

**Bauske, Shelly A.**

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**From:** Cooper Anderson <coopera@prairiescale.com>  
**Sent:** Wednesday, March 22, 2017 2:53 PM  
**To:** Bauske, Shelly A.  
**Subject:** Fw: Geotechnical Engineering Report - Grain Storage Bin, Westhope, ND  
**Attachments:** M5125023 Report.pdf

**CAUTION:** This email originated from an outside source. Do not click links or open attachments unless you know they are safe.

Shelly,

Attached is the soil test report for when a new bin was installed a couple of years ago at Mitch's facility. The scale is located about 50' straight west of these boring locations in the roadway. The psf readings are on pages 14-16.

Please review and let me know if you have questions.

Thanks,

Cooper Anderson

Prairie Scale Systems Inc.  
7805 112th Ave S.  
Horace, ND 58047  
Office: 701-281-9591  
Fax: 701-281-9373  
[www.prairiescale.com](http://www.prairiescale.com)

# Geotechnical Engineering Report

Proposed Grain Storage Bin

Westhope, North Dakota

May 23, 2012

MTL/Terracon Project No. M5125023



**Prepared for:**

Advanced Grain Handling Systems  
Mayville, North Dakota

**Prepared by:**

Midwest Testing Laboratory  
Grand Forks, North Dakota



Offices Nationwide  
Employee-Owned

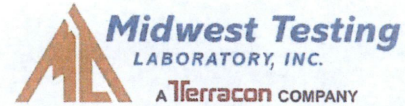
Established in 1965  
terracon.com

# Terracon

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

May 23, 2012

Advanced Grain Handling Systems  
823 Main Street West  
Mayville, ND 58016



Attn: Mr. Chad Kylo  
P: [701] 788 8929

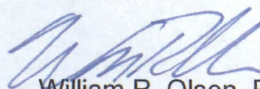
Re: Geotechnical Engineering Report  
Proposed Grain Storage Bin  
Westhope, North Dakota  
MTL/Terracon Project Number: M5125023

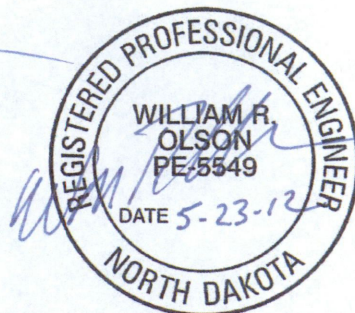
Dear Mr. Kylo:

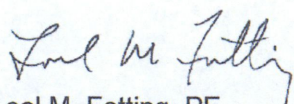
Midwest Testing Laboratory (A Terracon Company) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number PM5120041 dated April 9, 2012. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed bin.

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

Sincerely,  
**Midwest Testing Laboratory, A Terracon Company**

  
William R. Olson, PE  
Geotechnical Engineer



  
Loel M. Fetting, PE  
Senior Associate

Enclosures

cc: 3 - Client (mail)  
1 - Client (pdf)  
1 - File

Midwest Testing Laboratory, Inc., A Terracon Company 1555 N. 42<sup>nd</sup> Street - Unit B Grand Forks, ND 58203-0809  
P [701] 772 2832 F [701] 772 2633 midwesttestinglabs.com terracon.com

Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

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## **EXECUTIVE SUMMARY**

Geotechnical engineering services have been completed for the proposed grain storage bin near Westhope, North Dakota. Two (2) soil test borings were advanced to depths ranging from about 30 to 60 feet below the existing ground surface.

Based on the information obtained from our subsurface exploration, the site can be developed for the proposed project. The following geotechnical considerations were identified:

- In our opinion, standard ring foundation construction is feasible for support of the grain storage bin with a net soil bearing pressure of 3500 psf or less.
- The bin will be subject to long term settlement. Equipment must be capable of tolerating the anticipated movement. If the estimated settlement is not acceptable to the owner or tolerable to the structure, consideration could be given to a deep foundation system.
- We estimate a groundwater level on the order of 12 to 15 feet below the existing grade at the time of our field activities. We do not expect the groundwater level to be a concern for the proposed construction. We anticipate any groundwater seepage in open excavations would be controllable by sump pumping.
- Close monitoring of the construction operations discussed herein will be critical in achieving the design subgrade support. We therefore recommend that the MTL/Terracon be retained to monitor this portion of the work.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

**GEOTECHNICAL ENGINEERING REPORT  
 PROPOSED GRAIN STORAGE BIN  
 WESTHOPE, NORTH DAKOTA  
 MTL/Terracon Project No. M5125023  
 MAY 23, 2012**

**1.0 INTRODUCTION**

Geotechnical engineering services have been completed for the proposed grain storage bin near Westhope, North Dakota. Two (2) soil test borings were advanced to depths ranging from about 30 to 60 feet below the existing ground surface. Logs of the borings along with a site location map and boring location plan are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- foundation design and construction
- earthwork

**2.0 PROJECT INFORMATION**

**2.1 Project Description**

| Item                            | Description   |
|---------------------------------|---|
| <b>Site layout</b>              | See Appendix A, Exhibit A-2: Boring Location Plan   |
| <b>Structure</b>                | The project will include construction of one grain storage tank with a diameter of 60 feet, eave height of 48 feet and a capacity of about 126,000 bushels. |
| <b>Finished floor elevation</b> | The bin floor will be on the order of 5 to 6 feet above the existing grade.   |
| <b>Maximum loads</b>            | We estimate the grain storage bin will require an allowable soil bearing pressure on the order of 3000 to 3500 pounds per square foot.                      |

**2.2 Site Location and Description**

| Item                        | Description                                     |
|-----------------------------|---|
| <b>Location</b>             | See Appendix A, Exhibit A-1: Site Location Plan |
| <b>Current ground cover</b> | Grass/aggregate surface                         |

| Item                | Description      |
|---------------------|------------------|
| Existing topography | Relatively level |

### 3.0 SUBSURFACE CONDITIONS

#### 3.1 Typical Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

| Stratum | Approximate Depth to Bottom of Stratum (feet) | Material Description          | Consistency/ Density  |
|---------|---|-------------------------------|-----------------------|
| 1       | 2 - 4   | Existing fill <sup>1</sup>    | N/A                   |
| 2       | 4   | Undisturbed native lean clays | Soft                  |
| 3       | Undetermined <sup>2</sup>                     | Sandy lean clay               | Medium stiff to stiff |

1. Uncontrolled fill is material that was placed without moisture and density control. This material is typically variable in composition, consistency, density, moisture, and depth. Fill without documentation regarding the placement methods and compaction records is assumed to be uncontrolled.
2. Borings terminated in this stratum at the planned maximum depth of 61 feet.

Conditions at each boring location are indicated on the attached individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report. A discussion of the field sampling is included in Appendix A.

#### 3.2 Groundwater

Groundwater was not observed in the borings while drilling. Boring two was left open and a groundwater level of about 20 feet was measured after about 6 hours. Due to the low permeability of the soils encountered in the borings, a relatively long period of time may be needed for a groundwater level to develop and stabilize in a borehole in these materials. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Based on the moisture condition of the samples and information available, we estimate a groundwater level on the order of 12 to 15 feet below the existing grade at the time of our field activities.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

## **4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION**

### **4.1 Geotechnical Considerations**

Based on the results of the subsurface exploration, laboratory testing, and our analysis, it is our opinion that standard ring foundation is feasible for support of a bin with a net allowable soil bearing pressure of 3500 psf or less. The bins should be supported on a well compacted engineered fill after removal of the existing fill.

The bin will be subject to settlement. Estimates of settlement are provided below. Equipment must be capable of tolerating the estimated settlement. If the estimated settlement is not tolerable to the structure or acceptable to the owner, consideration could be given to a deep foundation system.

### **4.2 Earthwork**

#### **4.2.1 Site Preparation**

In preparing the site for bin construction, we recommend excavating the bin areas to a uniform elevation that will remove the existing fill as well as the soft lean clays encountered in the upper portion of the borings. Based on the soil conditions encountered, we estimate an excavation depth on the order of 5 feet below the existing grade will be needed. This corresponds to an elevation of approximately 89 referenced to our temporary benchmark. The excavation should be oversized a minimum of 1 foot beyond the outer edge of the foundation for each 2 feet of engineered fill beneath the foundation.

We recommend that MTL/Terracon be retained to evaluate the bearing material for the foundations, floor slab and pavement subgrade soils to evaluate whether additional subgrade excavation is required. Subsurface conditions, as identified by the field and laboratory testing programs, have been reviewed and evaluated with respect to the proposed building plans known to us at this time.

#### 4.2.2 Material Requirements

Compacted structural fill should meet the following material property requirements:

| Fill Type <sup>1</sup> | USCS Classification                                 | Acceptable Location for Placement      |
|------------------------|---|--|
| Select Granular Fill   | SP, SP-SM, SP-SC,<br>SW, SW-SM, SW-SC<br>(P200<12%) | Support of foundations and floor slabs |

1. Controlled, compacted fill should consist of approved materials that are free of organic matter, debris, or other deleterious substance. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.

#### 4.2.3 Compaction Requirements

| ITEM  | DESCRIPTION                 |
|---|-----------------------------|
| Fill lift thickness                             | 6 inches in loose thickness |
| Compaction requirements <sup>1</sup>            | 98% minimum                 |
| Moisture content granular material <sup>2</sup> | Workable moisture levels    |

1. We recommend that engineered 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. Compaction levels are relative to the soil's standard Proctor maximum dry density (ASTM D698).
2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

#### 4.2.4 Earthwork Construction Considerations

We estimate a ground water level on the order of 12 to 15 feet below existing grade at the time of our field activities. We do not expect the groundwater level to be a concern for the proposed construction. We expect any groundwater encountered would be controllable by sump pumping.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs and pavements. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab and pavement construction. Fill should not be placed on frozen 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 operations.

The grading contractor, by his 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.

MTL/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 compacted structural fill, and backfilling of excavations into the completed subgrade.

### **4.3 Foundations**

In our opinion, the proposed bin can be supported by shallow, spread footings bearing on engineered fill placed and compacted as recommended above. In no case should foundations bear on existing uncontrolled fill. Design recommendations for shallow foundations are presented in the following paragraphs.

#### **4.3.1 Foundation Design Recommendations**

Based on the standard penetration resistance, and our past experience with similar soils, we recommend a net allowable bearing pressure of 3500 psf for design of the bins. If the floor is elevated, the weight of the fill and concrete added to the site must be included in the calculation of bearing pressure. A loading of this magnitude will provide a factor of safety on the order of 3 against a shear failure.

We estimate immediate settlement on the order of 1 inch as loads are applied. Total long-term settlement will be on the order of 3 to 4 inches. We estimate differential tilting at the base of the footings could approach half of the total settlement. Also, some additional settlement of the existing adjacent bin may occur.

Foundations supported near the final elevation would be subject to movement from frost action. If seasonal movement is not acceptable, we recommend supporting the foundations at frost depth (6 feet).

We recommend monitoring settlement during the initial filling of the bin. Any unusual settlement should be reported to us for review.

#### **4.3.2 Foundation Construction Considerations**

The base of all foundation excavations should be free of water and loose soil prior to placing engineered fill or concrete. Engineered fill or concrete should be placed soon after excavating to reduce bearing soil disturbance. If excavations are left exposed for an extended period of time, consideration should be given to protecting the foundation subgrades with a lean concrete

mud mat. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete. It is recommended that MTL/Terracon be retained to observe and test the soil foundation bearing materials.

## **5.0 GENERAL COMMENTS**

MTL/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. MTL/Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction 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. 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 MTL/Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

**APPENDIX A**  
**FIELD EXPLORATION**

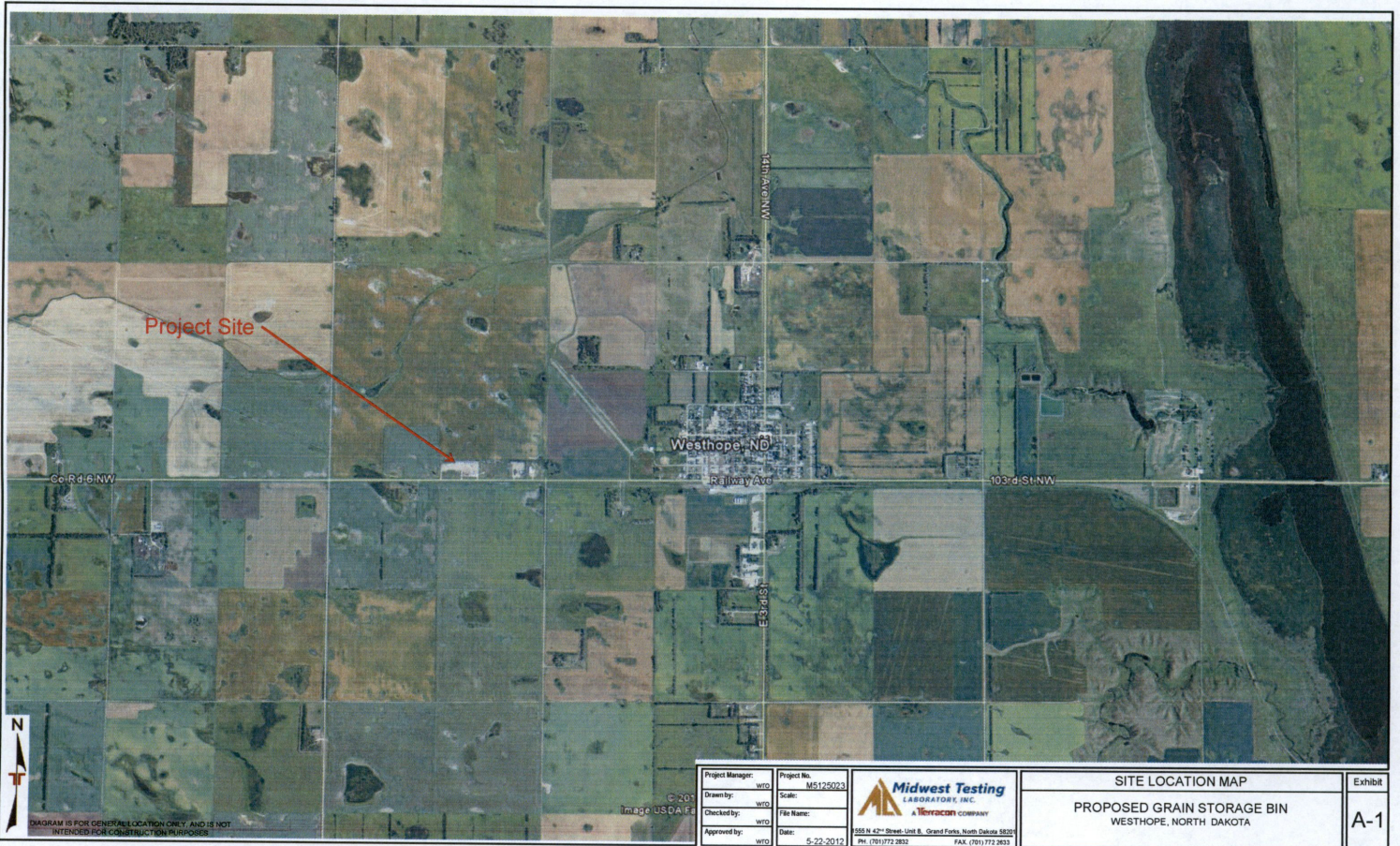


DIAGRAM IS FOR GENERAL LOCATION ONLY AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

© 2012 Image USA, LLC

|                  |     |              |           |
|------------------|-----|--------------|-----------|
| Project Manager: | WTD | Project No.: | MS125023  |
| Drawn by:        | WTD | Scale:       |           |
| Checked by:      | WTD | File Name:   |           |
| Approved by:     | WTD | Date:        | 5-22-2012 |



|  |  |
|--|--|
| SITE LOCATION MAP                                    |  |
| PROPOSED GRAIN STORAGE BIN<br>WESTHOPE, NORTH DAKOTA |  |

|         |     |
|---------|-----|
| Exhibit | A-1 |
|---------|-----|

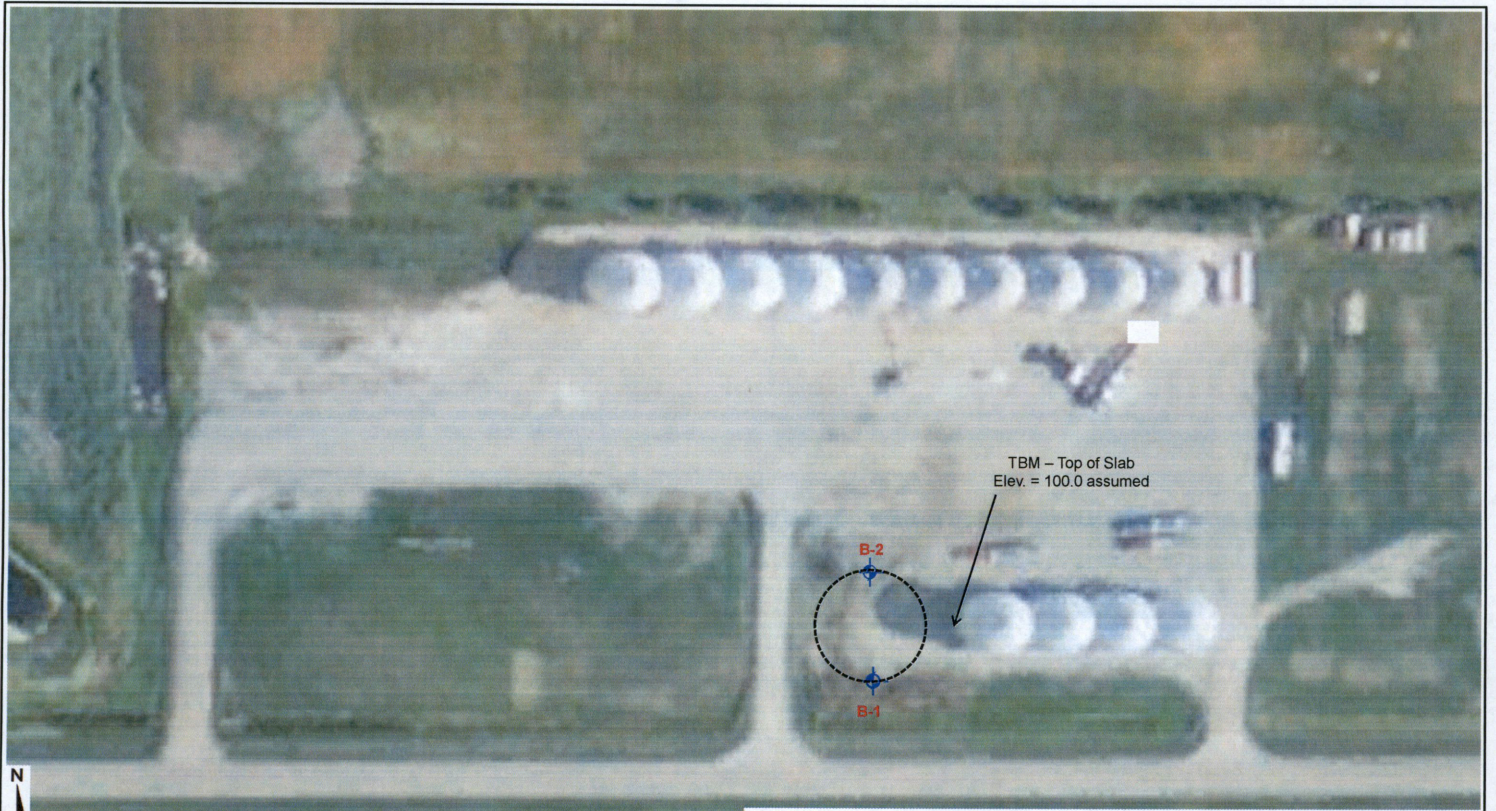


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

Project Manager:  
WTD  
Drawn by:  
WTD  
Checked by:  
WTD  
Approved by:  
WTD

Project No.  
MS1250233  
Scale:  
1" = 50'  
File Name:  
Date:  
5-21-2017



BORING LOCATION DIAGRAM  
PROPOSED GRAIN STORAGE BIN  
WESTHOPE, NORTH DAKOTA

Exhibit  
A-2

# BORING LOG NO. B-1

**PROJECT:** Proposed Grain Storage Bin

**CLIENT:** Advanced Grain Handling Systems  
Mayville, North Dakota

**SITE:** 1535 103rd Street Northwest  
Westhope, North Dakota

| GRAPHIC LOG | LOCATION See Exhibit A-2   | DEPTH | Approximate Surface Elev.: 94.3<br>ELEVATION | DEPTH (ft) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (ft) | FIELD TEST RESULTS | UNCONFINED COMPRESSIVE STRENGTH (psf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS |          |
|-------------|--|-------|--|------------|--------------------------|-------------|---------------|--------------------|---------------------------------------|-------------------|-----------------------|------------------|----------|
|             |  |       |  |            |                          |             |               |                    |                                       |                   |                       | LL-PL-PI         |          |
|             | <b>FILL - SANDY LEAN CLAY</b> , dark brown   | 2.0   | 92.5   |            |                          |             | 1             | 1-1-2<br>N=3       |                                       |                   |                       |                  |          |
|             | <b>LEAN CLAY (CL)</b> , light olive brown, soft  | 4.0   | 90.5   |            |                          |             | 1.1           | 0-1-2<br>N=3       |                                       | 32                |                       |                  |          |
|             | <b>SANDY LEAN CLAY (CL)</b> , light olive brown, medium stiff to stiff, with a trace of gravel |       |  | 5          |                          |             | 1.3           | 1-2-3<br>N=5       |                                       | 25                |                       |                  |          |
|             |  |       |  |            |                          |             | 1.7           | 1-3-4<br>N=7       |                                       | 18                |                       |                  |          |
|             |  |       |  |            | 10                       |             |               | 1.5                | 2-3-5<br>N=8                          |                   | 16                    |                  |          |
|             |  |       |  |            |                          |             |               | 1.8                |                                       | 4050.0            | 17                    | 116              | 30-14-16 |
|             |  |       |  | 15         |                          |             | 1.7           | 3-5-4<br>N=9       |                                       |                   |                       |                  |          |
|             |  |       |  | 20         |                          |             | 1.5           | 3-6-6<br>N=12      |                                       |                   |                       |                  |          |
|             |  | 24.0  | 70.5   |            |                          |             |               |                    |                                       |                   |                       |                  |          |
|             | <b>SANDY LEAN CLAY (CL)</b> , dark gray, stiff, with a trace of gravel                         |       |  | 25         |                          |             | 1.7           | 3-7-8<br>N=15      |                                       |                   |                       |                  |          |
|             |  |       |  | 30         |                          |             | 1.7           | 3-5-7<br>N=12      |                                       |                   |                       |                  |          |
|             | <b>Boring Terminated at 31 Feet</b>  | 31.0  | 63.5   |            |                          |             |               |                    |                                       |                   |                       |                  |          |

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

Hammer Type: Automatic

Advancement Method:  
3 1/4" HSA

See Exhibit A-6 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data, (if any).

Notes:

Abandonment Method:  
Borings backfilled with soil cuttings upon completion.

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

Not measurable before HSA removal

Dry cave-in at 7.0



Boring Started: 5/9/2012

Boring Completed: 5/9/2012

Drill Rig: Diedrich D50

Driller: DH

Project No.: M5125023

Exhibit A-3


THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO.WELL. M5125023.GPJ TERRACON2012.GDT 5/23/12

# BORING LOG NO. B-2

**PROJECT:** Proposed Grain Storage Bin

**CLIENT:** Advanced Grain Handling Systems  
Mayville, North Dakota

**SITE:** 1535 103rd Street Northwest  
Westhope, North Dakota

| GRAPHIC LOG  | LOCATION See Exhibit A-2   | DEPTH  | Approximate Surface Elev.: 93.4<br>ELEVATION | DEPTH (ft) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (ft) | FIELD TEST RESULTS | UNCONFINED COMPRESSIVE STRENGTH (psf) | WATER CONTENT (%) | DRY UNIT WEIGHT (pcf) | ATTERBERG LIMITS |  |
|--|--|--|--|------------|--------------------------|-------------|---------------|--------------------|---------------------------------------|-------------------|-----------------------|------------------|--|
|  |  |  |  |            |                          |             |               |                    |                                       |                   |                       | LL-PL-PI         |  |
|  | <p><b>FILL - SANDY LEAN CLAY</b>, dark brown to dark grayish brown</p> | 4.0  | 89.5   | 0.8        | X                        |             | 0.8           | 1-1-2<br>N=3       |                                       |                   |                       |                  |  |
|  |  |  |  |            | 1.1                      | X           |               | 1.1                | 2-2-4<br>N=6                          |                   |                       |                  |  |
|  |  | <p><b>SANDY LEAN CLAY (CL)</b>, olive brown, medium stiff to stiff, with a trace of gravel</p> |  |            | 1.2                      | X           |               | 1.2                | 1-2-4<br>N=6                          | 3561.4            | 16                    |                  |  |
|  |  |  |  |            | 1.5                      | X           |               | 1.5                | 2-3-5<br>N=8                          |                   | 17                    |                  |  |
|  |  |  |  |            | 1.5                      | █           |               | 1.5                |                                       | 2368.0            | 18                    | 106              |  |
|  |  |  |  |            | 1.8                      | X           |               | 1.8                | 2-4-5<br>N=9                          |                   | 16                    |                  |  |
|  |  |  |  |            | 2                        | X           |               | 2                  | 3-4-5<br>N=9                          |                   | 17                    |                  |  |
|  |  |  |  |            | 1.5                      | █           |               | 1.5                |                                       | 5545.4            | 14                    | 118              |  |
|  |  | <p><b>SANDY LEAN CLAY (CL)</b>, dark gray, stiff to very stiff, with a trace of gravel</p>     | 23.0   | 70.5       |                          |             |               |                    |                                       |                   |                       |                  |  |
|  |  |  |  |            | 2                        | X           |               | 2                  | 3-5-8<br>N=13                         |                   | 11                    |                  |  |
|  |  |  |  | 1.5        | X                        |             | 1.5           | 2-5-6<br>N=11      | 4770.8                                | 15                |                       |                  |  |
|  |  |  |  |            |                          |             |               |                    |                                       |                   |                       |                  |  |
|  |  |  |  | X          |                          |             |               |                    |                                       |                   |                       |                  |  |

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

Hammer Type: Automatic

Advancement Method:  
3 1/4" HSA

See Exhibit A-6 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data, (if any).

Notes:

Abandonment Method:  
Borings backfilled with soil cuttings upon completion.

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

Not measurable before HSA removal

Dry cave-in at 23.8

▼ 6 hours



Boring Started: 5/9/2012

Boring Completed: 5/9/2012

Drill Rig: Diedrich D50

Driller: DH

Project No.: M5125023

Exhibit A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL. M5125023.GPJ TERRACON2012.GDT 5/23/12



### **Field Exploration Description**

Two (2) soil test borings were completed on May 9, 2012. The borings were advanced at the approximate locations indicated on the attached figure. The surface elevations displayed on the boring logs were referenced to the floor slab of the existing bin as indicated on the attached sketch. This floor elevation was assumed to be at elevation 100.0.

The borings were drilled with an ATV mounted rotary drill rig using 3 ¼ hollow stem to advance the boreholes. Samples of the soil encountered in the borings were obtained using the split-barrel sampling procedures.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in situ relative density of cohesionless soils and consistency of cohesive soils.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

**APPENDIX B**  
**SUPPORTING INFORMATION**

## Geotechnical Engineering Report

Proposed Grain Storage Bin ■ Westhope, North Dakota

May 23, 2012 ■ MTL/Terracon Project No. M5125023



### Laboratory Testing

Representative samples were selected for laboratory analysis. The testing program consisted of determining moisture content, dry density, unconfined compressive strength, and Atterberg limits. The laboratory test results can be found on the boring logs, opposite the samples they represent.

Some unconfined compressive strength tests were performed on split-barrel samples. Since the samples are disturbed during driving these results should be considered approximate.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the General Notes in Appendix C and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is included in Appendix C of this report. All classification was by visual manual procedures.

**APPENDIX C**  
**SUPPORTING DOCUMENTS**

## GENERAL NOTES

### DRILLING & SAMPLING SYMBOLS:

|     |  |     |                           |
|-----|--|-----|---------------------------|
| SS: | Split Spoon - 1- <sup>3</sup> / <sub>8</sub> " I.D., 2" O.D., unless otherwise noted | HS: | Hollow Stem Auger         |
| ST: | Thin-Walled Tube - 3" O.D., unless otherwise noted                                   | PA: | Power Auger (Solid Stem)  |
| RS: | Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted                           | HA: | Hand Auger                |
| DB: | Diamond Bit Coring - 4", N, B  | RB: | Rock Bit                  |
| BS: | Bulk Sample or Auger Sample  | WB: | Wash Boring or Mud Rotary |

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

### WATER LEVEL MEASUREMENT SYMBOLS:

|      |             |     |                |      |                       |
|------|-------------|-----|----------------|------|-----------------------|
| WL:  | Water Level | WS: | While Sampling | BCR: | Before Casing Removal |
| WCI: | Wet Cave in | WD: | While Drilling | ACR: | After Casing Removal  |
| DCI: | Dry Cave in | AB: | After Boring   | N/E: | Not Encountered       |

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

**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.

### CONSISTENCY OF FINE-GRAINED SOILS

| <u>Unconfined<br/>Compressive<br/>Strength, Qu, psf</u> | <u>Standard Penetration<br/>or N-value (SS)<br/>Blows/Ft.</u> | <u>Consistency</u> |
|---|---|--------------------|
| < 500   | 0 - 1   | Very Soft          |
| 500 - 1,000   | 2 - 4   | Soft               |
| 1,000 - 2,000   | 5 - 8   | Medium Stiff       |
| 2,000 - 4,000   | 9 - 15  | Stiff              |
| 4,000 - 8,000   | 16 - 30   | Very Stiff         |
| 8,000+  | 30+   | Hard               |

### RELATIVE DENSITY OF COARSE-GRAINED SOILS

| <u>Standard Penetration<br/>or N-value (SS)<br/>Blows/Ft.</u> | <u>Relative Density</u> |
|---|-------------------------|
| 0 - 3   | Very Loose              |
| 4 - 9   | Loose                   |
| 10 - 29   | Medium Dense            |
| 30 - 49   | Dense                   |
| 50+   | Very Dense              |

### RELATIVE PROPORTIONS OF SAND AND GRAVEL

| <u>Descriptive Term(s)<br/>of other constituents</u> | <u>Percent of<br/>Dry Weight</u> |
|--|----------------------------------|
| Trace  | <15                              |
| With   | 15 - 29                          |
| Modifier   | >29                              |

### GRAIN SIZE TERMINOLOGY

| <u>Major Component<br/>of Sample</u> | <u>Particle Size</u>               |
|--------------------------------------|------------------------------------|
| Boulders                             | Over 12 in. (300mm)                |
| Cobbles                              | 12 in. to 3 in. (300mm to 75mm)    |
| Gravel                               | 3 in. to #4 sieve (75mm to 4.75mm) |
| Sand                                 | #4 to #200 sieve (4.75 to 0.075mm) |
| Silt or Clay                         | Passing #200 Sieve (0.075mm)       |

### RELATIVE PROPORTIONS OF FINES

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

### PLASTICITY DESCRIPTION

| <u>Term</u> | <u>Plasticity<br/>Index</u> |
|-------------|-----------------------------|
| Non-plastic | 0                           |
| Low         | 1 - 10                      |
| Medium      | 11 - 30                     |
| High        | >30                         |

# UNIFIED SOIL CLASSIFICATION SYSTEM

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

<sup>A</sup> Based on the material passing the 3-inch (75-mm) sieve  
<sup>B</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.  
<sup>C</sup> 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.  
<sup>D</sup> 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  
<sup>E</sup>  $Cu = D_{60}/D_{10}$      $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$   
<sup>F</sup> If soil contains  $\geq 15\%$  sand, add "with sand" to group name.  
<sup>G</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup> If fines are organic, add "with organic fines" to group name.  
<sup>I</sup> If soil contains  $\geq 15\%$  gravel, add "with gravel" to group name.  
<sup>J</sup> If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.  
<sup>K</sup> If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.  
<sup>L</sup> If soil contains  $\geq 30\%$  plus No. 200 predominantly sand, add "sandy" to group name.  
<sup>M</sup> If soil contains  $\geq 30\%$  plus No. 200, predominantly gravel, add "gravelly" to group name.  
<sup>N</sup>  $PI \geq 4$  and plots on or above "A" line.  
<sup>O</sup>  $PI < 4$  or plots below "A" line.  
<sup>P</sup>  $PI$  plots on or above "A" line.  
<sup>Q</sup>  $PI$  plots below "A" line.

