APPENDIX B

Geotechnical Engineering Report

Teach AML Reclamation Project
11516 220th Avenue
Ottumwa, Iowa

January 17, 2013
Terracon Project No. 08125070-02

Prepared for:
Trihydro Corporation
Laramie, Wyoming

Prepared by:
Terracon Consultants, Inc.
Des Moines, Iowa

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January 17, 2013

Trihydro Corporation
1252 Commerce Drive
Laramie, Wyoming 82070

Attn: Mr. Derrick Thompson, EIT

Re: Geotechnical Engineering Report
Teach AML Reclamation
11516 220th Avenue
Ottumwa, Iowa
Terracon Project No. 08125070-02

Dear Mr. Thompson:

Terracon Consultants, Inc. (Terracon) completed a subsurface exploration and geotechnical engineering services for the Teach Abandoned Mine Land (AML) Reclamation project in Ottumwa, Iowa. Terracon performed these services in general accordance with our proposal dated September 6, 2012 (Terracon Proposal No. P08120509). Terracon completed a wetland delineation report for this site (Terracon Project No. 08127120, dated December 13, 2012), and was submitted under separate cover. This report presents the results of our subsurface exploration and provides geotechnical recommendations for earthwork.

We appreciate the opportunity to be of service to you on this project. If you have any questions regarding this report, or if we may be of further service to you, please contact us.

Sincerely,
Terracon Consultants, Inc.

Alexander J. Wolfe, E.I.
Staff Geotechnical Engineer

Brett E. Bradfield, P.E.
Senior Project Engineer

Report Distribution: Addressee (1) + PDF

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

January 17, 2013
Brett E. Bradfield, P.E. Date

My license renewal date is December 31, 2014.

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GEOTECHNICAL ENGINEERING REPORT
TEACH AML RECLAMATION PROJECT
11516 220TH AVENUE
OTTUMWA, IOWA

Terracon Project No. 08125070-02
January 17, 2013

1.0 INTRODUCTION

Terracon completed a subsurface exploration and geotechnical engineering services for the Teach Abandoned Mine Land (AML) Reclamation project northwest of the residence at 11516 220th Avenue in Ottumwa, Iowa. The exploration consisted of four (4) soil borings performed to depths of approximately 15½ to 50½ feet below the existing ground surface (SB-1 through SB-4), one (1) soil boring performed to a depth of about 5 feet below existing grades (SB-5), and three (3) surface samples obtained to depths of about ½ foot (SS-1 through SS-3) in the proposed reclamation area. Terracon performed these services in general accordance with our proposal dated September 6, 2012 (Terracon Proposal No. P08120509).

Logs of the borings along with a Boring Location Diagram are in Appendix A of this report. This report presents the results of our subsurface exploration and provides geotechnical engineering recommendations relative to

- subsurface soil conditions
- groundwater conditions
- earthwork

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Project location	■ The site is located in Township 72 North, Range 15 West, Section 9, northeast ¼ of Wapello County, Iowa. ■ The AML reclamation will be performed northwest of the residence at 11516 220th Avenue in Ottumwa, Iowa. ■ See Exhibit A-1 in Appendix A for the boring location diagram and vicinity map.
Site history	■ The site was a former coal strip mine. ■ Portions of the east side of the site were graded and excess compost was applied by Cargill in 2010. Thicknesses of the compost were not available at the time of this report.

Item	Description
Site history (continued)	■ From aerial photos, it appears mining activity began between 1950 and 1970. The mine appears to have stopped production in 1980's or 1990's. Specific information about the previous mining activities was not available at the time of this report.
Project information	■ The 28 acre site will be reclaimed by incorporating geomorphically stable landform design to reduce erosion that is typical with traditional mass grading techniques. ■ The on-site materials will be re-graded and used to backfill an existing pond in the southwest portion of the site. ■ Grading will extend to the top of the "highwall" earth embankment at the southwest edge of the site and into portions of the previously graded compost area along the eastern portion of the site. ■ The final reclamation design will provide for abatement of polluted drainage water from the area. ■ At the time of this report, the reclaimed land is anticipated to be used for livestock grazing. Structures are not anticipated within the re-graded area.
Existing topography	■ The site has numerous mine spoil piles with relatively steep slopes. ■ Current ground elevations range from about 805 feet near the northwest portion of the site to about 730 feet at the south side of the site. ■ The top of the "highwall" earth embankment, southwest of the pond, is at about elevation 745 feet (about 30 feet above the bottom of the pond). ○ Slopes along the "highwall" are on the order of 1:1 (horizontal to vertical). ■ Existing drainage ways are located on the north and west borders of the existing compost placement area and south of the existing pond. The drainage ways flow toward an outlet near the southeast portion of the site. ○ The drainage ways have side slopes on the order of 2:1.
Proposed grading (from Updated Conceptual Grading Plan and preliminary Cut/Fill Isomap, dated August 21 and 17, 2012, respectively)	■ *Northeast*: fills of 9 to 14 feet. ■ *East-central*: cuts of about 12 to 31 feet. ○ Cuts of about 30 to 31 feet are anticipated near Borings SB-1 and SB-2. ■ *West-central*: cuts of about 4 to 20 feet ○ Cuts of about 5 and 20 feet are anticipated near Borings 3 and 4, respectively ■ *Northwest*: cuts of about 2 to 20 feet ■ *West*: fills of about 15 to 23 feet. ■ *Pond*: fills of about 43 to 68 feet (south to north)

Item	Description
Cut and fill slopes	■ Most areas of the site are anticipated to be final graded to about 3:1 (horizontal to vertical) or flatter.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the borings, subsurface conditions at the tested locations can be generalized as follows:

Description	Approximate Elevation to Bottom of Stratum	Material Encountered	Consistency
Stratum 1	*Boring SB-1*: 740 feet (about 36 feet below existing grade) *Borings SB-2 through SB-5:* Stratum extended to terminations at about 770 ½ to 719½ feet (about 5 to 50½ feet below existing grades)	Mine Overburden Fills: Fat clay and sandy fat clay, shale of varying degrees of weathering, and variable sand contents Higher organic contents near the surface of Borings SB-1, 2, and 3	■ ***Water contents:***10 to 25% ■ ***SPT N-values***: 5 to 16 bpf ○ N-values of 20 to 56 bpf in Boring SB-4 at depths of about 4, 34, and 39 feet
Stratum 2	*Boring SB-1:* Stratum extended to termination at about elevation 736½ feet (39½ feet below existing grade)	Shale bedrock	Moderately hard

Conditions encountered at each boring location are indicated on the individual boring logs. The stratification lines shown on the boring logs represent the approximate boundaries between soil and bedrock types. In-situ, transitions between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report.

3.2 Groundwater

The borings were observed during drilling and shortly after completion of drilling operations for the presence and level of groundwater. The groundwater levels observed at these times are indicated on the appended boring logs and are summarized in the following table.

Boring No.	Observed Groundwater Elevation	
	While Drilling, ft	Shortly After Drilling, ft
SB-1	739 (37 ft below existing grade)	754 (22 ft below existing grade)
SB-2	761 (26 ft below existing grade)	765 (22 ft below existing grade)
SB-3	Not encountered	Not encountered
SB-4	726 (44 ft below existing grade)	729½ (40½ ft below existing grade)
SB-5	Not encountered	---

A relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, stages of the adjacent drainage ways and pond, and other factors not evident at the time the borings were performed. Therefore, groundwater levels at other times during earthwork operations may be different than the levels indicated on the boring logs.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

4.1.1 Variable Fill Materials

Relatively thick deposits of existing fill consisting of mine spoils (fat clay, shale, and sand) were encountered in all of the borings. The fill extended to about 36 feet below existing grade in Boring SB-1 and to termination depths at about 5 to 50½ feet in the remaining borings. The existing fill materials in the borings included occasional sand seams, bedrock materials of varying hardness (i.e., rock-like shale and apparent sandstone or limestone), variable moisture contents (ranging from 10 to 25%), and variable standard penetration test “N”-values (ranging from 5 to 56 bpf). These materials do not appear to have been placed in a controlled manner. These variable materials should be anticipated to be prevalent across the site.

Although not encountered in the borings, there is a risk that unsuitable materials (e.g., large size rock materials with open voids between pieces, tree stumps, logs, etc.) may be buried within the fill materials. If unsuitable materials are encountered during grading operations, the materials should be removed from the fill. Stone materials larger than 6 inches in any dimension should not be incorporated into new fill materials unless they are broken down to smaller fragments.

4.1.2 Deep Fills

Fills on the order of about 14 feet are planned near the northeast portion of the site, and fills of about 43 to 68 feet are planned within the existing pond at the southwest portion of the site. Where the relatively thick deposits of new fill will be placed to develop design grades, the weight of the new fill will likely compress in-place existing fill materials. The thick deposits of new fill will also be prone to compression under their own weight. These components of settlement will result in widespread to sporadic areas of non-uniform settlement of the completed fill surfaces. The settlement can be erratic over some distances if the new or existing fill contains unsuitable materials and zones of poorly compacted material.

Fill thicknesses should be placed to relatively uniform heights or elevations over broad areas during earthwork operations, but graded to control run-off and avoid standing water, to reduce differential settlements. Creation of slopes should be avoided so that fill materials can be placed on relatively horizontal surfaces.

The existing fill that will remain in place is apt to include unprocessed bedrock materials of varying sizes and hardness. There is a possibility of void spaces being present around these types of materials. As finer material migrates into these voids, there is a potential for ground loss or subsidence reflecting to the finished ground surface. As such, large size particles should not be used in new fill materials. Rock-like shale materials that are part of the existing fills or new fill have a tendency to soften with time and from the accumulation of water, resulting in long term compressibility. Rock-like shale materials require pulverization and moisture adjustments to utilize as new fill.

The pond is planned to be drained, but the site development plan might elect to leave pond sediments in place prior to placing new fill. Lacustrine deposits, or end-dumped materials at the bottom of ponds typically have relatively high moisture contents, low densities and strengths, and can be compressible.

If the construction schedule allows, consideration could be given to removing the high moisture content and low strength pond sediments, moisture conditioning (i.e., drying), and recompacting the sediments according to the recommendations in this report prior to placing new fill materials. Drying of the excavated pond materials could be performed by using chemical treatments or by air drying methods.

Potential settlements of the new fill materials could not be estimated with the available data, but additional field and laboratory studies can be performed to evaluate the settlements, if requested.

If the owner is concerned about settlements, we recommend installing monitoring devices in stages of the incremental fill placement, or at the time the new fill reaches final grade. The monuments should be surveyed on a regular basis and the data provided to Terracon for

evaluation of the magnitudes and rate of settlement. Terracon can provide additional recommendations regarding settlement monitoring upon request.

4.1.3 Groundwater and Dewatering

Groundwater was observed at depths of about 22 to 44 feet below the existing ground surface in Borings SB-1, 2, and 4. We anticipate that groundwater will be encountered in excavations and mass grading during construction (e.g., deeper cut areas). Even in areas where groundwater was not encountered in the borings, we would anticipate that the groundwater levels in different portions of the site would change with amounts of precipitation and site drainage patterns. Perched water is possible in the existing fill materials, especially in the occasional sand seams.

Dewatering of the site during construction should be addressed in advance of construction. Trench drains or diversion ditches may be needed to collect and divert accumulated water away from cut areas. Standing water should be removed promptly, and the site rough grading maintained in a crowned or pitched fashion to accommodate runoff. Dewatering systems (e.g., well points) will be required were excavations encounter sand seams below groundwater levels. The contractor is responsible for employing appropriate dewatering methods to control seepage and facilitate construction.

An outflow trench will likely be used when draining the existing pond. The pond drainage should be diverted to a reliable discharge area. The increased water flowing over on-site materials will likely erode the exposed soils. Prior to construction, the location of the trench should be selected to reduce the potential for erosion of materials at the toes of existing slopes. Consideration should be given to lining the trench and discharge point with rip-rap materials to maintain the sides and bottom of the trench.

Seepage exiting the face of cut slopes will reduce the stability of the slope. In addition, placement of new fill over areas where seepage occurs is not recommended. Seepage should be collected and removed before it exits the face of the slope, and before new fills are placed.

4.1.4 Slope Considerations

Our scope of services does not include slope stability analyses related to the new fill sections or cut-slope sections. From conversations with Trihydro Corporation, we understand slopes for the proposed grading are planned to be 3:1 (horizontal to vertical) or flatter.

Fill slopes on the order of 3:1 or 4:1 (horizontal to vertical) are generally stable when properly designed and side slopes are not subject to seepage from water bearing layers and toe erosion. Slope sections of 3:1 and steeper are more prone to develop stability issues, particularly when embankment heights exceed about 10 to 15 feet and would require further analysis to evaluate their potential performance.

Shallow surficial slumps/slides should be expected on the proposed 3:1 cut and fill slopes. Erosion protection or permanent vegetation should be established as soon as possible after slopes are graded to reduce the potential for surficial instability. The 3:1 slopes will be susceptible to erosion, and may be difficult to maintain. Alternately, the proposed slopes could be flattened, and Terracon would be pleased to provide additional analyses for flatter slope configurations. Alterations of grading and drainage patterns can also affect the stability of existing slopes.

Due to the relatively unknown characteristics of the existing deposits of mine spoils, stability analysis would be prudent for any new slopes, particularly:

- slopes cut steeper than existing grades,
- where new fill is added along or above existing slopes,
- new slope embankments supported above sediments within the existing pond

During the site preparation for areas where new fills are placed on existing slopes, care should be taken to ensure good bond between the new fill and existing soils. Existing slopes should be benched to provide horizontal surfaces for placement and compaction of new structural fill. The benching and removal of weak near surface soils, where encountered, would help to reduce the potential for creating a plane of weakness at the interface of the existing slope and new fill. Where existing slopes are steeper than 5:1 (horizontal to vertical), bench widths of about 10 feet (capable of allowing operation of compaction equipment) are recommended. Bench heights should be no higher than 3 feet.

4.2 Earthwork

4.2.1 Site Preparation

Site preparation should commence with stripping of all vegetation, organic soils, root systems, and any unsuitable materials (e.g., debris, desiccated soil, frozen soil, etc.) from the site surface. Terracon personnel should evaluate the depth of removal of unsuitable materials during construction.

Subgrades should be evaluated for the presence of unsuitable areas during earthwork operations. Unstable areas and exposed soft soils will not be suitable for immediate placement of fill materials. Options for subgrade improvement could include the following:

- Overexcavating soft or unstable areas to depths encountering firm and stable materials;
- Scarification, moisture conditioning (e.g., air drying), and recompaction of unstable areas;
- “Bridging” areas of unsuitable soils with lift thicknesses of 18 inches or less to provide relatively firm surficial conditions; or
- Placing a layer of approved crushed stone (less than 6 inches in any dimension) in unstable areas.

The use of low contact pressure, track equipment, or remote excavation equipment could be considered to assist in earthwork operations. Terracon should be retained to provide more detailed stabilization recommendations as the need for subgrade stabilization occurs.

Fill placed in excessive lift thicknesses as "bridging" material over soft or unstable deposits will be prone to future settlements. Where necessary, we recommend "bridging" lift areas be limited to areas less than 2,500 square feet. It would also be prudent to document the locations of unstable areas that are "bridged" or stabilized (i.e. with GPS coordinates) in order to correlate with final graded areas that may be susceptible to more settlement, or used for other developmental purposes.

4.2.2 Material Types

Fill for the AML reclamation work should meet the following material requirements:

- Materials should be free of organic matter and debris;
- Particle sizes should be smaller than 6 inches in any dimension;
- Rock-like shale materials should be processed (pulverized) and moisture conditioned; and
- Soils with organic contents greater than 5% are suitable for use as fill within 2 feet of final grades.

Limitations for use as fill material include:

- Large rock particles (larger than 6 inches in any dimension);
- Frozen materials should not be used as fill; and
- Fill should not be placed on frozen subgrades;

A sample of each material type should be submitted to Terracon for evaluation prior to use as fill.

4.2.3 Compaction Requirements

The table below presents recommended compaction and moisture control criteria for fill placed for the geomorphically altered site grading. We understand that the final grades will be tolerable to settlements, and no future structures are planned to be supported over the reclaimed land. Higher degrees of compaction could be considered in potential future site development areas that would be sensitive to settlement. Terracon should be contacted to provide additional recommendations for these areas.

Item	Description [1]
Fill lift thickness	■ 9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used.

Item	Description [1]
Compaction of cohesive materials and processed shale in green (non-structural) areas [2]	■ Each lift should be compacted with a sheepsfoot roller until the full weight of the sheepsfoot roller is supported entirely on its feet (i.e., roller walkout when foot penetration is less than 3 inches), but not less than four passes per lift, or ■ At least 90% of the material's standard Proctor maximum dry density (ASTM D 698).
Compaction of granular materials in green (non-structural) areas [2]	■ Each lift should be compacted with at least four passes of a smooth drum vibratory roller weighing at least 10 tons, or ■ At least 90% of the material's standard Proctor maximum dry density (ASTM D 698).
Moisture content of cohesive soil	■ Within the range of 0% to +4% of the optimum moisture content as determined by the standard Proctor test at the time of placement and compaction.
Moisture content of granular material [4]	■ Workable moisture levels.

1. Compaction values and moisture contents are relative to standard Proctor maximum dry density and optimum moisture content (ASTM D698).
2. We recommend the fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.
3. If the granular material is a coarse sand or gravel, is of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254).
4. Specifically, the moisture content of the granular material should be at a level to achieve compaction without the granular material bulking during placement or pumping when proofrolled.

4.2.4 Grading and Drainage

Adequate drainage should be provided on the site during construction. Excessive moisture can significantly reduce the support capability of soils and contribute to soft subgrades and difficult earthwork operations. During earthwork operations, exposed subgrades should be properly sloped to provide rapid drainage so that risks of saturation of the subgrades can be reduced. The soil types observed in the borings are easily eroded by surface water, so appropriate erosion control measures should be provided.

All surface water that accumulates on subgrades should be removed as soon as possible. Groundwater which collects in excavations should be removed as soon as possible.

4.2.5 Earthwork Construction Considerations

Unstable ground conditions will likely be encountered in deeper cut areas and prior to fill placement in the existing pond, and will be worsened if groundwater and surface water are not properly managed. Unstable ground conditions could develop during general construction

operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. Should unstable subgrade conditions develop, stabilization measures will need to be employed as discussed in section **4.2.1 Site Preparation**. Terracon should be contacted to discuss alternatives to stabilize subgrades.

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Safety and Health Administration (OSHA) regulations to provide stability and safe working conditions. Temporary excavations will probably be required during grading and utility installation operations. The grading/utility contractor, by their contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; placement and compaction of structural fill; and backfilling of excavations into the completed subgrade.

4.3 Liming Requirements

Seven (7) samples selected by Trihydro Corporation were tested for chemical analytical testing. The results are included in Appendix B. Trihydro requested that analyses be performed to evaluate the liming requirements to achieve a pH of 6.5. The liming results are summarized in the table below.

Sample Location	pH of Sample	Sample Buffer Index	Liming Requirement [1] (lbs/A)
SS-1 (0 to ½ ft)	4.4	5.4	10,780
SS-2 (0 to ½ ft)	4.6	6.1	5,703
SS-3 (0 to ½ ft)	6.3	7.1	Not required
SB-1 (29 to 30½ ft)	5.4	7.2	Not required
SB-2 (29 to 30½ ft)	7.1	7.5	Not required
SB-4 (0 to ½ ft)	3.3	4.8	15,140
SB-4 (19 to 20½ ft)	6.0	7.4	Not required

1. Lime needs as 100% effective neutralizing power (ENP) for pH = 6.5, for a 6” plow depth

5.0 GENERAL COMMENTS

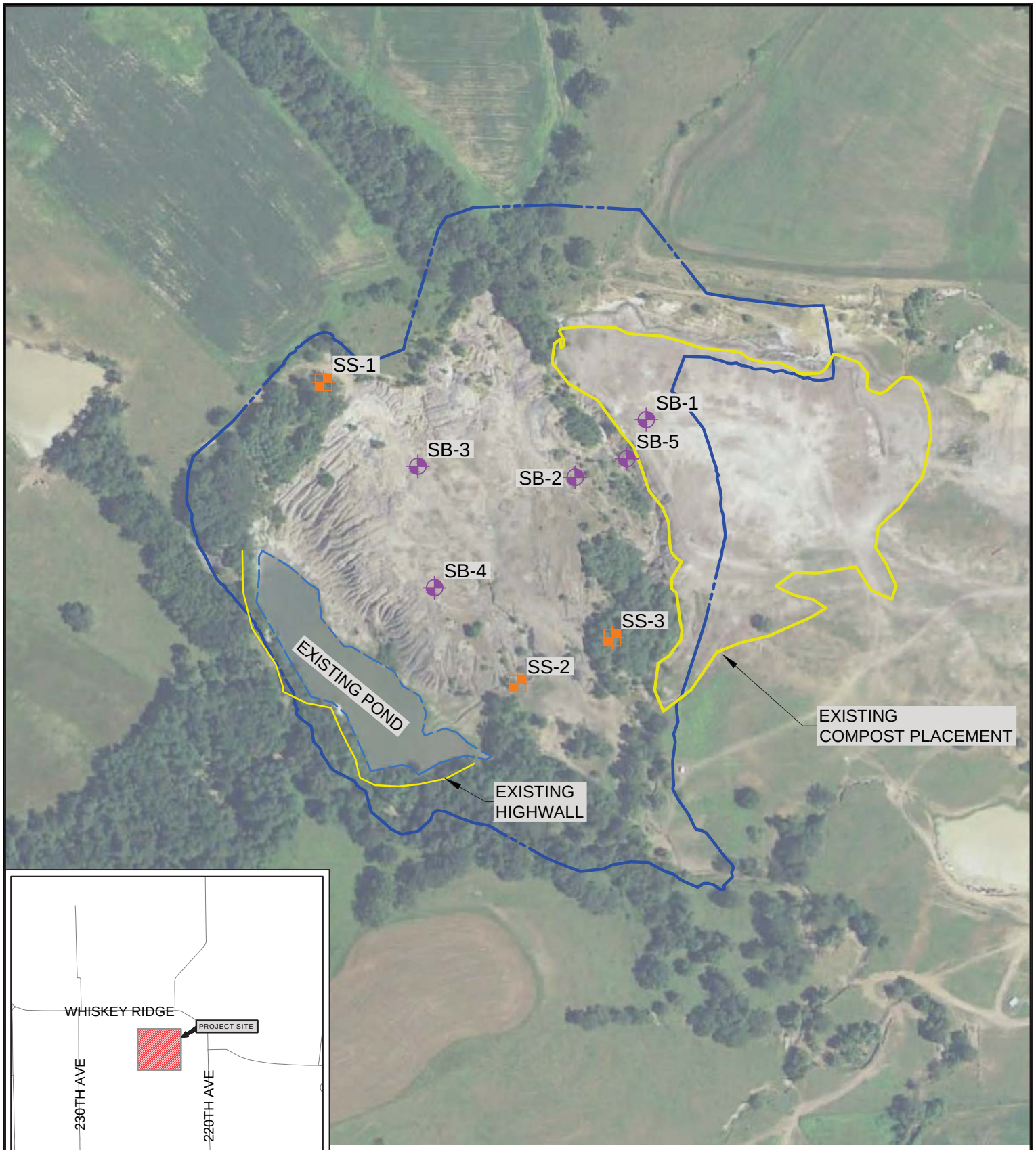
Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. A wetland delineation has been completed (Terracon Project No. 08127120, dated December 13, 2012) and has been submitted under separate cover. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing

APPENDIX A
FIELD EXPLORATION



SITE VICINITY MAP 1"=1 MILE

AERIAL PHOTO FROM IOWA GEOGRAPHIC MAP SERVER MAINTAINED BY IOWA STATE UNIVERSITY AND MIT - http://cairo.gis.iastate.edu/map.html

LEGEND

- BOUNDARY OF ASSESSED AREA
- APPROXIMATE SOIL BORING LOCATION
- APPROXIMATE SURFACE WATER SAMPLES
- APPROXIMATE SURFACE SOIL SAMPLES

NORTH

0 300'

APPROXIMATE DRAWING SCALE

Project No.	08125070
Date:	01/03/13
Project Mngr:	AJW
Drawn By:	KEK
File Name:	08125070-01.dwg
Layout Name:	A-1

Terracon
Consulting Engineers and Scientists
600 SW 7TH STREET DES MOINES, IOWA 50309
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BORING LOCATION DIAGRAM

TEACH AML RECLAMATION PROJECT
TRIHYDRO CORPORATION
220TH AVENUE
OTTUMWA, IOWA

EXHIBIT

A-1

Field Exploration Description

The boring locations were staked on-site by Terracon personnel using a handheld GPS device. Northing and easting coordinates provided on the boring logs are relative to the U.S. State Plane 1983, Iowa South 1402, NAD 1983 (Conus) CORS96 coordinate system. A copy of the Boring Location Diagram indicating the approximate boring locations is attached. The ground surface elevations indicated on the boring logs are for relative reference only and should not be considered accurate. The elevations were interpolated from plotting the boring locations on the Extra Services plan dated August 27, 2012 provided by Trihydro Corporation. True surface elevations at the boring locations could differ due to changes in interpolation and other differences could occur from superposing approximate boring locations on the topographic plan. The locations and elevations of the borings are considered accurate only to the degree implied by the means and methods used to define them.

Borings SB-1 through SB-4 were drilled with an ATV-mounted (rubber tire) rotary drill rig using continuous-flight solid-and hollow-stem augers to advance the boreholes. Representative samples were obtained using split-barrel sampling procedures. In the split-barrel sampling procedure, a standard 2-inch (outside diameter) split-barrel sampling spoon is driven into the ground with an automatic 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the standard penetration resistance value (N). These “N” values are indicated on the boring logs at the depths of occurrence. The samples were sealed and transported to the laboratory for testing and classification. Boring SB-5 was performed using a hand auger probe to obtain disturbed bulk samples.

The drill crew prepared a field log of each boring. These logs included visual classifications of the materials encountered during drilling as well as the driller’s interpretation of the subsurface conditions between samples. The boring logs included with this report represent an interpretation of the field logs and include modifications based on laboratory observation and testing of the samples.

BORING LOG NO. SB-1

PROJECT: Teach AML Reclamation Project

CLIENT: Trihydro Corporation Laramie, Wyoming

SITE: North of residence at 11516 220th Avenue Ottumwa, Iowa

LOCATION See Exhibit A-1

Northing: 386123 Easting: 1891872

Approximate Surface Elev: 776 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
2.0	774+/-	**FILL - CLAYEY SAND**, with organics, dark gray
8.0	768+/-	**FILL - LEAN TO FAT CLAY**, trace sand, with organics, dark gray
13.0	763+/-	**FILL - SANDY FAT CLAY**, with shale, dark gray, brown, dark brown, and gray dark gray carbonacious shale fragments encountered in sample #3
23.0	753+/-	**FILL - FAT CLAY**, with sand and shale, brown, dark brown, and gray
32.0	744+/-	**FILL - SANDY FAT CLAY**, with shale, brown, dark brown, and gray reddish-brown sandstone fragments encountered in sample #6
36.0	740+/-	**FILL - FAT CLAY**, with sand and shale, brown and gray
39.5	736.5+/-	**SHALE***, light gray, highly weathered, moderately hard
		Boring Terminated at 39.5 Feet

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	WATER CONTENT (%)	% PASSING #200
				1	51	45
5		12	3-3-5 N=8	2	23	88
10		12	2-4-8 N=12	3	19	53
15		14	4-3-5 N=8	4	16	74
20		15	2-3-4 N=7	5	15	71
25		14	3-3-5 N=8	6	16	57
30		18	3-3-6 N=9	7	13	45
35		16	3-3-4 N=7	8	19	76
		6	50/6" N=50/6"	9	7	89

Stratification lines are approximate. In-situ, the transition may be gradual.

* Classification of rock material based on driller's observation of characteristics during field operations. Core samples and/or petrographic analysis may indicate other rock types.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

37' While Drilling

22' After Drilling

Wet Cave in @ 31' After Drilling

Terracon
600 SW 7th St., Suite M
Des Moines, Iowa

Boring Started: 11/15/2012 | Boring Completed: 11/15/2012

Drill Rig: 897 | Driller: PF

Project No.: 08125070 | Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 08125070.GPJ TERRACON2012.GDT 1/8/13

BORING LOG NO. SB-2

PROJECT: Teach AML Reclamation Project

CLIENT: Trihydro Corporation Laramie, Wyoming

SITE: North of residence at 11516 220th Avenue Ottumwa, Iowa

LOCATION See Exhibit A-1

Northing: 385990 Easting: 1891707

Approximate Surface Elev: 787 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	WATER CONTENT (%)	% PASSING #200
		FILL - SANDY FAT CLAY, with organics, dark gray				1	23	54
3.0	784+/-							
		FILL - MIXTURE OF SANDY FAT CLAY AND SHALE, with sand, dark gray, gray, and gray brown	5	5	2-3-5 N=8	2	14	52
			10	6	1-3-3 N=6	3	14	78
14.0	773+/-							
		FILL - SANDY FAT CLAY, with shale, brown and brown gray	15	14	2-2-3 N=5	4	21	68
			20	16	2-2-3 N=5	5	23	57
			25	16	2-4-5 N=9	6	20	61
27.0	760+/-							
		FILL - CLAYEY SAND, with shale, dark gray	30	12	2-6-4 N=10	7	25	37
32.0	755+/-							
		FILL - SANDY FAT CLAY, with shale, dark gray	35	14	6-8-8 N=16	8	17	58
40.5	746.5+/-	brown fat clay with sand encountered in sample #9	40	16	3-4-5 N=9	9	19	85
		Boring Terminated at 40.5 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

26' While Drilling
22' After Drilling
Wet Cave in @ 30' After Drilling

Terracon
600 SW 7th St., Suite M
Des Moines, Iowa

Boring Started: 11/15/2012 | Boring Completed: 11/15/2012
Drill Rig: 897 | Driller: PF
Project No.: 08125070 | Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 08125070.GPJ TERRACON2012.GDT 1/8/13

BORING LOG NO. SB-3

PROJECT: Teach AML Reclamation Project

CLIENT: Trihydro Corporation Laramie, Wyoming

SITE: North of residence at 11516 220th Avenue Ottumwa, Iowa

LOCATION See Exhibit A-1

Northing: 386015 Easting: 1891344

Approximate Surface Elev: 786 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	WATER CONTENT (%)	% PASSING #200
	FILL - MIXTURE OF FAT CLAY AND SHALE, with sand, dark gray and gray organics encountered in sample #1							1	24	79
			5			12	3-4-6 N=10	2	20	81
	8.0	778+/-								
	FILL - SANDY FAT CLAY, with shale, dark gray and gray		10			12	3-3-4 N=7	3	13	60
	15.5 light gray shale encountered in sample #4	770.5+/-	15			12	3-2-9 N=11	4	10	73
	Boring Terminated at 15.5 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

None Encountered While Drilling
None Encountered After Drilling
Dry Cave in @ 15' After Drilling

Terracon
600 SW 7th St., Suite M
Des Moines, Iowa

Boring Started: 11/15/2012 | Boring Completed: 11/15/2012
Drill Rig: 897 | Driller: PF
Project No.: 08125070 | Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 08125070.GPJ TERRACON2012.GDT 1/8/13

BORING LOG NO. SB-4

PROJECT: Teach AML Reclamation Project

CLIENT: Trihydro Corporation Laramie, Wyoming

SITE: North of residence at 11516 220th Avenue Ottumwa, Iowa

LOCATION See Exhibit A-1

Northing: 385735 Easting: 1891383

Approximate Surface Elev: 770 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	WATER CONTENT (%)	% PASSING #200
FILL - MIXTURE OF CLAYEY SAND AND SHALE, dark gray, gray, and brown					1	17	46
		5	12	7-7-17 N=24	2	12	38
7.0	763+/-						
FILL - SANDY FAT CLAY, with shale, dark gray, gray, and brown							
		10	16	2-2-3 N=5	3	16	51
clayey sand seam encountered in sample #4		15	14	2-3-8 N=11	4	11	41
		20	14	2-3-4 N=7	5	10	56
23.0	747+/-						
FILL - FAT CLAY, with sand and shale, gray and brown							
		25	14	2-3-6 N=9	6	19	76
		30	15	3-4-6 N=10	7	12	75
32.0	738+/-						
FILL - CLAYEY SAND, with shale, dark gray, gray, and brown							
		35	13	3-12-8 N=20	8	10	42
clay seam encountered in sample #9		40	16	5-28-28 N=56	9	11	65
		45	12	8-5-9 N=14	10	20	26
50.5	719.5+/-	50	14	6-7-8 N=15	11	19	50
Boring Terminated at 50.5 Feet							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

44' While Drilling
40.5' After Drilling
Wet Cave in @ 45.5' After Drilling

Terracon
600 SW 7th St., Suite M
Des Moines, Iowa

Boring Started: 11/15/2012 | Boring Completed: 11/15/2012
Drill Rig: 897 | Driller: PF
Project No.: 08125070 | Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 08125070.GPJ TERRACON2012.GDT 1/8/13

BORING LOG NO. SB-5

PROJECT: Teach AML Reclamation Project

CLIENT: Trihydro Corporation Laramie, Wyoming

SITE: North of residence at 11516 220th Avenue Ottumwa, Iowa

LOCATION See Exhibit A-1

Northing: 386033 Easting: 1891826

Approximate Surface Elev: 749 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SAMPLE ID	WATER CONTENT (%)	% PASSING #200
	FILL - MIXTURE OF SANDY FAT CLAY AND SHALE, trace organics, dark gray						1	19	59
	3.0	746+/-							
	FILL - MIXTURE OF SANDY FAT CLAY AND SHALE, brown and reddish brown						2	20	59
	5.0	744+/-	5						
	Boring Terminated at 5 Feet								

Stratification lines are approximate. In-situ, the transition may be gradual.

Advancement Method:
Hand Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

None Encountered While Drilling

Terracon
600 SW 7th St., Suite M
Des Moines, Iowa

Boring Started: 11/15/2012 | Boring Completed: 11/15/2012
Drill Rig: Hand Auger | Driller: PF
Project No.: 08125070 | Exhibit: A-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 08125070.GPJ TERRACON2012.GDT 1/8/13

APPENDIX B
LABORATORY TESTING

Laboratory Testing

In the laboratory, moisture content tests and percent passing the No. 200 sieve analyses were performed on the recovered samples. The results of the laboratory tests are shown on the boring logs in Appendix A at their corresponding sample depths.

Seven (7) samples selected by Trihydro Corporation were tested for chemical analytical testing. The chemical analytical tests are summarized in the table below and are included as Exhibit B-2.

Analyte	Units	Sample Location						
		SS-1 (0 to ½ ft)	SS-2 (0 to ½ ft)	SS-3 (0 to ½ ft)	SB-1 (29 to 30½ ft)	SB-2 (29 to 30½ ft)	SB-4 (0 to ½ ft)	SB-4 (19 to 20½ ft)
Acid/Base Total Sulfur [1]	weight %	0.13	0.36	0.15	3.23	3.87	0.69	0.79
Acid/Base Pyritic Sulfur [1]	weight %	0.11	0.10	0.13	2.91	2.29	0.02	0.58
Buffer Index	-	5.4	6.1	7.1	7.2	7.5	4.8	7.4
Cation Exchange Capacity	meq+/ 100g [2]	21.1	16.9	12.1	13.7	39.9	32.7	8.9
Chloride	lb/A	78	84	86	68	88	66	70
Conductivity	mmhos /cm	0.3	0.7	0.3	1.9	1.6	0.3	1.7
Iron, Total	mg/kg	19,800	28,800	60,400	10,800	25,200	30,600	11,700
Manganese, Total	mg/kg	282	293	1,480	170	1,130	228	223
Moisture content	%	22	19	22	51	25	17	10
NO3-N [3]	ppm	0.3	0.5	14.8	0.3	0.3	0.8	0.3
Organic Matter	%	2.1	4.4	5.4	1.9	3.5	3.1	1.7
pH	-	4.4	4.6	6.3	5.4	7.1	3.3	6.0
Phosphorus, Total	mg/kg	257	587	999	257	889	436	94.5
Potassium, Total	mg/kg	1,330	1,570	1,070	1,510	1,740	2,170	1,420
Soluble Sulfate	mg/kg	152	454	28.3	7670	11700	2490	5660

1. Acid/Base Accounting
2. Milliequivalent of hydrogen per 100 grams of soil
3. Nitrogen

The samples were classified in the laboratory based on visual observation, texture, plasticity, and the laboratory testing described above. The descriptions of the soils indicated on the boring log are in general accordance with the General Notes in Appendix C and the Unified Soil Classification System (USCS). A summary of the USCS is included in Appendix C. Classification of rock materials are based on the driller's observation of drilling characteristics during field operations and visual identification of disturbed samples. Core samples or petrographic analysis may indicate other rock types. A summary of sedimentary rock classification is included in Appendix C.

MVTL Amended Final Report

Minnesota Valley Testing Lab – Nevada, Iowa
515-382-5486 mvtlia@mvtl.com

Report to: Terracon Cedar Rapids
2640 12th St. SW
Cedar Rapids, IA
52406-2987

Attention: Alexander Wolfe

Sample Number	Analyte	Concentration mg/kg	Quantitation Limit	Method	Date/ Time
SB 4 #1	Soluble Sulfate	2490	20.0	EPA 9056	17 Dec 2012 17:19
Depth 0-0.5	Iron, Total	30600	10.0	EPA 6010B	12 Dec 2012 20:10
	Potassium, Total	2170	100	EPA 6010B	12 Dec 2012 20:10
	Manganese, Total	228	1.0	EPA 6010B	12 Dec 2012 20:10
	Phosphorus, Total	436	100	EPA 6010B	12 Dec 2012 20:10
Sample Number	**Analyte**	**Concentration mg/kg**	**Quantitation Limit**	**Method**	**Date/ Time**
SB 1 #7	Soluble Sulfate	7670	500	EPA 9056	17 Dec 2012 17:37
Depth 29-30.5	Iron, Total	10800	7.2	EPA 6010B	12 Dec 2012 20:16
	Potassium, Total	1510	72.2	EPA 6010B	12 Dec 2012 20:16
	Manganese, Total	170	0.7	EPA 6010B	12 Dec 2012 20:16
	Phosphorus, Total	257	72.2	EPA 6010B	12 Dec 2012 20:16
Sample Number	**Analyte**	**Concentration mg/kg**	**Quantitation Limit**	**Method**	**Date/ Time**
SB 4 #5	Soluble Sulfate	5660	500	EPA 9056	17 Dec 2012 17:56
Depth 19-20.5	Iron, Total	11700	10.0	EPA 6010B	12 Dec 2012 20:23
	Potassium, Total	1420	100	EPA 6010B	12 Dec 2012 20:23
	Manganese, Total	223	1.0	EPA 6010B	12 Dec 2012 20:23
	Phosphorus, Total	94.5	50.0	EPA 6010B	12 Dec 2012 20:23

If you have any questions or concerns please call the MVTL lab. Samples were tested by Keystone Labs
515-382-5486 or mvtlia@mvtl.com

Exhibit B-2

MVTL Amended Final Report

Minnesota Valley Testing Lab – Nevada, Iowa
515-382-5486 mvtlia@mvtl.com

Sample Number	Analyte	Concentration mg/kg	Quantitation Limit	Method	Date/Time
SB 2 #7					
Depth 29-30.5	Soluble Sulfate	11700	500	EPA 9056	17 Dec 2012 18:14
	Iron, Total	25200	10.0	EPA 6010B	12 Dec 2012 20:28
	Potassium, Total	1740	100	EPA 6010B	12 Dec 2012 20:28
	Manganese, Total	1130	1.0	EPA 6010B	12 Dec 2012 20:28
	Phosphorus, Total	889	100	EPA 6010B	12 Dec 2012 20:28
Sample Number	**Analyte**	**Concentration mg/kg**	**Quantitation Limit**	**Method**	**Date/ Time**
SS 1 #1	Soluble Sulfate	152	10.0	EPA 9056	14 Dec 2012 12:32
Depth 0-0.5	Iron, Total	19800	7.8	EPA 6010B	12 Dec 2012 20:34
	Potassium, Total	1330	78.3	EPA 6010B	12 Dec 2012 20:34
	Manganese, Total	282	0.8	EPA 6010B	12 Dec 2012 20:34
	Phosphorus, Total	257	78.3	EPA 6010B	12 Dec 2012 20:34
Sample Number	**Analyte**	**Concentration mg/kg**	**Quantitation Limit**	**Method**	**Date/ Time**
SS 2 #1	Soluble Sulfate	454	10.0	EPA 9056	14 Dec 2012 12:50
Depth 0.2-0.5	Iron, Total	28800	10.0	EPA 6010B	12 Dec 2012 20:51
	Potassium, Total	1570	100	EPA 6010B	12 Dec 2012 20:51
	Manganese, Total	293	1.0	EPA 6010B	12 Dec 2012 20:51
	Phosphorus, Total	587	100	EPA 6010B	12 Dec 2012 20:51
Sample Number	**Analyte**	**Concentration mg/kg**	**Quantitation Limit**	**Method**	**Date/ Time**
SS 3 #1	Soluble Sulfate	28.3	10.0	EPA 9056	14 Dec 2012 13:08
Depth 0.2-0.5	Iron, Total	60400	73.6	EPA 6010B	13 Dec 2012 23:28
	Potassium, Total	1070	73.6	EPA 6010B	12 Dec 2012 20:56
	Manganese, Total	1480	7.4	EPA 6010B	13 Dec 2012 23:28
	Phosphorus, Total	999	73.6	EPA 6010B	12 Dec 2012 20:56

If you have any questions or concerns please call the MVTL lab. Samples were tested by Keystone Labs
515-382-5486 or mvtlia@mvtl.com

Exhibit B-2

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER
ACIL

Report Date: 2 Jan 2013
Work Order #: 201291-00650
Account #: 004072
Purchase Order Number: 08125070

Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
P.O. Box 4921
Des Moines IA 50306

Soil Sample Identification: SB4 #1 DEPTH 0-0.5'
Field ID: 5070
Soil Laboratory Number: 12-V44

ANALYSES	Results		Date Analyzed	Analyst
Acid/Base Total Sulfur	**0.690**	**wt %**	**6 Dec 2012**	
Acid/Base Pyritic Sulfur	**0.020**	**wt %**	**7 Dec 2012**	
Neutralization Potential	**-7.20**			
Calcium Carbonate Equiv	**-1.16**	**wt %**	**11 Dec 2012**	
Actual Acid Potential	**0.62**			
Maximum Acid Potential	**21.56**			

All potentials expressed as ton CaCO3 equivalent per 1000 tons of sample.

Deficiency in ton CaCO3 equivalent per 1000 tons of sample = 7.82

Analyses done in accordance with NCR-13 Methods. Phosphorus determined colorimetrically.

Exhibit B-2

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
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51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER
ACIL

Report Date: 2 Jan 2013
Work Order #: 201291-00650
Account #: 004072
Purchase Order Number: 08125070

Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
P.O. Box 4921
Des Moines IA 50306

Soil Sample Identification: SB1 #7 DEPTH29-30.5'
Field ID: 5070
Soil Laboratory Number: 12-V45

ANALYSES	Results		Date Analyzed	Analyst
Acid/Base Total Sulfur	**3.23**	**wt %**	**6 Dec 2012**	
Acid/Base Pyritic Sulfur	**2.91**	**wt %**	**7 Dec 2012**	
Neutralization Potential	**12.7**			
Calcium Carbonate Equiv	**0.88**	**wt %**	**11 Dec 2012**	
Actual Acid Potential	**90.9**			
Maximum Acid Potential	**100.9**			

All potentials expressed as ton CaCO3 equivalent per 1000 tons of sample.

Deficiency in ton CaCO3 equivalent per 1000 tons of sample = 78.2

Analyses done in accordance with NCR-13 Methods. Phosphorus determined colorimetrically.

Exhibit B-2

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.
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51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER
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Report Date: 2 Jan 2013
Work Order #: 201291-00650
Account #: 004072
Purchase Order Number: 08125070

Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
P.O. Box 4921
Des Moines IA 50306

Soil Sample Identification: SB4 #5 DEPTH19-20.5'
Field ID: 5070
Soil Laboratory Number: 12-V46

ANALYSES	Results		Date Analyzed	Analyst
Acid/Base Total Sulfur	**0.790**	**wt %**	**6 Dec 2012**	
Acid/Base Pyritic Sulfur	**0.580**	**wt %**	**7 Dec 2012**	
Neutralization Potential	**4.55**			
Calcium Carbonate Equiv	**0.03**	**wt %**	**11 Dec 2012**	
Actual Acid Potential	**18.1**			
Maximum Acid Potential	**24.69**			

All potentials expressed as ton CaCO3 equivalent per 1000 tons of sample.

Deficiency in ton CaCO3 equivalent per 1000 tons of sample = 13.6

Analyses done in accordance with NCR-13 Methods. Phosphorus determined colorimetrically.

Exhibit B-2

MVTL

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51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER
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Report Date: 2 Jan 2013
Work Order #: 201291-00650
Account #: 004072
Purchase Order Number: 08125070

Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
P.O. Box 4921
Des Moines IA 50306

Soil Sample Identification: SB2 #7 DEPTH29-30.5'
Field ID: 5070
Soil Laboratory Number: 12-V47

ANALYSES	Results		Date Analyzed	Analyst
Acid/Base Total Sulfur	**3.87**	**wt %**	**6 Dec 2012**	
Acid/Base Pyritic Sulfur	**2.29**	**wt %**	**7 Dec 2012**	
Neutralization Potential	**86.7**			
Calcium Carbonate Equiv	**7.68**	**wt %**	**11 Dec 2012**	
Actual Acid Potential	**71.6**			
Maximum Acid Potential	**120.9**			

All potentials expressed as ton CaCO3 equivalent per 1000 tons of sample.

Excess in ton CaCO3 equivalent per 1000 tons of sample = 15.1

Analyses done in accordance with NCR-13 Methods. Phosphorus determined colorimetrically.

Exhibit B-2

MVTL

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51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER
ACIL

Report Date: 2 Jan 2013
Work Order #: 201291-00650
Account #: 004072
Purchase Order Number: 08125070

Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
P.O. Box 4921
Des Moines IA 50306

Soil Sample Identification: SS1 #1 DEPTH 0-0.5'
Field ID: 5070
Soil Laboratory Number: 12-V48

ANALYSES	Results		Date Analyzed	Analyst
Acid/Base Total Sulfur	**0.130**	**wt %**	**6 Dec 2012**	
Acid/Base Pyritic Sulfur	**0.110**	**wt %**	**7 Dec 2012**	
Neutralization Potential	**0.63**			
Calcium Carbonate Equiv	**-0.37**	**wt %**	**11 Dec 2012**	
Actual Acid Potential	**3.44**			
Maximum Acid Potential	**4.06**			

All potentials expressed as ton CaCO3 equivalent per 1000 tons of sample.

Deficiency in ton CaCO3 equivalent per 1000 tons of sample = 2.81

Analyses done in accordance with NCR-13 Methods. Phosphorus determined colorimetrically.

Exhibit B-2

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER
ACIL

Report Date: 2 Jan 2013
Work Order #: 201291-00650
Account #: 004072
Purchase Order Number: 08125070

Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
P.O. Box 4921
Des Moines IA 50306

Soil Sample Identification: SS2 #1 DEPTH0.2-0.5'
Field ID: 5070
Soil Laboratory Number: 12-V49

ANALYSES	Results		Date Analyzed	Analyst
Acid/Base Total Sulfur	**0.360**	**wt %**	**6 Dec 2012**	
Acid/Base Pyritic Sulfur	**0.100**	**wt %**	**7 Dec 2012**	
Neutralization Potential	**-0.15**			
Calcium Carbonate Equiv	**-0.45**	**wt %**	**11 Dec 2012**	
Actual Acid Potential	**3.12**			
Maximum Acid Potential	**11.25**			

All potentials expressed as ton CaCO3 equivalent per 1000 tons of sample.

Deficiency in ton CaCO3 equivalent per 1000 tons of sample = 3.27

Analyses done in accordance with NCR-13 Methods. Phosphorus determined colorimetrically.

Exhibit B-2

MVTL

MINNESOTA VALLEY TESTING LABORATORIES, INC.
1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER
ACIL

Report Date: 2 Jan 2013
Work Order #: 201291-00650
Account #: 004072
Purchase Order Number: 08125070

Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
P.O. Box 4921
Des Moines IA 50306

Soil Sample Identification: SS3 #1 DEPTH0.2-0.5'
Field ID: 5070
Soil Laboratory Number: 12-V50

ANALYSES	Results		Date Analyzed	Analyst
Acid/Base Total Sulfur	**0.150**	**wt %**	**6 Dec 2012**	
Acid/Base Pyritic Sulfur	**0.130**	**wt %**	**7 Dec 2012**	
Neutralization Potential	**12.9**			
Calcium Carbonate Equiv	**0.88**	**wt %**	**11 Dec 2012**	
Actual Acid Potential	**4.06**			
Maximum Acid Potential	**4.69**			

All potentials expressed as ton CaCO3 equivalent per 1000 tons of sample.

Excess in ton CaCO3 equivalent per 1000 tons of sample = 8.84

Analyses done in accordance with NCR-13 Methods. Phosphorus determined colorimetrically.

Exhibit B-2

Report Date: 2 Jan 2013

Work Order #: 201291-00650
Account #: 004072
PO#: 08125070
Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
Des Moines IA 50306

Soil Sample Id: SB4 #1 DEPTH 0-0.5'
Field ID: 5070
Laboratory Number: 12-M33781

ANALYSES	RESULTS	
Electrical Conductivity	0.3	mmhos/cm

Exhibit B-2

MINNESOTA VALLEY TESTING LABORATORIES, INC.

MVTL

1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER ACIL

SUBMITTED BY: 004072	DATE RECEIVED: Nov 30 2012	SUBMITTED FOR:
	DATE REPORTED: Jan 2 2013	
Terracon Consultants	WORK ORDER NO: 201291-00650	
600 SW 7th St. Suite M		5070
P.O. Box 4921		
Des Moines IA 50306		

	SAMPLE ID PREV CROP LAB NUMBER	SB4 #1 DEPTH 0-0.5' 12-M33781					SAMPLE ID PREV CROP LAB NUMBER	SB1 #7 DEPTH29-30.5' 12-M33782				
		V-LOW	LOW	OPT	HIGH	V-HIGH		V-LOW	LOW	OPT	HIGH	V-HIGH
ORGANIC MATTER	3.1						1.9					
NITROGEN	0.8						0.3					
NO3-N ppm	0.8						0.3					
PHOSPHORUS P2O5-P Meh 3 ppm	8						19					
POTASSIUM (K) Meh 3 ppm	25.						162.					
ZINC (ppm)												
SULFUR ppm SO4-S												
ACIDITY pH	3.3	B ppm	Fe ppm	Mn ppm	Cu ppm	Na ppm	5.4	B ppm	Fe ppm	Mn ppm	Cu ppm	Na ppm
BUFFER INDEX	4.8						7.2					
CCE %		SALTS mmhos/cm		Cl lbs/A 66				SALTS mmhos/cm		Cl lbs/A 68		
		CEC	% BASE SATURATION					CEC	% BASE SATURATION			
CALCIUM ppm	1665		Ca	Mg	K	Na	H	2084		Ca	Mg	K	Na	H
MAGNESIUM ppm	280	32.7	25.5	7.0	0.2		67.3	346	13.7	76.2	20.7	3.0		0.0
		SAND %	SILT %	CLAY %				SAND %	SILT %	CLAY %		
		TEXTURE						TEXTURE				
ALL GUIDELINES ARE ON A BROADCAST BASIS		CROP FERTILIZER GUIDELINES						CROP FERTILIZER GUIDELINES				
CROP AND YIELD GOAL												
NITROGEN (lbs/A)												
P2O5 (lbs/A) ISU/ISU												
K2O (lbs/A) ISU/ISU												
ZINC (lbs/A)												
SULFUR (lbs/A)												
LIME NEEDS AS	to pH 6.5	15140 lbs of lime for 6" plow depth.					to pH 6.5	No lime required.				
100% ENP (lbs/A)	to pH 6.9	19240 lbs of lime for 6" plow depth.					to pH 6.9	No lime required.				

ADDITIONAL RECOMMENDATIONS AND COMMENTS - Analyses are by NCR-13 methodology. Phosphorus results are determined colorimetrically. See additional comments at http://www.mvtl.com
ISU guidelines based on VL subsoil levels and may be adjusted depending on site specific subsoil fertility.

Exhibit B-2

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Report Date: 2 Jan 2013

Work Order #: 201291-00650
Account #: 004072
PO#: 08125070
Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
Des Moines IA 50306

Soil Sample Id: SB1 #7 DEPTH29-30.5'
Field ID: 5070
Laboratory Number: 12-M33782

ANALYSES	RESULTS	
Electrical Conductivity	1.9	mmhos/cm

Exhibit B-2

Report Date: 2 Jan 2013

Work Order #: 201291-00650
Account #: 004072
PO#: 08125070
Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
Des Moines IA 50306

Soil Sample Id: SB4 #5 DEPTH19-20.5'
Field ID: 5070
Laboratory Number: 12-M33783

ANALYSES	RESULTS	
Electrical Conductivity	1.7	mmhos/cm

Exhibit B-2

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51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

MEMBER ACIL

SUBMITTED BY: 004072	DATE RECEIVED: Nov 30 2012	SUBMITTED FOR:
	DATE REPORTED: Jan 2 2013	
Terracon Consultants	WORK ORDER NO: 201291-00650	
600 SW 7th St. Suite M		5070
P.O. Box 4921		
Des Moines IA 50306		

	SAMPLE ID PREV CROP LAB NUMBER	SB4 #5 DEPTH19-20.5' 12-M33783					SAMPLE ID PREV CROP LAB NUMBER	SB2 #7 DEPTH29-30.5' 12-M33784				
		V-LOW	LOW	OPT	HIGH	V-HIGH		V-LOW	LOW	OPT	HIGH	V-HIGH
ORGANIC MATTER	1.7						3.5					
NITROGEN	0.3						0.3					
NO3-N ppm	0.3						0.3					
PHOSPHORUS P2O5-P Meh 3 ppm	8						5					
POTASSIUM (K) Meh 3 ppm	89.						132.					
ZINC (ppm)												
SULFUR ppm SO4-S												
ACIDITY pH	6.0	B ppm	Fe ppm	Mn ppm	Cu ppm	Na ppm	7.1	B ppm	Fe ppm	Mn ppm	Cu ppm	Na ppm
BUFFER INDEX	7.4						7.5					
CCE %		SALTS mmhos/cm		Cl lbs/A 70				SALTS mmhos/cm		Cl lbs/A 88		
		CEC	% BASE SATURATION					CEC	% BASE SATURATION			
CALCIUM ppm	1354		Ca	Mg	K	Na	H	7337	Ca	Mg	K	Na	H
MAGNESIUM ppm	236	8.9	75.8	21.7	2.6		0.0	356	39.9	91.8	7.3	0.8	0.0
		SAND %	SILT %	CLAY %				SAND %	SILT %	CLAY %		
		TEXTURE						TEXTURE				
ALL GUIDELINES ARE ON A BROADCAST BASIS		CROP FERTILIZER GUIDELINES						CROP FERTILIZER GUIDELINES				
CROP AND YIELD GOAL												
NITROGEN (lbs/A)												
P2O5 (lbs/A) ISU/ISU												
K2O (lbs/A) ISU/ISU												
ZINC (lbs/A)												
SULFUR (lbs/A)												
LIME NEEDS AS	to pH 6.5	No lime required.					to pH 6.5	No lime required.				
100% ENP (lbs/A)	to pH 6.9	No lime required.					to pH 6.9	No lime required.				

ADDITIONAL RECOMMENDATIONS AND COMMENTS - Analyses are by NCR-13 methodology. Phosphorus results are determined colorimetrically. See additional comments at http://www.mvtl.com
ISU guidelines based on VL subsoil levels and may be adjusted depending on site specific subsoil fertility.

Exhibit B-2

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Report Date: 2 Jan 2013

Work Order #: 201291-00650
Account #: 004072
PO#: 08125070
Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
Des Moines IA 50306

Soil Sample Id: SB2 #7 DEPTH29-30.5'
Field ID: 5070
Laboratory Number: 12-M33784

ANALYSES	RESULTS	
Electrical Conductivity	1.6	mmhos/cm

Exhibit B-2

Report Date: 2 Jan 2013

Work Order #: 201291-00650
Account #: 004072
PO#: 08125070
Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
Des Moines IA 50306

Soil Sample Id: SS1 #1 DEPTH 0-0.5'
Field ID: 5070
Laboratory Number: 12-M33785

ANALYSES	RESULTS	
Electrical Conductivity	0.3	mmhos/cm

Exhibit B-2

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51 W. Lincoln Way ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885

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SUBMITTED BY: 004072	DATE RECEIVED: Nov 30 2012	SUBMITTED FOR:
	DATE REPORTED: Jan 2 2013	
Terracon Consultants	WORK ORDER NO: 201291-00650	
600 SW 7th St. Suite M		5070
P.O. Box 4921		
Des Moines IA 50306		

	SAMPLE ID PREV CROP LAB NUMBER	SS1 #1 DEPTH 0-0.5' 12-M33785					SAMPLE ID PREV CROP LAB NUMBER	SS2 #1 DEPTH0.2-0.5' 12-M33786				
		V-LOW	LOW	OPT	HIGH	V-HIGH		V-LOW	LOW	OPT	HIGH	V-HIGH
ORGANIC MATTER	2.1						4.4					
NITROGEN	0.3						0.5					
NO3-N ppm	0.3						0.5					
PHOSPHORUS P2O5-P Meh 3 ppm	6						16					
POTASSIUM (K) Meh 3 ppm	89.						84.					
ZINC (ppm)												
SULFUR ppm SO4-S												
ACIDITY pH	4.4	B ppm	Fe ppm	Mn ppm	Cu ppm	Na ppm	4.6	B ppm	Fe ppm	Mn ppm	Cu ppm	Na ppm
BUFFER INDEX	5.4						6.1					
CCE %		SALTS mmhos/cm		Cl lbs/A 78				SALTS mmhos/cm		Cl lbs/A 84		
		CEC	% BASE SATURATION					CEC	% BASE SATURATION			
CALCIUM ppm	822		Ca	Mg	K	Na	H	1327		Ca	Mg	K	Na	H
MAGNESIUM ppm	92	21.1	19.5	3.6	1.1		75.9	126	16.9	39.3	6.1	1.3		53.3
		SAND %	SILT %	CLAY %				SAND %	SILT %	CLAY %		
		TEXTURE						TEXTURE				

ALL GUIDELINES ARE ON A BROADCAST BASIS	CROP FERTILIZER GUIDELINES			CROP FERTILIZER GUIDELINES		
CROP AND YIELD GOAL						
NITROGEN (lbs/A)						
P2O5 (lbs/A) ISU/ISU						
K2O (lbs/A) ISU/ISU						
ZINC (lbs/A)						
SULFUR (lbs/A)						
LIME NEEDS AS 100% ENP (lbs/A)	to pH 6.5	10780 lbs of lime for 6" plow depth.		to pH 6.5	5703 lbs of lime for 6" plow depth.	
	to pH 6.9	14290 lbs of lime for 6" plow depth.		to pH 6.9	8505 lbs of lime for 6" plow depth.	

ADDITIONAL RECOMMENDATIONS AND COMMENTS - Analyses are by NCR-13 methodology. Phosphorus results are determined colorimetrically. See additional comments at http://www.mvtl.com
ISU guidelines based on VL subsoil levels and may be adjusted depending on site specific subsoil fertility.

Exhibit B-2

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Report Date: 2 Jan 2013

Work Order #: 201291-00650
Account #: 004072
PO#: 08125070
Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
Des Moines IA 50306

Soil Sample Id: SS2 #1 DEPTH0.2-0.5'
Field ID: 5070
Laboratory Number: 12-M33786

ANALYSES	RESULTS	
Electrical Conductivity	0.7	mmhos/cm

Exhibit B-2

Report Date: 2 Jan 2013

Work Order #: 201291-00650
Account #: 004072
PO#: 08125070
Date Received: 30 Nov 2012

Terracon Consultants
600 SW 7th St. Suite M
Des Moines IA 50306

Soil Sample Id: SS3 #1 DEPTH0.2-0.5'
Field ID: 5070
Laboratory Number: 12-M33787

ANALYSES	RESULTS	
Electrical Conductivity	0.3	mmhos/cm

Exhibit B-2

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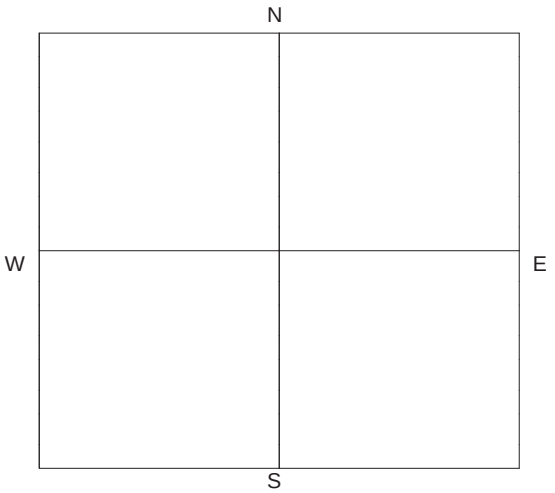
	DATE REPORTED: Jan 2 2013	
Terracon Consultants	WORK ORDER NO: 201291-00650	
600 SW 7th St. Suite M		5070
P.O. Box 4921		
Des Moines IA 50306		

	SAMPLE ID PREV CROP LAB NUMBER	SS3 #1 DEPTH0.2-0.5' 12-M33787				
		V-LOW	LOW	OPT	HIGH	V-HIGH
ORGANIC MATTER	5.4					
NITROGEN	14.8					
NO3-N ppm	14.8					
PHOSPHORUS P2O5-P Meh 3 ppm	12					
POTASSIUM (K) Meh 3 ppm	130.					
ZINC (ppm)						
SULFUR ppm SO4-S						
ACIDITY pH	6.3	B ppm	Fe ppm	Mn ppm	Cu ppm	Na ppm
BUFFER INDEX	7.1					
CCE %		SALTS mmhos/cm		Cl lbs/A 86		
		CEC	% BASE SATURATION			
CALCIUM ppm	2055		Ca	Mg	K	Na	H
MAGNESIUM ppm	177	12.1	85.2	12.0	2.8		0.0
		SAND %	SILT %	CLAY %		
		TEXTURE				



Additional Notes:

ALL GUIDELINES ARE ON A BROADCAST BASIS	CROP FERTILIZER GUIDELINES		
CROP AND YIELD GOAL			
NITROGEN (lbs/A)			
P2O5 (lbs/A) ISU			
K2O (lbs/A) ISU			
ZINC (lbs/A)			
SULFUR (lbs/A)			
LIME NEEDS AS	to pH 6.5	No lime required.	
100% ENP (lbs/A)	to pH 6.9	244 lbs of lime for 6" plow depth.	

ADDITIONAL RECOMMENDATIONS AND COMMENTS - Analyses are by NCR-13 methodology. Phosphorus results are determined colorimetrically. See additional comments at http://www.mvtl.com.
ISU guidelines based on VL subsoil levels and may be adjusted depending on site specific subsoil fertility.

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APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	Split Spoon
Shelby Tube	Macro Core
Ring Sampler	Rock Core
Grab Sample	No Recovery

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of 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:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			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:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 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 ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded 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 ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

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

[N] PI ≥ 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.

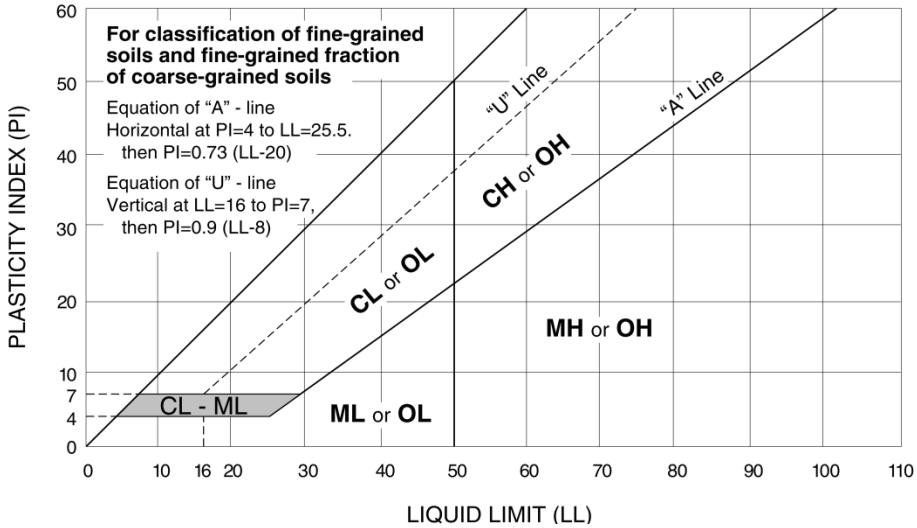

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Exhibit C-2

GENERAL NOTES
Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, or shale. Modifiers such as shaly, sandy, Dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

Limestone	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
Dolomite	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
Chert	Light to dark colored, very fine-grained texture, composed of micro-crystalline quarts (SiO_2), brittle breaks into angular fragments, will scratch glass.
Shale	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
Sandstone	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
Conglomerate	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

DEGREE OF WEATHERING:

Slight	Slight decomposition of parent material on joints. May be color change.
Moderate	Some decomposition and color change throughout.
High	Rock highly decomposed, may be extremely broken.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Classification of rock materials has been estimated from disturbed samples.
Core samples and petrographic analysis may reveal other rock types.