountered at the site are sensitive to disturbance and strength loss under the influence of construction traffic and/or additional moisture. Construction traffic in areas where these soils are used for structural support should be limited. Disturbance or saturation of these soils will require additional excavation and backfilling. In addition, the excavation should be left open a minimal amount of time to prevent strength loss of these soils by ponding of water. Excavation to expose these soils may require using a backhoe with a smooth bucket.

All excavations must comply with the requirements of OSHA 29 CFR Part 1926, Subpart P, "Excavations". Reference to this OSHA requirement should be included in the project specifications.

4.2 Fill Placement

Performance of the engineered fill and backfill at the site is dependent upon removing all unsuitable soils prior to fill placement and maintaining adequate compaction as the fill is placed. We recommend that all excavations be observed by a qualified geotechnical engineer or his representative prior to fill placement and that density testing be performed within the fill sequence.

5.0 STANDARD OF CARE

The recommendations contained in this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted engineering procedures at this time and location. Other than this, no warranty, either expressed or implied, is intended.

This report was prepared by:

REGISTERED PROFESSIONAL ENGINEER
REG. NO. 4430
BRUCE W. CARD
SOUTH DAKOTA

Bruce W. Card, PE
Branch Manager

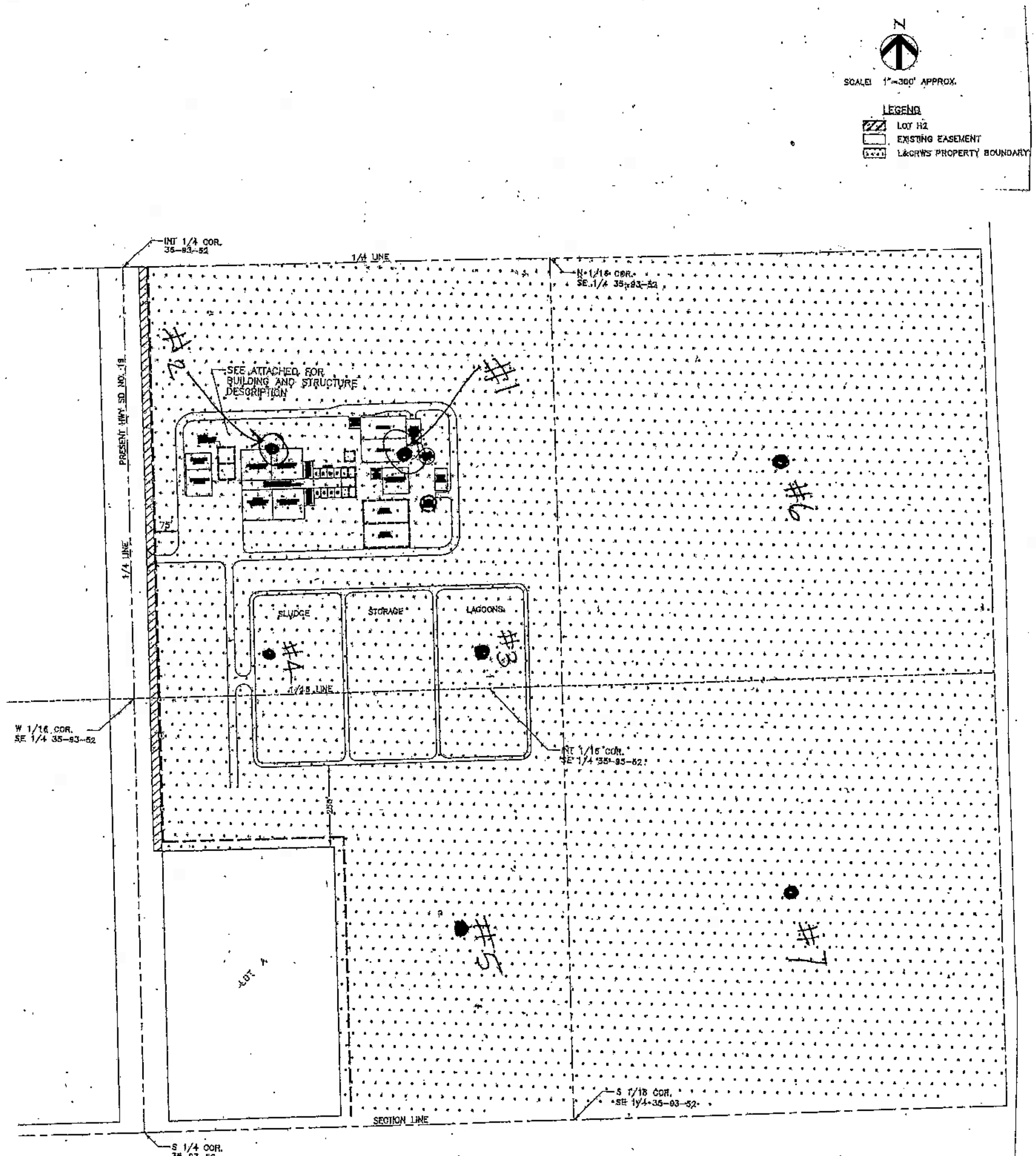
This report is being written in accordance with our quality assurance program. This service is provided as an additional assurance to you that our work was performed with the level of care and skill ordinarily exercised by members of the profession practicing under similar conditions at the time the service is performed.

This report was reviewed by:

Gary Sommerfeld
Regional Geotehcnical Manager

Proofread by:

MAXIM



LEWIS & CLARK RURAL WATER SYSTEM
PROPOSED WATER TREATMENT PLANT LOCATION

NOTE: SKETCH PROVIDED BY
BANNER ASSOCIATES, INC.

●-DENOTES SOIL BORING LOCATIONS

JOB NO. 443-0026	SCALE: NONE	DRAWN BY: AWJ	CHECKED BY: BWC

LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 1

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 1 OF 2

SURFACE ELEVATION 1207.57'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SILTY CLAY, dark brown, moist (ML-OL)	TOPSOIL			1	HSA					
1.5	**LEAN CLAY**, brown, moist, medium (CL/ML)	FINE ALLUVIUM		6	2	SB	24				
					3	3T	28	97	36	23	2200
5	**LEAN CLAY**, with a little gravel, brown mottled, moist, medium (CL)	WEATHERED TILL			4	B*					
				6	5	SB	24				
			▼	6	6	SB	26	101			2800
13	**SANDY LEAN CLAY**, with a little gravel, brown mottled, moist, stiff (CL)	TILL		7	7	SB	24	102			
				14	8	SB	23				
18	**SANDY LEAN CLAY**, with a little gravel, gray, moist, stiff to medium (CL)			9	9	SB	21				
	*Bag sample obtained from 5'-15'. Proctor & Permeability test-see attached sheets.			9	10	SB	20				

BORING CONTINUED ON NEXT PAGE

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	HOLE/ CAVE-IN	BAILED DEPTHS	WATER LEVEL
11-3	16'	14.5'	16'	16'		10.1 ▼
11-3	10:11	51'	49.5'	51'		NONE

START 10/30/03 COMPLETE 11/3/03 @ 10:10

METHOD 3 1/4" HSA 0-49 1/2'

CREW CHIEF: Roger Hanson

Maxim Technologies, Inc
601 East 48th Street North
Sioux Falls, South Dakota 57104
Telephone: 605-332-5371
Fax: 605-332-8488

LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 1

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SAME AS PREVIOUS PAGE	TILL		8	11	SB	21				
				7	12	SB	21				
				6	13	SB					
44	**SANDY SILTY CLAY**, gray, moist, medium (CL/ML)	MIXED ALLUVIUM		4	14	SB					
47	**SANDY LEAN CLAY,** with a little gravel, gray, moist, medium (CL)	TILL		8	15	SB					
51	**END OF BORING**										

GEOTECHLOG 443-0026.GPJ MAMIMLOG.GDT 11/5/03

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Fax: 605-332-8488

LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 2

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 1 OF 2

SURFACE ELEVATION 1208.75'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
1	**SILTY CLAY**, dark brown, moist (ML-OL)	TOPSOIL			1	HSA					
7	**LEAN CLAY**, brown mottled, moist to very moist, medium (CL/ML)	MIXED ALLUVIUM		4	2	SB	24				
				4	3	SB	29	92			
					4	B*					
	SANDY LEAN CLAY, with a little gravel, brown mottled, moist, stiff to medium to stiff, a lamination of waterbearing sand at 44.5' (CL)	TILL			5	3T	22	103			2400
				9	6	SB	25	100			
				9	7	SB	24				
				11	8	SB	25				
				10	9	SB	20				
	*Bag sample obtained from 7'-15'. Proctor & Permeability test-see attached sheets.			8	10	SB	18				
			▼								

BORING CONTINUED ON NEXT PAGE

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	HOLE/ CAVE-IN	BAILED DEPTHS	WATER LEVEL
11-3	11:58	31'	29.5'	31'		29 ▼

START 11/3/03 COMPLETE 11/3/03 @ 12:40

METHOD 3 1/4" HSA 0-49 1/2'

CREW CHIEF: Roger Hanson

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 2

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 2 OF 2

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SAME AS PREVIOUS PAGE	TILL		9	11	SB	19				
				8	12	SB	21				
				9	13	SB					
				9	14	SB					
				9	15	SB					
51	END OF BORING										

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 3

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 1 OF 2

SURFACE ELEVATION 1206.21'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SILTY CLAY, dark brown, dry to moist (ML-OL)	TOPSOIL			1	HSA					
1.5	**LEAN CLAY**, brown mottled, moist, medium (CL)	MIXED ALLUVIUM		7	2	SB	24				
					3	B*	21				
				5	4	SB	28	94			
7	**LEAN CLAY**, brown mottled, moist, medium, a lens of sand from 8'-8.5', a lens of sand at 10' (CL)			6	5	SB	31				
10	**LEAN CLAY**, with a little gravel, brown mottled, very moist, medium (CL)	WEATHERED TILL	▼	5	6	SB	32	89			
12	**SANDY LEAN CLAY**, with a little gravel, brown mottled, moist, stiff (CL)	TILL		14	7	SB	21				
14.5	**SANDY LEAN CLAY**, with a little gravel, gray, moist, stiff, a lamination of waterbearing sand at 50' (CL)			10	8	SB	19				
	*Bag sample obtained from 4'-10'. Proctor & Permeability test-see attached sheets.			9	9	SB	20				
				9	10	SB	20				

BORING CONTINUED ON NEXT PAGE

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	HOLE/ CAVE-IN	BAILED DEPTHS	WATER LEVEL
10-30	10:46	51'	49.5'	51'		49'
10-30	11:06	51'	---	11'		NONE
10-30	1:50	51'	---	11'		10.8 ▼

START 10/30/03 COMPLETE 10/30/03 @ 10:45

METHOD 3 1/4" HSA 0-49 1/2'

CREW CHIEF: Roger Hanson

GEOTECHLOG 443-0026.GPJ MAMIMLOG.GDT 11/5/03

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 3

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SAME AS PREVIOUS PAGE	TILL		9	11	SB	20				
				9	12	SB					
				11	13	SB					
				12	14	SB					
				12	15	SB					
51	END OF BORING										

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 4

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 1 OF 2

SURFACE ELEVATION 1209.34'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SILTY CLAY, dark brown, dry to moist (ML-OL)	TOPSOIL			1	HSA					
1.5	**LEAN CLAY**, brown, moist, medium (CL)	FINE ALLUVIUM		5	2	SB	22				
4	**LEAN CLAY**, gray mottled, very moist, medium (CL)	MIXED ALLUVIUM		4	3	SB	30	90			
					4	B*			34	18	
7	**SANDY LEAN CLAY,** with a little gravel, brown mottled, moist, medium to stiff (CL)	TILL			5	3T	27				
				6	6	SB	24	104			
				10	7	SB	24				
				10	8	SB	22				
				13	9	SB	22				
22	**SANDY LEAN CLAY,** with a little gravel, gray, moist, stiff (CL)			10	10	SB	20				

*Bag sample obtained from 6'-15'. Proctor & Permeability test-see attached sheets.

BORING CONTINUED ON NEXT PAGE

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	HOLE/ CAVE-IN	BAILED DEPTHS	WATER LEVEL
10-31	1:10	51'	49.5'	51'		NONE

START 10/30/03 COMPLETE 10/30/03 @ 1:08

METHOD 3 1/4" HSA 0-49 1/2'

CREW CHIEF: Roger Hanson

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 4

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 2 OF 2

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SAME AS PREVIOUS PAGE	TILL		9	11	SB	21				
				9	12	SB	20				
				9	13	SB					
				10	14	SB					
				9	15	SB					
51	**END OF BORING**										

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 5

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 1 OF 2

SURFACE ELEVATION 1210.15'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SILTY CLAY, dark brown, dry to moist (ML-OL)	TOPSOIL			1	HSA					
1	**LEAN CLAY**, brown, moist, medium (CL)	FINE ALLUVIUM		6	2	SB	21				
4	**SANDY LEAN CLAY,** with a little gravel, brown mottled, moist, medium to stiff, a lens of sand from 4'-5' (CL)	TILL			3	B*					
				6	4	SB	22				
					5	3T	21	103			2600
				14	6	SB	22				
				10	7	SB	22				
				14	8	SB	20				
20	**SANDY LEAN CLAY,** with a little gravel, gray, moist, stiff to medium to stiff (CL)			14	9	SB	20				
	*Bag sample obtained from 6'-10'. Proctor & Permeability test-see attached sheets.			9	10	SB	21				

BORING CONTINUED ON NEXT PAGE

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	HOLE/ CAVE-IN	BAILED DEPTHS	WATER LEVEL
10-29	3:31	51'	49.5'	51'		NONE
10-30	8:45	51'	---	15'		NONE

START 10/29/03 COMPLETE 10/29/03 @ 3:30

METHOD 3 1/4" HSA 0-49 1/2'

CREW CHIEF: Roger Hanson

Maxim Technologies, Inc

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Sioux Falls, South Dakota 57104
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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 5

PROJECT ~ P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SAME AS PREVIOUS PAGE	TILL		8	11	SB	20				
				10	12	SB	21				
				9	13	SB					
				10	14	SB					
51				9	15	SB					
	END OF BORING										

GEOTECHLOG 443-0026.GPJ MAMIMLOG.GDT 11/5/03

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 6

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 1 OF 2

SURFACE ELEVATION 1201.31'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SILTY CLAY, black, dry to moist (ML-OL)	TOPSOIL			1	HSA					
2	**LEAN CLAY**, dark brown, moist, medium (CL)	FINE ALLUVIUM		5	2	SB	23				
3.5	**LEAN CLAY**, brown and gray mottled, very moist, medium (CL/ML)	MIXED ALLUVIUM			3	B*					
				4	4	SB	29				
6	**SANDY LEAN CLAY**, with a little gravel, brown mottled, moist to very moist, medium (CL)	WEATHERED TILL		5	5	SB	25	97			
				6	6	SB	25	97			
11	**SANDY LEAN CLAY**, with a little gravel, brown mottled, moist, medium to stiff (CL)	TILL		8	7	SB	24				
			▼	10	8	SB	23				
	*Bag sample obtained from 5'-15'. Proctor & Permeability test-see attached sheets.			12	9	SB	23				
25	**SANDY LEAN CLAY**, with a little gravel, gray, moist, stiff to medium, a 2" lens of waterbearing sand at 35.3', lenses of silt (CL)			14	10	SB	21				

BORING CONTINUED ON NEXT PAGE

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	HOLE/ CAVE-IN	BAILED DEPTHS	WATER LEVEL
10-29	10:07	31'	29.5'	31'		NONE
10-29	10:50	51'	49.5'	51'		44'
10-30	8:20	51'	---	15'		14 ▼

START 10/29/03 COMPLETE 10/29/03 @ 10:50

METHOD 3 1/4" HSA 0-49 1/2'

CREW CHIEF: Roger Hanson

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 6

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SAME AS PREVIOUS PAGE	TILL		10	11	SB	20				
				10	12	SB	24				
				8	13	SB					
45	**SAND,** fine to medium grained, with a little gravel, gray, waterbearing, medium dense (SP)	COARSE ALLUVIUM		12	14	SB					
				10	15	SB					
51	**END OF BORING**										

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 7

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 1 OF 2

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1200.15')	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SILTY CLAY, black, dry to moist (ML-OL)	TOPSOIL			1	HSA					
1.5	**LEAN CLAY**, brown, moist, medium (CL)	FINE ALLUVIUM		5	2	SB	26				
4	**LEAN CLAY**, brown mottled, moist, medium, a lens of waterbearing sand at 8.5' (CL)	MIXED ALLUVIUM			3	B*					
				5	4	SB	25				
					5	3T	25	97			
			▼	6	6	SB	24	99			
10	**SANDY LEAN CLAY,** with a little gravel, brown mottled, moist, stiff (CL)	TILL		8	7	SB	24	101			
				7	8	SB	27				
				13	9	SB	22				
19	**SANDY LEAN CLAY,** with a little gravel, gray, stiff, a lenses of waterbearing sand at 34.8' and 44.5' (CL)			10	10	SB	19				
	*Bag sample obtained from 5'-15'. Proctor & Permeability test-see attached sheets.			10	11	SB	19				

BORING CONTINUED ON NEXT PAGE

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	HOLE/ CAVE-IN	BAILED DEPTHS	WATER LEVEL
10-29	12:28	26'	24.5'	26'		25'
10-29	1:11	51'	49.5'	51'		24'
10-30	8:30	51'	---	10'		8.6 ▼

START 10/29/03 COMPLETE 10/29/03 @ 1:10

METHOD 3 1/4" HSA 0-49 1/2'

CREW CHIEF: Roger Hanson

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LOG OF TEST BORING

JOB NO. 443-0026 VERTICAL SCALE 1" = 4' BORING NO. 7

PROJECT P. WATER TREATMENT PLANT, LEWIS & CLARK RURAL WATER, NEAR VERMILLION, SD SHEET 2 OF 2

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGICAL ORIGIN	WL	N or CR	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	SAME AS PREVIOUS PAGE	TILL		11	12	SB	20				
				12	13	SB					
				9	14	SB					
				10	15	SB					
51				11	16	SB					
	END OF BORING										

GEOTECHLOG 443-0026.GPJ MAMIMLOG.GDT 11/17/03

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MAXIM TECHNOLOGIES INC

Maxim Technologies Inc.
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Telephone: (605) 332-5371
FAX: (605) 332-8488

REPORT OF MOISTURE-DENSITY RELATIONS

CLIENT: BANNER & ASSOCIATES
PO BOX 298
BROOKINGS, SD 57005

PROJECT NO.: 4430026
REPORT NO.: 14204
DATE OF SERVICE: 11/05/2003
AUTHORIZATION:
REPORT DATE: 11/06/2003

PROJECT: LEWIS & CLARK RURAL WATER
GEOTECHNICAL EXPLORATION PRGM
VERMILLION, SD

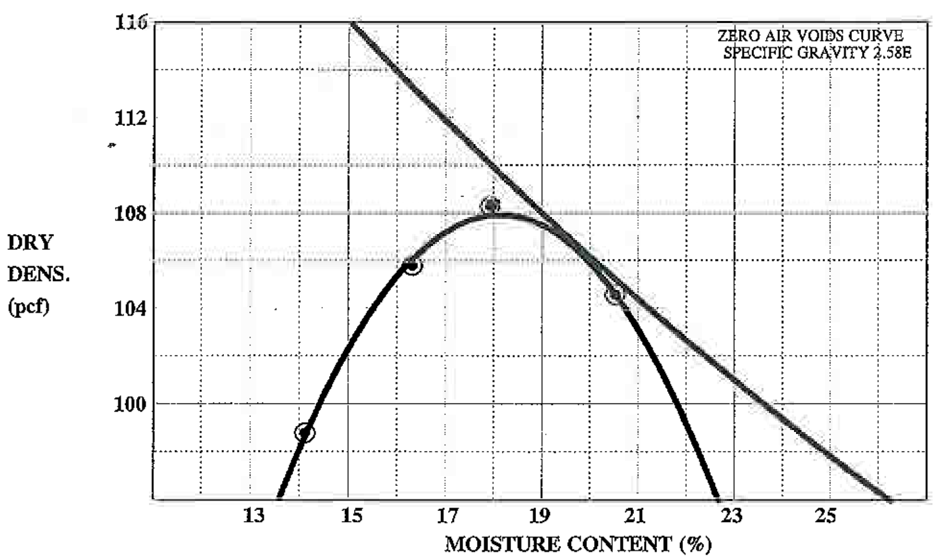
SERVICES: Obtain sample of material used for construction, prepare samples and perform moisture-density relations test to establish the maximum density and optimum moisture of the material.

PROJECT DATA

CONTRACTOR: BANNER & ASSOCIATES
DATE SAMPLED: 10/30/2003
SAMPLED BY: ROGER HANSON
TEST FOR:
SAMPLE LOCATION: BORING #1, SAMPLE #4
DEPTH 5'-15'

TEST DATE: 11/05/2003
MATERIAL: LEAN CLAY, BROWN
CLASSIFICATION: (CL)
MATERIAL PREPARATION METHOD Moist
RAMMER TYPE: MANUAL
METHOD OF TEST: ASTM D698, Method A

REPORT OF TESTS



MAXIMUM DENSITY, PCF: 108.0

OPTIMUM MOISTURE (%): 18.0

% PASSING #200: 71.0

E = Estimated Value

Technician: BILL SUNDVOLD
TECHNICIAN

Report Distribution:
(0) BANNER & ASSOCIATES

MAXIM TECHNOLOGIES INC.

ADAM JOHNSON
SR LAB TECHNICIAN

1006 M

TECHNOLOGIES INC

Maxim Technologies Inc.
601 East 48th Street North
Sioux Falls, SD 57104
Telephone: (605) 332-5371
FAX: (605) 332-8488

REPORT OF MOISTURE-DENSITY RELATIONS

CLIENT: BANNER & ASSOCIATES
PO BOX 298
BROOKINGS, SD 57005

PROJECT NO.: 4430026
REPORT NO.: 14203
DATE OF SERVICE: 11/05/2003
AUTHORIZATION:
REPORT DATE: 11/06/2003

PROJECT: LEWIS & CLARK RURAL WATER
GEOTECHNICAL EXPLORATION PRGM
VERMILLION, SD

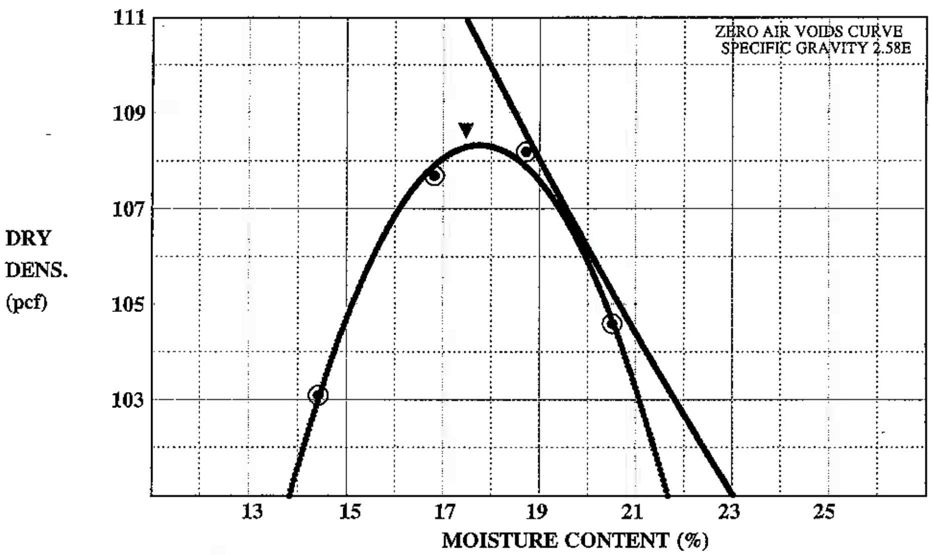
SERVICES: Obtain sample of material used for construction, prepare samples and perform moisture-density relations test to establish the maximum density and optimum moisture of the material.

PROJECT DATA

CONTRACTOR: BANNER & ASSOCIATES
DATE SAMPLED: 10/29/2003
SAMPLED BY: ROGER HANSON
TEST FOR:
SAMPLE LOCATION: BORING #2, SAMPLE #4
DEPTH 7'-15'

TEST DATE: 11/05/2003
MATERIAL: SANDY LEAN CLAY, BROWN
CLASSIFICATION: (CL)
MATERIAL PREPARATION METHOD Moist
RAMMER TYPE: MANUAL
METHOD OF TEST: ASTM D698, Method A

REPORT OF TESTS



MAXIMUM DENSITY, PCF: 108.5

OPTIMUM MOISTURE (%): 17.5

% PASSING #200: 69.0

E = Estimated Value

Technician: BILL SUNDVOLD
TECHNICIAN

Report Distribution:
(0) BANNER & ASSOCIATES

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REPORT OF MOISTURE-DENSITY RELATIONS

CLIENT: BANNER & ASSOCIATES
PO BOX 298
BROOKINGS, SD 57005

PROJECT NO.: 4430026
REPORT NO.: 13874
DATE OF SERVICE: 11/03/2003
AUTHORIZATION:
REPORT DATE: 11/06/2003

PROJECT: LEWIS & CLARK RURAL WATER
GEOTECHNICAL EXPLORATION PRGM
VERMILLION, SD

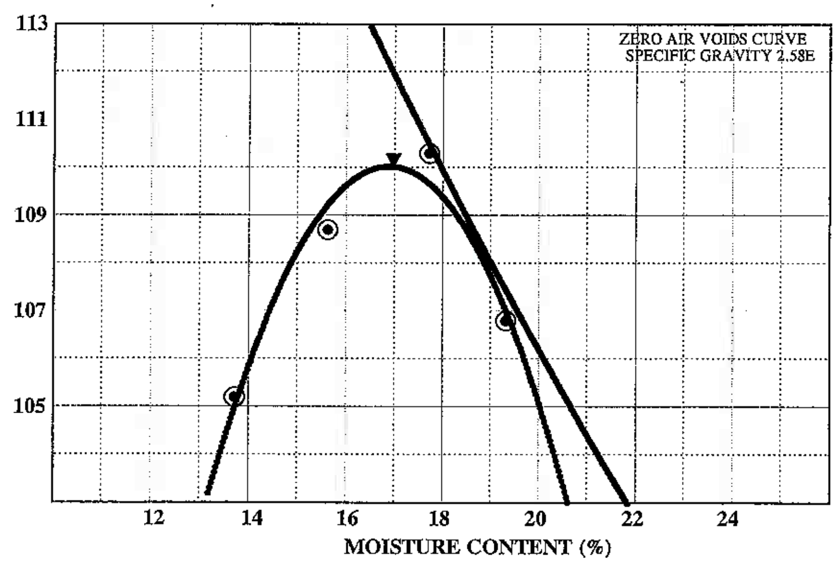
SERVICES: Obtain sample of material used for construction, prepare samples and perform moisture-density relations test to establish the maximum density and optimum moisture of the material.

PROJECT DATA

CONTRACTOR: BANNER & ASSOCIATES
DATE SAMPLED: 10/30/2003
SAMPLED BY: ROGER HANSON
TEST FOR:
SAMPLE LOCATION: BORING #3, SAMPLE #3
DEPTH 4' - 10'

TEST DATE: 11/03/2003
MATERIAL: LEAN CLAY, BROWN
CLASSIFICATION: (CL)
MATERIAL PREPARATION METHOD Moist
RAMMER TYPE: MANUAL
METHOD OF TEST: ASTM D698, Method A

REPORT OF TESTS



MAXIMUM DENSITY, PCF: 110.0

OPTIMUM MOISTURE (%): 17.0

% PASSING #200: 71.0

E = Estimated Value

Technician: BILL SUNDVOLD
TECHNICIAN

Report Distribution:
(0) BANNER & ASSOCIATES

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REPORT OF MOISTURE-DENSITY RELATIONS

CLIENT: BANNER & ASSOCIATES
PO BOX 298
BROOKINGS, SD 57005

PROJECT NO.: 4430026
REPORT NO.: 13875
DATE OF SERVICE: 11/04/2003
AUTHORIZATION:
REPORT DATE: 11/06/2003

PROJECT: LEWIS & CLARK RURAL WATER
GEOTECHNICAL EXPLORATION PRGM
VERMILLION, SD

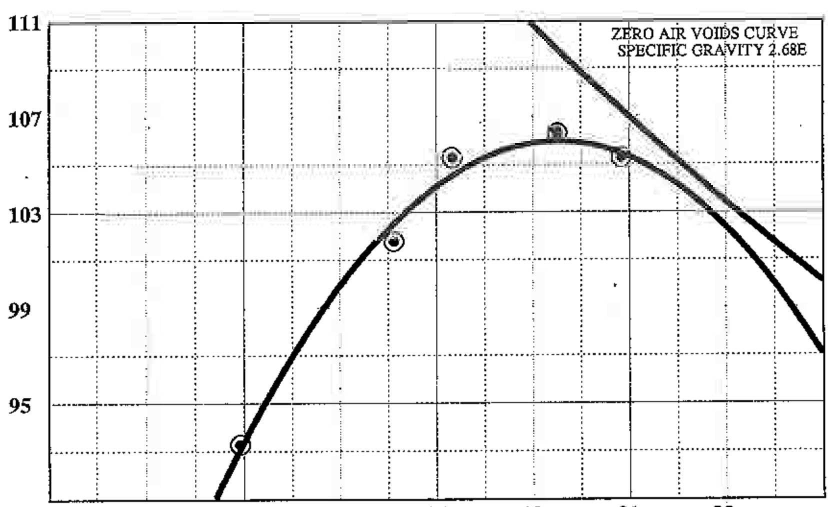
SERVICES: Obtain sample of material used for construction, prepare samples and perform moisture-density relations test to establish the maximum density and optimum moisture of the material.

PROJECT DATA

CONTRACTOR: BANNER & ASSOCIATES
DATE SAMPLED: 10/30/2003
SAMPLED BY: ROGER HANSON
TEST FOR:
SAMPLE LOCATION: BORING #4, SAMPLE #4
DEPTH 6' - 15'

TEST DATE: 11/03/2003
MATERIAL: LEAN CLAY, BROWN
CLASSIFICATION: (CL)
MATERIAL PREPARATION METHOD Moist
RAMMER TYPE: MANUAL
METHOD OF TEST: ASTM D698, Method A

REPORT OF TESTS



MAXIMUM DENSITY, PCF: 106.0

OPTIMUM MOISTURE (%): 19.5

LIQUID LIMIT: 34
PLASTIC LIMIT: 18
PLASTICITY INDEX: 16
% PASSING #200: 74.0

E = Estimated Value

Technician: BILL SUNDVOLD
TECHNICIAN

Report Distribution:
(0) BANNER & ASSOCIATES

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REPORT OF MOISTURE-DENSITY RELATIONS

CLIENT: BANNER & ASSOCIATES
PO BOX 298
BROOKINGS, SD 57005

PROJECT NO.: 4430026
REPORT NO.: 13873
DATE OF SERVICE: 11/03/2003
AUTHORIZATION:
REPORT DATE: 11/06/2003

PROJECT: LEWIS & CLARK RURAL WATER
GEOTECHNICAL EXPLORATION PRGM
VERMILLION, SD

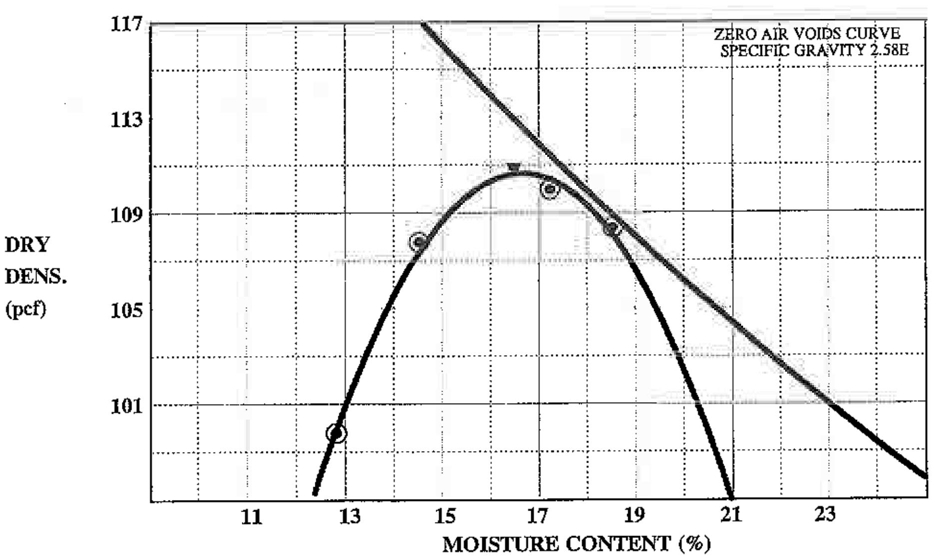
SERVICES: Obtain sample of material used for construction, prepare samples and perform moisture-density relations test to establish the maximum density and optimum moisture of the material.

PROJECT DATA

CONTRACTOR: BANNER & ASSOCIATES
DATE SAMPLED: 10/29/2003
SAMPLED BY: ROGER HANSON
TEST FOR:
SAMPLE LOCATION: BORING #5, SAMPLE #3
DEPTH 5' - 15'

TEST DATE: 11/03/2003
MATERIAL: SANDY LEAN CLAY, BROWN
CLASSIFICATION: (CL)
MATERIAL PREPARATION METHOD Moist
RAMMER TYPE: MANUAL
METHOD OF TEST:

REPORT OF TESTS



MAXIMUM DENSITY, PCF: 110.5

OPTIMUM MOISTURE (%): 16.5

% PASSING #200: 65.0

E = Estimated Value

Technician: BILL SUNDVOLD
TECHNICIAN

Report Distribution:
(0) BANNER & ASSOCIATES

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SR LAB TECHNICIAN

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REPORT OF MOISTURE-DENSITY RELATIONS

CLIENT: BANNER & ASSOCIATES
PO BOX 298
BROOKINGS, SD 57005

PROJECT NO.: 4430026
REPORT NO.: 14202
DATE OF SERVICE: 11/05/2003
AUTHORIZATION:
REPORT DATE: 11/06/2003

PROJECT: LEWIS & CLARK RURAL WATER
GEOTECHNICAL EXPLORATION PRGM
VERMILLION, SD

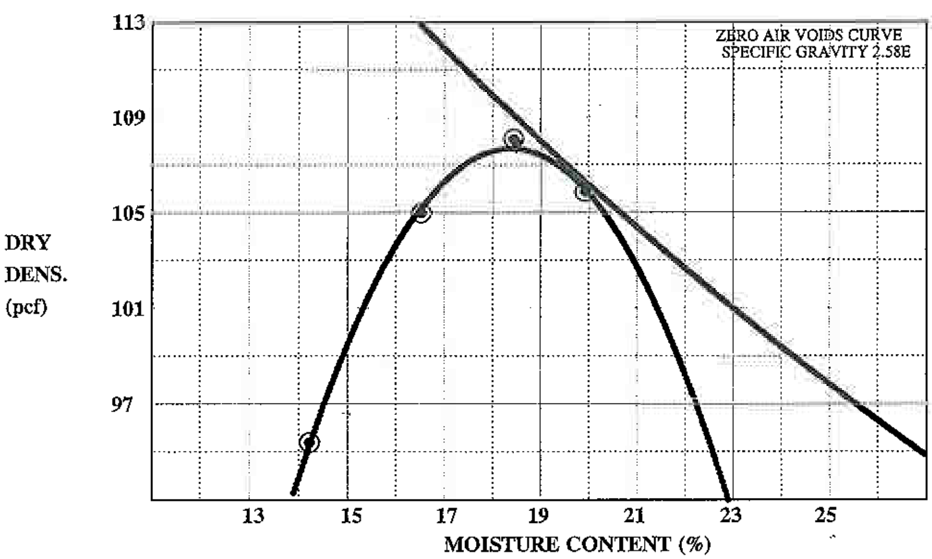
SERVICES: Obtain sample of material used for construction, prepare samples and perform moisture-density relations test to establish the maximum density and optimum moisture of the material.

PROJECT DATA

CONTRACTOR: BANNER & ASSOCIATES
DATE SAMPLED: 10/29/2003
SAMPLED BY: ROGER HANSON
TEST FOR:
SAMPLE LOCATION: BORING #6, SAMPLE #3
DEPTH 5' - 15'

TEST DATE: 11/05/2003
MATERIAL: LEAN CLAY, BROWN
CLASSIFICATION: (CL)
MATERIAL PREPARATION METHOD Moist
RAMMER TYPE: MANUAL
METHOD OF TEST: ASTM D698, Method A

REPORT OF TESTS



MAXIMUM DENSITY, PCF: 107.5
OPTIMUM MOISTURE (%): 18.5
% PASSING #200: 75.0

E = Estimated Value

Technician: BILL SUNDVOLD
TECHNICIAN

Report Distribution:
(0) BANNER & ASSOCIATES

MAXIM TECHNOLOGIES INC.

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Sioux Falls, SD 57104
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FAX: (605) 332-8488

REPORT OF MOISTURE-DENSITY RELATIONS

CLIENT: BANNER & ASSOCIATES
PO BOX 298
BROOKINGS, SD 57005

PROJECT NO.: 4430026
REPORT NO.: 13876
DATE OF SERVICE: 11/04/2003
AUTHORIZATION:
REPORT DATE: 11/06/2003

PROJECT: LEWIS & CLARK RURAL WATER
GEOTECHNICAL EXPLORATION PRGM
VERMILLION, SD

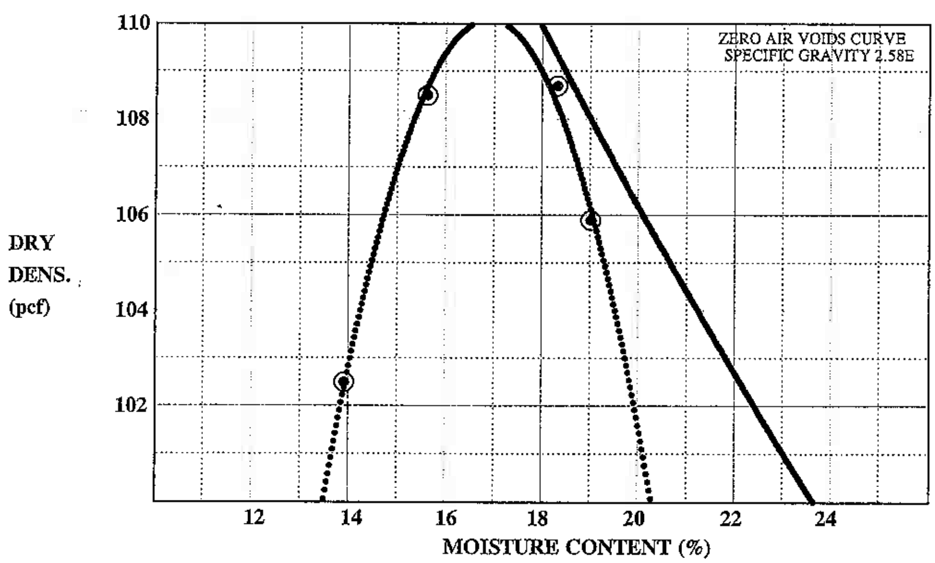
SERVICES: Obtain sample of material used for construction, prepare samples and perform moisture-density relations test to establish the maximum density and optimum moisture of the material.

PROJECT DATA

CONTRACTOR: BANNER & ASSOCIATES
DATE SAMPLED: 10/29/2003
SAMPLED BY: ROGER HANSON
TEST FOR:
SAMPLE LOCATION: BORING #7, SAMPLE #3
DEPTH 5' - 15'

TEST DATE: 11/04/2003
MATERIAL: LEAN CLAY, BROWN
CLASSIFICATION: (CL)
MATERIAL PREPARATION METHOD Moist
RAMMER TYPE: MANUAL
METHOD OF TEST: ASTM D698, Method A

REPORT OF TESTS



MAXIMUM DENSITY, PCF: 110.0

OPTIMUM MOISTURE (%): 17.0

% PASSING #200: 71.0

E = Estimated Value

Technician: BILL SUNDVOLD
TECHNICIAN

Report Distribution:
(0) BANNER & ASSOCIATES

MAXIM TECHNOLOGIES INC.

ADAM JOHNSON
SR LAB TECHNICIAN

PERMEABILITY TEST DATA

PROJECT P. Water Treatment Plant Site
Lewis & Clark Rural Water Systems
Near Vermillion, SD
DATE 11/12/2003

REPORTED TO Banner & Associates
JOB NO. 443-0026

Boring No.	1	2	3	4
Sample No.	4	4	3	4
Depth	5' - 15'	7' - 15'	4' - 10'	6' - 15'
Type of Sample	Bag	Bag	Bag	Bag
Soil Classification (ASTM: D 2487) Symbol	Lean Clay, brown (CL)	Sandy Lean Clay, brown (CL)	Lean Clay, brown (CL)	Lean Clay, brown (CL)
In-place Moisture Content (%)	18.8	17.9	17.6	19.8
Moisture Density Relation of Soil (ASTM:D698)				
Max. Dry Density (PCF)	108.0	108.5	110.0	106.0
Optimum Moisture Content (%)	18.0	17.5	17.0	19.5
Permeability Test				
Trial No.	12	12	12	12
Type of Test	Falling Head	Falling Head	Falling Head	Falling Head
Type of Specimen	Remolded	Remolded	Remolded	Remolded
Specimen Height (inches)	3.00	3.00	3.00	3.00
Specimen Diameter (inches)	2.82	2.82	2.82	2.83
Dry Density (PCF)	102.5	103.0	104.2	101.0
Percent of Max. Density	95	95	95	95
Moisture Content (%)	18.8	17.9	17.6	19.8
Max. Head Differential (ft)	5	5	5	5
Confining Pressure (effective-PSI)	2	2	2	2
Water Temperature (°C)	21	21	21	21
Coefficient of Permeability				
K @ 20°C (cm/sec)	7.98×10^{-8}	8.13×10^{-8}	7.34×10^{-8}	8.05×10^{-8}
K @ 20°C (ft/min)	1.56×10^{-7}	1.59×10^{-7}	1.44×10^{-7}	1.58×10^{-7}
Atterberg Limits				
Liquid Limit (%)	Not Tested	Not Tested	Not Tested	34
Plastic Limit (%)	Not Tested	Not Tested	Not Tested	18
Plastic Index	Not Tested	Not Tested	Not Tested	16

PERMEABILITY TEST DATA

PROJECT	P. Water Treatment Plant Site	DATE	11/12/2003
	Lewis & Clark Rural Water Systems		
	Near Vermillion, SD		
REPORTED TO	Banner & Associates	JOB NO.	443-0026

Boring No.	5	6	7	
Sample No.	3	3	3	
Depth	5' - 15'	5' - 15'	5' - 15'	
Type of Sample	Bag	Bag	Bag	
Soil Classification (ASTM: D 2487) Symbol	Sandy Lean Clay, brown (CL)	Lean Clay, brown (CL)	Lean Clay, brown (CL)	
In-place Moisture Content (%)	17.0	19.0	17.4	
Moisture Density Relation of Soil (ASTM:D698) Max. Dry Density (PCF)	110.5	107.5	110.0	
Optimum Moisture Content (%)	16.5	18.5	17.0	
Permeability Test Trial No.	12	12	12	
Type of Test	Falling Head	Falling Head	Falling Head	
Type of Specimen	Remolded	Remolded	Remolded	
Specimen Height (inches)	3.00	3.00	3.00	
Specimen Diameter (inches)	2.82	2.83	2.83	
Dry Density (PCF)	105.0	102.3	104.1	
Percent of Max. Density	95	95	95	
Moisture Content (%)	17.0	19.0	17.4	
Max. Head Differential (ft)	5	5	5	
Confining Pressure (effective-PSI)	2	2	2	
Water Temperature (^oC)	21	21	21	
Coefficient of Permeability K @ 20°C (cm/sec)	$7.24X10^{-8}$	$7.65X10^{-8}$	$6.13X10^{-8}$	
K @ 20°C (ft/min)	$1.42X10^{-7}$	$1.50X10^{-7}$	$1.20X10^{-7}$	
Atterberg Limits Liquid Limit (%)	Not Tested	Not Tested	Not Tested	
Plastic Limit (%)	Not Tested	Not Tested	Not Tested	
Plastic Index	Not Tested	Not Tested	Not Tested	

MAXIM

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A TETRA TECH COMPANY

Maxim Technologies, Inc.®
601 East 48th Street North
Sioux Falls, South Dakota 57104-0698
(605) 332-5371
Fax: (605) 332-8488

REPORT OF: CHEMICAL ANALYSIS

PROJECT: LEWIS & CLARK RURAL WATER **DATE:** November 18, 2003

REPORTED TO: BANNER ASSOCIATES, INC.
ATTN: MR. TIMOTHY R. CONNER, PE
402 22ND AVENUE SOUTH
PO BOX 298
BROOKING, SD 57006-0298

LABORATORY NO: 443-0027
Date Received: 11-04-02

Parameter	B-1 6'-10' 03-6684	B-1 15'-25' 03-6685	B-2 6'-10' 03-6686	B-2 15'-25' 03-6687	PQL	Method*	Date Analyzed
pH	7.57	7.08	7.59	7.10	---	T289	11-17
Chloride, mg/kg	<6.0	<6.0	12	<6.0	6.0	T291	11-11
Sulfate, mg/kg	290	220	310	190	25	T290	11-11
Resistivity, ohm-cm	1201	749	1329	806	---	T288	11-17

Parameter	B-3 6'-10' 03-6688	B-3 15'-25' 03-6689	B-4 6'-10' 03-6690	B-4 15'-25' 03-6691	PQL	Method*	Date Analyzed
pH	7.53	7.01	7.52	7.37	---	T289	11-17
Chloride, mg/kg	<6.0	<6.0	<6.0	<6.0	6.0	T291	11-11
Sulfate, mg/kg	430	49	7400	1500	25	T290	11-11
Resistivity, ohm-cm	1596	800	616	542	---	T288	11-17

Parameter	B-5 6'-10' 03-6692	B-5 15'-25' 03-6693	B-6 6'-10' 03-6694	B-7 6'-10' 03-6695	PQL	Method	Date Analyzed
pH	7.46	7.08	7.65	7.65	---	T289	11-17
Chloride, mg/kg	25	<6.0	<6.0	<6.0	6.0	T291	11-11
Sulfate, mg/kg	6900	100	1400	1900	25	T290	11-11
Resistivity, ohm-cm	665	716	640	893	---	T288	11-17

* - American Association of State Highway and Transportation Officials, AASHTO
mg/kg is equal to parts per million.

LABORATORY QUALITY CONTROL

		ACCURACY DATA		PRECISION DATA
Parameter	Sample #	Matrix Spike Percent Recovery	Matrix Spike Duplicate Percent Recovery	Relative Percent Difference
Sulfate	03-6687	---	---	0.2%

If you have any questions or comments concerning this report, please feel free to contact us.

MAXIM TECHNOLOGIES, INC.

Pari Skoog
Inorganic Chemist

Dan T. Hanson
Chemistry Manager

G:data/wpfiles/dth/2003/4430027-gsi-soil-001

SAMPLE RECEIPT CHECKLIST

27

CLIENT NAME: SF Geotech.
PROJECT: Lewis & clark Rural water
LABORATORY NUMBER: 4430026

DATE RECEIVED: 11/4/9
CARRIER: Hand

CHECKLIST COMPLETED BY: DH

	YES	NO
1. Shipping container in good condition?	N/A	
2. Custody seals present on shipping container?		
3. Condition: Intact___ Broken___		
4. Chain of custody present?		X
5. Chain of custody signed when relinquised and recieved?	N/A	
6. Chain of custody agrees with sample labels?	X	
7. Custody seals on sample bottles?		X
8. Condition: Intact___ Broken___		
9. Samples in proper container/bottle?	X	
10. Samples intact?	X	
11. VOA vials have zero headspace?	N/A	
12. Trip Blank recieved?		

	YES	NO
13. Ice/Frozen Blue Ice present?		✓
14. Container temperature? Ambient		
15. All samples recieved within holding time?	X	
PRESERVATION:		
16. pH check performed by: N/A		
17. Metals bottle(s) pH < 2?		
18. Nutrient bottle(s) pH < 2?		
19. Cyanide bottle(s) pH > 12?		
20. Oil & Grease bottle(s) pH < 2?		
21. DRO/418.1 bottle(s) pH < 2?		
22. Phenolics bottle(s) pH < 2?		
23. Volatiles (VOA) pH < 2? (checked by analyst)		

Client contacted for any reason? YES____ NO X

Person contacted? ______

Date contacted? ______

Contacted by? ______

Regarding? ______

Additional Comments: ______

GENERAL NOTES

DRILLING AND SAMPLING SYMBOLS

SYMBOL	DEFINITION
HSA	3 1/4" I.D. Hollow Stem Auger
_FA	4", 6" or 10" Diameter Flight Auger
_HA	2", 4" or 6" Hand Auger
_DC	2 1/2", 4", 5" or 6" Steel Drive Casing
_RC	Size A, B, or N Rotary Casing
PD	Pipe Drill or Cleanout Tube
CS	Continuous Split Barrel Sampling
DM	Drilling Mud
JW	Jetting Water
SB	2" O.D. Split Barrel Sample
_L	2 1/2" or 3 1/2" O.D. SB Liner Sample
_T	2" or 3" Thin Walled Tube Sample
3TP	3" Thin Walled Tube (Pitcher Sampler)
_TO	2" or 3" Thin Walled Tube (Osterberg Sampler)
W	Wash Sample
B	Bag Sample
P	Test Pit Sample
_Q	BQ, NQ, or PQ Wireline System
_X	AX, BX, or NX Double Tube Barrel
CR	Core Recovery - Percent
NSR	No Sample Recovered, classification based on action of drilling equipment and/or material noted in drilling fluid or on sampling bit.
NMR	No Measurement Recorded, primarily due to presence of drilling or coring fluid.
▼	Water Level Symbol

TEST SYMBOLS

SYMBOL	DEFINITION
W	Water Content - % of Dry Wt. - ASTM D 2216
D	Dry Density - Pounds Per Cubic Foot
LL, PL	Liquid and Plastic Limit - ASTM D 4318

Additional Insertions in Last Column

Qu	Unconfined Comp. Strength-psf - ASTM D 2166
Pq	Penetrometer Reading - Tons/Square Foot
Ts	Torvane Reading - Tons/Square Foot
G	Specific Gravity - ASTM D 854
SL	Shrinkage Limits - ASTM D 427
OC	Organic Content - Combustion Method
SP	Swell Pressure - Tons/Square Foot
PS	Percent Swell
FS	Free Swell - Percent
pH	Hydrogen Ion Content, Meter Method
SC	Sulfate Content - Parts/Million, same as mg/L
CC	Chloride Content - Parts/Million, same as mg/L
C*	One Dimensional Consolidation - ASTM D 2435
Qc*	Triaxial Compression
D.S.*	Direct Shear - ASTM D 3080
K*	Coefficient of Permeability - cm/sec
D*	Dispersion Test
DH*	Double Hydrometer - ASTM D 4221
MA*	Particle Size Analysis - ASTM D 422
R	Laboratory Resistivity, in ohm.- cm - ASTM G 57
E*	Pressuremeter Deformation Modulus - TSF
PM*	Pressuremeter Test
VS*	Field Vane Shear - ASTM D 2573
IR*	Infiltrometer Test - ASTM D 3385
RQD	Rock Quality Designation - Percent

* See attached data sheet or graph

WATER LEVEL

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels may be considered reliable ground water levels. In clay soil, it may not be possible to determine the ground water level within the normal time required for test borings, except where lenses or layers of more pervious waterbearing soil are present. Even then, an extended period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the ground water table. Perched water refers to water above an impervious layer, thus impeded in reaching the water table. The available water level information is given at the bottom of the log sheet.

DESCRIPTIVE TERMINOLOGY

DENSITY TERM	"N" VALUE	CONSISTENCY TERM
Very Loose	0-4	Soft
Loose	5-8	Medium
Medium Dense	9-15	Rather Stiff
Dense	16-30	Stiff
Very Dense	Over 30	Very Stiff

Standard "N" Penetration: Blows Per Foot of a 140 Pound Hammer Falling 30 inches on a 2 inch OD Split Barrel Sampler

Lamination	Up to 1/2" thick stratum
Layer	1/2" to 6" thick stratum
Lens	1/2" to 6" discontinous stratum, pocket
Varved	Alternating laminations of clay, silt and /or fine grained sand, or colors thereof
Dry	Powdery, no noticeable water
Moist	Below saturation
Wet	Saturated, above liquid limit
Waterbearing	Pervious soil below water

RELATIVE GRAVEL PROPORTIONS

CONDITION	TERM	RANGE
Coarse Grained Soils	A little gravel	2 - 14%
	With gravel	15 - 49%
Fine Grained Soils		
15-29% + No. 200	A little gravel	2 - 7%
15-29% + No. 200	With gravel	8 - 29%
30% + No. 200	A little gravel	2 - 14%
30% + No. 200	With gravel	15 - 24%
30% + No. 200	Gravelly	16 - 49%

RELATIVE SIZES

Boulder	Over 12"
Cobble	3" - 12"
Gravel	
Coarse	3/4" - 3"
Fine	#4 - 3/4"
Sand	
Coarse	#4 - #10
Medium	#10 - #40
Fine	#40 - #200
Silt & Clay	—#200, Based on Plasticity

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM Designation: D 2487 - 83
(Based on Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	$PI > 7$ and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			$PI < 4$ or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains $\geq$15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains $\geq$30% plus no. 200, predominantly sand, add "sandy" to group name.

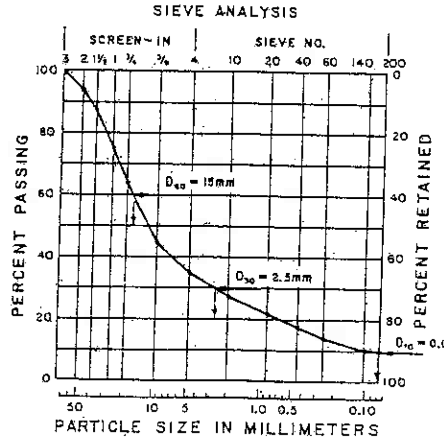
[M] If soil contains $\geq$30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] $PI \geq 4$ and plots on or above "A" line.

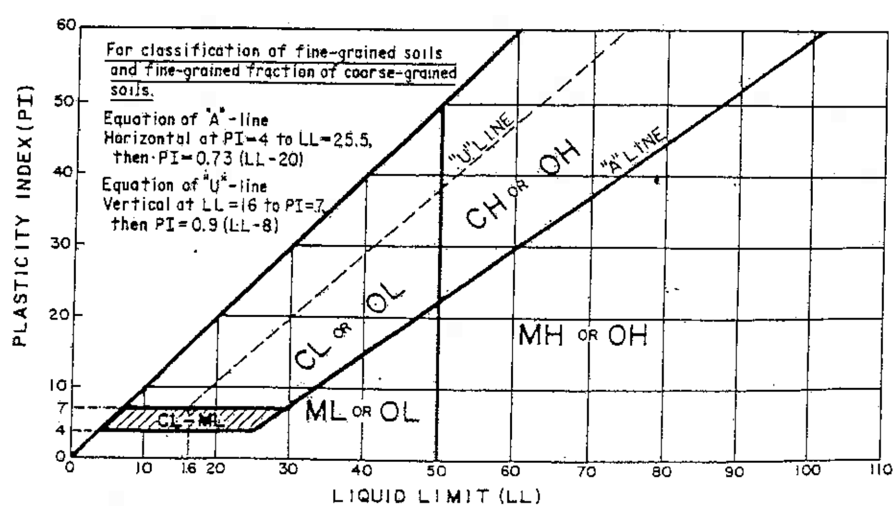
[O] $PI < 4$ or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200 \qquad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$

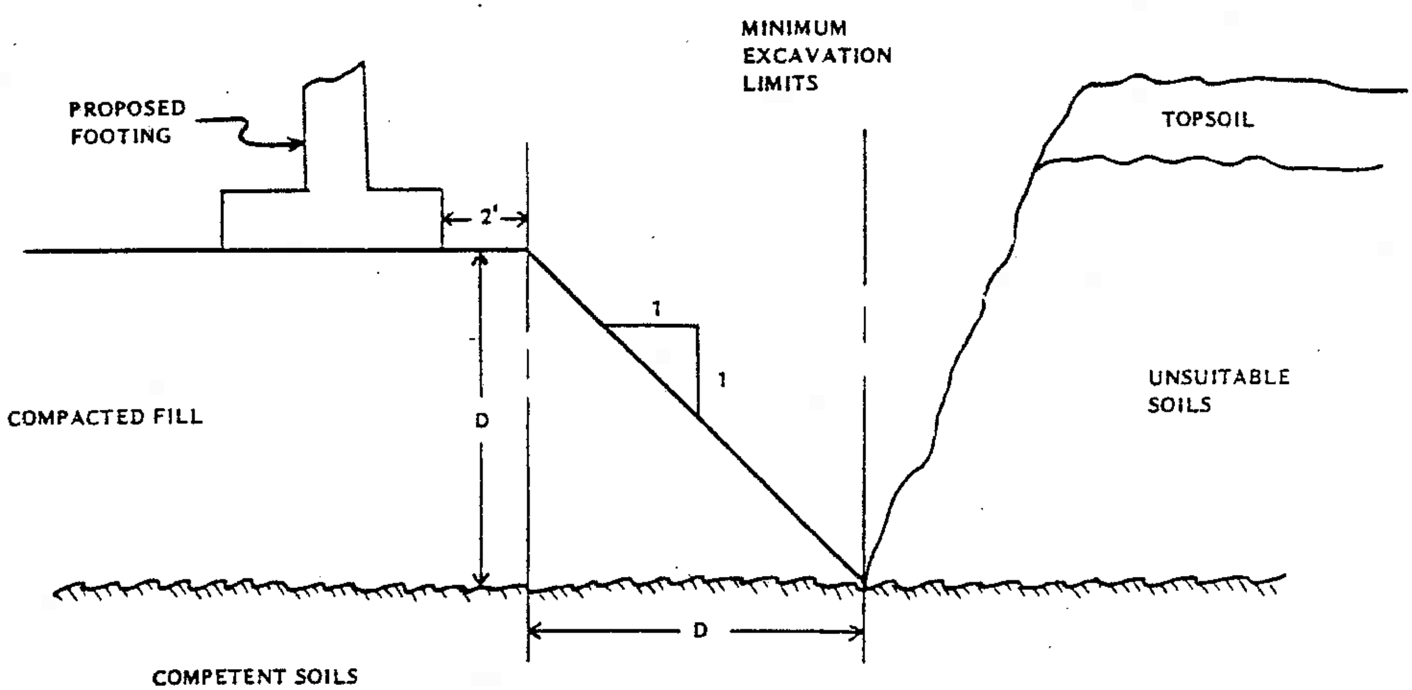


GLOSSARY OF TERMS

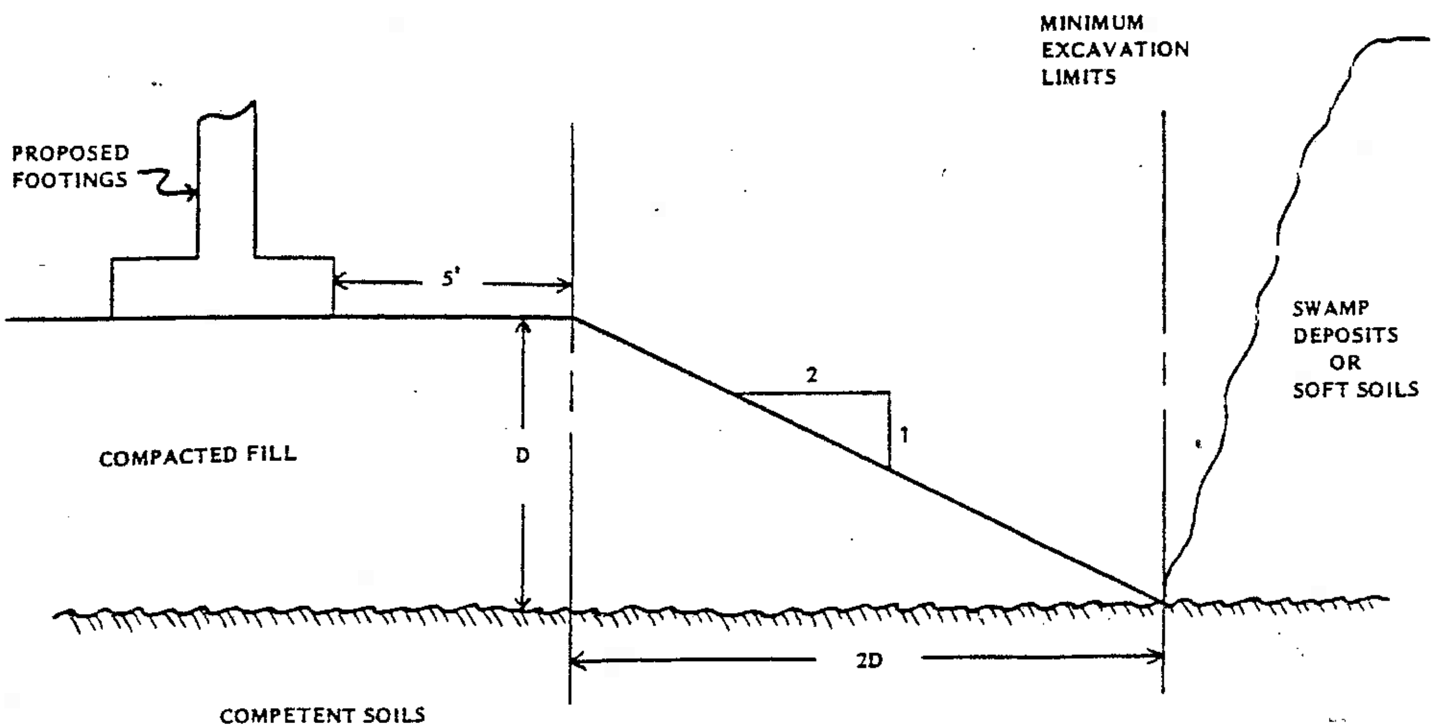
AGGREGATE	Mineral material such as sand, gravel or combinations thereof.
ALLOWABLE BEARING PRESSURE	The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.
ALLUVIUM	Deposits from modern rivers.
ARGILLACEOUS	Rocks composed of or having a notable proportion of clay in their composition.
ARENACEOUS	Derived from or containing sand.
BACKFILL	A specified material placed and compacted in a confined area.
BASE COURSE	A layer of specified material placed on a subgrade or subbase.
BEDROCK	The solid rock underlying soils and other earthy surface formations.
BENCH	A horizontal surface in a sloped deposit.
BLOCKY STRUCTURE	Soil particles arranged around a point with the three dimensions of the same order of magnitude.
CAISSON	A concrete foundation element cast in a circular excavation, which may have an enlarged base. Sometimes referred to as a cast-in- place pier.
CALCAREOUS	Containing calcium carbonate determined by effervescence when treated with dilute hydrochloric acid.
COLLUVIUM	Mixtures of soil and rock materials moved by gravity usually near base of strong slopes.
COMPACTION	Mechanical densification of soils causing the expulsion of air from the void spaces.
CONCRETE SLAB-ON-GRADE	A concrete surface layer cast directly on a base, subbase or subgrade.
CONSOLIDATION	The reduction of the void ratio of a soil mass due to its own weight or superimposed loads. The time rate of consolidation is dependent on the permeability of the soil and the rate of loading.
CRUSHED ROCK BASE COURSE	A base course composed of crushed rock of a specified gradation.
DIFFERENTIAL SETTLEMENT	Unequal settlement between or within foundation elements of a structure.
ENGINEERED FILL	Specified material placed and compacted to specified density and/or moisture conditions under observation of a representative of a soil engineer.
EXISTING FILL	Materials deposited through the action of man prior to exploration of the site.
EXISTING GRADE	The ground surface at the time for field exploration.
EXPANSIVE POTENTIAL	The potential of a soil to expand (increase in volume) due to the absorption of moisture.

FILL	Materials deposited by the action of a man.
FINISHED GRADE	The final grade created as a part of the project.
HORIZON	The various layers that comprise a soil (A-C) distinguished principally by its texture, color, structure and chemical content.
LOESS	Geological deposit of relatively uniform, primarily silt material presumably transported by wind.
NATIVE SOIL	The naturally occurring soils on the site.
OUTCROP	The exposure of bedrock at the surface of the ground.
OVERBURDEN	Undifferentiated, unconsolidated material directly over a deposit of rock.
PERMEABILITY	The capacity of a material to transmit a fluid.
PUMPING	Phenomenon where the soil surface undulates under transient loads due to applied stress being carried by the fluids in the voids in the soil mass. Severe cases result in rupture of the soil surface.
ROCK	A natural agglomerate of mineral grains connected by strong and permanent cohesive forces. usually requires drilling, wedging, blasting of other methods of extraordinary force for excavation.
SCARIFY	To mechanically loosen soil or break down existing soil structure.
SETTLEMENT	Downward movement.
SILICEOUS	Containing silica.
SLICKENSIDE	Polished and striated surface that results from friction along a plane of movement.
SOIL	Any unconsolidated material composed of discrete solid particles, derived from the physical and/or chemical disintegration of vegetable or mineral matter, which can be separated by gentle mechanical means such as agitation in water.
STRIP	To remove from present location.
SUBBASE	A layer of specified material placed to form a layer between the subgrade and base course.
SUBBASE GRADE	Top of subbase.
SUBGRADE	Prepared soil surface.
TILL	Nonsorted, nonstratified sediment carried or deposited by a glacier.
VOID RATIO	The ratio of the volume of voids to the volume of solid particles in a soil mass.
WEATHERING	The physical and chemical disintegration and decomposition of rocks and materials.
VARVE	Alternating thin layers of silt (or fine sand) and clay.
VUG	A cavity, often lined with a mineral of different composition than the parent material.

NORMAL EXCAVATION OVERSIZE



OVERSIZE FOR SWAMP OR EXTREMELY SOFT SOIL CONDITONS



PRECAUTIONS FOR EXCAVATING AND REFILLING DURING COLD WEATHER

The winter season in this area presents specific problems for foundation construction. Soils which are allowed to freeze undergo a moisture volume expansion, resulting in a loss of density. These frost-expanded soils will consolidate upon thawing, causing settlement of any structure supported on them. To prevent this settlement, frost should not be allowed to penetrate into the soils below any proposed structure.

Ideally, winter excavation should be limited to areas small enough to be refilled to a grade higher than footing grade on the same day. Typically, these areas should be filled to floor grade. Trenching back down to unfrozen soils for foundation construction can then be performed just prior to footing placement. The excavated trenches should be protected from freezing by means of insulating or heating during foundation construction. Backfilling of the foundation trenches should be performed immediately after the below-grade foundation construction is finished. In addition, any interior footings, or footings designed without frost protection should be extended below frost depth, unless adequate precautions are taken to prevent frost intrusion until the building can be enclosed and heated.

In many cases, final grade cannot be attained in one day's time, even though small areas are worked. In the event final grade cannot be attained in one day's time, frost can be expected to develop overnight. The depth of frost penetration can be minimized by leaving a layer of loose soil on top of the compacted material overnight. However, any frost which forms in this loose layer, or snow which accumulates, should be completely removed from the fill area prior to compaction and additional soil placement. Frozen soils, or soils containing frozen material or snow should never be used as fill material.

After the structure has been enclosed, all floor slab areas should be subjected to ample periods of heating to allow thawing of the soil system. Alternatively, the frozen soils can be completely removed and be replaced with an engineered fill. The floor slab areas should be checked at random and representative locations for remnant areas of frost, and density tests should be performed to document fill compaction prior to slab placement.

Due to the potential problems associated with fill placement during cold weather, any filling operations should be monitored by a full-time, on-site soils technician. Full-time monitoring aids in detecting areas of frozen material, or potential problems with frozen material within the fill, so that appropriate measures can be taken. The choice of fill material is particularly important during cold weather, since clean granular fill materials can be placed and compacted more efficiently than silty or clayey soils. In addition, greater magnitudes of heaving can be expected with freezing of the more frost susceptible silts and clays.

If more specific frost information or cold weather data concerning other construction materials is required, please contact us.

CONSTRUCTION OBSERVATIONS AND TESTING

The recommendations made in this report have been made based on the subsurface conditions found in the borings. It is possible that there are soil and water conditions on-site that were not represented by those borings. Consequently, 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.

We recommend that the completed excavation and prepared subgrade be observed and tested by a soils engineer/technician prior to fill placement or construction of any foundation elements. These observations would be necessary to judge if all unsuitable materials have been removed from within the planned construction area and that an appropriate degree of lateral oversize has been provided for in those areas where fill will be placed below the bottom of foundation grade.

We recommend a representative number of field density tests be taken in all engineered fill placed to aid in judging its suitability. We suggest that at least one density test be performed for at least every 2000 square feet of engineered fill placed for every 2' of fill depth. Additional tests should be taken where confined areas are compacted. The actual number of tests should be left to the discretion of a qualified engineer or his representative. Any proposed fill material should be submitted to the laboratory for tests to check compliance with our recommendations and project specifications.

FIELD EXPLORATION PROCEDURES

Soil Sampling

Soil sampling was performed in accordance with ASTM:D1586. Using this procedure, a 2", outer diameter, split barrel sampler is driven into the soil by a 140 pound weight falling 30". After an initial set of 6", the number of blows required to drive the sampler an additional 12" is known as the penetration resistance or "N" values. The "N" value is an index of the relative density of the cohesionless soils and the consistency of cohesive soils. Thin walled tube samples, if taken, were obtained according to ASTM:D1587 where indicated by the appropriate symbol on the boring logs. Rock core samples, if taken, were obtained by rotary drilling in accordance with ASTM:D2113. Power auger borings, if performed, were done in general accordance with ASTM:D1452.

Soil Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief in accordance with ASTM:D2487. Representative portions of the samples were then returned to the laboratory for further examination and for verification of the field classification. Logs of the borings indicating the depth and identification of the various strata, the "N" value, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are attached. Charts illustrating the soil classification procedure, the descriptive terminology and the symbols used on the boring logs are also included in Appendix A.