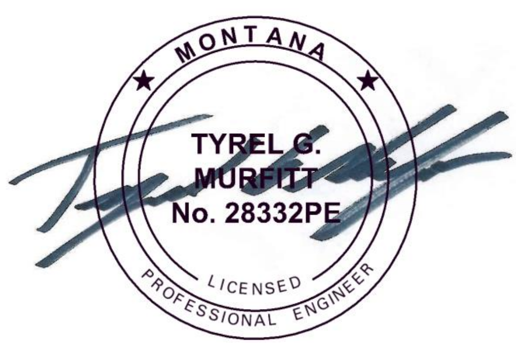
OSTERBERG CELL TEST REPORT

THOMPSON RIVER - EAST
STPB-STPP-HSIP 6-1(106)56
Contract: 12514
Experimental Project MT-13-02
2015

TYREL MURFITT, P.E.

GEOTECHNICAL SECTION

MONTANA DEPARTMENT OF TRANSPORTATION



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Executive Summary

During construction of the new bridge over the Thompson River east of Thompson Falls on HWY 200, a sacrificial test shaft was installed for conducting a static load test. A sacrificial shaft was installed because of uncertainties in the post test behavior of a twin production shaft bent over the lifetime of the structure. The static load test was conducted using Osterberg Load Cell (O-Cell) technology and procedures.

Sletten Construction Co. Inc. was awarded the contract on June 3, 2014. The construction of the test shaft started on November 17^{th}, 2014; with the shaft being poured on December 8^{th}, 2014; and the static load test conducted on December 29^{th}, 2014.

Figure E 1 Osterberg Test Assembly

The test shaft was installed using an oversized temporary casing (8.5 ft. diameter) penetrating to a depth of 31 ft. below ground surface, with 8.0 ft. diameter casing installed to the planned penetration depth of 60.5 ft. below ground surface. The casing used to install the drilled shaft was removed during the shaft concrete pour leaving an uncased drilled shaft. A Contractor-designed reinforcing cage was installed with the O-Cell located near the bottom of the cage. Additionally there were strain gauges, linear vibrating wire displacement transducers (LVWDT's) and telltales installed in the rebar cage at strategic locations for monitoring the behavior of the drilled shaft while load was applied via the O-Cell.

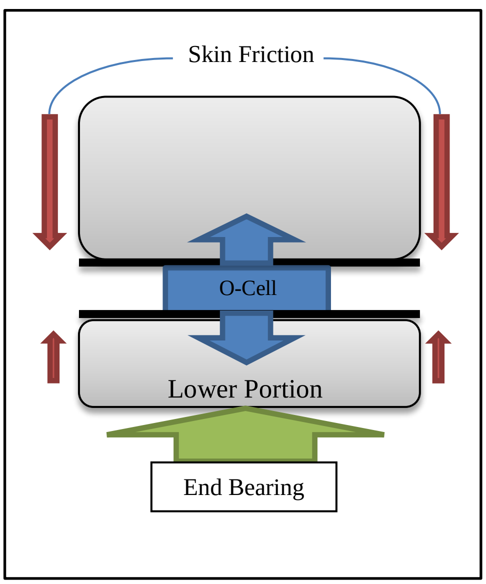

Fig. E 2 Load Test Free Body Diagram

The test shaft was installed in granular material consisting of gravel with scattered boulders in the top 31 feet of the shaft and medium dense sand for the bottom 30 feet of shaft and the tip. Refer to Boring 4039-18 (Appendix A) for a representation of the ground conditions and Appendix I for the bridge footing plan.

The O-Cell load test was successful. The estimated capacity of the drilled shaft determined during design was 4,560 kips. The load test recorded a maximum test capacity of 3,847 kips. The shaft fully mobilized the available skin friction first; therefore the base resistance was unable to be tested to capacity, therefore there was considerable more capacity in end bearing. The O-Cell test method uses the upper part of the drilled shaft to resist the loading on the base of the shaft and uses the base of the shaft to resist the loading on the upper part of the shaft. Basically two tests are being conducted at the same time and when one fully mobilizes the soil capacity the other is unable to be continued due to the loss of resistance.

O-Cell results are a combination of the data recorded during a test to produce an equivalent top-load, load vs. displacement curve. The equivalent tested top-load capacity of 3,000 kips at 0.88 inches of shaft displacement, corresponds to an approximate Factor of Safety of 2 (ASD design). At a shaft displacement of 1.672 inches the capacity to demand ratio (C/D) was approximately 1.04 (LRFD design). Both ASD and LRFD design criteria were satisfied by the load test.

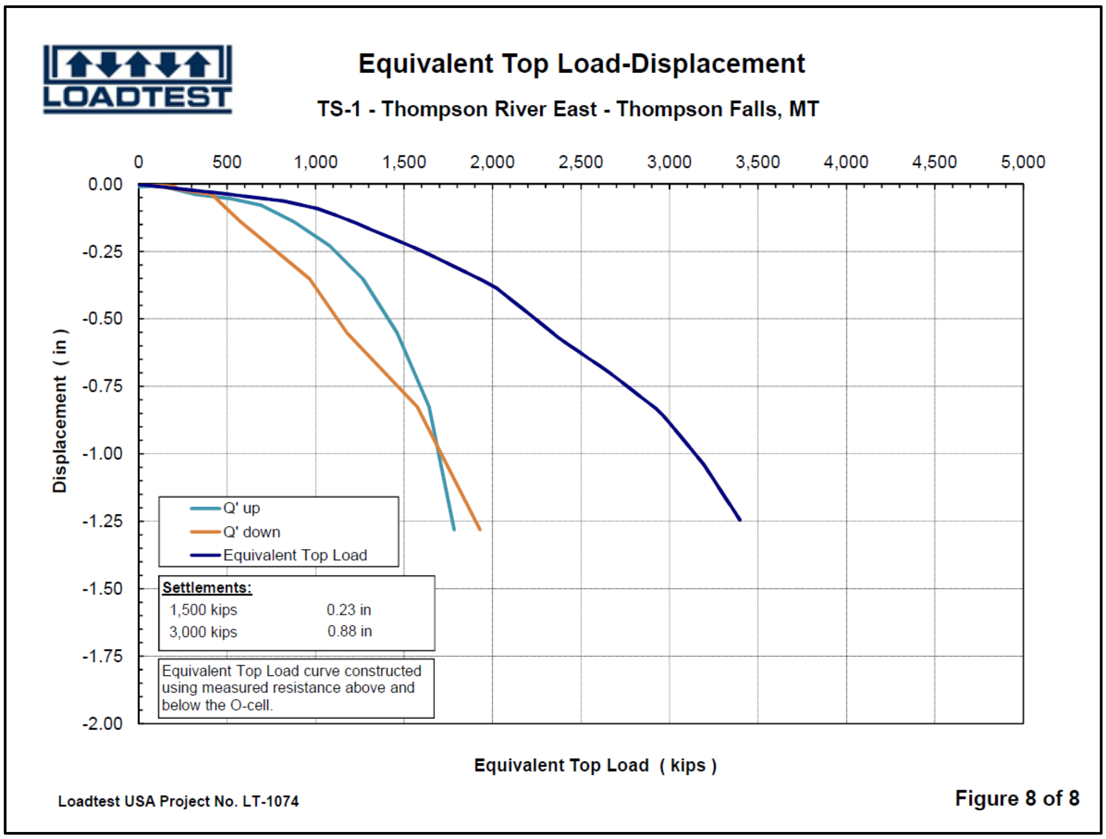

Chart Courtesy of LoadTest USA 1074-Report-v3

The data obtained by the successful load test allowed the Pier 2 shaft design lengths (2 shafts) to be shortened by a total of 72 feet. The reduction in drilled shaft length offset the cost for the installation and execution of the O-Cell test. Approximately $64,000 was saved based on the unit bid prices for the project.

We recommend that O-Cell testing be considered on future projects to realize potential cost savings for bridge replacement using high capacity or multiple drilled shaft foundations. These cost savings can be realized by:

- Using higher resistance factors in design
- Reduce uncertainty on design models
- Lower risk by proving installation methodologies
- Fine tuning soil/structure interaction models
- Reducing construction time with more efficient designs

Please refer to the main report and appendices for more information regarding the load test as well as example contract documents for future projects where O-Cell testing is a consideration.

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Introduction

The construction project STPB-STPP-HSIP 6-1(106)56, Thompson River – East included a full scale sacrificial load tested drilled shaft to confirm design assumptions, increase efficiency of the design, and confidence in the load capacity of large diameter drilled shafts, and test the typical installation methods of drilled shafts used by MDT.

Project Background

The proposed structure over the Thompson River on HWY 200 demanded a high level of performance from the foundation elements. During the design process multiple foundation options were investigated. Drilled shafts were chosen as the preferred foundation type for the bridge due to site constraints, load demand, available capacity, and seismic concerns.

During the drilled shaft design a number of approaches were used to estimate the nominal axial capacity of the drilled shaft. The design methods used included procedures from Naval Facilities (NAVFAC), Federal Highways (FHWA), Hans F. Winterkorn and Hsai-Yang Fang (W&F), and Joseph E. Bowles (Bowles). The different approaches produced significant difference in estimated available capacity at equivalent tip elevations. Once the structure design was nearing conclusion, the NAVFAC method was chosen to estimate the nominal axial capacity of the drilled shafts based on site conditions, experience with the model, previous performance, and engineering judgment.

Due to the uncertainties with the various models and the fact that large diameter drilled shafts had not been load tested in Montana, MDT contacted LoadTest USA to inquire about Osterberg Load Cell (O-Cell) testing.

Based on the conversation with LoadTest USA, MDT Bridge Bureau, and the general goal of providing cost efficient, safe, long-lasting transportation infrastructure, the Geotechnical Section recommended conducting an O-Cell test on a large diameter drilled shaft for the bridge over the Thompson River.

Geology

The structure spans the Thompson River near its confluence with the Clark Fork River. This area was subjected to numerous cycles of erosion and deposition as Glacial Lake Missoula repeatedly filled and catastrophically drained through the Clark Fork River valley. Silts and clays were deposited in the times that the glacial lake was filled. Erosion of these fine-grained deposits and deposition of sand, gravel, cobbles and boulders occurred as the lake drained. Overlying these deposits is Quaternary alluvium from the Thompson River, consisting primarily of sands and gravels, with some cobbles and smaller boulders. The bedrock beneath and adjacent to the highway is composed of steeply dipping metasedimentary rocks of the Proterozoic Belt Super Group, specifically the Burke Formation, which is made up of quartzite, argillite and siltite. The adjacent terrain is steeply rolling, especially east of the bridge, which features a steep grade with a high hill on the north side, and a steep slope to the railroad and river on the south side.

Site Conditions

A conventional subsurface investigation was conducted, which included drilling with hollow-stem augers and casing advancer, with Standard Penetration Tests (SPT) conducted at regular intervals. The SPT's provided an indication of material density, and a sample for classification and moisture content determination in our soils laboratory.

The material encountered in Boring 4039-18 is indicative of the subsurface conditions in which the test shaft was installed. A relatively thin layer of silty sand (5.0 ft. thick) was encountered overlying medium dense to loose, poorly graded subrounded gravel with occasional cobbles and boulders (25.0 ft. thick). Below the gravel, loose to medium dense poorly graded sand, with occasional layers of gravel was encountered for the remainder of the planned drilled shaft installation depth. Groundwater was encountered at 14.4 ft. below ground surface at the approximate elevation of the Thompson River. The test shaft plan tip was in a medium dense sand layer approximately 61 feet below ground surface as referenced on boring 4039-18. Please refer to Appendix A for the boring logs conducted for the bridge foundations.

Existing Structure

The bridge slated for replacement over the Thompson River was built in 1935. It has a total of 5 spans, two cast in place concrete "T" beam spans, two rolled steel girder spans, and a deck truss main span for a total length of 428-ft. The abutments and piers are concrete columns founded on concrete caps and timber piles with the exception of Abutment No. 1 and Pier No. 2 which are founded on spread footings. The roadway width is 24-ft.
The bridge spans the 100-ft deep chasm of the Thompson River about 1,200-ft upstream of its confluence with the Clark Fork River

The bridge is structurally deficient due to poor superstructure and deck ratings. It is functionally obsolete due the narrow bridge deck width. Replacement was chosen over rehabilitation because of the overall poor condition of the bridge and that widening is not practical with this type of superstructure.

Table 1 Existing Structure Conditions

Year constructed	1935
Eligible for replacement	Yes
Structurally deficient	Yes
Functionally obsolete	Yes
Fracture critical	Yes
Roadway width	24 ft 0 in
Total length	428 ft 0 in
Span lengths	53 ft – 201 ft – 62 ft – 62 ft – 50 ft
Superstructure types	Concrete 'T' beam, deck truss, rolled beam, rolled beam, concrete 'T' beam
Deck rating	4 (Poor)
Superstructure rating	3 (Serious)
Substructure rating	5 (Fair)
Sufficiency rating	4 (out of 100)
Deck Geometry	2 (Intolerable-Replace)

Original Shaft Design

In a memorandum dated February 27, 2012 the Bridge Bureau provided loading information for the proposed Thompson River Bridge. In Table 2 below is a summary of "Per Column" loading for Pier 2 only. The loading for this bridge was developed using AASHTO LRFD Bridge Design Specification – 4th Edition – 2007.

Table 2 Per Column Loading

Foundation	Axial (kip)	Lateral (kip, ft-kip)	Loading Type
Pier	2240	44 (V), 2990 (M)	Strength I
Pier	1990	113 (V), 5920 (M)	Strength III

In a memo dated November 8, 2012, the Geotechnical Section recommended a foundation system consisting of two 8.0 foot diameter shafts penetrating to a depth of 96 feet would be required to transfer the imposed loading to the subsurface soils in accordance with LRFD. From February to November there were a number of iterations between MDT Bridge and Geotech on the foundation loading. Table 3 reports the final axial loading that was used in design of the foundation elements for Pier 2 for both Load Resistance Factor Design (LRFD) and Allowable Stress Design (ASD). The drilled shaft design was controlled by the axial load, meaning that the tip elevation required to resist the axial loading imposed on the drilled shaft was deeper than the tip elevation required to resist the lateral loading imposed on the drilled shaft.

Table 3 Design Parameters for Pier 2 Drilled Shaft Design

Parameter:	Value:	Comments/Reference:
Axial Service Load	1560 kips	Internal Memo
Axial Strength I Load	2070 kips	Internal Memo
Shaft Diameter	8.0 feet	
Shaft Depth	96 feet	
LRFD Resistance Factor*	0.32	AASHTO
ASD desired FOS	3.0	NAVFAC (used as a check)
Shaft Design	Both skin and End Bearing	
Casing	Temporary Only	
LRFD C/D ratio	2.24	

*LRFD resistance factor is reduced per AASHTO requirements for non-redundant shafts; redundancy is three or more shafts per bent.

O-Cell Design

In the November 8, 2012 Geotechnical Design Memo, installation of a sacrificial drilled test shaft near Pier 2 was recommended. By performing static load tests on foundation elements, LRFD design procedures allow increasing of the phi (Φ), or resistance factor, thereby decreasing the required nominal capacity of a design element. Following are the design parameters for the O-Cell design (axial only) for Pier 2 in Table 4.

Table 4 Design Parameters for Pier 2 O-Cell Drilled Shaft Design

Parameter:	Value:	Comments/Reference:
Axial Service Load	1560 kips	Internal Memo
Axial Strength I Load	2070 kips	Internal Memo
Shaft Diameter	8.0 feet	
Shaft Depth	58.7 feet	
LRFD Resistance Factor*	0.56	AASHTO
ASD desired FOS	2.0	NAVFAC (used as a check)
Shaft Design	Both skin and End Bearing	
Casing	Temporary Only	
Nominal Capacity	4,560 kips	
LRFD C/D ratio	1.23	

*LRFD resistance factor is reduced per AASHTO requirements for non-redundant shafts; redundancy is three or more shafts per bent.

The biggest hurdles in conducting an O-Cell test are the additional perceived cost and added time to a construction project. MDT drilled shaft bid items historically are not a statistically valid data-set for an average bid price. The cost is heavily dependent on the Contractor, the subsurface conditions, and the available construction equipment, amongst other factors. However, the recommendation to perform an O-Cell test, despite the variability in cost, was agreed upon and plans and specifications were developed for the project. It should be noted that by conducting static load test on the project all 8.0 ft. diameter drilled shafts for the project transferred to a laterally controlled design. The load test optimized the axial design to a point where design requirements were met at or near the minimum tip elevation for Pier 2 and were exceeded for Pier 3.

O-Cell Option Consideration

Load testing of large capacity drilled shafts is very difficult if performed in accordance with ASTM D1143 (Standard Test Methods for Deep Foundations Under Static Axial Compressive Load) using a reaction frame or reaction weight, primarily due to the very large loads that drilled shafts can resist. The reaction frames and necessary foundations are cost prohibitive. If a reaction weight were chosen as the means of load testing, a concrete block of approximately 1400 cubic yards (34' x 34' x 34') would be the minimal size required; it would have been difficult to provide a support frame for the reaction weight and hydraulic rams within the space provided to safely conduct the test and construct the project. Osterberg Load Cell testing is a static load testing method that uses the drilled shaft itself as a reaction frame/weight. O-Cell testing does not require large reaction frames, because the loading apparatus is contained within the drilled shaft itself.

Fig. 1 Osterberg Load Cell.

Osterberg Load Cell testing uses hydraulic pressure to test a shaft. The device is a specialized hydraulic ram that is installed in series or parallel within a drilled shaft between steel plates that spread the load to the shaft cross sectional area within the reinforcing cage. The O-Cell used on this project had a load rating of 3900 kips in both directions which means that a drilled shaft could theoretically be loaded to 7800 kips. The O-Cell uses a 1:1 mix of potable water and bio-degradable antifreeze as the hydraulic fluid. Special pumps are used to provide the maximum cell pressure of 10,000 psi. Embedded linear vibrating wire displacement transducers (LVWDT's) and strain gauges are used to monitor the test above and below the O-Cell as well as multiple locations along the shaft.

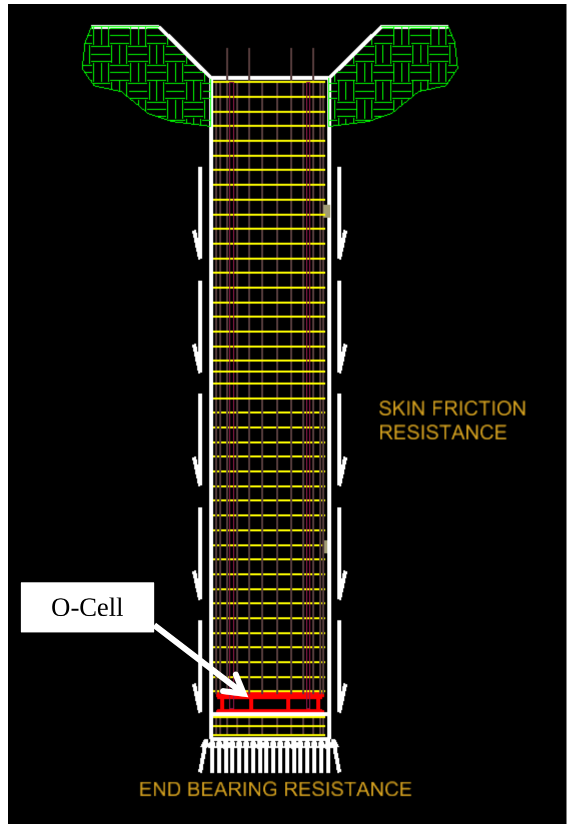


Fig. 2 Load Resistance Schematic

The basic principle of loading a drilled shaft with an O-Cell is that two tests are occurring at the same time. The O-Cell uses the upper portion (skin friction) of the drilled shaft to resist the loading imposed on the bottom of the shaft, and uses the bottom of the drilled shaft (end bearing plus some skin friction) to resist the loading imposed on the upper portion of the drilled shaft. LVWDT's are used to measure the movement of the top bearing plate, the expansion of the O-Cell and automated laser levels are used to measure the displacement of the top of shaft. The displacement instrumentation allows calculation of all displacement monitored in the shaft based on a fixed point outside of the influence of the drilled shaft that the laser levels are back-sighted to. Multiple locations are monitored to ensure the test is performed in accordance with ASTM procedures. The locations monitored were:

- Top of Shaft using the laser levels
- Expansion of the O-Cell using LVWDT's placed next to the O-Cell
- Expansion of the bearing plates using four LVWDT's
- Compression of the shaft using LVWDT's connected to telltale rods on the top plate

To start the test the O-Cell is pressurized to break the drilled shaft into two independent pieces. After the initial break is achieved the O-Cell is depressurized and all instruments are reset to zero and the automated test is started.

Testing drilled shafts through this method is economical and accurate, but O-Cell testing does have a weakness. The test is dependent on having equal capacity above and below the O-Cell to fully mobilize the available resistances (i.e. enough movement to mobilize both upper shear resistance and lower end bearing resistance at the same time). Due to this the location of the O-Cell is critical in the performance of a test. If the O-Cell is placed too high in the shaft the available skin friction above the cell will not be sufficient to fully test the shaft below the cell and vice versa. The test shaft on the Thompson River project relied primarily on end bearing so the cell was placed very near the bottom of the shaft to maximize the skin friction resistance of the upper section. One of the strengths of O-Cell testing is that it's possible to be performed on a production drilled shaft. After the O-Cell test is complete high pressure grout is pumped into the O-Cell and the annulus created by the expansion of the O-Cell to prevent further movement of the drilled shaft and cell throughout the service life of the foundation.

The Geotechnical Section contacted LoadTest USA during the development of the project to discuss O-Cell load testing and preliminary cost estimates. MDT provided some project information that LoadTest USA used to develop a preliminary quote to perform a load test up to a 7800 kip capacity. The cost for this test was estimated to be $54,000 in January 2012 (refer to Appendix H). Several discussions were held with the design team to optimize the risk vs. cost of O-Cell testing and it was determined two options were viable for the contract.

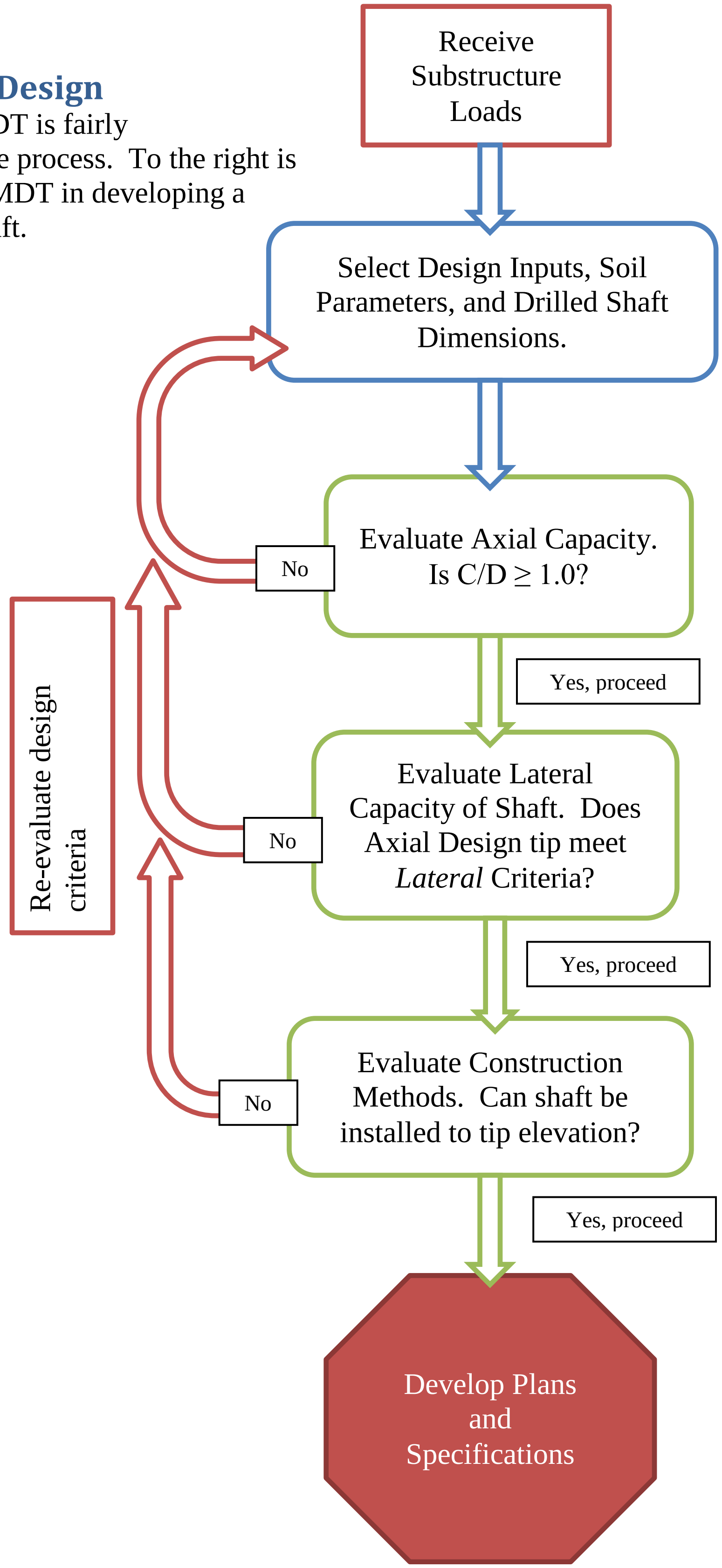
1.) Install a full scale sacrificial test shaft, 2.) Test a production shaft (one of the two on Pier 2). The design team determined that the risk of performing an O-Cell test on a production shaft was too high and therefore the development and installation of a test shaft was selected. The deciding factors for using a sacrificial test shaft were:

1. Potential for post construction settlement was higher for the untested production shaft because the tested shaft would have been pre-loaded by the O-Cell possibly allowing the untested shaft to develop differential settlement across the bent. This differential settlement would have imposed forces into the pile cap and superstructure that are typically not accounted for, and are difficult to model and mitigate.
2. If the load test indicated that the minimum nominal capacity was not achieved then additional length of production drilled shafts would not have been possible on the test shaft.
3. Installing a sacrificial test shaft and incorporating the results during construction would allow for maximum flexibility in the contract of other foundation elements.
4. The sacrificial test shaft had the added bonus of giving the Contract the opportunity to fine tune their installation methods for the specific site conditions.
5. This was the first O-Cell load test conducted by MDT.

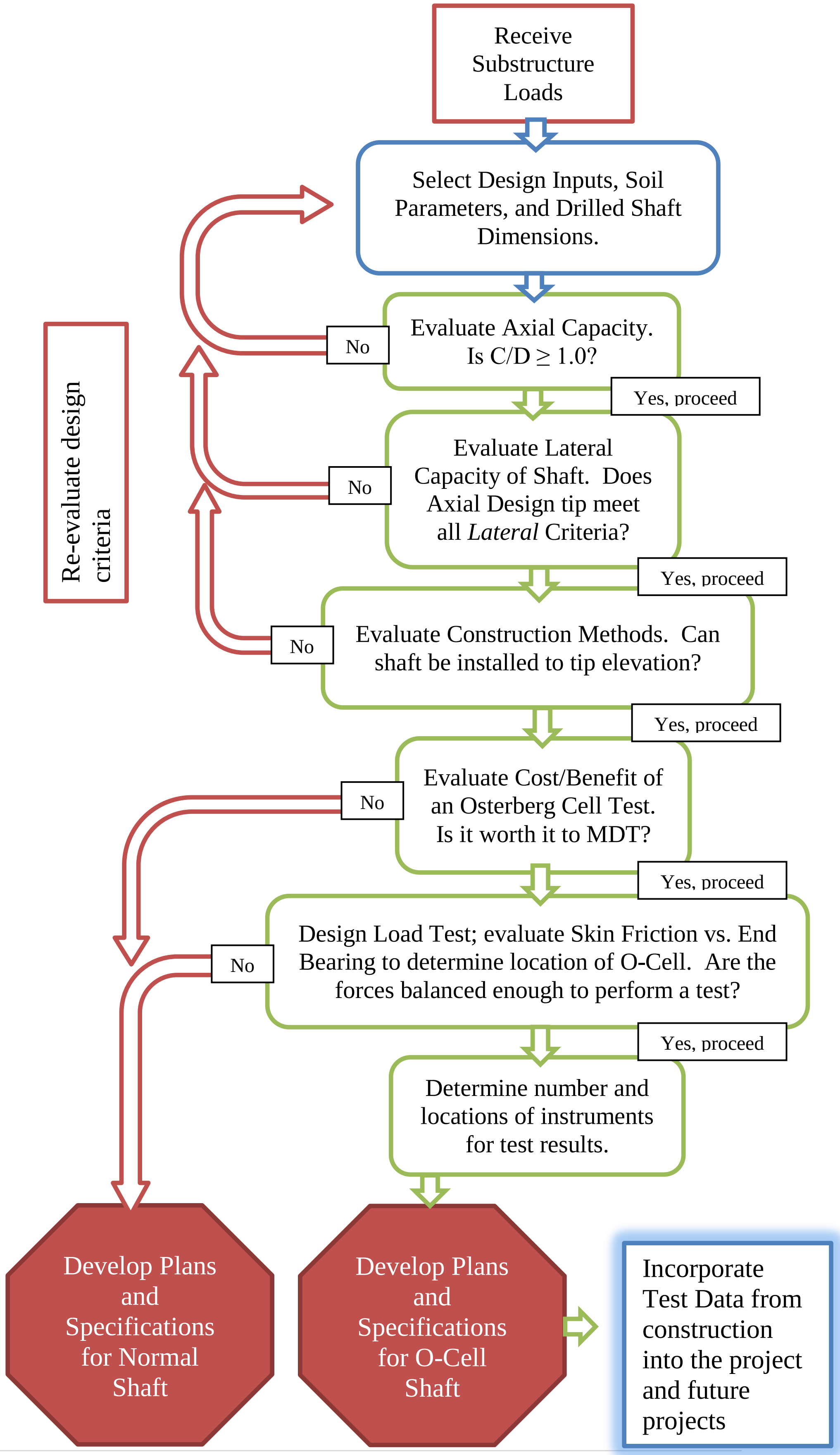
Based upon the determinations above and the participation with FHWA as a research project/experimental feature, the Osterberg Load Cell sacrificial test drilled shaft was included in the contract.

Standard Design vs. O-Cell Design

Standard drilled shaft design for MDT is fairly straightforward and follows a simple process. To the right is the generalized flow chart used by MDT in developing a geotechnical design for a drilled shaft.



Osterberg Cell load testing adds a number of steps to the process the additional steps are shown in the adjusted flowchart to the right.



Osterberg Cell Project Development

The MDT Research Section was contacted regarding developing a research project based on an O-Cell load test. Craig Abernathy of the Research Section was instrumental in developing a work plan for the proposed research project and getting our FHWA Montana Division partners involved in authorizing Federal Highway Funds for the testing program in the Thompson River Bridge project. The authorization to include the O-Cell test in this project as an experimental feature was crucial to the development of the specifications and overall success of the load test.

Development of the plans for the testing program was fairly straightforward. A simple profile of the test shaft with the elevation of the O-Cell, strain gauge elevations, tip elevations, and top of shaft elevation was developed. In addition to the profile view, the footing plan included the test shaft in relation to the other foundation elements with a set of coordinates (center of shaft) for construction. The plans also included notes detailing the maximum test load and that the reinforcing cage be designed and provided by the Contractor. See Appendix I for the final details included in the project bridge plans.

Contract requirements for the O-Cell load testing were included in a single special provision. This special provision was developed by the Geotechnical Section, in conjunction with Construction Services Bureau (Bridge Reviewers), Bridge Bureau, Research Section, and LoadTest USA. See Appendix J for the final version that was included in the contract documents. The special provision required that LoadTest USA be hired (as an experimental feature, proprietary products/processes can be required in Federal Aid projects) to oversee the installation of the O-Cell and test shaft, as well as to conduct the test and provide a report detailing the test results.

The O-Cell required the development of a new bid item "Static Load Test – Drilled Shaft" (item number 559 040 027). It was decided to measure and pay the cost of installing the test shaft, reinforcing steel, concrete, O-Cell, O-Cell ancillary equipment, and the load test in a lump sum bid item for ease of contract administration. However, provisions were included that if a defective shaft was constructed and a successful load test could not be conducted, no payment would be released to the Contractor until repairs acceptable to the Department and LoadTest USA were performed and accepted.

During advertisement of the project, no questions were posted in MDT's Bid Q&A forum with regard to the O-Cell static load test requirement of the project. The Contract was awarded to Sletten Construction Co., Inc. on June 3, 2014. Sletten subcontracted with LoadTest USA in accordance with the contract documents. Refer to Table 5 for the drilled shaft and static load test bid items. There was considerable cost spread between the bid items.

Table 5 Drilled Shaft Related Bid Items

Contractor	Drilled Shaft Concrete (CUYD)	Drilled Shaft 8.0 (LNFT)	Drilled Shaft 6.0 (LNFT)	Reinforcing Steel (LB)	Static Load Test – Drilled Shaft (LUMP)
Engineer's Est.	$330.00	$1,400.00	$875.00	$1.14	$200,000.00
Sletten Co.*	$350.00	$900.00	$900.00	$1.50	$65,000.00
Dick Anderson	$225.75	$1,812.00	$1,226.00	$0.80	$208,550.00
Garco Co.	$372.00	$1,125.00	$860.00	$0.80	$500,000.00

Test Shaft Construction

The Contractor proposed to excavate the drilled shafts using nested temporary casing of 8.5 foot and 8.0 foot diameter. The excavation plan called for driving the oversized 8.5 foot casing to 31 ft. (2381.7 ft.) and then placing the 8.0 foot diameter casing inside the larger casing and advancing to the final tip penetration of 63.5 ft. (2352.2 ft.). Use of multiple augers of varying diameter were proposed to be used to advance the boring in stages. For the shaft installation:

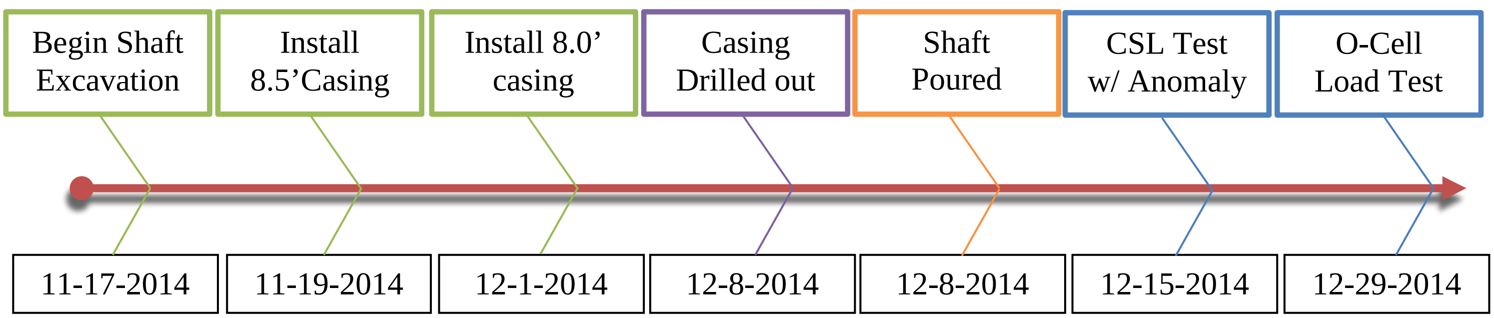
- The drill rig was a Steven Hains Co. 165k S-2 drill mounted on a Sumitomo 110-Ton crawler crane.
- An ICE 66C vibratory hammer was used to drive and remove the temporary casing.
- Concrete placement was by the hard pipe method, with a pump truck provided by Champion Concrete.
- For the test shaft the Contractor was required to design the reinforcing cage to support the loading and testing equipment.

Fig. 3 Test Shaft Jobsite and Initial Excavation.

A Geotechnical Representative was on-site to monitor the test shaft excavation, construction of the rebar cage, installation of the O-Cell and instrumentation, the pouring of the shaft, and the static load test itself. The shaft excavation started on November 17th, 2014 with the shaft being poured on December 8th, 2014, and the static load test conducted on December 29th, 2014.

Initially three boulders were encountered in the first 8.0 feet of shaft excavation that were removed by an excavator with thumb attachment. Due to the presence of these boulders the auger bit "wallowed" and over-reamed the hole considerably, therefore the Contractor elected to drive the 8.5 ft. casing. The 8.5 ft. casing was advanced to approximately 17 ft. below the template and the top was cut off to facilitate drilling. Drilling continued until it reached an elevation approximately 8 feet below the temporary casing. 8.5 ft. casing was then welded back on and driven to the planned penetration of 31 ft. (2381.7 ft.). The material within the oversized casing was excavated with the drill, and because caving began to occur, drilling ceased about 3.0 feet beyond the oversized casing tip depth.

With the oversized casing in place, the 8.0 ft. casing was driven to within approximately two feet of the planned shaft final tip elevation. A section of damaged casing was removed, and then the material within the casing was drilled out and removed. On December 1st, 2014 additional new 8.0 ft. casing was welded on and driven to 60.5 ft. below ground surface (2352.2 ft.). The shaft was drilled to within one foot of planned final tip elevation on December 2nd, 2014. On December 8th, 2014, the shaft was excavated to an elevation of 2352.8 ft. with the cleanout bucket and a Geotechnical Representative inspected the bottom of the shaft. Upon acceptance of the shaft foundation base, the Contractor lifted and stood up the rebar cage, finished installing the O-Cell, and then set the rebar cage in the shaft. At the request of LoadTest the rebar cage was suspended approximately 6 feet from the bottom of the shaft while a seating layer of concrete was placed in the bottom of the shaft. The rebar cage was plunged into the fluid concrete while concrete placement continued. This practice was to ensure that sound concrete encapsulated the steel plates and O-Cell. Concrete was placed to an elevation of 2410.4 ft. for a total constructed length of 57.6 ft.



Cross-Hole Sonic Logging (CSL) testing was conducted a week after concrete was placed in the shaft. The CSL test results indicated a potential anomaly at 21 feet below the top of shaft near CSL tubes 2 and 8. After discussion with LoadTest it was decided that coring of the shaft was not required. Since the shaft was a sacrificial test element, its integrity was acceptable and coring posed an unnecessary risk of damage to the embedded testing equipment. MDT may core the test shaft with the Geotechnical Sections drilling equipment post construction to

Fig. 4 Completed Cage with O-Cell.

determine the nature of the defect. No penalty to the Contractor was pursued. A supplemental memorandum will be distributed as an addendum to this report if and when the information becomes available.

Reinforcing Cage and Osterberg Cell Construction

As designed, the test shaft used 24 #14 rebar and #6 hoops for the reinforcing cage. The cage constructed on site was changed to 34 #14 bars and #6 hoops. LoadTest requested this change to ensure the stiffness of the rebar cage during lifting and installation maneuvers. The O-Cell sustained no damage during installation and handling of the rebar cage.

Fig. 5 O-Cell and steel bearing plates.

The final configuration of the O-Cell included four steel bearing plates and various LVWDT's, strain gauges, telltales, hoses, and instrumentation cables. The O-Cell is sandwiched between steel plates that are stepped in diameter to transfer the load to the entire drilled shaft cross section. The bottom of the O-Cell was placed one foot eight inches from the bottom of the shaft as required by the contract. LVWDT's were placed at four equidistant locations around the bearing plates to measure the displacement of the bearing plates under load.

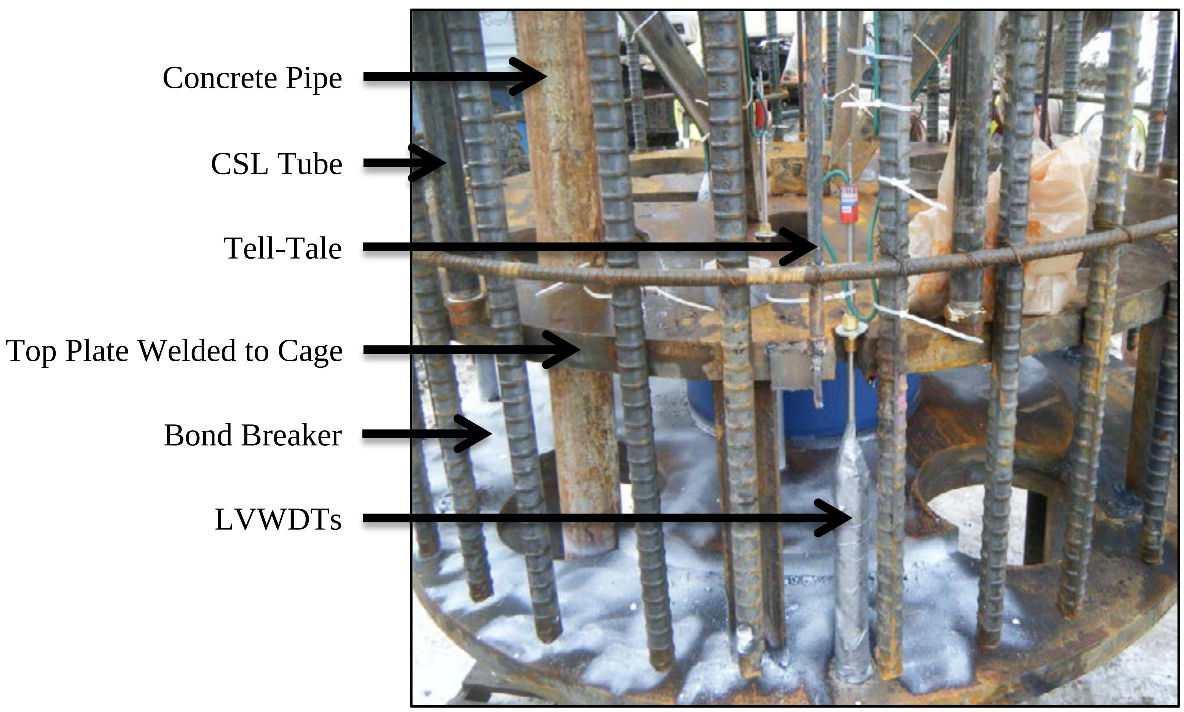


Fig. 6 O-Cell with monitoring equipment and concrete bond breaker.

Osterberg Cell Static Load Test and Results

The load test was performed on December 29th, 2014 beginning at 10:06 a.m. and ending at 12:45 p.m. The contract required a test capacity of 5600 kips. The flowchart depicts the steps taken performing the load test. Refer to Appendix B for LoadTest USA's Report.

The O-Cell was pressurized very slowly after all instrumentation and hydraulic lines were connected and purged to break the drilled shaft into two sections connected by the O-Cell. The force required to break the shaft was 772 kips. This force cracked the concrete between the steel bearing plates at the bottom plate and broke the four tack welds that held the O-Cell in the closed position during shipping and installation.

- Connect and Initialize instruments and O-Cell
- Pressurize the O-Cell and split the shaft
- Re-zero instruments and O-Cell pressure
- Begin Loading
- Terminated loading when displacement increased without load increase, at shaft failure
- Begin Unload
- Finish Unload and measure instruments

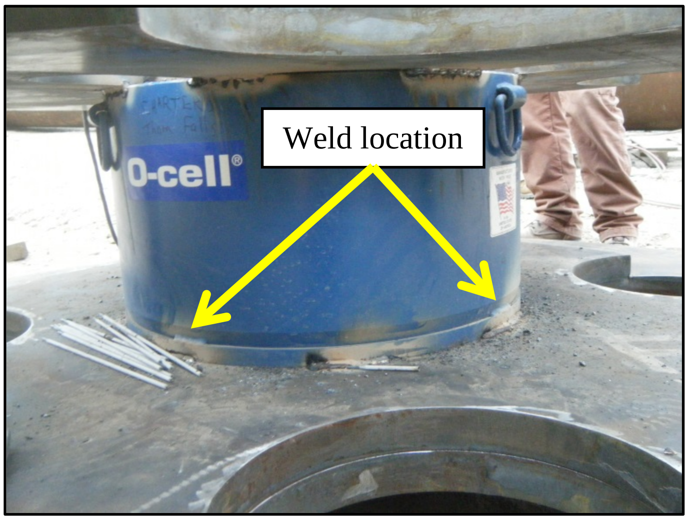


Fig. 7 O-Cell installation.

After the separation of the shaft, the O-Cell was depressurized and all instrumentation was reset to zero. A laptop containing a control program was used to read all of the instruments in real-time to almost real-time (maximum of 30 second delay) accuracy. This laptop controlled the pumps that pressurized the O-Cell and generally automated the entire test. Very little input from the technician was required after the test was initiated.

Some of the exposed instruments and various sensors and equipment used to record movement and perform the test are shown in Figures 8 through 12.

Fig. 8 Laptop Controller

Fig. 9 Data Collector

Fig. 10 High Pressure Pump

Fig. 11 Leica NA 3000 Survey Levels

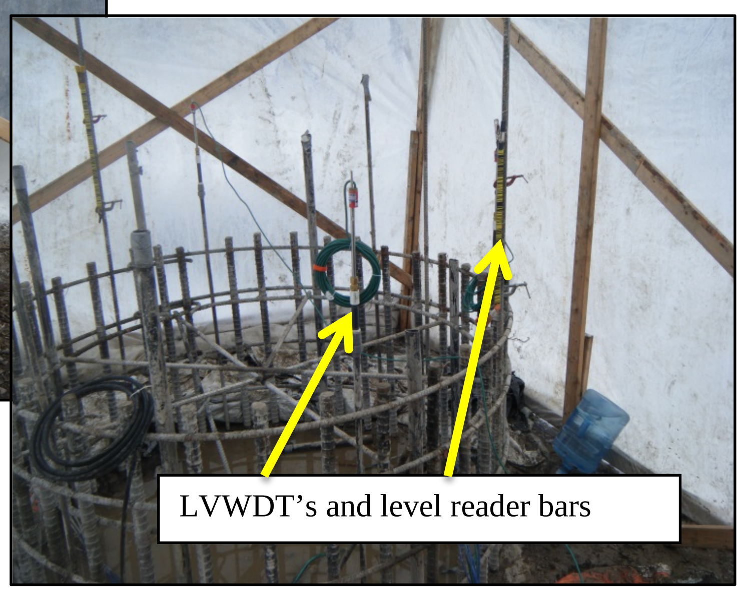


Fig. 12 Top of Shaft Instrumentation

During the loading process signs indicating displacement of the upper portion of the shaft became evident in the surrounding soil. Refer to figure 13 to see the cracks created by the movement of the shaft.

Fig. 13 Displacement Cracks near end of test.

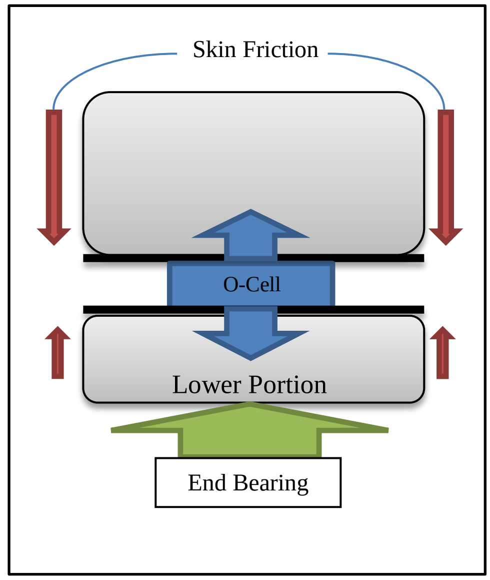


Fig. 14 Load Test Free Body Diagram

Test Results

Loading increments of the O-Cell were performed in 11 nominally equal steps. Approximately 1 minute was required to pressurize the O-Cell between steps. Linear displacement, strain, and pressure data were read at 30 second intervals throughout the test but only the 1, 2, 4, and 8 minute readings were provided in the final load test report from LoadTest USA.

The test was performed to "skin" friction failure (i.e. the soil no longer had the ability to resist movement of the shaft through friction) of the upper section of the drilled shaft. This capacity was measured to be 1,784 kips at a displacement at the top of the O-Cell of 1.282 inches. The capacity is a net capacity because the buoyant weight of the drilled shaft was subtracted from the measured load (it is assumed that the O-Cell does not impart any forces into the upper portion of the drilled shaft until the buoyant weight of the drilled shaft is overcome). The buoyant weight of the shaft was calculated at 279 kips.

The combined end bearing and lower side shear resistance was measured at 2,063 kips with the downward displacement of the O-Cell of 1.672 inches. There was more capacity available in the combined end bearing and lower side shear resistance (mostly end bearing, because of the short length of shaft below the O-Cell) but because the upper portion experienced shear failure first, additional reaction force was unavailable to fully mobilize and fail the end bearing and lower side shear resistance.

The maximum sustained load occurred at load step 11 with a 2,063 kip bi-directional load being applied to the shaft (this included the buoyant weight of the shaft). The O-Cell had expanded on average 2.954 inches. The shaft was unloaded in five decrements and the test was concluded.

Equivalent Top-Down Loading Analysis

LoadTest USA, converts the two loading curves generated from the O-Cell load test and transfers the data to an equivalent (traditional) top-down loading curve. The data is converted by creating data points at equivalent displacements and summing the shaft capacity for both the upper and lower portions together. Refer to Appendix B for more information regarding the load test and creation of the top-down loading curve.

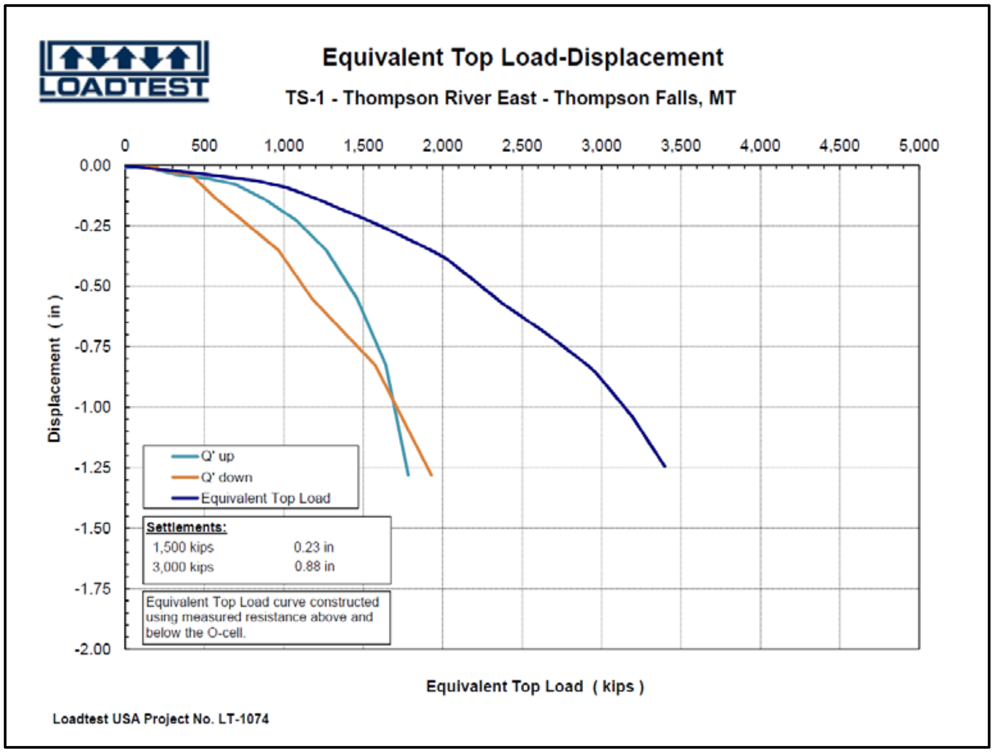


Chart Courtesy of LoadTest USA report 1074-Report-v3

As shown in the equivalent top load curve above, the test shaft resisted a 1,500 kip load with a measured displacement of 0.23 inches. The design service load for the production shafts was calculated to be 1,560 kips. At a displacement of 0.88 inches the shaft resisted a load of 3,000 kips which, under ASD design methodology, would compute to an approximate Factor of Safety (FOS) of 2.

The maximum top-down equivalent load was approximately 3,400 kips at a displacement of 1.25 inches. Using the top load and bottom load curves, it is estimated at 1.672 inches of displacement that the ultimate load carried by the shaft would be 3,847 kips (assuming upper side shear resistance does not change with continued displacement). LRFD uses a capacity to demand ratio (C/D) instead of a FOS value. The C/D is balanced when it is equal to 1, any value less than 1 indicates the member is not sufficient to resist the imposed loading, and values greater than 1 indicate the member has extra capacity for the loading condition. The

Strength 1 design load for the test shaft was 2,070 kips, when resistance factors are applied the required nominal capacity of the shaft was 3,696 kips. The calculated C/D is 1.04, resulting in a balanced design. However, because the shaft failed in skin friction first the C/D ratio is interpolated from the data reported by LoadTest USA.

The test had three levels of strain gauges embedded in the upper portion of the test shaft. These strain gauges were used to determine the load transfer from the shaft to the surrounding soil during the load test. These strain gauges were placed at 12, 24, and 37 feet above the O-Cell. These measurements are taken from the height above the lower plate on the bottom of the O-Cell. The strain gauges were placed in sets of 4 at each location for a total of 12 strain gauges (Geokon model 4911 sister bar vibrating wire gauges). The results were averaged across the sets to obtain the overall dilled shaft strain. An estimated composite stiffness (stiffness is a material property that resists deformation in response to an applied force) was calculated for the test shaft. This stiffness was used to develop skin friction resistance values between the strain gauges. Refer to Table 6 for the skin friction values as tested from the field as compared to the estimated values calculated during the design process. As reported, the tested values were generally greater than the design values. Even using the maximum allowable skin friction values for the NAVFAC model (phi angle of 40), the tested skin friction exceeded the design values by a considerable margin except for Section 3 where the estimated value was 50% greater than the tested value. All other tested skin friction values were much greater than the maximum allowable skin friction from the design model. The total estimated skin friction was 692 kips and the tested skin friction was 1933 kips (combined upper and lower skin friction capacity). The tested value was 2.79 times the estimated capacity.

Table 6 Design vs. Tested resistance values.

Shaft Section	Shaft Elevations (ft)	Tested Skin Friction Value (ksf)	Design Skin Friction Value (ksf) NAVFAC	Maximum Model Skin Friction (ksf) NAVFAC*	Soil Description
4	Top of Shaft to 2392’	1.2	0.25	0.31	GP, M. Dense to Loose
3	2392’ to 2379’	0.3	0.45	0.57	GP and SP, Loose
2	2379’ to 2367’	0.9	0.57	0.81	SP, Loose to M. Dense
1	2367’ to O-Cell	2.7	0.53	1.01	SP, GP M. Dense

* These values were obtained by using the maximum allowable value for phi angle (40) in the NAVFAC design method for comparison to the tested skin friction values only, base resistance was unable to be compared due to termination of the test.

Table 6 indicates that the skin friction values estimated by the NAVFAC method were very conservative. Even though this project was designed using the NAVFAC method the FWHA method was used to develop a comparison for design vs. design vs. tested values. Table 7 reports the values for the estimated ultimate capacities from NAVFAC and FHWA compared to the tested capacities of the O-Cell.

Table 7 Design Method Comparisons (equivalent tip elevations)

Type of Capacity	NAVFAC (kips)	FHWA** (kips)	O-Cell (kips)
Skin Friction	692	2140	1933
Base Resistance	3868	480	1914
Total Capacity*	4560	2620	3847

*No factors-of-safety or resistance factors were applied to the capacities.
** SHAFT 2012 was used to determine the estimated capacities.

Based on the results of the O-Cell the two production shafts for Pier 2 were authorized to be installed to the original contract tip elevation of 2352.00 ft. No modification to the drilled shaft tip elevation was necessary (up to 15.0 ft. of additional length was allowed in the contract) unless different subsurface conditions were encountered. After the test concluded the Contractor removed the exposed instrumentation, cut off the rebar flush with the top of the test shaft and buried the test shaft 3.0 ft. below finished grade in accordance with contract requirements.

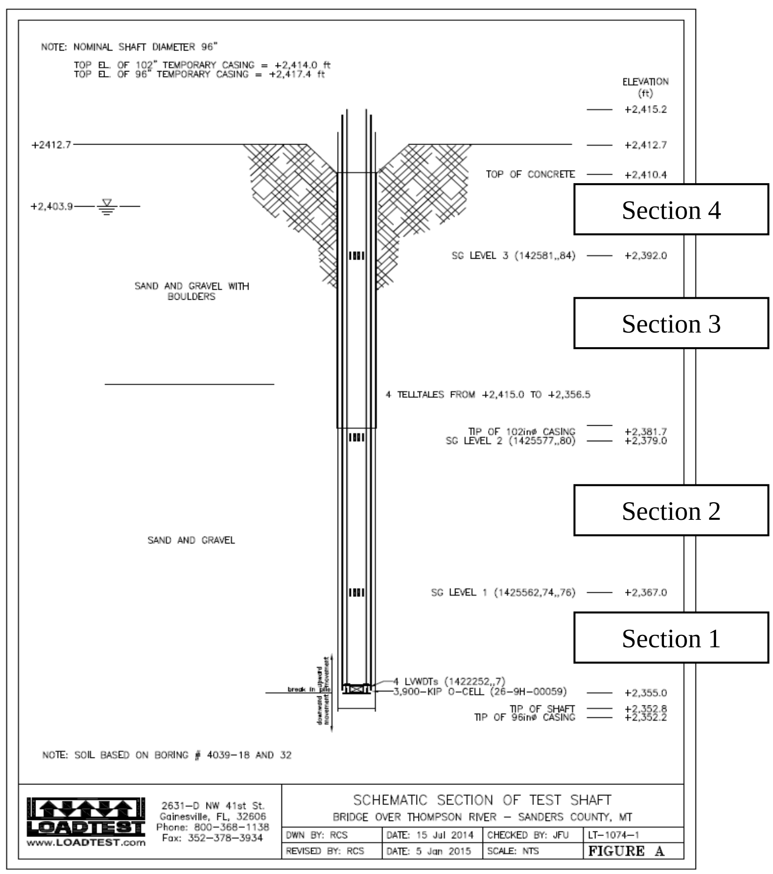


Fig. 15 Schematic of drilled shaft courtesy of LoadTest USA, report 1074-Report-v3

Conclusions and Lessons Learned

Overall the Osterberg Load Cell Test performed as intended and was successful. Sletten Construction Co., Inc. and LoadTest USA worked well together, installed the O-Cell, and conducted the test with minimal issues. All necessary equipment required for installation and testing were available and readily accessible.

LoadTest USA was very knowledgeable and accommodating throughout the course of the design phase and into the construction phase. LoadTest USA was instrumental in helping MDT develop the specifications and create the requirements for the Thompson River Bridge load test program.

After the successful implementation and conduct of this O-Cell load test it is recommended that MDT consider more O-Cell tests as projects become available where the testing may provide a benefit. Testing of production shafts may be preferred due to the increased costs associated with a sacrificial shaft. It should also be noted that testing a less than full-scale drilled shaft typically results in un-conservative resistance values.

The optimum situation for O-Cell load testing will be on single-shaft bents, where differential settlement does not occur. If tests are performed on bents with more than one foundation shaft, additional consideration for differential settlement should be accounted for during design. Mitigation options for differential settlement are to increase shaft length and therefore capacity, or pressure grouting the tip of the non-tested shaft post-pour. Pressure grouting the tips of drilled shafts may be the better option, although further investigation into this practice will be required before implementation. A production shaft O-Cell is grouted post-test, along with the annular expansion space created during the test, resulting in a structurally sound foundation element that will not settle due to the closure of the O-Cell after superstructure loads are imposed.

Coordination with the Structural Engineer is necessary to design the shaft, and shaft cage to allow for the testing equipment and execution of the test. We also recommend that Thermal Image Profiling be used for O-Cell loaded shafts because these could be easier to install below the O-Cell for determining shaft integrity, an alternative would be to place the CSL tubes on the exterior of the reinforcing cage and extending them to the bottom of the shaft. A bond breaker would need to be applied to the CSL tubes to reduce the influence on the test.

Future projects that have the potential of using an O-Cell load test are:

- Russell Street Broadway to Idaho (already recommended)
  - UPN 4128
  - STPU-NHPB-MT 8105(16)
- Bridge over the S. Fork of the Flathead – Hungry Horse
  - UPN 8083
  - NHPB 1-2(187)142
- I-90 Yellowstone R - Billings
  - UPN 7972
  - NHPB-IM 90-8(177)450
- Rarus/Silver Bow CR Structures
  - UPN 7659
  - IM-NHPB 15-2(113)124
- Toston Structures (US-287)
  - UPN 7668
  - NH-NHPB 8-4(66)86

It is likely the projects mentioned could see significant cost savings through the use of an O-Cell load test. It would also allow MDT to gain knowledge and verify the design methodology in regards to high capacity drilled shaft foundations.

Alternatively, on large projects (>$20 million), pre-construction or design phase static load testing could be used to optimize drilled shaft lengths and installation methodology prior to the project advertisement. Other DOT's have used this to great success, including Missouri, Illinois, Indiana, and Kentucky, who have collaborated on bridges crossing the major rivers between these states. The testing programs conducted set world record load test capacities in excess of 72,000 kips.

In conclusion, the Osterberg Cell static load test was a successful part of the Thompson River Bridge design and construction. The implementation of the load test in this project saved approximately $64,000 based on unit bid prices. The cost savings include the cost of installing a test shaft, providing all of the testing equipment, and executing a static load test. The O-Cell allowed the shafts on Pier 2 to be shortened by 36 feet each to the minimum embedment for resisting lateral forces, combined for a total reduction of 72 feet of 8.0 ft. diameter drilled shaft. Other drilled shafts on the project were already laterally controlled and therefore the O-Cell did not affect the final design tip elevation. Had the lateral demands of the substructure been less, further reduction in drilled shaft length could have been realized.

Now that we have one test "under our belt," and some experience with an Osterberg Static Load test, we recommend evaluating future projects for Osterberg Load Cell testing to realize more of the cost savings and optimization of high capacity drilled shaft foundation designs. Given that the larger structures nearing the end of their design life are classified as functionally obsolete and/or structurally deficient in the State of Montana more opportunities will come to the fore.

APPENDIX A

MDT Boring Log Descriptive Terminology

8/16/10

MONTANA MDT DEPARTMENT OF TRANSPORTATION

Geotechnical Section

Key to Soil Symbols and Terms

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	Well-graded gravels, gravel sand mixtures, little or no fines.
				GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	Silty gravels, gravel-sand-silt mixtures.
				GC	Clayey gravels, gravel-sand-clay mixtures.
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS (LITTLE OR NO FINES)		SW	Well-graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands, gravelly sands, little or no fines.
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	Silty sands, sand-silt mixtures.
				SC	Clayey sands, sand-clay mixures.
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
				OL	Organic silts and organic silty clays of low plasticity.
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
				CH	Inorganic clays of high plasticity, fat clays.
				OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS				PT	Peat and other highly organic soils.

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Order of Descriptors

- Group Name
- Consistency or Relative Density
- Moisture Condition
- Color
- Particle size descriptor(s) (coarse grained soils only)
- Angularity of coarse grained soils
- Other relevant notes

Criteria For Descriptors

Consistency of Fine Grained Soils

Consistency	N-Value (uncorrected)
Very Soft	< 2
Soft	2 - 4
Medium Stiff	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	> 30

Apparent Density of Coarse Grained Soils

Relative Density	N-Value (uncorrected)
Very Loose	< 4
Loose	4 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

Moisture Condition

Dry -Absence of moisture, dusty, dry to the touch.
Moist -Damp, but no visible water.
Wet -Visible free water.

Definition of Particle Size Ranges

Soil Component	Size Range
Boulder	> 12 in (300 mm)
Cobble	3 in (75 mm) - 12 in (300 mm)
Gravel	No. 4 Sieve (4.75 mm) to 3 in (75 mm)
Sand	No. 200 (0.075 mm) to No. 4 Sieves (4.75 mm)
Silt	< No. 200 Sieve (0.075 mm)*
Clay	< No. 200 Sieve (0.075 mm)*

*Atterberg limits and chart below to differentiate between silt and clay.

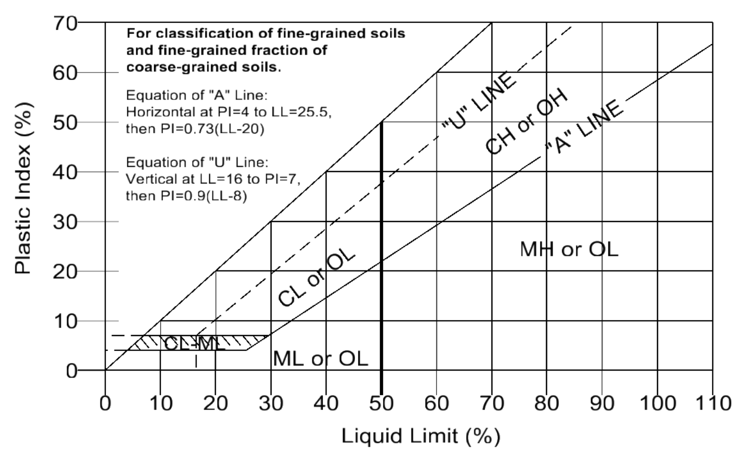
Notes

See Soil Boring Information Special Provision.

SPT (Standard Penetration Test-ASTM D1586):
The number of blows of a 140 lb (63.6 kg) hammer falling 2.5 ft (750 mm) used to drive a 2 in (50 mm) O.D. Split Spoon sampler for a total of 1.5 ft (0.45 m) of penetration.
Written as follows:
first 0.5 ft (0.15 m) - second 0.5 ft (0.15 m) - third 0.5 ft (0.15 m) (ex: 1-3-9)
Note: if the number of blows exceeds 50 before 0.5 ft (0.15 m) of penetration is achieved, the actual penetration rounded to the nearest 0.1 ft (0.03 m) follows the number of blows in parentheses (ex: 12-24-50 (0.09 m), 34-50 (0.4 ft), or 100 (0.3 ft)).WR denotes a zero blow count with the weight of the rods only.
WH denotes a zero blow count with the weight of the rods plus the weight of the hammer.

MC=Moisture Content, LL=Liquid limit, PL=Plastic Limit
-200%=percent soil passing 200 sieve, DD=Dry Density

Soil Classifications are Based on the Unified Soil Classification System, ASTM D2487 and D2488. Also included are the AASHTO group classifications (M145). Descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.



Angularity of Coarse-Grained Particles

Angular -Particles have sharp edges and relative plane sides with unpolished surfaces.
Subangular -Particles are similar to angular description, but have rounded edges.
Subrounded-Particles have nearly plane sides, but have no edges.
Rounded -Particles have smoothly curved sides and well-rounded corners and edges.

Example soil description: Sandy FAT CLAY (CH), soft, wet, brown. (A-7)

MDT Boring Log Descriptive Terminology

Key to Rock Symbols and Terms

MONTANA MDT DEPARTMENT OF TRANSPORTATION
Geotechnical Section

Rock Type	Symbol	Rock Type	Symbol	Rock Type	Symbol
Argillite		Dolomite		Quartzite	
Basalt		Gneiss		Rhyolite	
Bedrock (other)		Granitic		Sandstone	
Breccia		Limestone		Schist	
Claystone		Siltstone		Shale	
		Conglomerate			

Order of Descriptors

- Rock Type
- Color
- Grain size (if applicable)
- Stratification/Foliation (as applicable)
- Field Hardness
- Other relevant notes

Criteria For Descriptors

Grain Size

Description	Characteristic
Coarse Grained	-Individual grains can be easily distinguished by eye
Fine Grained	-Individual grains can be distinguished with difficulty

Stratum Thickness

Thickly Bedded	3-10 ft (1-3 m)
Medium Bedded	1-3 ft (300 mm - 1 m)
Thinly Bedded	2-12 in (50-300 mm)
Very Thinly Bedded	< 2 in (50 mm)

Rock Field Hardness

Very Soft	-Can be carved with knife. Can be excavated readily with point of rock hammer. Can be scratched readily by fingernail.
Soft	-Can be grooved or gouged readily by knife or point of rock hammer. Can be excavated in fragments from chips to several inches in size by moderate blows of the point of a rock hammer.
Medium	-Can be grooved or gouged 0.05 in (2 mm) deep by firm pressure of knife or rock hammer point. Can be excavated in small chips to pieces about 1 in (25 mm) maximum size by hard blows of the point of a rock hammer.
Moderately hard	-Can be scratched with knife or pick. Gouges or grooves to 0.25 in (6 mm) can be excavated by hard blow of rock hammer. Hand specimen can be detached by moderate blows.
Hard	-Can be scratched with knife or pick only with difficulty. Hard hammer blows required to detach hand specimen.
Very Hard	-Cannot be scratched with knife or sharp rock hammer point. Breaking of hand specimens requires several hard blows of a rock hammer.

Notes:

UCS = Unconfined Compressive Strength obtained from laboratory testing at the given depth.

See Soil Boring Information Special Provision.

Miscellaneous Soil/Rock Symbols and Terms

- **Concrete**
- **Asphalt**
- **Water**
- **Boulders and Cobbles**
- **Coal**
- **Fill**
- **Millings**
- **Topsoil**

Explanation of Text Fields in Boring Logs:

Material Description: Lithologic Description of soil or rock encountered.

Remarks: Comments on drilling, including method, bit type, and problems encountered.

Unless stated on logs as being surveyed by district survey, all locations are considered approximate.

General Notes

- Descriptions on these boring logs apply only at the specific boring, and at the time the borings were made. These logs are not warranted to be representative of subsurface conditions at other locations or times.
- Water level observations apply only at the specific boring, and at the time the borings were made. Due to the variability of groundwater measurements given the type of drilling used, and the stratification of the soil in the boring, these logs are not warranted to be representative of groundwater conditions at other locations or times.
- Other terms may be used as descriptors, as defined by the profession.

-Soil and Rock descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.

Operation Types: Auger; Casing Advancer; Core Barrel; Drive Casing

Sample Types: Split Spoon; Shelby; Bulk Sample; Grab Sample; Cone Penetrometer; Vane Shear; Special Samplers; Testpit

Example Rock Log

SANDSTONE, gray, fine grained, thickly bedded, hard field hardness.

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-17

Project: Thompson River - East		**Rig:** CS 2000 **Hammer:** Auto	**Boring Location Coordinates** N: 1265689.127 ft E: 554428.6482 ft	**Station:** 22 + 03 **Offset:** 26 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2428.1 ft
Date Started: 11/8/05	**Date Finished:** 11/10/05	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: I. Boyd **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							BASE COURSE, Sandy GRAVEL moist, fine to coarse grained, subrounded, [A-1]. Mixed lithologies	1.0 *2427.1*						Hollow stem augers with bullet bit.
							Poorly-Graded GRAVEL (GP), medium dense to dense, moist, fine to coarse grained, subrounded, [A-1]. Mixed lithologies, occasional cobbles/boulders, possibly fill							
			20		5 - 9 - 12				6					
5 *2423.1*									6		NP	5		
			20		7 - 12 - 28			6.0 *2422.1*						
							SILT with sand (ML), loose to medium dense, moist, brown, [A-4].							
			75		3 - 4 - 4				9		NP	82		
10 *2418.1*			55		5 - 9 - 10				4					
			80		6 - 11 - 12				5					
15 *2413.1*			65		11 - 13 - 13		Silty SAND with gravel (SM), medium dense, moist, brown, fine to coarse grained, [A-1].	15.0 *2413.1* 16.0 *2412.1*	3		NP	22		
							Well-Graded SAND with silt and gravel (SW-SM), medium dense, moist to wet, brown, fine to coarse grained, [A-1].							
20 *2408.1*			50		6 - 9 - 12				6		NP	9		
25 *2403.1*			50		9 - 11 - 8				4		NP	13		
							Wet below 27.8 ft							
30 *2398.1*														

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: 27.8 ft (2400.3 ft)	
	After Drilling: ()	

(2) MDT LOG OF BORING - MDT_REVISED_2009+.GDT - 2/20/14 11:19 - S:\GINTW\PROJECTS\2009+PROJECTS\4039E.GPJ

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-17

Project: Thompson River - East		**Rig:** CS 2000 **Hammer:** Auto	**Boring Location Coordinates** N: 1265689.127 ft E: 554428.6482 ft	**Station:** 22 + 03 **Offset:** 26 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2428.1 ft
Date Started: 11/8/05	**Date Finished:** 11/10/05	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: I. Boyd **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		3 - 6 - 6									
							Silty SAND (SM), loose, wet, brown, fine to coarse grained, [A-2].	32.0 / 2396.1						
35 / 2393.1			100		2 - 3 - 7									About 2.0 ft of heave in augers after SPT.
							Sandy SILT (ML), loose, wet, brown, [A-4].	36.0 / 2392.1	26		NP	13		
							Poorly-Graded SAND with silt and gravel (SP-SM), medium dense, wet, brown, fine to coarse grained, [A-1].	37.0 / 2391.1						
40 / 2388.1			90		8 - 6 - 6						NP	8		
							Poorly-Graded SAND with silt (SP-SM), medium dense to loose, wet, brown, fine to coarse grained, [A-2]. Occasional layers of silty sand	43.0 / 2385.1						
45 / 2383.1			100		3 - 5 - 7									About 2.0 ft of heave in augers before SPT. About 6.0 ft of heave in augers after SPT. NW casing advancer with tricone bit at 45.0 ft.
50 / 2378.1			<5		5 - 7 - 13									About 4.0 ft of heave in augers before SPT, Augers dropped about 0.5 ft during SPT.
55 / 2373.1							Layer with gravel from 57.5 ft. to 59.0 ft							Bit sanded in at 56.0 ft. Pulled casing and redrilled. Bit sanded in at 56.0 ft second time. Pulled casing and redrilled to 61.0 ft.
60 / 2368.1							Layer of silt from 59.0 ft. to 60.0 ft							

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: 27.8 ft (2400.3 ft)	
	After Drilling: ()	

(2) MDT LOG OF BORING - MDT_REVISED_2009+ GDT - 2/20/14 11:19 - S:\GINTW\PROJECTS\2009+PROJECTS\4039E.GPJ

LOG OF BORING

Boring 4039-17

Project: Thompson River - East		**Rig:** CS 2000 **Hammer:** Auto	**Boring Location Coordinates** N: 1265689.127 ft E: 554428.6482 ft	**Station:** 22 + 03 **Offset:** 26 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2428.1 ft
Date Started: 11/8/05	**Date Finished:** 11/10/05	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: I. Boyd **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
		X	30		1 - 1 - 4						NP	11		About 0.3 ft of heave in casing before SPT.
65 / 2363.1														
		X	70		8 - 10 - 11									
70 / 2358.1														
		X	100		5 - 7 - 13						NP	16		
75 / 2353.1														
														Bit sanded in at 76.0 ft. Pulled casing and redrilled to 81.0 ft.
80 / 2348.1														
							Occasional to frequent layers of silty clay below 81.0 ft							About 20 ft. of heave in casing at 81.0 ft - no SPT.
85 / 2343.1														
90 / 2338.1														

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: 27.8 ft (2400.3 ft) After Drilling: ()	

LOG OF BORING

Boring 4039-17

Project: Thompson River - East		**Rig:** CS 2000 **Hammer:** Auto	**Boring Location Coordinates** N: 1265689.127 ft E: 554428.6482 ft	**Station:** 22 + 03 **Offset:** 26 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2428.1 ft
Date Started: 11/8/05	**Date Finished:** 11/10/05	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: I. Boyd **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			100		1 - 12 - 12		0.5 ft. layer of SILT with Sand (A-4) at 90.0 ft			17	15	74		Drilled without bit to 90.0 ft. About 30.0 ft. of sand inside casing. Washed split spoon down to sample depth at 90.0 ft.
95 / *2333.1*														
100 / *2328.1*														
			100		9 - 13 - 15			102.5 / *2325.6*						

Boring Depth: 102.5 ft, *Elevation: 2325.6 ft*

Water Level Observations		
	During Drilling: **27.8 ft** ***(2400.3 ft)***	Remarks:
After Drilling: *()*	After Drilling: *()*	

LOG OF BORING

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			20		2 - 2 - 1		TOPSOIL.	0.5 / 2413.5						HW casing advancer with tricone bit.
							Silty SAND (SM), very loose, moist, brown, [A-4].							
			40		1 - 1 - WH						NP	33		
5 / 2409.0			20		4 - 5 - 12		Poorly-Graded GRAVEL (GP), medium dense to loose, moist to wet, fine to coarse grained, subrounded, [A-1]. Mixed mineralogy, occasional cobbles/boulders	4.5 / 2409.5				8		
			5		13 - 4 - 2									
10 / 2404.0			<5		6 - 4 - 7									
			5		2 - 1 - 2									
15 / 2399.0			10		3 - 3 - 3									
20 / 2394.0			10		3 - 4 - 5									
25 / 2389.0			30		4 - 4 - 4									
30 / 2384.0														

Water Level Observations		
After Drilling: ()	During Drilling: 14.4 ft (2399.6 ft) After Drilling: Not Encountered, Casing Out	Remarks: cave in at 12.5 ft.

LOG OF BORING

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Poorly-Graded SAND (SP), loose to medium dense, wet, brown, fine to coarse grained, [A-2]. Occasional layers with gravel	30.0 / *2384.0*						About 1.0 ft. of heave before SS at 30.8 ft.
			30		3 - 3 - 4									
35 / *2379.0*														
			60		3 - 4 - 5						NP	12		
40 / *2374.0*														
			40		6 - 8 - 4									
45 / *2369.0*														
			20		WH - 2 - 3									
50 / *2364.0*														
			40		7 - 7 - 9									
55 / *2359.0*														
			50		10 - 10 - 9		Poorly-Graded GRAVEL (GP), medium dense, wet, fine to coarse grained, subangular to subrounded, [A-1]. Mixed mineralogy	56.0 / *2358.0*				4		
							Poorly-Graded SAND (SP), medium dense, wet,	59.0 / *2355.0*						
60 / *2354.0*														

Water Level Observations

During Drilling: **14.4 ft** ***(2399.6 ft)***

After Drilling: **Not Encountered, Casing Out**

After Drilling: *()*

Remarks: cave in at 12.5 ft.

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							brown, fine to coarse grained, [A-2]. Occasional seams of Silty Sand and Silt							
			70		3 - 7 - 9									
65 / 2349.0														
			100		6 - 10 - 17						NP	11		About 2.0 ft. of heave after SS at 66.0 ft.
70 / 2344.0														
			100		4 - 6 - 7									
75 / 2339.0														
			50		5 - 9 - 13									
80 / 2334.0														
			90		7 - 8 - 11		Silty SAND (SM) with layers of Poorly Graded SAND (SP), medium dense, wet, brown, fine to medium grained. (A-2)	81.5 / 2332.5						
85 / 2329.0														
			100		6 - 8 - 13						NP	50		
90 / 2324.0														

Water Level Observations		
During Drilling: 14.4 ft (2399.6 ft)	After Drilling: Not Encountered, Casing Out	Remarks: cave in at 12.5 ft.
After Drilling: ()		

LOG OF BORING

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft		**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83		**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected		**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings		**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Recovery (%)	RQD (%)	Blow Count	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
	90		14 - 13 - 19								About 0.3 ft. of heave before SS at 91.0 ft.
				Varved seams of SILT (ML), Silty SAND (SM), and Silty CLAY (CL-ML), dense/hard, wet, tan. (A-4)	92.0 / 2322.0	24					
95 / 2319.0											
	100		7 - 12 - 12	Poorly-Graded SAND (SP), medium dense to dense, wet, brown and gray, fine to coarse grained, [A-2]. Occasional seams of Silty Sand and Silty Clay.	96.0 / 2318.0			NP	40		About 1.0 ft. of heave before SS at 96.0 ft.
100 / 2314.0											
	100		11 - 15 - 18								
105 / 2309.0											
	90		13 - 19 - 22					NP	63		
				Lean CLAY (CL), hard, moist, tan, [A-6].	109.0 / 2305.0						About 1.5 ft of heave before SS at 109.0 ft.
110 / 2304.0											Pen
	100		11 - 15 - 18			23	37	22	92		
115 / 2299.0											
	100		8 - 15 - 18	Silty SAND (SM), dense to medium dense, wet, brown, fine to coarse grained, [A-2]. Occasional to frequent seams and layers of Silty Clay	116.5 / 2297.5			NP	89		
120 / 2294.0											

Water Level Observations		
After Drilling: ()	During Drilling: **14.4 ft (2399.6 ft)** After Drilling: **Not Encountered, Casing Out**	Remarks: cave in at 12.5 ft.

LOG OF BORING

MONTANA MDT DEPARTMENT OF TRANSPORTATION

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			100		6 - 8 - 13				26					
125 / 2289.0														
			100		10 - 12 - 13									
							Lean CLAY (CL), stiff, moist, brown, [A-6]. Occasional layers of Sand and Silty Sand	129.0 / 2285.0						
130 / 2284.0														
			100		5 - 8 - 10				30	44	26	99		Pen
135 / 2279.0														
			100		4 - 7 - 10									Pen
							Boring Depth: 137.5 ft, *Elevation: 2276.5 ft*	137.5 / 2276.5						

Water Level Observations		
After Drilling: ()	During Drilling: **14.4 ft *(2399.6 ft)***	Remarks: cave in at 12.5 ft.
	After Drilling: **Not Encountered, Casing Out**	

LOG OF BORING

Boring 4039-19

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265738.564 ft E: 554353.358 ft	**Station:** 21 + 20 **Offset:** 63 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2425.3 ft
Date Started: 2/27/06	**Date Finished:** 3/1/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Warfield		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Recovery (%)	RQD (%)	Blow Count	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
	100		4 - 2 - 2	Sandy SILT (SM), loose, dry, [A-4]. Trace of clay		28					Hollow stem augers with finger bit.
	NP/NR		50/0.0ft	Boulders.	2.0 / 2423.3						
5 / 2420.3	73										Switched to HQ3 coring with surface set bit and water.
	55		43 - 19 - 19	Poorly-Graded GRAVEL with sand (GP), dense, dry, subrounded to angular, [A-1]. Mixed lithologies	5.0 / 2420.3	4		NP	8		Hollow stem augers with finger bit.
	70		2 - 3 - 2	Silty SAND (SM), loose, dry, [A-1]. Mixed mineralogies	7.8 / 2417.5	3		NP	12		
10 / 2415.3	50		4 - 7 - 8	Poorly-Graded SAND with gravel (SP), medium dense to very loose, dry to wet, rounded to subrounded, [A-1]. Mixed lithologies, occasional cobble/boulder/gravel layers	11.0 / 2414.3	2					
	70		7 - 9 - 12			2					
15 / 2410.3	60		7 - 9 - 12			6		NP	9		
20 / 2405.3	60		9 - 9 - 14			3					
25 / 2400.3	100		2 - 2 - 2			35					
30 / 2395.3											

Water Level Observations		
▽ During Drilling: **24.0 ft** ***(2401.3 ft)***	▼ After Drilling: **Not Encountered, Casing Out**	Remarks: Dry-Hole caved in at 17.0 ft.
▼ After Drilling: *()*		

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-19

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265738.564 ft E: 554353.358 ft	**Station:** 21 + 20 **Offset:** 63 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2425.3 ft
Date Started: 2/27/06	**Date Finished:** 3/1/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Warfield		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		5 - 8 - 6				13		NP	5		Unable to proceed deeper due to crooked hole. Offset 5.0 ft. NW and redrilled with HW casing advancer. Offset 2.3 ft. SW due to second crooked hole. Redrilled with HW casing advancer to BOH.
35 / 2390.3							Well-Graded SAND (SW), medium dense, wet, [A-1]. Trace silt, occasional gravelly layers	35.0 / 2390.3						
			30		19 - 25 - 25				7					
40 / 2385.3														
			100		8 - 10 - 13				11					
45 / 2380.3														
			100		6 - 8 - 8				36					
50 / 2375.3														
			100		14 - 10 - 10			52.5 / 2372.8	7					

Boring Depth: 52.5 ft, *Elevation: 2372.8 ft*

Water Level Observations	During Drilling: **24.0 ft** ***(2401.3 ft)***	Remarks: Dry-Hole caved in at 17.0 ft.
After Drilling: *()*	After Drilling: **Not Encountered, Casing Out**	

LOG OF BORING

Boring 4039-20

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265747.539 ft E: 554224.5859 ft	**Station:** 19 + 92 **Offset:** 51 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2433.5 ft
Date Started: 3/1/06	**Date Finished:** 3/1/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Warfield		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / *Elev. (ft)*	Recovery (%)	RQD (%)	Blow Count	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
	100		2 - 2 - 2	SILT with sand (ML), very loose, moist, brown, [A-4].		28					HW casing advancer with button bit.
	100		2 - 1 - 2			22		NP	72		
5 / *2428.5*	80		3 - 1 - 27	Silty GRAVEL with sand (GM), very dense, wet, tan, [A-1].	4.5 / *2429.0*	8		NP	24		
	<10		11 - 50/0.5ft			1					
10 / *2423.5*	0		4 - 7 - 9	Silty SAND (SM), medium dense, moist to wet, [A-2]. Mixed mineralogies	9.0 / *2424.5*						
	65		6 - 7 - 6			6					
15 / *2418.5*	65		5 - 7 - 8			6		NP	17		
20 / *2413.5*	65		7 - 8 - 8			12					
25 / *2408.5*	50		6 - 5 - 6			30					
30 / *2403.5*											

Water Level Observations

During Drilling: **25.0 ft** ***(2408.5 ft)***

After Drilling: **Not Encountered, Casing Out**

After Drilling: *()*

Remarks: Dry-Hole caved in at 31.2 ft.

(2) MDT LOG OF BORING - MDT_REVISED 2009+ GDT - 2/20/14 11:19 - S:\GINTW\PROJECTS\2009+PROJECTS\4039E.GPJ

LOG OF BORING

Boring 4039-20

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265747.539 ft E: 554224.5859 ft	**Station:** 19 + 92 **Offset:** 51 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2433.5 ft
Date Started: 3/1/06	**Date Finished:** 3/1/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Warfield		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		6 - 6 - 7				28		NP	11		
35 / *2398.5*														
			40		7 - 7 - 8				35					
							Poorly-Graded GRAVEL with sand (GP), dense to medium dense, wet, [A-1]. Mixed mineralogies	38.5 / *2395.0*						
40 / *2393.5*														
			50		11 - 10 - 11				9					
45 / *2388.5*														
			40		15 - 16 - 18				8		NP	6		
50 / *2383.5*														
			70		15 - 14 - 9				5					
							Boring Depth: 52.5 ft, *Elevation: 2381.0 ft*	52.5 / *2381.0*						

Water Level Observations	During Drilling: **25.0 ft *(2408.5 ft)***	Remarks: Dry-Hole caved in at 31.2 ft.
After Drilling: *()*	After Drilling: **Not Encountered, Casing Out**	

LOG OF BORING

Boring 4039-21

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265613.453 ft E: 554969.9431 ft	**Station:** 27 + 49 **Offset:** 39 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2531.1 ft
Date Started: 3/6/06	**Date Finished:** 3/7/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Warfield		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACC	

Depth (ft) / Elev. (ft)	Recovery (%)	RQD (%)	Blow Count	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
	30		WH - WH - 2	TOPSOIL, ORGANIC SOIL soft, moist, dark brown.	0.5 / 2530.6						Hollow stem augers with bullet bit.
				Silty SAND (SM), very loose, moist, brown, [A-2].		38					
	40		6 - 10 - 11	Poorly-Graded GRAVEL with silt and sand (GP-GM), medium dense, moist, fine to coarse grained, subrounded to subangular, [A-1]. Mixed mineralogy	2.0 / 2529.1						
5 / 2526.1	50		6 - 10 - 10	occasional cobbles/boulders		3		NP	9		
10 / 2521.1	50		7 - 10 - 13			2					
15 / 2516.1	30		10 - 10 - 17			2					
				Poorly-Graded SAND with silt (SP-SM), medium dense, moist, brown, fine to coarse grained, [A-3].	17.0 / 2514.1						
20 / 2511.1	70		5 - 7 - 12			2		NP	7		
				Poorly-Graded SAND with silt and gravel (SP-SM), medium dense, moist, brown, fine to coarse grained, [A-1]. Occasional layers of sand	22.0 / 2509.1						
25 / 2506.1	50		6 - 10 - 11			1		NP	6		
30 / 2501.1											

Water Level Observations

During Drilling: Not Encountered
After Drilling: ()
After Drilling: ()

Remarks:

LOG OF BORING

Boring 4039-21

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265613.453 ft E: 554969.9431 ft	**Station:** 27 + 49 **Offset:** 39 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2531.1 ft
Date Started: 3/6/06	**Date Finished:** 3/7/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Warfield		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACC	

Depth (ft) / *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		7 - 11 - 11				2					
35 / *2496.1*			40		5 - 9 - 10									
40 / *2491.1*			60		8 - 13 - 15				2		NP	8		
45 / *2486.1*			40		5 - 10 - 20				2					
50 / *2481.1*			30		4 - 9 - 9			51.5 / *2479.6*	2					

Boring Depth: 51.5 ft, *Elevation: 2479.6 ft*

Water Level Observations	During Drilling: **Not Encountered**	Remarks:
After Drilling: *()*	After Drilling: *()*	

LOG OF BORING

Boring 4039-22

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265596.428 ft E: 555161.7847 ft	**Station:** 29 + 41 **Offset:** 53 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2551.2 ft
Date Started: 3/7/06	**Date Finished:** 3/7/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACC	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			30		1 - 4 - 7		TOPSOIL, ORGANIC SOIL soft, moist, dark brown.	0.5 / 2550.7	26					Hollow stem augers with bullet bit.
							Silty SAND (SM), medium dense, moist, brown, fine to coarse grained, [A-2].	2.0 / 2549.2						
			20		4 - 6 - 7		Poorly-Graded SAND with silt and gravel (SP), medium dense, moist, brown, fine to coarse grained, [A-1].	5.0 / 2546.2	9					
5 / 2546.2			90		4 - 4 - 4		Silty SAND (SM), loose, moist, brown, fine to coarse grained, [A-2].	7.5 / 2543.7	20		NP	28		
							Well-Graded GRAVEL with silt and sand (GW-GM), medium dense, moist, fine to coarse grained, [A-1]. Mixed mineralogy							
10 / 2541.2			40		12 - 10 - 12									
15 / 2536.2			30		10 - 11 - 10				2		NP	6		
20 / 2531.2			30		4 - 3 - 7				3					
25 / 2526.2			40		2 - 6 - 7				4					
30 / 2521.2														

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: Not Encountered After Drilling: ()	

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-22

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265596.428 ft E: 555161.7847 ft	**Station:** 29 + 41 **Offset:** 53 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2551.2 ft
Date Started: 3/7/06	**Date Finished:** 3/7/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACC	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			30		6 - 7 - 5									
35 / 2516.2			30		4 - 4 - 5				3		NP	8		
40 / 2511.2			60		9 - 22 - 23				2					
45 / 2506.2			100		6 - 7 - 7		Silty SAND (SM), medium dense, moist, brown, fine to coarse grained, [A-3].	45.5 / 2505.7	8		NP	42		
50 / 2501.2			100		6 - 8 - 7		Poorly-Graded SAND with silt (SP-SM), medium dense, moist, brown, fine to coarse grained, [A-3].	49.0 / 2502.2	6		NP	8		
55 / 2496.2			100		5 - 7 - 9			56.5 / 2494.7	4					

Boring Depth: 56.5 ft, *Elevation: 2494.7 ft*

Water Level Observations		Remarks:
	During Drilling: Not Encountered	
After Drilling: ()	After Drilling: ()	

LOG OF BORING

Boring 4039-23

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265617.743 ft E: 555442.735 ft	**Station:** 32 + 18 **Offset:** 119 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2579.5 ft
Date Started: 3/8/06	**Date Finished:** 3/8/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			30		2 - 3 - 5		TOPSOIL, ORGANIC SOIL medium dense, moist, dark brown.	0.5 / 2579.0	50					Hollow stem augers with bullet bit.
			60		5 - 10 - 25		Poorly-Graded GRAVEL with clay (GP-GC), loose to dense, moist, fine to coarse grained, subrounded to subangular, [A-1]. Mixed mineralogy, occasional cobbles and boulders							
5 / 2574.5			60		11 - 11 - 15				4	21	17	7		
10 / 2569.5			40		10 - 15 - 13				2					
							Poorly-Graded GRAVEL with silt and sand (GP-GM), medium dense to dense, moist, fine to coarse grained, subrounded to subangular, [A-1]. Mixed mineralogy, occasional cobbles and boulders	13.0 / 2566.5						
15 / 2564.5			70		10 - 13 - 14				4		NP	7		
							Occasional sand layers							
20 / 2559.5			80		14 - 21 - 23				4					
25 / 2554.5			70		13 - 14 - 38				4					
30 / 2549.5														

Water Level Observations	During Drilling: **Not Encountered**	Remarks:
After Drilling: *()*	After Drilling: *()*	

LOG OF BORING

Boring 4039-23

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265617.743 ft E: 555442.735 ft	**Station:** 32 + 18 **Offset:** 119 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2579.5 ft
Date Started: 3/8/06	**Date Finished:** 3/8/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACD	

Depth (ft) / *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		8 - 13 - 22				3					
							Silty SAND (SM), loose, moist, brown, fine to coarse grained, [A-2].	32.0 / *2547.5*						
35 / *2544.5*			70		5 - 5 - 5				4		NP	18		
							Well-Graded GRAVEL with silt and sand (GW-GM), medium dense to loose, moist, fine to coarse grained, subangular to subrounded, [A-1]. Mixed mineralogy, occasional cobbles and boulders	39.0 / *2540.5*						
40 / *2539.5*			70		13 - 20 - 12				1		NP	9		
							Occasional sand layers							
45 / *2534.5*			30		6 - 5 - 4				2					
50 / *2529.5*			30		3 - 3 - 5				3					
55 / *2524.5*			30		10 - 14 - 15				2					
60 / *2519.5*														

Water Level Observations

During Drilling: Not Encountered

After Drilling: ()

After Drilling: ()

Remarks:

LOG OF BORING

Boring 4039-23

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265617.743 ft E: 555442.735 ft	**Station:** 32 + 18 **Offset:** 119 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2579.5 ft
Date Started: 3/8/06	**Date Finished:** 3/8/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACD	

Depth (ft) / *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
		X	40		13 - 11 - 10			61.5 / *2518.0*	5					

Boring Depth: 61.5 ft, *Elevation: 2518.0 ft*

Water Level Observations		Remarks:
	During Drilling: **Not Encountered**	
After Drilling: *()*	After Drilling: *()*	

(2) MDT LOG OF BORING - MDT_REVISED_2009+.GDT - 2/20/14 11:19 - S:\GINTW\PROJECTS\2009+PROJECTS\4039E.GPJ

LOG OF BORING

Boring 4039-24

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265537.079 ft E: 555711.6164 ft	**Station:** 34 + 99 **Offset:** 69 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2579.7 ft
Date Started: 3/8/06	**Date Finished:** 3/8/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACD	

Depth (ft) / Elev. (ft)	Recovery (%)	RQD (%)	Blow Count	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
	10		1 - 1 - 3	TOPSOIL, ORGANIC SOIL soft, moist, dark brown.	0.3 / 2579.4						Hollow stem augers with bullet bit.
				Gravelly SILT with sand (ML), very loose, moist, brown, [A-4].	1.1 / 2578.6	32					
	60		4 - 6 - 12	Poorly-Graded GRAVEL with silt and sand (GP), medium dense, moist, fine to coarse grained, subrounded to subangular, [A-1]. Mixed mineralogy, occasional cobbles and boulders		4					
5 / 2574.7	70		12 - 18 - 22								
10 / 2569.7	70		16 - 35 - 50/0.5ft			2		NP	11		
15 / 2564.7	80		15 - 27 - 32			1					
20 / 2559.7	80		32 - 49 - 30			2					
				Occasional sand layers below 22.5 ft							
25 / 2554.7	90		19 - 28 - 33								
30 / 2549.7											

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: Not Encountered After Drilling: ()	

LOG OF BORING

Boring 4039-24

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265537.079 ft E: 555711.6164 ft		**Station:** 34 + 99 **Offset:** 69 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83		**Top of Boring Elevation:** 2579.7 ft
Date Started: 3/8/06	**Date Finished:** 3/8/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected		**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings		**Township, Range, and Section:** 21N 28W 18 - ACD	

Depth (ft) / *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			80		13 - 16 - 14				3		NP	8		
35 / *2544.7*			100		30 - 35 - 25				2					
40 / *2539.7*			60		5 - 5 - 6				2					
45 / *2534.7*			40		6 - 8 - 8				2					
50 / *2529.7*			20		8 - 12 - 11				2					
55 / *2524.7*			60		13 - 23 - 43									
60 / *2519.7*														

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: **Not Encountered** After Drilling: ()	

(2) MDT LOG OF BORING - MDT_REVISED_2009+.GDT - 2/20/14 11:19 - S:\GINTW\PROJECTS\2009+PROJECTS\4039E.GPJ

LOG OF BORING

Boring 4039-24

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265537.079 ft E: 555711.6164 ft	**Station:** 34 + 99 **Offset:** 69 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2579.7 ft
Date Started: 3/8/06	**Date Finished:** 3/8/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACD	

Depth (ft) *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			40		7 - 9 - 8			61.5 *2518.2*	2		NP	6		

Boring Depth: 61.5 ft, *Elevation: 2518.2 ft*

Water Level Observations	During Drilling: Not Encountered	Remarks:
After Drilling: *()*	After Drilling: *()*	

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-25

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265503.159 ft E: 555969.0498 ft	**Station:** 37 + 61 **Offset:** 50 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2578.6 ft
Date Started: 3/13/06	**Date Finished:** 3/14/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			30		1 - 2 - 4		TOPSOIL, ORGANIC SOIL medium stiff, moist, dark brown.	0.3 / 2578.3	20					Hollow stem augers with bullet bit.
			20		4 - 4 - 5		Silty GRAVEL (GM), loose, moist, brown, fine to coarse grained, subrounded, [A-1].		3		NP	8		
5 / 2573.6			50		8 - 16 - 20		Poorly-Graded GRAVEL with silt and sand (GP-GM), dense, moist, brown, fine to coarse grained, subrounded, [A-1]. Mixed mineralogy, occasional cobbles and boulders	5.0 / 2573.6	3					
			60		8 - 14 - 18				5					
10 / 2568.6			50		12 - 24 - 18				2					
			50		7 - 20 - 24				1					
15 / 2563.6			70		12 - 24 - 19				2		NP	10		
20 / 2558.6			70		10 - 18 - 26		Well-Graded SAND with silt and gravel (SW), dense, moist, brown, fine to coarse grained, [A-1].	19.0 / 2559.6	3		NP	11		
25 / 2553.6			40		10 - 9 - 6		Poorly-Graded GRAVEL with silt and sand (GP-GM), medium dense, moist, fine to coarse grained, subrounded, [A-1]. Mixed mineralogy, occasional cobbles and boulders	24.0 / 2554.6	2					
30 / 2548.6														

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: Not Encountered After Drilling: ()	

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-25

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265503.159 ft E: 555969.0498 ft	**Station:** 37 + 61 **Offset:** 50 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 8"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2578.6 ft
Date Started: 3/13/06	**Date Finished:** 3/14/06	**Drilling Fluid:** None	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ACD	

Depth (ft) / *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			80		17 - 30 - 45				2		NP	10		
35 / *2543.6*			50		8 - 8 - 7				4					
40 / *2538.6*			30		6 - 9 - 10									
45 / *2533.6*			80		10 - 8 - 8		Silty SAND (SM), medium dense, moist, brown, fine to coarse grained, [A-4].	45.5 / *2533.1*	5		NP	10		
								46.5 / *2532.1*	5		NP	39		

Boring Depth: 46.5 ft, *Elevation: 2532.1 ft*

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: Not Encountered After Drilling: ()	

LOG OF BORING

Boring 4039-28

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265587.743 ft E: 554772.2654 ft	**Station:** 25 + 58 **Offset:** 18 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2485.3 ft
Date Started: 3/28/06	**Date Finished:** 3/29/06	**Drilling Fluid:** Water	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ADD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							FILL, Poorly-Graded SAND with silt and gravel (SP), moist, brown, fine to coarse grained, [A-1].	0.5 / 2484.8	17		NP	7		Casing advancer with tri-cone roller bit and water.
							Well-Graded GRAVEL with silt and sand (GW-GM), moist, brown, fine to coarse grained, subrounded to subangular, [A-1]. Occasional cobbles and boulders	3.0 / 2482.3						
			10		50/0.5ft		Well-Graded GRAVEL with silt and sand (GW-GM), very loose to medium dense, moist, fine to coarse grained, subrounded to subangular, [A-1]. Mixed lithologies							
5 / 2480.3			30		3 - 3 - 4									Rock lodged in split spoon shoe.
			30		3 - 3 - 3							2		
10 / 2475.3			5		4 - 3 - 3									
			10		3 - 3 - 2									
15 / 2470.3			0		3 - 2 - 1									
			10		6 - 4 - 4									
20 / 2465.3			20		5 - 4 - 4									
25 / 2460.3			35		6 - 8 - 9									
30 / 2455.3														

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: 84.2 ft (2401.1 ft)	
	After Drilling: ()	

LOG OF BORING

Boring 4039-28

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265587.743 ft E: 554772.2654 ft	**Station:** 25 + 58 **Offset:** 18 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2485.3 ft
Date Started: 3/28/06	**Date Finished:** 3/29/06	**Drilling Fluid:** Water	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ADD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			35		4 - 6 - 6						NP	10		
35 / 2450.3														
			20		6 - 4 - 5									
40 / 2445.3														
			20		7 - 4 - 4									
45 / 2440.3							Poorly-Graded GRAVEL (GP), medium dense to dense, moist, fine to coarse grained, subrounded to subangular, [A-1]. Mixed lithologies, occasional cobbles and boulders	45.0 / 2440.3						
			60		5 - 6 - 7									
50 / 2435.3														
			40		7 - 13 - 18						NP	4		
55 / 2430.3														
			5		5 - 6 - 7									
60 / 2425.3														

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: 84.2 ft (2401.1 ft) After Drilling: ()	

LOG OF BORING

Boring 4039-28

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265587.743 ft E: 554772.2654 ft	**Station:** 25 + 58 **Offset:** 18 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2485.3 ft
Date Started: 3/28/06	**Date Finished:** 3/29/06	**Drilling Fluid:** Water	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ADD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		4 - 5 - 5									
65 / 2420.3														
			65		7 - 9 - 9									
							Some coarse sand							
70 / 2415.3														
			65		7 - 7 - 7							7		
75 / 2410.3														
			40		6 - 6 - 9									
80 / 2405.3														
			35		6 - 9 - 7									Stopped for day 3/28/06, continued 3/29/06, checked water, dry hole with 81 ft. of casing in.
85 / 2400.3								▽						
			5		8 - 9 - 8									
90 / 2395.3														

Water Level Observations	▽ During Drilling: 84.2 ft *(2401.1 ft)*	Remarks:
▼ After Drilling: ()	▼ After Drilling: ()	

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-28

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265587.743 ft E: 554772.2654 ft	**Station:** 25 + 58 **Offset:** 18 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2485.3 ft
Date Started: 3/28/06	**Date Finished:** 3/29/06	**Drilling Fluid:** Water	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ADD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		10 - 5 - 4		Some medium to coarse sand, sand and gravel are very clean							
95 / 2390.3														
			65		5 - 8 - 8							2		
100 / 2385.3														
			60		10 - 8 - 7									
105 / 2380.3														
			40		22 - 15 - 12									0.6 ft of heave in casing before split spoon, unable to wash out casings by pulling back and redrilling.
110 / 2375.3														
			30		8 - 7 - 7		Fine to coarse gravel							Stated adding E2 mud drilling polymer at 111.0 ft.
115 / 2370.3														
			40		6 - 7 - 7									
120 / 2365.3														

Water Level Observations		Remarks:
After Drilling: ()	During Drilling: 84.2 ft (2401.1 ft) After Drilling: ()	

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-28

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265587.743 ft E: 554772.2654 ft	**Station:** 25 + 58 **Offset:** 18 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2485.3 ft
Date Started: 3/28/06	**Date Finished:** 3/29/06	**Drilling Fluid:** Water	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ADD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			10		7 - 10 - 11									
125 / 2360.3														
			50		5 - 9 - 12									Drilled to 126.0 ft. waited 0.5 hour, water at 70.6 ft. with 121 ft. of casing in. 8 ft. heave in casing, pulled back five ft. and redrilled.
130 / 2355.3														
			30		8 - 11 - 9									
135 / 2350.3														
			20		5 - 8 - 11									
140 / 2345.3														
			30		9 - 9 - 11									
145 / 2340.3														
			30		9 - 14 - 10									
							Poorly-Graded GRAVEL with sand (GP), medium	149.0 / 2336.3						
150 / 2335.3														

Water Level Observations		
After Drilling: ()	During Drilling: 84.2 ft (2401.1 ft) After Drilling: ()	Remarks:

LOG OF BORING

Boring 4039-28

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265587.743 ft E: 554772.2654 ft	**Station:** 25 + 58 **Offset:** 18 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2485.3 ft
Date Started: 3/28/06	**Date Finished:** 3/29/06	**Drilling Fluid:** Water	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - ADD	

Depth (ft) *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		11 - 13 - 13		dense, wet, fine to coarse grained, subrounded to subangular, [A-1]. Mixed lithologies	152.5 *2332.8*						

Boring Depth: 152.5 ft, *Elevation: 2332.8 ft*

Water Level Observations	During Drilling: **84.2 ft** ***(2401.1 ft)***	Remarks:
After Drilling: *()*	After Drilling: *()*	

LOG OF BORING

Boring 4039-32

Project: Thompson River - East		**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 554686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2423.0 ft
Date Started: 4/15/09	**Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: I. Boyd **Logger:** Grosch/Holley		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Sandy GRAVEL (GW), medium dense to loose, moist, rounded, [A-1]. Frequent cobbles and boulders							NW casing advancer with tricone roller bit and water.
5 / 2418.0			5		4 - 2 - 3				2					
10 / 2413.0			25		7 - 6 - 7				8					
15 / 2408.0			5		2 - 3 - 2				2					
20 / 2403.0			25		5 - 7 - 21				10					
25 / 2398.0			10		4 - 3 - 2				3					
30 / 2393.0														

Water Level Observations

During Drilling: ()
After Drilling: ()
After Drilling: ()

Remarks: Water not recorded due to use of water to advance boring.

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-32

Project: Thompson River - East		**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 554686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2423.0 ft
Date Started: 4/15/09	**Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: I. Boyd **Logger:** Grosch/Holley		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			30		6 - 7 - 4				14			3		Sand heaved 2.0 ft., hole washed out to correct elevation.
35 / 2388.0			5		2 - 2 - 2				4					
40 / 2383.0			5		2 - 2 - 5				5					
45 / 2378.0			30		5 - 6 - 4				2					
50 / 2373.0			40		3 - 10 - 7				3 4			1		
55 / 2368.0			30		11 - 7 - 5				4					
60 / 2363.0														

Water Level Observations

During Drilling: ()

After Drilling: ()

After Drilling: ()

Remarks: Water not recorded due to use of water to advance boring.

LOG OF BORING

Boring 4039-32

Project: Thompson River - East		**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 554686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2423.0 ft
Date Started: 4/15/09	**Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: I. Boyd **Logger:** Grosch/Holley		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			30		5 - 5 - 6				2					
65 / 2358.0			5		10 - 5 - 7				13					
70 / 2353.0			15		10 - 10 - 8				19					Began using bentonite drilling mud.
75 / 2348.0			40		9 - 6 - 5				2					
80 / 2343.0			60		4 - 9 - 6				7		NP	3		Sand heaved 1.5 ft., hole washed out to correct elevation. Split spoon sample mostly cuttings.
85 / 2338.0			20		7 - 8 - 9				2					Rock wedged in driving shoe.
							ARGILLITE BOULDER.	88.0 / 2335.0						
90 / 2333.0								89.6						

Water Level Observations

During Drilling: ()

After Drilling: ()

After Drilling: ()

Remarks: Water not recorded due to use of water to advance boring.

LOG OF BORING

Boring 4039-32

Project: Thompson River - East		**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 554686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2423.0 ft
Date Started: 4/15/09	**Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: I. Boyd **Logger:** Grosch/Holley		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			25		15 - 29 - 16		Sandy GRAVEL (GW), dense to loose, moist, rounded, [A-1]. Frequent cobbles and boulders	2333.4	18		NP	19		Sand heaved 2.0 ft., hole washed out to correct elevation.
95 / 2328.0			25		5 - 7 - 10				6					Rock wedged in driving shoe.
							ARGILLITE BOULDER.	98.5 / 2324.5						
100 / 2323.0			40		4 - 7 - 10		Sandy GRAVEL with silt (GW), dense to medium dense, moist, rounded to angular, [A-1]. Frequent cobbles	99.5 / 2323.5	8					
105 / 2318.0			60		11 - 8 - 7				2					
110 / 2313.0			15		8 - 7 - 17				2					
115 / 2308.0									2					
120 / 2303.0														

Water Level Observations

During Drilling: ()

After Drilling: ()

After Drilling: ()

Remarks: Water not recorded due to use of water to advance boring.

LOG OF BORING

Boring 4039-32

Project: Thompson River - East		**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 554686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2423.0 ft
Date Started: 4/15/09	**Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Plans
Driller: I. Boyd **Logger:** Grosch/Holley		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / *Elev. (ft)*	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / *Elev. (ft)*	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			40		12 - 15 - 16				9					
125 / *2298.0*			40		9 - 10 - 11				12					
130 / *2293.0*			60		10 - 13 - 14				4					60 feet of NW casing left in hole after completion of drilling operations due to shear failure.
135 / *2288.0*			60		13 - 22 - 20			136.5 / *2286.5*	5		NP	4		Casing advancer refusal at 137 ft.

Boring Depth: 136.5 ft, *Elevation: 2286.5 ft*

Water Level Observations		
After Drilling: ()	During Drilling: () After Drilling: ()	Remarks: Water not recorded due to use of water to advance boring.

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-32A

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265651 ft E: 554295 ft	**Station:** 20 + 77 **Offset:** 33 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2478.0 ft
Date Started: 9/25/12	**Date Finished:** 9/26/12	**Drilling Fluid:** Water	**Location Source:** Scaled from Plans	**Elevation Source:** Plans
Driller: J. Winfield **Logger:** Childs		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
							Asphalt.	0.6 / 2477.4						"H" casing advancer with tri-cone roller bit and water.
							Silty GRAVEL with sand (GM), Boulders, medium dense, multi-colored, fine to coarse grained, angular to rounded, [A-2].							
5 / 2473.0			50		9 - 15 - 13				6					
							Silty GRAVEL with sand (GM), loose, multi-colored, fine to coarse grained, subangular to subrounded, [A-2].	7.0 / 2471.0						
10 / 2468.0			5		5 - 4 - 3				4					
15 / 2463.0			25		6 - 4 - 3				4					
20 / 2458.0														
			5		5 - 2 - 2				9					
25 / 2453.0														
			35		4 - 3 - 2				3					
30 / 2448.0														

Water Level Observations		
After Drilling: ()	During Drilling: () After Drilling: ()	Remarks: Groundwater not recorded.

LOG OF BORING

Boring 4039-32A

MONTANA MDT DEPARTMENT OF TRANSPORTATION

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265651 ft E: 554295 ft	**Station:** 20 + 77 **Offset:** 33 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2478.0 ft
Date Started: 9/25/12	**Date Finished:** 9/26/12	**Drilling Fluid:** Water	**Location Source:** Scaled from Plans	**Elevation Source:** Plans
Driller: J. Winfield **Logger:** Childs		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			50		4 - 7 - 7		Silty SAND with gravel (SM), Boulders, medium dense, multi-colored, fine to coarse grained, subrounded to angular, [A-1].	32.0 / 2446.0	9		NP	20		
35 / 2443.0														
			35		7 - 9 - 10				10					
40 / 2438.0														
			40		18 - 10 - 11				5					
45 / 2433.0														
			75		10 - 27 - 39				14					
50 / 2428.0														
			70		3 - 5 - 7		Silty SAND (SM), medium dense, moist, brown, fine to coarse grained, [A-2].	52.0 / 2426.0	20					
55 / 2423.0														
			75		7 - 8 - 10				16					
60 / 2418.0														

Water Level Observations		
After Drilling: ()	During Drilling: () After Drilling: ()	Remarks: Groundwater not recorded.

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-32A

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265651 ft E: 554295 ft	**Station:** 20 + 77 **Offset:** 33 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2478.0 ft
Date Started: 9/25/12	**Date Finished:** 9/26/12	**Drilling Fluid:** Water	**Location Source:** Scaled from Plans	**Elevation Source:** Plans
Driller: J. Winfield **Logger:** Childs		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
			75		8 - 9 - 10				17					
65 / 2413.0														
			75		7 - 9 - 10				20		NP	13		
70 / 2408.0							Poorly-Graded GRAVEL with silt and sand (GP-GM), medium dense to dense, moist, multi-colored, fine to coarse grained, rounded to subrounded, [A-1].	69.5 / 2408.5						
			75		14 - 18 - 22				7					
75 / 2403.0														
			0		23 - 13 - 10									
80 / 2398.0														
			0		13 - 9 - 11									
85 / 2393.0														
			50		8 - 7 - 9				13		NP	6		
90 / 2388.0														

Water Level Observations		
After Drilling: ()	During Drilling: () / After Drilling: ()	Remarks: Groundwater not recorded.

LOG OF BORING

Boring 4039-32A

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265651 ft E: 554295 ft	**Station:** 20 + 77 **Offset:** 33 ft R
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2478.0 ft
Date Started: 9/25/12	**Date Finished:** 9/26/12	**Drilling Fluid:** Water	**Location Source:** Scaled from Plans	**Elevation Source:** Plans
Driller: J. Winfield **Logger:** Childs		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD	Remarks and Other Tests
								92.0 / 2386.0						
			65		8 - 13 - 14		Well-Graded GRAVEL with sand (GW), medium dense to dense, moist, multi-colored, fine to coarse grained, subangular to rounded, [A-1].		10					
95 / 2383.0														
			1		8 - 16 - 18				18					
100 / 2378.0														
			70		10 - 11 - 13			103.5 / 2374.5	6		NP	2		

Boring Depth: 103.5 ft, *Elevation: 2374.5 ft*

Water Level Observations		
After Drilling: ()	During Drilling: () After Drilling: ()	Remarks: Groundwater not recorded.

APPENDIX B

D A T A   R E P O R T

REPORT ON DRILLED SHAFT LOAD TESTING (OSTERBERG METHOD)

TS-1 - Thompson River East
Thompson Falls, MT (LT-1074)

Prepared for: Sletten Construction Company
1000 25th Street North, PO Box 2467
Great Falls, MT, 59403

Attention: Mr. Chad Mares

PROJECT NO: LT-1074, January 07, 2015

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Issue and Revision History

Issue History

ISSUE	ISSUED TO	ISSUED BY	DATE OF ISSUE
01	Mr. Chad Mares, Sletten Construction Company	RCS	January 07, 2015

Revision History

Date	Rev. No.	Detailed Description of Change	Ref. Section

January 07, 2015

Sletten Construction Company
1000 25th Street North, PO Box 2467
Great Falls, MT, 59403

Attention: Mr. Chad Mares

Load Test Report: TS-1 - Thompson River East
Location: Thompson Falls, MT (LT-1074)

Dear Mr. Mares,

The enclosed report contains the data and analysis summary for the Osterberg Cell (O-cell) test performed on TS-1 - Thompson River East, on December 29, 2014. For your convenience, we have included an executive summary of the test results in addition to our standard detailed data report.

We would like to express our gratitude for the on-site and off-site assistance provided by your team and we look forward to working with you on future projects.

We trust that the information contained herein will suit your current project needs. If you have any questions or require further technical assistance, please do not hesitate to contact us at 352-378-3717.

Best Regards,

Robert C. Simpson, M. S.
Regional Manager, Loadtest USA

EXECUTIVE SUMMARY

On December 29, 2014, Loadtest USA performed an O-cell test on the nominal 96-inch diameter test shaft, TS-1. Sletten Construction Company completed construction of the 59.8-foot deep shaft on December 08, 2014. Sub-surface conditions at the test shaft location consist primarily of gravel and sand with some boulders. Representatives of Sletten Construction Company , the MDT and others observed construction and testing of the shaft.

The maximum sustained bi-directional load applied to the shaft was 2,063 kips. At the maximum load, the displacements above and below the O-cell assembly were 1.282 inches and 1.672 inches, respectively. Unit side shear data calculated from strain gages indicated a maximum mobilized average net side shear of 2.7 ksf between the O-cell and Strain Gage Level 1. The maximum applied unit end bearing is calculated to be 38.1 ksf. Unit values correspond to the above respective displacements.

Using the procedures described in the report text and in Appendix C, an equivalent top load curve for the test shaft was constructed. For a top loading of 1,500 kips, the adjusted test data indicate this shaft would displace approximately 0.23 inches. For a top loading of 3,000 kips, the adjusted test data indicate this shaft would displace approximately 0.88 inches.

LIMITATIONS OF EXECUTIVE SUMMARY

We include this executive summary to provide a very brief presentation of some of the key elements of this O-cell test. It is by no means intended to be a comprehensive or stand-alone representation of the test results. The full text of the report and the attached appendices contain important information which the engineer can use to come to more informed conclusions about the data presented herein.

TABLE OF CONTENTS

TABLES AND FIGURES

SITE CONDITIONS AND SHAFT CONSTRUCTION

Site Sub-surface Conditions: The sub-surface stratigraphy at the general location of the test shaft is reported to consist of sand and gravel with some boulders. The generalized subsurface profile is included in Figure A and boring logs indicating conditions near the shaft are presented in Appendix E. More detailed geologic information can be obtained from the MDT.

Test Shaft Construction: Sletten Construction Company completed construction of the dedicated test shaft on December 08, 2014. The nominal 96-inch diameter test shaft was excavated to a base elevation of +2,352.8 ft. under natural groundwater seepage. The shaft was started by installing a 102-inch O.D. casing after pre-drilling. A 96-inch O.D. casing was inserted by using a vibratory hammer in two sections and as the drilling progressed. An auger was used for drilling the shaft. After a planned delay, a clean-out bucket was used to finish drilling the shaft to plan tip elevation and for cleaning the base. After the shaft was approved for concrete placement, the reinforcing cage with attached O-cell assembly was inserted into the excavation and temporarily supported from the steel casing. Concrete was then delivered by pump through a 6-inch O.D. pipe into the base of the shaft until the top of the concrete reached an elevation of +2,410.4 ft. The contractor removed the casings immediately after concrete placement. Representatives of the MDT and others observed construction of the shaft.

OSTERBERG CELL TESTING

Shaft Instrumentation: Loadtest USA assisted Sletten Construction Company with the assembly and installation of test shaft instrumentation. The loading assembly consisted of one 26-inch diameter O-cell located 2.2 feet above the shaft base. The Osterberg cell were calibrated to 2,895 kips and then welded closed prior to shipping by American Equipment and Fabricating Corporation. Calibrations of the O-cell and instrumentation used for this test are included in Appendix B. Embedded O-cell testing instrumentation included the following:

- Four upper compression telltale casings (nominal ½-inch steel pipe) attached at 90° spacing to the reinforcing cage, extending from the top of the O-cell assembly to ground level.
- Six Linear Vibrating Wire Displacement Transducers (LVWDTs, Geokon Model 4450 series) positioned between the lower and upper plates of the O-cell assembly.
- Three levels of four sister bar vibrating wire strain gages (Geokon Model 4911 Series) attached at 90° spacing to the reinforcing cage.

- Two lengths of ½-inch steel pipe, extending from the top of the shaft to the top of the bottom plate, to vent the break in the shaft formed by the expansion of the O-cells.

Details concerning the instrumentation placement appear in Table B and Figures A and B. The strain gages were positioned as approved by MTD and Sletten Construction Company .

Test Arrangement: Throughout the load test, key elements of shaft displacement response were monitored using the equipment and instruments detailed below:

- Top of shaft displacement was monitored using a pair of automated digital survey levels (Leica NA3000 series) from an average distance of 40 feet (Appendix A, Page 1). Fixed backsight readings were obtained to confirm both digital levels remained stationary throughout the test. These backsight readings were recorded prior to the start of the test, again at the maximum load and finally after unloading the shaft.

- Upper compression displacement was measured using ¼-inch telltale rods positioned inside the four casings and monitored by Linear Vibrating Wire Displacement Transducers (LVWDTs, Geokon Model 4450 series) (Appendix A, Page 2).

- Expansion of the O-cell assembly was measured using the six expansion LVWDTs described under Shaft Instrumentation (Appendix A, Page 2).

Both a Bourdon pressure gage and a vibrating wire voltage pressure transducer were used to measure the pressure applied to the O-cells at each load interval. The pressure transducer was used for automatically setting and maintaining loads and real time plotting and for data analysis. The Bourdon pressure gage readings were used as a real-time visual reference and as a check on the transducer and for data analysis. There was close agreement between the Bourdon gage and the pressure transducer.

Data Acquisition: All instrumentation were connected through a data logger (Electronics GeoLogger) to a laptop computer allowing data to be recorded and stored automatically at 30-second intervals and displayed in real time. The same laptop computer synchronized to the data logging system was used to acquire the Leica NA3000 data.

Testing Procedures: Loadtest USA technical staff conducted the load test. Testing was begun by pressurizing the O-cell in order to break the tack welds that hold it closed (for handling and for placement in the shaft) and to form the fracture plane in the concrete surrounding the base of the O-cell. After the break occurred, the pressure was immediately released and the testing recommenced from zero pressure. Zero readings for all instrumentation were taken prior to the preliminary weld-breaking load-unload cycle, which in this case involved a maximum load of 772 kips at the O-cell.

The Osterberg cell load test was conducted as follows: The 26-inch diameter O-cell, with its base located 2.2 feet above the shaft base, was pressurized in 11 nominally equal increments, resulting in a maximum bi-directional load of 2,063 kips applied to the shaft above and below the O-cell. The loading was halted after increment 1L-11 because the upper side shear had reached ultimate capacity and further loading was not possible due to rapid displacement. The shaft was then unloaded in five decrements and the test was concluded.

The load increments were applied using the Quick Load Test Method for Individual Piles (ASTM D1143 *Standard Test Method for Piles Under Static Axial Load*). Each successive load increment was held constant for eight minutes by automatically/manually adjusting the O-cell pressure. Approximately one minute was used to move between increments. The data logger automatically recorded the instrument readings every 30 seconds, but herein only the 1, 2, 4 and 8 minute readings during each increment of maintained load are reported.

TEST RESULTS AND ANALYSES

General: The loads applied by the O-cell assembly act in two opposing directions, counteracted by the resistance of the shaft above and below. For the purpose of the analysis herein, it is assumed that the O-cell assembly does not impose an additional upward load until its expansion force exceeds the buoyant weight of the shaft above the O-cell assembly. Therefore, *net load*, which is defined as gross O-cell load minus the buoyant weight of the shaft above, is used to determine side shear resistance above the O-cell and to construct the equivalent top load displacement curve. For this test a shaft buoyant weight of 279 kips above the O-cell was calculated.

Upper Side Shear Resistance: The O-cell assembly applied a maximum upward *net load* of 1,784 kips to the upper side shear at load interval 1L-11 (<u>Appendix A, Page 3</u>, <u>Figures 1 to 3</u>). At this loading, the upward displacement of the top of the O-cell was 1.282 inches.

Combined End Bearing and Lower Side Shear Resistance: The O-cell assembly applied a maximum downward load of 2,063 kips at load interval 1L-11 (<u>Appendix A, Page 3</u>, <u>Figures 1 to 3</u>). At this loading, the average downward displacement of the O-cell base was 1.672 inches.

Strain Gage Analysis: The strain gage data appear in Appendix A, Pages 4 to 6 and the average strain measured at each level of strain gages during the test is plotted in Figure 5. On the day of the test, the unconfined compressive strength f'_c was reported to be 6,417 psi. Assuming a concrete unit weight γ_c of 145 pcf, the ACI formula (E_c=0.033 standard × $\gamma_c^{1.5}$ × $\sqrt{f'_c}$) was used to calculate an elastic modulus of 4,616 ksi for the concrete. Shaft stiffness estimates for each strain gage level computed from this modulus plus reinforcing steel details and nominal shaft dimensions are listed in Table B. This, combined with the area of reinforcing steel and nominal shaft diameter, provided an average shaft stiffness (AE) of 39,582,000 kips in the upper 102-inch cased shaft section, 35,275,000 kips in the 96-inch cased section and uncased shaft section above the O-cell and 33,409,000 kips below the O-cell.

The load distribution curves for each load increment, based on applied O-cell load and computed strain gage loads, are presented in Figure 5. Mobilized net unit side shear vs. displacement (t-z) curves based on the strain gage data and estimated ACI shaft stiffness are presented in Figure 6. Shear values for loading increment 1L-11 follow in Table A:

TABLE A: Average Net Unit Side Shear Values for 1L-11

Load Transfer Zone	Displacement[1]	Net Unit Side Shear[2]
Zero Shear to Strain Gage Level 3	↑ 1.27 in	1.2 ksf
Strain Gage Level 3 to Strain Gage Level 2	↑ 1.27 in	0.3 ksf
Strain Gage Level 2 to Strain Gage Level 1	↑ 1.28 in	0.9 ksf
Strain Gage Level 1 to O-cell	↑ 1.28 in	2.7 ksf

1 Average displacement of load transfer zone.
2 For upward-loaded shear, the buoyant weight of shaft in each zone has been subtracted from the load shed in the respective zone. Note that net unit shear values derived from the strain gages may not be ultimate values. See Figure 6 for unit shear vs. displacement (t-z) plots.

The load resisted by side shear in the 2.2-foot shaft section below the O-cell is calculated to be 149 kips assuming a measured unit side shear value of 2.7 ksf and a nominal shaft diameter of 96 inches. The maximum applied load to end bearing is 1,914 kips and the unit end bearing at the base of the shaft is calculated to be 38.1 ksf at a displacement of 1.672 inches. A mobilized unit end bearing vs. displacement (q-z) curve is presented in Figure 7.

Equivalent Top Load-Displacement: Figure 8 presents the equivalent top load (ETL) curve. The procedure for calculating the curve is described in Appendix C. The curve is generated assuming the load is applied at top of shaft elevation (+2,410.4 ft.). A combined side shear and end-bearing resistance of 3,847 kips was mobilized during the test. For a top loading of 1,500 kips, the adjusted test data indicate this shaft would displace approximately 0.23 inches. For a top loading of 3,000 kips, the adjusted test data indicate this shaft would displace approximately 0.88 inches. For reference, Figure 8 also includes the two component curves of O-cell displacements vs. net loads, which if summed would produce a "rigid" equivalent top load. The plotted ETL curve includes the additional elastic compression of a top-loaded shaft.

Creep Limit: See Appendix D for our O-cell method for determining creep limit loading. The combined end bearing and lower side shear creep data (Appendix A, Page 3, Figure D-1) indicate that a creep limit of 1,600 kips was reached at a displacement of 0.84 inches. The upper side shear creep data (Appendix A, Page 3, Figure D-2) indicate that a possible creep limit of 750 kips was reached at a displacement of 0.09 inches. A top loaded shaft will not begin creep until both components begin creep displacement. This will occur at the maximum of the displacements required to reach the creep limit for each component. A possible interpretation of this data is that that significant creep for this shaft will not begin until a top loading exceeds 3,550 kips.

Shaft Compression Comparison: The measured maximum shaft compression, averaged from four telltales is 0.011 inches at 1L-11 (Appendix A, Page 1). Using a weighted average shaft stiffness of 37,508,500 kips and the load distribution in Figure 5 at 1L-11, an elastic compression of 0.014 inches over the length of the compression telltales is calculated. This good agreement provides evidence that the values of the estimated shaft stiffness are reasonable.

LIMITATIONS AND STANDARD OF CARE

The instrumentation, testing services and data analysis provided by Loadtest USA, outlined in this report, were performed in accordance with the accepted standards of care recognized by professionals in the drilled shaft and foundation engineering industry.

Please note that some of the information contained in this report is based on data (i.e. shaft diameter, elevations and concrete strength) provided by others. The engineer, therefore, should come to his or her own conclusions with regard to the analyses as they depend on this information. In particular, Loadtest USA typically does not observe and record drilled shaft construction details to the level of precision that the project engineer may require. In many cases, we may not be present for the entire duration of shaft construction. Since construction technique can play a significant role in determining the load bearing capacity of a drilled shaft, the engineer should pay close attention to the drilled shaft construction details that were recorded elsewhere.

We trust that this information will meet your current project needs. If you have any questions, please do not hesitate to contact us at 352-378-3717.

Prepared for Loadtest USA by

Robert C. Simpson, M.S.

Reviewed for Loadtest USA by

Shing Pang, P.E.

Brian Haney, P.E.

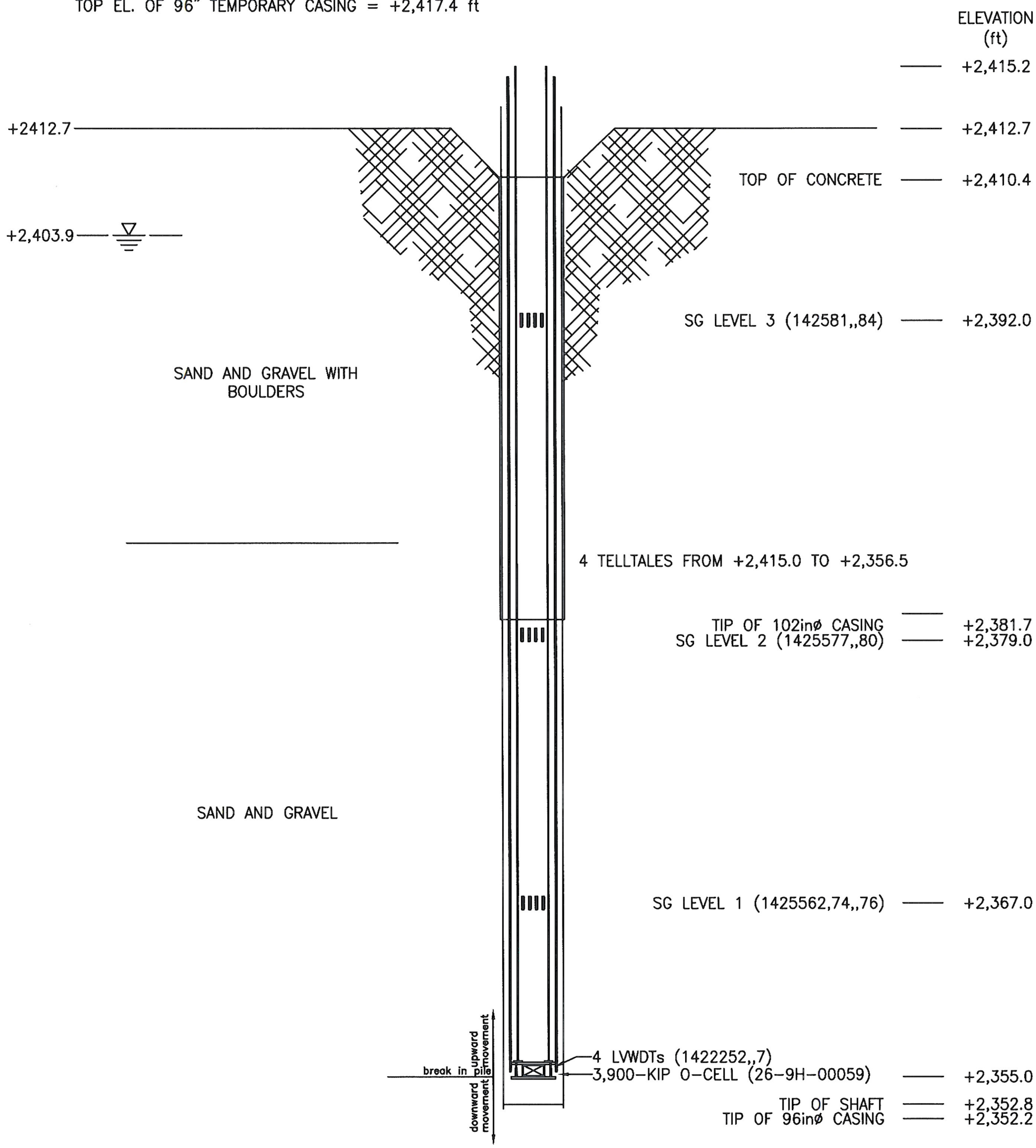
TABLE B
SUMMARY OF DIMENSIONS, ELEVATIONS & SHAFT PROPERTIES

Shaft: (TS-1 - Thompson River East - Thompson Falls, MT)		
Nominal shaft diameter (EL +2,410.4 ft to +2,381.7 ft)	=	102 in
Nominal shaft diameter (EL +2,381.7 ft to +2,352.8 ft)	=	96 in
O-cell: 26-9-00059	=	26 in
Length of shaft zone above break at base of O-cell	=	55.3 ft
Length of shaft zone below break at base of O-cell	=	2.2 ft
Side shear area above O-cell base	=	1435.7 ft^2
Side shear area below O-cell base	=	55.0 ft^2
Shaft base area	=	50.3 ft^2
Buoyant weight of shaft above base of O-cell	=	279 kips
Estimated shaft stiffness, AE (EL +2,410.4 ft to +2,381.7 ft)	=	39,582,000 kips
Estimated shaft stiffness, AE (EL +2,381.7 ft to +2,355.0 ft)	=	35,275,000 kips
Estimated shaft stiffness, AE (EL +2,355.0 ft to +2,352.8 ft)	=	33,409,000 kips
Elevation of ground surface	=	+2,412.7 ft
Elevation of top of shaft concrete	=	+2,410.4 ft
Elevation of water table (Assumed elevation of natural water table)	=	+2,403.9 ft
Elevation of base of O-cell assembly [1]	=	+2,355.0 ft
Elevation of shaft base	=	+2,352.8 ft
Casings:		
Elevation of top of inner temporary casing	=	+2,421.7 ft
Elevation of top of outer temporary casing	=	+2,420.0 ft
Elevation of bottom of outer temporary casing	=	+2,381.7 ft
Elevation of bottom of inner temporary casing	=	+2,352.2 ft
Telltale Sections:		
Elevation of top of telltale used for shaft compression	=	+2,412.7 ft
Elevation of bottom of telltale used for shaft compression	=	+2,356.5 ft
Strain Gages:		
Elevation of Strain Gage Level 3 (AE = 39,582,000 kips)	=	+2,392.0 ft
Elevation of Strain Gage Level 2 (AE = 35,275,000 kips)	=	+2,379.0 ft
Elevation of Strain Gage Level 1 (AE = 35,275,000 kips)	=	+2,367.0 ft
Miscellaneous:		
O-cell assembly top plate diameter (2 in thick)	=	83", 60"
O-cell assembly bottom plate diameter (2 in thick)	=	86 3/4", 60"
Reinforcing cage vertical bar size (EL. +2,415.2 ft to +2,355.0, 34 No.)	=	#14
Reinforcing cage spiral size (12 in spacing)	=	6
Rebar cage diameter	=	88 in
Assumed concrete unit weight	=	145 pcf
Estimated 21-day unconfined compressive concrete strength	=	6,417 psi
Calculated 21-day concrete modulus	=	4,616 ksi
O-cell LVWDTs @ 0°, 90°, 180° and 270° with radius	=	39", 18"

[1] The break between upward and downward movement at the O-cell assembly

NOTE: NOMINAL SHAFT DIAMETER 96"

TOP EL. OF 102" TEMPORARY CASING = +2,414.0 ft
TOP EL. OF 96" TEMPORARY CASING = +2,417.4 ft



NOTE: SOIL BASED ON BORING # 4039-18 AND 32

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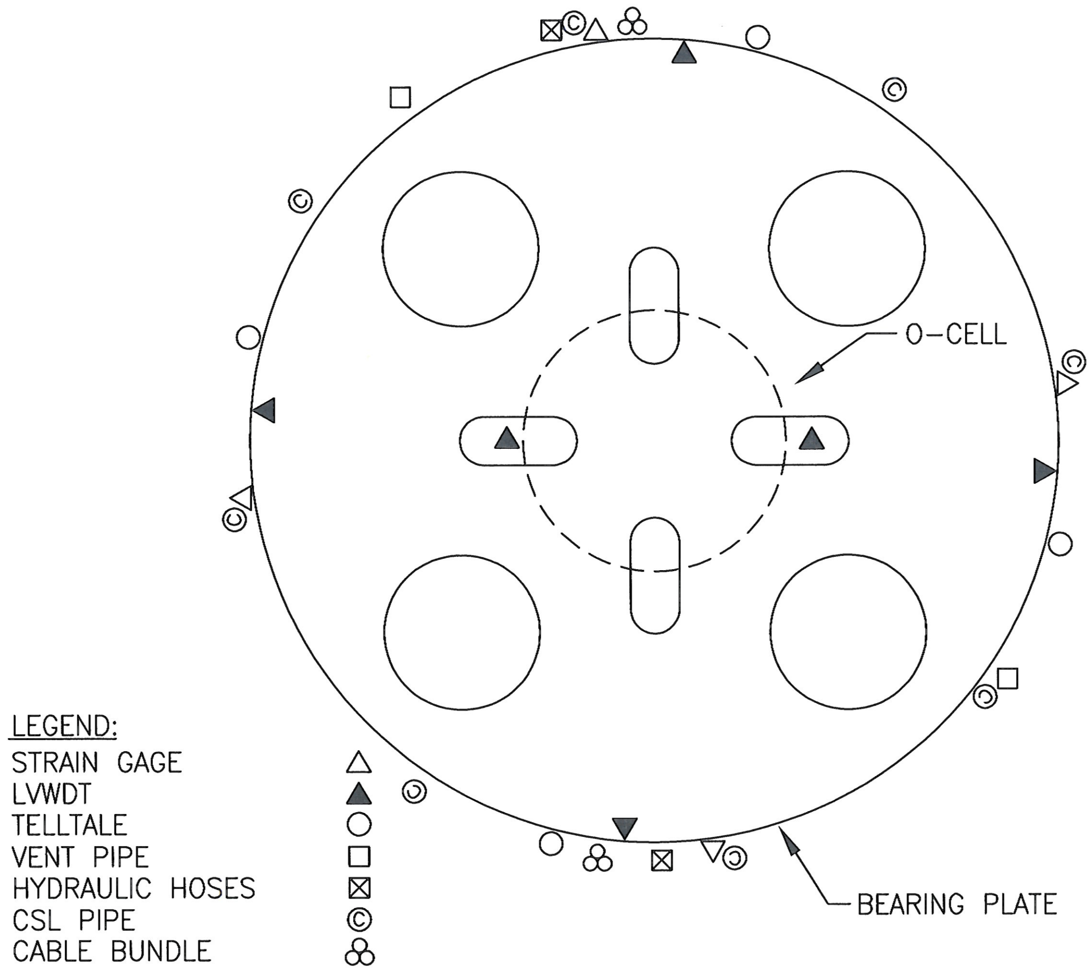
SCHEMATIC SECTION OF TEST SHAFT

BRIDGE OVER THOMPSON RIVER – SANDERS COUNTY, MT

DWN BY: RCS	DATE: 15 Jul 2014	CHECKED BY: JFU	LT-1074-1
REVISED BY: RCS	DATE: 5 Jan 2015	SCALE: NTS	**FIGURE A**



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INSTRUMENTATION LAYOUT

BRIDGE OVER THOMPSON RIVER – SANDERS COUNTY, MT

DWN BY: RCS	DATE: 15 Jul 2014	CHECKED BY: RCS	LT-1074-1
REVISED BY: RCS	DATE: 5 Jan 2015	SCALE: NTS	**FIGURE B**

Osterberg Cell Load-Displacement

TS-1 - Thompson River East - Thompson Falls, MT

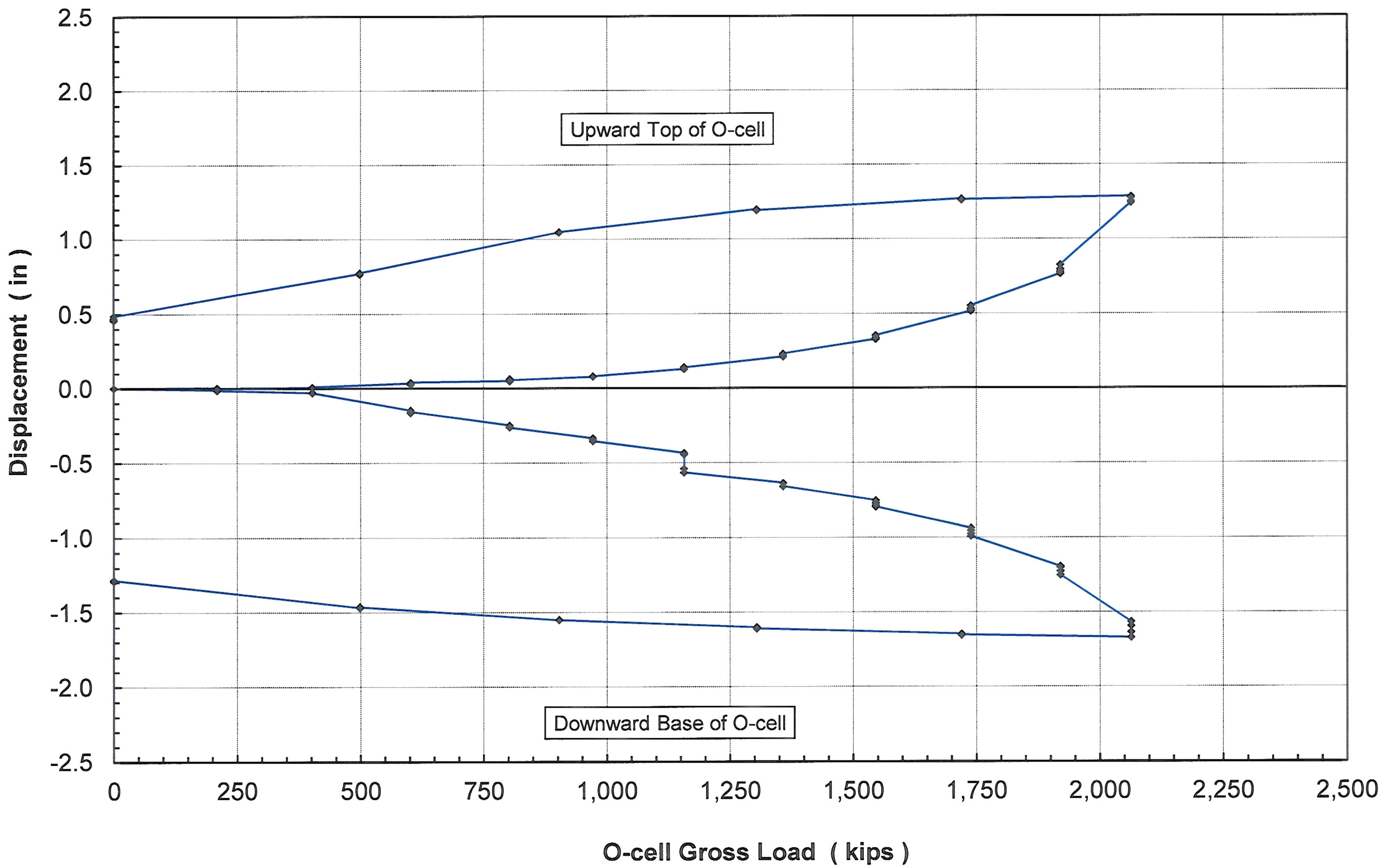

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Figure 1 of 8

Time-Osterberg Cell Load

TS-1 - Thompson River East - Thompson Falls, MT

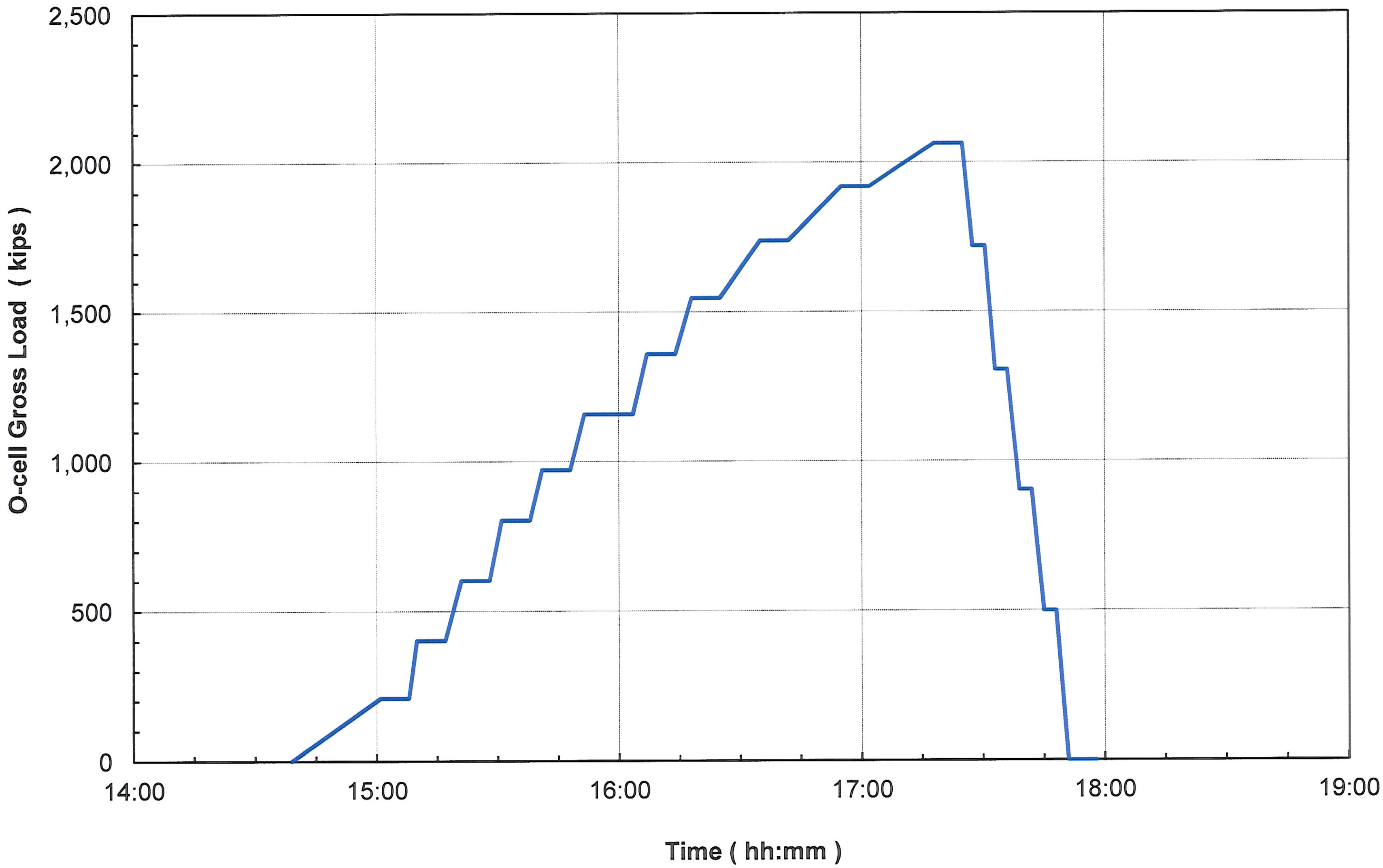

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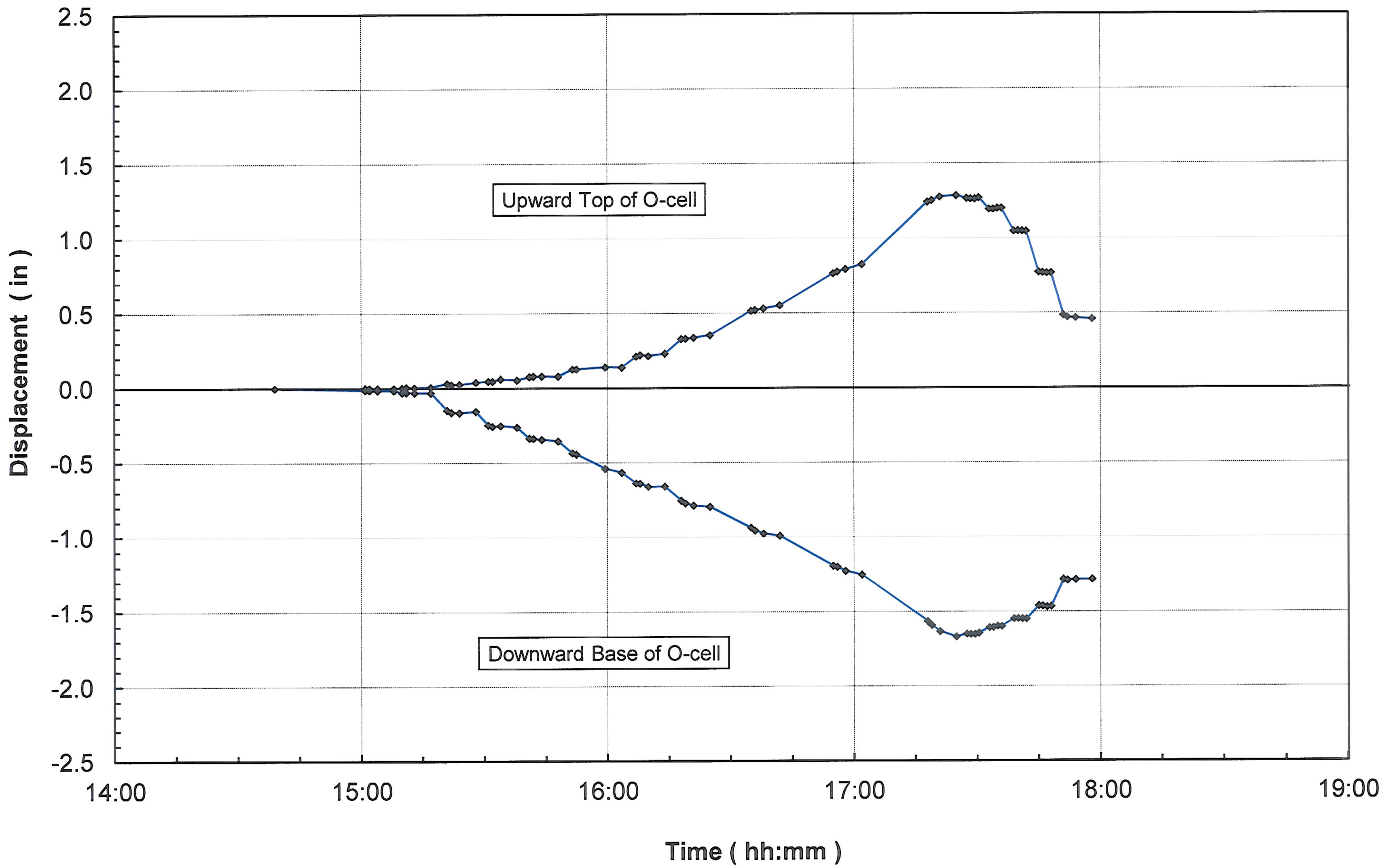
Figure 2 of 8

Time-Osterberg Cell Displacement

TS-1 - Thompson River East - Thompson Falls, MT



Osterberg Cell Load-Strain Gage Microstrain

TS-1 - Thompson River East - Thompson Falls, MT

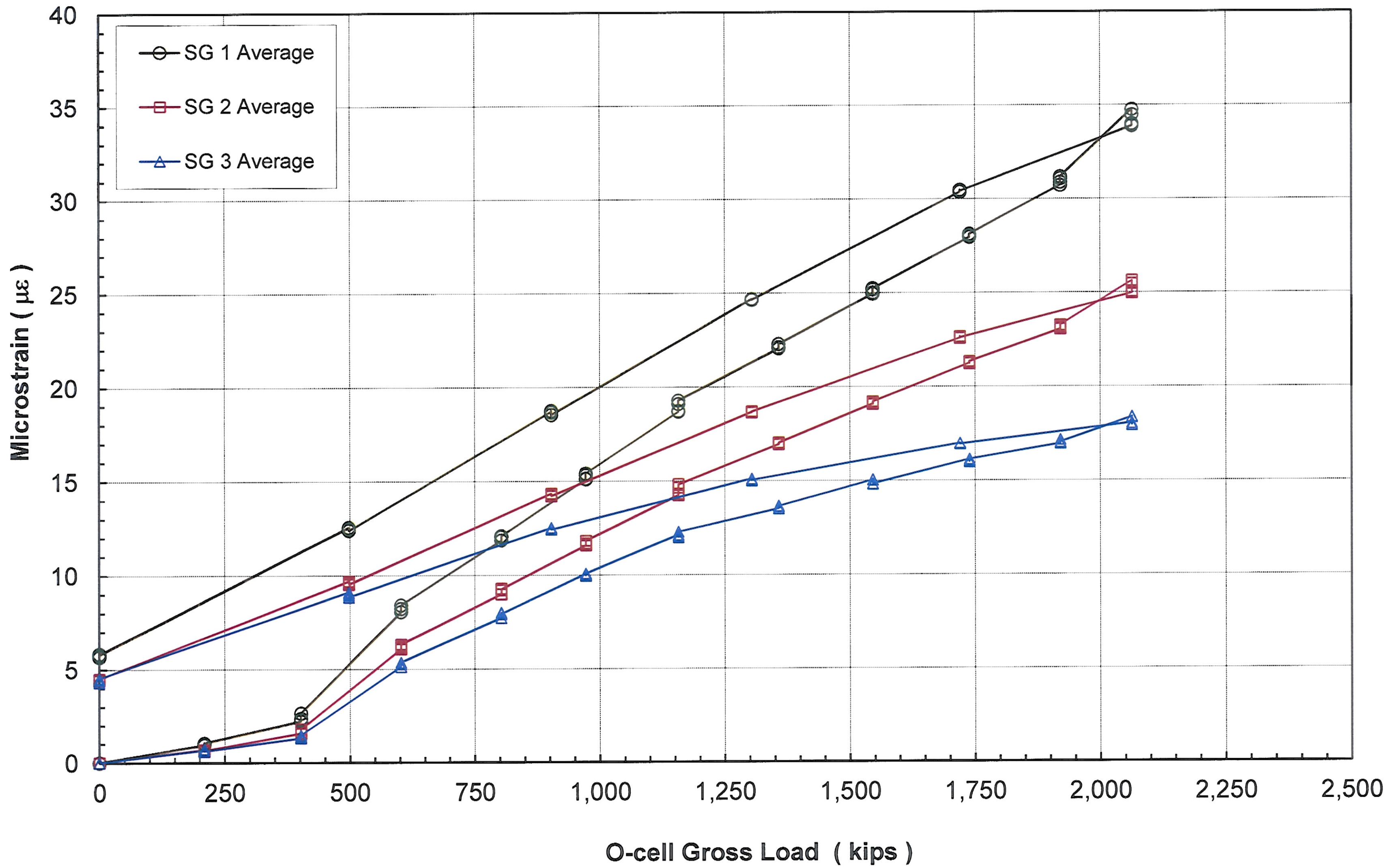


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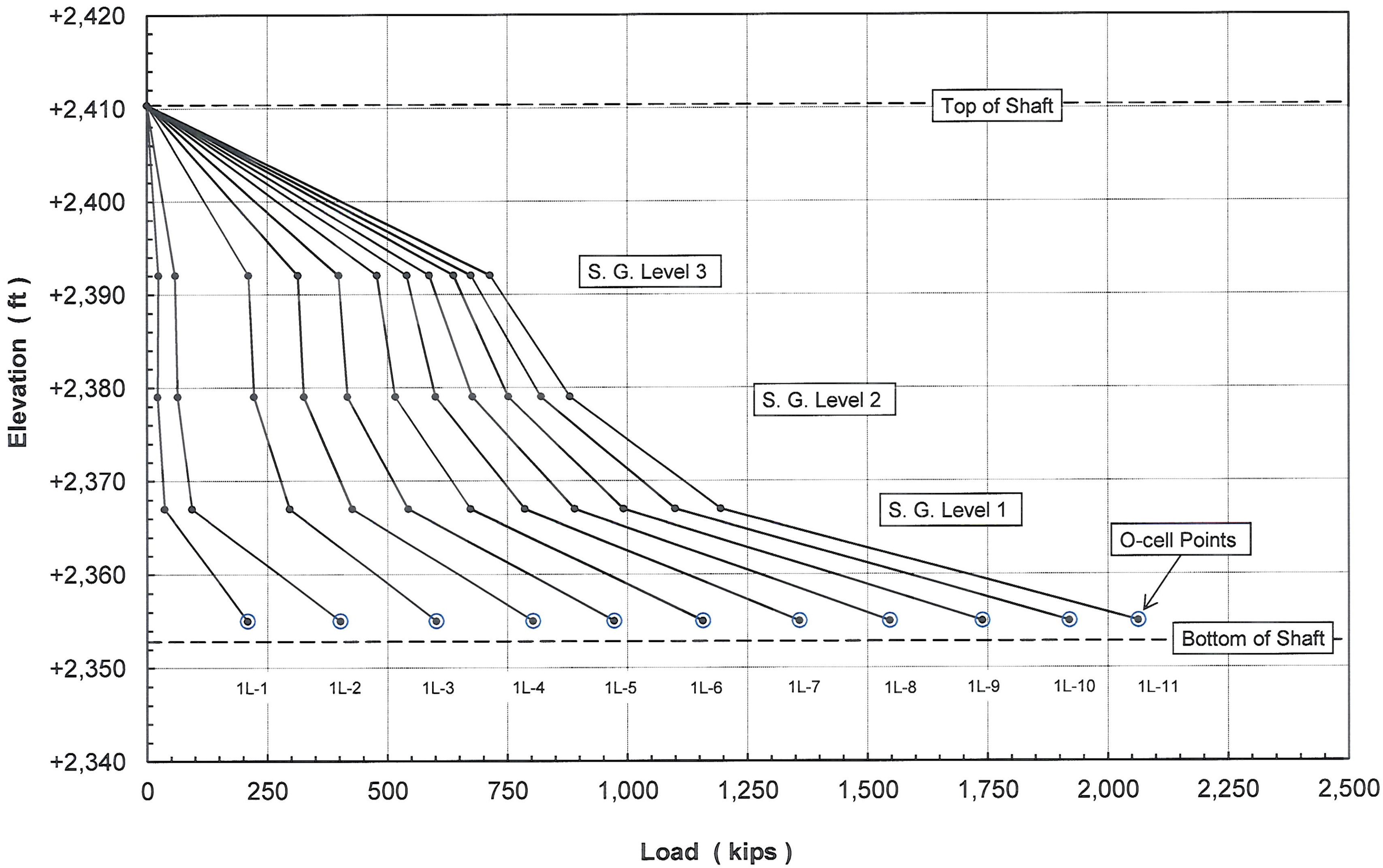
Figure 4 of 8

Strain Gage Load Distribution

TS-1 - Thompson River East - Thompson Falls, MT



Loadtest USA Project No. LT-1074

Figure 5 of 8

Mobilized Upward Net Unit Side Shear

TS-1 - Thompson River East - Thompson Falls, MT

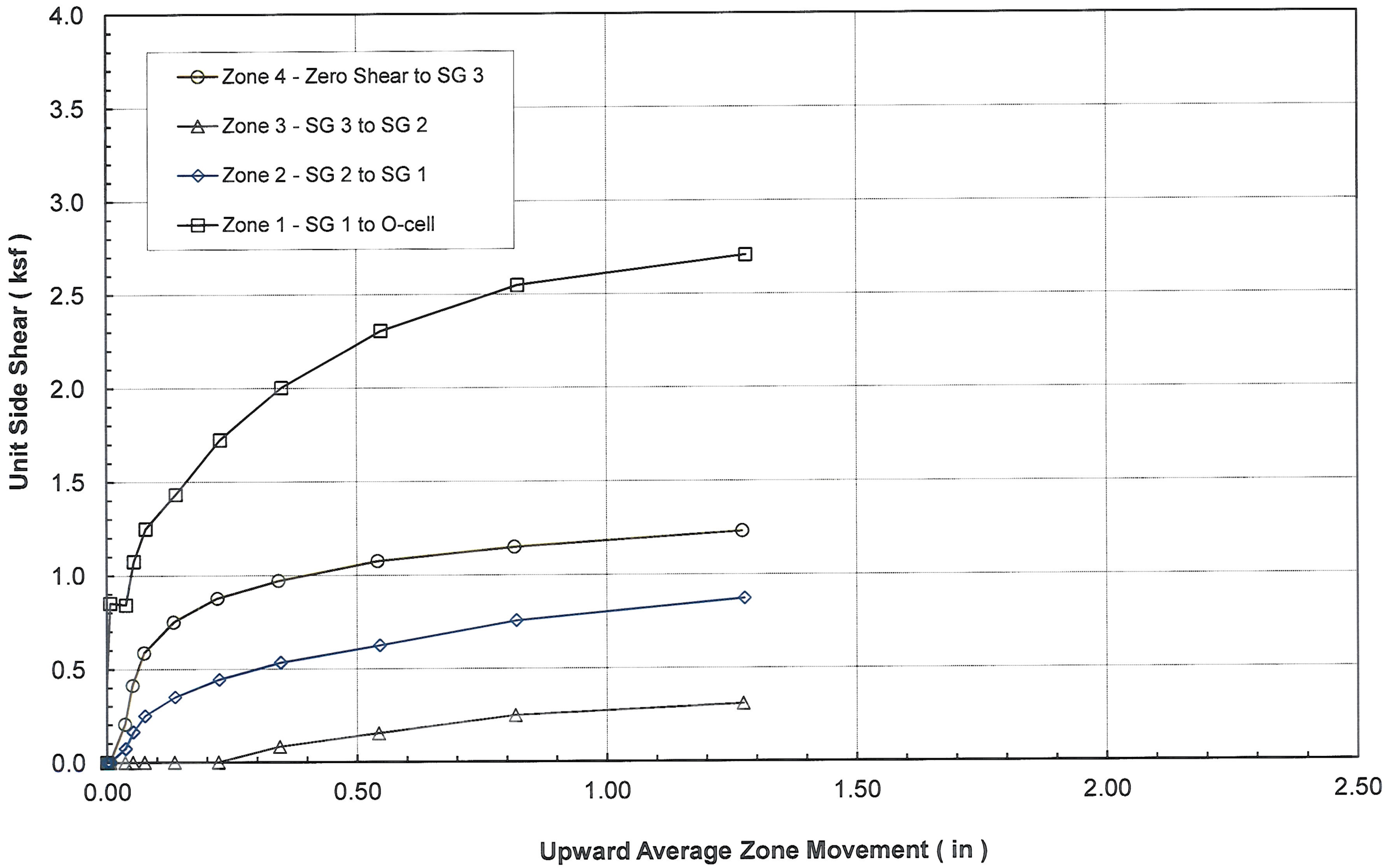
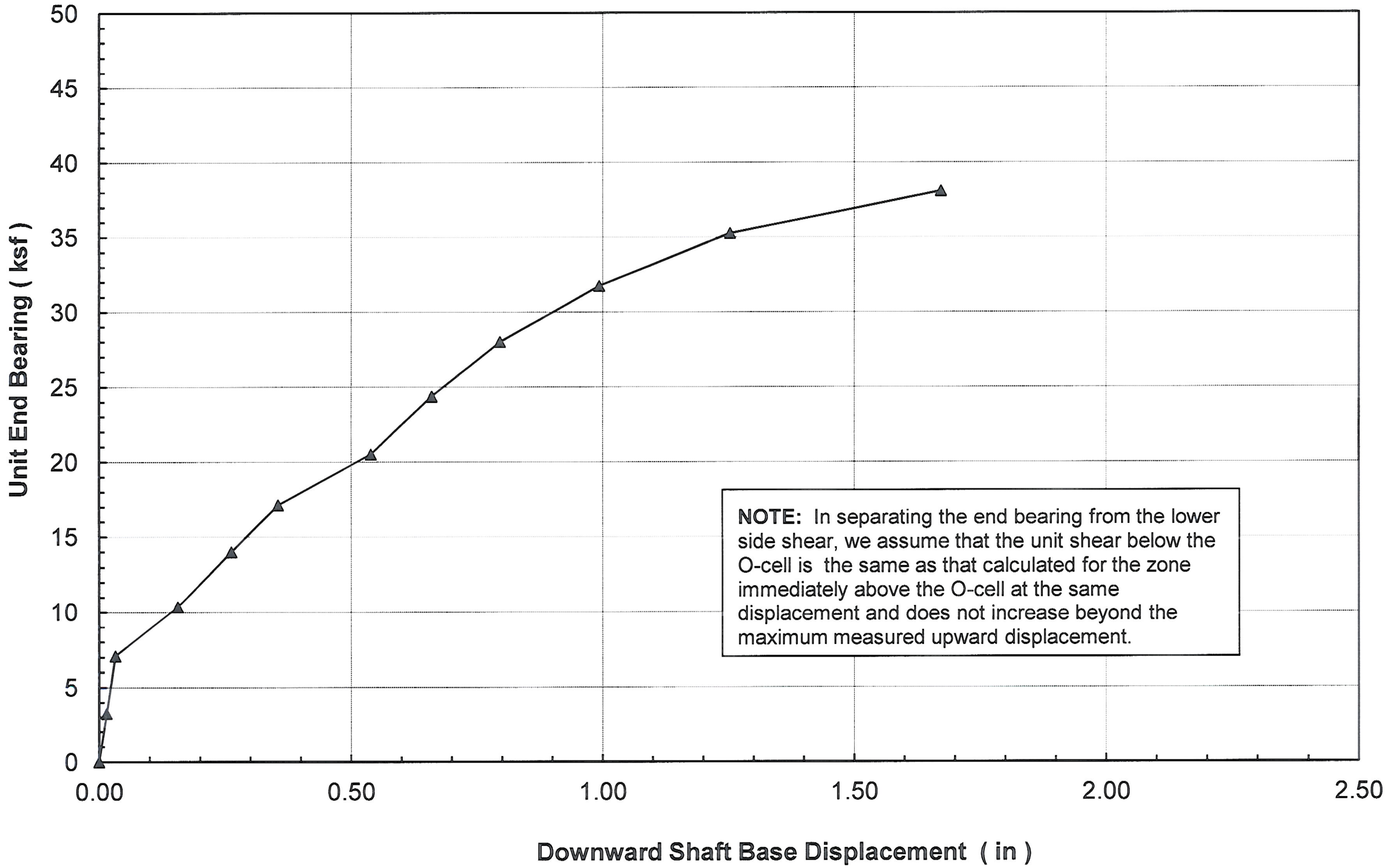


Figure 6 of 8

Mobilized Unit End Bearing

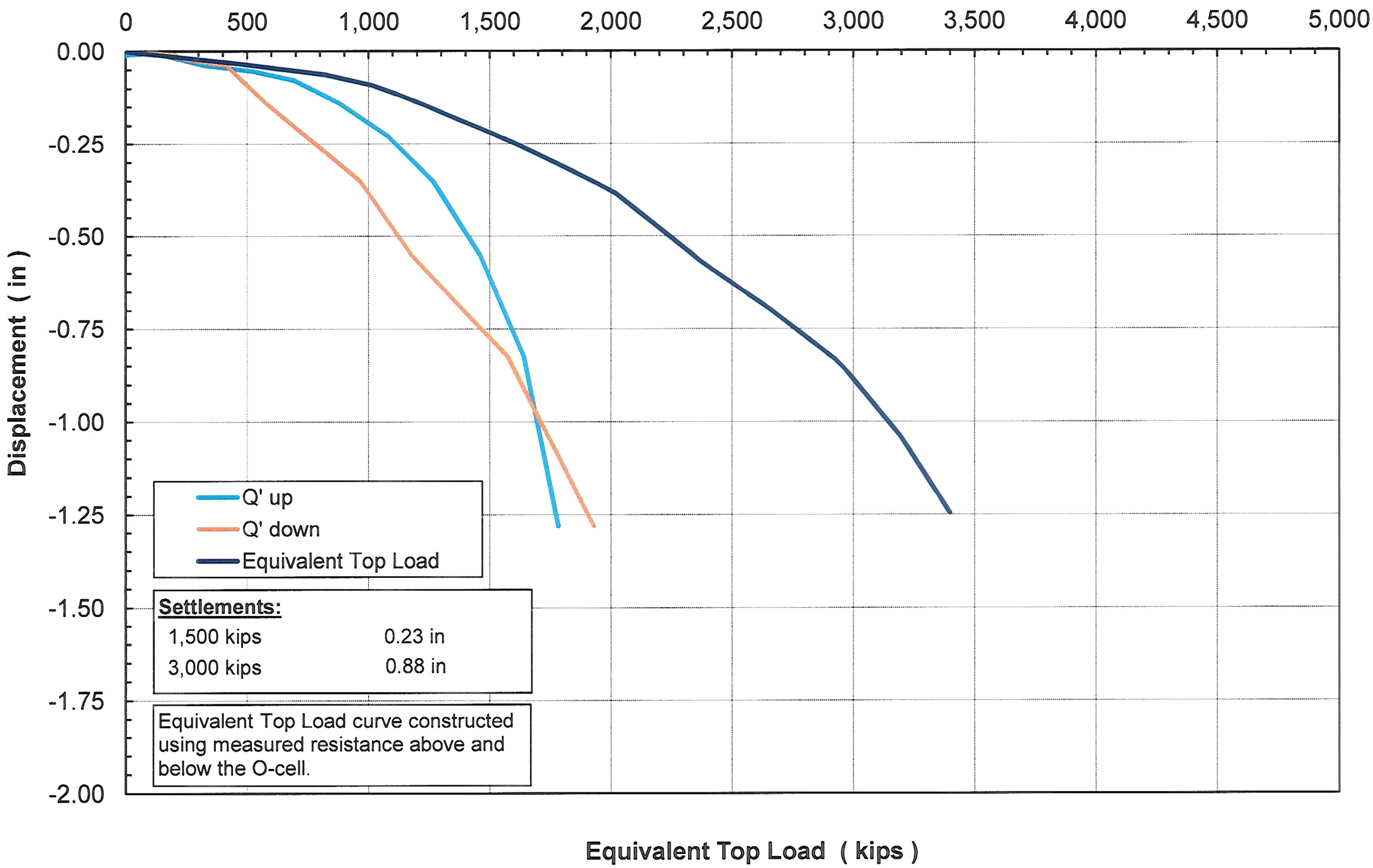
TS-1 - Thompson River East - Thompson Falls, MT



NOTE: In separating the end bearing from the lower side shear, we assume that the unit shear below the O-cell is the same as that calculated for the zone immediately above the O-cell at the same displacement and does not increase beyond the maximum measured upward displacement.

Equivalent Top Load-Displacement

TS-1 - Thompson River East - Thompson Falls, MT



APPENDIX A

FIELD DATA AND DATA REDUCTION TABLES

Upward Top of Shaft Movement and Upper Shaft Compression
TS-1 - Thompson River East - Thompson Falls, MT

Load	Hold		O-cell		Top of Shaft			Upper Compression Telltales				
Test Increment	Time (minutes)	Time (hh:mm:ss)	Pressure (psi)	Load (kips)	A-282904 (in)	B-310351 (in)	Average (in)	A-1424657 (in)	B-1424658 (in)	C-1424659 (in)	D-1428888 (in)	Average (in)
1 L - 0	-	14:39:00	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1 L - 1	1	15:01:00	540	209	0.004	-0.003	0.001	0.000	0.001	0.000	0.000	0.000
1 L - 1	2	15:02:00	540	209	0.003	-0.003	0.000	0.000	0.001	0.000	0.000	0.000
1 L - 1	4	15:04:00	540	209	0.001	-0.004	-0.001	0.000	0.001	0.000	0.000	0.000
1 L - 1	8	15:08:00	540	209	0.003	-0.005	-0.001	0.000	0.001	0.000	0.000	0.000
1 L - 2	1	15:10:00	1,040	402	0.005	-0.001	0.002	0.001	0.001	0.000	0.001	0.001
1 L - 2	2	15:11:00	1,040	402	0.007	0.002	0.005	0.001	0.001	0.000	0.001	0.001
1 L - 2	4	15:13:00	1,040	402	0.006	0.000	0.003	0.001	0.001	0.001	0.001	0.001
1 L - 2	8	15:17:00	1,040	402	0.003	0.008	0.006	0.001	0.001	0.001	0.001	0.001
1 L - 3	1	15:21:00	1,560	602	0.028	0.032	0.030	0.003	0.002	0.003	0.001	0.002
1 L - 3	2	15:22:00	1,560	602	0.024	0.018	0.021	0.003	0.002	0.003	0.002	0.002
1 L - 3	4	15:24:00	1,560	602	0.027	0.020	0.024	0.003	0.002	0.003	0.002	0.002
1 L - 3	8	15:28:00	1,560	602	0.031	0.041	0.036	0.004	0.003	0.003	0.002	0.003
1 L - 4	1	15:31:00	2,080	803	0.049	0.036	0.043	0.005	0.004	0.004	0.002	0.004
1 L - 4	2	15:32:00	2,080	803	0.051	0.034	0.043	0.005	0.004	0.004	0.002	0.004
1 L - 4	4	15:34:00	2,080	803	0.051	0.063	0.057	0.005	0.005	0.004	0.003	0.004
1 L - 4	8	15:38:00	2,080	803	0.050	0.052	0.051	0.005	0.005	0.004	0.003	0.004
1 L - 5	1	15:41:00	2,520	972	0.073	0.068	0.071	0.006	0.006	0.005	0.003	0.005
1 L - 5	2	15:42:00	2,520	972	0.077	0.070	0.074	0.006	0.006	0.005	0.003	0.005
1 L - 5	4	15:44:00	2,520	972	0.076	0.074	0.075	0.006	0.006	0.005	0.003	0.005
1 L - 5	8	15:48:00	2,520	972	0.077	0.070	0.074	0.006	0.006	0.006	0.003	0.005
1 L - 6	1	15:51:30	3,000	1,157	0.128	0.111	0.120	0.008	0.007	0.007	0.004	0.007
1 L - 6	2	15:52:30	3,000	1,157	0.120	0.120	0.120	0.008	0.008	0.007	0.004	0.007
1 L - 6	9	15:59:30	3,000	1,157	0.126	0.140	0.133	0.007	0.008	0.007	0.005	0.007
1 L - 6	13	16:03:30	3,000	1,157	0.134	0.127	0.131	0.007	0.008	0.007	0.005	0.007
1 L - 7	1	16:07:00	3,520	1,358	0.201	0.201	0.201	0.008	0.008	0.008	0.005	0.008
1 L - 7	2	16:08:00	3,520	1,358	0.211	0.213	0.212	0.008	0.008	0.008	0.005	0.008
1 L - 7	4	16:10:00	3,520	1,358	0.207	0.203	0.205	0.008	0.008	0.008	0.005	0.008
1 L - 7	8	16:14:00	3,520	1,358	0.214	0.227	0.221	0.008	0.009	0.009	0.005	0.008
1 L - 8	1	16:18:00	4,010	1,546	0.313	0.320	0.317	0.009	0.010	0.010	0.006	0.009
1 L - 8	2	16:19:00	4,010	1,546	0.317	0.320	0.319	0.009	0.010	0.010	0.006	0.009
1 L - 8	4	16:21:00	4,010	1,546	0.334	0.318	0.326	0.009	0.010	0.010	0.006	0.009
1 L - 8	8	16:25:00	4,010	1,546	0.340	0.346	0.343	0.009	0.010	0.010	0.006	0.009
1 L - 9	1	16:35:00	4,510	1,739	0.496	0.513	0.505	0.010	0.011	0.010	0.007	0.010
1 L - 9	2	16:36:00	4,510	1,739	0.515	0.505	0.510	0.010	0.011	0.010	0.007	0.009
1 L - 9	4	16:38:00	4,510	1,739	0.521	0.520	0.521	0.010	0.011	0.010	0.007	0.009
1 L - 9	8	16:42:00	4,510	1,739	0.537	0.545	0.541	0.010	0.011	0.010	0.007	0.010
1 L - 10	1	16:55:00	4,980	1,920	0.761	0.748	0.755	0.011	0.011	0.010	0.007	0.010
1 L - 10	2	16:56:00	4,980	1,920	0.779	0.755	0.767	0.011	0.011	0.010	0.007	0.010
1 L - 10	4	16:58:00	4,980	1,920	0.783	0.784	0.784	0.010	0.011	0.011	0.007	0.010
1 L - 10	8	17:02:00	4,980	1,920	0.807	0.822	0.815	0.010	0.011	0.010	0.007	0.010
1 L - 11	1	17:18:00	5,350	2,063	1.227	1.233	1.230	0.012	0.012	0.011	0.008	0.011
1 L - 11	2	17:19:00	5,350	2,063	1.240	1.239	1.240	0.012	0.013	0.011	0.008	0.011
1 L - 11	4	17:21:00	5,350	2,063	1.264	1.262	1.263	0.012	0.014	0.010	0.008	0.011
1 L - 11	8	17:25:00	5,350	2,063	1.266	1.276	1.271	0.012	0.014	0.011	0.008	0.011
1 U - 1	1	17:27:30	4,460	1,720	1.245	1.260	1.253	0.011	0.014	0.010	0.007	0.010
1 U - 1	2	17:28:30	4,460	1,720	1.248	1.252	1.250	0.011	0.014	0.010	0.007	0.010
1 U - 1	3	17:29:30	4,460	1,720	1.249	1.249	1.249	0.011	0.014	0.010	0.007	0.011
1 U - 1	4	17:30:30	4,460	1,720	1.245	1.267	1.256	0.011	0.014	0.010	0.007	0.011
1 U - 2	1	17:33:00	3,380	1,304	1.180	1.184	1.182	0.009	0.014	0.009	0.006	0.009
1 U - 2	2	17:34:00	3,380	1,304	1.177	1.187	1.182	0.009	0.014	0.009	0.006	0.009
1 U - 2	3	17:35:00	3,380	1,304	1.179	1.200	1.190	0.009	0.014	0.008	0.006	0.009
1 U - 2	4	17:36:00	3,380	1,304	1.182	1.196	1.189	0.009	0.014	0.008	0.006	0.009
1 U - 3	1	17:39:00	2,340	903	1.032	1.046	1.039	0.007	0.014	0.007	0.004	0.008
1 U - 3	2	17:40:00	2,340	903	1.033	1.047	1.040	0.006	0.013	0.007	0.004	0.008
1 U - 3	3	17:41:00	2,340	903	1.034	1.042	1.038	0.006	0.013	0.007	0.004	0.008
1 U - 3	4	17:42:00	2,340	903	1.032	1.041	1.037	0.006	0.013	0.007	0.004	0.008
1 U - 4	1	17:45:00	1,290	498	0.760	0.776	0.768	0.004	0.013	0.004	0.002	0.006
1 U - 4	2	17:46:00	1,290	498	0.764	0.764	0.764	0.004	0.013	0.004	0.002	0.006
1 U - 4	3	17:47:00	1,290	498	0.753	0.767	0.760	0.004	0.013	0.004	0.002	0.006
1 U - 4	4	17:48:00	1,290	498	0.753	0.771	0.762	0.004	0.013	0.004	0.002	0.006
1 U - 5	1	17:51:00	0	0	0.480	0.481	0.481	0.002	0.013	0.002	0.001	0.004
1 U - 5	2	17:52:00	0	0	0.464	0.466	0.465	0.002	0.013	0.002	0.001	0.004
1 U - 5	4	17:54:00	0	0	0.462	0.462	0.462	0.002	0.013	0.001	0.001	0.004
1 U - 5	8	17:58:00	0	0	0.451	0.457	0.454	0.002	0.013	0.001	0.001	0.004

O-cell Expansion

TS-1 - Thompson River East - Thompson Falls, MT

Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell		O-cell Expansion						
			Pressure (psi)	Load (kips)	A-1422252 (in)	B-1422253 (in)	C-1422254 (in)	D-1422255 (in)	E-1422256 (in)	F-1422257 (in)	Average[1] (in)
1 L - 0	-	14:39:00	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1 L - 1	1	15:01:00	540	209	0.019	0.019	0.009	0.009	0.020	0.021	0.014
1 L - 1	2	15:02:00	540	209	0.019	0.019	0.009	0.010	0.021	0.021	0.014
1 L - 1	4	15:04:00	540	209	0.019	0.019	0.009	0.010	0.021	0.021	0.014
1 L - 1	8	15:08:00	540	209	0.019	0.019	0.009	0.009	0.021	0.021	0.014
1 L - 2	1	15:10:00	1,040	402	0.040	0.037	0.026	0.028	0.042	0.044	0.033
1 L - 2	2	15:11:00	1,040	402	0.041	0.039	0.027	0.030	0.044	0.046	0.034
1 L - 2	4	15:13:00	1,040	402	0.042	0.039	0.028	0.030	0.044	0.046	0.035
1 L - 2	8	15:17:00	1,040	402	0.046	0.043	0.031	0.035	0.048	0.050	0.039
1 L - 3	1	15:21:00	1,560	602	0.185	0.193	0.174	0.165	0.193	0.186	0.179
1 L - 3	2	15:22:00	1,560	602	0.192	0.200	0.181	0.171	0.200	0.192	0.186
1 L - 3	4	15:24:00	1,560	602	0.196	0.204	0.185	0.176	0.204	0.197	0.190
1 L - 3	8	15:28:00	1,560	602	0.201	0.209	0.190	0.180	0.209	0.202	0.195
1 L - 4	1	15:31:00	2,080	803	0.301	0.315	0.289	0.275	0.313	0.300	0.295
1 L - 4	2	15:32:00	2,080	803	0.311	0.326	0.300	0.284	0.324	0.310	0.305
1 L - 4	4	15:34:00	2,080	803	0.318	0.334	0.308	0.291	0.331	0.317	0.313
1 L - 4	8	15:38:00	2,080	803	0.323	0.338	0.312	0.296	0.336	0.321	0.317
1 L - 5	1	15:41:00	2,520	972	0.416	0.438	0.407	0.385	0.434	0.415	0.412
1 L - 5	2	15:42:00	2,520	972	0.422	0.444	0.414	0.391	0.440	0.420	0.418
1 L - 5	4	15:44:00	2,520	972	0.429	0.452	0.421	0.398	0.448	0.428	0.425
1 L - 5	8	15:48:00	2,520	972	0.438	0.461	0.430	0.406	0.457	0.436	0.434
1 L - 6	1	15:51:30	3,000	1,157	0.568	0.596	0.556	0.527	0.590	0.563	0.562
1 L - 6	2	15:52:30	3,000	1,157	0.577	0.606	0.565	0.536	0.599	0.572	0.571
1 L - 6	9	15:59:30	3,000	1,157	0.723	0.691	0.645	0.657	0.853	0.838	0.679
1 L - 6	13	16:03:30	3,000	1,157	0.747	0.717	0.668	0.679	0.896	0.882	0.703
1 L - 7	1	16:07:00	3,520	1,358	0.899	0.864	0.807	0.816	1.102	1.089	0.846
1 L - 7	2	16:08:00	3,520	1,358	0.913	0.877	0.819	0.828	1.120	1.108	0.859
1 L - 7	4	16:10:00	3,520	1,358	0.929	0.892	0.833	0.841	1.142	1.129	0.874
1 L - 7	8	16:14:00	3,520	1,358	0.946	0.907	0.847	0.855	1.164	1.151	0.889
1 L - 8	1	16:18:00	4,010	1,546	1.152	1.099	1.031	1.038	1.424	1.409	1.080
1 L - 8	2	16:19:00	4,010	1,546	1.174	1.120	1.049	1.058	1.452	1.436	1.100
1 L - 8	4	16:21:00	4,010	1,546	1.199	1.143	1.070	1.079	1.485	1.468	1.123
1 L - 8	8	16:25:00	4,010	1,546	1.228	1.168	1.094	1.103	1.521	1.503	1.148
1 L - 9	1	16:35:00	4,510	1,739	1.564	1.478	1.382	1.389	1.935	1.913	1.453
1 L - 9	2	16:36:00	4,510	1,739	1.590	1.501	1.404	1.409	1.967	1.944	1.476
1 L - 9	4	16:38:00	4,510	1,739	1.625	1.533	1.433	1.438	2.010	1.987	1.507
1 L - 9	8	16:42:00	4,510	1,739	1.666	1.570	1.466	1.473	2.061	2.038	1.544
1 L - 10	1	16:55:00	4,980	1,920	2.122	1.997	1.854	1.863	2.609	2.585	1.959
1 L - 10	2	16:56:00	4,980	1,920	2.142	2.016	1.872	1.880	2.641	2.612	1.978
1 L - 10	4	16:58:00	4,980	1,920	2.189	2.062	1.912	1.919	2.696	2.669	2.021
1 L - 10	8	17:02:00	4,980	1,920	2.253	2.121	1.965	1.972	2.773	2.745	2.078
1 L - 11	1	17:18:00	5,350	2,063	3.046	2.870	2.655	2.658	3.716	3.675	2.807
1 L - 11	2	17:19:00	5,350	2,063	3.085	2.920	2.687	2.688	3.787	3.729	2.845
1 L - 11	4	17:21:00	5,350	2,063	3.147	2.989	2.750	2.756	3.898	3.850	2.910
1 L - 11	8	17:25:00	5,350	2,063	3.191	3.032	2.793	2.800	3.980	3.926	2.954
1 U - 1	1	17:27:30	4,460	1,720	3.148	2.990	2.751	2.774	3.949	3.875	2.916
1 U - 1	2	17:28:30	4,460	1,720	3.147	2.990	2.750	2.774	3.949	3.875	2.915
1 U - 1	3	17:29:30	4,460	1,720	3.146	2.989	2.750	2.770	3.948	3.875	2.914
1 U - 1	4	17:30:30	4,460	1,720	3.146	2.989	2.750	2.770	3.948	3.875	2.914
1 U - 2	1	17:33:00	3,380	1,304	3.030	2.875	2.639	2.659	3.817	3.740	2.801
1 U - 2	2	17:34:00	3,380	1,304	3.029	2.874	2.638	2.656	3.816	3.739	2.799
1 U - 2	3	17:35:00	3,380	1,304	3.029	2.874	2.638	2.656	3.815	3.739	2.799
1 U - 2	4	17:36:00	3,380	1,304	3.028	2.874	2.637	2.656	3.815	3.739	2.799
1 U - 3	1	17:39:00	2,340	903	2.822	2.672	2.437	2.455	3.585	3.504	2.596
1 U - 3	2	17:40:00	2,340	903	2.822	2.672	2.437	2.455	3.585	3.504	2.596
1 U - 3	3	17:41:00	2,340	903	2.821	2.671	2.436	2.455	3.584	3.504	2.596
1 U - 3	4	17:42:00	2,340	903	2.821	2.671	2.436	2.455	3.585	3.504	2.596
1 U - 4	1	17:45:00	1,290	498	2.454	2.313	2.079	2.097	3.179	3.096	2.236
1 U - 4	2	17:46:00	1,290	498	2.453	2.313	2.078	2.097	3.178	3.096	2.235
1 U - 4	3	17:47:00	1,290	498	2.453	2.313	2.078	2.097	3.179	3.096	2.235
1 U - 4	4	17:48:00	1,290	498	2.453	2.312	2.077	2.097	3.179	3.096	2.235
1 U - 5	1	17:51:00	0	0	2.000	1.826	1.613	1.637	2.523	2.464	1.769
1 U - 5	2	17:52:00	0	0	1.988	1.816	1.604	1.631	2.511	2.455	1.760
1 U - 5	4	17:54:00	0	0	1.983	1.806	1.596	1.623	2.502	2.444	1.752
1 U - 5	8	17:58:00	0	0	1.973	1.798	1.589	1.612	2.494	2.437	1.743

1 Average expansion computed from gages A, B, C and D only due to symmetry.

O-cell Plate Movements and Creep (calculated)
TS-1 - Thompson River East - Thompson Falls, MT

Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell Pressure (psi)	O-cell Load (kips)	O-cell Net Load (kips)	Top of Shaft Movement (in)	Total Comp. (in)	Upward Movement (in)	O-cell Expansion (in)	Downward Movement (in)	Creep Up Per 8 Min. (in)	Creep Dn Per 8 Min. (in)
1 L - 0	-	14:39:00	0	0	0	0.000	0.000	0.000	0.000	0.000		
1 L - 1	1	15:01:00	540	209	0	0.001	0.000	0.001	0.014	-0.013		
1 L - 1	2	15:02:00	540	209	0	0.000	0.000	0.000	0.014	-0.014		
1 L - 1	4	15:04:00	540	209	0	-0.001	0.000	-0.001	0.014	-0.015		
1 L - 1	8	15:08:00	540	209	0	-0.001	0.000	-0.001	0.014	-0.015	0.000	0.000
1 L - 2	1	15:10:00	1,040	402	123	0.002	0.001	0.003	0.033	-0.030		
1 L - 2	2	15:11:00	1,040	402	123	0.005	0.001	0.006	0.034	-0.028		
1 L - 2	4	15:13:00	1,040	402	123	0.003	0.001	0.004	0.035	-0.031		
1 L - 2	8	15:17:00	1,040	402	123	0.006	0.001	0.007	0.039	-0.032	0.003	0.001
1 L - 3	1	15:21:00	1,560	602	323	0.030	0.002	0.032	0.179	-0.147		
1 L - 3	2	15:22:00	1,560	602	323	0.021	0.002	0.023	0.186	-0.163		
1 L - 3	4	15:24:00	1,560	602	323	0.024	0.002	0.026	0.190	-0.164		
1 L - 3	8	15:28:00	1,560	602	323	0.036	0.003	0.039	0.195	-0.156	0.013	-0.008
1 L - 4	1	15:31:00	2,080	803	524	0.043	0.004	0.047	0.295	-0.248		
1 L - 4	2	15:32:00	2,080	803	524	0.043	0.004	0.047	0.305	-0.258		
1 L - 4	4	15:34:00	2,080	803	524	0.057	0.004	0.061	0.313	-0.252		
1 L - 4	8	15:38:00	2,080	803	524	0.051	0.004	0.055	0.317	-0.262	0.000	0.010
1 L - 5	1	15:41:00	2,520	972	693	0.071	0.005	0.076	0.412	-0.336		
1 L - 5	2	15:42:00	2,520	972	693	0.074	0.005	0.079	0.418	-0.339		
1 L - 5	4	15:44:00	2,520	972	693	0.075	0.005	0.080	0.425	-0.345		
1 L - 5	8	15:48:00	2,520	972	693	0.074	0.005	0.079	0.434	-0.355	0.000	0.010
1 L - 6	1	15:51:30	3,000	1,157	878	0.120	0.007	0.127	0.562	-0.435		
1 L - 6	2	15:52:30	3,000	1,157	878	0.120	0.007	0.127	0.571	-0.444		
1 L - 6	9	15:59:30	3,000	1,157	878	0.133	0.007	0.140	0.679	-0.539		
1 L - 6	13	16:03:30	3,000	1,157	878	0.131	0.007	0.138	0.703	-0.565		
1 L - 7	1	16:07:00	3,520	1,358	1,079	0.201	0.008	0.209	0.846	-0.637		
1 L - 7	2	16:08:00	3,520	1,358	1,079	0.212	0.008	0.220	0.859	-0.639		
1 L - 7	4	16:10:00	3,520	1,358	1,079	0.205	0.008	0.213	0.874	-0.661		
1 L - 7	8	16:14:00	3,520	1,358	1,079	0.221	0.008	0.229	0.889	-0.660	0.016	-0.001
1 L - 8	1	16:18:00	4,010	1,546	1,267	0.317	0.009	0.326	1.080	-0.754		
1 L - 8	2	16:19:00	4,010	1,546	1,267	0.319	0.009	0.328	1.100	-0.772		
1 L - 8	4	16:21:00	4,010	1,546	1,267	0.326	0.009	0.335	1.123	-0.788		
1 L - 8	8	16:25:00	4,010	1,546	1,267	0.343	0.009	0.352	1.148	-0.796	0.017	0.008
1 L - 9	1	16:35:00	4,510	1,739	1,460	0.505	0.010	0.515	1.453	-0.938		
1 L - 9	2	16:36:00	4,510	1,739	1,460	0.510	0.009	0.519	1.476	-0.957		
1 L - 9	4	16:38:00	4,510	1,739	1,460	0.521	0.009	0.530	1.507	-0.977		
1 L - 9	8	16:42:00	4,510	1,739	1,460	0.541	0.010	0.551	1.544	-0.993	0.021	0.016
1 L - 10	1	16:55:00	4,980	1,920	1,641	0.755	0.010	0.765	1.959	-1.194		
1 L - 10	2	16:56:00	4,980	1,920	1,641	0.767	0.010	0.777	1.978	-1.201		
1 L - 10	4	16:58:00	4,980	1,920	1,641	0.784	0.010	0.794	2.021	-1.227		
1 L - 10	8	17:02:00	4,980	1,920	1,641	0.815	0.010	0.825	2.078	-1.253	0.031	0.026
1 L - 11	1	17:18:00	5,350	2,063	1,784	1.230	0.011	1.241	2.807	-1.566		
1 L - 11	2	17:19:00	5,350	2,063	1,784	1.240	0.011	1.251	2.845	-1.594		
1 L - 11	4	17:21:00	5,350	2,063	1,784	1.263	0.011	1.274	2.910	-1.636		
1 L - 11	8	17:25:00	5,350	2,063	1,784	1.271	0.011	1.282	2.954	-1.672	0.008	0.036
1 U - 1	1	17:27:30	4,460	1,720	1,441	1.253	0.010	1.263	2.916	-1.653		
1 U - 1	2	17:28:30	4,460	1,720	1,441	1.250	0.010	1.260	2.915	-1.655		
1 U - 1	3	17:29:30	4,460	1,720	1,441	1.249	0.011	1.260	2.914	-1.654		
1 U - 1	4	17:30:30	4,460	1,720	1,441	1.256	0.011	1.267	2.914	-1.647		
1 U - 2	1	17:33:00	3,380	1,304	1,025	1.182	0.009	1.191	2.801	-1.610		
1 U - 2	2	17:34:00	3,380	1,304	1,025	1.182	0.009	1.191	2.799	-1.608		
1 U - 2	3	17:35:00	3,380	1,304	1,025	1.190	0.009	1.199	2.799	-1.600		
1 U - 2	4	17:36:00	3,380	1,304	1,025	1.189	0.009	1.198	2.799	-1.601		
1 U - 3	1	17:39:00	2,340	903	624	1.039	0.008	1.047	2.596	-1.549		
1 U - 3	2	17:40:00	2,340	903	624	1.040	0.008	1.048	2.596	-1.548		
1 U - 3	3	17:41:00	2,340	903	624	1.038	0.008	1.046	2.596	-1.550		
1 U - 3	4	17:42:00	2,340	903	624	1.037	0.008	1.045	2.596	-1.551		
1 U - 4	1	17:45:00	1,290	498	219	0.768	0.006	0.774	2.236	-1.462		
1 U - 4	2	17:46:00	1,290	498	219	0.764	0.006	0.770	2.235	-1.465		
1 U - 4	3	17:47:00	1,290	498	219	0.760	0.006	0.766	2.235	-1.469		
1 U - 4	4	17:48:00	1,290	498	219	0.762	0.006	0.768	2.235	-1.467		
1 U - 5	1	17:51:00	0	0	0	0.481	0.004	0.485	1.769	-1.284		
1 U - 5	2	17:52:00	0	0	0	0.465	0.004	0.469	1.760	-1.291		
1 U - 5	4	17:54:00	0	0	0	0.462	0.004	0.466	1.752	-1.286		
1 U - 5	8	17:58:00	0	0	0	0.454	0.004	0.458	1.743	-1.285		

Strain Gage Readings and Loads at Level 1
TS-1 - Thompson River East - Thompson Falls, MT

Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell		Strain Gage Level 1					
			Pressure (psi)	Load (kips)	1A-1425562 (με)	1B-1425574 (με)	1C-1425575 (με)	1D-1425576 (με)	Av. Strain (με)	Load (kips)
1 L - 0	-	14:39:00	0	0	0.0	0.0	0.0	0.0	0.0	0
1 L - 1	1	15:01:00	540	209	1.0	1.8	0.9	0.0	0.9	33
1 L - 1	2	15:02:00	540	209	1.2	2.0	0.9	0.1	1.0	37
1 L - 1	4	15:04:00	540	209	1.1	2.0	0.8	0.1	1.0	35
1 L - 1	8	15:08:00	540	209	1.1	2.0	0.9	0.1	1.0	37
1 L - 2	1	15:10:00	1,040	402	2.6	3.3	1.7	1.3	2.2	79
1 L - 2	2	15:11:00	1,040	402	2.7	3.3	1.9	1.3	2.3	81
1 L - 2	4	15:13:00	1,040	402	2.7	3.3	2.1	1.3	2.4	84
1 L - 2	8	15:17:00	1,040	402	3.2	3.7	2.1	1.6	2.7	94
1 L - 3	1	15:21:00	1,560	602	8.3	10.5	7.9	5.5	8.1	284
1 L - 3	2	15:22:00	1,560	602	8.4	10.6	8.2	5.7	8.2	290
1 L - 3	4	15:24:00	1,560	602	8.4	10.7	8.2	5.7	8.2	290
1 L - 3	8	15:28:00	1,560	602	8.4	11.1	8.4	5.8	8.4	297
1 L - 4	1	15:31:00	2,080	803	12.0	15.2	12.0	8.2	11.9	418
1 L - 4	2	15:32:00	2,080	803	12.1	15.4	12.2	8.4	12.0	425
1 L - 4	4	15:34:00	2,080	803	12.0	15.6	12.4	8.4	12.1	426
1 L - 4	8	15:38:00	2,080	803	12.1	15.6	12.3	8.3	12.1	427
1 L - 5	1	15:41:00	2,520	972	14.9	19.1	15.8	10.7	15.1	533
1 L - 5	2	15:42:00	2,520	972	15.0	19.2	15.7	10.7	15.1	534
1 L - 5	4	15:44:00	2,520	972	15.2	19.4	15.8	10.8	15.3	540
1 L - 5	8	15:48:00	2,520	972	15.2	19.5	16.0	10.9	15.4	544
1 L - 6	1	15:51:30	3,000	1,157	18.9	23.6	18.9	13.2	18.7	659
1 L - 6	2	15:52:30	3,000	1,157	18.7	23.8	19.1	13.2	18.7	660
1 L - 6	9	15:59:30	3,000	1,157	17.6	22.9	21.1	14.7	19.1	673
1 L - 6	13	16:03:30	3,000	1,157	17.5	23.4	21.4	14.7	19.3	680
1 L - 7	1	16:07:00	3,520	1,358	19.8	26.3	24.8	17.3	22.0	777
1 L - 7	2	16:08:00	3,520	1,358	19.8	26.4	25.0	17.2	22.1	780
1 L - 7	4	16:10:00	3,520	1,358	20.0	26.5	25.3	17.3	22.3	785
1 L - 7	8	16:14:00	3,520	1,358	19.8	26.6	25.4	17.3	22.3	786
1 L - 8	1	16:18:00	4,010	1,546	22.3	29.4	28.4	19.7	24.9	880
1 L - 8	2	16:19:00	4,010	1,546	22.2	29.5	28.6	19.7	25.0	882
1 L - 8	4	16:21:00	4,010	1,546	22.4	29.8	28.8	19.7	25.2	888
1 L - 8	8	16:25:00	4,010	1,546	22.2	30.0	29.1	19.7	25.2	890
1 L - 9	1	16:35:00	4,510	1,739	24.8	32.8	32.0	22.2	27.9	986
1 L - 9	2	16:36:00	4,510	1,739	25.1	32.9	32.1	22.2	28.1	991
1 L - 9	4	16:38:00	4,510	1,739	24.8	33.0	32.0	22.3	28.0	988
1 L - 9	8	16:42:00	4,510	1,739	24.9	33.1	32.3	22.2	28.1	992
1 L - 10	1	16:55:00	4,980	1,920	27.9	36.0	34.7	24.3	30.7	1,083
1 L - 10	2	16:56:00	4,980	1,920	28.0	36.2	35.0	24.4	30.9	1,089
1 L - 10	4	16:58:00	4,980	1,920	28.1	36.4	35.0	24.7	31.1	1,096
1 L - 10	8	17:02:00	4,980	1,920	28.3	36.6	35.1	24.6	31.2	1,099
1 L - 11	1	17:18:00	5,350	2,063	31.9	40.8	39.1	27.2	34.7	1,226
1 L - 11	2	17:19:00	5,350	2,063	29.7	42.6	40.8	24.7	34.5	1,215
1 L - 11	4	17:21:00	5,350	2,063	33.6	42.0	35.8	24.6	34.0	1,199
1 L - 11	8	17:25:00	5,350	2,063	32.5	41.3	36.6	25.1	33.9	1,195
1 U - 1	1	17:27:30	4,460	1,720	28.2	38.6	34.1	20.8	30.4	1,073
1 U - 1	2	17:28:30	4,460	1,720	28.2	38.6	34.2	20.8	30.4	1,074
1 U - 1	3	17:29:30	4,460	1,720	28.1	38.6	34.3	20.9	30.5	1,075
1 U - 1	4	17:30:30	4,460	1,720	28.0	38.6	34.1	20.8	30.4	1,071
1 U - 2	1	17:33:00	3,380	1,304	21.1	33.3	29.5	14.6	24.6	869
1 U - 2	2	17:34:00	3,380	1,304	21.3	33.3	29.6	14.6	24.7	871
1 U - 2	3	17:35:00	3,380	1,304	21.2	33.3	29.5	14.7	24.7	870
1 U - 2	4	17:36:00	3,380	1,304	21.1	33.4	29.6	14.6	24.7	870
1 U - 3	1	17:39:00	2,340	903	14.3	27.2	23.9	8.7	18.5	654
1 U - 3	2	17:40:00	2,340	903	14.3	27.3	24.2	8.8	18.7	658
1 U - 3	3	17:41:00	2,340	903	14.5	27.3	24.3	8.9	18.7	661
1 U - 3	4	17:42:00	2,340	903	14.4	27.4	24.2	8.9	18.7	659
1 U - 4	1	17:45:00	1,290	498	8.1	20.3	17.9	3.4	12.4	438
1 U - 4	2	17:46:00	1,290	498	8.3	20.4	17.9	3.4	12.5	441
1 U - 4	3	17:47:00	1,290	498	8.2	20.3	18.0	3.4	12.5	440
1 U - 4	4	17:48:00	1,290	498	8.4	20.2	18.1	3.6	12.6	443
1 U - 5	1	17:51:00	0	0	4.5	11.7	7.9	-1.1	5.8	203
1 U - 5	2	17:52:00	0	0	4.7	11.7	7.9	-1.1	5.8	205
1 U - 5	4	17:54:00	0	0	4.5	11.4	7.8	-1.1	5.7	200
1 U - 5	8	17:58:00	0	0	4.6	11.2	7.9	-1.0	5.7	201

Strain Gage Readings and Loads at Level 2
TS-1 - Thompson River East - Thompson Falls, MT

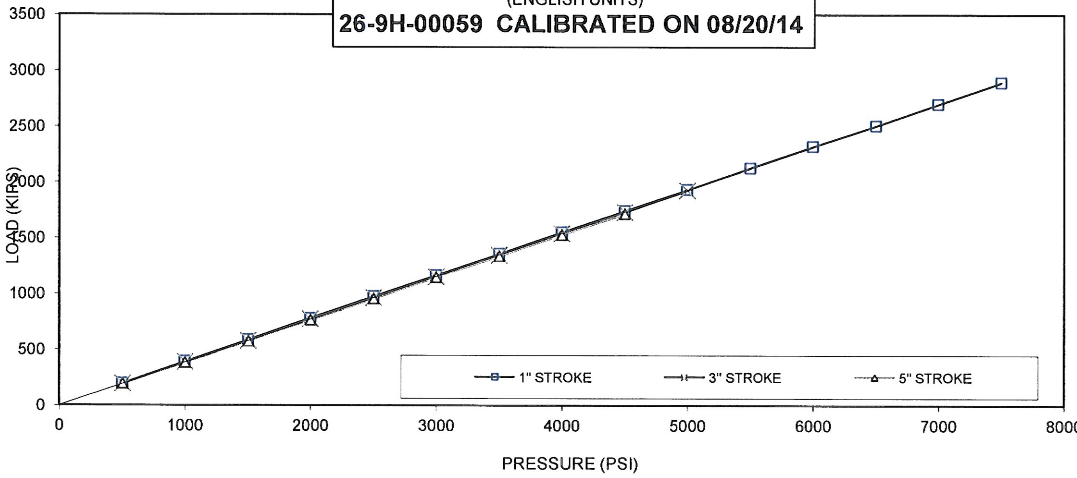
Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell Pressure (psi)	O-cell Load (kips)	Strain Gage Level 2 2A-1425577 (με)	2B-1425578 (με)	2C-1425579 (με)	2D-1425580 (με)	Av. Strain (με)	Load (kips)
1 L - 0	-	14:39:00	0	0	0.0	0.0	0.0	0.0	0.0	0
1 L - 1	1	15:01:00	540	209	0.7	1.4	0.6	0.0	0.7	24
1 L - 1	2	15:02:00	540	209	0.6	1.3	0.5	0.0	0.6	22
1 L - 1	4	15:04:00	540	209	0.6	1.4	0.7	0.0	0.7	24
1 L - 1	8	15:08:00	540	209	0.6	1.4	0.6	0.0	0.6	22
1 L - 2	1	15:10:00	1,040	402	1.9	2.4	1.3	0.8	1.6	56
1 L - 2	2	15:11:00	1,040	402	1.8	2.4	1.3	0.8	1.6	56
1 L - 2	4	15:13:00	1,040	402	1.6	2.4	1.5	0.8	1.6	55
1 L - 2	8	15:17:00	1,040	402	2.0	2.7	1.6	1.0	1.8	64
1 L - 3	1	15:21:00	1,560	602	6.1	8.5	5.9	3.7	6.1	214
1 L - 3	2	15:22:00	1,560	602	6.3	8.7	5.9	3.7	6.2	217
1 L - 3	4	15:24:00	1,560	602	6.3	8.9	6.0	3.7	6.2	219
1 L - 3	8	15:28:00	1,560	602	6.4	8.9	6.2	3.7	6.3	223
1 L - 4	1	15:31:00	2,080	803	8.9	12.5	9.0	5.5	9.0	317
1 L - 4	2	15:32:00	2,080	803	9.2	12.8	9.2	5.6	9.2	324
1 L - 4	4	15:34:00	2,080	803	9.3	13.0	9.2	5.6	9.3	327
1 L - 4	8	15:38:00	2,080	803	9.2	12.8	9.3	5.7	9.2	326
1 L - 5	1	15:41:00	2,520	972	11.2	15.7	11.9	7.5	11.6	408
1 L - 5	2	15:42:00	2,520	972	11.3	15.8	12.0	7.5	11.6	410
1 L - 5	4	15:44:00	2,520	972	11.4	15.8	12.0	7.5	11.7	412
1 L - 5	8	15:48:00	2,520	972	11.4	16.1	12.1	7.6	11.8	417
1 L - 6	1	15:51:30	3,000	1,157	14.0	19.1	14.5	9.3	14.2	502
1 L - 6	2	15:52:30	3,000	1,157	14.2	19.2	14.5	9.4	14.3	505
1 L - 6	9	15:59:30	3,000	1,157	13.0	18.4	16.3	10.8	14.6	516
1 L - 6	13	16:03:30	3,000	1,157	13.0	18.6	16.9	10.9	14.8	523
1 L - 7	1	16:07:00	3,520	1,358	14.4	20.7	19.5	13.0	16.9	597
1 L - 7	2	16:08:00	3,520	1,358	14.6	20.9	19.6	13.0	17.0	600
1 L - 7	4	16:10:00	3,520	1,358	14.3	20.9	19.6	13.0	17.0	598
1 L - 7	8	16:14:00	3,520	1,358	14.3	20.9	19.7	13.1	17.0	600
1 L - 8	1	16:18:00	4,010	1,546	16.1	23.2	22.1	15.0	19.1	673
1 L - 8	2	16:19:00	4,010	1,546	16.0	23.2	22.2	14.8	19.0	672
1 L - 8	4	16:21:00	4,010	1,546	16.1	23.2	22.3	14.8	19.1	674
1 L - 8	8	16:25:00	4,010	1,546	16.1	23.4	22.4	14.9	19.2	677
1 L - 9	1	16:35:00	4,510	1,739	18.1	25.5	24.6	16.7	21.2	749
1 L - 9	2	16:36:00	4,510	1,739	17.8	25.6	24.7	16.7	21.2	748
1 L - 9	4	16:38:00	4,510	1,739	18.0	25.6	24.7	16.6	21.2	749
1 L - 9	8	16:42:00	4,510	1,739	18.2	25.7	24.7	16.7	21.3	752
1 L - 10	1	16:55:00	4,980	1,920	20.0	27.9	26.2	18.0	23.0	813
1 L - 10	2	16:56:00	4,980	1,920	20.1	28.0	26.4	18.1	23.1	817
1 L - 10	4	16:58:00	4,980	1,920	20.1	28.1	26.5	18.2	23.2	820
1 L - 10	8	17:02:00	4,980	1,920	20.3	28.1	26.4	18.2	23.3	820
1 L - 11	1	17:18:00	5,350	2,063	22.8	30.9	28.7	20.0	25.6	903
1 L - 11	2	17:19:00	5,350	2,063	20.9	32.5	30.1	18.3	25.5	898
1 L - 11	4	17:21:00	5,350	2,063	24.3	32.0	26.1	17.8	25.0	883
1 L - 11	8	17:25:00	5,350	2,063	23.5	31.4	26.7	18.2	25.0	880
1 U - 1	1	17:27:30	4,460	1,720	20.3	29.6	25.1	15.5	22.6	797
1 U - 1	2	17:28:30	4,460	1,720	20.6	29.5	25.1	15.5	22.7	799
1 U - 1	3	17:29:30	4,460	1,720	20.3	29.5	25.1	15.5	22.6	798
1 U - 1	4	17:30:30	4,460	1,720	20.2	29.5	25.1	15.5	22.6	796
1 U - 2	1	17:33:00	3,380	1,304	15.4	25.8	22.2	11.2	18.7	659
1 U - 2	2	17:34:00	3,380	1,304	15.2	25.8	22.2	11.2	18.6	657
1 U - 2	3	17:35:00	3,380	1,304	15.3	25.8	22.2	11.2	18.7	658
1 U - 2	4	17:36:00	3,380	1,304	15.1	26.0	22.3	11.2	18.6	657
1 U - 3	1	17:39:00	2,340	903	10.0	21.5	18.7	6.6	14.2	501
1 U - 3	2	17:40:00	2,340	903	10.3	21.5	18.8	6.7	14.3	505
1 U - 3	3	17:41:00	2,340	903	10.3	21.6	18.8	6.7	14.3	506
1 U - 3	4	17:42:00	2,340	903	10.2	21.7	18.9	6.7	14.3	506
1 U - 4	1	17:45:00	1,290	498	5.1	16.3	14.3	2.3	9.5	336
1 U - 4	2	17:46:00	1,290	498	5.2	16.3	14.4	2.5	9.6	338
1 U - 4	3	17:47:00	1,290	498	5.1	16.4	14.5	2.5	9.7	341
1 U - 4	4	17:48:00	1,290	498	5.2	16.4	14.5	2.6	9.7	342
1 U - 5	1	17:51:00	0	0	2.9	9.5	6.6	-1.0	4.5	158
1 U - 5	2	17:52:00	0	0	2.8	9.4	6.7	-1.0	4.5	158
1 U - 5	4	17:54:00	0	0	2.6	9.3	6.7	-0.9	4.4	156
1 U - 5	8	17:58:00	0	0	2.7	9.1	6.7	-0.8	4.4	156

Strain Gage Readings and Loads at Level 3
TS-1 - Thompson River East - Thompson Falls, MT

Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell Pressure (psi)	O-cell Load (kips)	Strain Gage Level 3 3A-1425581 (με)	3B-1425582 (με)	3C-1425583 (με)	3D-1425584 (με)	Av. Strain (με)	Load (kips)
1 L - 0	-	14:39:00	0	0	0.0	0.0	0.0	0.0	0.0	0
1 L - 1	1	15:01:00	540	209	0.5	1.4	0.5	0.2	0.7	26
1 L - 1	2	15:02:00	540	209	0.6	1.7	0.5	0.3	0.7	29
1 L - 1	4	15:04:00	540	209	0.5	1.5	0.4	0.2	0.7	26
1 L - 1	8	15:08:00	540	209	0.5	1.5	0.5	-0.1	0.6	24
1 L - 2	1	15:10:00	1,040	402	1.1	2.5	1.1	0.5	1.3	52
1 L - 2	2	15:11:00	1,040	402	1.1	2.5	1.1	0.7	1.3	53
1 L - 2	4	15:13:00	1,040	402	1.1	2.7	1.1	0.7	1.4	56
1 L - 2	8	15:17:00	1,040	402	1.2	2.6	1.2	0.8	1.5	59
1 L - 3	1	15:21:00	1,560	602	4.3	9.3	4.4	2.5	5.1	202
1 L - 3	2	15:22:00	1,560	602	4.4	9.5	4.3	2.8	5.3	208
1 L - 3	4	15:24:00	1,560	602	4.4	9.8	4.4	2.8	5.3	211
1 L - 3	8	15:28:00	1,560	602	4.5	9.5	4.5	2.9	5.3	211
1 L - 4	1	15:31:00	2,080	803	6.4	13.8	6.6	4.1	7.7	306
1 L - 4	2	15:32:00	2,080	803	6.6	14.3	7.0	4.0	8.0	316
1 L - 4	4	15:34:00	2,080	803	6.6	14.3	7.1	4.1	8.0	317
1 L - 4	8	15:38:00	2,080	803	6.6	14.1	7.0	4.0	7.9	314
1 L - 5	1	15:41:00	2,520	972	8.2	17.6	8.9	5.6	10.1	398
1 L - 5	2	15:42:00	2,520	972	8.1	17.4	8.9	5.5	9.9	394
1 L - 5	4	15:44:00	2,520	972	8.2	17.4	8.9	5.5	10.0	396
1 L - 5	8	15:48:00	2,520	972	8.2	17.5	8.9	5.7	10.1	399
1 L - 6	1	15:51:30	3,000	1,157	9.8	21.3	10.5	6.9	12.1	480
1 L - 6	2	15:52:30	3,000	1,157	9.9	20.9	10.5	6.7	12.0	475
1 L - 6	9	15:59:30	3,000	1,157	9.5	20.1	11.4	7.4	12.1	478
1 L - 6	13	16:03:30	3,000	1,157	9.5	20.5	11.6	7.6	12.3	486
1 L - 7	1	16:07:00	3,520	1,358	10.3	22.2	12.9	8.6	13.5	535
1 L - 7	2	16:08:00	3,520	1,358	10.4	22.7	13.0	8.5	13.7	541
1 L - 7	4	16:10:00	3,520	1,358	10.3	22.7	12.9	8.5	13.6	539
1 L - 7	8	16:14:00	3,520	1,358	10.6	22.4	13.0	8.7	13.7	541
1 L - 8	1	16:18:00	4,010	1,546	11.5	25.1	14.2	9.4	15.0	595
1 L - 8	2	16:19:00	4,010	1,546	11.5	24.8	14.3	9.4	15.0	595
1 L - 8	4	16:21:00	4,010	1,546	11.4	24.7	13.9	9.3	14.8	587
1 L - 8	8	16:25:00	4,010	1,546	11.4	24.5	14.2	9.2	14.8	587
1 L - 9	1	16:35:00	4,510	1,739	12.6	26.8	15.0	10.1	16.1	638
1 L - 9	2	16:36:00	4,510	1,739	12.5	26.8	14.9	10.0	16.0	635
1 L - 9	4	16:38:00	4,510	1,739	12.5	26.7	14.8	9.9	16.0	632
1 L - 9	8	16:42:00	4,510	1,739	12.6	27.0	15.1	9.9	16.1	638
1 L - 10	1	16:55:00	4,980	1,920	13.6	28.6	15.3	10.3	17.0	671
1 L - 10	2	16:56:00	4,980	1,920	13.7	28.8	15.3	10.2	17.0	673
1 L - 10	4	16:58:00	4,980	1,920	13.7	29.0	15.6	10.3	17.2	679
1 L - 10	8	17:02:00	4,980	1,920	13.8	28.9	15.3	10.2	17.0	674
1 L - 11	1	17:18:00	5,350	2,063	15.1	31.3	16.0	11.0	18.3	726
1 L - 11	2	17:19:00	5,350	2,063	14.5	32.3	16.7	10.0	18.4	727
1 L - 11	4	17:21:00	5,350	2,063	15.6	31.4	14.9	9.8	17.9	710
1 L - 11	8	17:25:00	5,350	2,063	15.2	31.4	15.3	10.2	18.0	714
1 U - 1	1	17:27:30	4,460	1,720	13.9	30.0	14.6	9.2	16.9	670
1 U - 1	2	17:28:30	4,460	1,720	14.2	29.9	14.6	9.2	17.0	671
1 U - 1	3	17:29:30	4,460	1,720	14.0	30.1	14.5	9.3	17.0	671
1 U - 1	4	17:30:30	4,460	1,720	14.1	30.0	14.5	9.3	17.0	672
1 U - 2	1	17:33:00	3,380	1,304	11.9	27.1	13.4	7.7	15.0	595
1 U - 2	2	17:34:00	3,380	1,304	11.9	27.2	13.2	7.9	15.0	595
1 U - 2	3	17:35:00	3,380	1,304	11.9	27.1	13.2	7.8	15.0	594
1 U - 2	4	17:36:00	3,380	1,304	11.9	27.3	13.3	7.9	15.1	598
1 U - 3	1	17:39:00	2,340	903	9.2	22.9	11.6	6.1	12.4	492
1 U - 3	2	17:40:00	2,340	903	9.2	22.7	11.7	6.4	12.5	495
1 U - 3	3	17:41:00	2,340	903	9.2	22.9	11.7	6.1	12.5	494
1 U - 3	4	17:42:00	2,340	903	9.4	22.9	11.5	6.3	12.5	496
1 U - 4	1	17:45:00	1,290	498	6.0	16.9	8.7	3.8	8.8	350
1 U - 4	2	17:46:00	1,290	498	6.0	17.0	8.9	3.9	9.0	354
1 U - 4	3	17:47:00	1,290	498	6.0	17.0	8.9	4.2	9.0	357
1 U - 4	4	17:48:00	1,290	498	6.1	17.2	9.1	4.0	9.1	360
1 U - 5	1	17:51:00	0	0	3.8	9.3	3.5	1.5	4.5	179
1 U - 5	2	17:52:00	0	0	3.8	9.2	3.3	1.5	4.5	177
1 U - 5	4	17:54:00	0	0	3.8	9.0	3.4	1.5	4.4	175
1 U - 5	8	17:58:00	0	0	3.6	8.5	3.6	1.5	4.3	170

APPENDIX B

O-CELL AND INSTRUMENTATION CALIBRATION SHEETS



26" O-CELL, SERIAL # 26-9H-00059

STROKE:	1 INCH	3 INCH	5 INCH
PRESSURE PSI	LOAD KIPS	LOAD KIPS	LOAD KIPS
0	0	0	0
500	196	196	194
1000	391	389	383
1500	587	579	575
2000	780	774	764
2500	975	964	955
3000	1165	1153	1148
3500	1358	1348	1337
4000	1551	1540	1529
4500	1743	1730	1718
5000	1933	1927	
5500	2127		
6000	2319		
6500	2506		
7000	2701		
7500	2895		

LOAD CONVERSION FORMULA

LOAD = PRESSURE * 0.3854 + (0.95)
{KIPS} {PSI}

Regression Output:

Constant	0.9484 kips
X Coefficient	0.3854 kip / psi
R Square	0.9999
No. of Observations	34
Degrees of Freedom	32
Std Err of Y Est	7.23
Std Err of X Coeff	0.0007

CALIBRATION STANDARDS:

All data presented are derived from 6" dia. certified hydraulic pressure gauges and electronic load transducer, manufactured and calibrated by the University of Illinois at Champaign, Illinois. All calibrations and certifications are traceable through the Laboratory Master Deadweight Gauges directly to the National Institute of Standards and Technology. No specific guidelines exist for calibration of load test jacks and equipment but procedures comply with similar guidelines for calibration of gages, ANSI specifications B40.1.

* AE & FC CUSTOMER: LOADTEST INC.
* AE & FC JOB NO: SO12823
* CUSTOMER P.O. NO.: LT-1074-1

* CONTRACTOR.: SLETTEN CONST. CO.
* JOB LOCATION: GREAT FALLS, MT
* DATED: 08/20/14

SERVICE ENGINEER: [signature] DATE: 8-20-14

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 15, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425562

Cable Length: 80 feet

Prestress: 35,000 psi

Regression Zero: 6967

Temperature: 22.6 °C

Technician:

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7029	7027	7028		
1500	7667	7668	7668	640	-0.37
3000	8376	8378	8377	709	-0.43
4500	9097	9102	9100	723	-0.03
6000	9816	9823	9820	720	0.28
100	7029	7030	7030		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.353 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425674

Cable Length: 80 feet

Prestress: 35,000 psi

Regression Zero: 6995

Temperature: 21.7 °C

Technician:

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7043	7048	7046		
1500	7694	7698	7696	650	-0.09
3000	8399	8400	8400	704	-0.09
4500	9107	9110	9109	709	0.10
6000	9809	9811	9810	701	0.03
100	7047	7049	7048		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.356 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425675

Cable Length: 80 feet

Prestress: 35,000 psi

Regression Zero: 7065

Temperature: 21.7 °C

Technician:

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7111	7112	7112		
1500	7765	7765	7765	653	0.00
3000	8465	8464	8465	700	-0.01
4500	9165	9168	9167	702	0.07
6000	9864	9863	9864	697	-0.04
100	7113	7111	7112		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.358 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425676

Cable Length: 80 feet

Prestress: 35,000 psi

Regression Zero: 6962

Temperature: 21.7 °C

Technician: [signature]

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7014	7014	7014		
1500	7675	7674	7675	661	-0.11
3000	8391	8387	8389	714	-0.16
4500	9111	9110	9111	722	0.04
6000	9826	9828	9827	716	0.07
100	7015	7014	7015		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.352 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425677

Cable Length: 60 feet

Prestress: 35,000 psi

Regression Zero: 7036

Temperature: 21.7 °C

Technician:

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7084	7088	7086		
1500	7747	7747	7747	661	-0.11
3000	8459	8461	8460	713	-0.16
4500	9185	9187	9186	726	0.25
6000	9889	9891	9890	704	-0.11
100	7088	7089	7089		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.352 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425678

Cable Length: 60 feet

Prestress: 35,000 psi

Regression Zero: 6780

Temperature: 21.7 °C

Technician: [signature]

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	6827	6821	6824		
1500	7478	7479	7479	655	0.05
3000	8182	8174	8178	699	0.13
4500	8877	8871	8874	696	0.08
6000	9568	9564	9566	692	-0.11
100	6822	6819	6821		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.359 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425679

Cable Length: 60 feet

Prestress: 35,000 psi

Regression Zero: 6825

Temperature: 21.7 °C

Technician: [signature]

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	6874	6873	6874		
1500	7538	7536	7537	663	-0.11
3000	8258	8254	8256	719	0.02
4500	8974	8978	8976	720	0.18
6000	9682	9683	9683	707	-0.12
100	6873	6868	6871		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.352 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425680

Cable Length: 60 feet

Prestress: 35,000 psi

Regression Zero: 6746

Temperature: 21.7 °C

Technician: [signature]

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	6792	6791	6792		
1500	7450	7449	7450	658	0.00
3000	8155	8153	8154	704	0.04
4500	8862	8856	8859	705	0.10
6000	9559	9555	9557	698	-0.10
100	6791	6792	6792		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.356 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425681

Cable Length: 40 feet

Prestress: 35,000 psi

Regression Zero: 6965

Temperature: 21.7 °C

Technician: [signature]

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7016	7015	7016		
1500	7676	7673	7675	659	-0.07
3000	8383	8384	8384	709	-0.15
4500	9107	9102	9105	721	0.18
6000	9810	9810	9810	705	-0.02
100	7016	7017	7017		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.353 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425682

Cable Length: 40 feet

Prestress: 35,000 psi

Regression Zero: 7156

Temperature: 21.7 °C

Technician:

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7210	7205	7208		
1500	7853	7853	7853	645	-0.15
3000	8555	8554	8555	702	-0.15
4500	9266	9265	9266	711	0.19
6000	9961	9961	9961	695	-0.01
100	7205	7205	7205		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.357 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425683

Cable Length: 40 feet

Prestress: 35,000 psi

Regression Zero: 7093

Temperature: 21.7 °C

Technician: [signature]

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7149	7150	7150		
1500	7806	7809	7808	658	-0.03
3000	8509	8504	8507	699	-0.60
4500	9245	9245	9245	738	0.21
6000	9959	9959	9959	714	0.17
100	7150	7151	7151		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.352 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

48 Spencer St. Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: August 18, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1425684

Cable Length: 40 feet

Prestress: 35,000 psi

Regression Zero: 7141

Temperature: 21.7 °C

Technician:

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7191	7189	7190		
1500	7839	7839	7839	649	-0.04
3000	8536	8534	8535	696	-0.15
4500	9242	9240	9241	706	0.10
6000	9938	9937	9938	697	0.01
100	7189	7192	7191		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.358 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 230 mm

Serial Number: 1422252

Calibration Instruction: CI-4400

Cable Length: 90 feet

Calibration Date: July 10, 2014

This calibration has been verified/validated as of 08/22/2014

Temperature: 23.4 °C

Technician: [signature]

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement Linear	Error Linear (%FS)	Calculated Displacement Polynomial	Error Polynomial (%FS)
0.0	2687	2686	2687	-0.45	-0.19	0.05	0.02
46.0	3673	3673	3673	45.98	-0.01	45.90	-0.04
92.0	4659	4658	4659	92.36	0.16	92.00	0.00
138.0	5638	5637	5638	138.44	0.19	138.08	0.03
184.0	6607	6607	6607	184.06	0.03	183.99	0.00
230.0	7572	7572	7572	229.48	-0.23	229.98	-0.01

(mm) Linear Gage Factor (G): 0.04706 (mm/ digit) **Regression Zero: 2696**

Polynomial Gage Factors: A: 1.509E-07 B: 0.04552 C: ________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gage Factor (G): 0.001853 (inches/digit)

Polynomial Gage Factors: A: 5.9409E-09 B: 0.001792 C: ________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 230 mm

Serial Number: 1422253

Calibration Instruction: CI-4400

Cable Length: 90 feet

Calibration Date: July 10, 2014

This calibration has been verified/validated as of 08/22/2014

Temperature: 23.4 °C

Technician: [signature]

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement Linear	Error Linear (%FS)	Calculated Displacement Polynomial	Error Polynomial (%FS)
0.0	2543	2543	2543	-0.23	-0.10	0.24	0.10
46.0	3523	3524	3524	45.64	-0.16	45.54	-0.20
92.0	4525	4523	4524	92.45	0.20	92.06	0.03
138.0	5510	5510	5510	138.58	0.25	138.20	0.09
184.0	6484	6484	6484	184.16	0.07	184.06	0.03
230.0	7451	7452	7452	229.42	-0.25	229.89	-0.05

(mm) Linear Gage Factor (G): 0.04679 (mm/ digit) **Regression Zero: 2548**

Polynomial Gage Factors: A: 1.483E-07 B: 0.04531 C: ______

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gage Factor (G): 0.001842 (inches/digit)

Polynomial Gage Factors: A: 5.8386E-09 B: 0.001784 C: ______

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 230 mm

Calibration Date: July 10, 2014

This calibration has been verified/validated as of 08/22/2014

Serial Number: 1422254

Temperature: 23.4 °C

Calibration Instruction: CI-4400

Technician: [signature]

Cable Length: 90 feet

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement Linear	Error Linear (%FS)	Calculated Displacement Polynomial	Error Polynomial (%FS)
0.0	2606	2606	2606	-0.43	-0.19	-0.04	-0.02
46.0	3589	3590	3590	46.17	0.08	46.08	0.04
92.0	4562	4564	4563	92.30	0.13	91.98	-0.01
138.0	5533	5535	5534	138.31	0.13	137.99	-0.01
184.0	6500	6499	6500	184.06	0.02	183.97	-0.01
230.0	7462	7461	7462	229.64	-0.16	230.02	0.01

(mm) Linear Gage Factor (G): 0.04738 (mm/ digit)

Regression Zero: 2615

Polynomial Gage Factors: A: 1.2525E-07 B: 0.04612 C: ________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gage Factor (G): 0.001865 (inches/digit)

Polynomial Gage Factors: A: 4.9311E-09 B: 0.001816 C: ________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement:

Linear, $D = G(R_1 - R_0)$

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 230 mm

Serial Number: 1422255

Calibration Instruction: CI-4400

Cable Length: 90 feet

Calibration Date: July 10, 2014

This calibration has been verified/validated as of 08/22/2014

Temperature: 23.4 °C

Technician: [signature]

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement Linear	Error Linear (%FS)	Calculated Displacement Polynomial	Error Polynomial (%FS)
0.0	2580	2581	2581	-0.45	-0.19	-0.01	0.00
46.0	3570	3569	3570	46.10	0.04	46.01	0.00
92.0	4552	4553	4553	92.37	0.16	92.01	0.01
138.0	5530	5529	5530	138.36	0.16	138.00	0.00
184.0	6501	6500	6501	184.06	0.03	183.97	-0.01
230.0	7468	7467	7468	229.58	-0.18	230.01	0.01

(mm) Linear Gage Factor (G): 0.04707 (mm/ digit) **Regression Zero: 2590**

Polynomial Gage Factors: A: 1.3904E-07 B: 0.04567 C: ______

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gage Factor (G): 0.001853 (inches/digit)

Polynomial Gage Factors: A: 5.4741E-09 B: 0.001798 C: ______

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 230 mm

Serial Number: 1422256

Calibration Instruction: CI-4400

Cable Length: 90 feet

Calibration Date: July 10, 2014

This calibration has been verified/validated as of 08/22/2014

Temperature: 23.4 °C

Technician: [signature]

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement Linear	Error Linear (%FS)	Calculated Displacement Polynomial	Error Polynomial (%FS)
0.0	2607	2611	2609	-0.33	-0.14	0.07	0.03
46.0	3586	3588	3587	45.96	-0.02	45.88	-0.05
92.0	4566	4565	4566	92.28	0.12	91.96	-0.02
138.0	5540	5540	5540	138.40	0.17	138.09	0.04
184.0	6506	6506	6506	184.12	0.05	184.05	0.02
230.0	7465	7466	7466	229.54	-0.20	229.95	-0.02

(mm) Linear Gage Factor (G): 0.04733 (mm/ digit) **Regression Zero: 2616**

Polynomial Gage Factors: A: 1.2755E-07 B: 0.04605 C: ________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gage Factor (G): 0.001863 (inches/digit)

Polynomial Gage Factors: A: 5.0218E-09 B: 0.001813 C: ________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 230 mm

Serial Number: 1422257

Calibration Instruction: CI-4400

Cable Length: 90 feet

Calibration Date: July 10, 2014

This calibration has been verified/validated as of 08/22/2014

Temperature: 23.4 °C

Technician:

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement Linear	Error Linear (%FS)	Calculated Displacement Polynomial	Error Polynomial (%FS)
0.0	2611	2610	2611	-0.40	-0.17	0.06	0.03
46.0	3594	3595	3595	45.99	0.00	45.89	-0.05
92.0	4578	4578	4578	92.36	0.16	91.99	0.00
138.0	5556	5555	5556	138.45	0.20	138.08	0.04
184.0	6524	6523	6524	184.09	0.04	184.00	0.00
230.0	7487	7487	7487	229.52	-0.21	229.98	-0.01

(mm) Linear Gage Factor (G): 0.04715 (mm/ digit) **Regression Zero: 2619**

Polynomial Gage Factors: A: 1.4553E-07 B: 0.04568 C: ________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gage Factor (G): 0.001856 (inches/digit)

Polynomial Gage Factors: A: 5.7294E-09 B: 0.001798 C: ________

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

APPENDIX C

CONSTRUCTION OF THE EQUIVALENT TOP LOAD-DISPLACEMENT CURVE

CONSTRUCTION OF THE LOADTEST TOP LOAD PLOT FROM THE RESULTS OF AN O-CELL TEST (March, 2009)

Introduction: Some engineers find it useful to see the results of an O-cell load test in the form of a curve showing the load versus settlement of a top-loaded driven or bored pile (drilled shaft). We believe that an O-cell test can provide a good estimate of this curve when using the method described herein.

Assumptions: We make the following assumptions, which we consider both reasonable and usually conservative:

1. The upward and downward load displacement plots generated by the O-cell test accurately represent the load bearing capacity for the given pile installation technique and dimensions, and are similar to load displacement plots which would be generated by a traditional compression or tension load test. For upward O-cell loading, the net load is used to compute the load displacement plot for a given zone (subtract buoyant weight of the given pile zone above the O-cell).

2. The load displacement plot in a top loaded pile has the same net shear multiplied by an adjustment factor 'F', for a given downward displacement as occurred in the O-cell test for that same displacement at the top of the O-cell in the upward direction. Unless noted otherwise, we use the following adjustment factors: (a) F = 1.00 in all rock sockets and for primarily cohesive soils in compression (b) F = 0.95 in primarily cohesionless soils (c) F = 0.80 for all soils in top load tension tests.

t-z Method: Using the separate pile section data generated by the O-cell load test method to full benefit, a solution of the calculated top load displacement plot can be derived using the t-z method (see references below). The pile is sub-divided into a number of distinct zones, based on data collected from the embedded strain gauges and load displacement plots. The input for the t-z analysis is the unit shear and end bearing plots presented in Figures 6 to 8 of the Data Report.

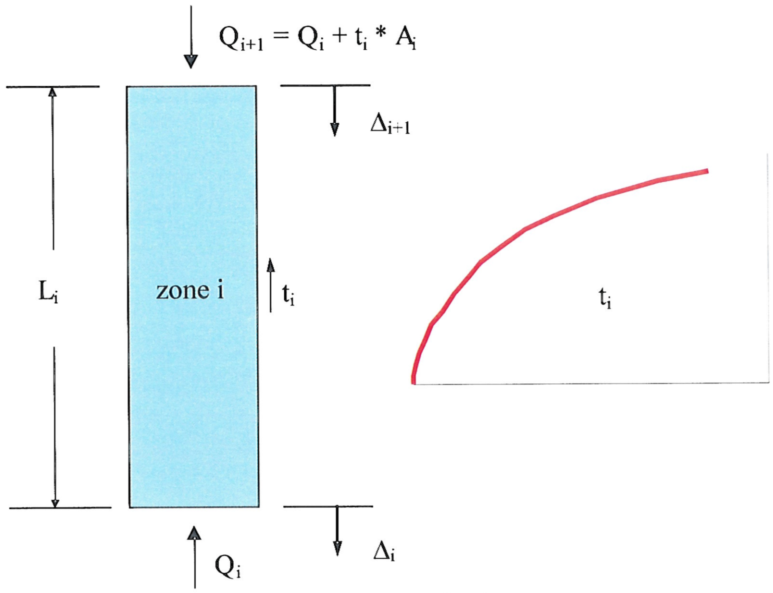


Figure C- 1

Figure C-1 above illustrates a sample pile segment zone. The zone has an associated unit shear capacity plot t_i (which is a non-linear function of displacement), pile dimensions and properties L_i and AE_i, computed elastic compression δ_i, and computed loads and displacements at the top and bottom of the zone, Δ_i, Q_i and Δ_{i+1}, Q_{i+1}, respectively. For each zone i, the following three equations are solved in an iterative fashion until the output displacement and load Δ_{i+1} and Q_{i+1} match the input.

I) $\delta_i = \frac{(Q_i + Q_{i+1})}{2} \cdot \frac{L_i}{AE_i}$ II) $\Delta_{i+1} = \Delta_i + \delta_i$ III) $Q_{i+1} = Q_i + t\left(\frac{\Delta_i + \Delta_{i+1}}{2}\right) \cdot A_i$

The next zone i+1 is then analyzed, until the load transfer mechanism of the full pile length is modeled. Additionally, there is an end-bearing capacity plot q-z which must also be considered.

References:

Lee, Jong-Sub and Park, Yung-Ho "Equivalent Pile Load-Head Settlement Curve Using a Bi-Directional Pile Load Test", *Computers and Geotechnics*, Volume 35, Issue 2, March 2008, Pages 124-133.

Meyer, P. L., Holmquist, D. V. and Matlock, H. "Computer predictions for axially-loaded Piles with Non-linear Supports", *Proceedings of the 7th Offshore Technology Conference*, Paper No. 2186, Houston, Texas 1975.

APPENDIX D

O-CELL METHOD FOR DETERMINING CREEP LIMIT LOADING

O-CELL METHOD FOR DETERMINING A CREEP LIMIT LOADING ON THE EQUIVALENT TOP-LOADED SHAFT (September, 2000)

Background: O-cell testing provides a sometimes useful method for evaluating that load beyond which a top-loaded drilled shaft might experience significant unwanted creep behavior. We refer to this load as the "creep limit," also sometimes known as the "yield limit" or "yield load".

To our knowledge, Housel (1959) first proposed the method described below for determining the creep limit. Stoll (1961), Bourges and Levillian (1988), and Fellenius (1996) provide additional references. This method also follows from long experience with the pressuremeter test (PMT). Figure 8 and section 9.4 from ASTM D4719-94, reproduced below, show and describe the creep curve routinely determined from the PMT. The creep curve shows how the movement or strain obtained over a fixed time interval, 30 to 60 seconds, changes versus the applied pressure. One can often detect a distinct break in the curve at the pressure P_e in Figure 8. Plastic deformations may become significant beyond this break loading and progressively more severe creep can occur.

Definition: Similarly with O-cell testing using the ASTM Quick Method, one can conveniently measure the additional movement occurring over the final time interval at each constant load step, typically 2 to 4 minutes. A break in the curve of load vs. movement (as at P_e with the PMT) indicates the creep limit.

We usually indicate such a creep limit in the O-cell test for either one, or both, of the side shear and end bearing components, and herein designate the corresponding movements as M_{CL1} and M_{CL2}. We then combine the creep limit data to predict a creep limit load for the equivalent top loaded shaft.

Procedure if both M_{CL1} and M_{CL2} available: Creep cannot begin until the shaft movement exceeds the M_{CL} values. A conservative approach would assume that creep begins when movements exceed the lesser of the M_{CL} values. However, creep can occur freely only when the shaft has moved the greater of the two M_{CL} values. Although less conservative, we believe the latter to match behavior better and therefore set the creep limit as that load on the equivalent top-loaded movement curve that matches the greater M_{CL}.

Procedure if only M_{CL1} available: If we cannot determine a creep limit in the second component before it reaches its maximum movement M_x, we treat M_x as M_{CL2}. From the above method one can say that the creep limit load exceeds, by some unknown amount, that obtained when using $M_{CL2} = M_x$.

Procedure if no creep limit observed: Then, according to the above, the creep limit for the equivalent top-loaded shaft will exceed, again by some unknown amount, that load on the equivalent curve that matches the movement of the component with the maximum movement.

Limitations: The accuracy in estimating creep limits depends, in part, on the scatter of the data in the creep limit plots. The more scatter, the more difficult to define a limit. The user should make his or her own interpretation if he or she intends to make important use of the creep limit interpretations. Sometimes we obtain excessive scatter of the data and do not attempt an interpretation for a creep limit and will indicate this in the report.

Excerpts from ASTM D4719
"Standard Test Method for Pressuremeter Testing in Soils"

9.4 For Procedure A, plot the volume increase readings (V_{60}) between the 30 s and 60 s reading on a separate graph. Generally, a part of the same graph is used, see Fig. 8. For Procedure B, plot the pressure decrease reading between the 30 s and 60 s reading on a separate graph. The test curve shows an almost straight line section within the range of either low volume increase readings (V_{60}) for Procedure A or low pressure decrease for Procedure B. In this range, a constant soil deformation modulus can be measured. Past the so-called creep pressure, plastic deformations become prevalent.

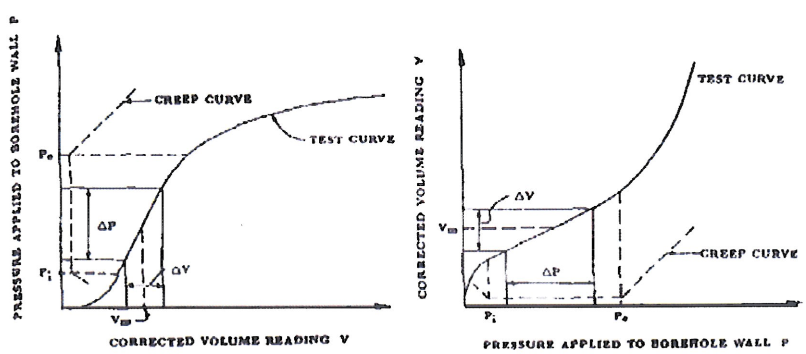


FIG. 8 Pressuremeter Test Curves for Procedure A

References

Housel, W.S. (1959), "Dynamic & Static Resistance of Cohesive Soils", ASTM STP 254, pp. 22-23.

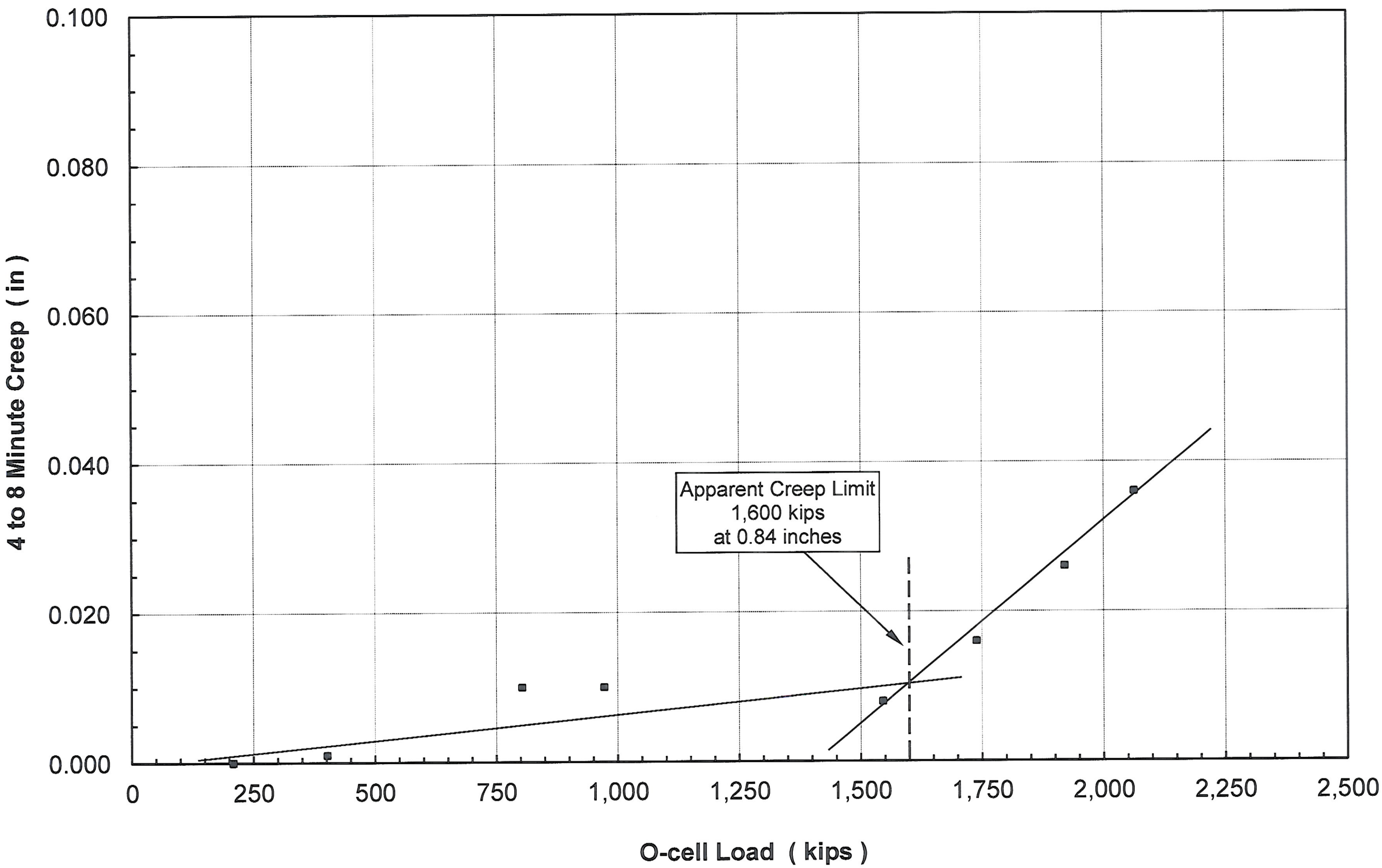
Stoll, M.U.W. (1961, Discussion, Proc. 5th ICSMFE, Paris, Vol. III, pp. 279-281.

Bourges, F. and Levillian, J-P (1988), "force portante des rideaux plans metalliques charges verticalmement," Bull. No. 158, Nov.-Dec., des laboratoires des ponts et chaussees, p. 24.

Fellenius, Bengt H. (1996), Basics of Foundation Design, BiTech Publishers Ltd., p.79.

Combined End Bearing and Lower Side Shear Creep Limit

TS-1 - Thompson River East - Thompson Falls, MT



Loadtest USA Project No. LT-1074

Figure D-1

Upper Side Shear Creep Limit

TS-1 - Thompson River East - Thompson Falls, MT

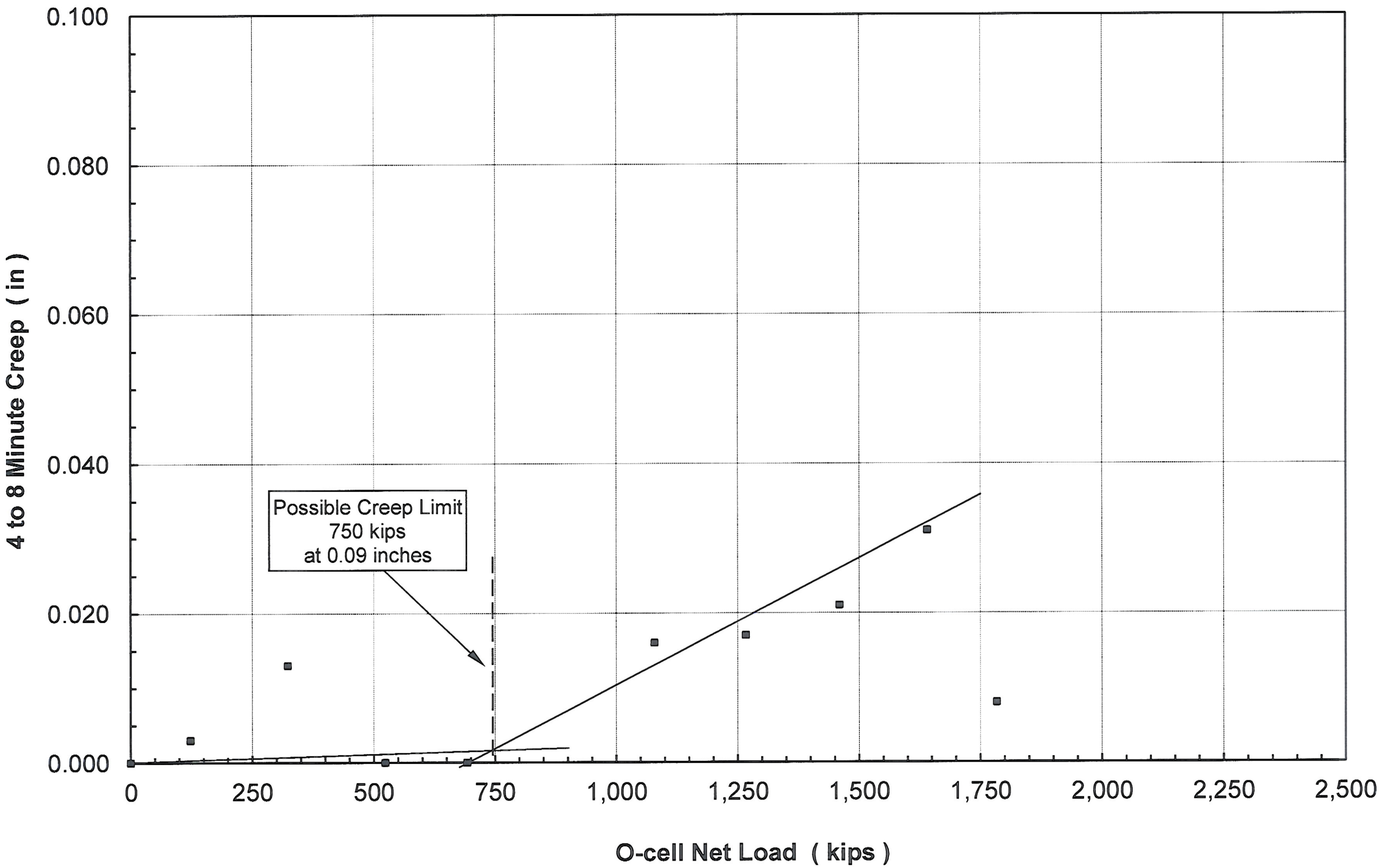


Figure D-2

APPENDIX E

SOIL BORING LOGS

LOG OF BORING

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
			20		2 - 2 - 1		TOPSOIL.	0.5 / 2413.5						HW casing advancer with tricone bit.
							Silty SAND (SM), very loose, moist, brown, [A-4].							
			40		1 - 1 - WH						NP	33		
5 / 2409.0			20		4 - 5 - 12		Poorly-Graded GRAVEL (GP), medium dense to loose, moist to wet, fine to coarse grained, subrounded, [A-1]. Mixed mineralogy, occasional cobbles/boulders.	4.5 / 2409.5				8		
			5		13 - 4 - 2									
10 / 2404.0			<5		6 - 4 - 7									
			5		2 - 1 - 2		▽							
15 / 2399.0														
			10		3 - 3 - 3									
20 / 2394.0														
			10		3 - 4 - 5									
25 / 2389.0														
			30		4 - 4 - 4									
30 / 2384.0														

Water Level Observations

▽ During Drilling: **14.4 ft** ***(2399.6 ft)***

▼ After Drilling: *()*

▼ After Drilling: **Not Encountered, Casing Out**

Remarks: cave in at 12.5 ft.

LOG OF BORING

MONTANA MDT DEPARTMENT OF TRANSPORTATION

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
							Poorly-Graded SAND (SP), loose to medium dense, wet, brown, fine to coarse grained, [A-2]. Occasional layers with gravel.	30.0 / 2384.0						
			30		3 - 3 - 4									About 1.0 ft. of heave before SS at 30.8 ft.
35 / 2379.0														
			60		3 - 4 - 5						NP	12		
40 / 2374.0														
			40		6 - 8 - 4									
45 / 2369.0														
			20		WH - 2 - 3									
50 / 2364.0														
			40		7 - 7 - 9									
55 / 2359.0														
							Poorly-Graded GRAVEL (GP), medium dense, wet, fine to coarse grained, subangular to subrounded, [A-1]. Mixed mineralogy.	56.0 / 2358.0						
			50		10 - 10 - 9							4		
							Poorly-Graded SAND (SP), medium dense, wet,	59.0 / 2355.0						
60 / 2354.0														

Water Level Observations

During Drilling: 14.4 ft (2399.6 ft)

After Drilling: ()

After Drilling: Not Encountered, Casing Out

Remarks: cave in at 12.5 ft.

LOG OF BORING

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
							brown, fine to coarse grained, [A-2]. Occasional seams of Silty Sand and Silt.							
			70		3 - 7 - 9									
65 / 2349.0														
			100		6 - 10 - 17						NP	11		About 2.0 ft. of heave after SS at 66.0 ft.
70 / 2344.0														
			100		4 - 6 - 7									
75 / 2339.0														
			50		5 - 9 - 13									
80 / 2334.0														
			90		7 - 8 - 11		Silty SAND (SM) with layers of Poorly Graded SAND (SP), medium dense, wet, brown, fine to medium grained. (A-2).	81.5 / 2332.5						
85 / 2329.0														
			100		6 - 8 - 13						NP	50		
90 / 2324.0														

Water Level Observations		
After Drilling: ()	During Drilling: 14.4 ft (2399.6 ft) After Drilling: Not Encountered, Casing Out	Remarks: cave in at 12.5 ft.

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
			90		14 - 13 - 19									About 0.3 ft. of heave before SS at 91.0 ft.
							Varved seams of SILT (ML), Silty SAND (SM), and Silty CLAY (CL-ML), dense/hard, wet, tan. (A-4).	92.0 / 2322.0	24					
95 / 2319.0														
			100		7 - 12 - 12		Poorly-Graded SAND (SP), medium dense to dense, wet, brown and gray, fine to coarse grained, [A-2]. Occasional seams of Silty Sand and Silty Clay..	96.0 / 2318.0			NP	40		About 1.0 ft. of heave before SS at 96.0 ft.
100 / 2314.0														
			100		11 - 15 - 18									
105 / 2309.0														
			90		13 - 19 - 22						NP	63		
							Lean CLAY (CL), hard, moist, tan, [A-6].	109.0 / 2305.0						About 1.5 ft of heave before SS at 109.0 ft.
110 / 2304.0														Pen
			100		11 - 15 - 18				23	37	22	92		
115 / 2299.0														
			100		8 - 15 - 18		Silty SAND (SM), dense to medium dense, wet, brown, fine to coarse grained, [A-2]. Occasional to frequent seams and layers of Silty Clay.	116.5 / 2297.5			NP	89		
120 / 2294.0														

Water Level Observations		
After Drilling: ()	During Drilling: **14.4 ft** ***(2399.6 ft)*** After Drilling: **Not Encountered, Casing Out**	Remarks: cave in at 12.5 ft.

LOG OF BORING

Boring 4039-18

Project: Thompson River - East		**Rig:** CME 850 **Hammer:** Auto	**Boring Location Coordinates** N: 1265652.29 ft E: 554520.5169 ft	**Station:** 22 + 99 **Offset:** 4 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 4.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2414.0 ft
Date Started: 2/22/06	**Date Finished:** 2/23/06	**Drilling Fluid:** Polymer	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: J. Winfield **Logger:** Collins		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Recovery (%)	Blow Count	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
	100	6 - 8 - 13			26					
125 / 2289.0										
	100	10 - 12 - 13								
			Lean CLAY (CL), stiff, moist, brown, [A-6]. Occasional layers of Sand and Silty Sand.	129.0 / 2285.0						
130 / 2284.0										
	100	5 - 8 - 10			30	44	26	99		Pen
135 / 2279.0										
	100	4 - 7 - 10								Pen
			Boring Depth: 137.5 ft, *Elevation: 2276.5 ft*	137.5 / 2276.5						

Water Level Observations	During Drilling: **14.4 ft** ***(2399.6 ft)***	Remarks: cave in at 12.5 ft.
After Drilling: *()*	After Drilling: **Not Encountered, Casing Out**	

LOG OF BORING

Boring 4039-32

Project: Thompson River - East		**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 564686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2395.0 ft
Date Started: 4/15/09	**Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: I. Boyd **Logger:** Grosch/Holley		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
0 / 2395.0							Sandy GRAVEL (GW), medium dense to loose, moist, rounded, [A-1]. Frequent cobbles and boulders.							NW casing advancer with tricone roller bit and water.
5 / 2390.0		X	5		4 - 2 - 3				2					
10 / 2385.0		X	25		7 - 6 - 7				8					
15 / 2380.0		X	5		2 - 3 - 2				2					
20 / 2375.0		X	25		5 - 7 - 21				10					
25 / 2370.0		X	10		4 - 3 - 2				3					
30 / 2365.0														

Water Level Observations		Remarks: Water not recorded due to use of water to advance boring.
After Drilling: *0*	During Drilling: *0* After Drilling: *0*	

LOG OF BORING

Boring 4039-32

MONTANA MDT DEPARTMENT OF TRANSPORTATION

Project: Thompson River - East
Rig: CME 45
Hammer: Auto
Boring Location Coordinates N: 1265659 ft E: 564686.2 ft
Station: 24 + 62
Offset: 38 ft L
Project Number: STPP 6-1(87)56
UPN: 4039
Boring Diameter: 3.5"
System: MT S.P. (E)
Datum: NAD83
Top of Boring Elevation: 2395.0 ft
Date Started: 4/15/09
Date Finished: 4/22/09
Drilling Fluid: Bentonite
Location Source: Handheld GPS, Uncorrected
Elevation Source: Surveyed
Driller: I. Boyd
Logger: Grosch/Holley
Abandonment Method: Backfilled with Cuttings
Township, Range, and Section: 21N 28W 18 - BDD

Depth (ft) / Elev. (ft)	Recovery (%)	RQD (%)	Blow Count	Material Description	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
	30		6 - 7 - 4		14			3		Sand heaved 2.0 ft., hole washed out to correct elevation.
35 / 2360.0	5		2 - 2 - 2		4					
40 / 2355.0	5		2 - 2 - 5		5					
45 / 2350.0	30		5 - 6 - 4		2					
50 / 2345.0	40		3 - 10 - 7		3 4			1		
55 / 2340.0	30		11 - 7 - 5		4					
60 / 2335.0										

Water Level Observations
During Drilling: 0
After Drilling: 0
After Drilling: 0

Remarks: Water not recorded due to use of water to advance boring.

LOG OF BORING

Boring 4039-32

Project: Thompson River - East		**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 564686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2395.0 ft
Date Started: 4/15/09	**Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: I. Boyd **Logger:** Grosch/Holley		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
			30		5 - 5 - 6				2					
65 / 2330.0			5		10 - 5 - 7				13					
70 / 2325.0			15		10 - 10 - 8				19					Began using bentonite drilling mud.
75 / 2320.0			40		9 - 6 - 5				2					
80 / 2315.0			60		4 - 9 - 6				7		NP	3		Sand heaved 1.5 ft., hole washed out to correct elevation. Split spoon sample mostly cuttings.
85 / 2310.0			20		7 - 8 - 9				2					Rock wedged in driving shoe.
							ARGILLITE BOULDER.	88.0 / 2307.0						
								89.6						
90 / 2305.0														

Water Level Observations	During Drilling: 0	Remarks: Water not recorded due to use of water to advance boring.
After Drilling: 0	After Drilling: 0	

MONTANA MDT DEPARTMENT OF TRANSPORTATION

LOG OF BORING

Boring 4039-32

Project: Thompson River - East		**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 564686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56	**UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2395.0 ft
Date Started: 4/15/09	**Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: I. Boyd **Logger:** Grosch/Holley		**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
			25		15 - 29 - 16		Sandy GRAVEL (GW), dense to loose, moist, rounded, [A-1]. Frequent cobbles and boulders.	2305.4	18		NP	19		Sand heaved 2.0 ft., hole washed out to correct elevation.
95 / 2300.0			25		5 - 7 - 10				6					Rock wedged in driving shoe.
							ARGILLITE BOULDER.	98.5 / 2296.5						
100 / 2295.0			40		4 - 7 - 10		Sandy GRAVEL with silt (GW), dense to medium dense, moist, rounded to angular, [A-1]. Frequent cobbles.	99.5 / 2295.5	8					
105 / 2290.0			60		11 - 8 - 7				2					
110 / 2285.0			15		8 - 7 - 17				2					
115 / 2280.0									2					
120 / 2275.0														

Water Level Observations		
After Drilling: ()	During Drilling: () After Drilling: ()	Remarks: Water not recorded due to use of water to advance boring.

LOG OF BORING

Boring 4039-32

Project: Thompson River - East	**Rig:** CME 45 **Hammer:** Auto	**Boring Location Coordinates** N: 1265659 ft E: 564686.2 ft	**Station:** 24 + 62 **Offset:** 38 ft L
Project Number: STPP 6-1(87)56 / **UPN:** 4039	**Boring Diameter:** 3.5"	**System:** MT S.P. (E) **Datum:** NAD83	**Top of Boring Elevation:** 2395.0 ft
Date Started: 4/15/09 / **Date Finished:** 4/22/09	**Drilling Fluid:** Bentonite	**Location Source:** Handheld GPS, Uncorrected	**Elevation Source:** Surveyed
Driller: I. Boyd **Logger:** Grosch/Holley	**Abandonment Method:** Backfilled with Cuttings	**Township, Range, and Section:** 21N 28W 18 - BDD	

Depth (ft) / Elev. (ft)	Operation	Sample Type	Recovery (%)	RQD (%)	Blow Count	Lithology	Material Description	Depth (ft) / Elev. (ft)	MC (%)	LL	PL	-200 (%)	DD (pcf)	Remarks and Other Tests
			40		12 - 15 - 16				9					
125 / 2270.0			40		9 - 10 - 11				12					
130 / 2265.0			60		10 - 13 - 14				4					60 feet of NW casing left in hole after completion of drilling operations due to shear failure.
135 / 2260.0			60		13 - 22 - 20			136.5 / 2258.5	5		NP	4		Casing advancer refusal at 137 ft.

Boring Depth: 136.5 ft, *Elevation: 2258.5 ft*

Water Level Observations		Remarks: Water not recorded due to use of water to advance boring.
After Drilling: *()*	During Drilling: *()* After Drilling: *()*	

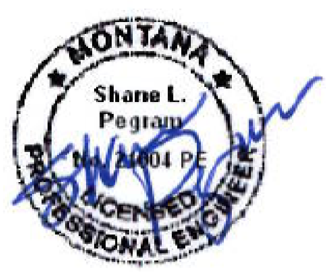
APPENDIX C

Cross-hole Sonic Logging Report

THOMPSON RIVER - EAST
STPB-STPP-HSIP 6-1(106)56
CN 4039

OSTERBERG-CELL TEST SHAFT

Prepared By:
Shane Pegram, PE
Montana Department of Transportation
Construction Engineering Services Bureau
December 19, 2014



Background

Cross-hole Sonic Logging (CSL) is a non-destructive testing method that can be used to provide general information about the integrity of drilled shaft concrete. The ASTM testing method (D6760) was employed to evaluate an eight foot diameter test shaft on the Thompson River-East project.
There were 8 steel CSL tubes evenly spaced around the perimeter of the shaft, containing antifreeze which provides a medium to transmit the ultrasonic vibration pulses in the access tubes. During testing, the transmitter and receiver were simultaneously pulled from the bottom of the access tubes to the top of the drilled shaft concrete at a consistent rate, taking readings at 2-inch intervals. Each combination of access tube pairs was tested in order to scan as much of the drilled shaft concrete as possible. Data acquisition was performed using the Cross Hole Analyzer (CHAMP) by Pile Dynamics, Inc.

Summary of Results

CSL testing indicates an anomalous area approximately 21 feet from the top of the shaft in the vicinity of tubes 1, 2, and 8 (Fig. 3). A course of action will be determined after discussing these results with MDT Geotechnical Section, MDT's EPM, and Loadtest USA (Sletten's subcontractor performing the O-Cell test).

Shaft Construction

The drilled shaft discussed in this report is a test shaft only and will not be part of the substructure for the new Thompson River Bridge east of Thompson Falls. Eight production shafts that will support a three span bridge that spans 434 feet over the Thompson River will be constructed after load testing is completed on the test shaft.

The test shaft was specified to be drilled to an elevation of 2352.50 feet for a total shaft depth of sixty feet. The shaft was excavated with the aid of temporary steel casing that was removed during the concrete pour. Sletten Construction's method for constructing the shaft included telescoping the steel casing starting with an 8'-6" diameter casing that was installed simultaneously with excavation of the shaft to approximately 30' below the planned top of the shaft elevation. An 8'-0" diameter casing was then installed simultaneously with excavation of the shaft to the planned tip elevation (Fig.1). The steel reinforcement cage and Osterberg load cell (Fig. 2) were placed into the drilled shaft following a final clean out of the drilled shaft. Concrete was placed with a pump truck to fifteen feet above the bottom of the 8'-6" diameter casing before removing the 8'-0" diameter casing. Concrete placement continued once the casing was removed. The 8'-6" diameter casing was removed once concrete placement reached slightly above the finished elevation.

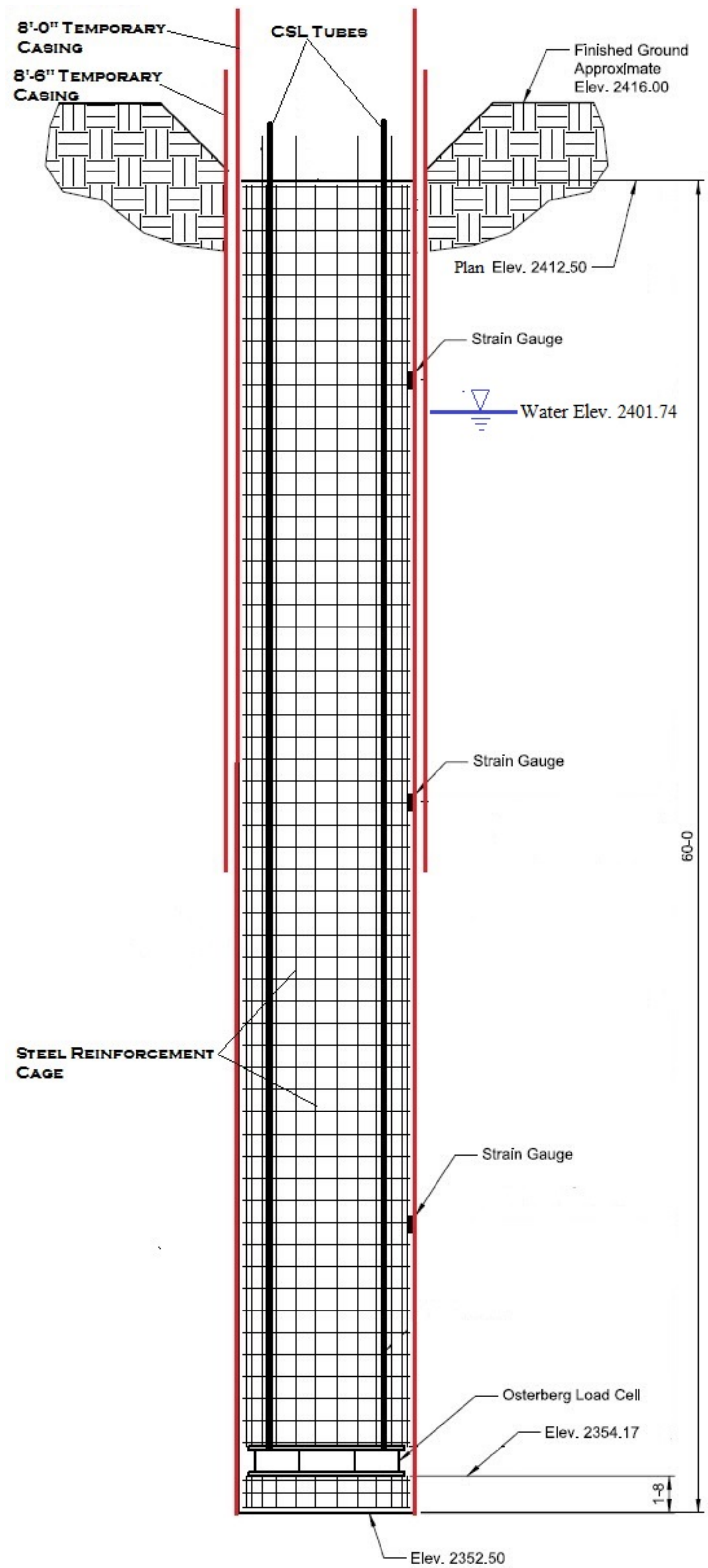


Figure 1: Osterberg Test Shaft Elevation

Figure 2: Setting reinforcement cage with Osterberg Load Cell

CSL Evaluations

Pile Dynamics Inc. provided the following criteria for initial evaluation:

(G) (Good) FAT increase 0 to 10% and Energy Reduction < 6 db
(Q) (Questionable) FAT increase 11 to 20% and Energy Reduction of < 9 db
(P/F) (Poor/Flaw) FAT increase 21 to 30% **or** Energy Reduction of 9 to 12 db
(P/D) (Poor/Defect) FAT increase >31% **or** Energy Reduction > 12 db

Defect thresholds were set at 22% for First Arrival Time (FAT) delay and at 8dB for Energy reduction for this report. CSL indications exceeding these thresholds are listed in the tabulated defect summary table below (Appendix).

An anomalous area was indicated by CSL readings that exceeds the defect thresholds (Appendix). The area of concern is located at approximately 21 feet from the top of the shaft in the vicinity of CSL tubes 1, 2, and 8. Data collected at the top 10 feet of the shaft is inconclusive due to poor signal transmission.

Seventeen profiles indicate reduced energy readings between 19 and 22 feet from the top of the shaft. Thirteen of those readings show an energy decrease in excess of 50 dB and a 100% increase in FAT. The anomaly can be seen in the waterfall diagrams (Appendix).

TomoSonic imagery was used to illustrate the general location of the anomaly. Variations in wave speed are indicated as different colors in the images (Fig. 3 and 4). The color red indicates wave speeds that were greater than or equal to 80% of the average wave speed. The color blue indicates the lowest wave speeds and potential defects. The vertical cross section between tube pairs 4 and 8 is shown on the left of Figure 3.

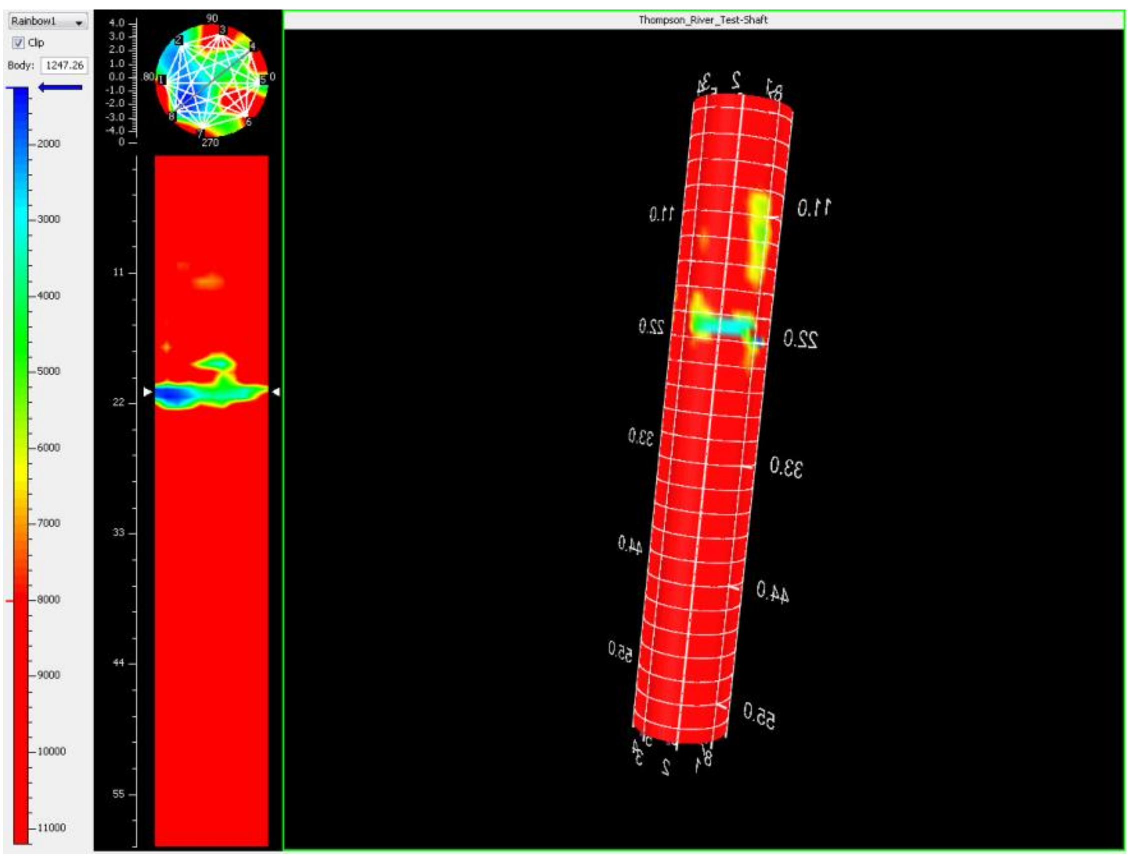


Figure 3: TomoSonic color coded 3D imagery

The horizontal cross section shown in Figure 4 is located approximately 21 feet from the top of the shaft. The darker blue color illustrates the general location of a potential defect.

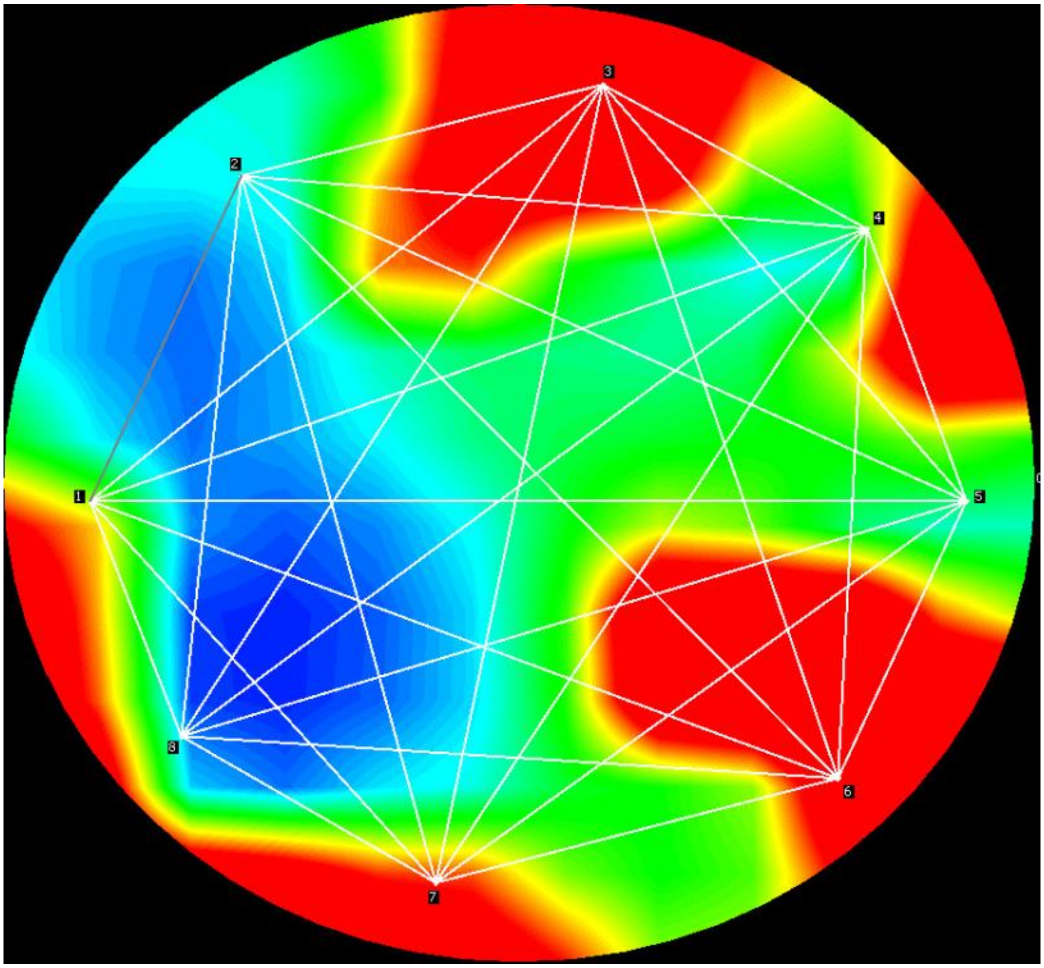


Figure 4: TomoSonic Imagery horizontal cross section

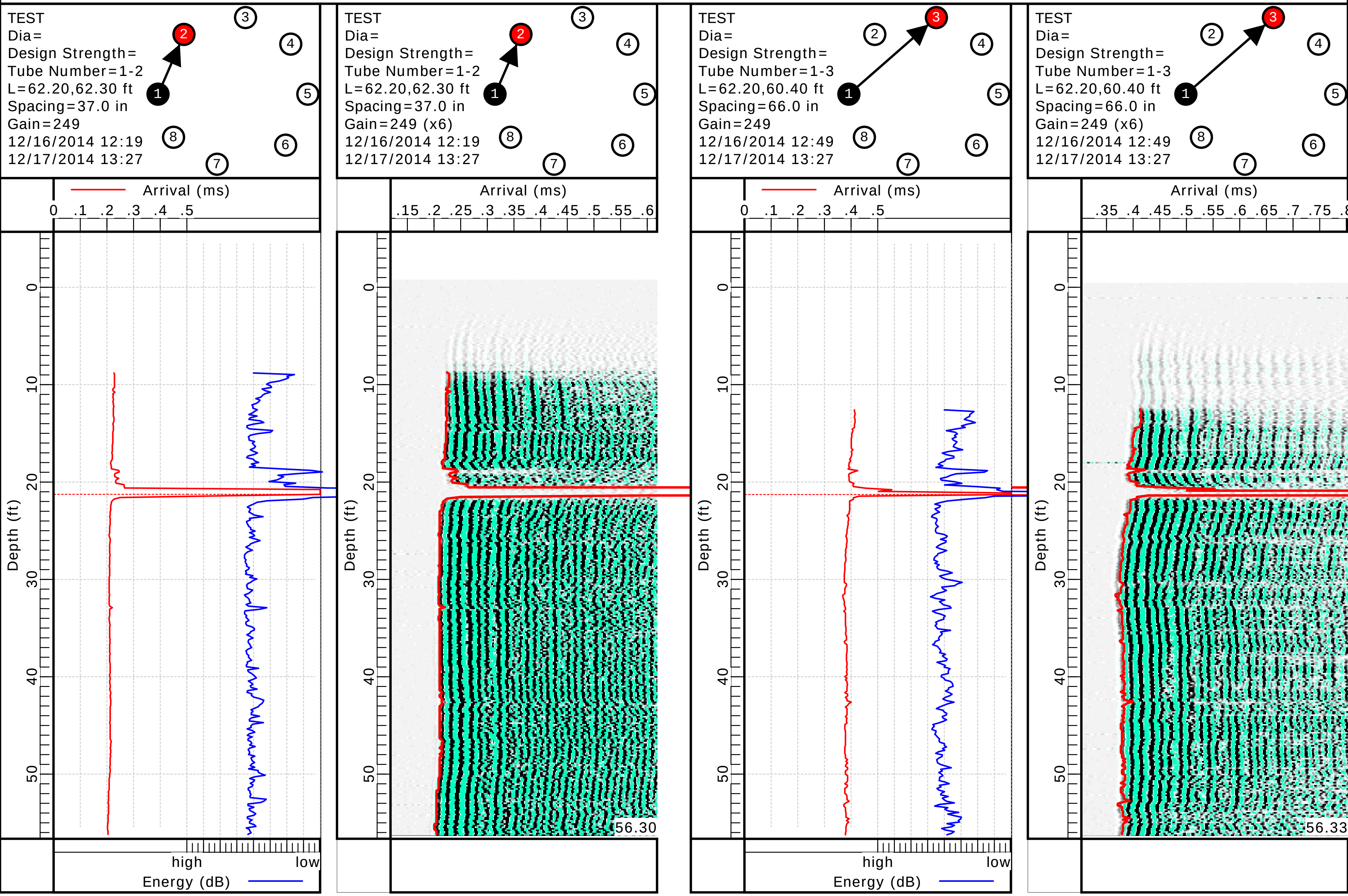
Conclusion

CSL waterfall diagrams indicate an anomalous area approximately 21 feet from the top of the shaft. The 3D imagery created with the TomoSonic software was used to illustrate the approximate extents of the anomaly. The imagery indicates that the anomaly is located between CSL tubes 2 and 8. Further investigation of this shaft is warranted but there is some risk of damaging embedded instrumentation. LoadTest USA will be asked to review the CSL results and advise MDT to the effects of this anomaly on the O-Cell test and the risks of further investigation. Further investigation will be at the direction of MDT.

APPENDIX:

CSL Waterfall Diagrams

MDT CES Bureau
TEST SHAFT



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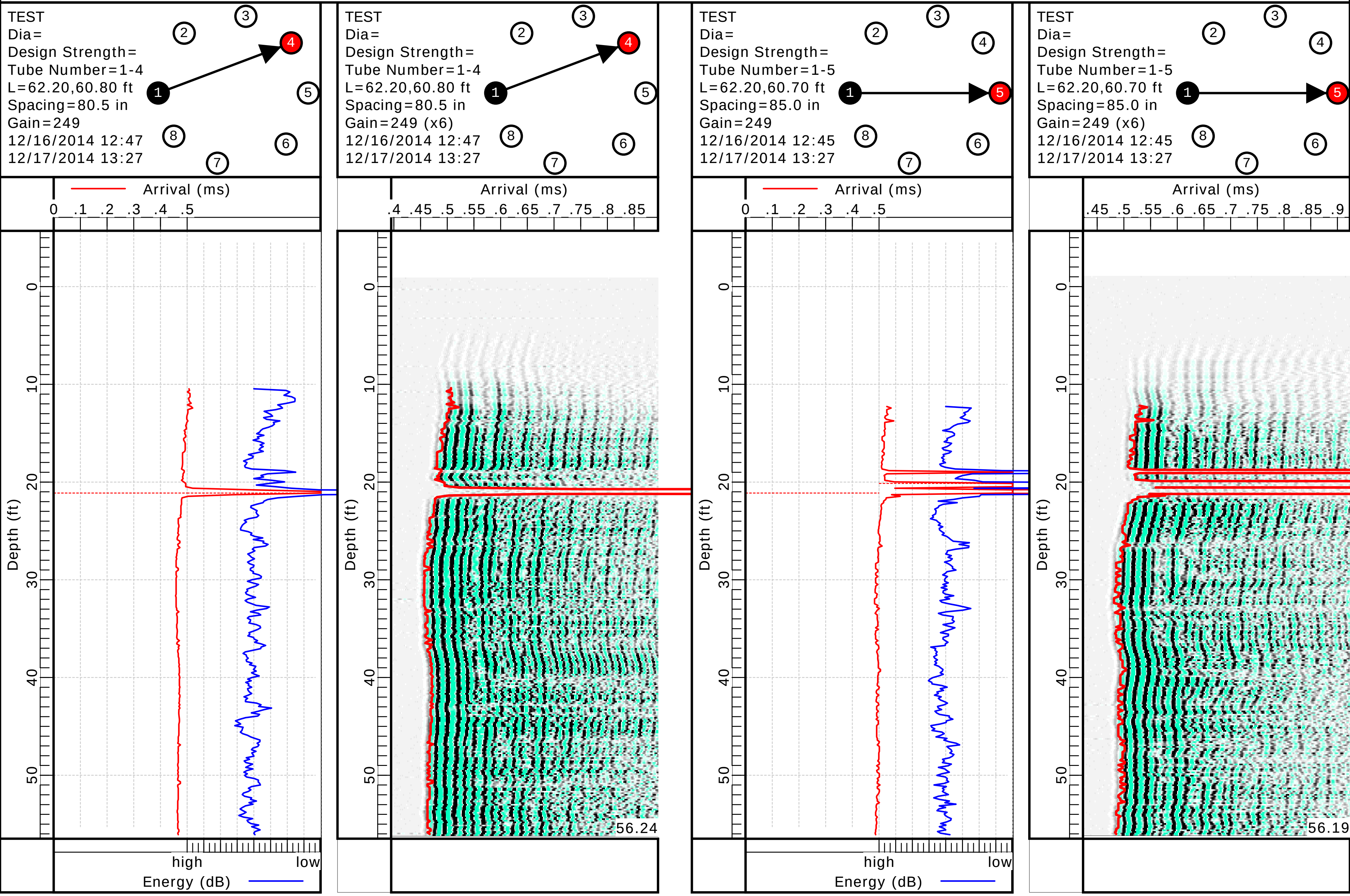
TEST SHAFT



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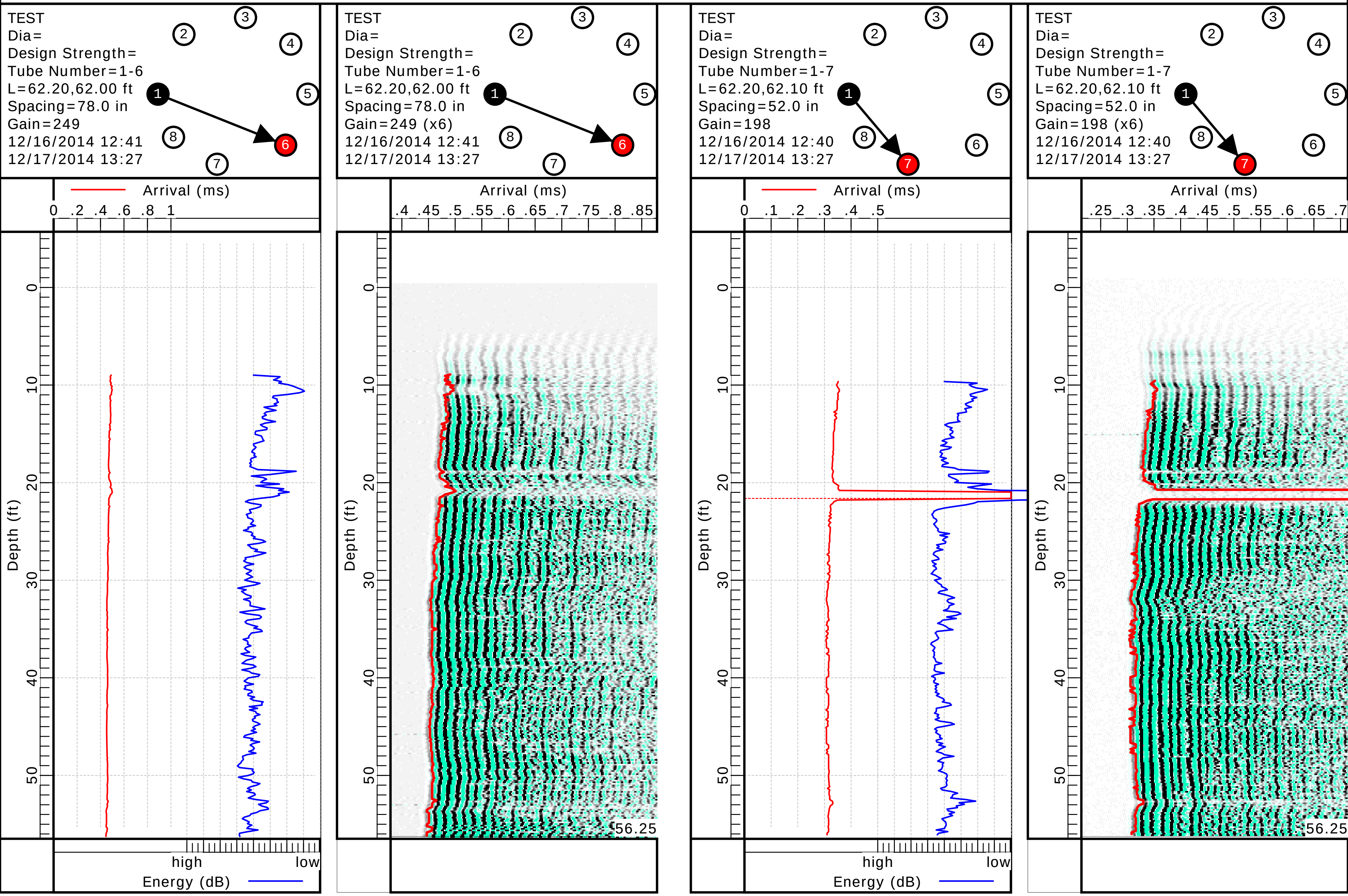

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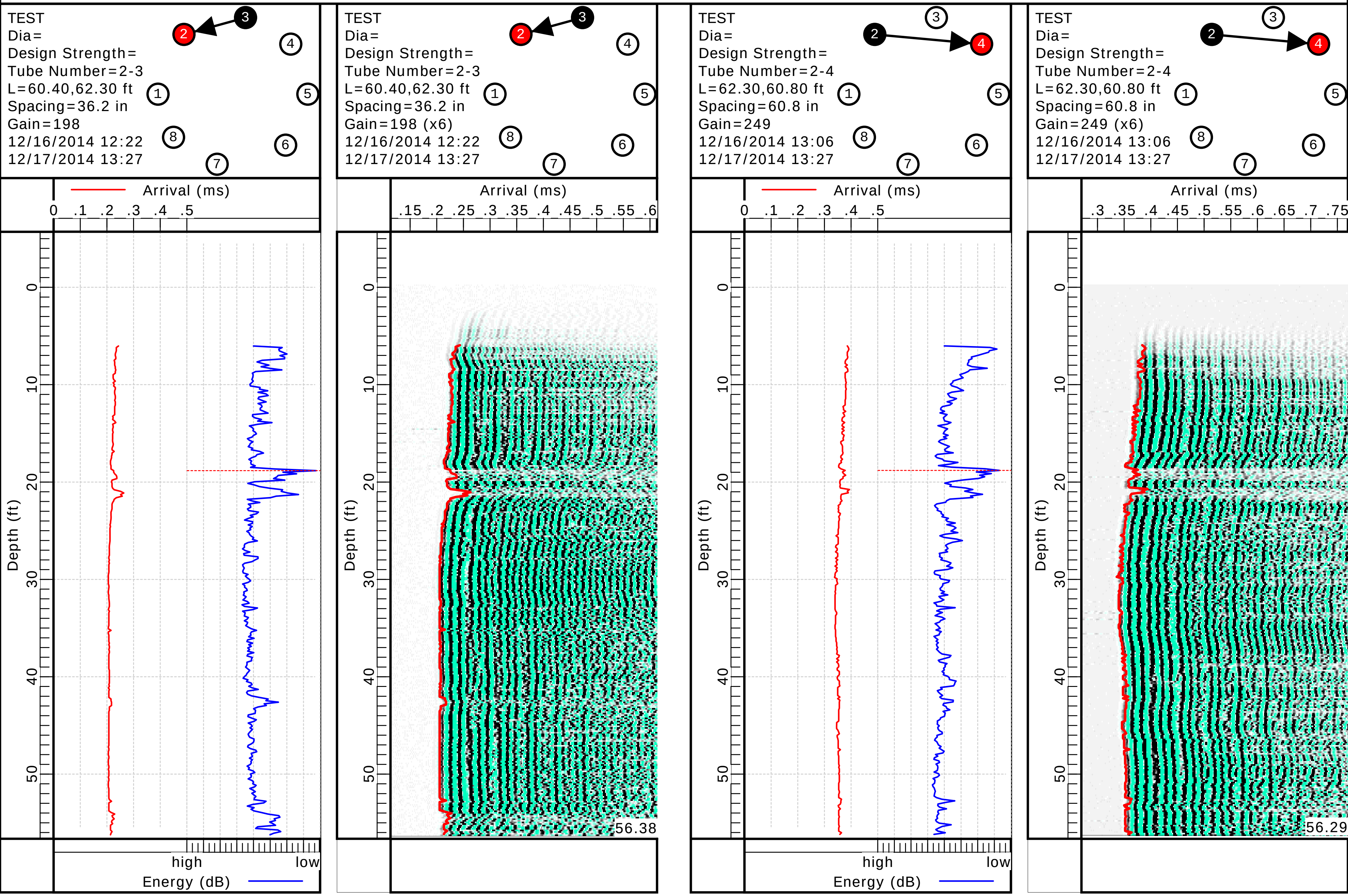

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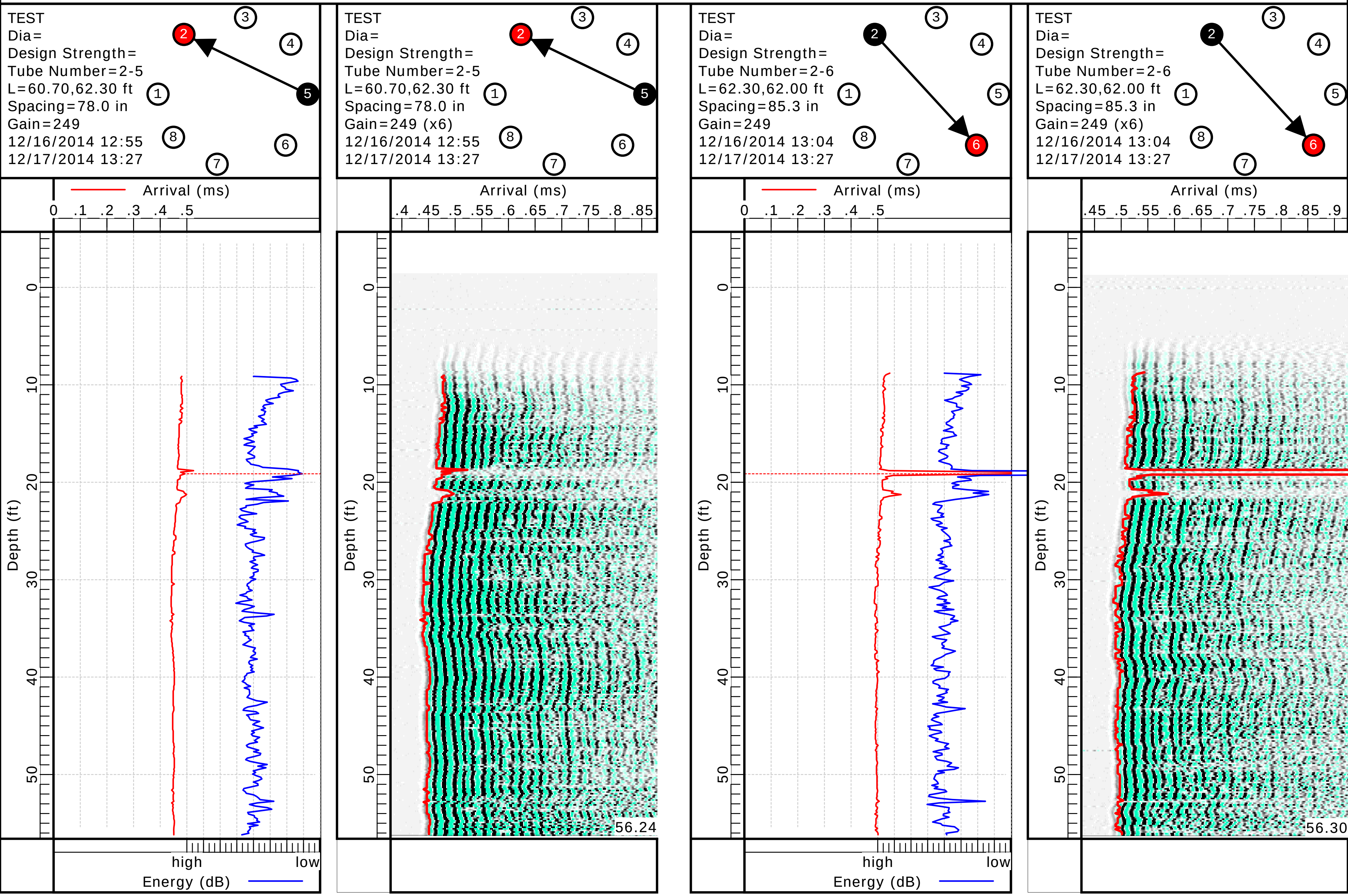

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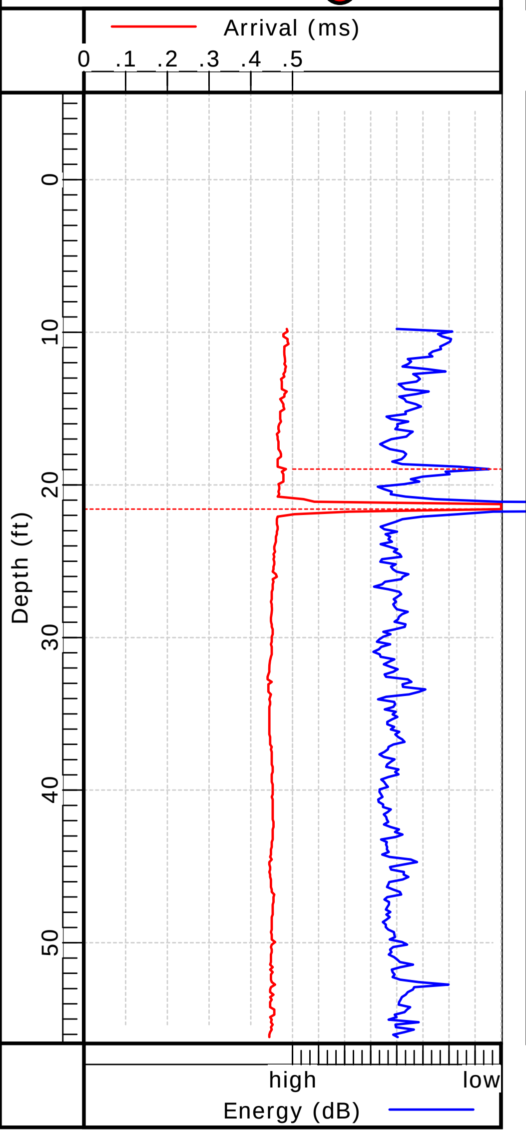

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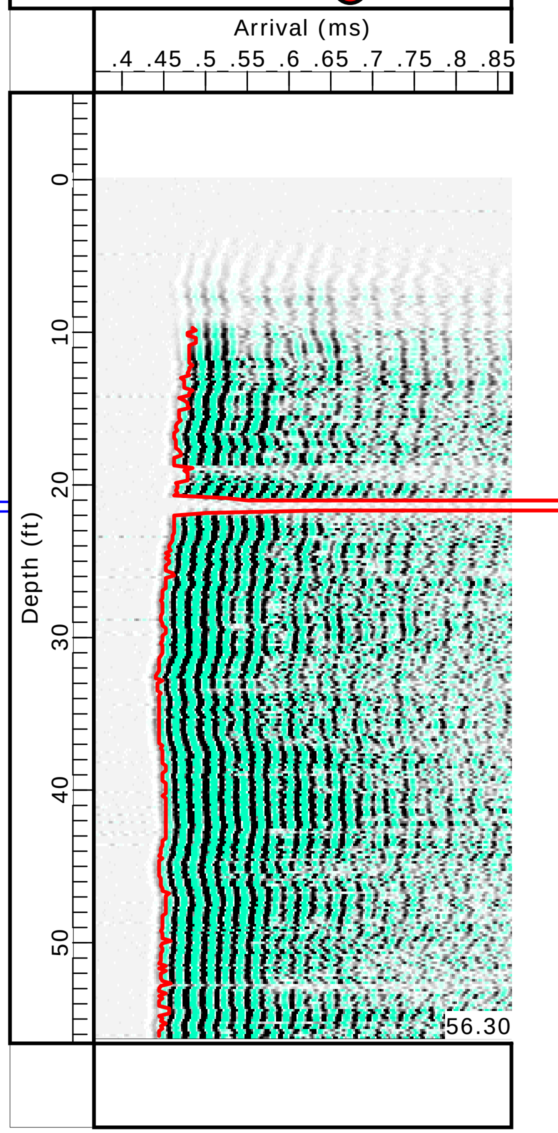

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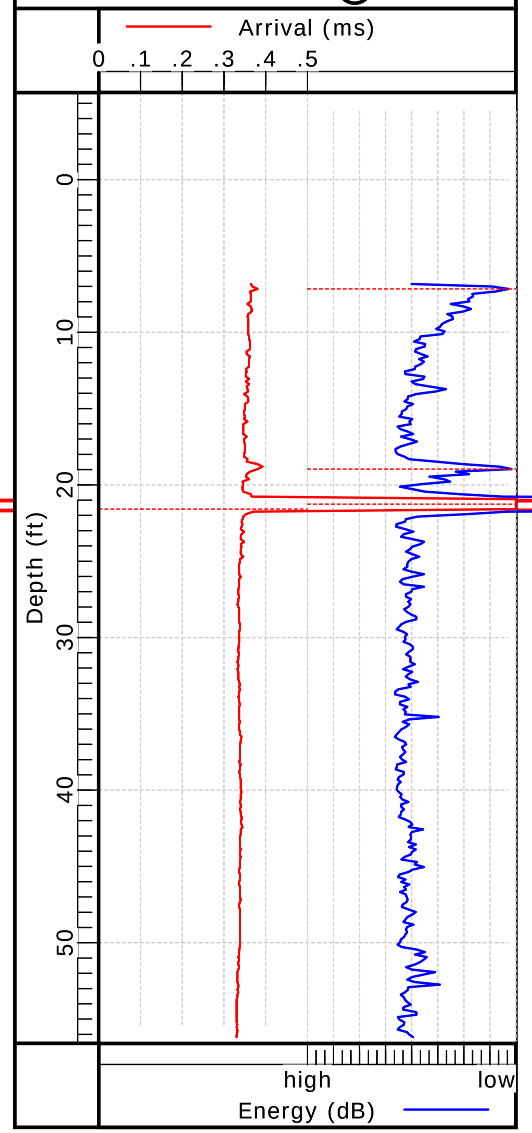

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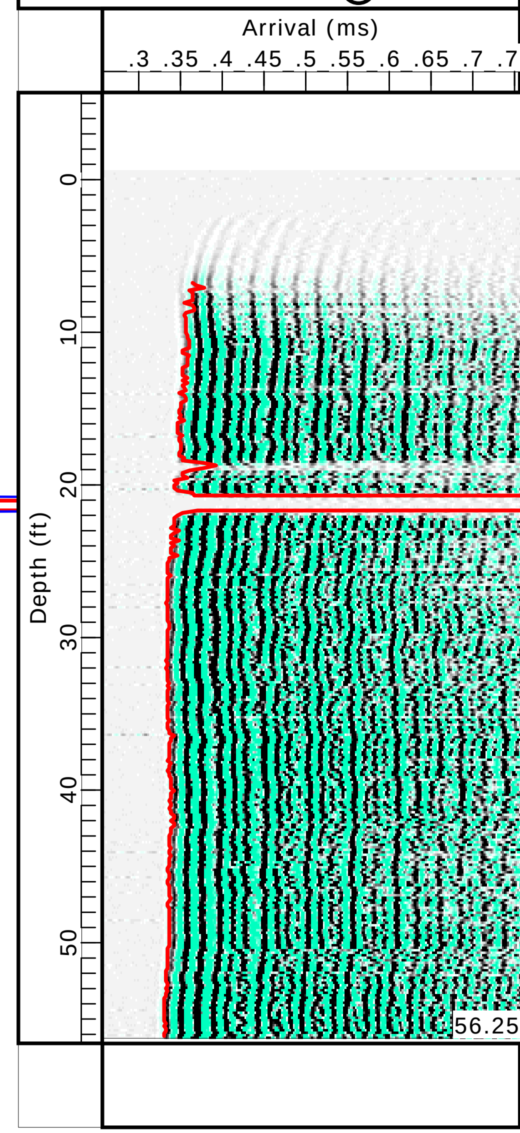

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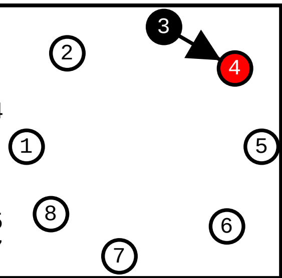

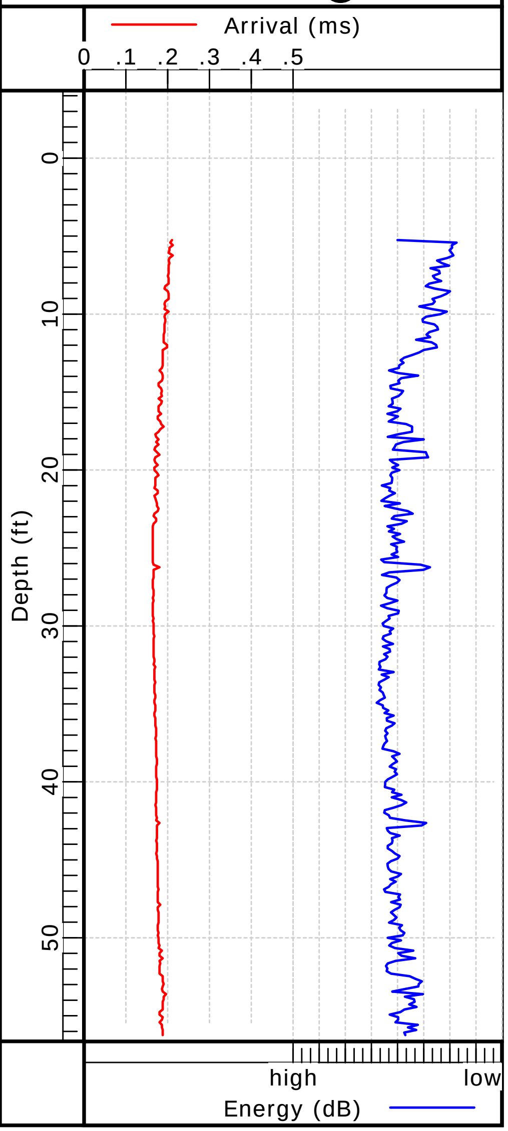

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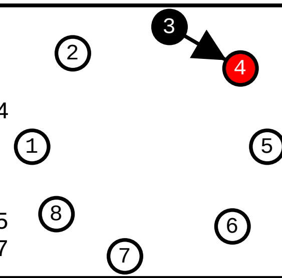

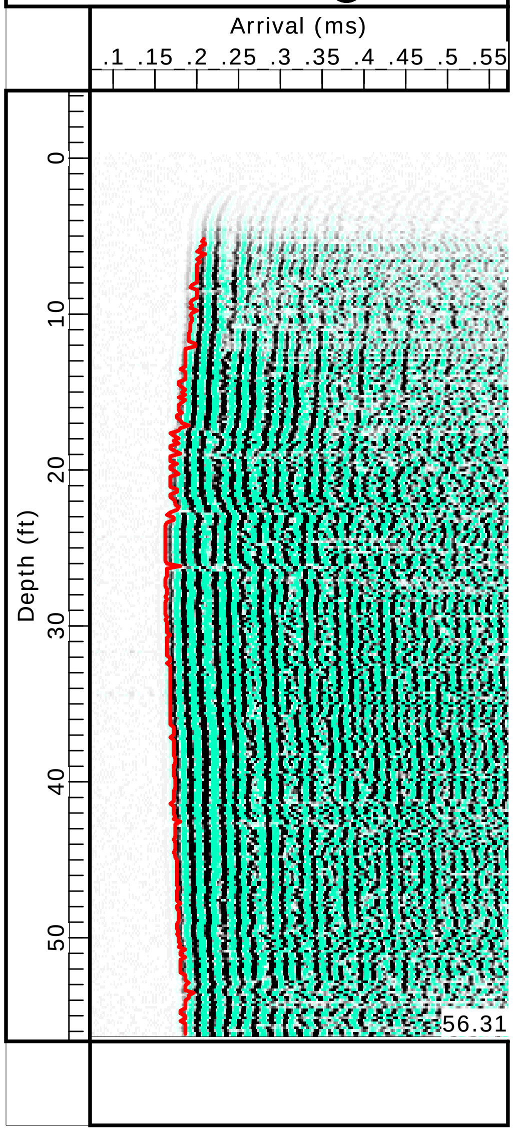

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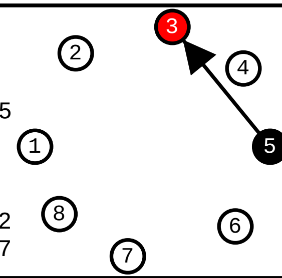

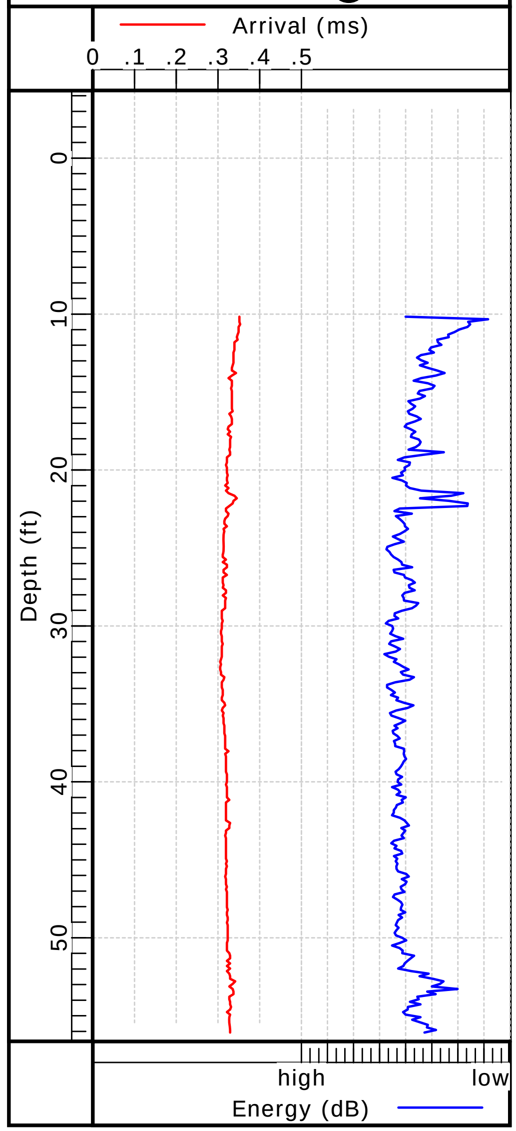

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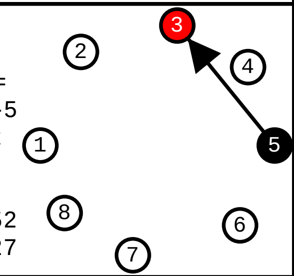

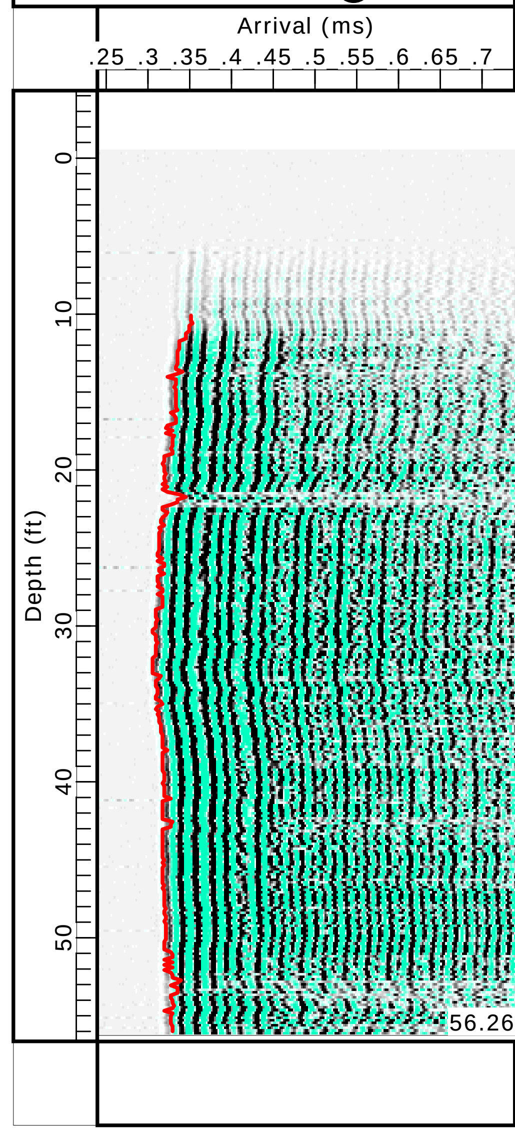

MDT CES Bureau
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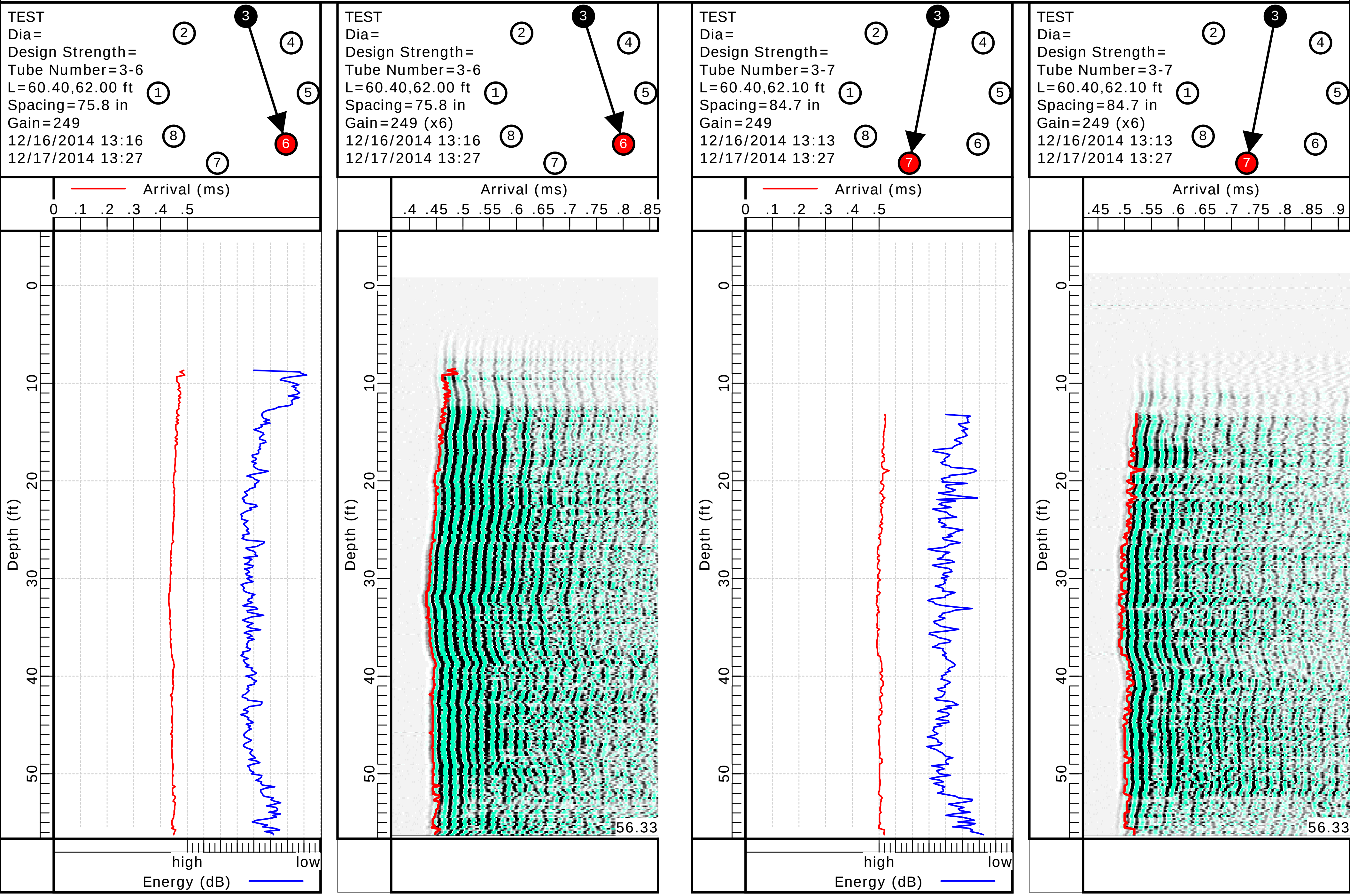

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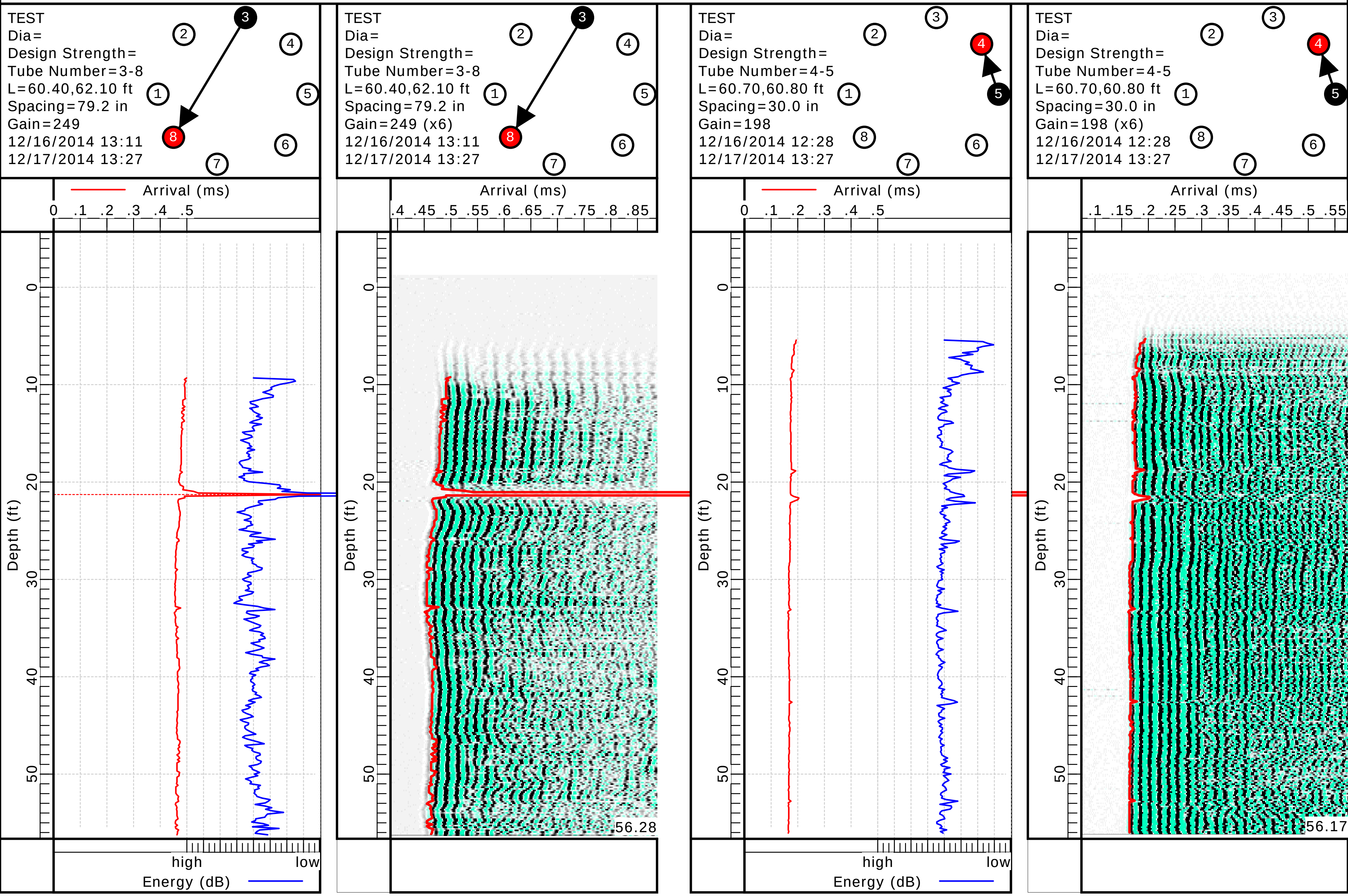

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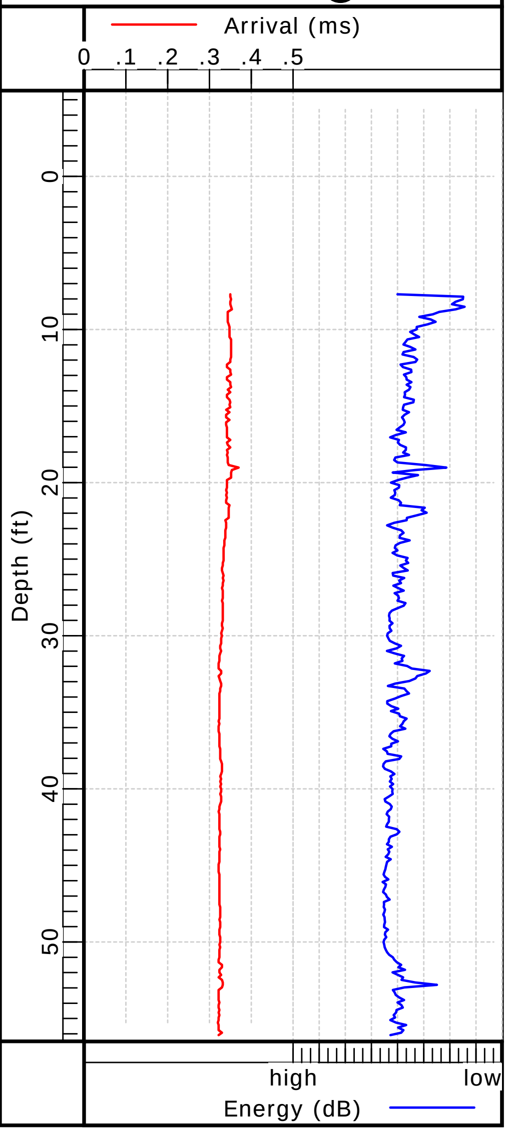

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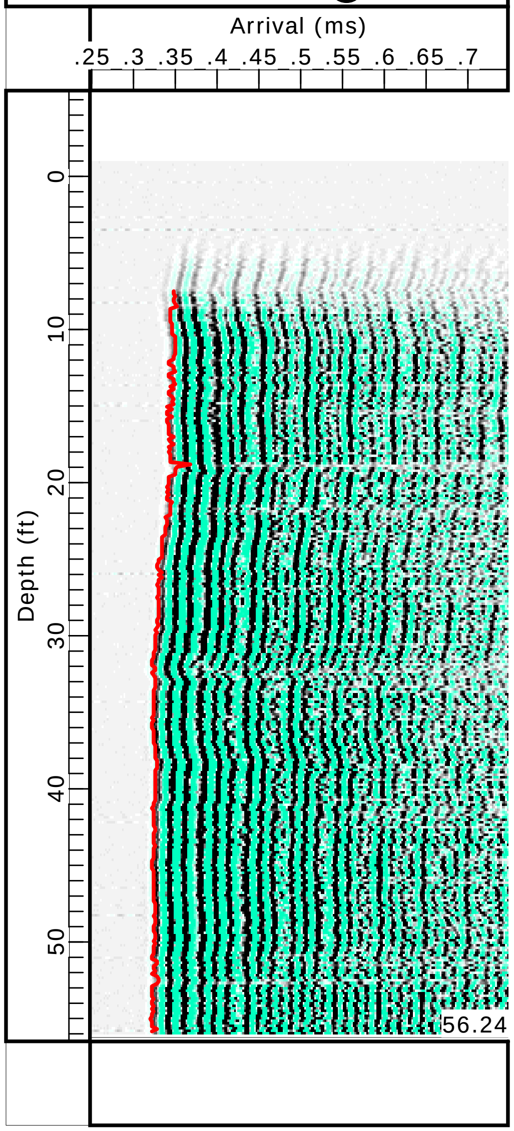

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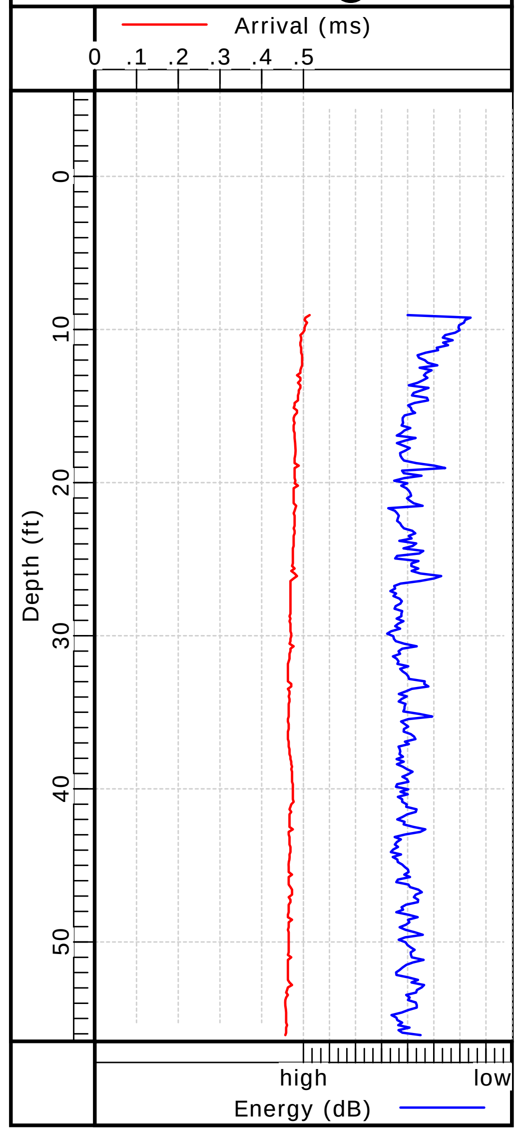

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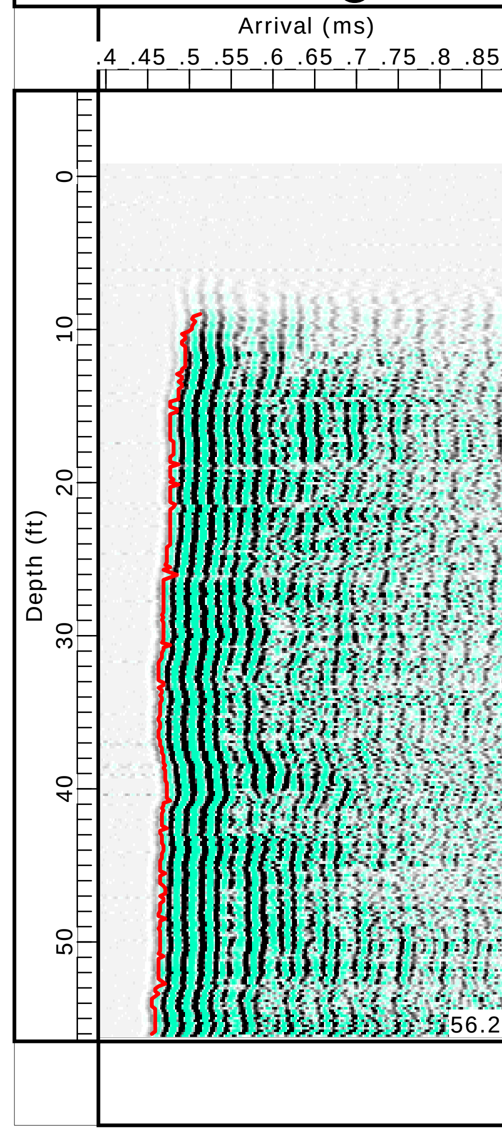

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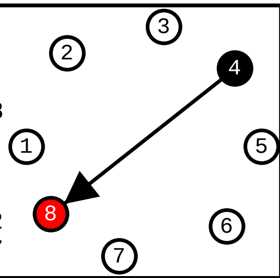

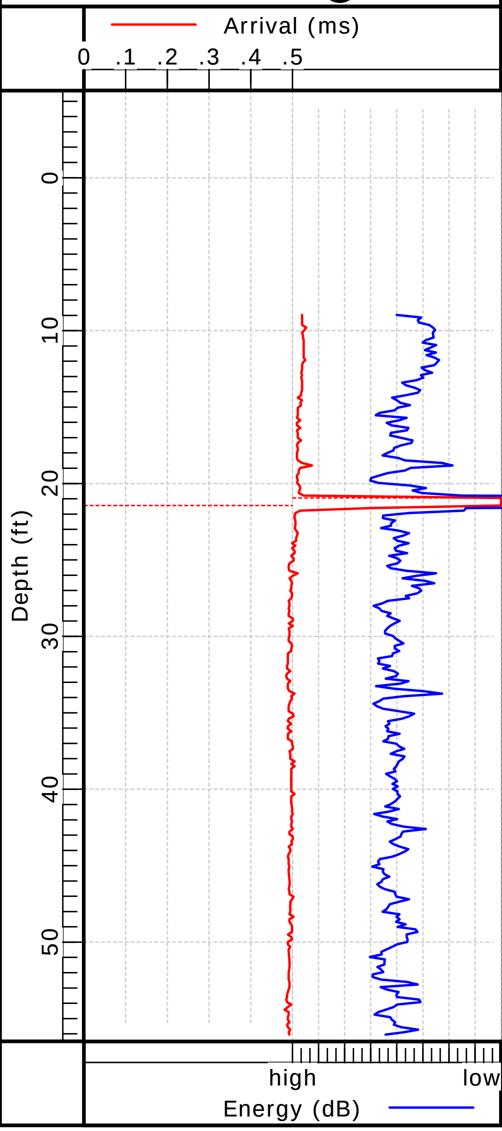

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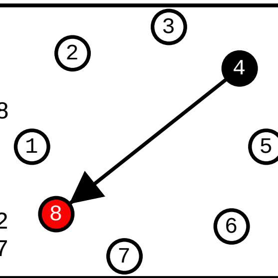

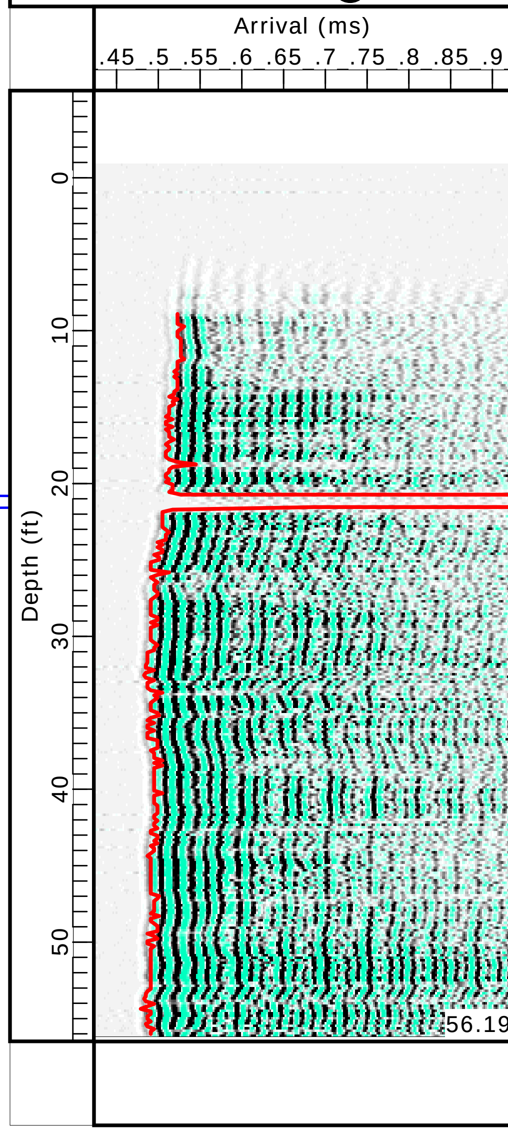

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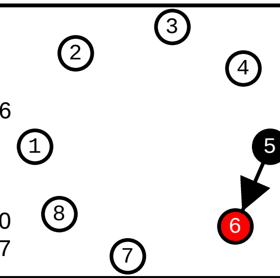

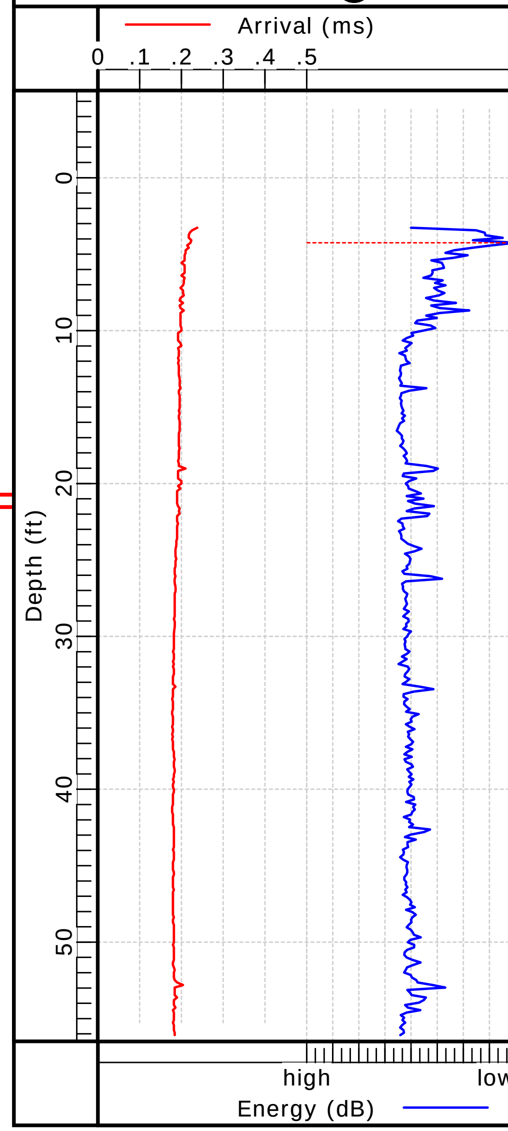

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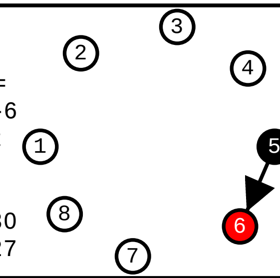

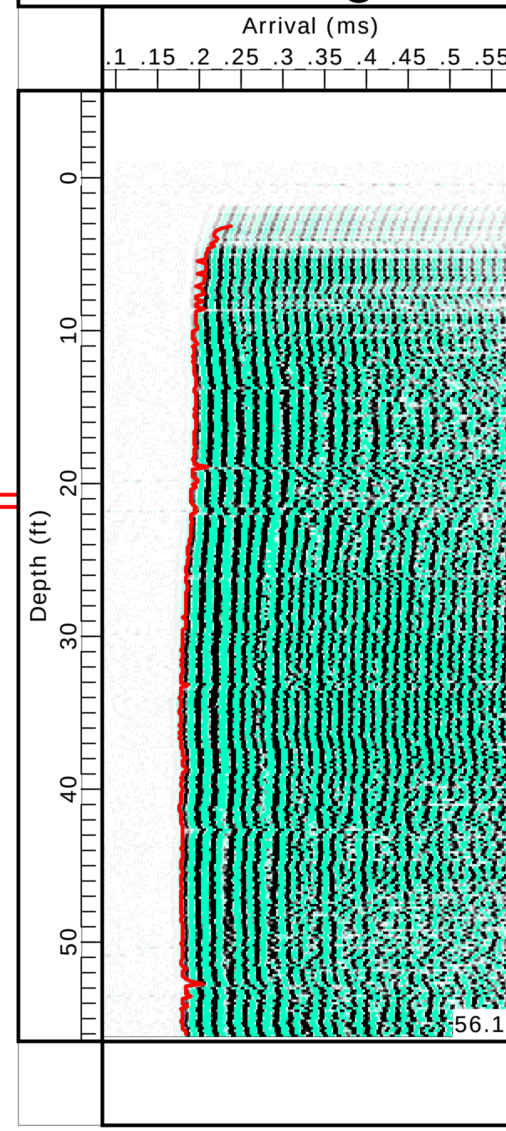

MDT CES Bureau
TEST SHAFT

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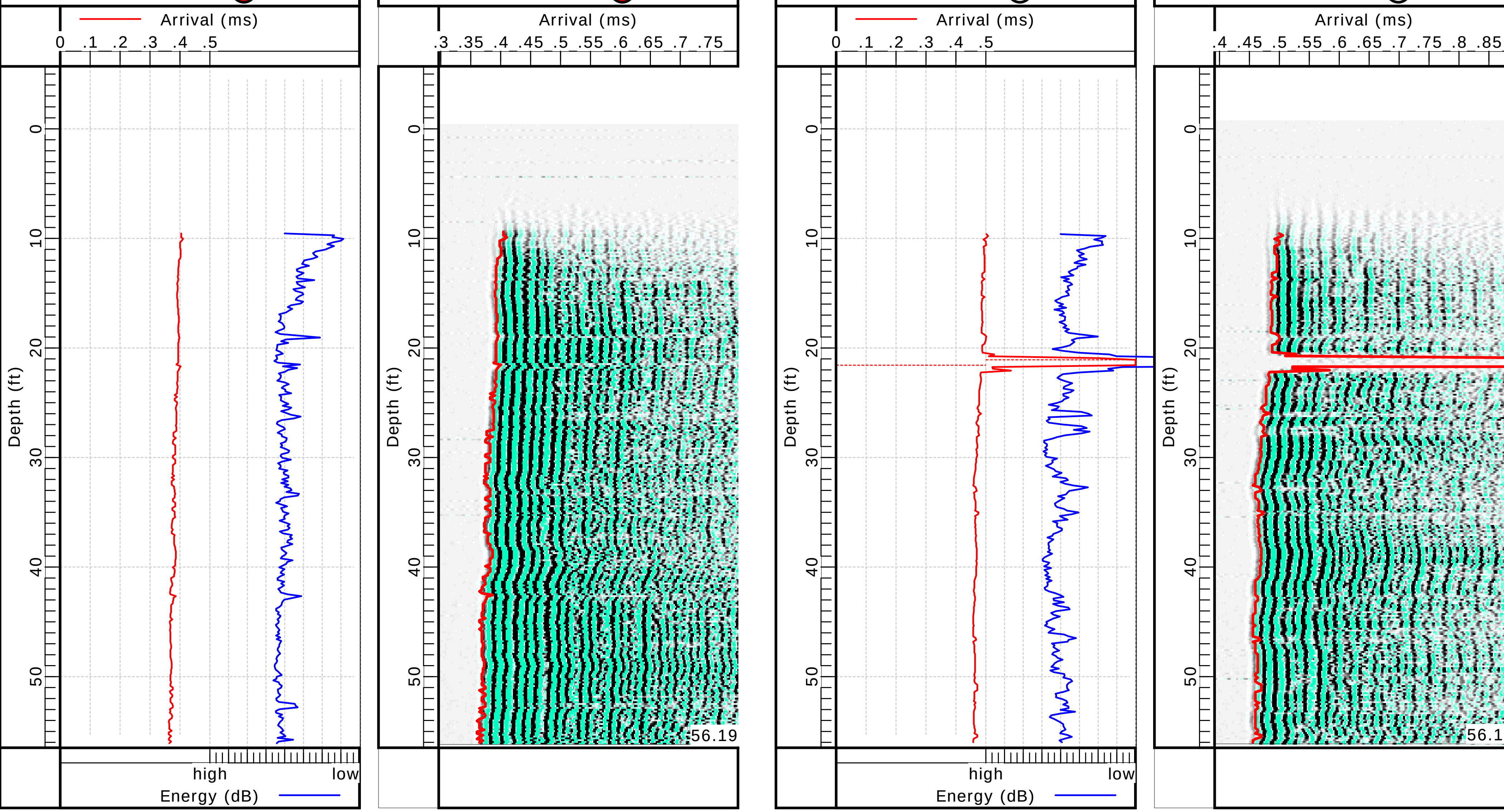

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TEST SHAFT

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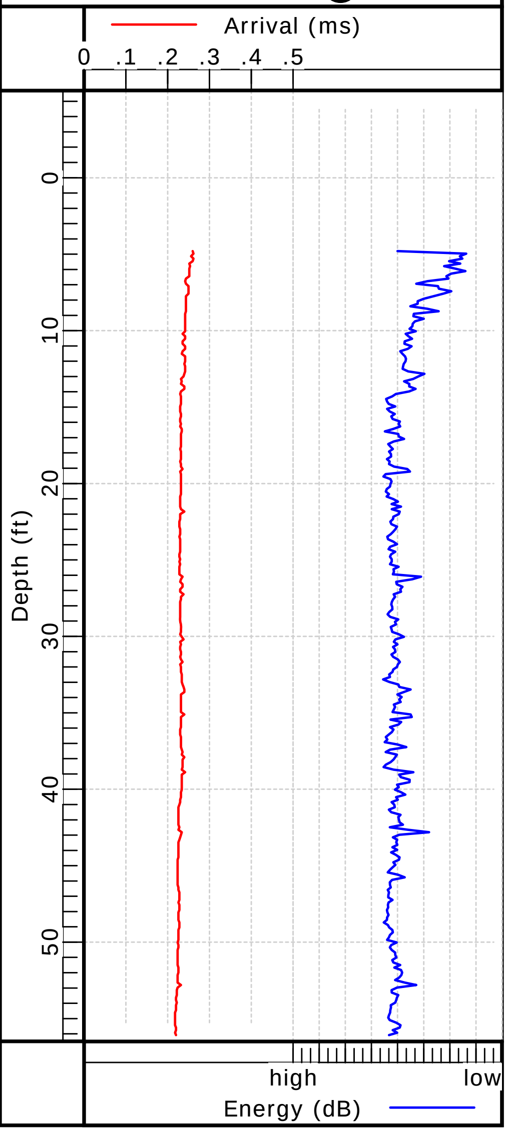

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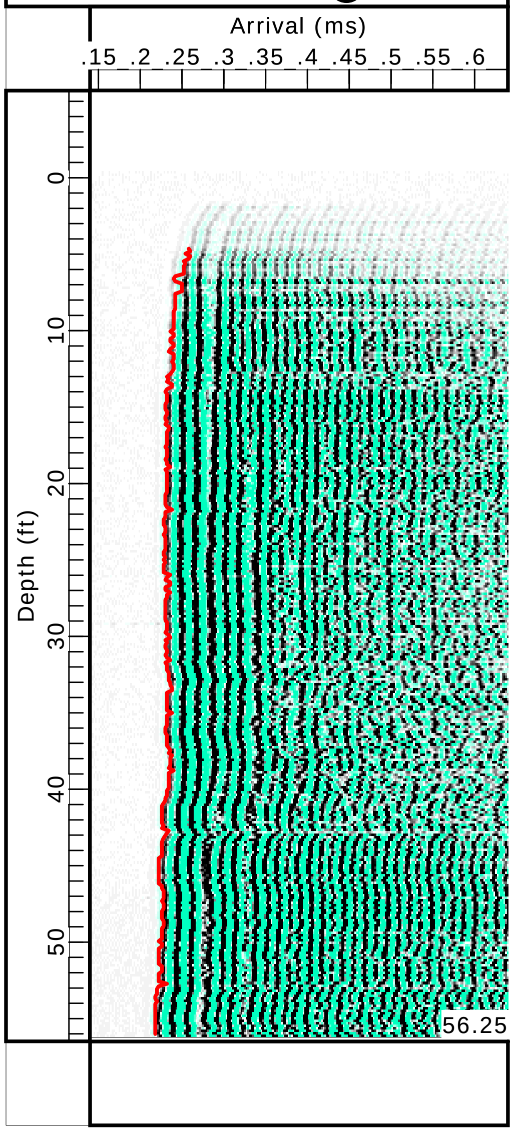

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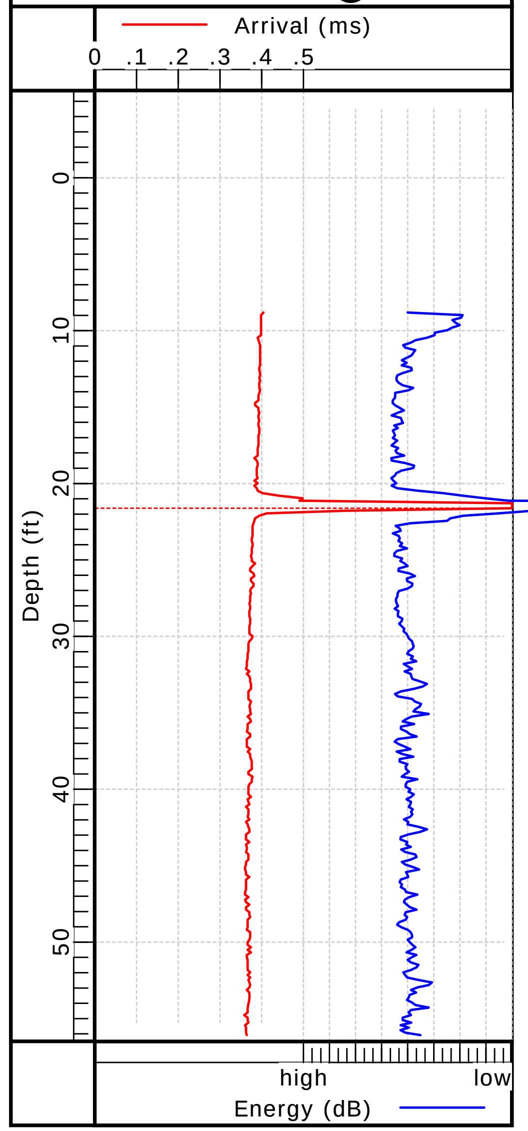

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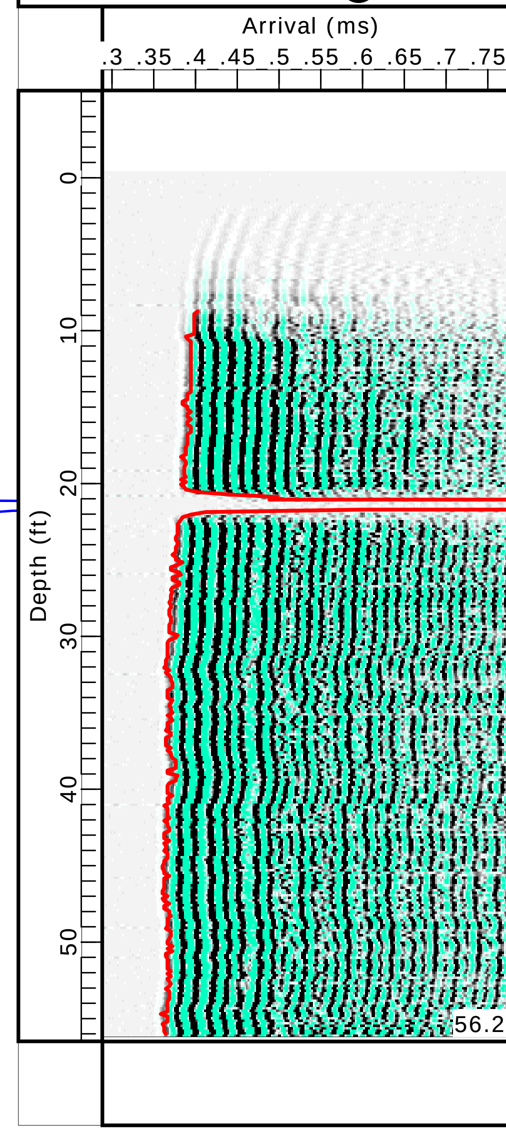

MDT CES Bureau
TEST SHAFT

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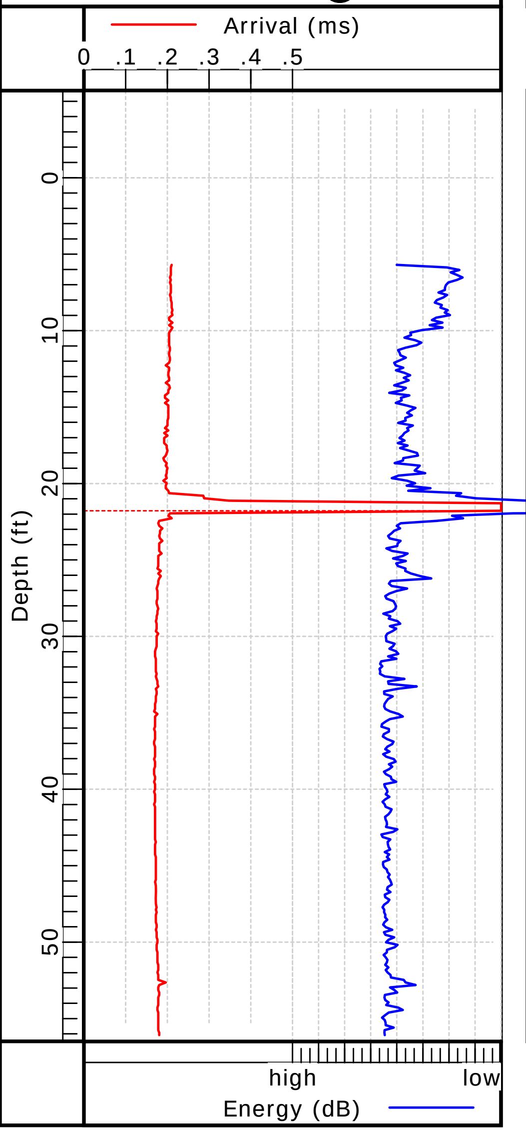

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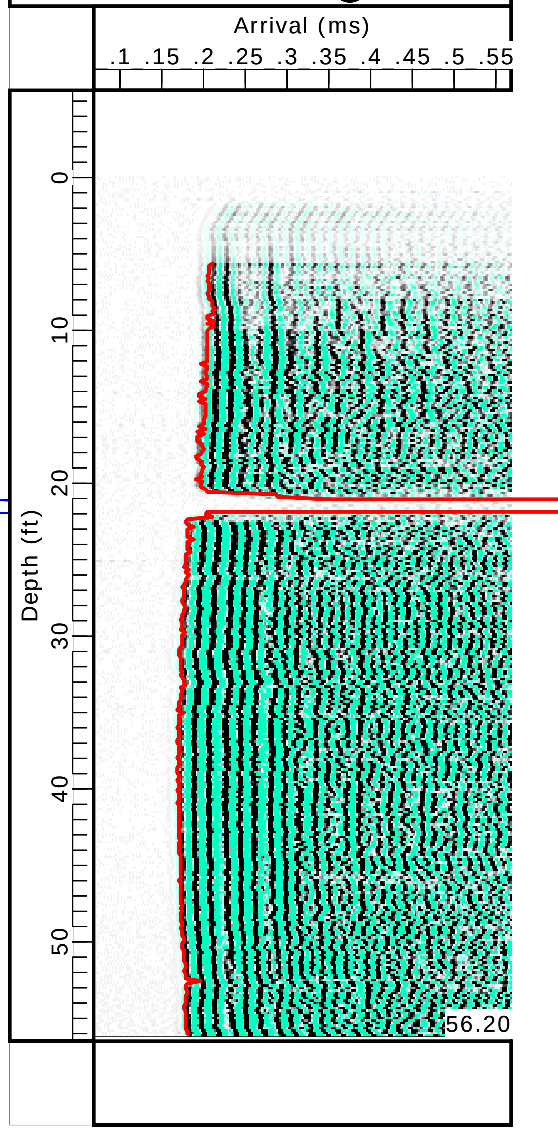
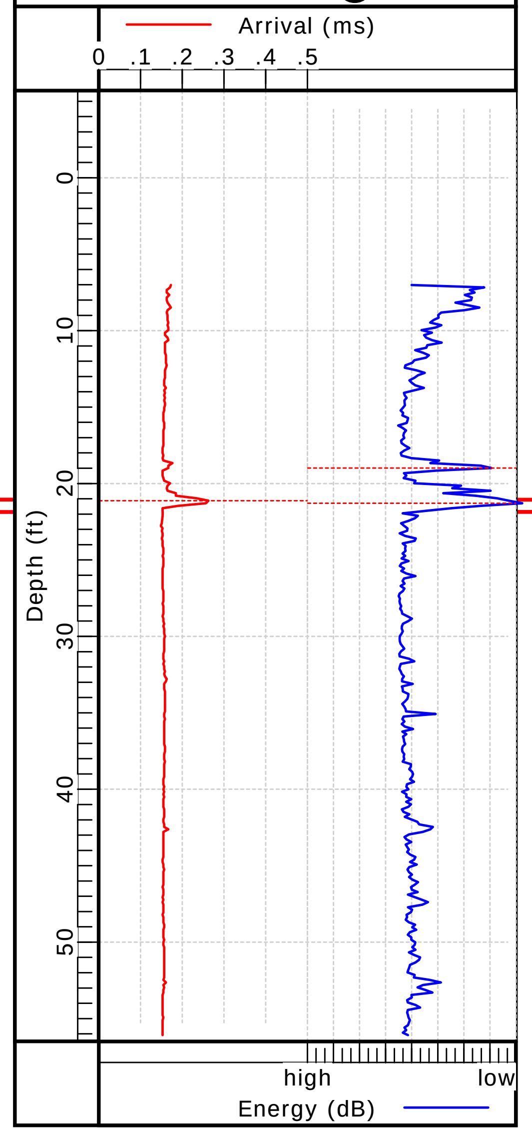
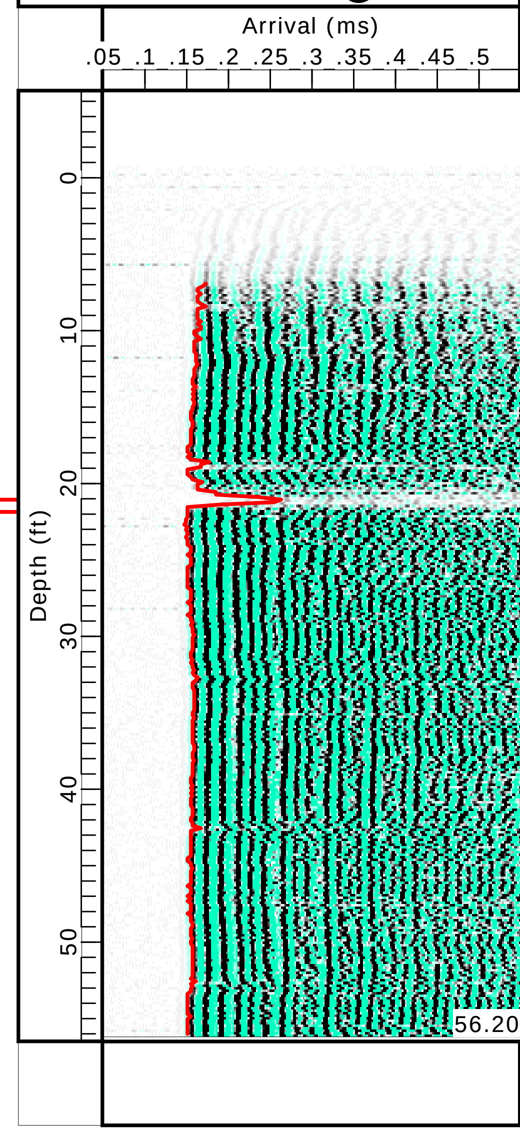
12/16/2014 12:35
12/17/2014 13:27



TEST
Dia=
Design Strength=
Tube Number=8-1
L=62.20,62.10 ft
Spacing=26.0 in
Gain=198
12/16/2014 12:38
12/17/2014 13:27



TEST
Dia=
Design Strength=
Tube Number=8-1
L=62.20,62.10 ft
Spacing=26.0 in
Gain=198 (x6)
12/16/2014 12:38
12/17/2014 13:27



Pile	Profile	Start feet	To feet	Peak feet	Energy Decrease	FAT Delay
TEST	5-6	3.28	5.24	4.26	8.6dB	
TEST	2-8	6.84	10.12	7.17	8.6dB	
TEST	2-4	18.48	19.96	18.81	9.2dB	
TEST	2-3	18.67	19.81	18.83	10.8dB	
TEST	2-7	18.81	19.96	18.97	9.9dB	
TEST	2-8	18.48	19.96	18.97	10.9dB	
TEST	8-1	18.51	19.16	19.00	9.0dB	
TEST	2-5	18.32	19.79	19.14	8.7dB	
TEST	2-6	18.15	21.76	19.14	57.4dB	>100%
TEST	1-5	18.67	21.79	20.15	57.3dB	>100%
TEST	4-8	20.14	21.94	20.96	57.4dB	>100%
TEST	5-8	20.43	22.24	21.09	57.6dB	>100%
TEST	1-4	20.15	21.46	21.13	58.3dB	>100%
TEST	1-2	18.65	21.93	21.27	61.2dB	>100%
TEST	2-8	20.45	22.09	21.27	61.0dB	>100%
TEST	1-3	20.14	21.78	21.29	59.9dB	>100%
TEST	3-8	20.14	22.44	21.29	59.4dB	>100%
TEST	8-1	19.82	21.79	21.30	12.7dB	64%
TEST	2-7	20.78	22.25	21.60	59.6dB	>100%
TEST	6-8	20.48	22.61	21.63	61.4dB	>100%
TEST	1-7	19.49	22.45	21.63	60.9dB	>100%
TEST	7-8	20.48	22.28	21.79	60.6dB	>100%

APPENDIX D

Montana Department of Transportation
2701 Prospect Ave.
P.O. Box 201001
Helena, MT 59620-1001

MEMORANDUM

To:	Kevin Christensen, PE Construction Engineer
From:	Paul Jagoda, PE Construction Engineering Services Engineer
Date:	January 7, 2015

Subject:	Construction Review Report:	Missoula District
	Project Number:	STPB-STPP-HSIP 6-1(106)56
	Project Description	Thompson River-East
	Control Number:	4039
	Contract Number:	12514

Please find the attached Construction Review Report for the subject project. If you have any questions or require additional information, please contact me or Shane Pegram.

PJ/SP/sp

cc:

Ed Toavs, DA	Jim Walther, PE	Chris Riley, PE-FHWA
Bob Vosen, DCE	Lesly Tribelhorn, PE	Gene Kaufman, PE-FHWA
Dean Jones, DOE	Kent Barnes, PE	Lisa Durbin, PE
Tami Hembree, EPM	Ryan Dahlke, PE	Suzy Price
CES Bureau	Chris Hardan, PE	Tyrel Murfitt, PE
Matt Strizich, PE	Tom Martin, PE	
Oak Metcalfe, PE	Heidy Bruner, PE	
Jeff Jackson, PE	Doug McBroom	

Montana Department of Transportation
2701 Prospect Ave.
P.O. Box 201001
Helena, MT 59620-1001

CONSTRUCTION ENGINEERING SERVICES PROJECT REVIEW REPORT

Project Number:	STPB-STPP-HSIP 6-1(106)56	**MDT District:**	Missoula
Project Description:	Thompson River-East	**EPM:**	Tami Hembree
Control Number:	4039	**Contract #:**	12514
Review Date:	Nov. 19 and 20, Dec. 8, 16, and 29, 2014		
Reviewed By:	Shane Pegram	**In Company With:**	Tyrel Murfitt, Paul Coulston, Jason Sorenson
Description of Project:	Construction of a 434 foot continuous welded plate girder structure, approaches, drainages, retaining walls, fencing, signing, and pavement markings. The 1.0 mile project is located over the Thompson River, 4.6 miles east of Thompson Falls, on P-6 (HWY 200) between RP 55.9 and RP 56.9.		
Review Type:	☐ Constructability ☐ Post Construction	■ Investigatory ☐ Subject Specific-	■ Oversight ☐ Training

CONTRACT INFORMATION	
Contractor:	Sletten Construction Company
Contract Amount:	$6,698,801.84
Contract Payments To-Date	$1,089,409.69
Contract Time/Completion Date:	250 Working Days
Contract Time Used to-Date:	62 Working Days
Letting Date:	May 22, 2014
Designed By:	MDT

Background:

The Thompson River-East project's contract requires construction and testing of a sacrificial 8'-0" diameter Osterberg Cell (O-Cell) Load Test drilled shaft before the 8'-0" diameter production shafts are constructed. The test shaft is part of a MDT research project that is described in the special provision, O-Cell Load Testing. The O-Cell Load Test includes placing a sacrificial hydraulic load cell (O-Cell) within the shaft between bearing plates. Hydraulic supply lines, displacement transducers, strain gages, and telltale rods are placed in the shaft prior to pouring concrete. A hydraulic controller, movement transducers, PC, and data logger (Fig. 17 – 20) are attached to these after the shaft has been poured and concrete test cylinders indicate the concrete has reached sufficient strength.

The test is conducted by pressurizing the O-cell through the hydraulic lines, thereby expanding the O-cell and vertically loading the drilled shaft. The O-Cell applies load vertically to both top and bottom plates. This in turn tests the shaft's side shear capacity above the O-cell and the end bearing capacity below the O-cell. Measurements taken and recorded include load applied, O-cell expansion, top of shaft movement, compression of shaft, and strain gage readings. This data is then used to calculate displacements above and below the O-Cell, side shear above the O-Cell, and end bearing below the O-Cell.

Cross Hole Sonic Logging (CSL) was also required for the test shaft. The contract requires placement of CSL tubes by the contractor in order for MDT to complete the CSL testing prior to the O-Cell test.

Sletten Construction Company was awarded the contract for the project after the competitive bidding process. Loadtest USA was subcontracted by Sletten, as per the O-Cell Load Testing special provision, to oversee construction, instrumentation, and testing the shaft.

Sletten's drilled shaft construction plan submittal, along with Load Test's submittal for installation and testing the shaft, was approved prior to beginning construction of the shaft. Sletten's plan for constructing the drilled shafts included telescoping a temporary steel casing starting with an 8'-6" diameter steel casing (Fig. 1) installed simultaneously with excavation of the shaft to approximately 30' below the planned top of the shaft elevation. The next planned step included an 8'-0" diameter steel casing (Fig. 1) installed simultaneously with excavation of the shaft to the planned tip elevation.

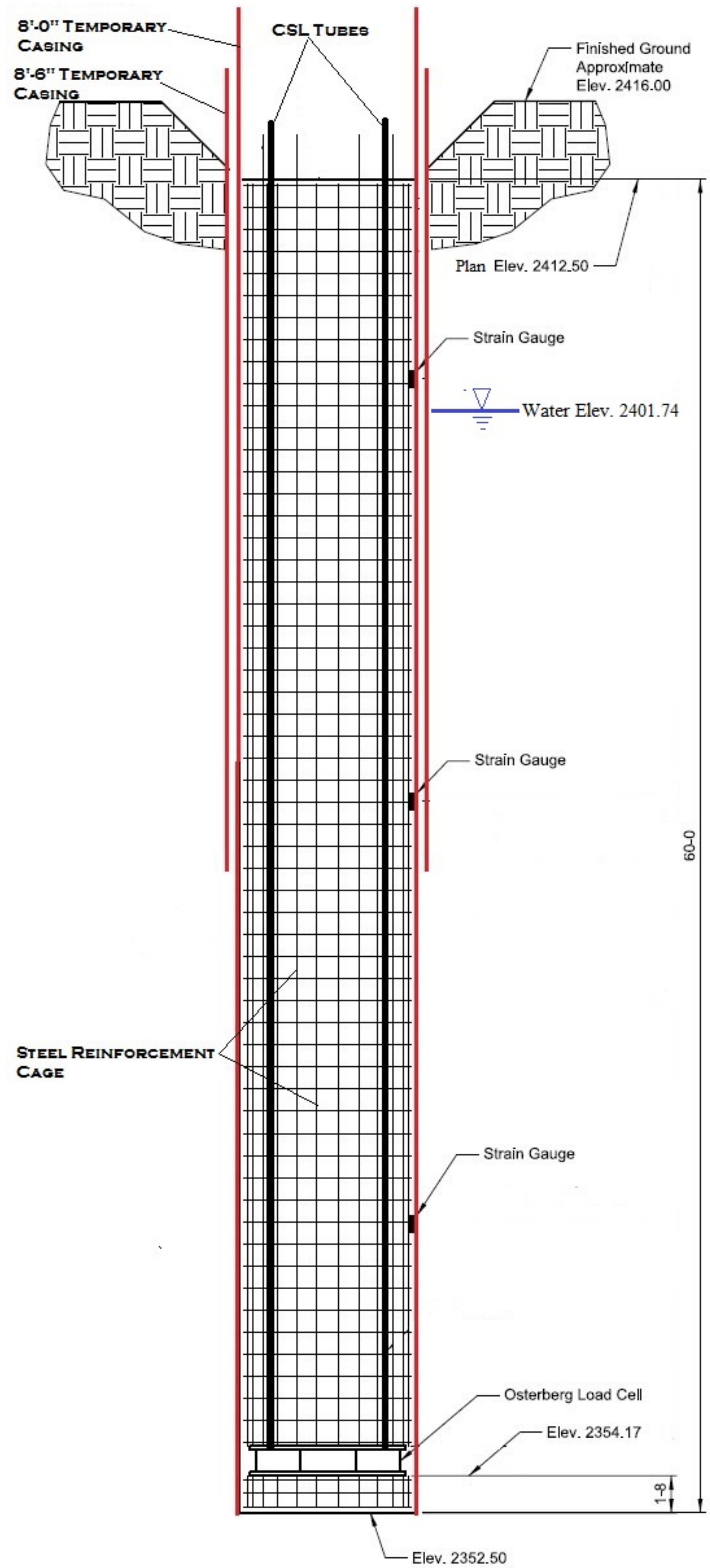


Figure 1: Test Shaft Elevation

Work in Progress:

November 19th and 20th, 2014

The contractor started driving the 8’-6” temporary steel casing and excavating the test shaft on November 17th, 2014 prior to this review. The contractor drove approximately 20’ of an 8’-6” diameter steel casing on the 17th and 18th using a vibratory hammer (Fig. 2) and excavated to the bottom of the casing using a crane mounted drill rig (Fig. 3).

Figure 2: Vibratory Hammer driving temporary steel casing

Figure 3: Crane mounted drill rig

The contractor was welding approximately 11' of temporary steel casing onto the previously driven casing during this review on the 19th. The contractor completed welding and driving the casing as per the approved drilled shaft plan at approximately 5 PM. The steel reinforcement subcontractor, Grizzly Steel, was constructing the steel reinforcement cage (Fig. 4) during the review on the 19th and 20th.

Figure 4: Moving steel reinforcement cage with crane

The contractor assembled the load cell and bearing plates after the review on the 19th and 20th. Figures 5, 6, and 7 were taken by Tyrel Murfitt from the MDT Geotechnical Section during assembly.

Figure 5: O-Cell

Figure 6: Setting the O-Cell into place on the bottom plate assembly

Figure 7: Setting the top plate assembly in place

December 8th, 2014

The contractor scheduled the drilled shaft concrete pour for December 8th after completing the drilled shaft excavation and installing the O-Cell load assembly in the steel reinforcement cage (Fig.8). The water level in the shaft was approximately 50’ above the bottom of the shaft, so a tremie pipe was required to place the concrete according to the “Wet excavation” requirements listed in the special provision. In addition to the special provision requirements, the O-Cell assembly warranted the use of a tremie pipe in order to place concrete beneath both plates of the assembly. The tremie pipe was fastened in place in the cage (Fig. 8) prior to setting the cage in the shaft to aid in placing concrete through the holes in the O-Cell assemblies top and bottom plate.

Figure 8: O-Cell load assembly installed in reinforcement cage

The bottom of the shaft was sounded by MDT inspectors after final cleanout of the drilled shaft. Sounding indicated less than 1 inch of sediment on the bottom of the shaft and met the requirements of the Drilled Shafts special provision. The steel reinforcement cage along with the O-Cell assembly was placed in the shaft shortly afterwards (Fig. 9).

Figure 9: Setting steel reinforcement cage with O-cell assembly into shaft

The approved drilled shaft concrete mix design required a slump flow test instead of a standard slump test. The air content requirements indicated in the special provision were 4-7 %, however unlike SD or DD-Bridge concrete there is no deduct for low air in Drilled Shaft concrete. A change order was approved that removed the air content requirement for Drilled Shaft concrete. This change matches the 2014 Edition of Standard Specification's. MDT's testing indicated that the slump flow tests (Fig. 10) were within tolerances of the mix design and the air tests were between 4% and 5%.

Figure 10: Measuring slump flow

Concrete was placed with a pump truck to fifteen feet above the bottom of the 8'-6" diameter casing before removing the 8'-0" diameter casing (Fig. 1 & 12). Concrete placement continued once the casing was removed. The 8'-6" diameter casing was removed once concrete placement reached slightly above the finished elevation.

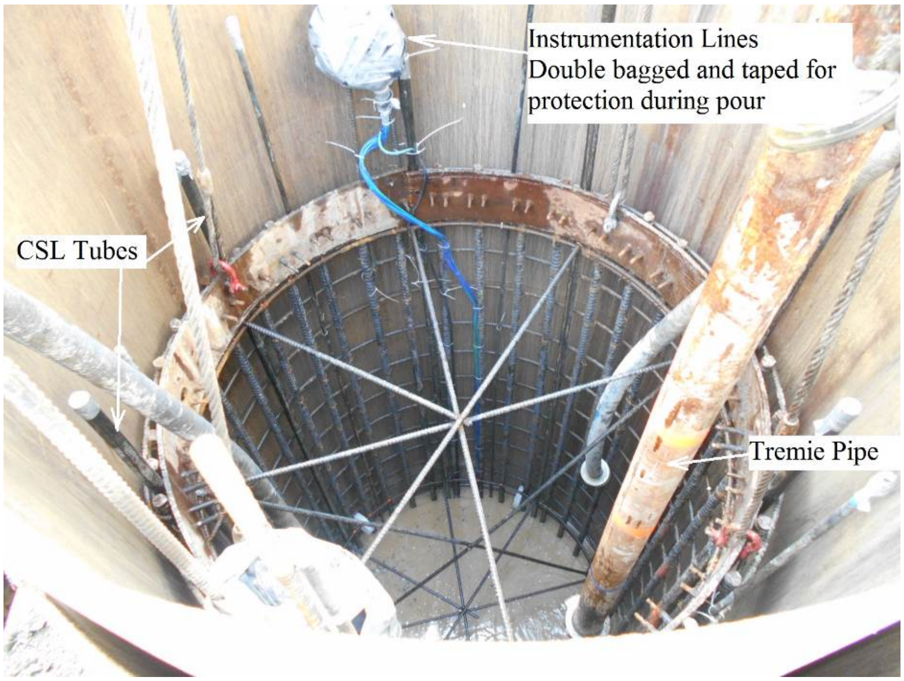


Figure 11: Pumping concrete beneath water with tremie pipe

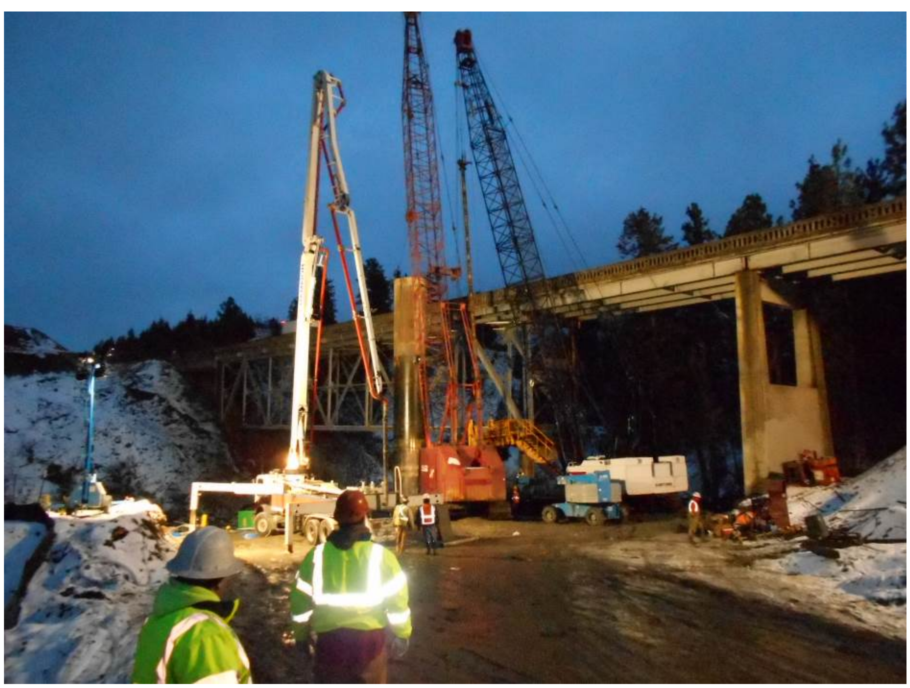


Figure 12: Removing 8'-0" diameter temporary steel casing

The shaft was overfilled after removing the temporary casing to pump off all undesirable concrete that was contaminated during the underwater placement. (Fig. 13)

Figure 13: Cleaning undesirable/contaminated concrete from the top of the shaft

Figure 14: Removing template day after pour

December 16th, 2014

CSL testing of the test shaft (Fig. 15) was done on the 16th of December. The O-Cell Load Test special provision specifies that CSL testing acceptance and corrective action for the test shaft will follow the requirements of the Drill Shaft special provision.

Figure 15: CSL testing O-Cell test shaft

The 8'-0" diameter shaft has eight 1.5" steel tubes spaced evenly around the perimeter of the reinforcement cage that were used for CSL testing. All tube pair combinations were tested. CSL testing indicated an anomaly (Fig. 16) approximately 21 feet below the top of the shaft that is located between tubes 2 and 8.

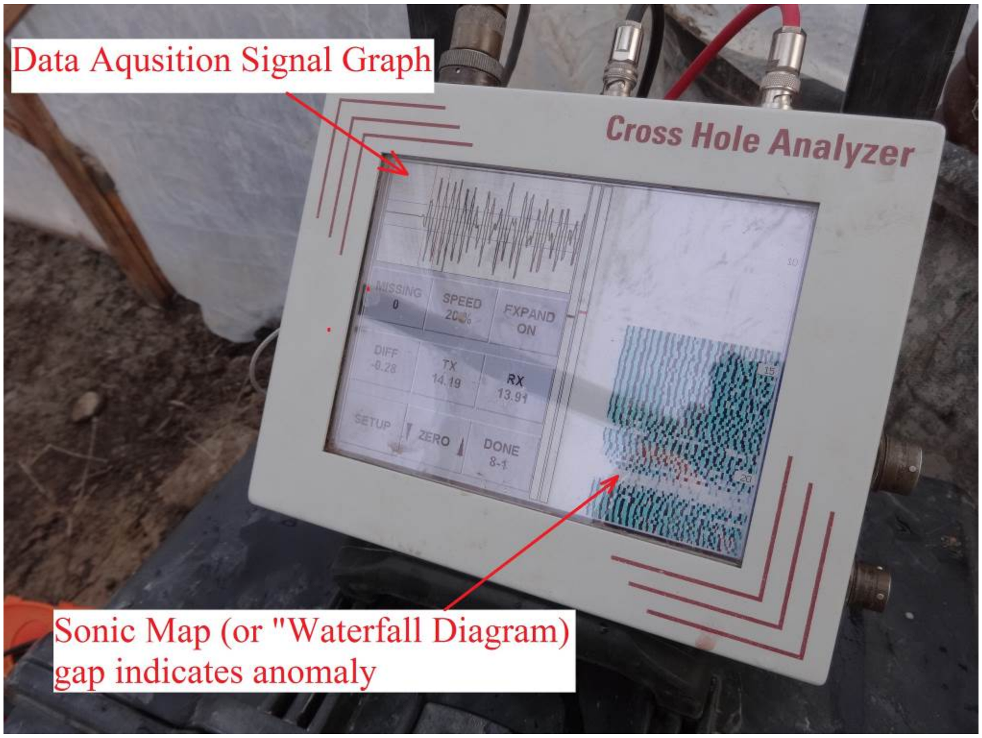


Figure 16: Cross Hole Analyzer view while testing

MDT requested that LoadTest review the CSL results found in the CSL report and advise MDT to the effects of the anomaly on the O-Cell test. LoadTest reviewed the results and did not believe the anomaly would affect the test and believed that the potential to damage the O-Cell instrumentation outweighed any potential benefit that further investigation might have. Following review of LoadTest's assessment, MDT approved the contractor to move forward with the O-Cell test. MDT's CSL report can be found at the following link:
S:\WEB\INTERNAL\REPORTS\CONSTRUCTION_REVIEW_REPORTS\4039_THOMPSON_RIVER_EAST-TEST_SHAFT_CSL_REPORT.PDF

December 29th, 2014

The O-Cell test was performed by LoadTest on the 29th of December. The results of the test were submitted to MDT in report form on January 7, 2015. The maximum tested load was 3,847 kips @ a displacement of 1.67". Displacements of 0.23" and 0.88" were recorded at 1500 kips and 3000 kips, respectively. MDT's Geotechnical Section reviewed the report and determined that the test was successful and in compliance with the contract documents.

MDT's Geotechnical Section will complete a report that documents the test and results as part of the research project. The report will be available on MDT's Research Projects web page:
http://www.mdt.mt.gov/research/projects/sub_listing.shtml

Figure 17: O-Cell testing the shaft

Figure 18: Instrumentation and wiring at top of shaft

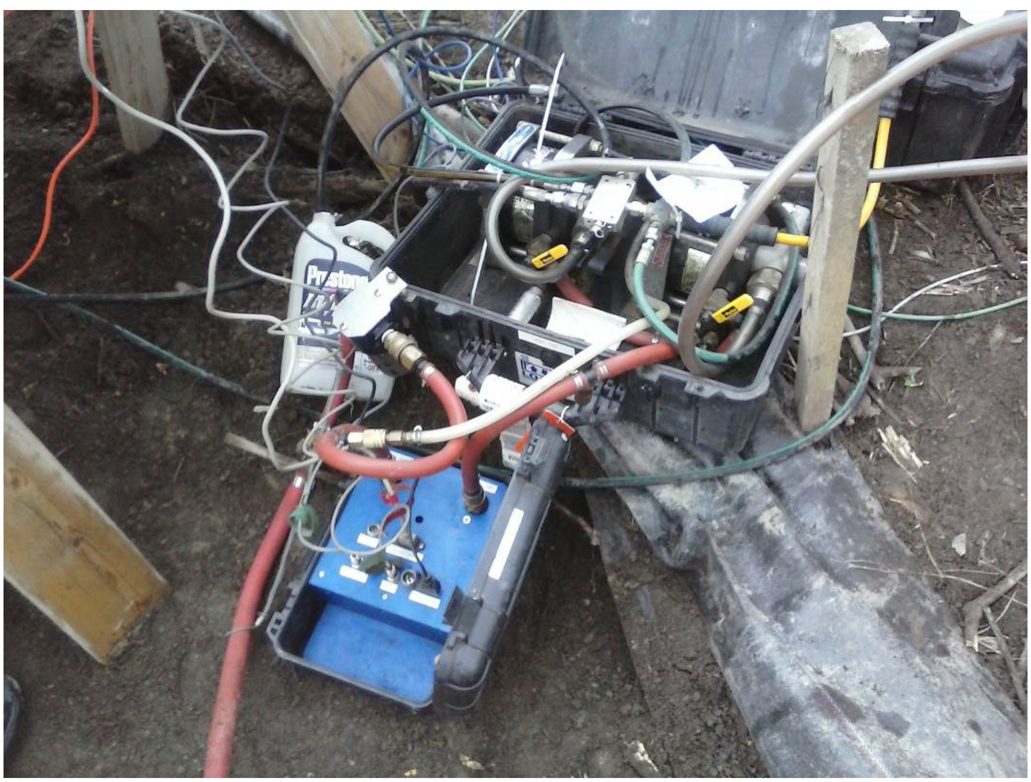


Figure 19: Hydraulic Pump and Controller

Figure 20: Automated Digital Survey Levels

Figure 21: PC used to collect data

Traffic Control: The bridge work that was occurring during these reviews is on the new alignment and was not affecting traffic. There was no traffic control on the roadway.

Erosion Control and Environmental Issues: Silt fence was installed throughout the project but was not inspected.

Change Orders:

Table 1: Change Order Summary Table

#	Description	Amount	Days
001	Migratory Bird Treaty Act – Vegetation Removal	$0	0
002	Delete air content requirement – drilled shaft concrete	$0	0

Claims: N/A

Daily Work Reports (DWRs) & EPM Diaries: Daily Work Reports and EPM Diaries for the review dates were reviewed and appear to document the daily work activities.

Questions from Project Staff: N/A

Issues Discussed and Resolved: Sletten's superintendent and MDT's inspectors requested additional information on how MDT wanted the top of the drilled shafts on Pier 3 to be formed. The top of the left and right 8'-0" diameter shafts will be approximately 8 feet and 3 feet, respectively, above the existing ground level. The existing topography and the shafts' location in relation to the river are not conducive to backfilling. The top of the shafts will need to be constructed with either a permanent steel casing or with a cold joint at ground level then formed above that. The plans did not indicate a cold joint or permanent casing, so the contractor was seeking direction from MDT. Furthermore, Drilled Shaft concrete was specified for the entire shaft.

It appeared that forming the top of the shaft was the most likely solution since permanent casing was not planned for and the contractor does not have the documentation required for the temporary steel casing on site to meet Buy America requirements if used as a permanent steel casing. However, this is part of the contractor's means and methods, so MDT requested the contractor submit a plan for constructing the top of the shaft. The contractor was notified that air entrained concrete (DD-Bridge) would be required above ground level instead of Drilled Shaft concrete.

The contractor submitted a plan to form the top of the shafts with 8’-0” diameter column forms and DD-Bridge concrete. The plan was approved by MDT.

Issues Discussed and Follow-Up Needed: Sletten will submit an additional compensation request for forming the top of the 8’-0” diameter shafts at Pier 3 for MDT’s review prior to beginning work on the shafts.

Areas of Good Practice/Positive Aspects: MDT’s EPM and crew responsible for this project is an experienced bridge construction crew. They have consistently kept MDT’s Bridge, Geotech, and the Bridge Reviewer up to speed on the contractor’s schedule and copied us on relevant correspondence.

Other Follow-Up Items: N/A

End of Report

APPENDIX E

Montana Department of Transportation
PO Box 201001
Helena, MT 59620-1001

MASTER FILE COPY

Memorandum

To: Jeff Jackson, P.E.
Geotechnical Engineer

From: Nigel Mends, P.E.
Missoula Bridge Area Engineer

Date: February 27, 2012

Subject: STPP 6-1(87)56
Thompson River - East
UPN 4039
Preliminary Geotechnical Loads

Attached are the axial loads, lateral forces and moments for the applicable LRFD load combinations for the bridge over Thompson River at Sta. 23+20.50. Also attached are sketches of the bridge crossing, end bent and pier. The bridge is a three-span, continuous, steel beam structure with spans of 165-165 and 104 feet. The bridge section consists of a 42 ft. 1 in. wide bridge deck with four 72 in. beams spaced at 11 ft. 6 in. centers.

The end bents consist of free standing U-shaped abutments that allow for superstructure movement in the longitudinal direction. For system stiffness considerations and estimating seismic loads, two 4.5 ft. diameter drilled shafts were assumed as foundations for each end bent. The loads are calculated at the bottom of cap elevation and are reported per end bent, as well as per drilled shaft.

The piers consist of two 6.0 ft. diameter concrete columns that are connected by a pier cap, a strut and a foundation cap. The bottom of the foundation cap is assumed to be at elevation 2405.0 (0.7 ft. above the Q2 elevation). In order to estimate seismic loads at the piers, the two 6.0 ft. diameter columns were assumed to extend below the foundation cap and serve as drilled shaft foundations for each pier (subject to change based on the January 23, 2012 meeting). The distance between the two columns is 34.50 feet. The loads are calculated at the bottom of foundation cap elevation and are reported per pier, as well as per column.

Please furnish geotechnical foundation recommendations for the end bents and piers based on these preliminary loads. Also, please provide appropriate LPILE data for further modeling of the bridge structure.

NNM:JJS:4039BRCSP002.DOCX, w/ attachments

cc: Crew file
File

Total End Bent *Load at Bottom of Cap*

Design by: JJS 2/27/2012

Chk'd by: ________________

STPP 6-1(87)56
Thompson River - East
UPN 4039

Service I - Axial Force Total =	1220	kip
Service I - Shear Force Total (Trans.) =	20	kip
Service I - Shear Force Total (Long.) =	268	kip
Extreme Event I - Axial Force Total =	1290	kip
Extreme Event I - Shear Force Total (Trans.) =	839	kip
Extreme Event I - Shear Force Total (Long.) =	364	kip
Strength I - Axial Force Total =	1700	kip
Strength I - Shear Force Total (Trans.) =	0	kip
Strength I - Shear Force Total (Long.) =	349	kip
Strength III - Axial Force Total =	1220	kip
Strength III - Shear Force Total (Trans.) =	57	kip
Strength III - Shear Force Total (Long.) =	347	
Strength V - Axial Force Total =	1570	kip
Strength V - Shear Force Total (Trans.) =	24	kip
Strength V - Shear Force Total (Long.) =	354	kip

End Bent Load Summary - ***Per Column***

Design by: JJS 2/27/2012

Chk'd by: ________________

STPP 6-1(87)56
Thompson River - East
UPN 4039

Service I - Axial Force Total =	652	kip
Service I - Shear Force Total =	134	kip
Extreme Event I - Axial Force Total =	650	kip
Extreme Event I - Shear Force Total =	457	kip
Strength I - Axial Force Total =	931	kip
Strength I - Shear Force Total =	174	kip
Strength III - Axial Force Total =	636	kip
Strength III - Shear Force Total =	176	kip
Strength V - Axial Force Total =	841	kip
Strength V - Shear Force Total =	178	kip

Total Pier *Load at Bottom of Foundation Cap**

Design by: JJS 2/27/2012

Chk'd by: ________________

STPP 6-1(87)56
Thompson River - East
UPN 4039

Service I - Axial Force Total =	3190	kip
Service I - Shear Force Total (Trans.) =	48	kip
Service I - Shear Force Total (Long.) =	96	kip
Service I - Moment Total (Trans.) =	3320	ft-kip
Service I - Moment Total (Long.) =	6590	ft-kip
Extreme Event I - Axial Force Total =	3570	kip
Extreme Event I - Shear Force Total (Trans.) =	16	kip
Extreme Event I - Shear Force Total (Long.) =	111	kip
Extreme Event I - Moment Total (Trans.) =	1100	ft-kip
Extreme Event I - Moment Total (Long.) =	7610	ft-kip
Strength I - Axial Force Total =	4300	kip
Strength I - Shear Force Total (Trans.) =	0	kip
Strength I - Shear Force Total (Long.) =	87	kip
Strength I - Moment Total (Trans.) =	0	ft-kip
Strength I - Moment Total (Long.) =	5980	ft-kip
Strength III - Axial Force Total =	3470	kip
Strength III - Shear Force Total (Trans.) =	149	kip
Strength III - Shear Force Total (Long.) =	164	kip
Strength III - Moment Total (Trans.) =	12280	ft-kip
Strength III - Moment Total (Long.) =	11290	ft-kip
Strength V - Axial Force Total =	4060	kip
Strength V - Shear Force Total (Trans.) =	59	kip
Strength V - Shear Force Total (Long.) =	119	kip
Strength V - Moment Total (Trans.) =	4050	ft-kip
Strength V - Moment Total (Long.) =	8190	ft-kip

*Transverse moments are about bottom center of assumed foundation cap.

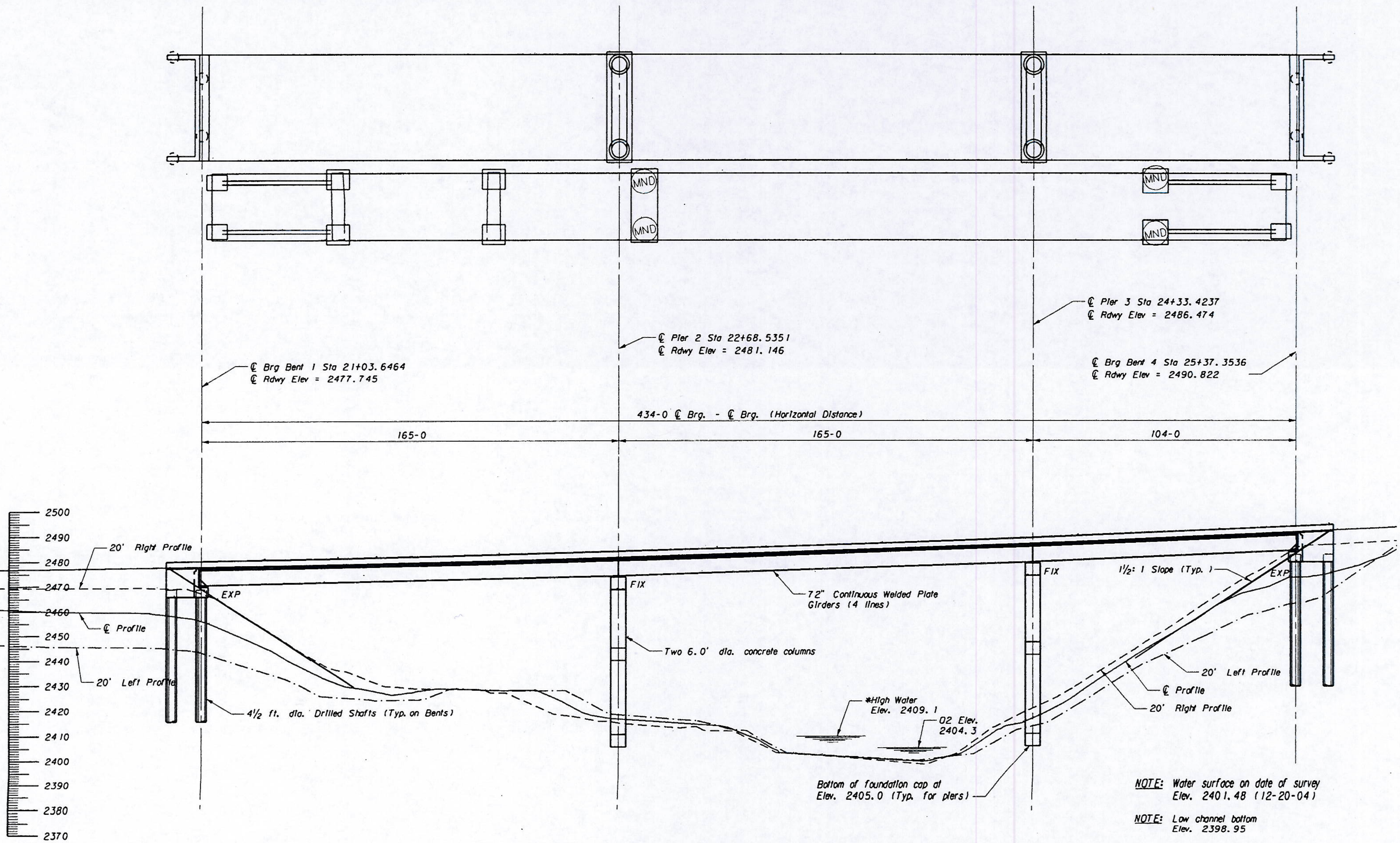
*Pier Load Summary - **Per Column***

Design by: JJS 2/27/2012

Chk'd by: ____________________

STPP 6-1(87)56
Thompson River - East
UPN 4039

Service I - Axial Force Total =	1710	kip
Service I - Shear Force Total =	54	kip
Service I - Moment Total =	3340	ft-kip
Extreme Event I - Axial Force Total =	1880	kip
Extreme Event I - Shear Force Total =	56	kip
Extreme Event I - Moment Total =	3810	ft-kip
Strength I - Axial Force Total =	2240	kip
Strength I - Shear Force Total =	44	kip
Strength I - Moment Total =	2990	ft-kip
Strength III - Axial Force Total =	1990	kip
Strength III - Shear Force Total =	113	kip
Strength III - Moment Total =	5920	ft-kip
Strength V - Axial Force Total =	2180	kip
Strength V - Shear Force Total =	67	kip
Strength V - Moment Total =	4150	ft-kip


MND
MND
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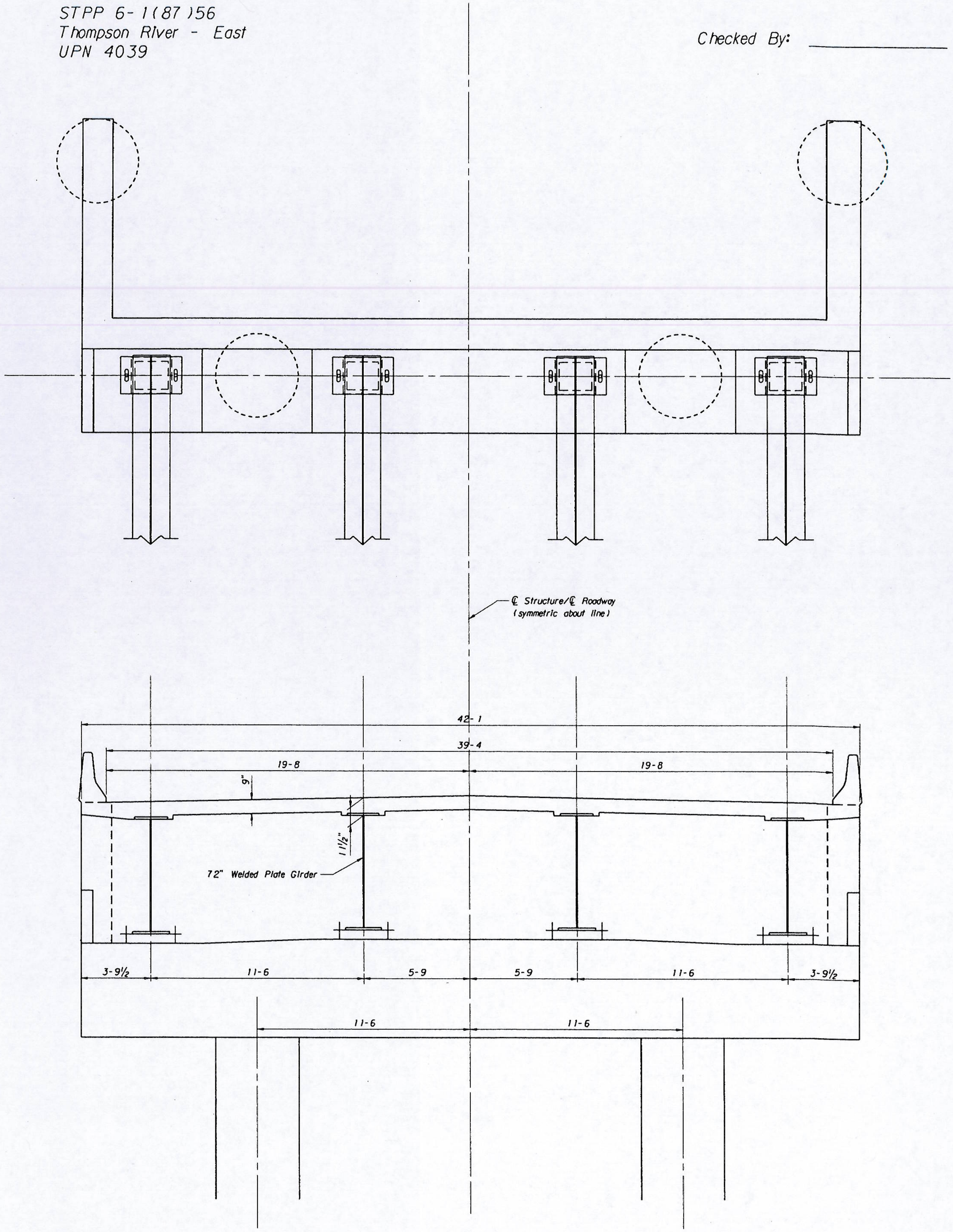
MND
℄ Pier 3 Sta 24+33.4237
℄ Rdwy Elev = 2486.474
℄ Pier 2 Sta 22+68.5351
℄ Rdwy Elev = 2481.146
℄ Brg Bent 1 Sta 21+03.6464
℄ Rdwy Elev = 2477.745
℄ Brg Bent 4 Sta 25+37.3536
℄ Rdwy Elev = 2490.822
434-0 ℄ Brg. - ℄ Brg. (Horizontal Distance)
165-0
165-0
104-0
2500
2490
2480
2470
2460
2450
2440
2430
2420
2410
2400
2390
2380
2370
20' Right Profile
℄ Profile
20' Left Profile
EXP
FIX
FIX
EXP
72" Continuous Welded Plate Girders (4 lines)
1½: 1 Slope (Typ.)
Two 6.0' dia. concrete columns
4½ ft. dia. Drilled Shafts (Typ. on Bents)
*High Water Elev. 2409.1
02 Elev. 2404.3
Bottom of foundation cap at Elev. 2405.0 (Typ. for piers)
20' Left Profile
℄ Profile
20' Right Profile
NOTE: Water surface on date of survey Elev. 2401.48 (12-20-04)
NOTE: Low channel bottom Elev. 2398.95

Preliminary Sketch - Bent 1

STPP 6-1(87)56
Thompson River - East
UPN 4039

Designed By: JJS 2-22-12

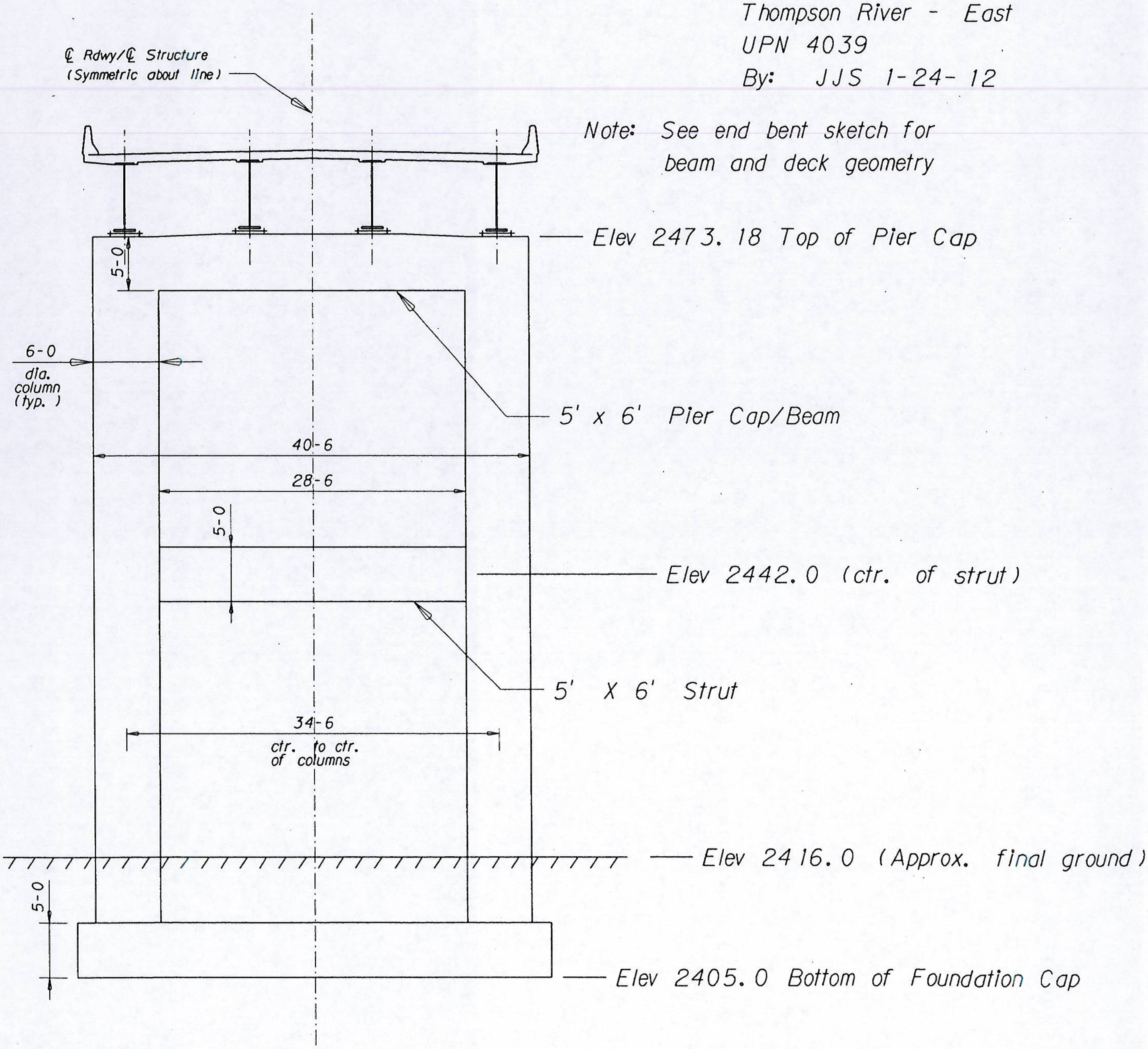
Checked By: ____________



Elevation View of Pier 2

STPP 6-1(87)56
Thompson River - East
UPN 4039
By: JJS 1-24-12

Note: See end bent sketch for beam and deck geometry



APPENDIX F

MASTER FILE COPY

Montana Department of Transportation
PO Box 201001
Helena, MT 59620-1001

To: Doug Moeller
District Administrator - Missoula

From: Tim Holley, E.I.
Geotechnical Engineer – Missoula District

Bret Boundy, P.G.
Geotechnical Engineering Manager – Missoula District

Date: August 26, 2009

Subject: Geotechnical Engineering Alignment Report (464)
Thompson River - East
STPP 6-1(87)56
UPN 4039

The enclosed geotechnical report provides our recommendations for completion of Activity 464 (Geotechnical - Alignment). This report and enclosed attachments describes our field investigations, subsurface conditions encountered, laboratory testing performed, and our recommendations for cut and fill slopes, embankment foundations, and general recommendations for construction of the roadway only. Recommendations pertaining to the bridge portion of this project will be addressed later in the Geotechnical Structures Report. We will provide appropriate special provisions after we have received any comments or concerns from the design team.

This geotechnical report is based upon the proposed alignment and grade, as of August 12, 2009. In the event changes to the alignment or grade are required, the Geotechnical Section should be notified to review the changes, and determine if they affect the recommendations contained within this report.

1.0. PROJECT LOCATION AND INFORMATION

1.1. Project Location. This project is located on Montana Highway 200 in Sanders County. The project begins at Reference Post (RP) 55.8 and extends approximately 0.9 miles to the east to RP 56.8.

1.2. Proposed Scope of Work.

The proposed scope of work is to reconstruct the existing highway between RP 55.96 and 56.75 (Station 1+50 to 46+50), and replace the bridge over the Thompson River at RP 56.3. The existing bridge is 427 feet long, with a 24-ft. roadway. The new bridge would be about 338 feet long, with a 40-ft roadway. The proposed alignment centerline will be offset from the Present Traveled Way (PTW) centerline approximately 30' to the north.

Earthwork will consist of fill placement to maximum heights on the order of 30 feet and excavations with maximum cut heights of approximately 40 feet. Standard cut and fill slopes appropriate for this route have for the most part been used. Depending on the height of fill, the proposed fill slopes for this project are either 4:1, 3:1 or 2:1. Proposed cut slopes are 1.5:1 or flatter.

The MDT Pavement Analysis Section has recommended the following surfacing typical section:

0.30 ft - Plant Mix Bituminous Surfacing
0.90 ft - Crushed Aggregate Course
1.20 ft - Total

1.3. Geotechnical Summary. The soils along the alignment consist mostly of relatively loose sands and gravels. Our recommendations for design and construction in these soil conditions are discussed in the text of the report.

2.0 GEOTECHNICAL INVESTIGATION AND SUBSURFACE CONDITIONS

2.1. Geology and Site Conditions. The area is mapped as the Precambrian Ravalli Group (pCr) of the upper Belt Super Group. In this area, the rocks are siliceous, ranging from quartzite to siliceous shale, mostly gray, green, purple, and red. Faulting is prevalent in the area. Bedding generally dips to the west, with some variation due to localized folding.

At approximately RP 56.2, an old slope failure can be observed on the south side of the highway. Barrier rail is placed along the shoulder in this area. The proposed alignment is set back away from this slide, which will reduce impact on the existing slide. Any further shift in alignment to the north, away from the slide, would be beneficial in terms of stability.

2.2. Subsurface Investigation. The MDT Field Investigation Unit completed 12 geotechnical borings along the alignment of this project. Borings numbered 4039-17 through 4039-28, were completed between February and April 2006 with a CME 850 ATV drill rig. Boring 4039-32 was completed along the alignment with a CME 45 skid rig drill in April of 2009. Borings 4039-17, 4039-18, 4039-28, and 4039-32 were completed at the proposed bridge foundation locations, and are therefore not included in this report. The geotechnical boring logs for the remaining borings are provided in the Appendix. The depths of the geotechnical borings for the roadway varied from 45 to 65 feet below existing grade. Hollow-stem auger and casing advancer techniques were used to advance the borings. Sampling consisted of split-spoon Standard Penetration Tests (SPT) and rock coring.

2.3. Subsurface Conditions. Predominantly sands and gravels were encountered in the soil borings. Scattered cobbles and boulders were also encountered

2.3.a. Sands and Gravels. The predominant soils along the alignment consist of A-1 (sand and gravel), A-2 (silty sand), with some A-4 (silt). The soils are loose to dense with SPT N-values between 5 and 40 blows/foot. The average N-values for borings from approximately Station 15+50 to 21+50 were in the range of 7 to 10 blows per foot, indicating the soils are generally loose. Some of the loose sands could potentially liquefy during a seismic event, and this potential will be analyzed and included in the Geotechnical Structures Report.

2.3.b. Groundwater Observations. Groundwater was encountered in some of the geotechnical borings. Table 1 summarizes groundwater observations for the four borings where groundwater was encountered. The observations were made on the date(s) the borings were drilled.

Table 1. Groundwater Observations.

Location	Boring No.	Ground Surface Elevation (ft)	Water Level Observations (ft)	
			Depth While Drilling	Remarks
Sta. 15+90	4039-20	2433.5	25	Water used as drilling fluid
Sta. 17+19	4039-19	2425	24	Cave-in @ 17 ft after augers and casing removed
Sta. 18+01	4039-17	2428	27.5	Heaving sands encountered
Sta. 18+98	4039-18	2414	14.5	Cave-in @ 12.5 ft after casing removal

The groundwater levels encountered during our drilling program are also presented on the attached boring logs. These water levels are representative of the time and location where the boring was advanced. Groundwater levels will fluctuate in response to seasonal variations and may be encountered at different depths during construction. Water levels will likely be higher during spring conditions or in a year with higher precipitation.

3.0 LABORATORY AND IN-SITU TESTING

Geotechnical index testing including gradations, Atterberg limits, and moisture content was performed on select Standard Penetration Test (SPT) split spoon samples. Generally, the soils exhibited low moisture contents, averaging approximately 5 percent. The majority of samples tested were non-plastic, as to be expected with predominantly granular soils. Loose sands below the water table are of particular concern for liquefaction potential in a seismic event.

For additional information regarding the subsurface conditions, see the attached boring logs in the Appendix.

4.0 DESIGN AND CONSTRUCTION RECOMMENDATIONS

As was briefly discussed within sections 2.0 and 3.0 of this report, loose sands are present throughout the project. These soils may be susceptible to liquefaction, and will require further analysis. The areas most likely to be affected by this potential are those closest to the water table, namely from approximate Stations 11+00 to 17+00, and near the ends of the bridge. Additional design and construction recommendations for the vicinity of the bridge will be discussed within the Geotechnical Structures Report.

4.1 Embankment Foundations

The proposed alignment typically utilizes the existing PTW embankment within the new embankment prism. Given the granular nature of the in-situ soils, overall settlements should be small and occur during construction.

4.2 Embankment Slopes

Depending on the height of the fill, the majority of the proposed fill slopes for this project are either 4:1, 3:1 or 2:1. These slopes should be acceptable for backfill materials consisting of native A-1 or A-2 soils compacted to 95% of maximum density.

4.3 Cut Sections

Proposed cuts are generally 1.5H:1V or flatter. We anticipate these proposed cut slopes will be globally stable in their proposed slope ratios. However, slopes of 2H:1V would be better suited for revegetation purposes, and increased surficial stability. This project is to be constructed in loose sand and gravel soil types that are highly susceptible to surface erosion and potentially difficult to re-establish vegetation. An aggressive slope erosion protection and revegetation plan will be especially important for cut slopes steeper than 2H:1V. Areas where drainage paths are directed downhill, away from the road, would benefit from riprap armoring backed by drainage geotextile to help prevent surface erosion.

4.4 Grading Material (Shrink/Swell)

We estimate a 25 to 35 percent volume shrink factor based on the compaction of the in-situ soil, and loss of material due to grading and haul operations. We did not encounter any materials during our investigation that would be expected to undergo a volume expansion (swell) when excavated and compacted.

4.5 Seismicity

The site is mapped as a zone of moderate seismic ground movement. Based on the coarse grained nature of the soils and relative proximity of the water table, there is some risk of liquefaction, lateral spreading, or slope failure. Based upon the required costs associated with constructing cut slopes or embankments to withstand seismic loading, we anticipate the Department will not elect to mitigate the potential for seismically induced slope instability or settlement not directly associated with the new bridge. We should be notified if this assumption is incorrect or if additional recommendations with respect to seismic stability are requested. We will provide further recommendations for the bridge foundation and liquefaction potential in our Geotechnical Structures Report.

4.6 Special Borrow/Typical Section

The 2 feet of special borrow typically utilized for Missoula District projects should not be necessary due to the generally coarse-grained nature of the native soils available on this project.

5.0 Limitations

Professional judgments and recommendations are presented in this report. They are based partly on evaluation of the technical information gathered, partly on historical reports and partly on the Geotechnical Section's general experience with subsurface conditions in the Missoula District. The Geotechnical Section does not guarantee the performance of the project in any respect other than that the engineering work and the judgment rendered meet the standards and care of the profession. It should be noted that the borings may not represent potentially unfavorable subsurface conditions between borings. If, during construction, soil, rock, or water conditions are encountered that vary from those discussed in this report or historical reports, or if alignment and grade changes are required, the Geotechnical Section should be notified immediately in order that it may evaluate effects, if any, on our recommendations. The recommendations presented in this report are applicable only to this specific site. These data are not to be used for other purposes.

If there are any questions regarding the report or a meeting is requested, please contact Tim Holley by phone at (406) 444-7617 or email at tholley@mt.gov or Bret Boundy at (406) 444-6278 or via email at bboundy@mt.gov.

CC: Shane Stack, P.E., D.E.S.S. – Missoula (w/o attachments)
Jake Goettle, P.E., Construction – Helena
Matt Strizich, P.E., Materials – Helena (w/o attachments)
Mark Goodman, P.E., Hydraulics - Helena (w/o attachments)
Tom Martin, P.E, Environmental - Helena (w/o attachments)
Nigel Mends, P.E., Bridge – Helena (w/o attachments)

Geotechnical Correspondence File

Attachments: Boring Logs
Boring Log Key
Summary of Soil Index Tests

Logs of Boring have been removed, please refer to Appendix A

Montana Department of Transportation
PO Box 201001
Helena, MT 59620-1001

Memorandum

To: Chris Hardan, P.E.
Bridge Design Engineer

From: Tyrel Murfitt, E.I.
District Geotechnical Engineer - Missoula

Thru: Bret Boundy, P.G.
District Geotechnical Manager - Missoula

Date: 8 November 2012

Subject: Geotechnical Engineering Report (466 - Structures)
Thompson River East
STPP-BR 6-1(106)56
UPN 4039

The Geotechnical Section has been requested to provide a geotechnical engineering report for the proposed structure over the Thompson River, East of Thompson Falls for the subject project. This report includes the results of the subsurface exploration, laboratory testing, analyses, and geotechnical recommendations in relation to the design of the bridge foundations and retaining walls. Geotechnical recommendations for the design and construction of the project alignment and minor structure features were provided in a Geotechnical Alignment Reported Dated 26 August 2009.

1.0 PROJECT LOCATION AND INFORMATION

The subject project proposes to replace the existing structure over the Thompson River at RP 56.3 and to reconstruct the highway approaches to the bridge. The new structure will be built on an offset alignment and the road approaches will be reconstructed to tie into the PTW. The reconstruction begins at RP 55.9± and extends easterly to RP 56.9±.

The existing 24 foot wide and 428 foot long structure was constructed in 1935. The structure is fracture critical, structurally deficient, and functionally obsolete.

2.0 PHYSIOGRAPHY AND GEOLOGY

The local geology is mapped as Quaternary alluvium, dominantly alluvial terrace, abandoned channel and floodplain, also remnant alluvial fans, and local glacial outwash. The local bedrock is mapped as the Piegan, and Lower Missoula group. The Piegan group consists of both the Wallace and Helena formations, consisting of dolomitic quartzite and siltite, with black argillite and quartzite with green siltite and argillite capped by dolomite beds, also includes gray limestone and dolomitic limestone.

3.0 SUBSURFACE INVESTIGATION

The MDT Field Investigation Unit advanced six borings near the proposed bridge foundation elements. The borings were advanced with a Central Mine Equipment (CME) 850 and 45, and a Christensen CS 2000 drill rig. Drilling was performed utilizing hollow stem auger, and both H and N casing advancers. Subsurface sampling procedures included the Standard Penetration Test. Samples were obtained in accordance with generally accepted geotechnical and ASTM procedures.

3.1 Subsurface Conditions

Subsurface soil varied widely from one side of the river to the other. Generally on the western side of the Thompson River, the subsurface soils encountered were gravel from the surface to approximately 30 feet, followed by alternating layers of sand, silt, and clay. On the eastern side of the Thompson River, gravel with varying contents of sand and silt was encountered. Formation material was not encountered.

Groundwater was encountered in all borings advanced for the bridge foundation elements. Groundwater levels will fluctuate in response to seasonal variations and may be encountered at different depths during construction when compared to the depths indicated on our boring logs.

For more information regarding the subsurface conditions, see the attached Boring Logs and Summary of Laboratory Tests.

4.0 DESIGN RECOMMENDATIONS

4.1 Bridge Foundation Loading

Loading information was provided to the Geotechnical Section by the Bridge Bureau via memorandum on 27 February 2012. In the table below is a summary of "Per Column" loading. The loading for this bridge was developed using AASHTO LRFD Bridge Design Specification – 4th Edition – 2007.

Table 1 Per Column Loading

Foundation	Axial (kip)	Lateral (kip, ft-kip)	Loading Type
End Bent	931	174 (V)	Strength I
End Bent	650	457 (V)	Extreme Event I
Pier	2240	44 (V), 2990 (M)	Strength I
Pier	1990	113 (V), 5920 (M)	Strength III

4.2 Bent 1 Foundation Recommendations

We recommend a foundation system consisting two 6.0 ft. Diameter drilled shafts penetrating to a design tip of 2390 ft.

4.3 Bent 2 Foundation Recommendations

We recommend a foundation system consisting of two 8.0 foot diameter drilled shafts penetrating an estimated 70 feet below existing grade to a tip elevation of 2342.0 ft. with a center to center spacing of 4 diameters (32 feet). We also recommend an 8.0 ft. diameter test shaft be constructed within 30 feet of the production shafts, at coordinate (N,E), (1265651, 554508). For the Test Shaft we recommend that a subcontractor be hired to design and install an Osterberg-cell load test to verify design data used in the development of the foundation at this Pier. The results of this test shaft will be used to determine if the production shafts will require more depth or can be stopped at the estimated 70 feet of penetration. The Research Section has been contacted and will be developing a work plan to be submitted to FHWA for approval to allow the experimental use of Osterberg Load Cells on the project.

4.4 Bent 3 Foundation Recommendations

We recommend a foundation system consisting of two 8.0 foot diameter drilled shafts penetrating 75 feet below existing grade to a tip elevation of 2345 ft. with a center to center spacing of 4 diameters (32 feet).

4.5 Bent 4 Foundation Recommendations

We recommend a foundation system consisting of two 6.0 foot diameter drilled shafts penetrating 65 feet below existing grade to a tip elevation of 2420 ft.

4.6 Table of Foundation Recommendations

Bent	Diameter	Tip Elevation
1	Twin 6.0’	2390
2	Twin 8.0’	2342
3	Twin 8.0’	2345
4	Twin 6.0’	2420
Test Shaft	Single 8.0’	TBD

4.7 Test Shaft

In January 2012 the Geotechnical Section contacted a Contractor specializing in Osterberg Load Cells and asked for an estimate for an 8.0 ft. diameter bi-directional test. This estimate was solicited in January 2012. The cost for performing an O-cell test was estimated at $54,000 per test. The specific estimate was for a maximum test capacity of 7800 kips.

When designing the shaft, a larger phi factor (LRFD) can be used if a static load test will be performed to verify design assumptions. This higher factor allows a design tip to be placed at 70 feet of penetration. If no load test is performed, the drilled shafts would need to be installed to an estimated penetration depth of 96 feet.

When comparing the cost of a load test and test shaft the Geotechnical Section found that the load test with test shaft is approximately $30,000 dollars more than installing two shafts to the full depth, although drilled shaft cost estimates from bid prices vary significantly. Meaning the cost increase could become a cost savings depending on the cost per foot of drilled shaft. Even though the estimate does not show a cost savings to the project, the information and data gained from a static load test on a drilled shaft founded in granular soils would be beneficial to the nearby foundations, as well as future designs.

4.7 Abutment Options

In discussion with the Bridge Bureau the Geotechnical Section recommended that an MSE wall be used instead of turn-back style bridge abutments. This would eliminate the need for two additional shafts placed at or near the end of the turn-back wings. A wire-faced MSE retaining wall is construction friendly when having to deal with small obstructions and typical guardrail systems.

A second option would be to use a standard stub abutment in place of turn-back wings or MSE walls. A wider 2:1 embankment would be required but this would still be within our right-of-way and should not negatively impact any more utilities than we already are. The cost of an MSE wall abutment to widening the slope is approximately the same.

4.8 Western Bridge Approach Embankment

As discussed in the AGR meeting we recommend that the western bridge approach embankment be constructed entirely out of Special Borrow (see attached special). We also recommend that 4 to 6 feet of Stabilization Geotextile be placed near the edge of the slope every couple of lifts (approximately 2.0 ft. between layers) to aid in the compaction of the edge of the slope and to prevent erosion prior to vegetation being established.

4.9 Continued Geotechnical Involvement

If any changes are made to the current general layout or the loading changes more than 10% the Geotechnical Section should be notified to allow a re-evaluation of our recommendations in this report and revision of them as necessary. For all bents if the center to center spacing of the shafts are moved closer together then the Geotechnical Section must be notified due to group effects which can impact the foundation system, lowering the overall efficiency of each individual shaft.

Draft Special Provisions are attached, the Geotechnical Section will provide more project special provisions as the needs arise as the project develops.

5.0 Limitations

Professional judgments and recommendations are presented in this report. They are based partly on evaluation of the technical information gathered, partly on historical reports and partly on the Geotechnical Section's general experience. It should be noted that the borings may not represent potentially unfavorable subsurface conditions between borings. If, during construction, soil, rock, or water conditions are encountered that vary from those discussed in this report or historical reports, or if alignment and grade changes are required, the Geotechnical Section should be notified immediately in order that it may evaluate effects, if any, on our recommendations. The recommendations presented in this report are applicable only to this specific site. These data are not to be used for other purposes.

Questions regarding this project may be directed to Tyrel Murfitt, MDT Geotechnical Section @ (406) 444-9259 or via email at tmurfitt@mt.gov.

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Attachments: Boring Logs (Bridge Foundation Logs only)
Special Provision – Draft Drilled Shaft Installation
Special Provision – Draft Prequalified Drilled Shaft Contractors
Special Provision – Draft Slurry Drilling
Special Provision – Draft Embankment Construction
Special Provision – Draft Special Borrow
Special Provision – Draft MSE Wall

Original: Geotechnical Project File

Copies: Ed Toavs, P.E., District Administrator – Missoula
Jake Goettle, P.E., Construction – Helena
Matt Strizich, P.E., Materials – Helena
Bill Squires, P.E., Road Design - Helena
Mark Goodman, P.E., Hydraulics - Helena
Tom Martin, P.E, Environmental - Helena

Montana Department of Transportation
PO Box 201001
Helena, MT 59620-1001

Memorandum

To: Chris Hardan, P.E.
Bridge Area Engineer - Missoula

From: Tyrel Murfitt, P.E.
District Geotechnical Specialist - Missoula

Thru: Bret Boundy, P.G.
District Geotechnical Manager - Missoula

Date: 19 June 2013

Subject: Geotechnical Supplemental (Activity 468)
Thompson River - East
STPP-BR 6-1(106)56
UPN 4039

This memo provides our recommendations for seismic site characterization, seismic ground acceleration, and other seismic considerations for the foundation and superstructure design for the referenced project. If changes to the alignment, grade, or scope of work are required, the Geotechnical Section should be notified to review the changes, and determine if they affect the recommendations contained within this report.

PROJECT LOCATION AND OVERVIEW

The project is located approximately four miles east of the town of Thompson Falls, along Highway 200 (P-6). The existing structure was constructed in 1935 under FHP 6-1, over the Thompson River, just north of the confluence with the Clark Fork River. This structure is situated in a narrow side valley that connects to the major valley that conveys the Clark Fork River.

SEISMICITY, SITE CLASSIFICATION, and LIQUAFACTION

Seismic conditions of the proposed project site were evaluated to determine the NEHRP site classification and liquefaction potential. The long-period ground acceleration coefficients were determined by using AASHTO Seismic Design Parameters. A seismic-hazard deaggregation for 0.0s, 0.2s, and 1.0s (V_{s30}=760m/s, NEHRP B/C) was evaluated to determine the peak horizontal ground acceleration (PHGA), and spectral accelerations for the project site. The return period for this PGA is 975 years (USGS equivalent to 1000 years). The mean contributing magnitude is 5.9. Please see Table 1 for a summary of the AASHTO factors and design parameters.

Table 1 AASHTO Seismic Design Factors for project Site Class **D**

Period (s)	Accelerations (g)	Factor		DRS Points* (g)	
0.0 (PGA)	0.135	Fpga	1.530	As	0.207
0.2 (Ss)	0.327	Fa	1.538	Sds	0.503
1.0 (S1)	0.081	Fv	2.500	Sd1	0.202

*Design Response Spectrum (DRS) construction points for three point method

After correcting the SPT blow counts for hammer efficiency the site soils are classified as an NEHRP site class "D."

The on-site soils were deposited sometime in the Pleistocene to Holocene age and they are alluvial, river, and floodplain deposits consisting of gravels, sands, with some fine-grained silts and clay mixed lithologies. The risk of liquefaction is low to high according to Table 6-2 (FHWA-NHI-11-032). Therefore further screening of the on-site soils was conducted using the "simplified procedure" for liquefaction. Based on this conservative analysis, the on-site soils were found to be very low risk for liquefaction, and therefore no further analysis was conducted.

LIMITATIONS

Professional judgments and recommendations are presented in this report. They are based partly on evaluation of the technical information gathered, partly on historical reports and partly on the Geotechnical Section's general experience. The Geotechnical Section does not guarantee the performance of the project in any respect other than that the engineering work and the judgment rendered meet the standards and care of the profession. It should be noted that the borings may not represent potentially unfavorable subsurface conditions between borings. If, during construction, soil, rock, or water conditions are encountered that vary from those discussed in this report or historical reports, or if alignment and grade changes are required, the Geotechnical Section should be notified immediately in order that it may evaluate effects, if any, on our recommendations. The recommendations presented in this report are applicable only to this specific site. These data are not to be used for other purposes.

Questions regarding this project may be directed to Tyrel Murfitt, MDT Geotechnical Section @ (406) 444-9259 or via email at tmurfitt@mt.gov.

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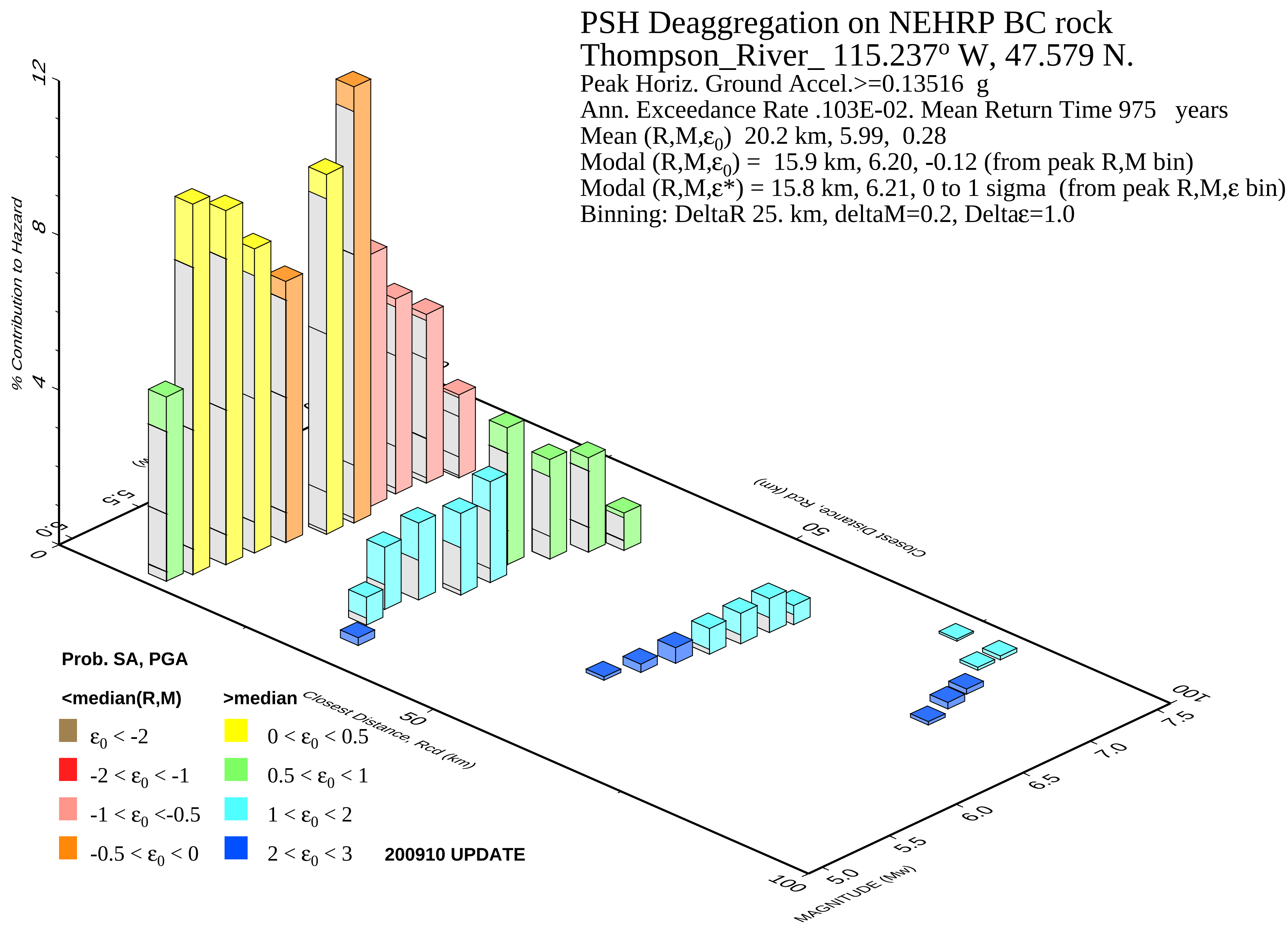
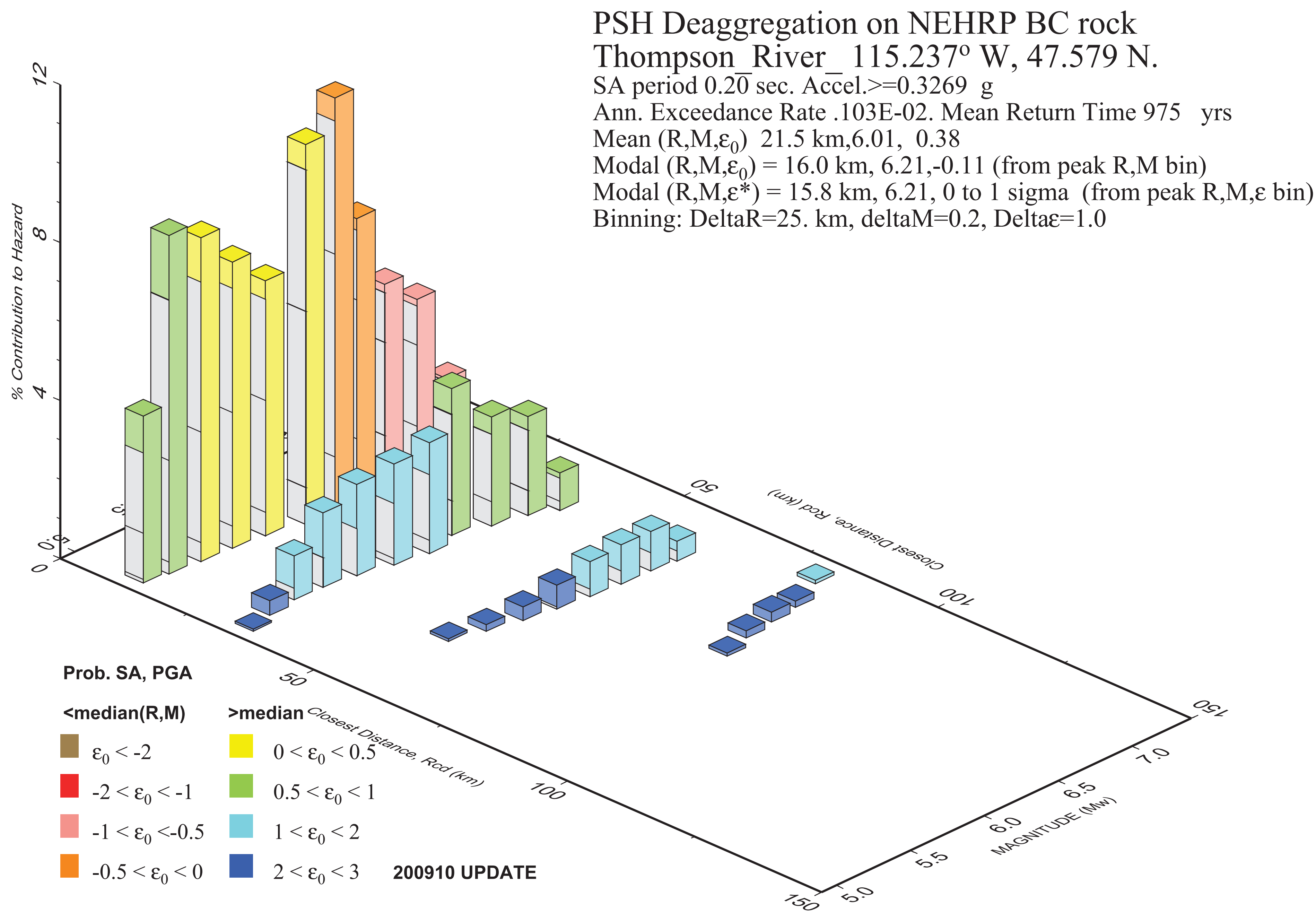
Attachments: USGS Deaggregation Summary Report for PHGA
USGS Deaggregation Summary Report for SA 0.2s
USGS Deaggregation Summary Report for SA 1.0s

Original: Geotechnical Project File

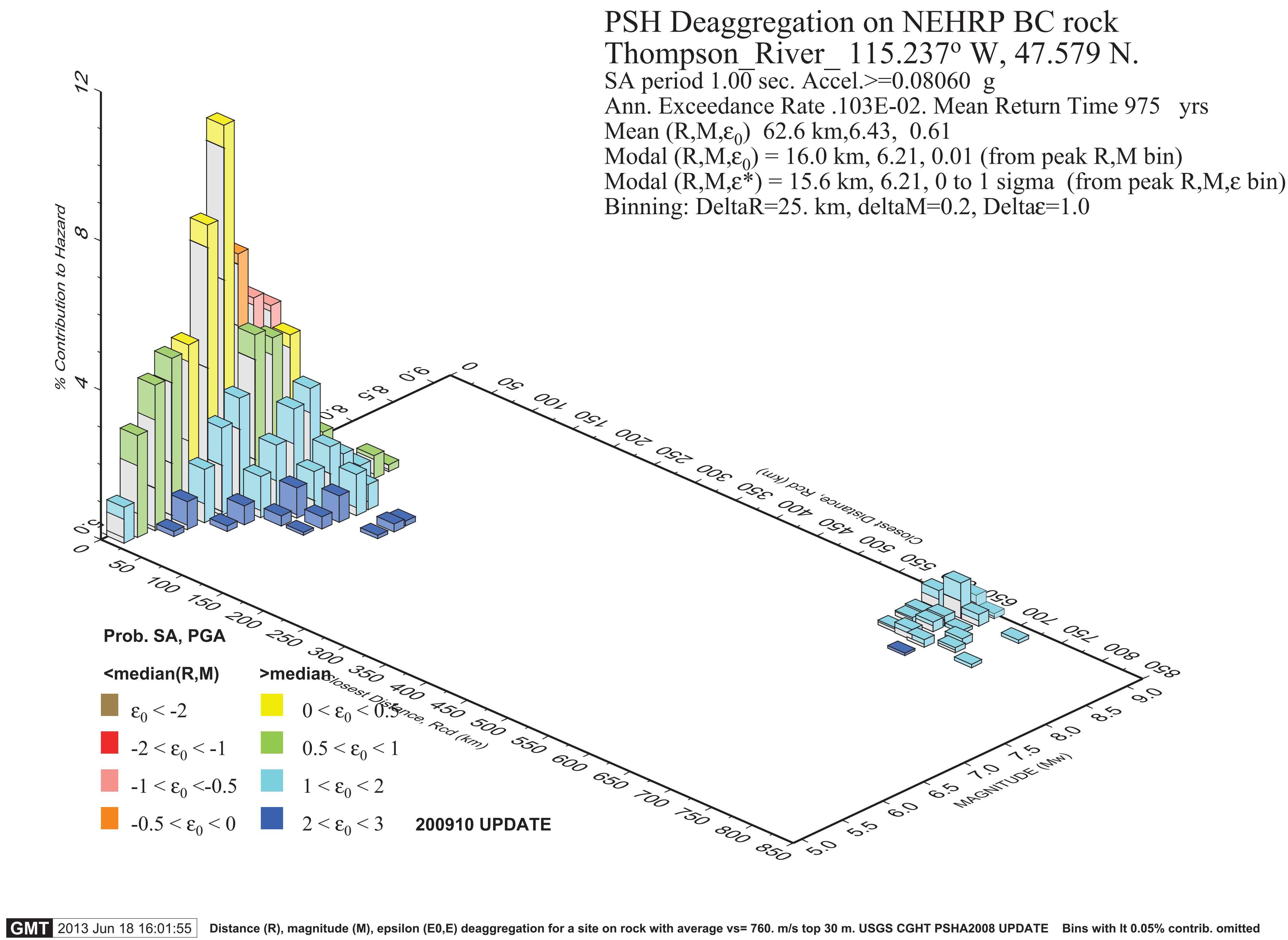
Copies: Matt Strizich, P.E., Materials – Helena (w/o attachments)



GMT 2013 Jun 17 19:24:46 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted



GMT 2013 Jun 18 15:56:45 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted



PSH Deaggregation on NEHRP BC rock
Thompson_River_ 115.237° W, 47.579 N.
SA period 1.00 sec. Accel.>=0.08060 g
Ann. Exceedance Rate .103E-02. Mean Return Time 975 yrs
Mean (R,M,ε0) 62.6 km,6.43, 0.61
Modal (R,M,ε0) = 16.0 km, 6.21, 0.01 (from peak R,M bin)
Modal (R,M,ε*) = 15.6 km, 6.21, 0 to 1 sigma (from peak R,M,ε bin)
Binning: DeltaR=25. km, deltaM=0.2, Deltaε=1.0
% Contribution to Hazard
Closest Distance, Rcd (km)
MAGNITUDE (Mw)
Prob. SA, PGA
<median(R,M)
>median
ε0 < -2
-2 < ε0 < -1
-1 < ε0 <-0.5
-0.5 < ε0 < 0
0 < ε0 < 0.5
0.5 < ε0 < 1
1 < ε0 < 2
2 < ε0 < 3
200910 UPDATE
GMT 2013 Jun 18 16:01:55
Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

Montana Department of Transportation
PO Box 201001
Helena, MT 59620-1001

Memorandum

To: Chris Hardan, P.E.
Bridge Area Engineer - Missoula

From: Tyrel Murfitt, P.E.
District Geotechnical Specialist - Missoula

Thru: Jeff Jackson, P.E.
Geotechnical Engineer

Date: February 10, 2014

Subject: Geotechnical Design Supplemental #2
Revised Foundation Recommendations
Thompson River East Bridge and Approaches
STPP-BR 6-1(106)56
UPN 4039

The enclosed geotechnical report provides our revised recommendations for the substructures on the referenced projects, all other recommendations in the Geotechnical Structure report dated November 8, 2012 are still valid. In the event changes to the alignment or grade are required, the Geotechnical Section should be notified to review the changes, and determine if they affect the recommendations contained within this report.

1.0 PROJECT INFORMATION

The Bridge Bureau requested that the Geotechnical Section review the final L-pile runs that modeled the impacts of the superstructure design. These L-pile analyses were created initially by the Geotechnical Section for soil parameters and initial sizing of the shaft for Geotechnical limit states and provided with the structures report on November 8, 2012. Bridge then finished the model and incorporated the loading and structural components for final modeling. We feel the revised tip elevations are sufficiently embedded to provide adequate lateral resistance and any small predicted movement at the toe of the shaft is more precise than the accuracy of the model.

2.0 REVISED FOUNDATION RECOMMENDATIONS

2.1 Bent 1 Revised Foundation

We do not recommend any changes to Bent 1, this foundation should still consist of twin 6.0 foot diameter drilled shafts with a center to center spacing of 25.0 feet, extended below ground surface to an elevation of 2390 ft.

2.2 Pier 2 Revised Foundation

We recommend that the foundation consist of twin 8.0 foot diameter drilled shafts with a center to center spacing of 34.5 feet, extended below ground surface to an elevation of 2352 ft.

2.3 Pier 3 Revised Foundation

We recommend that the foundation consist of twin 8.0 foot diameter drilled shafts with a center to center spacing of 34.5 feet, extended below ground surface to an elevation of 2355 ft.

2.4 Bent 4 Revised Foundation

We recommend that the foundation consist of twin 6.0 foot diameter drilled shafts with a center to center spacing of 25.0 feet, extended below ground surface to an elevation of 2421.6 ft.

Table 1: Summary of Shaft Design Recommendations

Bent/Pier	Shaft Diameter (ft.)	Number of Shafts	Center to Center Spacing	Design Tip Elevation (ft.)
1	6.0	2	25.0	2390.0
2	8.0	2	34.5	2352.0
3	8.0	2	34.5	2355.0
4	6.0	2	25.0	2421.6

3.0 Limitations

Professional judgments and recommendations are presented in this report. They are based partly on evaluation of the technical information gathered, partly on historical reports and partly on the Geotechnical Section's general experience. If, during construction, soil, rock, or water conditions are encountered that vary from those discussed in this report or historical reports, or if alignment and grade changes are required, the Geotechnical Section should be notified immediately in order that it may evaluate effects, if any, on our recommendations. The recommendations presented in this report are applicable only to this specific site. These data are not to be used for other purposes.

Questions regarding this project may be directed to Tyrel Murfitt, MDT Geotechnical Section @ (406) 444-9259 or via email at tmurfitt@mt.gov.

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Original: Geotechnical Project File

Copies: Matt Strizich, P.E., Materials – Helena

APPENDIX G

NAVFAC DRILLED SHAFT AXIAL DESIGN

Project:	**East of Thompson River East**		Legend:	Input Cell
Project Number:	**STPP-BR 6-1(106)56**			Calculation Cell
Control Number:	**4039**			Notes
Engineer:	**Tyrel G. Murfitt, P.E.**			
Date:	**7/17/2014**			
Boring Number:	**4039-18**			
Bent Number:	**Pier 2**			

Basic Description of Subsurface Conditions

Approximately 30 feet of gravel overlying sand, then a gravel and sand layer at tip.

Water Depth: 10 ft.

Soil Layer Profile (all depth units in FT, density in PCF):

	Layer 1:	Layer 2:	Layer 3:	Layer 4:	Layer 5:
Analysis type:	Non-Cohesive	Non-Cohesive	Non-Cohesive	Non-Cohesive	Non-Cohesive
Description:	Silt	Gravel	Sand	sand	sand
Phi:	27	33	32	33	33
C (psf):	0	0	0	0	0
Start Depth:	0	5	30	40	45
End Depth:	5	30	40	45	55
Unit weight:	110	115	115	115	115
Nc:	9	9	9	9	9
Nq:	6.5	17	14	17	17
Unit Skin (psf):					

	Layer 6:	Layer 7:	Layer 8:	Layer 9:	Layer 10:
Analysis type:	Non-Cohesive				
Description:	Sand				
Phi:	34	26	26	26	26
C (psf):	0				
Start Depth:	55				
End Depth:	101				
Unit weight:	120				
Nc:	9	9	9	9	9
Nq:	21	5	5	5	5
Unit Skin (psf):					

Design Requirements/Inputs:

Shaft Diameter:	8	ft.	Area of Toe:	50.3	sq. ft.
Shaft Depth:	58.7	ft.	Area per unit length:	25.1	sq. ft.
Non-contributing depth:	0	ft.	Ratio of depth to width:	7.3	Z/b
LRFD Phi:	0.7		Limiting Depth:	160	OK
ASD desired FOS	2		Khc Hor/vert stress	0.5	
Redundant Shafts:	No		Delta Friction Angle (steel)	20	(degrees)
Load Test:	Yes		Delta Friction Angle (concrete)	0.75	of phi (degrees)
Shaft Bearing Resistance Type:	Both		LRFD phi redundancy mod.	0.56	
Bottom of Cap Elevation:	2410.4	ft.			
Ground Elevation:	2415.2	ft.			
Permanent Casing:	No	ft.	Shaft Ultimate Axial Capacity	4,560	Kips
Perm. Casing Depth:	0	ft.	Shaft Nominal Axial Capacity	2,554	Kips
Concrete PSI:	4000	psi.	Factor of Safey (ASD)	2.92	OK
Strength Load	2070	Kips	LRFD Capacity/Demand Ratio:	1.23	OK
Service Load	1560	Kips	Shaft Ult. Load Tested Capacity	3,847	Kips
Temporary Casing Required:	Yes		Shaft Nom. Load Tested Capacity	2,154	Kips
Temporary Casing Depth:	58.2	ft.	Static Load FOS (ASD)	2.47	OK
			Static LRFD Cap/Dem Ratio	1.04	OK

RESULT SUMMARIES

Axial Design Summary

Shaft Diameter:	8	ft.
Shaft Penetration Depth:	58.7	ft.
Shaft Top Elevation:	2410.4	ft.
Shaft Tip Elevation:	2351.7	ft.
Factor of Safety (ASD):	2.92	
LRFD Capacity/Demand Ratio:	1.23	
Shaft ultimate Capacity:	4,560	kips
Shaft Nominal Capactiy:	2,554	kips
Strength Load:	2,070	kips
Service Load:	1,560	kips
Shaft Bearing Type:	Both	
Water Depth:	10	ft.

Casing Summary

Temporary Casing Required:	Yes	
Temporary Casing Depth:	58.20	ft.
Temporary Casing Tip Elevation:	2352.2	ft.
Permanent Casing Required:	No	
Permanent Casing Depth:	0	ft.
Permanent Casing Tip Elevation:	N/A	ft.

Load Test Results

Calculated Ultimate Capacity (kips):	4,560
Static Load Ultimate Capacity (kips):	3,400
Over/Under Ultimate Cap (kips)*:	~~-1,160~~
Tested FOS:	2.47
Calculated Nominal Capacity (kips):	2,554
Static Load Nominal Capacity (kips):	2,154
Over/Under Nominal Cap (kips)*:	~~-400~~
LRFD Tested Capacity/Demand ratio:	1.04

*Unable to compare due to upper portion failing in shear

NAVFAC DRILLED SHAFT AXIAL DESIGN

Project:	**East of Thompson River East**
Project Number:	**STPP-BR 6-1(106)56**
Control Number:	**4039**
Engineer:	**Tyrel G. Murfitt, P.E.**
Date:	**7/17/2014**
Boring Number:	**4039-18**
Bent Number:	**Pier 2**

Legend:

Input Cell
Calculation Cell
Notes

Basic Description of Subsurface Conditions

Approximately 30 feet of gravel overlying sand, then a gravel and sand layer at tip.

Water Depth: 10 ft.

Soil Layer Profile (all depth units in FT, density in PCF):

	Layer 1:	Layer 2:	Layer 3:	Layer 4:	Layer 5:
Analysis type:	Non-Cohesive	Non-Cohesive	Non-Cohesive	Non-Cohesive	Non-Cohesive
Description:	Silt	Gravel	Gravel	sand	sand
Phi:	27	31	31	30	34
C (psf):	0	0	0	0	0
Start Depth:	0	5	20	30	50
End Depth:	5	20	30	50	60
Unit weight:	110	115	115	115	115
Nc:	9	9	9	9	9
Nq:	6.5	12	12	10	21
Unit Skin (psf):					

	Layer 6:	Layer 7:	Layer 8:	Layer 9:	Layer 10:
Analysis type:	Non-Cohesive	Non-Cohesive	Non-Cohesive	Non-Cohesive	Non-Cohesive
Description:	Sand	sand	sand	sand	sand
Phi:	35	34	32	38	33
C (psf):	0	0	0	0	0
Start Depth:	60	70	81	96	109
End Depth:	70	81	96	109	129
Unit weight:	120	120	125	125	120
Nc:	9	9	9	9	9
Nq:	25	21	14	43	17
Unit Skin (psf):					

Design Requirements/Inputs:

Shaft Diameter:	8	ft.	Area of Toe:	50.3	sq. ft.	
Shaft Depth:	96	ft.	Area per unit length:	25.1	sq. ft.	
Non-contributing depth:	0	ft.	Ratio of depth to width:	12.0	Z/b	
LRFD Phi:	0.4		Limiting Depth:	160		OK
ASD desired FOS	3		Khc Hor/vert stress	0.5		
Redundant Shafts:	No		Delta Friction Angle (steel)	20	(degrees)	
Load Test:	No		Delta Friction Angle (concrete)	0.75	of phi (degrees)	
Shaft Bearing Resistance Type:	Both		LRFD phi redundancy mod.	0.32		
Bottom of Cap Elevation:	2410.4	ft.	Unit Toe Res. From static Load		psf	
Ground Elevation:	2412.7	ft.				
Permanent Casing:	No	ft.	Shaft Ultimate Axial Capacity	14,471	Kips	
Perm. Casing Depth:	0	ft.	Shaft Nominal Axial Capacity	4,631	Kips	
Concrete PSI:	4000	psi.	Factor of Safey (ASD)	9.28		OK
Strength Load	2070	Kips	LRFD Capacity/Demand Ratio:	2.24		OK
Service Load	1560	Kips	Shaft Ult. Load Tested Capacity	0	Kips	
Temporary Casing Required:	Yes		Shaft Nom. Load Tested Capacity	0	Kips	
Temporary Casing Depth:	96	ft.	Static Load FOS (ASD)	0.00		N/A
			Static LRFD Cap/Dem Ratio	0.00		N/A

RESULT SUMMARIES

Axial Design Summary

Shaft Diameter:	8	ft.
Shaft Penetration Depth:	96	ft.
Shaft Top Elevation:	2410.4	ft.
Shaft Tip Elevation:	2314.4	ft.
Factor of Safety (ASD):	9.28	
LRFD Capacity/Demand Ratio:	2.24	
Shaft ultimate Capacity:	14,471	kips
Shaft Nominal Capactiy:	4,631	kips
Strength Load:	2,070	kips
Service Load:	1,560	kips
Shaft Bearing Type:	Both	
Water Depth:	10	ft.

Casing Summary

Temporary Casing Required:	Yes	
Temporary Casing Depth:	96.00	ft.
Temporary Casing Tip Elevation:	2314.4	ft.
Permanent Casing Required:	No	
Permanent Casing Depth:	0	ft.
Permanent Casing Tip Elevation:	N/A	ft.

Load Test Results

Calculated Ultimate Capacity (kips):	14,471
Static Load Ultimate Capacity (kips):	
Over/Under Ultimate Cap (kips):	-14,471
Tested FOS:	0.00
Calculated Nominal Capacity (kips):	4,631
Static Load Nominal Capacity (kips):	0
Over/Under Nominal Cap (kips):	-4,631
LRFD Tested Capacity/Demand ratio:	0.00

Not Applicable

APPENDIX H

PROPOSAL

LOADTEST

Project #: LT-1074

2631-D NW 41st Street
Gainesville, FL 32606
800-368-1138 or 352-378-3717
Fax: 352-378-3934

Date: January 12, 2012

To: Mr. Tyrel Murfitt
Company: Montana DOT
Fax: 406-444-0808
Email: tmurfitt@mt.gov

From: Robert Simpson

SUBJECT: Proposal - Bridge over Thompson River - Sanders County, MT, Loadtest Project No.: LT-1074

Message:

*****IN CASE OF PROBLEMS PLEASE CALL 800-368-1138*****

Americas
LOADTEST USA
2631-D NW 41st St
Gainesville, FL 32606, USA
Phone: +1 352 378 3717
Fax: +1 352 378 3934

Middle East
FUGRO LOADTEST MIDDLE EAST BV
P.O. Box 2863, Dubai, UAE.
Phone: +(971) 4 3474060
Fax: +(971) 4 3474069

Europe & Africa
Fugro LOADTEST Ltd.
14 Scotts Avenue, Sunbury Upon Thames
Middlesex, TW16 7HZ, UK
Phone: +44 (0) 1932 784807
Fax: +44 (0) 1932 784807

Asia
Fugro LOADTEST Asia Pte. Ltd.
159 Sin Ming Road, #05-07 Amtech Building
Singapore, 575625
Phone: +(65) 6377 5665
Fax: +(65) 6377 3359

PROPOSAL

Mr. Tyrel Murfitt
Montana DOT
2701 Prospect Avenue, PO Box 201001, Helena, MT, 59620
Phone: 406-444-99259
Fax: 406-444-0808

SUBJECT: Proposal for Osterberg Cell Load Testing Equipment & Services for Bridge over Thompson **River** - Sanders County, MT, Loadtest, Project No.: LT-1074

Dear Sirs,

We are pleased to furnish you with the attached proposal for providing Osterberg Cell (O-cell) bi-directional load testing equipment and services for your project at Bridge over Thompson River, Sanders County, MT. Enclosed is our general contract agreement (Annex D) together with the following:

- Annex A: Schedule of prices and payment terms
- Annex B: Particular conditions and terms;
- Annex C: Labor, equipment, plant, tools and materials to be supplied by the contractor or others; Contractor's Worksheet.
- Annex D: General terms of business.
- Appendix 1: Tents, reference beam and post-test grouting procedures, if applicable.

Please note that your notice to proceed with the work described herein, shall be deemed that you have accepted the terms of this offer in its entirety, notwithstanding that you have not signed and returned the Agreement.

We thank you for the opportunity to provide this proposal for your project and look forward to working with you.

Yours faithfully,

____

Robert Simpson
Regional Manager
Loadtest USA
Phone: +1-352-219-4367

Enc: Annex A, Annex B, Annex C, Annex D, Appendix 1

Americas
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Asia
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159 Sin Ming Road, #05-07 Amtech Building
Singapore, 575625
Phone: +(65) 6377 5665
Fax: +(65) 6377 3359

PROPOSAL

This proposal has been prepared for **Loadtest USA's** Client:

Montana DOT

PROJECT DESCRIPTION:

We understand that the project, located in Sanders County, MT, requires Osterberg Cell bi-directional load testing. Testing will be performed on one production shaft to evaluate and confirm the design capacity of the shaft. The test shaft will be tested using an O-cell on a single level.

We understand that the goal of the testing is to obtain as much information as possible about the side shear and end bearing characteristics of the ground supporting the test shaft. As geotechnical engineering professionals, we recognize the importance of shaft shape on the interpretation of the load test results. As such, we use the SONICALIPER, when and where conditions permit, to generate a profile of the shaft excavation geometry prior to concrete placement for all test shafts. These profiles yield verticality and cross sectional information which can be used for more accurate data analysis and interpretation. These data are also very valuable to allow the piling contractor to define and refine concrete placement procedures to minimize the chance of integrity problems during installation of all of the shafts.

It should be noted that although it is not a requirement of an O-cell test to concrete above cut-off level, it is however, necessary to extend the reinforcement cage (or equivalent)[1] up to the testing platform or ground surface, providing support for the instrumentation and hydraulics. The area above concrete cast level should be carefully backfilled with clean sand or otherwise made safe according to local standards or specifications.

OSTERBERG CELL INSTALLATION AND TESTING:

It is understood that the test shafts will be drilled to the target elevation as determined by the project Geotechnical Engineer. After the shaft base has been carefully cleaned and approved by the Engineer for concrete placement, an excavation profile will be generated for the excavation using our SONICALIPER, when and where conditions permit. This process is likely to require up to 1 hour for completion. It should be noted that drilling fluids having suspended solids content higher than the normally accepted range of values for successful concreting of the shaft excavation may cause either incomplete or missing readings by the caliper equipment. After the caliper profile is complete, the reinforcing steel cage with attached O-cells and instrumentation will be lowered by the piling contractor into the shaft and secured with the O-cell assembly at the specified elevation. Concrete will then be placed by the piling contractor using an approved method until reaching the specified concrete cutoff elevation. We recommend

[1] Often some steel structure other than shaft reinforcement (the rebar cage) is used, such as a carrying frame. For the purpose of simplicity all these terms are used interchangeably herein.

that Loadtest review the proposed concrete placement technique to confirm its compatibility with the O-cell technique.

LOAD TEST CONFIGURATIONS				
Test Shaft	**Required Test Capacity**	**Shaft Diameter**	**Shaft Length**	**Maximum Test Capacity[2]**
TS 1	3,900 kips[1]	96 inches	75 feet	7,800 kips

[1]Uni-direction requirement.
[2]The O-cell applies a bi-directional load. The total load is the sum of the loads applied to the pile above and below the O-cell. The maximum test capacity assumes that a reasonable balance can be achieved between pile resistance above and below the O-cell assembly.

Testing can proceed after the shaft concrete has reached the required compressive strength, which typically occurs after a concrete curing time of seven days. The test may be performed earlier with the Engineer's approval. In the absence of an otherwise specified concrete compressive strength, we recommend a minimum compressive strength of 3,000 psi (and not less than 85% of the design mix strength) is attained before load testing of a particular shaft is performed. After the shaft is approved for testing, the O-cell will be internally pressurized creating an equal upward and downward force on the components of the shaft above and below the O-cell. The unidirectional load for a given internal pressure is determined using the cell's calibration coefficient.

Unless otherwise agreed to prior to finalization of our contract, the O-cell load test is performed in general compliance with *ASTM D1143-07 Standard Test Method for Deep Foundations Under Static Axial Compressive Load* using Procedure A: Quick Test loading schedule,. Throughout the test, all instrumentation will be automatically logged at 30-second intervals and load-movement curves for the shaft below and above the O-cell are plotted in real time. Other loading schedules are possible with the O-cell test. Please consult with Loadtest to determine their feasibility and any additional costs.

EQUIPMENT AND SERVICES FURNISHED BY LOADTEST (LT):

A. LT will supply one (1) 3,900-kip capacity calibrated Osterberg cell.
B. In addition to the O-cell, we will furnish hydraulic pumps and hoses, certified hydraulic pressure gages, instrumentation and data acquisition equipment required to perform the O-cell load test.
C. LT will provide engineering and/or technical personnel to observe and assist with the assembly of the O-cell and instrumentation into the reinforcing steel cage. **Note:** Welding or cutting the O-cell without LT personnel present may result in damage and require replacement of the O-cell at the client's expense.
D. LT engineering and/or technical personnel will attend on-site to observe the installation of the O-cell in the shaft and concrete placement past the O-cell elevation.
E. LT engineering personnel will operate all electronic equipment and hydraulic pumps while performing the load test, record the load test data, perform data analysis and prepare a report of the results of the load test.

TERMS OF PROPOSAL:

This Proposal is based on the performance of the load test program as described above. The Proposal rates and prices are listed in Annex “A” (Schedule of Prices). This Proposal and the prices herein are valid for acceptance for a period of 90 days from the date of this Proposal, after which time they are subject to review and possible amendment prior to revalidation.

Terms particular to this Proposal are listed in Annex "B" (Particular Terms and Conditions of Proposal).

The Client shall supply free of charge to Loadtest the attendances, equipment, plant and tools as listed in Annex “C” (“Labor, Equipment, Plant and Tools to be provided by Client”) to enable Loadtest to perform the work covered by this Proposal

Our general terms of business are listed in Annex "D" (Contract Terms).

The language for all written submissions, including the method statement and the test report, will be English.

We thank you for the opportunity to provide a proposal for this project and look forward to working with you. To confirm your acceptance of this proposal, please sign and return this copy of the PROPOSAL and attached Annexes and Terms to our Gainesville office and retain a copy for your records.

SIGNED ____________________
Ray Wood
Executive Vice-President
for Loadtest USA

ACCEPTED BY ____________________
for Montana DOT

____
Robert Simpson
Regional Manager
for Loadtest USA

POSITION ____________________

DATE **January 12, 2012**

DATE ____________________

PRICES FOR OSTERBERG CELL LOAD TESTING EQUIPMENT AND SERVICES:

Our schedule of prices for the work described in the Proposal is summarized in the Table below (All fees in US Dollars):

TEST SHAFT FEE SCHEDULE		**TS 1**
1.0	Expendables (O-cell, hydraulic system, sensors, telltales, etc.)	US$ 34,000
2.0	Shaft excavation profile by SONICALIPER[1]	Included
3.0	Fee for Installation Assistance	US$ 3,000
4.0	Load Test and Report Preparation	US$ 5,500
5.0	Instrumentation (see below)	US$ 6,000
6.0	Total Standard Mobilization / Demobilization Fee (see below)[2]	US$ 6,000
ESTIMATED TOTAL PER LOAD TEST (excluding all applicable sales tax))[3]		US$ 54,500

VARIABLE AND ADDITIONAL FEES SCHEDULE		
A	Additional Days on Site for Personnel and Equipment (Installation)	US$ 1,500 per man day[4] or part thereof
B	Additional Days on Site for Personnel and Equipment (Testing)	US$ 1,750 per man day[4] or part thereof
C	Interim Mobilization / Demobilization	US$ 3,500 per man round trip
D	Weekend/US Public Holiday Premium	US$ 1,500 per man day[4] or part thereof
E	Additional Strain Gages	US$ 500 per gage

[1]If applicable.
[2]Standard Mobilization Fee excludes all costs associated with travel time, shipping and accommodations.
[3]Please add any applicable sales tax to this total. Applicable sales tax to be paid by the client.
[4]A man day is defined as any work day where one person is required to be on site for not more than 10 hours during a 24 hour period.

Initial______

ITEM COVERAGE

1.0 Expendables

Our prices for expendables include all calibrated O-cells; hydraulic hoses and fittings; O-cell measurement sensors and telltale rods. Our Client is responsible for the supply of any necessary load distributing steel plates; reservation tubes (pipe) and fittings for the telltale rods; and for all miscellaneous items of steelwork necessary to adequately protect the O-cell and instrumentation installation within the shaft reinforcing cage. Our prices for expendables include shipping costs consistent with receiving notice to proceed at least 14 days before the expendables are required on site. If shorter notice is given additional express shipping costs will be charged at cost plus 15% plus an expediting fee of 5% of the price of the relevant expendables shipped.

2.0 SONICALIPER Testing

The SONICALIPER test will be performed to acquire shaft cross-sectional information at intervals to be determined by LT within uncased sections of the shaft bore.

3.0 Installation Assistance

Our price for installation assistance assumes that no more than nine 10 hour man shifts will be required for the entire test program. Installation assistance includes time to observe and assist with preparation of the instrumented shaft reinforcing cage and its installation in the shaft excavation including concreting operations to a level above the O-cell. Time required on site additional to this allowance will be charged at the rate of US$ 1,500 Per 10 hour man shift or part thereof. Any work required on a weekend day or recognized US public holiday will attract a premium of US$ 1,500 per 10 hour man shift.

4.0 Load Test and Report Preparation

Our price for performing the load test on the drilled shaft and for preparing the report assumes a maximum period on site for our testing engineers and equipment of two 10 hour man shifts per test. It also assumes we prepare our standard report. Time required on site additional to this allowance will be charged at the rate of US$ 1,750 Per 10 hour man shift or part thereof. Any work required on a weekend day or recognized US public holiday will attract a premium of US$ 1,500 per 10 hour man shift.

Initial______

5.0 Instrumentation

Based on the goals of the test program, we have included twelve (12) Geokon Model #4911 strain gages to assist in the determination of side shear load transfer. The total cost for all instrumentation is US$ 6,000. Additional strain gages, if required, may be purchased at a unit rate of US$ 500 **per** gage. The unit rate for each strain gage includes cable, installation, monitoring, analyses and reporting.

6.0 Mobilization / Demobilization

Our standard mobilization / demobilization rate is a minimum rate and is included for up to four man trips per test shaft; to cover two man trips (round trip) for installation assistance and two man trips (round trip) for load testing and excludes all costs associated with travel time, shipping and accommodations. If our Client's program requires additional interim mobilization / demobilizations, these will be charged at a rate of US$ 3,500 per man round trip. The mobilization / demobilization rate includes travelling time from the LT office to the site and back and shipping costs of the test equipment, accommodations and direct travel costs.

Note: Most O-cell tests require two trips to the site per test shaft, however, efficient scheduling may result in fewer trips to the site per test shaft when multiple shafts are installed and tested. Loadtest may waive some or all mobilization fees at its sole discretion.

All rates and prices exclude any and all sales taxes, permanent and temporary import and customs duties, withholding taxes, Value Added Taxes (VAT), Goods and Services Taxes, which will be added to our billings unless accounted for and paid directly by our Client.

Initial______

PARTICULAR CONDITIONS AND TERMS OF PROPOSAL

This proposal is made subject to our general terms of business included as Annex D and subject to the additional special conditions listed below:

A. Loadtest requires 14 days notice, from receipt of written confirmation to proceed, in order to procure and deliver expendables (O-cell, hydraulic system and instrumentation);

B. Loadtest requires 7 days notice, prior to being on site to perform their work associated with the assembly and installation of the test shaft;

C. Unless alternative arrangements are made in advance, a working day is defined as not exceeding a continuous 10-hour period and where the start of one work day must be not less than 12 hours after the end of the first.

D. Each Loadtest engineer will only either assemble, install or test one O-cell test assembly per day;

E. Loadtest has the right acting reasonably to inspect and reject the completed test setup provided by the Client 24 hours prior to the scheduled commencement of load testing and has the right to subsequent rescheduling of test commencement, if deemed reasonably necessary by Loadtest;

F. Loadtest personnel require a safe and secure working environment to carry out the services proposed herein. Compliance with published OSHA (USA) or HSE standards and generally accepted safe working procedures are required as a condition of our work. **Loadtest reserves the right to suspend work on notice related to our proposed services if our personnel reasonably consider that their personal safety on the jobsite may be compromised**;

G. Invoices for the expendables and Instrumentation components of the service will be raised as soon as the equipment is delivered to site. Risk in the expendables and the instrumentation shall pass to our Client on delivery to site and this equipment must be stored in a secure and dry environment until it is required for installation. Invoices for Installation Fees shall be raised on completion of the installation work. Invoices for Mobilization / Demobilization and Testing and Reporting Fees shall be raised on submission of the load test report.

H. An early payment discount of 2.5% of the invoice value is offered for invoices for expendables paid in full within 20 days of date of invoice.

I. Loadtest reserves the right to withhold issue of the final report and any test data if any invoices at the time of submission are delinquent.

Initial______

EQUIPMENT AND SERVICES FURNISHED BY CONTRACTOR OR OTHERS:

Our Proposal is subject to the following equipment and attendances being provided by the general or drilled shaft contractor at no cost to Loadtest:

1. Rebar cage. Specific reinforcement and shaft details must be provided to Loadtest, before any instrumentation can be shipped. **If the reinforcement details or shaft length(s) are changed after the instrumentation has been shipped, the client may have to replace some or all of the instrumentation at their expense.**
2. Personnel, welding equipment, torches, etc. necessary for on-site assembly and attachment of O-cell and ancillary equipment.
3. Lifting equipment for handling, assembling, and installing the cell on site (should be able to pick and install the cage with minimal deflections).
4. **Two 2-inch thick steel bearing plates per test shaft, approximately the same diameter as the shaft** (drawings provided by LT).
5. Twenty-four (24) nos. 21-ft. lengths of ½" black iron pipe threaded on both ends with couplers (504 total linear feet).
6. Miscellaneous angle iron or channel iron pieces (Recommend 5 pieces 20-ft lengths of 2" x 2" angle iron).
7. Four (4) concrete test cylinders **in addition** to those specified elsewhere to be tested at Loadtest's direction.
8. Air compressor with hose and Chicago type fitting: 185 cfm (85 lps) at 125 psi (850 kPa).
9. 110V/60Hz Stable AC power source with extension cord to reach to the test shaft.
10. Drinking water (used as a hydraulic fluid see attached worksheet).
11. Two (2) surveyors tripods for use with digital levels provided by LT for measuring top of shaft movement.
12. Two (2) 10'x10' canopies or Tarp w/ frame large enough to completely shade reference system.
13. Lighting as required.
14. Post test grouting, if required.

It is our understanding that the design, installation and inspection of the test pile will be the responsibility of others. **See "Contractor's Worksheet" for summary of responsibilities.**

Initial______

Loadtest (LT) Contractor's Worksheet			January 12, 2012
PROJECT NAME: Bridge over Thompson River			PROJECT NUMBER: LT-1074
PROJECT LOCATION: Sanders County			STATE MT
NUMBER OF TESTS ON SITE: 1		PRODUCTION SHAFTS TESTED? Yes	
LOADTEST PROJECT MANAGER: Robert Simpson		CONTRACTOR'S PROJECT MANAGER: Mr. Tyrel Murfitt	
PHONE: +1-352-219-4367	FAX: +1-352-378-3934	PHONE: 406-444-99259	FAX: 406-444-0808
		MOBILE PHONE:	

FIELD RESPONSIBILITIES FOR INSTALLATION & TESTING

Equipment/Supplies	Contractor	Loadtest	Remarks
Reinforcing Steel Cage	✓		
Steel Bearing Plates	✓		Drawings Provided by LT
½" Iron Pipe: 24 x 21' pieces	✓		Threaded Both Ends
2 x 2 inch Angle Iron	✓		5 x 20 ft. Pieces
Lifting Equipment	✓		
O-cell and Instrumentation		✓	
Welding Personnel	✓		
Welding Equipment & Torches	✓		
Hand Tools	✓	✓	
Air Compressor	✓		
Drinking Water (25 Gallons)	✓		
Work Platform	✓		If Appropriate
Test Instrumentation		✓	
Test Equipment		✓	
Two Surveyors Tripod(s)	✓		
Weather Protection (sun / rain)	✓		

Initial______

Loadtest (LT) Contractor's Worksheet			January 12, 2012
PROJECT NAME: Bridge over Thompson River			PROJECT NUMBER: LT-1074
PROJECT LOCATION: Sanders County			STATE MT
NUMBER OF TESTS ON SITE: 1		PRODUCTION SHAFTS TESTED? Yes	
LOADTEST PROJECT MANAGER: Robert Simpson		CONTRACTOR'S PROJECT MANAGER: Mr. Tyrel Murfitt	
PHONE: +1-352-219-4367	FAX: +1-352-378-3934	PHONE: 406-444-99259	FAX: 406-444-0808

FIELD RESPONSIBILITIES FOR INSTALLATION & TESTING (CONTINUED)

Procedures	Contractor	Loadtest	Remarks
Fabrication of Cage	✓		
Attach O-cell to Cage	✓	LT Observe	
Attach Instruments to Cage		✓	
Excavation of Drilled Shaft	✓		Per Specifications
Inspection of Drilled Shaft	✓		Per Specifications
Quality Control of Shaft	✓		Per Specifications
Placement of O-cell and Cage	✓	LT Observe	Per Specifications
Concrete Placement in Shaft	✓	LT Observe	Per Specifications
Molding of Test Cylinders	✓		
Set up of Weather Protection	✓		
Set up Test Instrumentation		✓	
Operation of Test Equipment		✓	
Recording of Load Test Data		✓	
Submission of Load Test Report		✓	Within 7 working days
Set up of Reference Beam	✓	LT Observe	If Applicable
Post-Test			
Breakdown of Reference Beam & Weather Protection	✓		Where Applicable
Breakdown of Work Platform	✓		If Applicable
Post Test Grouting	✓		If Required

Initial______

TERMS FOR LOAD TESTING SERVICES

AGREEMENT:

This AGREEMENT is made between Fugro Consultants Inc. doing business as LOADTEST, hereinafter referred to as the LOAD TEST SUPPLIER and Montana DOT, hereinafter referred to as CLIENT.

This AGREEMENT consists of these TERMS, the attached PROPOSAL for this project dated January 12, 2012 and any exhibits or attachments noted in the PROPOSAL. Together, these elements constitute the entire AGREEMENT superseding any and all prior negotiations, correspondence, or agreements either written or oral. Any changes to this AGREEMENT must be mutually agreed to in writing.

RELATIONSHIP OF PARTIES:

The relationship between the parties shall be limited to the performance of services as set forth in this AGREEMENT and shall not constitute a joint venture nor a partnership nor an employer-employee relationship. Neither party may obligate the other to any expense or liability outside of this AGREEMENT except upon written consent of the other.

STANDARD OF CARE:

Services performed by the LOAD TEST SUPPLIER under this AGREEMENT are expected by the CLIENT to be conducted in a manner consistent with the level of care and skill ordinarily exercised by those performing the same or similar services. Under no circumstance is any warranty, express or implied, made in connection with the providing of services by LOAD TEST SUPPLIER. CLIENT recognizes that LOAD TEST SUPPLIER is not responsible for subsurface conditions nor for the installation of the element being tested

HEALTH AND SAFETY:

The LOAD TEST SUPPLIER shall comply with all health, safety, and training obligations required by law. Compliance with these health, safety, and training requirements is the sole responsibility of the LOAD TEST SUPPLIER. Special health and safety training for employees of the LOAD TEST SUPPLIER that is required for access to the project job site shall be the responsibility of the CLIENT. The LOAD TEST SUPPLIER is not responsible in any way for the health, safety, or training of the CLIENT'S employees. LOAD TEST SUPPLIER may suspend work related to their services by notice if their personnel reasonably consider their personal safety to be at risk.

RISK ALLOCATION and LIMITATION of LIABILITY:

Many risks potentially affect the LOAD TEST SUPPLIER by virtue of entering into this AGREEMENT to perform load testing services on behalf of the CLIENT. For the CLIENT to obtain the benefit of a fee which includes nominal allowance for dealing with the LOAD TEST SUPPLIER'S liability, CLIENT agrees to limit LOAD TEST SUPPLIER'S liability to CLIENT and to all parties for claims arising out of LOAD TEST SUPPLIER'S performance of the services described in this AGREEMENT. The aggregate liability of the LOAD TEST SUPPLIER will not exceed the contract value amount for errors, or omissions, and CLIENT agrees to indemnify and hold harmless LOAD TEST SUPPLIER from and against all liabilities in excess of the monetary limit established above.

Limitations on liability and indemnities in this AGREEMENT are business understandings between the parties voluntarily and knowingly entered into, and shall apply to all theories of recovery including, but not limited to, breach of contract, warranty, tort (including negligence), strict or statutory liability, or any other cause of action, except for willful misconduct or gross negligence. The parties also agree that CLIENT will not seek damages in excess of the limitations indirectly through suits with other parties who may join LOAD TEST SUPPLIER as a third party defendant. Parties mean CLIENT and LOAD TEST SUPPLIER and their officers, employees, agents, affiliates, and subcontractors.

Both CLIENT and LOAD TEST SUPPLIER agree that they will not be liable to each other, under any circumstances, for special, indirect, consequential, or punitive damages arising out of or related to this AGREEMENT.

In the event that the equipment provided by the LOAD TEST SUPPLIER and installed in the element to be tested fails to operate as expected and it can be reasonably demonstrated that the cause arises from defective equipment supplied by LOAD TEST SUPPLIER and not from the operations of our CLIENT, LOAD TEST SUPPLIER's liability shall be limited to the supply of replacement own equipment and installation of the same. LOAD TEST SUPPLIER shall have no liability for any costs incurred by others arising out of the installation of replacement elements for test.

INSURANCE:

The LOAD TEST SUPPLIER shall procure and maintain, at its sole expense, the following insurance:

(a.) Workers' Compensation, USL&H and Employers' Liability Insurance as prescribed by applicable law.

(b.) Commercial General Liability Insurance (Personal Injury and Property Damage), the limits of which shall be $1,000,000 per occurrence.

Limits in excess of these stated limits will be available at additional cost to the CLIENT.

(c.) The LOAD TEST SUPPLIER does not offer professional, product, job completed liability insurance policy. If the CLIENT requires such insurance, The CLIENT agrees to make a written request in a timely manner to allow for procurement, and to pay the full premium cost to the insurer.

BILLING AND PAYMENT:

CLIENT will pay LOAD TEST SUPPLIER in accordance with the procedures indicated in the PROPOSAL and its attachments. Invoices will be submitted to CLIENT by LOAD TEST SUPPLIER, and will be due and payable upon presentation. If CLIENT objects to all or any portion of any invoice, CLIENT will so notify LOAD TEST SUPPLIER in writing within fourteen (14) calendar days of the invoice date, identifying the causes of disagreement, and pay when due that portion of the invoice not in dispute. The parties will immediately make every effort to settle the disputed portion of the invoice. In the absence of written notification described above, the balance as stated on the invoice will be paid. Payment to the LOAD TEST SUPPLIER is in no way to be dependent upon prior payment by others, unless expressly agreed to as outlined in the PROPOSAL. Invoices are to be paid in full without any deductions for retention or discounts.

Invoices are delinquent if payment has not been received within thirty (30) calendar days from the date of invoice. CLIENT will pay an additional service charge of one-and-one-half (1.5) percent per month (or the maximum percentage allowed by law, whichever is lower) on any delinquent amount, excepting any portion of the invoiced amount in dispute and resolved in favor of the CLIENT. Payment thereafter will first be applied to the accrued service charge and then to the principal unpaid amount. All money spent and expenses incurred (including any attorney's fees) in connection with collection of any delinquent amount will be paid by CLIENT to LOAD TEST SUPPLIER per LOAD TEST SUPPLIER'S current fee schedules. In the event CLIENT fails to pay LOAD TEST SUPPLIER within forty-five (45) days after invoices are rendered, CLIENT agrees that LOAD TEST SUPPLIER will have the right to consider the failure to pay the LOAD TEST SUPPLIER'S invoice as a breach of this AGREEMENT and LOAD TEST SUPPLIER shall have the right to suspend work and/or withhold test results or reports until delinquent invoices are paid.

SEVERABILITY AND SURVIVAL:

If any element of this AGREEMENT is held to violate a law, then the element shall be deemed void and all remaining provisions shall remain in force. However, LOAD TEST SUPPLIER and CLIENT will in good faith attempt to replace any invalid or unenforceable provision with one that is valid and enforceable, and which comes as close as possible to expressing the intent of the original provision. All terms and conditions of this AGREEMENT allocating risk and liability between LOAD TEST SUPPLIER and CLIENT shall survive the completion of services hereunder and the termination of this AGREEMENT.

TERMINATION:

This AGREEMENT may be terminated by either party seven (7) days after written notification in the event of any breach of any provision of this AGREEMENT or in the event of substantial failure of performance by the other party, or if the CLIENT suspends work for more than three (3) months. In the event of termination, LOAD TEST SUPPLIER will be paid for services performed prior to the date of termination plus reasonable termination expenses, including, but not limited to the cost of completing analyses, records, and reports necessary to document job status at the time of termination.

FORCE MAJEURE:

Neither party to this AGREEMENT will be liable to the other party for delays in performing the services, nor for the direct or indirect cost resulting from such delays, that may result from labor strikes, riots, war, acts of governmental authorities, extraordinary weather conditions or other natural catastrophe, or any other cause beyond the reasonable control or contemplation of either party.

DISPUTES and GOVERNING LAW

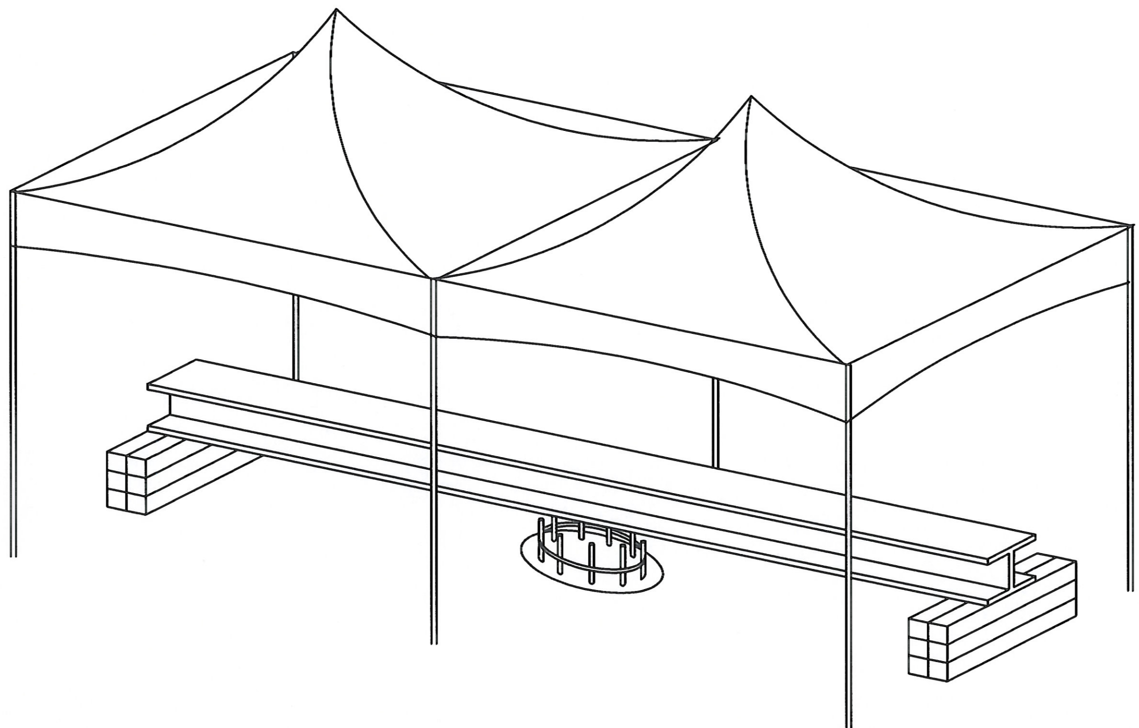
The Parties to this Agreement agree to use reasonable endeavours between their respective senior management representatives to resolve any dispute arising under or in connection with this Agreement or its breach. Failing such agreement the Parties agree to submit to the jurisdiction of the Courts of the State of Florida and further agree that this Agreement shall be governed by the laws of the State of Florida.

Initial______

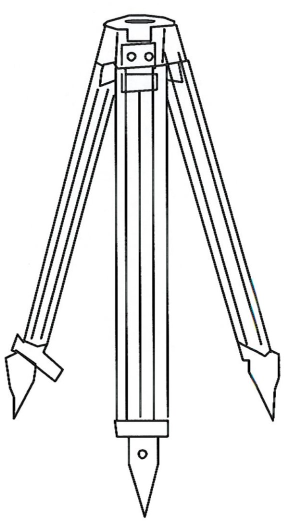
APPENDIX 1
TENTS AND REFERENCE BEAM, IF APPLICABLE

Initial______

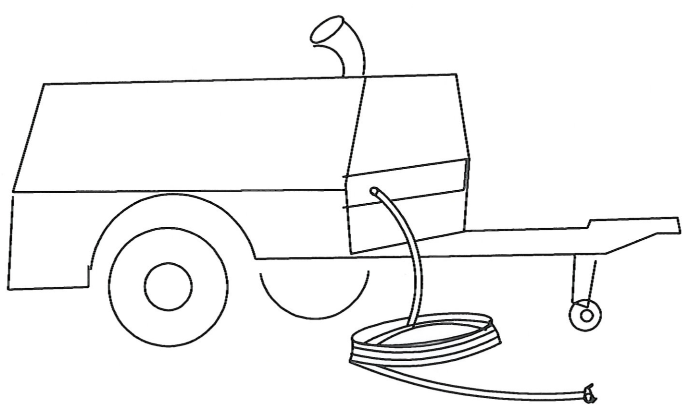
CONTRACTOR'S WORKSHEET



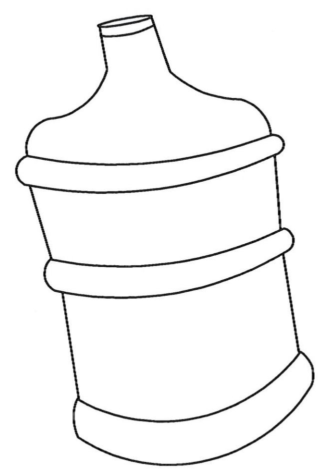
Reference Beam and supports (if applicable--see note), and canopies (2)



Tripod(s)



Air Compressor
(185 cfm at 125 psi)

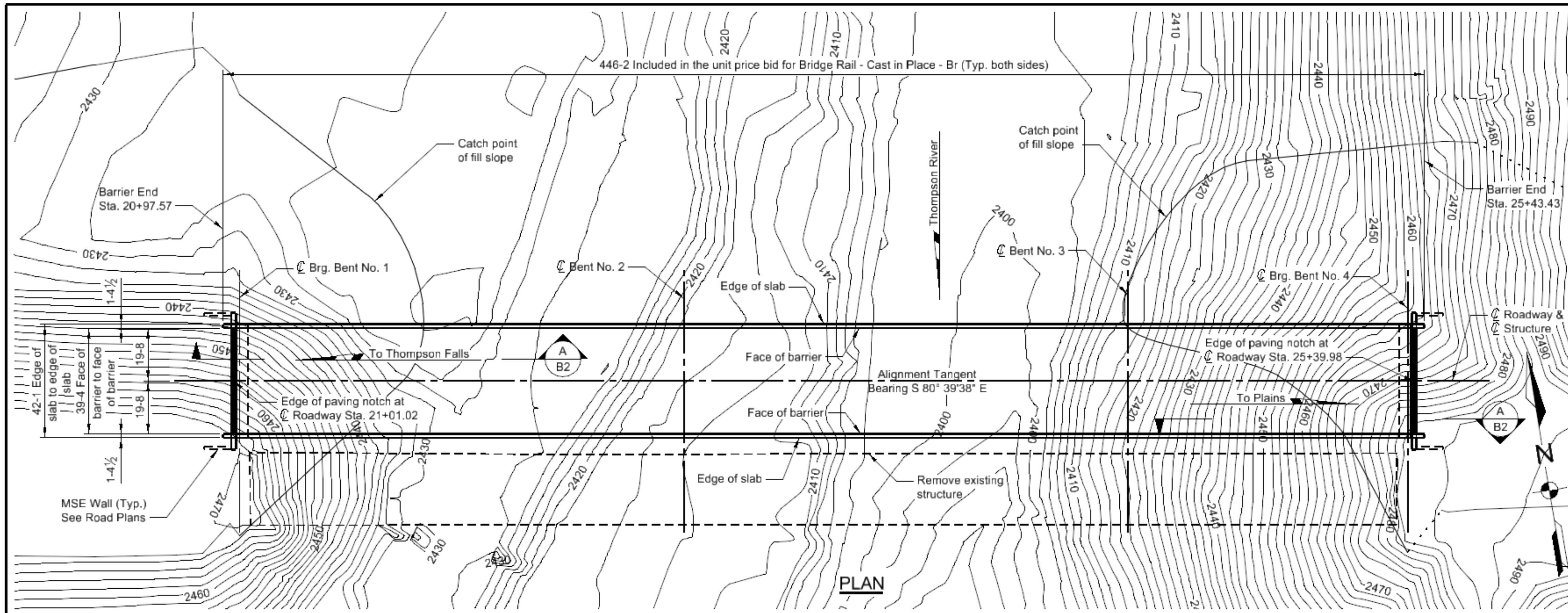


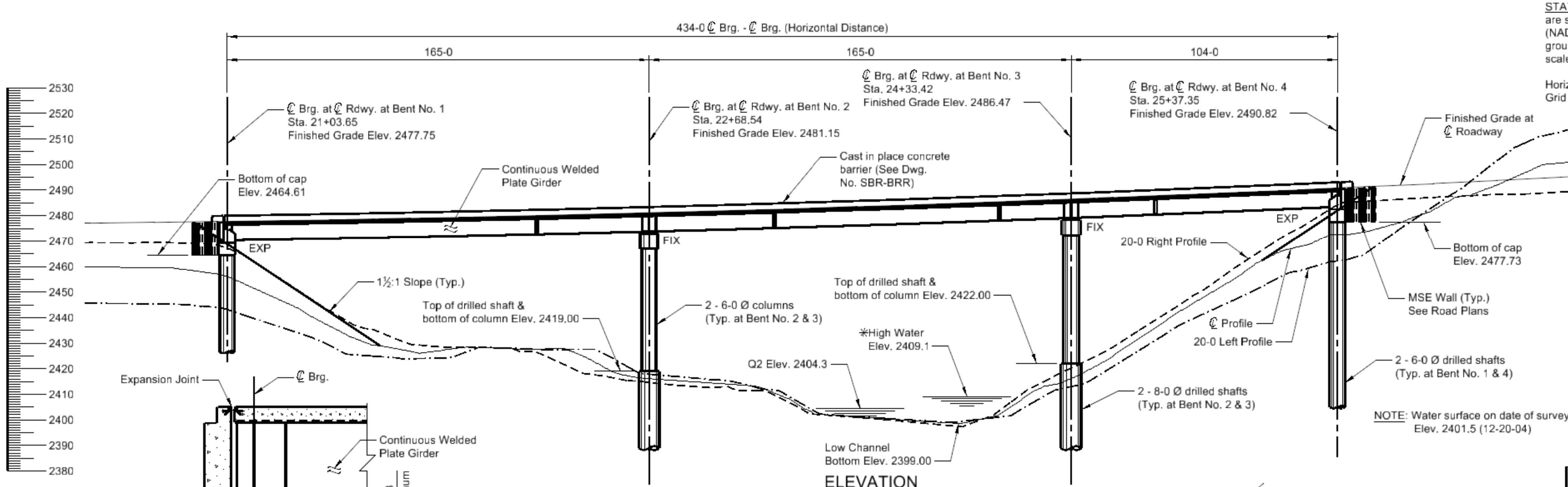
15 Gallons
Clean Water

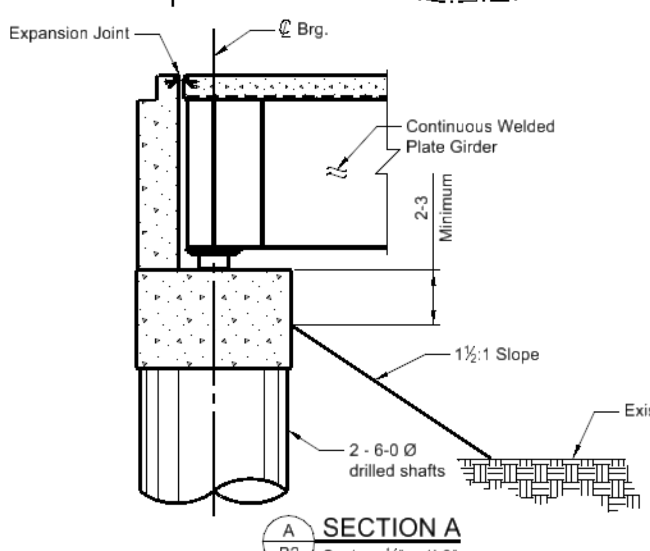
NOTE: Depending on test pile location, reference beam may not be required. Must be replaced by two (2) each surveyors tripods and canopies. Consult with LOADTEST Engineer for applicability.

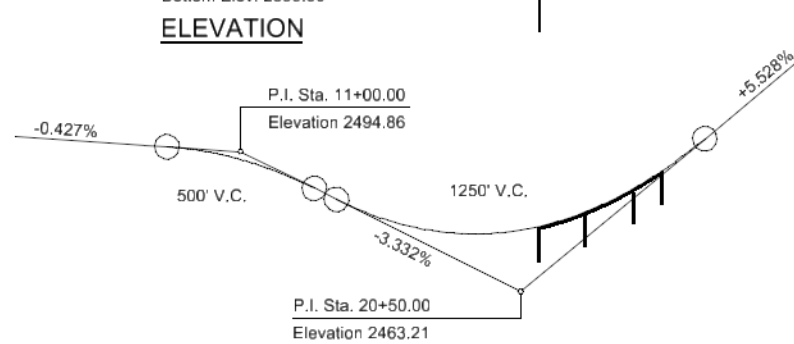
LOADTEST INC.	2631-D NW 41st St. Gainesville, FL 32606 Phone 800-368-1138 FAX (352) 378-3934	Typical O-cell Testing Contractor Supplied Items
		Date: 2008 — Appendix A

APPENDIX I









NOTES

FINISHED GRADE: Finished grade of bridge at centerline roadway is the same as the Profile Grade shown on Road Plans.

LIVE LOAD: Standard HL-93 loading.

SPECIFICATIONS: Montana Department of Transportation and the Montana Transportation Commission Standard Specifications for Road and Bridge Construction, 2006 edition, and any amendments thereto, and the Special Provisions govern unless otherwise noted. The design was prepared in accordance with AASHTO LRFD Bridge Design Specifications, Fourth edition - 2007 with 2009 Interim revisions.

REINFORCING STEEL: Use new deformed type reinforcing steel meeting the requirements of AASHTO M 31 Grade 60 or ASTM Specification A 706 Grade 60 as specified. Include all costs associated with furnishing and placing new reinforcing steel in the unit price bid for either Reinforcing Steel, Reinforcing Steel - Epoxy or Reinforcing Steel - Seismic.

CAST IN PLACE CONCRETE: Unless otherwise approved or specified, use Class DD-Bridge for all substructure concrete and Class SD for all superstructure and barrier concrete.

CONCRETE STRENGTH: Use f'c = 4000 p.s.i. for Class DD-Bridge concrete. Use f'c = 4000 p.s.i. for Class SD concrete.

TRAFFIC CONTROL PLAN AND SEQUENCE OF OPERATIONS: See Special Provisions.

UTILITIES: Call 1-800-424-5555 for utility locates at least two working days prior to starting any construction activity that could disturb the utility.

EXISTING STRUCTURE: Remove the existing structure (see Road Plans sheets and Special Provisions).

STRUCTURE EXCAVATION: Structure Excavation will be calculated from berm elevations.

STRUCTURAL STEEL: All structural steel will be measured and paid for on the lump sum basis as set forth in the Standard Specifications. Use structural steel meeting the requirements of AASHTO M 270 Grade 50W: Estimated weight = 619,602 lbs.

STATE PLANE COORDINATES: Stations shown on the bridge plans are state plane grid stations based on state plane coordinates (NAD83-1992). Dimensions shown on the bridge plans are horizontal ground distances and not state plane grid distances. The combination scale factor (CSF) at this locations is 0.99932516.

Horizontal ground distance x CSF = Grid Distance
Grid Distance/CSF = Distance to stake.

HYDRAULIC DATA

Drift:	Moderate
Bent No. 2 & 3 Scour (Q100):	None
Contraction Scour (Q100):	None
Ice:	Moderate
Drainage Area:	642 sq. mi.
2-Year Stage (Q2):	2404.3
Base Flood Flow (Q100):	7340 cfs
✻ Base Flood Stage:	2409.1
Base Flood Velocity:	9.4 fps
Actual Low Beam Elevation:	2470.34
Allowable Low Beam Elevation:	2470.34

Also see Hydraulic Data Summary sheet.
✻ Base Flood Stage elevation includes backwater.

SHEET NO. B2

GENERAL LAYOUT

Scale ~ 1" = 25'-0" Except As Noted

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO. STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

MDT MONTANA DEPARTMENT OF TRANSPORTATION BRIDGE BUREAU

REVISED		
REVISED		
REVISED		
CHECKED	2-14-14	C.W.H.
DRAWN	9-19-11	T.J.B.
DESIGNED	8-23-11	J.J.S.
$DATE$	$TIME$	$FILEABBREV$

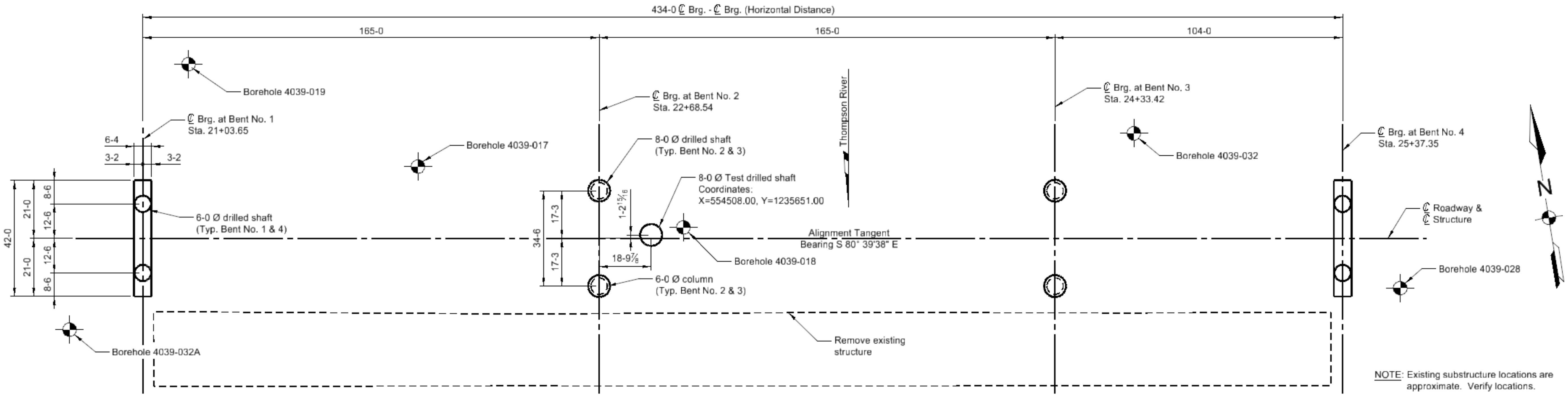
UPN NUMBER 4039

DRAWING NO. 22051

NOTES

SOILS AND FOUNDATION MATERIALS: The Footing Plan shows points where the State of Montana, Department of Transportation, drilled boreholes.

NOTE: See Sheet B4 for Summary of Log of Borings.



FOOTING PLAN

NOTE: Existing substructure locations are approximate. Verify locations.

NOTE: Dimensions shown for Bent No. 1 and Bent No. 4 are typical. Dimensions shown for Bent No. 2 and Bent No. 3 are typical.

SHEET NO.
B3

FOOTING PLAN

Scale ~ 1" = 20'-0"

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO.
STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

MDT MONTANA DEPARTMENT OF TRANSPORTATION

BRIDGE BUREAU

REVISED		
REVISED		
REVISED		
CHECKED	2-14-14	C.W.H.
DRAWN	9-20-11	T.J.B.
DESIGNED	8-23-11	J.J.S.
$DATE$	$TIME$	$FILEABBREV$

UPN NUMBER
4039

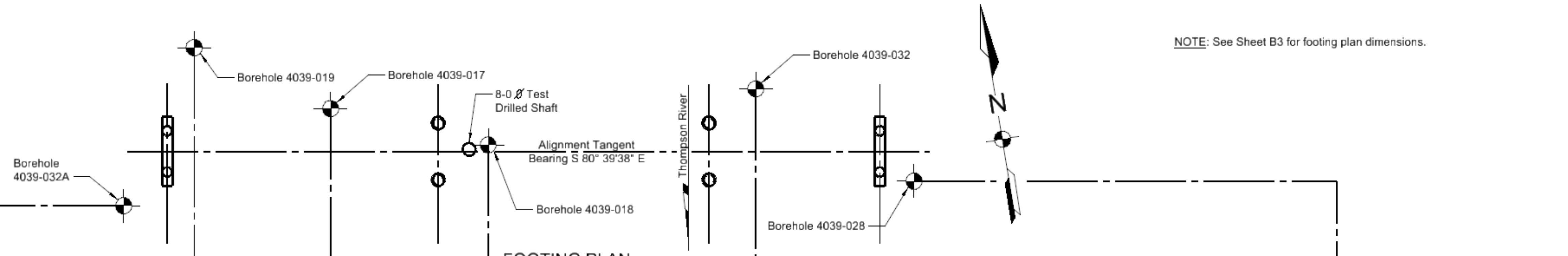
DRAWING NO.
22052

NOTES

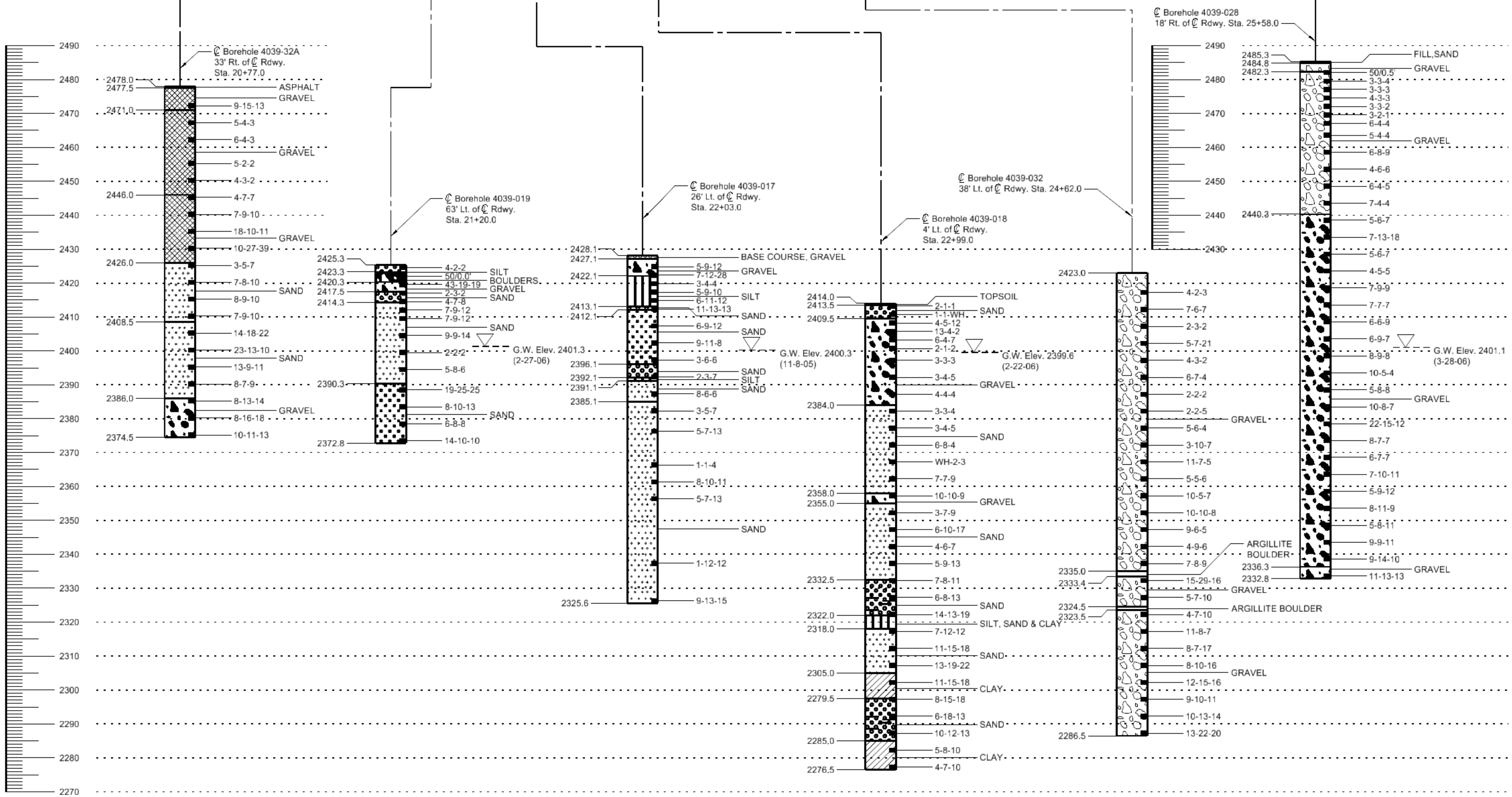
SOILS AND FOUNDATION MATERIALS: The series of numbers on the Log of Borings shows the number of blows from a 140 pound hammer with a 30" drop required todrive a 2" split spoon sampler 6" (Standard Penetration Test). The length of the split spoon sampler is 18". The sampler length is measured as three 6" intervals. If the split spoon sampler did not penetrate 6" after 50 blows, the Log of Borings shows the measured penetration within that particular interval.

See the Special Provisions for original boring logs and additional subsurface information.

NOTE: See Sheet B3 for footing plan dimensions.



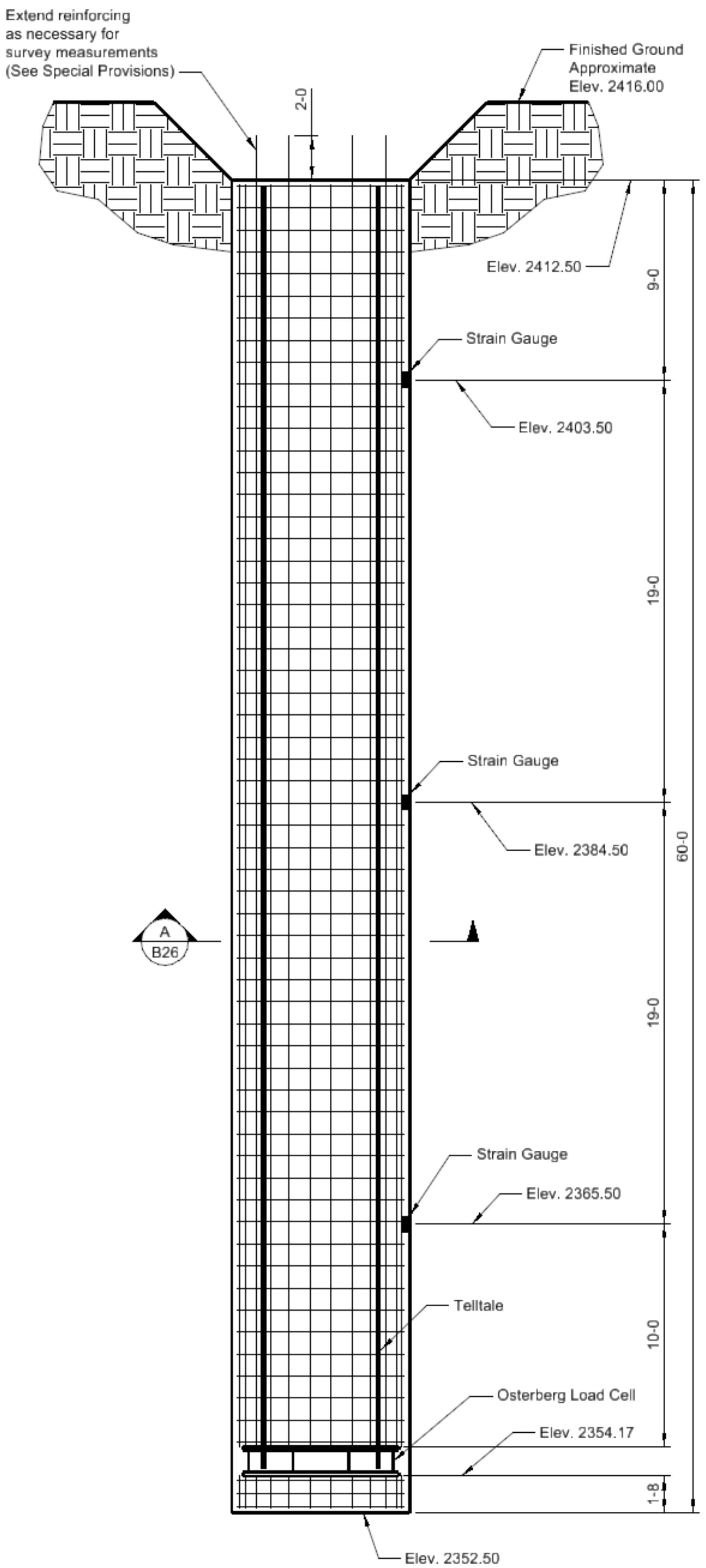
FOOTING PLAN
Scale ~ 1" = 40'-0"



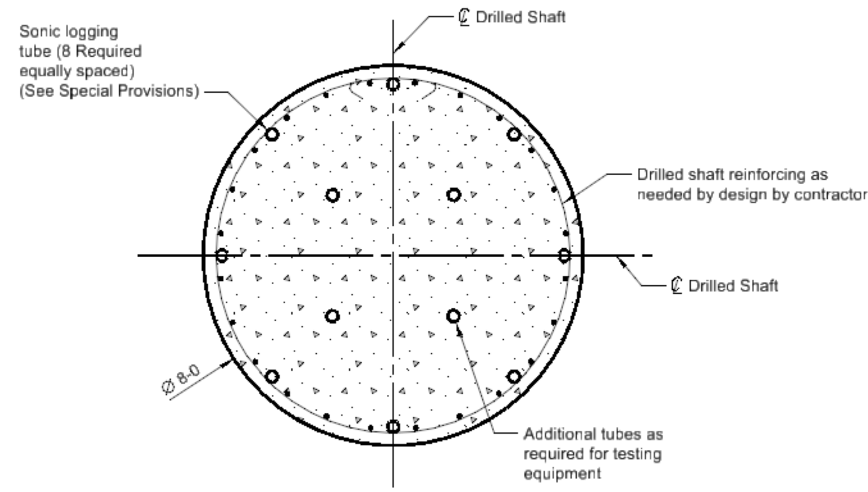
SUMMARY OF LOG OF BORINGS

SHEET NO.	B4
LOG OF BORINGS	Scale 1" = 15'-0" Except As Noted
BRIDGE OVER THOMPSON RIVER	AT STA. 23+20.50
FEDERAL AID PROJECT NO. STPB-STPP-HSIP 6-1(106)56	SANDERS COUNTY
MDT MONTANA DEPARTMENT OF TRANSPORTATION	BRIDGE BUREAU
CHECKED	2-14-14 C.W.H.
DRAWN	9-20-11 T.J.B.
DESIGNED	8-23-11 J.J.S.
UPN NUMBER	4039
DRAWING NO.	22053

$DATE$ $TIME$ $FILEABBREV$



TEST DRILLED SHAFT ELEVATION



A B26 SECTION A

Scale ~ ½" = 1'-0"

NOTES

Include all costs associated with furnishing and placing drilled shaft in the unit price bid for Static Load Test - Drilled Shaft.

Include all costs associated with furnishing and performing the Osterberg Load Cell Test in the unit price bid for Static Load Test - Drilled Shaft.

Drilled shaft reinforcing shown on this sheet is for reference only. Provide reinforcing as needed by design for load cell test.

Design the drilled shaft and conduct the Osterberg Load Cell Test for an ultimate test capacity of 5600 kips

Cut reinforcing steel that is extended out of drilled shaft for survey flush with top of drilled shaft at the completion of the Osterber Load Cell Test.

Strain gauge locations are approximate. Place gauges as needed to conduct the Osterberg Load Test.

SHEET NO.
B26

OSTERBERG LOAD CELL
TEST DETAILS

Scale ~ ¼" = 1'-0" Except As Noted

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO.
STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

MDT MONTANA DEPARTMENT OF TRANSPORTATION

BRIDGE BUREAU

REVISED		
REVISED		
REVISED		
CHECKED	2-27-14	C.W.H.
DRAWN	11-25-13	T.J.B.
DESIGNED	11-25-13	T.J.B.
$DATE$	$TIME$	$FILEABBREV$

UPN NUMBER
4039

DRAWING NO.
22075

APPENDIX J

1. O-CELL LOAD TESTING [560]

A. Description. This work consists of furnishing all materials, equipment and labor necessary for conducting an Osterberg Cell (O-Cell) Load Test and reporting the results. Supply all material and labor as hereinafter specified and including prior to, during and after the load test. The test shaft is to be constructed at the location shown in the plans and in accordance with the requirements of these special provisions and as outlined elsewhere in the contract.

Employ the services of:

Loadtest USA
2631-D NW 41st Street
Gainsville, FL 32606
Phone (800) 368-1138
(352)378-3717
Fax: (352)378-3934

Loadtest USA must oversee the drilled shaft installation, instrument installation and operation, and conduct the load test(s) on the drilled shaft(s). The Contractor is to provide auxiliary equipment and services as detailed herein and in coordination with Loadtest USA Loadtest USA has the authority to modify the Contractor's drilled shaft installation methods if deemed detrimental to the O-cell test. Coordinate with Loadtest USA to have a representative on-site during shaft excavation, construction, installation, and all aspects of instrument installation.

Work on production 6 foot diameter shafts is allowed prior to the test shaft installation however no work is allowed on any production shafts during the O-cell test day. Unless otherwise approved by Loadtest USA and the Project Manager.

Only minor work is allowed on the 8 foot diameter production shafts until after the results of the O-cell load test is evaluated,

It is the responsibility of the Contractor to inform the Project Manager if during the installation of the shaft any occurrences which may affect the quality of the performance of the O-cell test.

Once the project is complete, Research will conduct any necessary ongoing analysis and reporting requirement. The needs for Research may entail interviews with the contractors and applicable staff throughout the course of the project. This will include anecdotal information that may be digitally recorded.

Inform the Project Manager a minimum of 2 weeks prior to the beginning of this experimental feature. Who will contact Craig Abernathy, MDT Research ExPM, avaliable at 444-6269 (cabernathy@mt.gov) 2 weeks prior to the beginning of this project for schedule purposes. Keep the Project Manager informed of any changes in schedule relating to the O-cell test.

1) Preconstruction meeting. The following must attend the Preconstruction meeting:

- A representative from Loadtest USA
- The project Foreman from the Drilled Shaft Contractor.
- Craig Abernathy – Statewide Experimental Program Manager (444-6269) or an experimental program representative.

2) Experience. The Drilled Shaft Foreman must have installed and been a part of at least five successful drilled shafts (8 foot diameter) in the last five years. The Drilled Shaft Foremen must be on-site during all work described in this special provision and related to the test shaft. Submit at the Preconstruction meeting a written narrative with the following information at a minimum:

a) Name of the Drilled Shaft Foreman
b) Project description of previous verifiable drilled shafts including:
(1) Project Name.
(2) Project Location.

(3) Owners Name and contact representative with current address and phone number.

(4) Type and size of test shaft.

(5) O-Cell testing company.

(6) General Description of the O-Cell test conducted and the results.

B. Materials. Furnish all materials required to install the O-Cell, conduct the load test, and remove the load test apparatus as required. Furnish 1 or more O-Cell as required for each load test. The O-Cell(s) to be provided are to have a minimum bi-directional capacity as called for in the project plans or documents and be equipped with all necessary hydraulic lines, fittings, pressure source, pressure gage and telltale devices.

C. Construction Requirements.

1) Submittals. A minimum of 30 days prior to starting the excavation for the test shaft, submit 3 copies of a testing plan with working drawings which outline the test setup, including details of all system elements, instrumentation, materials, data collection system and procedures. Develop the testing submittal in coordination with and submit concurrently with the Drilled Shaft working drawing submittal as required in related specifications found elsewhere in the contract documents. The Department has 20 business days to review and comment on the submittal. Do not begin work on the test shaft or O-Cell until receiving written approval from the Project Manager and Loadtest USA

2) Equipment. Supply equipment and labor required to install the O-Cell, conduct the load test, and remove the load test apparatus as required. Required equipment includes but is not limited to:

a) Fresh, clean, potable water from an approved source to be used as hydraulic fluid to pressurize the O-Cell (typically bottled water or tap water).

b) A minimum of two digital survey levels capable of being read to the nearest 0.001 inch (0.025 mm) division with a minimum range of 10 inches (254 mm).

c) A protected work area (including provisions such as a tent or shed for protection from inclement weather for the load test equipment and personnel) of size and type required by Loadtest USA Protect the work area from cold weather. Do not conduct the O-Cell test below an ambient air temperature of 40°F (4.5°C).

d) Stable electric power source, as required for lights, welding, instruments, etc.

e) Materials for carrier frame, steel bearing plates and/or other devices needed to attach O-Cell to rebar cage, as required.

f) Welding equipment certified welding personnel and labor, as required, to assemble the test equipment under the supervision of Loadtest USA, attach instrumentation to the O-Cell(s) and prepare the work area.

g) Equipment and labor to construct the steel reinforcing cage and/or placement frame including any steel bearing plates required for the shaft.

h) Equipment and operators for handling the O-Cell, instrumentation and placement frame or steel reinforcing cage during the installation of the O-Cell and during the conduct of the test, including but not limited to a crane or other lifting device, manual labor, and hand tools as required by Loadtest USA

i) Air compressor of sufficient size required by Loadtest USA for pump operation during the load test.

3) Installation and Removal of Load Testing Apparatus. Construct the drilled shaft using the approved shaft installation techniques.

Assemble the O-cell, hydraulic supply lines and other instruments and make ready for installation under the direction of Loadtest USA. Provide a suitable area, adjacent to the test shaft, for installation and assembly of the O-Cell. Construct the steel reinforcing cage required for the test shaft; the O-Cell assembly is to be welded at the appropriate location within the cage or equivalent in conjunction with the construction of the cage. The plane of the bottom plate(s) of the O-Cell(s) are to be set at right angles to the long axis of the cage. Use care in handling the test assembly so as not to damage the instrumentation during installation. Limit the deflection of the cage to 2 feet (610 mm) between pick points while lifting the cage from the horizontal position to vertical. Provide support bracing as needed to maintain the deflection within the specified tolerance. Ensure the O-Cell assembly remains perpendicular to the long axis of the reinforcing cage throughout the lifting and installation process.

When the test shaft excavation has been completed, inspected and accepted by the Project Manager, install the O-Cell assembly and the reinforcing steel. A common method is to install the O-Cell assembly using a pump line or tremie pipe extending through the O-Cell assembly to the base of the shaft. Depending on the configuration of the test assembly, it may be necessary to deliver a seating layer of concrete prior to installing the O-Cell. In this case, the O-Cell assembly would be installed while the concrete or grout at the base is still fluid, under the direction of the Loadtest USA.

After seating the O-Cell, if applicable concrete the remainder of the drilled shaft in the same manner as that approved in the production and test shaft(s) submittal. Make the concrete available for sampling; MDT will sample at least ten (10) concrete test cylinders; more if required by Loadtest USA, in addition to those specified elsewhere from the concrete used in the test shaft, to be tested at the direction of Loadtest USA.

The acceptance criterion and corrective action criterion as detailed in the Drilled Shaft special provision for testing, accepting, and repairing production drilled shafts also applies to the test shaft. CSL tubes must be installed to a minimum depth of the top of the O-Cell. Coordinate with Loadtest USA for installing the CSL tubes and the O-cell testing equipment. The Department will not pay for the installation of the test shaft if the test shaft is deemed “Defective” as detailed in the Drilled Shaft special provision unless repairs satisfactory to Loadtest USA and the Department are performed and accepted.

Do not begin load testing until cylinder break testing has confirmed that the drilled shaft concrete has obtained the compressive strength as called for in the plans or contract documents.

Notify the Geotechnical Section a minimum of 5 business days prior to the beginning of the load test so a representative can observe the load test.

During the load test, no casings may be vibrated into place in the foundation area near the load test. Drilling may not continue within a 300-foot (90 m) radius of the test shaft. If test apparatus shows any interference due to construction activities outside of this perimeter, cease work immediately at the direction of Loadtest USA or the Project Manager.

After the completion of the load test, remove any protruding external equipment, material, waste, etc. which are not to be a part of the finished structure. The load test shaft is not intended to carry service loads. Demolish the load test shaft in accordance with Subsection 202.03.1. Monitor the backfill for the project duration and continue adding material if settlement occurs.

4) Testing and Reporting. Loadtest USA will perform the load testing and reporting. Perform the load testing in compliance with ASTM D1143 using the Quick Load Test Method for Individual Piles. Initially, apply loads in increments equaling 5% to 8% of the maximum test load. The magnitude of the load increments may be increased or decreased depending on the project requirements but should not be changed during the test.

Direct movement indicator measurements should be made of the following: O-Cell expansion either directly or with telltales (minimum of 4 indicators required), upward top-of-shaft displacement (minimum of 2 levels required) and shaft compression above O-Cell (minimum of 2 indicators required).

Apply loads at the prescribed intervals until the ultimate capacity of the shaft is reached in either end bearing or side shear, until the maximum capacity or maximum stroke of the O-Cell is reached, or unless otherwise directed by the Project Manager.

At each load increment, or decrement, read movement indicators at 1, 2, 4 and 8-minute intervals while the load is held constant.

During unloading cycles, acquire at least 5 data points of the load decrement for the load versus movement curve. Additional cycles of loading and unloading using similar procedures may be required by the Project Manager following the completion of the initial test cycle.

Use digital dial gages, LVDTs, or LVWDTs with a minimum travel of 6 inches (152 mm) and capable of being read to the nearest 0.001 inch (0.025 mm) division to measure O-Cell expansion. Top-of-shaft displacement is required to be measured by a pair of digital survey levels as described in section C.2.b of this special provision. The survey levels must be placed no closer than 5 shaft diameters from the center of the test shaft. When O-Cell expansion is measured directly, or when testing requires the maximum stroke of the O-Cell to be reached, use LVWDTs capable of measuring the full stroke of the O-Cell. Use digital dial gages, LVDTs, or LVWDTs to measure shaft compression that have a minimum travel of 2 inch (50 mm) and are capable of being read to the nearest 0.001 inch (0.025 mm) division.

Supply 6 copies of a report of the load test, as prepared by Loadtest USA coordinate the report with Craig Abernathy and the Project Manager. Provide an initial data report containing the load-movement curves and data tables to the Project Manager within 4 business days of the completion of load testing, to allow evaluation of the test results. Submit a final report on the load testing to the Project Manager within 7 business days after completion of the load testing. As a minimum, include in the final report the following:

a) As-installed location of the test shaft.
b) Logs of the test borings conducted at the test shaft location.
c) Installation records of test shaft showing locations of all instrumentation.
d) Summary of the load test procedure and data collected during load testing.
e) Analysis of unit side adhesion in the test socket and unit end-bearing pressure.
f) Plots of axial load versus displacement at the base of the shaft, and axial load versus displacement and/or strain along the test socket.

5) Upon submission of the final report of the O-cell test, the Department has five business days to evaluate the results of the load test and determine the final depth of the 8 foot diameter productions shafts.

D. Method of Measurement. The “Osterberg Cell Load Testing of Drilled Shaft” will be measured by the Lump Sum for the actual number of shafts tested, and will include any material, labor and equipment necessary for the installation of the drilled shaft(s) and O-Cell load testing of the drilled shaft(s). Include any material, labor and equipment necessary to assemble, install and remove the load test apparatus (if necessary), conduct and report results of the load. All costs associated with the construction of normal production drilled shafts are measured and paid for elsewhere in the contract documents.

E. Basis of Payment. The O-Cell load tests will be paid for at the Lump Sum price for the accepted “Static Load Test – Drilled Shaft.”

Payment at the contract unit price is full compensation for all resources necessary to complete the items of work under the contract.

2. <u>SYNTHETIC SLURRY FOR DRILLED SHAFTS (ADDED 4-28-11)</u>

A. Description. Use of synthetic slurry construction methods, meeting the requirements herein, is permissible as an alternative to or in conjunction with temporary casing for drilled shaft excavations.

B. Materials. Do not use Mineral or water slurry. It is only permissible to use Synthetic slurries in conformance with the manufacturer's recommendations, the submitted quality control plan and these Special Provisions. The following synthetic slurries are approved as slurry systems:

Product	Manufacturer
Novagel	Geo-Tech Services, LLC 220 North Zapata Highway, Suite 11A

	Laredo, TX 78043-4464
ShorePac GCV	CETCO 1500 West Shure Drive Arlington Heights IL, 60004
SlurryPro CDP	KB International, LLC Suite 216, 735 Broad Street Chattanooga, TN 37402-1855
Super Mud*	PDS Company 8140 East Rosecrans Ave. Paramount, CA 90723-2754

*Approval as a product applies to the liquid product only.

Submit other proposed synthetic slurry products for approval. Submit proposed additives for approval.

C. Submittals. As part of the shaft installation plan provide the following:

1) Product name and manufacturer's technical data sheets.

2) Detailed procedures for mixing, using, maintaining, and disposing of the slurry.

3) A detailed mix design (including all additives and their specific purpose in the slurry mix), and a discussion of its suitability to the anticipated subsurface conditions.

4) A detailed plan for quality control of the selected slurry, including tests to be performed, test methods to be used, and minimum and/or maximum property requirements which must be met to ensure that the slurry functions as intended, considering the anticipated subsurface conditions and shaft construction methods, in accordance with the slurry manufacturer's recommendations and these Special Provisions. At a minimum include in the quality control plans the following tests:

Property	Test Method
Density	Mud Weight (Density), API 13B-1, Section 1
Viscosity	Marsh Funnel and Cup, API 13B-1, Section 2.2
PH	Glass Electrode, pH Meter, or pH Paper
Sand Content	Sand, API 13B-1, Section 5

5) Arrange for a representative from the slurry manufacturer to provide technical assistance in the use of the slurry and submit the following to the Project Manager:

a) The name, current phone number and training/experience record of the slurry manufacturer's technical representative assigned to the project, and the frequency of scheduled visits to the project site by the representative.

b) The name(s) of the Contractor's personnel assigned to the project and trained by the slurry manufacturer in the proper use of the slurry. Include a signed training certification letter from the slurry manufacturer for each trained Contractor's employee listed, including the date of the training. If training and certification are to be performed on-site, indicate that in the submittal and furnish the certifications when they are available.

D. Construction.

1) Manufacturer's Representative. The manufacturer's representative described above is required to: Provide technical assistance for the use of the slurry, be at the site prior to introduction of the slurry into the first drilled hole, and remain at the site during the construction and completion of a minimum of one shaft to adjust the slurry mix to the specific site conditions.

In the manufacturer's representative absence, the Contractor's employee trained in the use of the slurry, as identified to the Project Manager in accordance with this Special Provision, is required to be present at the site during shaft slurry operations to perform the duties specified above.

2) Slurry installation requirements. Do not begin work until all the required submittals have been approved in writing by the Project Manager. All approvals given by the Project Manager will be subject to trial in the field and do not relieve the Contractor of the responsibility to satisfactorily complete the work.

When using slurry once the excavation operation has been started, perform the excavation in a continuous operation until the excavation of the shaft is completed, except for pauses and stops as noted, using equipment capable of excavating through the type of material expected. .

Pauses, defined as momentary interruptions of the excavation operation, are allowed only for casing splicing, tooling changes, slurry maintenance, and removal of obstructions. Shaft excavation operation interruptions not conforming to this definition are considered stops. Stops for uncased excavations (including partially cased excavations) cannot exceed 16 hours duration. For stops exceeding the 16 hour duration, stabilize the excavation using one or both of the following methods:

a) Install casing in the hole to the depth of the excavation. Provide casing with outside diameter no less than six inches less than either the Plan diameter of the shaft or the actual excavated diameter of the hole, whichever is greater. Prior to removing the casing and resumption of shaft excavation, sound the annular space outside the casing. If the sounding operation indicates that caving has occurred, do not remove the casing or resume shaft excavation until the excavation has been stabilized in accordance with the shaft installation plan conforming to this Special Provision.

b) For both a cased and uncased excavations, backfill the hole with granular material. Backfill the hole to the ground surface, if the excavation is not cased, or to a minimum of five feet above the bottom of casing (temporary or permanent), if the excavation is cased. Backfilling of shafts with casing fully seated into rock, as determined by the Project Manager, will not be required.

Conform to the requirements of this Special Provision regarding the maintenance of the slurry and the minimum level of drilling slurry throughout the stoppage of the shaft excavation operation, and recondition the slurry to the required slurry properties in accordance with the submitted quality control plan and this Special Provision prior to recommencing shaft excavation operations.

Maintain the slurry level in the excavation a minimum of 10 feet above the groundwater level or greater as required to provide and maintain a stable hole. Provide casing, or other means, as necessary to meet these requirements. Maintain slurry above all unstable zones a sufficient distance to prevent bottom heave, caving or sloughing of those zones.

3) Slurry Mixing, Sampling and Testing. Thoroughly mix slurry hydrated in slurry tanks, ponds, storage areas, or as recommended by the Manufacturers technical representative. Draw sample sets from the slurry storage facility and test the samples for conformance with the appropriate specified material properties before beginning slurry placement in the shaft excavation. Conform to the quality control plan included in the shaft installation plan in accordance with this Special Provision and as approved by the project manager. Sample sets are composed of samples taken at mid-height and within two feet of the bottom of the storage area.

Sample and test all slurry in the presence of the project manager, unless otherwise directed. Record the results of the tests and date, time and names of the persons sampling and testing the slurry. Submit a copy of the recorded slurry test results to the project manager at the completion of each shaft, and during construction of each shaft when requested by the project manager.

Take and test sample sets of all slurry, composed of samples taken at mid-height and within two feet of the bottom of the shaft, during drilling as necessary to verify the control of the properties of the slurry. As a minimum, sample sets of synthetic slurry shall be taken and tested at least once every four hours after beginning its use during each shift. Take and test sample sets of all slurry at least once every two hours if the slurry is not re-circulated in the drilled hole or if the previous sample set did not have consistent specified properties. Recirculate or agitate slurry with the drilling equipment, when tests show that the sample sets do not have consistent specified properties.

Take and test sample sets of all slurry, as specified, prior to final cleaning of the bottom of the hole and again just prior to placing concrete. Do not start cleaning of the bottom of the hole and placement of the concrete until tests show that the samples taken at mid-height and within two feet of the bottom of the hole have consistent specified properties.

Clean, recirculate, de-sand, or replace the slurry to maintain the required slurry properties as necessary.

Demonstrate to the satisfaction of the project manager that stable conditions are being maintained. If the project manager determines that stable conditions are not being maintained, immediately take action to stabilize the shaft. Submit a revised shaft installation plan which addresses the problem and prevents future instability. Do not continue with shaft construction until the damage which has already occurred is repaired in accordance with the specifications, and until receiving the Project Managers approval of the revised shaft installation plan.

Dispose of the slurry as specified in the shaft installation plan as approved by the project manager, and in accordance with the Contractor's permit requirements.

Immediately prior to commencing concrete placement, the shaft excavation and the properties of the slurry must conform to the quality control plan and this Special Provision. The sand content of slurry prior to final cleaning and immediately prior to placing concrete must be less than 2.0 percent, in accordance with API 13B-1, Section 5.

In the event a shaft is determined to be defective do not continue to use slurry construction methods without written approval from the Project Manager. The Project Manager may require amendment and resubmittal of the shaft construction methods.

E. Method of Measurement. Use of slurry for drilling is not measured for payment.

F. Basis of Payment. Include all costs associated with using slurry in bid item for "Drilled Shaft."

3. DRILLED SHAFTS (REVISED 5-17-2011)

A. Description. This work is constructing reinforced concrete shafts cast in cylindrically excavated holes that extend into soil or rock to support the structure and externally applied loads at the locations and to the lines and grades shown. Shaft depth may be increased by up to 15 feet (4.6 m) based on field conditions by written order from the Project Manager. Be prepared to construct the shaft to the adjusted depth if required.

B. Materials.

1) Drilled Shaft Concrete. Use Drilled Shaft Concrete for all concrete placed between the bottom of the shaft and the top of the casing, unless otherwise shown on the plans.

2) Permanent Drilled Shaft Casing. Furnish casing meeting the size and thickness requirements specified and casing material that meets the requirements of AASHTO M 270 (M 270M), Grade 36 (Grade 250). Casing materials, fabrication and inspection are as specified in Section 556.

C. Construction Requirements.

1) Submittals. Submit four copies of the following information to the Project Manager a minimum of thirty calendar days before start of drilling operations.

a) Drilled Shaft Activities Schedule Chart and Written Narrative outlining:

(1) Bent and shaft construction sequence. If more than one shaft will be worked on at any time, include that information in the submittal.

(2) Method of Shaft Excavation.

(3) Method to Clean Shaft Excavation.

(4) Temporary and Permanent Casing Installation and Removal Methods. Include casing top and bottom elevations and diameters.

(5) Method of Concrete Placement. Include descriptions of methods or devices that will be used to prevent the injection of air or water into the drilled shaft concrete when starting concrete placement and in the event the placement is stopped and restarted.

(6) Time necessary for complete concrete placement.

b) Name and experience record of Contractor, and Superintendent and Driller(s) to that will perform the drilled shaft work on this project. The experience record need only include the last 10 years.

c) List of proposed drilling equipment to be used, including any cranes, drills, augers, bits, temporary casings and cleaning tools. Include diameter of augers and cleaning buckets.

d) Proposed size and location of all reinforcing steel used to support or maintain the shape of the reinforcing steel cage.

2) Shaft pre-construction meeting. Schedule a shaft pre-construction meeting with the Project Manager for a time 7-14 days prior to drilling. The minimum required attendees are the superintendent, concrete supplier, and Project Manager. The purpose of the meeting is to review the requirements of this Provision, discuss the drilled shaft installation plan, and to discuss logistical and contingency plans.

3) Geotechnical logging. The Department will provide a Geotechnical Section representative on-site during drilling and installation operations to log the excavation. Notify the Project Manager at least seven calendar days prior to start of drilled shaft excavation so that the Project Manager can schedule the on-site representative.

4) Shaft Excavation. Use excavation methods that provide contact with firm, undisturbed soil or rock with the sides and bottom of the shaft concrete when the temporary casing is removed. Do not excavate holes larger than the outside diameter of permanent casings to facilitate casing installation.

5) Shaft Locations, Alignment and Tolerances. Drill all shafts to the bottom elevations specified or as directed by the Project Manager. Construct the shaft so the vertical centerline axis of the finished shaft is within 3 inches (75 mm) of the plan location at the top of the shaft. Drill all shafts to within 2 percent of vertical the entire depth of the shaft excavation.

6) Sloughing and Caving. Use construction methods that will ensure no sloughing or caving of the shaft side walls. In the event any sloughing or caving does occur, remove all sloughed material. Ensure that concrete completely fills the shaft. If caving occurs during placement of drilled shaft concrete, immediately stop the flow of concrete and undertake corrective measures to completely remove the sloughed materials from the shaft. If necessary to facilitate material removal, remove the concrete and reinforcing steel already placed in the shaft.

7) Permanent Casing.

a) Description. Furnish and install permanent casing when specified on the plans. Permanent casing remains in place and is included in the design of the drilled shaft. The permanent casing diameter may be oversized up to 3 inches (75 mm) if necessary to facilitate temporary casing installation.

b) Welding. If field welding, submit four copies of the weld procedures to the Project Manager for approval thirty calendar days prior to welding.

c) Corrosion Protection. Provide corrosion protection for all permanent casing. Galvanize the permanent casing to AASHTO M 111 (M 111M) and ASTM A 653 (A 653M) specifications or paint. If painting, meet the following requirements:

(1) Material. Furnish paint meeting the requirements of Subsection 710.02 (B)(3).

(2) Surface Preparation. Prepare the casing surface following the paint manufacturer's recommendations.

(3) Paint Application. Follow the paint manufacturer's recommendations for paint application. Apply paint to the casing before installation, starting 24 inches (610 mm) below ground surface, continuing to the top of exposed steel.

(4) Shop Painting. Apply the first two paint coats to produce a minimum 12 mil (300 μm) dry film thickness. Provide two copies of the painter's certification that the paint was applied following the manufacturer's recommendations and test results showing the paint coat thickness on the casing.

(5) Field Painting. Repair paint damage caused by transport, handling and welding following the paint manufacturer's recommendations before applying the finish coat.

For the finish coat, use the same paint or paint compatible with the first two coats. Provide a finish coat with a minimum 3 mil (75 μm) dry film thickness. Provide the finish coat paint color as follows:

COLOR	FEDERAL SPECIFICATION 595B PIGMENT CODE
Concrete Gray	36440

8) Temporary Casing. Do not use slurry construction methods as an alternative to or in conjunction with temporary casing on this project unless the Contract contains the Special Provision "Synthetic Slurry for Drilled Shafts". Use temporary casing to facilitate shaft construction and prevent sloughing and caving of the shaft sidewalls. Full depth temporary casing is required. Refer to the tip elevations on the bridge plans for temporary casing elevation, these elevations are minimum elevations. Place the temporary casing deeper if necessary to prevent material from entering the shaft excavation. Be prepared to provide up to 15 feet (4.6 m) of additional temporary casing in the event that the shaft bottom elevation is lowered during construction. Use casing with an outside diameter no less than the specified diameter of the shaft. Limit the excavation in advance of the casing tip to no more than 10 feet (3 m) unless synthetic slurry is being used. During casing extraction, maintain a sufficient level of fluid in the casing to counteract external hydrostatic pressures but no less than 5 feet of positive head. Maintain an adequate level of concrete within the casing and provide vibration of the temporary casing or the concrete as needed to ensure that fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete. Use equipment and methods capable of extracting temporary casings. Temporary casings that have become bound or fouled during shaft construction and cannot be removed are considered to be a defect in the drilled shaft. Correct defective shafts using approved methods at no cost to the Department. Corrective action may consist of, but is not limited to, the following:

a) Removing the drilled shaft concrete and extending the drilled shaft deeper to compensate for the loss of frictional capacity to the cased zone.
b) Providing straddle drilled shafts to compensate for capacity loss.
c) Providing a replacement drilled shaft.

9) Obstructions. An obstruction is considered a specific object exceeding 50 percent of the shaft diameter that cannot be removed from the drilled shaft excavation using conventional augers or core barrel tools. If an obstruction is encountered, promptly notify the Project Manager. Submit four copies of a proposed obstruction removal method to the Project Manager for approval within two calendar days of encountering the obstruction.

10) Cleaning. Remove all loose or disturbed material from the bottom of the shaft excavation immediately prior to placing reinforcing steel and concrete. After cleaning, 1.0 inch (25 mm) is the maximum thickness of loose or disturbed material permitted in the bottom of the shaft.

11) Installation of Cross-hole Sonic Logging (CSL) Tubes. As shown in the plans, install the CSL access tubes evenly spaced around the reinforcing cage and inside of all hoops

and spiral reinforcing steel. Use schedule 40 mild steel standard black pipe conforming to ASTM A 53 (A 53M), Grade A or B, Type E, F or S, 1 ½ inch (38 mm) nominal diameter CSL access tubes that extend the full length of the drilled shaft. Provide an end plug at the lower end of the pipe and make all joints watertight. Fill the CSL access tubes with a 1:1 mixture of potable water and biodegradable antifreeze prior to placing concrete in the drilled shaft. Temporarily cap the top of the tubes to prevent debris or concrete from entering the tubes.

12) Reinforcing Steel. Use “Figure eight” or “Saddle” ties at all intersecting bars. After inspection and approval of the drilled shaft excavation by the Project Manager, place the reinforcing steel cage into the shaft as one unit. Support the steel cage from the top so that racking and distortion are prevented. Remove internal stiffeners as necessary as the steel cage is placed in the excavation to prevent interference with the placement of concrete. Use non–corrosive, roller-type spacers or other non-corrosive devices as approved by the Project Manager along the steel cage length and around the steel cage perimeter to align and maintain clearance from reinforcing cage to edge of casing during concrete placement. Begin placing the drilled shaft concrete immediately after the Project Manager has inspected and approved the cage for location and alignment within the drilled shaft. Remove the steel cage and re-inspect the excavation if the concrete placement is not started within three hours of placing the steel cage in position.

13) Concrete Placement Record. Complete the MDT Drilled Shaft Concrete Placement Log. Accurately record all data required on the form as the concrete is placed. After the drilled shaft concrete has been placed and before the end of the day, give the completed form to the MDT inspector. MDT will provide copies to the Contractor upon request.

14) Drilled Shaft Concrete

15) Place concrete in the drilled shaft as specified for either dry excavations or wet excavations.

a) Dry Excavations. Place concrete by gravity tremie tube or pumping. Concrete may free fall into the shaft if the concrete can be directed so that it does not strike the reinforcing steel, the excavation wall or any other obstruction during the fall.

b) Wet Excavations.

(1) Place all drilled shaft concrete by tremie tube, pumping, or other approved method to avoid separation and segregation of the concrete mix components.

(2) Separate the first concrete placed from the fluid in the excavation using a plug in the tube, or other approved device.

(3) Begin concrete placement in a manner that minimizes mixing of the concrete with the water and material in the shaft.

(4) Continuously place drilled shaft concrete until the tremie tube or pumping pipe is removed from concrete at the top of the shaft. If at any time during concrete placement it is necessary to temporarily stop concrete placement, restart concrete placement in a manner that ensures that air, water, or other undesirable material is not mixed into the concrete or incorporated into the drilled shaft.

(5) Maintain 10 feet of tremie pipe embedment or more if necessary to ensure upward displacement of all contaminated concrete. If at any time during the pour, the tremie pipe orifice is removed from the concrete, stop and restart concrete placement in a manner that ensures that air, water, or other undesirable material is not allowed to be mixed into the concrete or incorporated into the drilled shaft. Concrete that is discharged above the rising concrete level in the shaft is considered undesirable material.

(6) Once concrete has reached the top of the drilled shaft, remove and dispose of the top layer of concrete and any concrete contaminated with mud or fluid from the drilled shaft. Remove sufficient concrete to fully expose sound, homogeneous and uncontaminated concrete in the shaft.

16) Shaft Testing and Acceptance

a) Cross-Hole Sonic Logging. The Project Manager may use CSL to check the structural soundness of any completed drilled shaft(s). The CSL testing will be performed when the concrete has cured sufficiently to give consistent test readings. Schedule construction activities to allow twelve calendar days from the time concrete is placed in the shaft until the shaft is tested. Provide a stable 110-Volt AC or a 12-Volt DC electrical supply if requested. When the CSL testing access tubes are no longer needed for testing, as determined by the Project Manager, cut off the tubes flush with the top surface of the drilled shaft and remove the antifreeze solution to a depth of 4 inches (100 mm) from the top of the tubes. Permanently cap the CSL access tubes to provide a watertight seal that does not interfere with the subsequent construction operations. The Project Manager will accept or reject the shaft based on the CSL testing or a subsequent drilled core sample. For any drilled shaft determined by CSL testing to be of uncertain quality, drill core samples with a minimum diameter of 2.5 inches (65 mm). Drill at locations and to depths specified by the Project Manager, to explore the shaft quality. Use a core drilling method that provides complete core recovery and minimizes abrasion and erosion of the core. Grout all core holes when directed by the Project Manager.

b) Corrective Action. If the CSL or subsequent coring identifies any defect in the shaft that compromises the capacity of the shaft repair the shaft by a method approved by the Project Manager. Submit a repair plan no later than fourteen calendar days after notification. Include four copies of calculations and working drawings, stamped by a Civil Engineer licensed in Montana, to the Project Manager. Furnish all materials and work necessary to correct shaft defects at no cost to the Department. Prior to constructing other shafts, submit four copies of a written proposal to the Project Manager that describes changes in construction methods or materials designed to avoid defects in subsequent drilled shafts.

D. Method of Measurement.

1) Drilled Shaft. Drilled shaft will be measured by the linear foot (meter) of shaft between the actual bottom elevation of the drilled shaft and the top of shaft elevation shown on the plans.

2) Reinforcing Steel. Drilled shaft reinforcing steel will be measured by the pound (kilogram) in accordance with Subsection 555.04.

3) Drilled Shaft Casing. Permanent drilled shaft casing will be measured by the linear foot (meter) of permanent casing installed as shown in the plans or as directed by the Project Manager in writing.

4) Temporary Casing. When the Contract contains the pay item “Temporary Drilled Shaft Casing”, temporary drilled shaft casing will be measured by the linear foot (meter) of temporary casing measured from the higher of the ground or water surface elevation down to the bottom elevation of the installed temporary casing.

5) Cross-hole Sonic Logging (CSL) Tubes and Testing. Include all costs associated with furnishing and installing CSL access tubes and any required extensions and providing a power source in the Drilled Shaft Pay Item. No measurement or payment will be made for construction delays resulting from the initial CSL drilled shaft testing. The Department will extend the contract time by one day for each day over twelve calendar days required to complete the CSL drilled shaft testing. The Department will pay the costs for the initial CSL drilled shaft testing. Pay for all costs associated with coring, engineering design, cost required to correct the defect and any construction delay costs, if a defect is found based on the CSL drilled shaft testing or coring. Pay the costs of CSL drilled shaft retesting of the repaired drilled shafts. If no defect is found in the drilled shaft based on the coring, the Department will pay all costs of coring and any delays necessitated by the coring.

E. Basis of Payment. Payment for the completed and accepted quantities is made under the following:

Pay Item	Pay Unit
Drilled Shaft	Linear Foot (meter)

Reinforcing Steel	Pound (kilogram)
Drilled Shaft Casing	Linear Foot (meter)
Drilled Shaft Concrete	Cubic Yard (cubic meter)

Payment at the contract unit price is full compensation for all resources necessary to complete the item of work under the contract. Temporary casings remain the property of the Contractor.

If the Contract contains the pay item Temporary Drilled Shaft Casing, all costs associated with temporary casing including, but not limited to, procurement, fabrication, transportation, installation and removal, are included in the Pay Item Temporary Drilled Shaft Casing. If the Contract does not contain the pay item Drilled Shaft Temporary Casing, no measurement or payment will be made. Include all costs associated with temporary casing including, but not limited to, fabrication, providing, transporting, installation and removal in the Drilled Shaft pay item.

Obstruction Removal. Payment for work associated with obstruction removal will be made on a Force Account basis.

APPENDIX K

CONSTRUCTION • DESIGN BUILD
Sletten COMPANIES
Las Vegas • Great Falls • Phoenix • Boise • Cody

Sletten, Inc.
1000 25th Street North
Great Falls, Montana 59401
Telephone (406) 761-7920
Fax (406) 761-0923

Sletten Construction Company
1000 25th Street North
Great Falls, Montana 59401
Telephone (406) 761-7920
Fax (406) 761-0923

July 14, 2014

Tami Hembree
Engineering Project Manager
Montana Department of Transportation
PO Box 7039
Missoula, MT 59807

Re: Thompson River - East
12514/STPB-STPP-HSIP 6-1(106)56

Dear Ms. Hembree:

Enclosed are four (4) copies of the Drilled Shaft submittal on the subject project. Please review for approval. If you have any questions, please feel free to contact me.

Sincerely,

SLETTEN CONSTRUCTION COMPANY

Tracy Gilbert
Assistant Project Manager/Bridge Division

Encl

cc: file-scan

Thompson River – East Drilled Shaft Submittal

ACTIVITIES SCHEDULE CHART AND NARRATIVE IS ATTACHED

1) METHOD OF SHAFT EXCAVATION;
   Sletten will use a crane-mounted drill and augers to excavate the shafts.
2) METHOD TO CLEAN SHAFT EXCATION;
   Sletten will us a crane-mounted drill and augers to and a clean-out bucket with bottom flap gate to clean holes.
3) TEMPORARY CASING INSTALLATION AND REMOVAL METHOD;
   Casing will be installed and/or removed with a crane and vibratory hammer. In order to insure the temporary casing can be removed 2 temporary casings will be required. First a template will be built to ensure proper placement of the casing. An 8ft. diameter or a 6ft. 6in. diameter temporary casing will be installed 30ft. down from finished grade of the shaft. The 8ft. or 6ft 6in casing will then be drilled out and cleaned down 30ft before the 6ft casing is installed. The 6ft. diameter casing will then be installed to the final depth of the shaft, a 6ft. diameter auger will be used.. The 8ft. diameter shafts will require a template installed to ensure proper placement of the casing. An 8ft. 6in. diameter casing will be installed 30ft down from the finished grade of the shaft. Inside the 8ft 6in casing will then be drilled and cleaned down 30ft before installing the 6ft. diameter casing. An 8ft. diameter casing will then be installed to the final depth of the shaft, a 6ft diameter auger will be used. (See attachment for detailed elevations).
4) HYROSTATIC PRESSURE;
   Sletten has taken into consideration the effects of hydrostatic pressure differentials that may occur during shaft excavation and construction. At all times, Sletten will keep a positive head of water in the drilled shaft excavation to equalize pressure from the outside water and soil pressure by pumping water into the drilled shaft.
5) METHOD OF CONCRETE PLACEMENT;
   Concrete will be pumped to the bottom of the shaft using a tremie tube. Tremie tube will be place to the bottom of the shaft, a foam pig (ball) will be installed at the top of the tremie pipe and the pump truck will then be hooked on to the pipe and the pumping of the concrete will begin. The tremie pipe will be left in the bottom of the shaft until at least 10ft. of concrete head is obtained and then raised slowly up as the shaft is filled. The concrete will be monitored continuously using the MDT drilled shaft log to control the rate of the concrete discharge. In the event that the concrete pour has to be stopped, the tremie pipe will slowly be filled and the pumping of the concrete will resume. During the placement of the concrete it will be necessary to pull the temporary casings. The concrete will be poured up 35ft from the bottom of the shaft, the inner temporary casing will then be pulled up 10 to 15 ft. to ensure the casing will pull out. The concrete will then be poured up 15ft above the outer temporary casing. The tremie pipe will always stay a minimum of 10ft to 15ft below the top of the concrete. The inner casing will then be removed and the concrete will be filled to the top of the shaft before removing the outer temporary casing.
   The estimated time to complete each shaft should be.

Bent	Place concrete hrs.	Pull Temporary casing hrs.	Total hrs.
1	96 yards. 4hrs	2.5hrs.	6.5 hrs.
2	126 yards 5hrs	2.5hrs	7.5hrs
3	126 yards 5hrs	2.5hrs	7.5hrs
4	60 yards 3hrs	2.5hr	5.5hrs
Test Shaft	118 yards 5hrs	2.5hrs	7.5hrs

6) NAME AND EXPERIENCE RECORD OF CONTRACTOR TO PERFORM THE DRILLED SHAFT WORK:
   Sletten Construction Company will perform the drilled shaft work. Our experience record is attached.
7) LIST OF DRILLING EQUIPMENT AND TOOLS AVAILABLE FOR USE:
   Please refer to the attached equipment list.
8) PROPOSED SUPPORTS AND BRACES TO MAINTAIN THE SHAPE OF THE REBAR CAGE:
   Please refer to the attached information for this item.
9) BENT AND SHAFT CONSTRUCTION SEQUENCE:
   Sletten Construction plans on drilling of the test shaft first, Pier 3, Pier 2,Bent 1, Bent 4 in that particular order. Sletten Construction may work on 2 shafts at a time on Bents 1 and 4 if necessary.

Thompson River – East

Project Narrative July 11, 2014

This project was awarded to Sletten Construction on June 3, 2014. The Joint Application Permit was submitted on July 1, 2014 along with the bridge removal plan, and the work bridge plan. Work is scheduled to start August 18, 2014 with LHC performing the clearing and grubbing. LHC will be working this season on the excavation, special borrow and building part of the road this season. After the clearing and grubbing has been completed, Sletten will then begin work on the temporary work bridge. This work should take approximately 20 shifts with the sheet pile wall being completed right afterwards. While the work bridge is being installed Sletten will be working on the test shaft for the o cell test. After the O cell test has been completed work will begin on pier shaft #3. The sequencing for the shafts will be pier 3, pier 2, bent 1, and bent 4 being done last. The pier columns and caps will be constructed along with the abutments throughout the winter. There should be no impact to the traffic throughout the winter while Sletten is working on the substructure. After the substructure has been completed the structural steel will be set and the decking of the super structure will commence. After the superstructure and rail has been completed the traffic will then be switched to the new structure and demolition will start on the old bridge. The removal of the old structure should take approximately 45 days to complete. For specified dates please refer to the schedule

Sletten plans on working 40 hour a week to start with. If the schedule should fall behind it may be necessary to work 2 shifts in order to perform the work on time.

Crew size will be 4 – 6 working on the temporary bridge and 4-5 working on the test shaft to start the project. Crew size will vary with different phase of the project.

The equipment Sletten plans to use on the project includes;

1. Leiberr 150 ton crawler crane
2. Sumitomo 110 ton crawler crane – w/Haines drill rig attached
3. Komatsu excavator
4. Komatsu Loader
5. Welders
6. Vibratorys
7. Temporary bridge
8. Pile hammer

DRILLED SHAFT DRILLING EQUIPMENT

CRANES

Sumitomo 110-Ton Crawler Crane
Liebherr 150-Ton Crawler Crane

CRANE MOUNTED DRILLS

Watson 5000 drill
Steven Hains Co. 165k S-2 drill

DRILLING TOOLS

1 ft. Auger
18 in. Auger
30 in. Auger
4 ft. Auger
5 ft. Auger
6 ft. Auger
7.5 ft. Auger
8 ft. Auger
5.8 Clean out bucket
7.8 Clean out bucket

VIBRATORY HAMMERS

MKT Vibratory
ICE 44-50 Vibratory
ICE 416 Vibratory
ICE 66C Vibratory

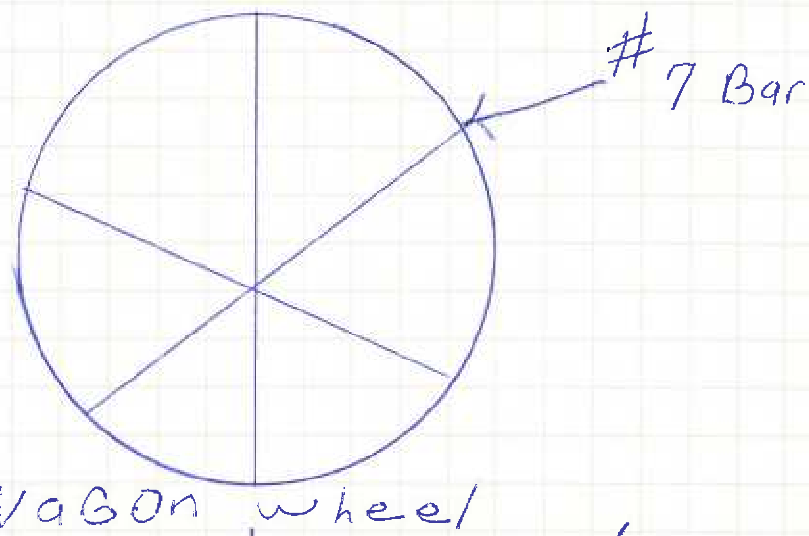
Sletten **CONSTRUCTION CO.** **WORK SHEET**

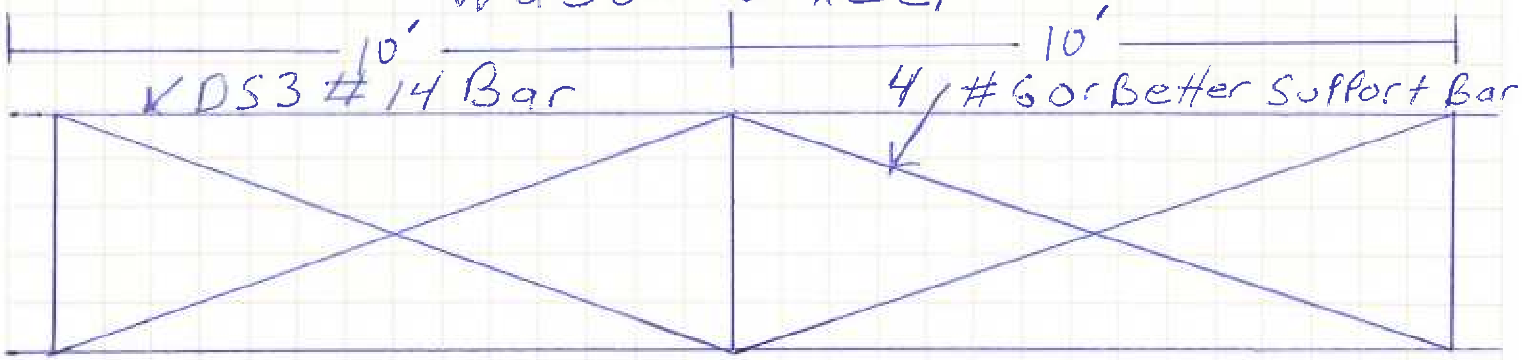
PROJECT

PROJECT NO.

SUBJECT Rebar Support Drilledshafts

SHEET BY





Side view #14 vertical Bars and #5 DSI Spiral excuded FoR Clarity

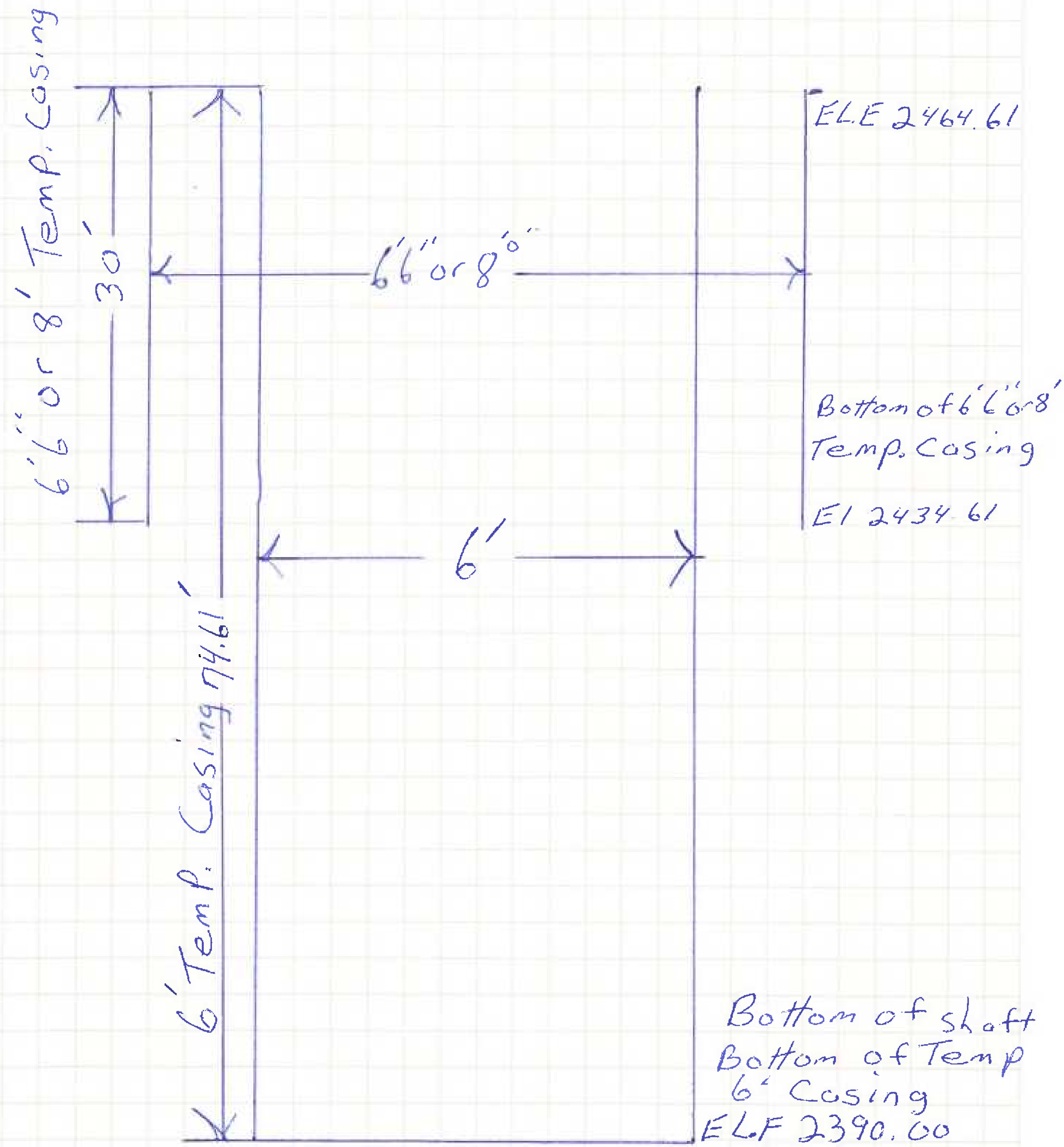
A wagon wheel will be placed every 10' using #7 Bar. 4 #7 Bar will be use to X Brace between wagon wheels, Spokes will be welded to circle.

SCC 127

Sletten CONSTRUCTION CO. WORK SHEET

PROJECT Thompson River – East PROJECT NO.

SUBJECT Bent 1 Drilled Shaft SHEET BY



SCC 127

Sletten **CONSTRUCTION CO.**

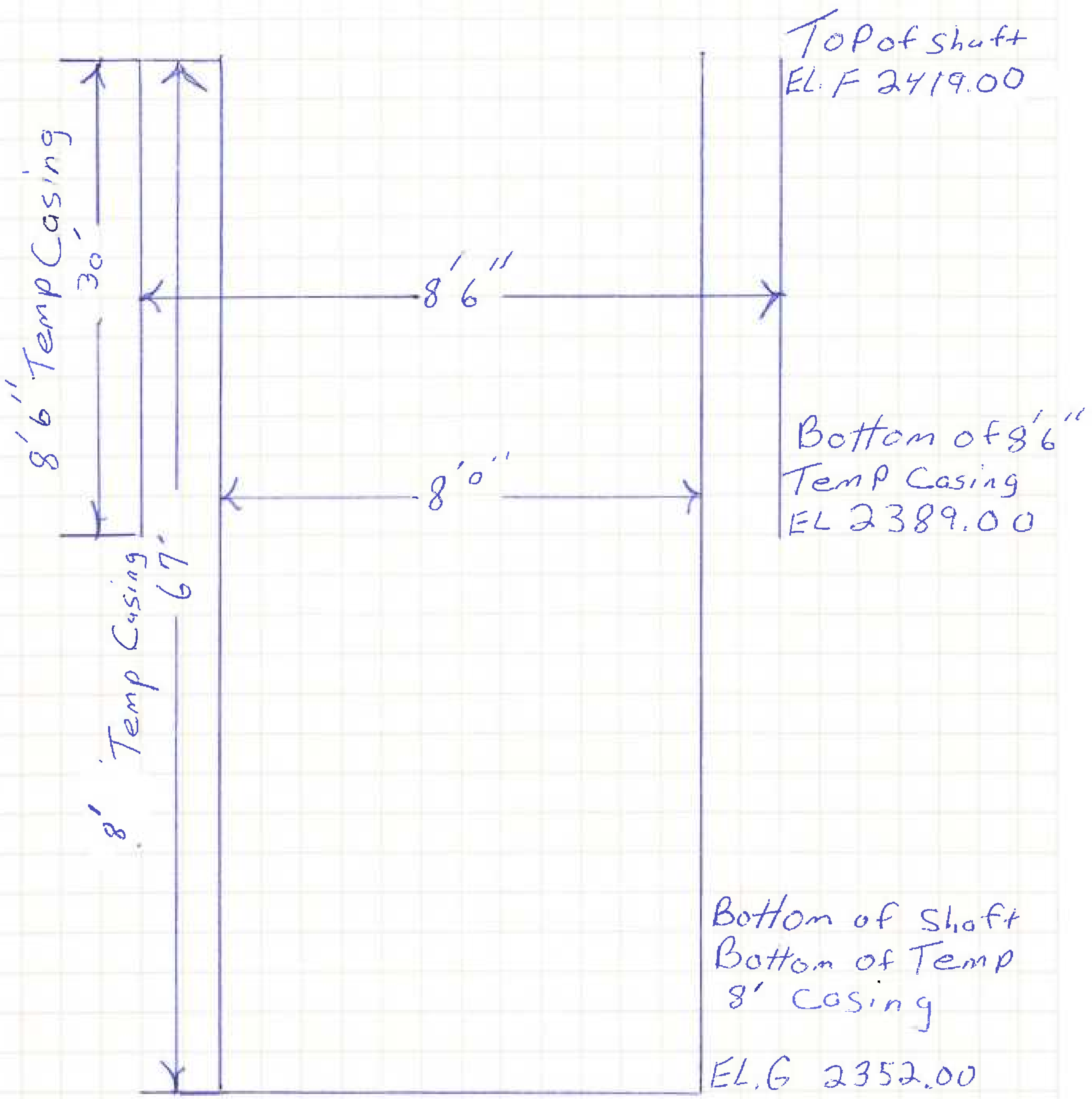
WORK SHEET

PROJECT

PROJECT NO.

SUBJECT Pier 2 Drilled Shaft

SHEET BY



Sletten CONSTRUCTION CO.

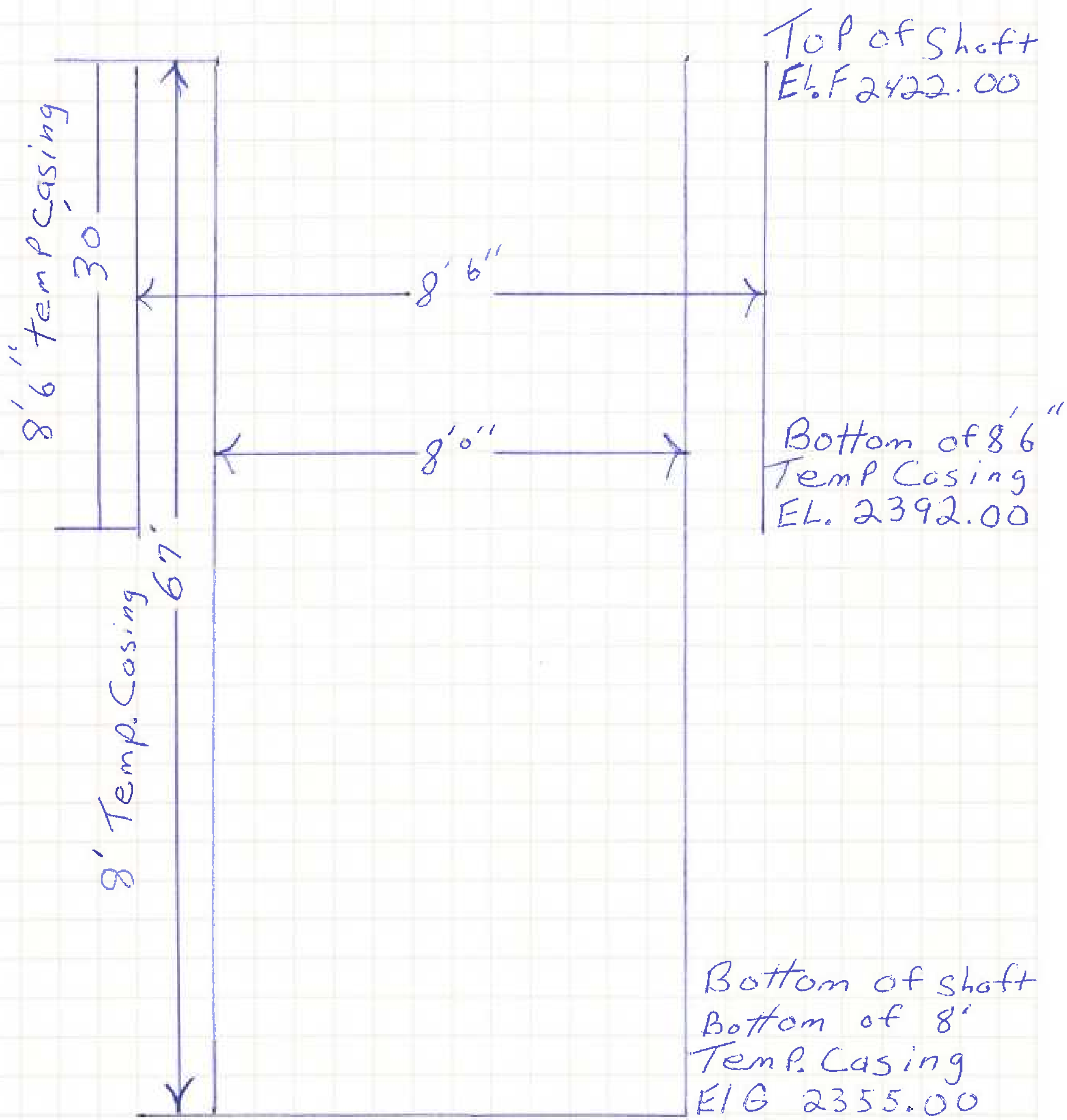
WORK SHEET

PROJECT

PROJECT NO.

SUBJECT Pier 3 Drilled shaft

SHEET BY



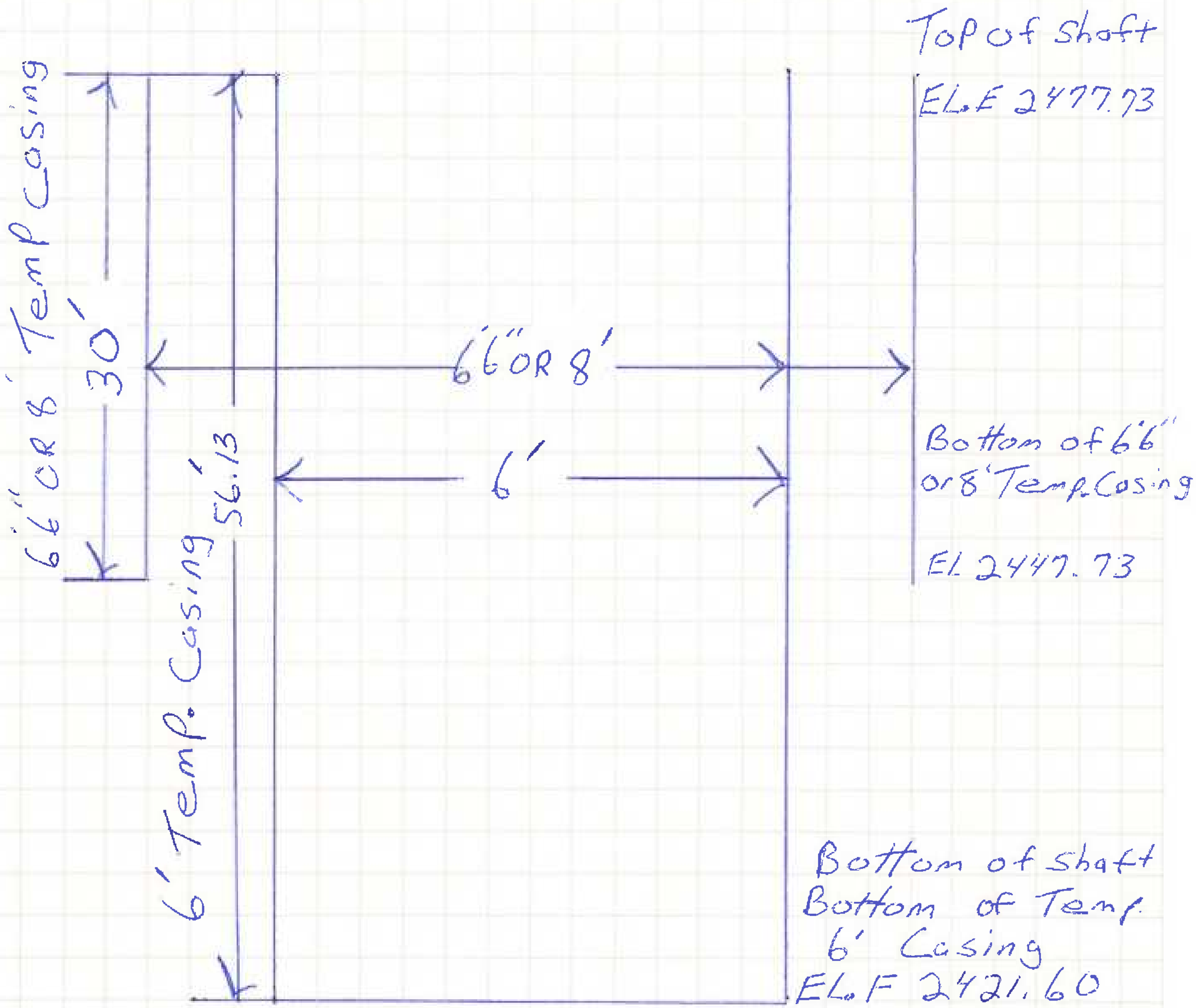
Sletten **CONSTRUCTION CO.** WORK SHEET

PROJECT

PROJECT NO.

SUBJECT Bent # 4 Drilled shaft

SHEET BY



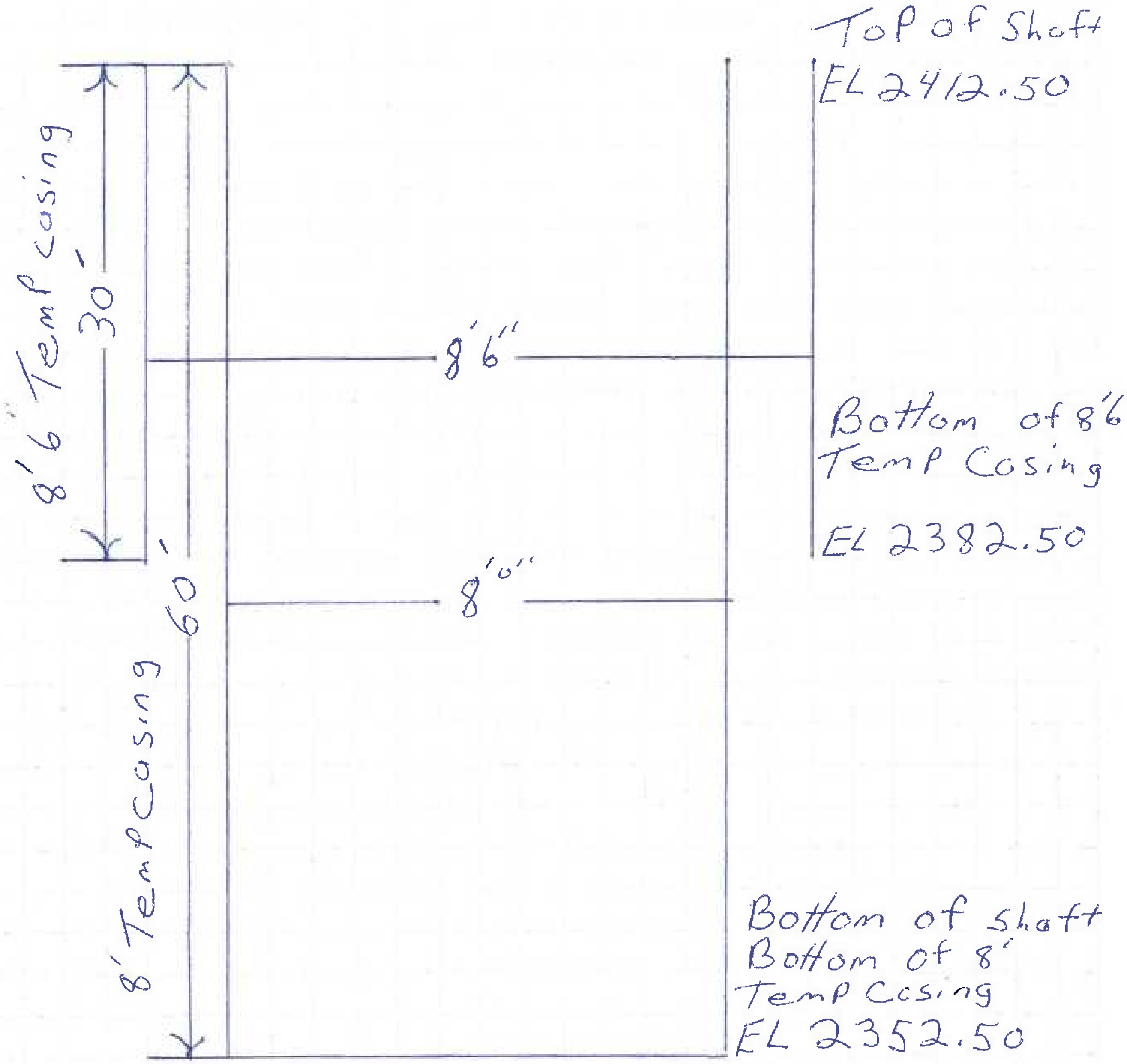
Sletten CONSTRUCTION CO. — WORK SHEET

PROJECT

PROJECT NO.

SUBJECT O Cell test Shaft

SHEET BY



Rebar For Shaft — Rebar will consit of 24 #14 vertical Bars, 61 #5 Bands. Bands will Be placed on 1 Ft center. 8 CSL tubes will Be Spaced equally. 4 CSL TUBES WILL BE PLACED IN THE CENTER OF THE SHAFT. REBAR CAGE OUTSIDE DIAMETER WILL BE 7'-4".

33 Yellowstone River - 6 M NE Livingston
BH 59-1(24)2
Two (2) Drilled Shafts:
72" (6-ft) diameter shafts - depth = 61.6 ft.
Permanent casing used

Owner: Montana DOT
P.O. Box 1110, Bozeman, MT 59771-1110
Matt Collingwood, EPM (406) 586-9562

2010
Supt: Miles Breider
Drillers: Miles Breider
Don Pinion

34 Sun River-2KM S Vaughn
Br-HSIP 7(45) 05C12
Two (2) Drilled Shafts
48' (4-ft) diameter shafts - depth=147.5 ft

Owner Montana DOT
Great Falls Mt 59404
Bill Lay PM 9 (406-455-8323)

2013
Supt Dusty Varty
Drillers Dusty Varty
Richard Potter

35 Yellowstone River Bridge - NE OF Livingston
BR 11-1(48)56
Five (5) Drilled Shafts
8ft 5in diameter shafts - depth - 58 ft
Temporary casing used and removed
Permament casing was driven into rock

Owner Montana DOT
P.O.Box 1110, Bozman MT 59771-1110
Paul Caughgly PM (406-586-9562)

2013
Supt Dan Frank
Drillers Scott Breider
Miles Breider
Dusty Varty
Richard Potter

36 West Three Forks Interchange
16311/M-STPP-NH-HSIP 9-4(37)107
Two (2) Drilled Shafts
8 FT Diameter Shafts - depth - 98.5 ft
Two Temporary casing used and removed

Ownr Montana DOT
P.O. BOX 69 Butte MT 59752
Shane Johnson PM (406-285-6783)

2012
Supt Miles Brieder
Drillers Miles Brieder
Dusty Varty

Mark Beckedahl, EPM (406) 873-8624

30 Billings - Airport Road — 2009 — Supt: Dan Frank; Drillers: Richard Potter, Tim Fowler

MT-CM-STPU (009)
Twenty (20) drilled shafts:
(8) 1.07 Meter (3.5-ft) diameter shafts-ave. depth = 2.9 M (9.6-ft)
(12) 0.76 Meter (2.5-ft) diameter shafts - ave. depth = 5.4 M (17.7-ft)
Temp casing used and removed

Owner: Montana D.O.T. (Riverside Contracting - Prime Contractor)
P.O. Box 20437, Billings, MT 59104-0437
Tom Shupak, EPM (406) 657-0271

31 Butte Area Structures — 2010 - 2011 — Supt: Dan Frank; Drillers: Tim Fowler, Don Pinion

ARRA 15-2(81)125
Four (4) drilled shafts:
1.980 mm (6.5 ft) diameter shafts - average depth = 22.8 meters (75 ft)
Temp. casing was used and removed

Owner: Montana DOT
PO Box 3068, Butte, MT 59702
John Starcevich, EPM (406) 494-9647

At this time, only the northbound drilled shafts have been completed.

32 Milk River - 7 Km West of Harlem — 2010 — Supt: Jason Ploufe; Driller: Don Pinion

ARRA 9003(39)
Two (2) drilled shafts:
2.44 meters (8 ft) diameter shafts - depth = 30.30 meters (99.41 ft)
Temporary casing was used and removed
Permanent casing was oversized by 3 inches. Temp. casing was placed inside the permanent casing

Owner: Montana DOT
1649 US Hwy 2 NW, Havre, MT 59501
Beth Doran, EPM (406) 262-5524

Owner: Idaho Transportation Department
District 3, 15430 Hwy 44
Caldwell, ID 83607
Shawna King, Resident Engineer (208) 459-7429

27 Flathead River - 3 Km E. of Kalispell — 2008 - 2009 — Supt: Kip Harris; Drillers:: Don Pinion
BR 9015 (47)
Three (3) 3.510 M (11.5 Ft.) diameter drilled shafts
Average depth: 30.2 M (99 Ft.)
Temp casings used and removed
Permanent casings used

Owner: Montana D.O.T.
P.O. Box 7308
Kalispell, MT 59904
Don Rasmussen, EPM (406) 751-2039

28 Belt Creek - 4 Km North of Jct S-331 — 2008 — Supt: Don Charters; Drillers: Don Pinion, Wade Robertson, Richard Potter
BR 228-1(6)16
Two 2.29 M (7.5 Ft) diameter drilled shafts
Average depth: 12.43 M (40.7 Ft)
Temp casings used and removed
Permanent casings used

Owner: Montana D.O.T.
P.O. Box 1359
Great Falls, MT 59403-1359
Robert Vosen, EPM (406) 454-5921

29 St. Mary River - North of Babb — 2008 — Supt: Dan Frank; Drillers: Don Pinion, Wade Robertson, Tim Fowler
MT 18(35)
One 6.0 Ft drilled shaft - 22.6 Feet deep
Temp casing used and removed
Permanent casing used

Owner: Montana D.O.T.
P.O. Box 97, Cut Bank, MT 59427

Owner: Montana D.O.T.
P.O. Box 20437, Billings, MT 59104-0437
Paul Rieger, EPM (406) 657-0260

23 Cut Bank - West — 2007 — Supt: Don Pinion; Drillers: Don Pinion, Richard Potter, Wade Robertson
MT-NH 1-3(40)247
Three 2.59 Meter (8.5 Ft) diameter drilled shafts
Average depth: 20.56 Meters
Each shaft received a permanent casing.

Owner: Montana D.O.T.
P.O. Box 97, Cut Bank, MT 59427
Mark Beckedahl, EPM (406) 873-8624

24 D2 Seismic Retrofit (Phase II) — 2007 — Supt: Rick Robertson; Drillers: Don Pinion
04606/IM 0002(697)
Two 1.8 Meter (6 Ft.) diameter drilled shafts
Average depth: 14.65 M (48 Ft)
Temporary casings were used and removed.

Owner: Montana D.O.T.
P.O. Box 973, Three Forks, MT 59752
Rickie Johnson, EPM (406) 285-4943

25 Dodson - East — 2007 — Supt: Jason Ploufe; Drillers: Don Pinion
02B06/NH 1-8(26)454 F
Two 2.59 Meter (8.5 Ft) diameter drilled shafts
Average depth: 26.3 M (86.26 Ft)
Temporary casings were used and removed

Owner: Montana D.O.T.
HC 31 - Box 3000, Wolf Point, MT 59201-9802
Mark Kurokawa, EPM (406) 653-1050

26 Snake River Bridge - Weiser, ID — 2008 - 2009 — Supt: Todd Fried; Drillers: Don Pinion, Scott Breider, Tim Fowler
BR-3110 (127)
Twenty 3.5 Ft. Diameter drilled shafts
Depths vary from 16 Ft. to 92 Ft.
Each shaft received a permanent casing.

19 BNRR Overpass - Toluca — 2005
BR 9002(27)
Two 3.0 meter diameter drilled shafts
Each drilled shaft extended approx. 21.4 meters into the ground.
Temporary casings were used and removed.

Owner: Montana D.O.T.
P.O. Box 20437, Billings, MT 59104-0437
Paul Rieger, EPM (406) 657-0260

Supt.: Don Pinion
Drillers: Don Pinion, Richard Potter, Dean Rittal, Scott Breider, Miles Breider

20 Clarks Fork River Bridge (WY) — 2006
ACBROS-0C11-00(058)
Four 3.5 Ft diameter drilled shafts
Drilled shafts extended 21 ft to 33 ft into the ground.
Temporary casings were used and removed.

Owner: Wyoming D.O.T.
P.O. Box 278
Cody, WY 82414
Todd Frost, P.E.

Supt.: Todd Fried
Driller: Todd Fried

21 Tongue River - Miles City — 2006 & 2007
BR 2-1(34)2
Eight 1.83 Meter diameter drilled shafts
Drilled shafts extend approx. 75 ft into the ground.
Temporary casings were used and removed
Permanent casings were installed.

Owner: Montana D.O.T.
P.O. Box 460
Miles City, MT 59301
Dave Bacon, EPM

Supt.: Byron Milender
Drillers: Don Pinion, Richard Potter, Tim Fowler, Wade Robertson

22 West Laurel Interchange — 2006 & 2007
IM-STPHS 90-8(154)433
Six 1.070 Meter diameter drilled shafts
Two shafts 17.7 meters deep, and Four shafts 11.8 meters deep
Temporary casings were used and removed

Supt: Don Charters
Driller: Don Pinion

15 Pompey's Pillar Interchange & BNRR-2 km West of Pompey's Pillar
IM 94-1(64)23 & BR 568-1(13)0
This project required four drilled shafts (2 per bent), each one 1.525 meters in diameter. The average depth was 15 meters. No permanent casing was required.

Owner: Montana D.O.T.
P.O. Box 20437, Billings, MT 59104-0437
Mike Taylor, EPM

2004
Supt.: Rick Robertson
Driller: Don Pinion
Don Charters

16 Clarks Fork - South of Belfry
BR 9005 (24)
Two 1.83 meter diameter drilled shafts were installed as a part of this project. Each drilled shaft extended approximately fifteen and one half meters into the river bottom. Permanent casings were required.

Owner: Montana D.O.T.
P.O. Box 20437, Billings, MT 59104-0437
Ray Studebaker (406) 252-4138

2004
Supt.: Don Pinion
Drillers: Don Pinion
Todd Fried

17 MRL Overpass - 7 km East of Bozeman
IM 90-6(91)313
Four 2.44 meter diameter drilled shafts
Each drilled shaft extended approximately 15.35 meters into the ground.
Temporary casings were used and removed.

Owner: Montana D.O.T.
P.O. Box 3068, Butte, MT 59702-3068
Rick Johnson, EPM (406) 285-4943

2005
Supt.: Rick Robertson
Drillers: Don Pinion
Kip Harris
Steve Cahill

18 Powell County Bridges
BRF-BR 9039(34)
One 1.524 meter diameter shaft, approx. 12.5 meters into the river bed.
Permanent casing was required.

Owner: Montana D.O.T.
P.O. Box 3068, Butte, MT 59702-3068
Michael Arvish, EPM (406) 563-7261

2005
Supt.: Rick Robertson
Drillers: Don Pinion
Kip Harris

10 Warren North & South — 2001 — Supt: Don Pinion; Drillers: Don Pinion, Jason Plouffe

NH 4-1(23)0 F

This project required two caissons, 2.44 meters in diameter and 21 meters deep

Owner: Montana D.O.T.
P.O. Box 20437, Billings, MT 59104-0437 (406) 252-4138

11 Milk River - N of Tampico — 2001 - 2002 — Supt: Don Pinion; Drillers: Don Pinion, Richard Potter, Jason Plouffe

BR 9053(27)

This project required two caissons, 2.29 meters in diameter and 26.6 meters deep.

Owner: Montana D.O.T.
P.O. Box 890, Glendive, MT 59330-0890
Larry Greufe (406) 653-1574

12 Jefferson River - Silver Star — 2002 — Supt: Chad Mares; Drillers: Don Pinion, Steve Beck, Todd Fried

BR 422-1(4)0

This project required two caissons, 1.83 meters in diameter and 21.65 meters deep.

Owner: Montana D.O.T.
P.O. Box 3068
Butte, MT 59702-3068
Rick Johnson (406) 494-9635

13 Dearborn River-20 Km South of Augusta — 2003 — Supt.: Rick Robertson; Driller: Don Pinion

BH 9025(33)

This project required seven drilled shafts. Four were cased part way down with 1.070 meter casings, and then drilled .760 meters in diameter the rest of the way down. Depths ranged from 5 - 11 meters each. The other three shafts were .760 meters in diameter and were approximately 2 meters deep.

Owner: Montana D.O.T.
P.O. Box 1359, Great Falls, MT 59403
Randy Aafedt - 454-5880

14 Valier - West — 2002 — Supt.: Dan Frank; Driller: Don Pinion

STPP 44-2(11)0

This project required one drilled shaft: 2.286 meters in diameter and 12.5 meters deep. The permanent casing plan length was 7.8 meters.

Owner: Montana D.O.T.
P.O. Box 1015, Conrad, MT 59425
Mike Klette, EPM

6 Cree Crossing - NW of Saco — 1998 - 1999 — Supt: Don Pinion; Drillers: Don Pinion, Jason Poulffe

ER 243-1(2)6

This project required two caissons, 2.286 Meters in diameter and 21.1 Meters deep.

Owner: Montana D.O.T.
P.O. Box 890
Glendive, MT 59330-0890
Mark Kurokawa (406) 653-1574

7 Poplar River Bridge - W. of Poplar — 1999 — Supt: Chad Mares; Drillers: Don Pinion, Steve Beck

NH 1-10(42)611

This project required two caissons,2.29 Meters in diameter and 29.6 meters deep.

Owner: Montana D.O.T.
P.O. Box 890
Glendive, MT 59330-0890
Larry Greufe (406) 653-1574

8 Yellowstone River Bridge - W of Reed Point — 1999 - 2000 — Supt: Don Pinion; Drillers: Don Pinion, Chad Mares, Todd Fried

BR 9048(15)

This project required three caissons, 2.134 Meters in diameter and 8 Meters deep. Drilling was conducted from barges.

Owner: Montana D.O.T.
P.O. Box 20437, Billings, MT 59104-0437
Ray Studebaker (406) 252-4138

9 Boulder River Bridge - S. of Boulder — 2000 — Supt: Rick Robertson; Drillers: Steve Beck, Don Pinion

BR-STPE 9022(13)

This project required ten caissons. Three were .61 Meters in diameter and 60 feet deep. Three were .61 Meters in diameter and 30 feet deep. Two were .76 Meters in diameter and 60 feet deep, and two were .76 Meters in diameter and 30 feet deep.

Owner: Montana D.O.T.
P.O. Box 3068, Butte, MT 59702-3068
Jay O'Brien (406) 494-9600

DRILLED SHAFT EXPERIENCE LIST

1 Roosevelt Dam

This bridge was 890 feet in length. The project had 5 piers in the water, a total of 15 caissons, 5'0" in diameter. They were installed in 30 to 60 feet of water, and extended into the lakebed another 60 feet. The drilling was conducted from barges.

Owner: Federal Highway Administration

2 Bridge over the Missouri River, 9th-10th Street — 1995

BR-STPU 5211(5)F, Cascade County

This project required 18 caissons, 72" in diameter, 35 feet deep.

Drilling was conducted from barges.

Owner: Montana D.O.T.
P.O. Box 1359, Great Falls, MT 59403
Randy Aafedt - 454-5880

Supt: Rick Robertson
Drillers: Don Pinion, Richard Potter, Todd Fried, Don Charters

3 Clark Fork of Yellowstone River Bridge - Carbon County — 1996 - 1997

BR 9005(8) [2291]

This project required two caissons, 1.83 Meters in diameter, 11.7 meters deep.

Owner: Montana D.O.T.
P.O. Box 20437, Billings, MT 59104-0437
Dave Sloe (406) 252-4138

Supt: Don Charters
Drillers: Don Pinion, Richard Potter

4 Missouri River Bridge - S. of Wolf Point — 1996 - 1997

BR 25-1(24)46

This project required two caissons, 10 feet in diameter and about 82 feet deep.

Drilling was conducted from barges.

Owner: Montana D.O.T.
P.O. Box 890
Glendive, MT 59330-0890
Larry Greufe (406) 653-1574

Supt: Don Charters
Drillers: Don Pinion, Steve Beck, Richard Potter, Todd Fried

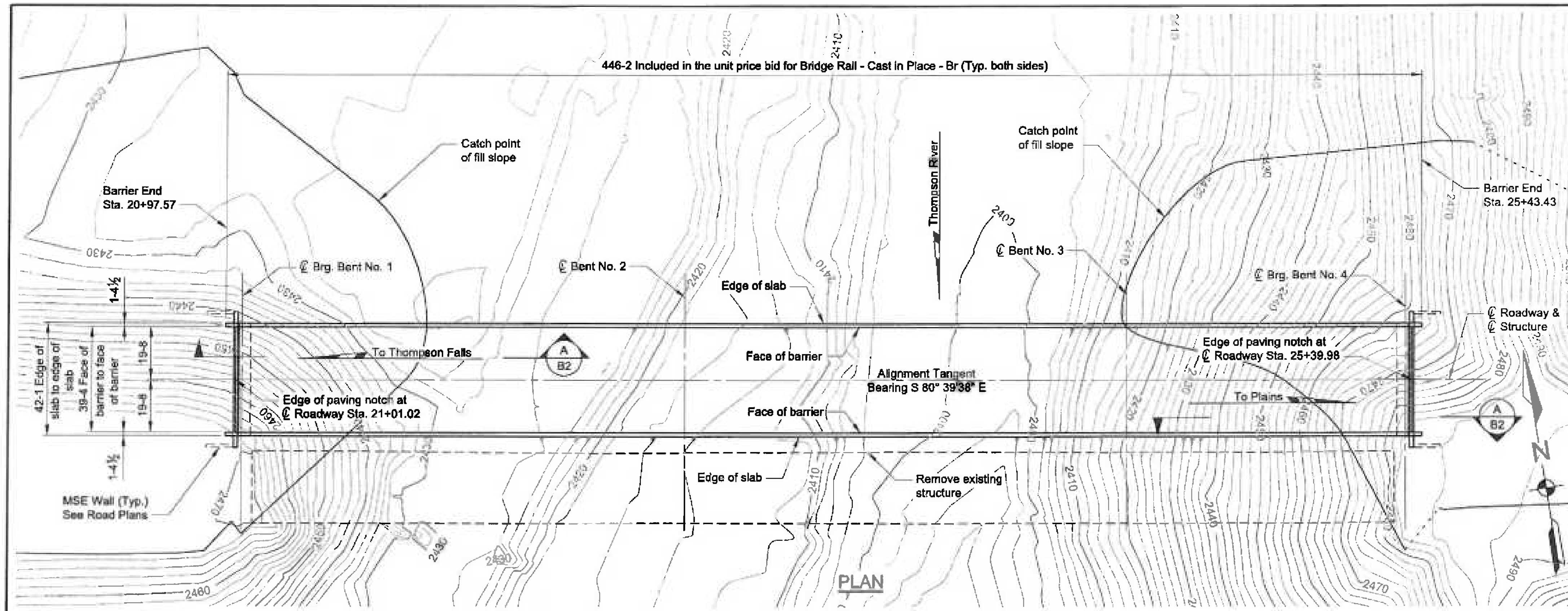
5 Warm Springs Creek - Anaconda — 1997

BR 9012(6)

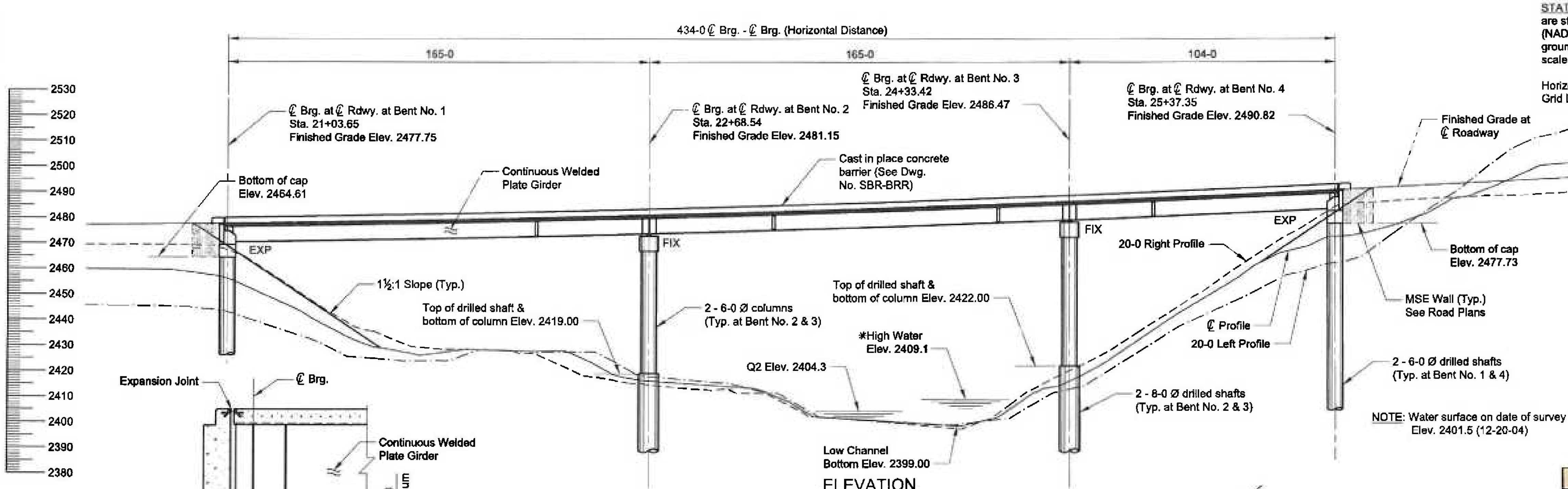
This project had eighteen caissons, 24 inches in diameter and approx. 23-35 feet deep.

Owner: Montana D.O.T.
P.O. Box 3068, Butte, MT 59702-3068
Mike Arvish (406) 494-9600

Supt: Don Pinion
Drillers: Don Pinion

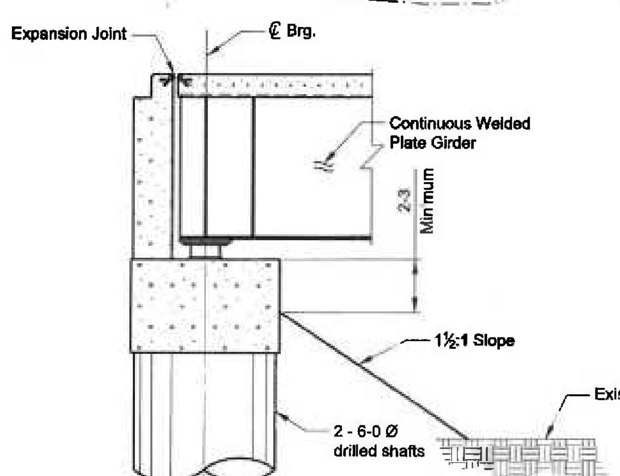


PLAN

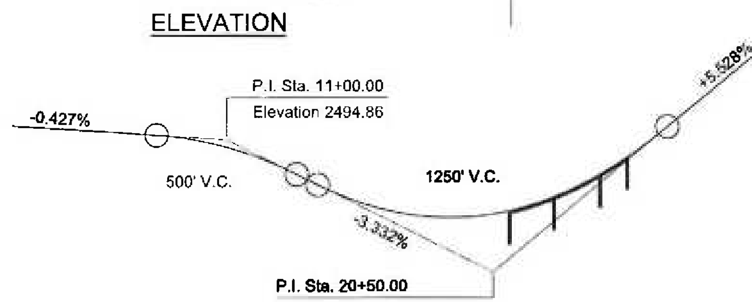


NOTE: Water surface on date of survey Elev. 2401.5 (12-20-04)

ELEVATION



SECTION A (A/B2)
Scale ~ ¼" = 1'-0"



PROFILE GRADE
No Scale

NOTES

FINISHED GRADE: Finished grade of bridge at centerline roadway is the same as the Profile Grade shown on Road Plans.

LIVE LOAD: Standard HL-93 loading.

SPECIFICATIONS: Montana Department of Transportation and the Montana Transportation Commission Standard Specifications for Road and Bridge Construction, 2006 edition, and any amendments thereto, and the Special Provisions govern unless otherwise noted. The design was prepared in accordance with AASHTO LRFD Bridge Design Specifications, Fourth edition - 2007 with 2009 Interim revisions.

REINFORCING STEEL: Use new deformed type reinforcing steel meeting the requirements of AASHTO M 31 Grade 60 or ASTM Specification A 706 Grade 60 as specified. Include all costs associated with furnishing and placing new reinforcing steel in the unit price bid for either Reinforcing Steel, Reinforcing Steel - Epoxy or Reinforcing Steel - Seismic.

CAST IN PLACE CONCRETE: Unless otherwise approved or specified, use Class DD-Bridge for all substructure concrete and Class SD for all superstructure and barrier concrete.

CONCRETE STRENGTH: Use f'c = 4000 p.s.i. for Class DD-Bridge concrete. Use f'c = 4000 p.s.i. for Class SD concrete.

TRAFFIC CONTROL PLAN AND SEQUENCE OF OPERATIONS: See Special Provisions.

UTILITIES: Call 1-800-424-5555 for utility locates at least two working days prior to starting any construction activity that could disturb the utility.

EXISTING STRUCTURE: Remove the existing structure (see Road Plans sheets and Special Provisions).

STRUCTURE EXCAVATION: Structure Excavation will be calculated from berm elevations.

STRUCTURAL STEEL: All structural steel will be measured and paid for on the lump sum basis as set forth in the Standard Specifications. Use structural steel meeting the requirements of AASHTO M 270 Grade 50W: Estimated weight = 619,602 lbs.

STATE PLANE COORDINATES: Stations shown on the bridge plans are state plane grid stations based on state plane coordinates (NAD83-1992). Dimensions shown on the bridge plans are horizontal ground distances and not state plane grid distances. The combination scale factor (CSF) at this locations is 0.99932516.

Horizontal ground distance x CSF = Grid Distance
Grid Distance/CSF = Distance to stake.

HYDRAULIC DATA

Drift:	Moderate
Bent No. 2 & 3 Scour (Q100):	None
Contraction Scour (Q100):	None
Ice:	Moderate
Drainage Area:	642 sq. mi.
2-Year Stage (Q2):	2404.3
Base Flood Flow (Q100):	7340 cfs
* Base Flood Stage:	2409.1
Base Flood Velocity:	9.4 fps
Actual Low Beam Elevation:	2470.34
Allowable Low Beam Elevation:	2470.34

Also see Hydraulic Data Summary sheet.
* Base Flood Stage elevation includes backwater.

SHEET NO.
B2

GENERAL LAYOUT
Scale ~ 1" = 25'-0" Except As Noted

BRIDGE OVER THOMPSON RIVER
AT STA. 23+20.50

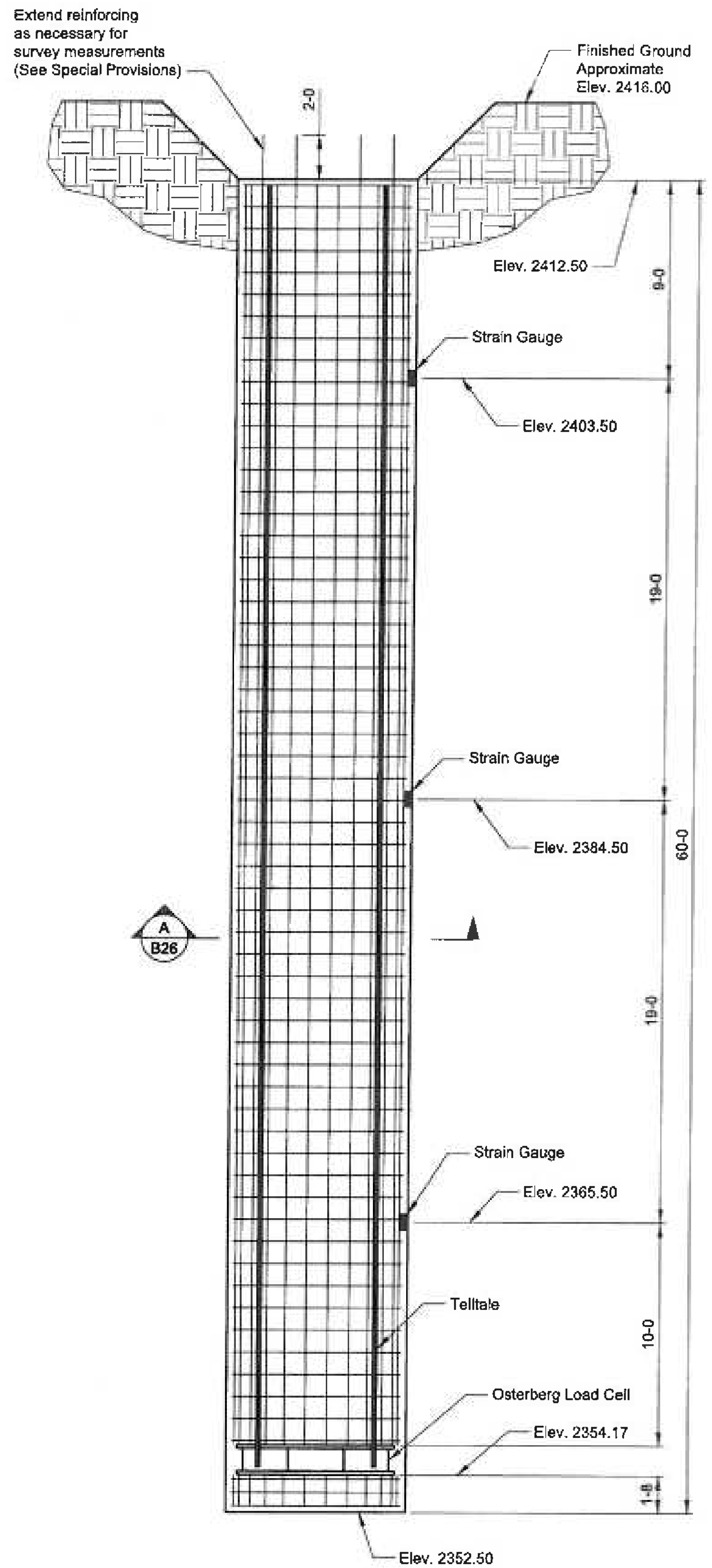
FEDERAL AID PROJECT NO.
STPB-STPP-HSIP 6-1(106)56
SANDERS COUNTY

MDT MONTANA DEPARTMENT OF TRANSPORTATION
BRIDGE BUREAU

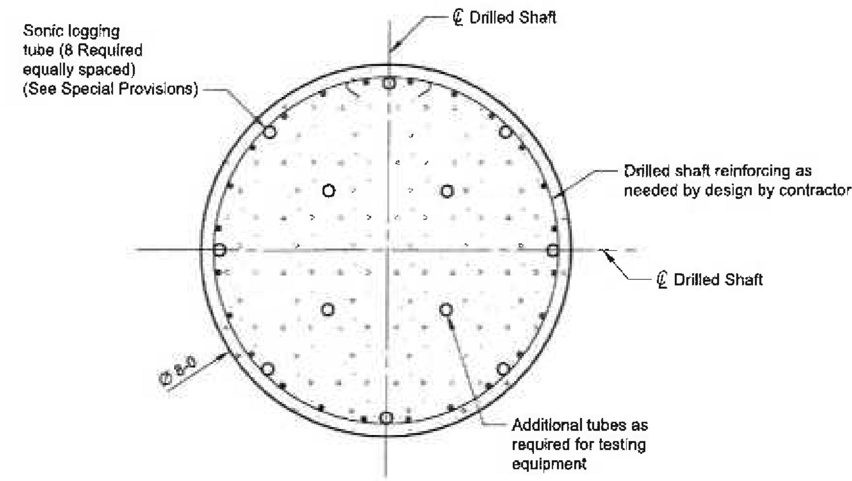
REVISED		
REVISED		
REVISED		
REVISED		
CHECKED	2-14-14	C.W.H.
DRAWN	9-19-11	T.J.B.
DESIGNED	8-23-11	J.J.S.

4/23/2014 1:21:18 PM c:\dgn\4039\brgen002.dgn

UPN NUMBER
4039
DRAWING NO.
22051



TEST DRILLED SHAFT ELEVATION



A
B26
SECTION A
Scale ~ ½" = 1'-0"

NOTES

Include all costs associated with furnishing and placing drilled shaft in the unit price bid for Static Load Test - Drilled Shaft.

Include all costs associated with furnishing and performing the Osterberg Load Cell Test in the unit price bid for Static Load Test - Drilled Shaft.

Drilled shaft reinforcing shown on this sheet is for reference only. Provide reinforcing as needed by design for load cell test.

Design the drilled shaft and conduct the Osterberg Load Cell Test for an ultimate test capacity of 5600 kips

Cut reinforcing steel that is extended out of drilled shaft for survey flush with top of drilled shaft at the completion of the Osterber Load Cell Test.

Strain gauge locations are approximate. Place gauges as needed to conduct the Osterberg Load Test.

REBAR QUANTITIES FOR TEST SHAFT

24 EA. #14 VERTICAL REBAR @ 60'-0" LONG

61 EA. #5 HOOPS @ 7'-4" O.D.

NOTE:

1.) #5 HOOPS WILL BE SPACED @ 1'-0" C-C

2.) #14 VERTICAL BARS WILL BE EQUALLY SPACED

3.) 12 EA. SONIC LOG TUBES WILL BE PLACED AS SHOWN ON THE DRAWING.

SHEET NO.
B26

OSTERBERG LOAD CELL
TEST DETAILS

Scale ~ ¼" = 1'-0" Except As Noted

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO.
STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

MDT MONTANA DEPARTMENT OF TRANSPORTATION

BRIDGE BUREAU

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DESIGNED	11-25-13	T.J.B.
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UPN NUMBER
4039

DRAWING NO.
22075

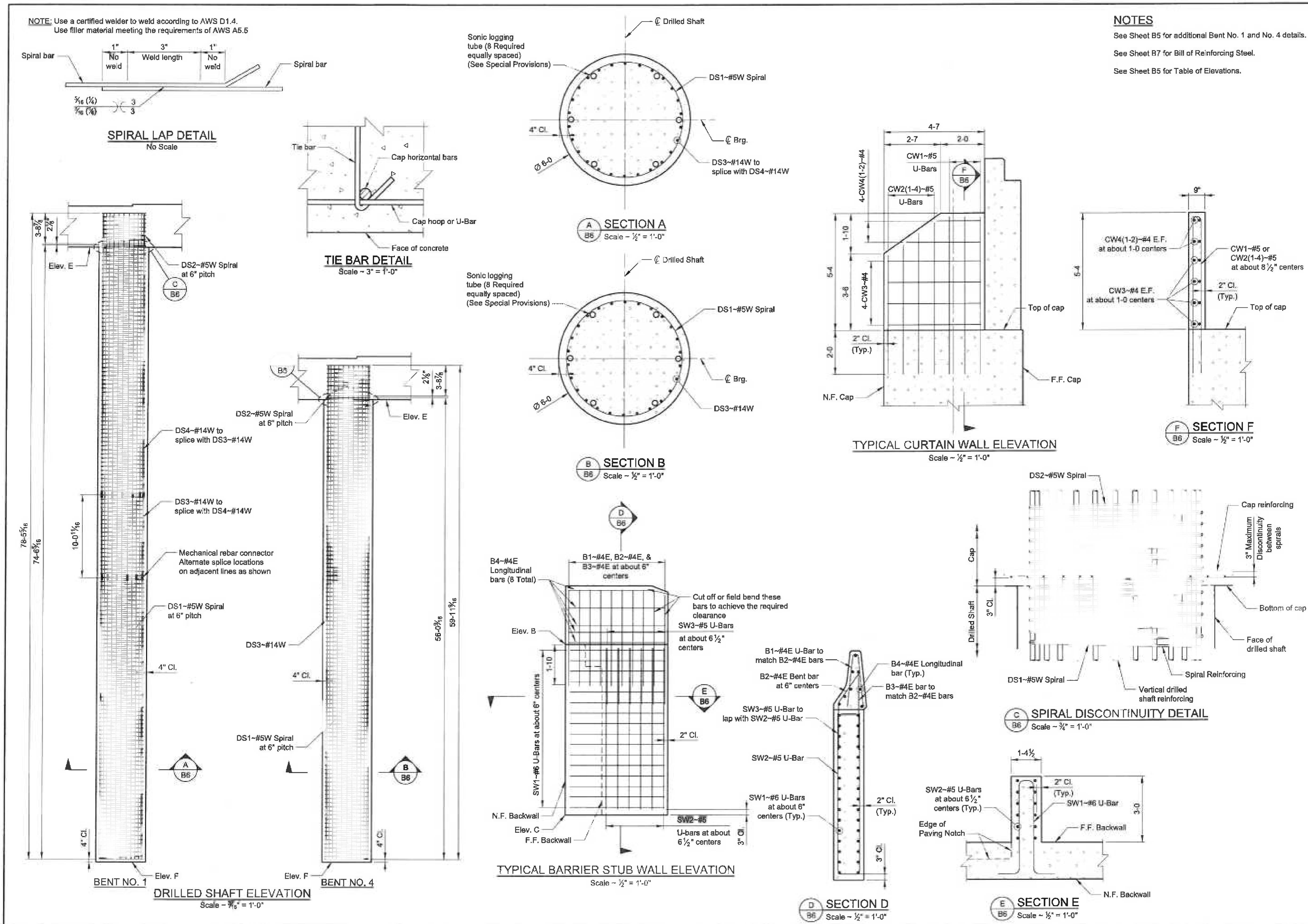
NOTE: Use a certified welder to weld according to AWS D1.4.
Use filler material meeting the requirements of AWS A5.5

NOTES

See Sheet B5 for additional Bent No. 1 and No. 4 details.

See Sheet B7 for Bill of Reinforcing Steel.

See Sheet B5 for Table of Elevations.



BENT NO. 1 & NO. 4 DETAILS

Scale ~ As Noted

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO. STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

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DESIGNED	8-29-13	T.J.S.
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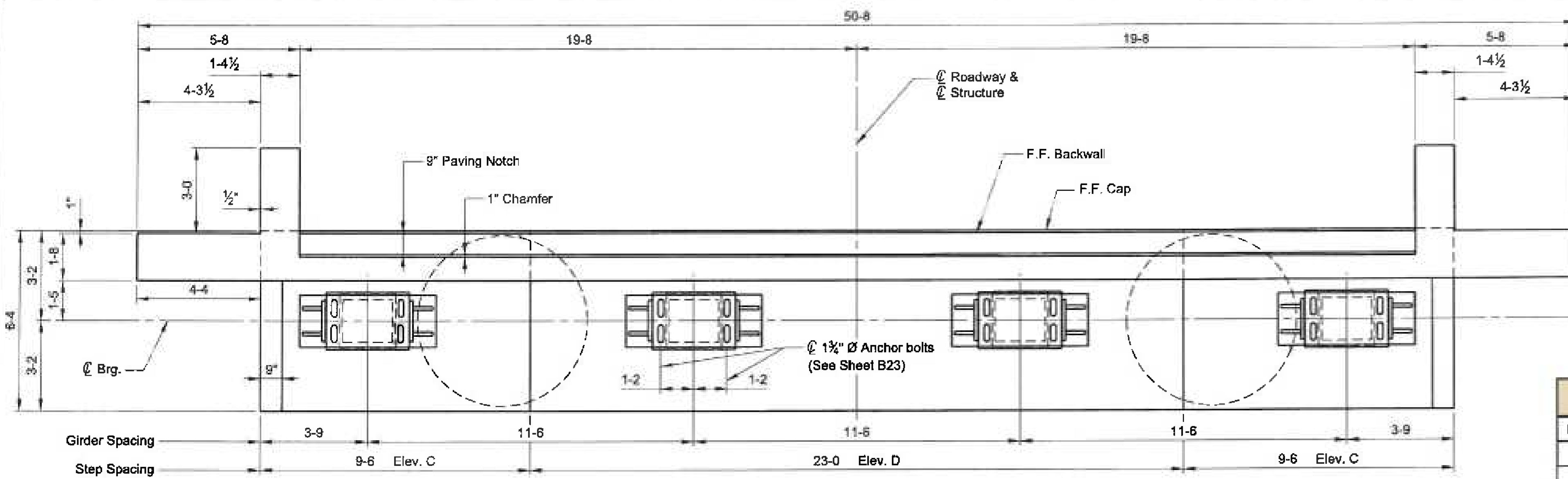
UPN NUMBER
4039

DRAWING NO.
22055



PLAN

NOTES

The suffix E denotes epoxy coated reinforcing steel.

The suffix W denotes ASTM A706 reinforcing steel.

N.F. denotes Near Face
F.F. denotes Fill Face
E.F. denotes Each Face

Lap #4 bars 1-6 minimum.
Lap #5 bars 1-10 minimum.
Lap #6 bars 2-4 minimum.

Sonic logging tubes do not extend more than 1-8 above top of drilled shaft.

Use only mechanical rebar connectors to splice DS3~#14W and DS4~#14W vertical bars.

Terminate spiral at each end by contact lap of 1½ turns in length. Weld tail end of lap as shown on spiral lap detail Sheet B6 or use mechanical rebar connectors.

See Sheet B7 for Bill of Reinforcing Steel.

Splice spirals by mechanical connectors or by welding according to Spiral Lap Detail Sheet B6.

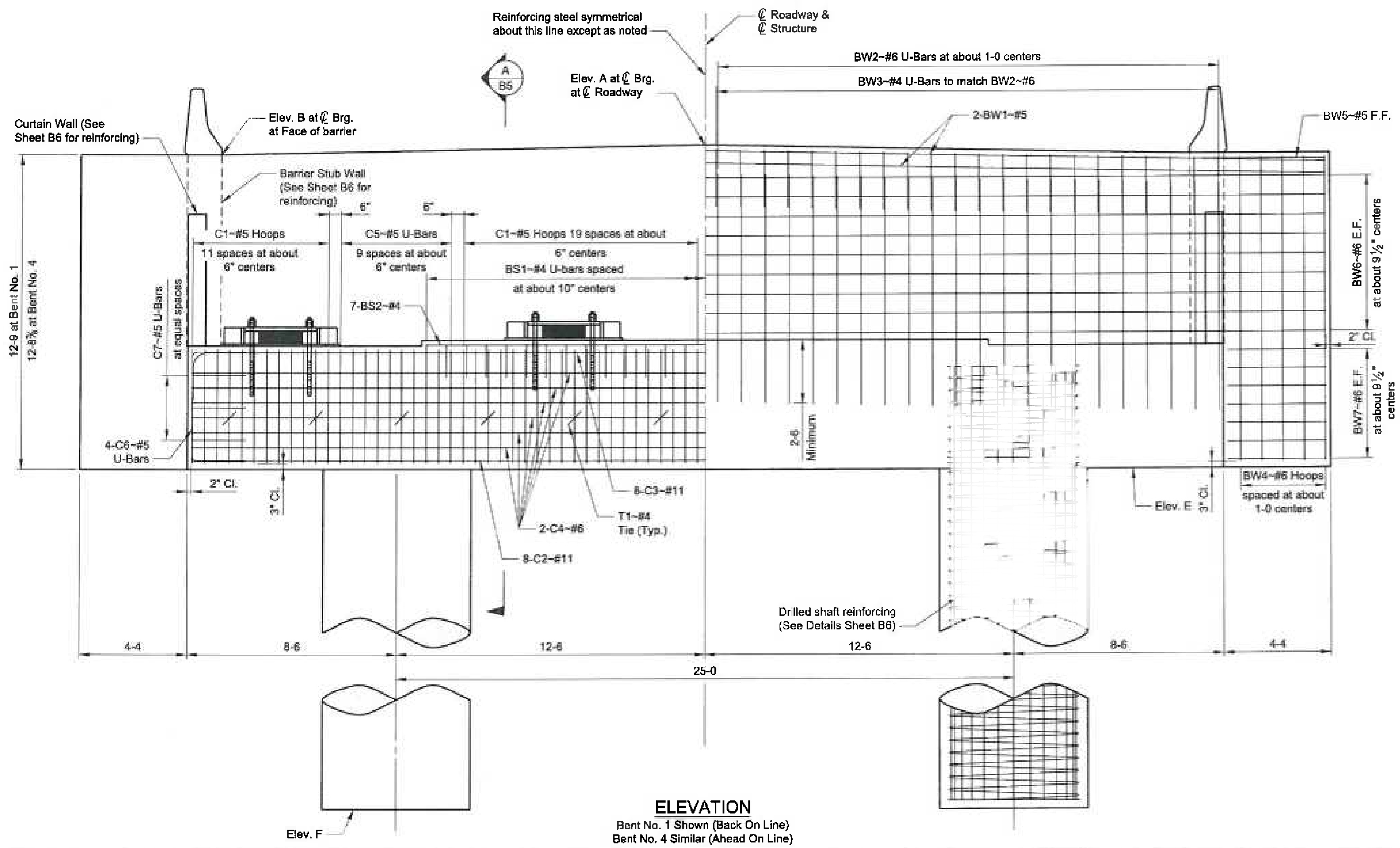
Ensure reinforcing steel does not interfere with anchor bolt placement.

See Sheet B23 for additional Bent No. 1 & No. 4 shoe details.

Clearances called out are to the main reinforcing steel. Clearances may be reduced at tie locations.

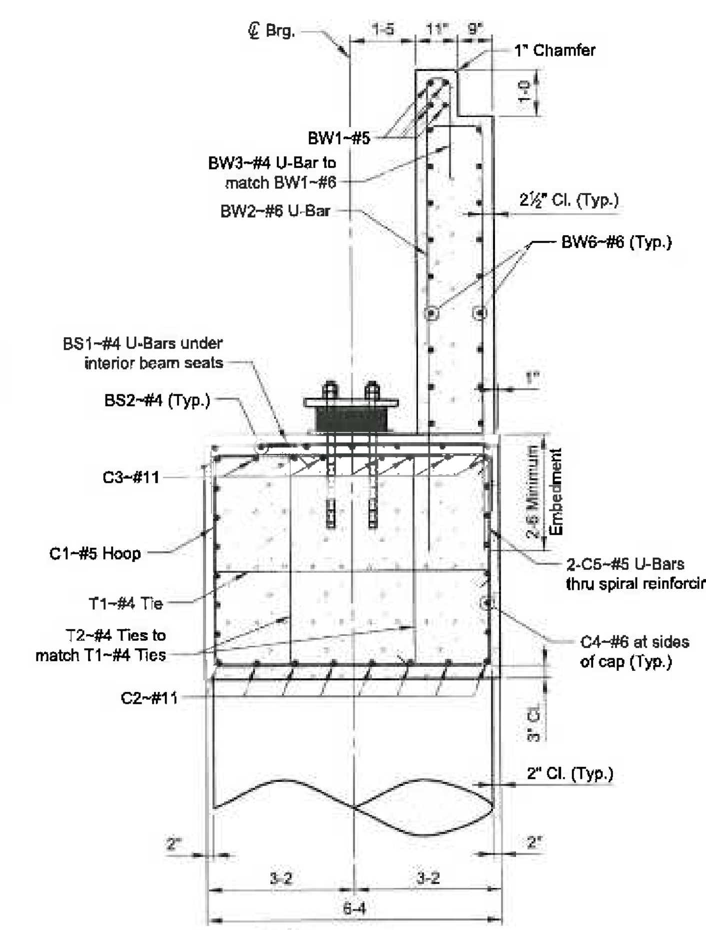
TABLE OF ELEVATIONS

ELEVATION	BENT NO. 1	BENT NO. 4
A	2477.75	2490.82
B	2477.36	2490.43
C	2469.61	2482.73
D	2469.84	2482.96
E	2464.61	2477.73
F	2390.00	2421.60



ELEVATION

Bent No. 1 Shown (Back On Line)
Bent No. 4 Similar (Ahead On Line)



SECTION A

Scale ~ ½" = 1'-0"

SHEET NO. B5

BENT NO. 1 & NO. 4

Scale ~ ⅜" = 1'-0" Except As Noted

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO. STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

MDT MONTANA DEPARTMENT OF TRANSPORTATION — BRIDGE BUREAU

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UPN NUMBER 4039

DRAWING NO. 22054

NOTES

See Sheets B8 & B10 for additional Bent No. 2 and No. 3 details.

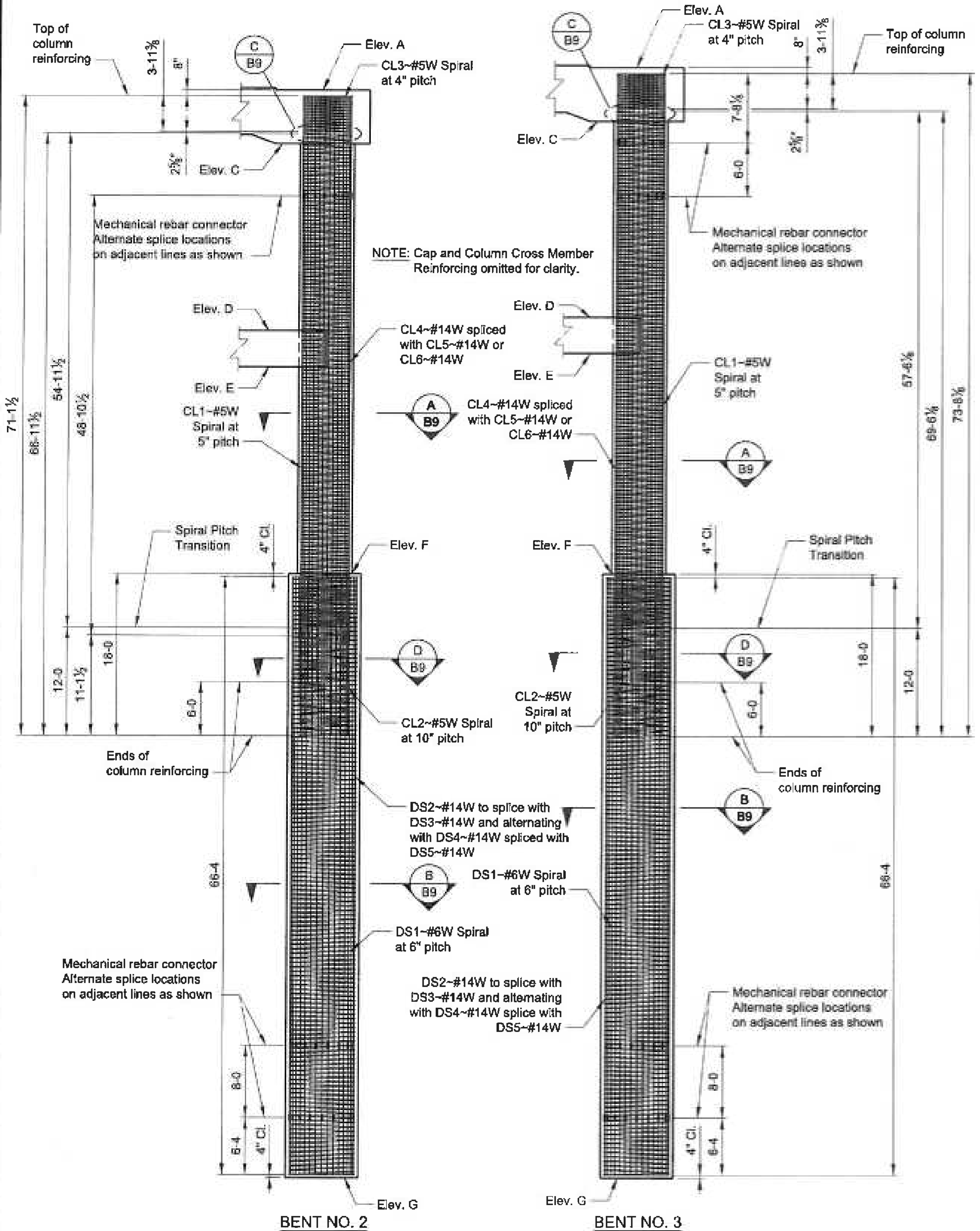
See Sheet B11 for Bill of Reinforcing Steel.

After completion of the drilled shaft testing remove the sonic logging tubes to 3" below the top of the drilled shaft.

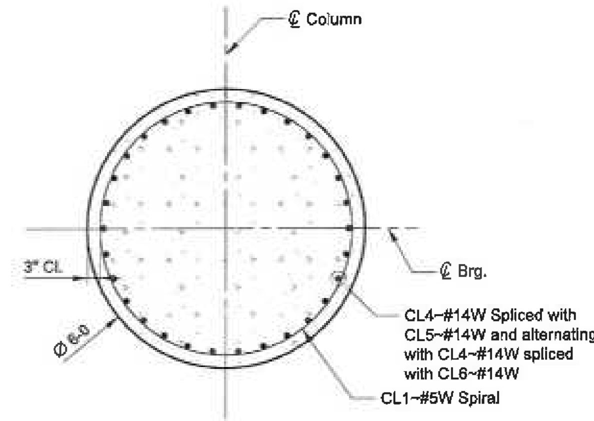
Orient vertical reinforcement in columns as shown in Section A to allow for clearance of longitudinal reinforcement in cap and cross member as shown on Sheets B8 & B10.

Splice CL1~#5W & CL2~#5W column spiral reinforcement using the Spiral Lap Detail (This Sheet) at 9 equal spaces for the full circumference of the spiral.

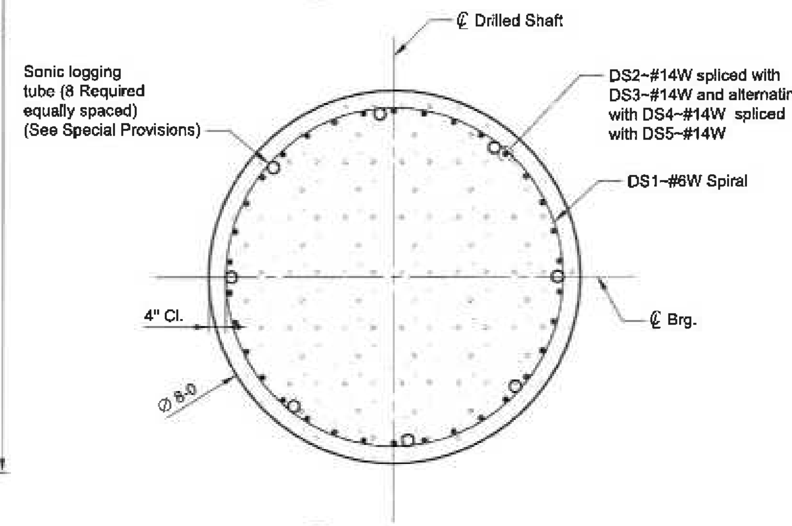
See Sheet B8 for Table of Elevations.



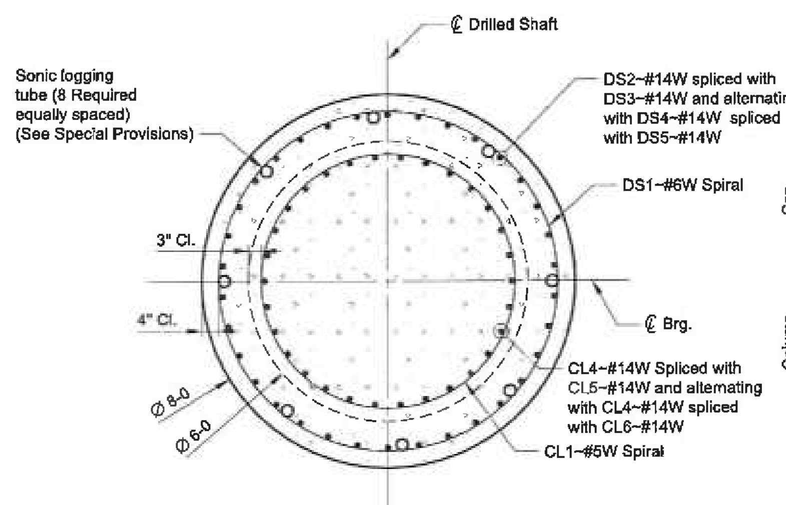
DRILLED SHAFT & COLUMN ELEVATION
Scale ~ ⅛" = 1'-0"



SECTION A (B9)
Scale ~ ½" = 1'-0"

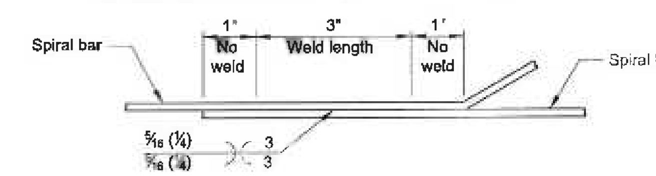


SECTION B (B9)
Scale ~ ½" = 1'-0"

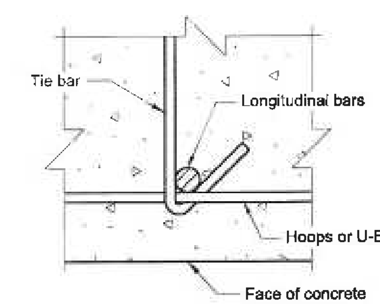


SECTION D (B9)
Scale ~ ½" = 1'-0"

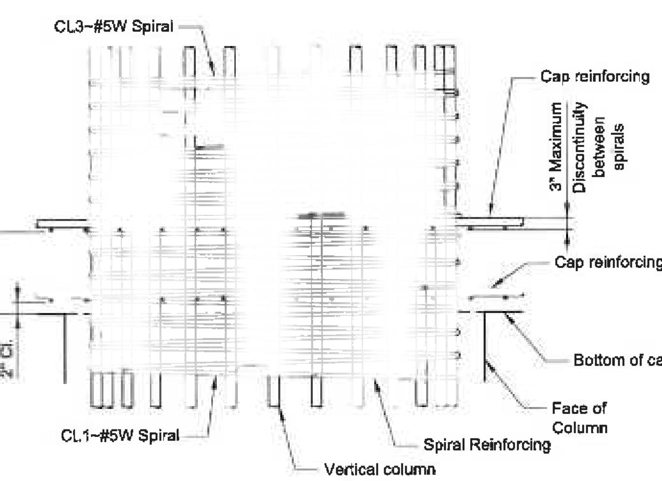
NOTE: Use a certified welder to weld according to AWS D1.4.
Use filler material meeting the requirements of AWS A5.5



SPIRAL LAP DETAIL
No Scale



TIE BAR DETAIL
Scale ~ 3" = 1'-0"



SPIRAL DISCONTINUITY DETAIL (C B9)
Scale ~ ¾" = 1'-0"

SHEET NO. B9

BENT NO. 2 & NO. 3 DRILLED SHAFT AND COLUMN DETAILS

Scale ~ As Noted

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO. STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

MDT MONTANA DEPARTMENT OF TRANSPORTATION — BRIDGE BUREAU

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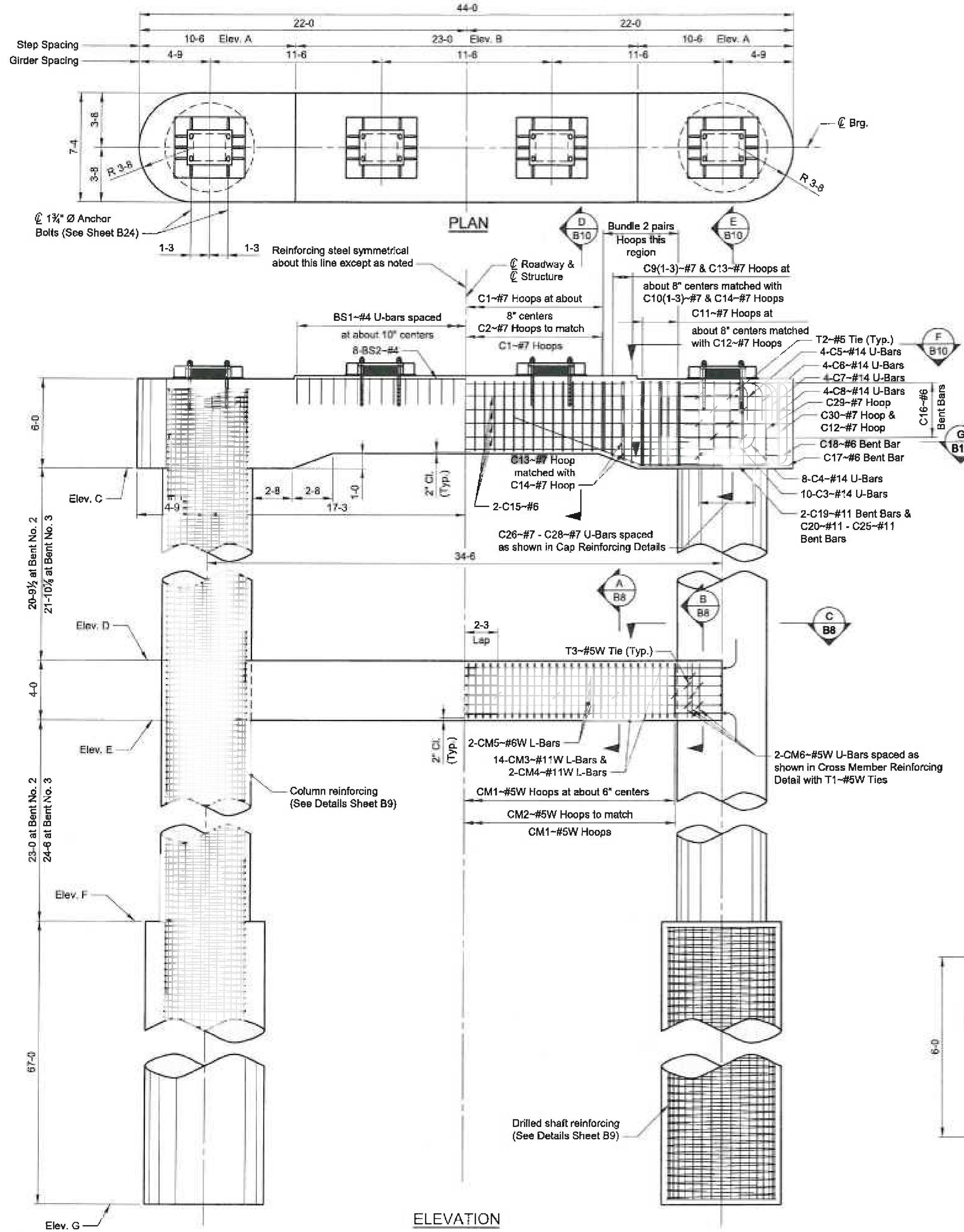
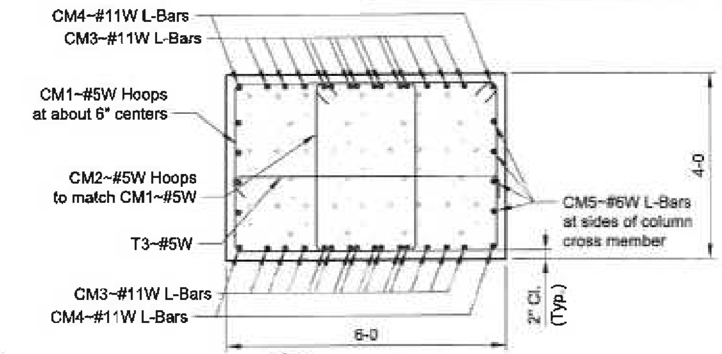
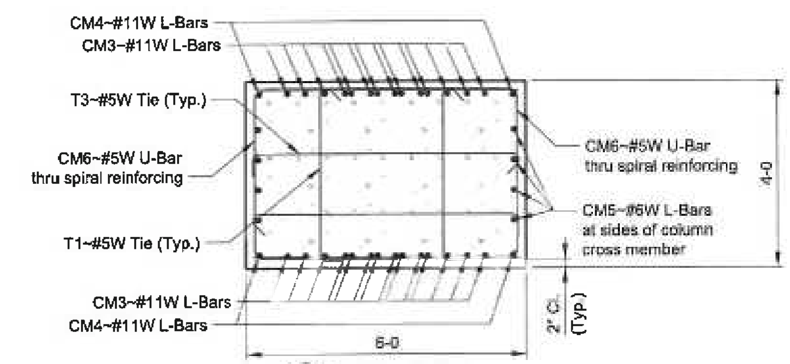
UPN NUMBER 4039

DRAWING NO. 22058

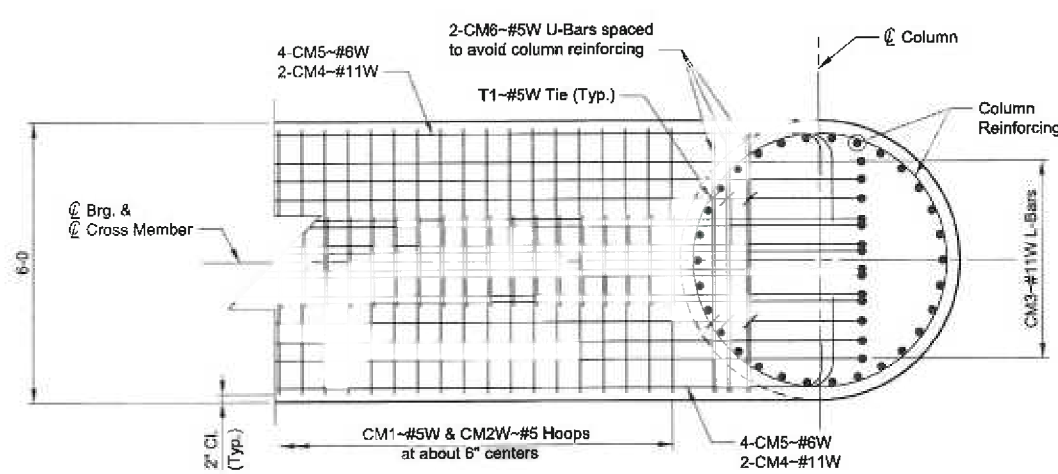




A/B8 SECTION A
Scale ~ ½" = 1'-0"



B/B8 SECTION B
Scale ~ ½" = 1'-0"



C/B8 CROSS MEMBER REINFORCING
Scale ~ ½" = 1'-0"

TABLE OF ELEVATIONS

ELEVATION	BENT NO. 2	BENT NO. 3
A	2472.79	2478.35
B	2473.02	2478.68
C	2466.79	2472.35
D	2446.00	2450.50
E	2442.00	2446.50
F	2419.00	2422.00
G	2352.00	2355.00

NOTES

The suffix E denotes epoxy coated reinforcing steel.

The suffix W denotes ASTM A706 reinforcing steel.

E.F. denotes Each Face

Lap #4 bars 1-6 minimum.
Lap #5 bars 1-10 minimum.
Lap #6 bars 2-4 minimum.

Sonic logging tubes do not extend more than 1-8 above top of drilled shaft.

Use only mechanical rebar connectors to splice DS2~#14W, DS3~#14W, DS4~#14W & DS5~#14W vertical bars.

Terminate spiral at each end by contact lap of 1½ turns in length. Weld tail end of lap as shown on spiral lap detail Sheet B9 or use mechanical rebar connectors.

See Sheet B11 for Bill of Reinforcing Steel.

Splice spirals by mechanical connectors or by welding according to Spiral Lap Detail Sheet B9.

Ensure reinforcing steel does not interfere with anchor bolt placement.

Clearances called out are to the main reinforcing steel. Clearances may be reduced at tie locations.

See Sheet B24 for Bent No. 2 & No. 3 shoe details.

See Sheets B9 & B10 for additional details.

SHEET NO. B8

BENT NO. 2 & NO. 3

Scale ~ ½" = 1'-0" Except As Noted

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO. STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

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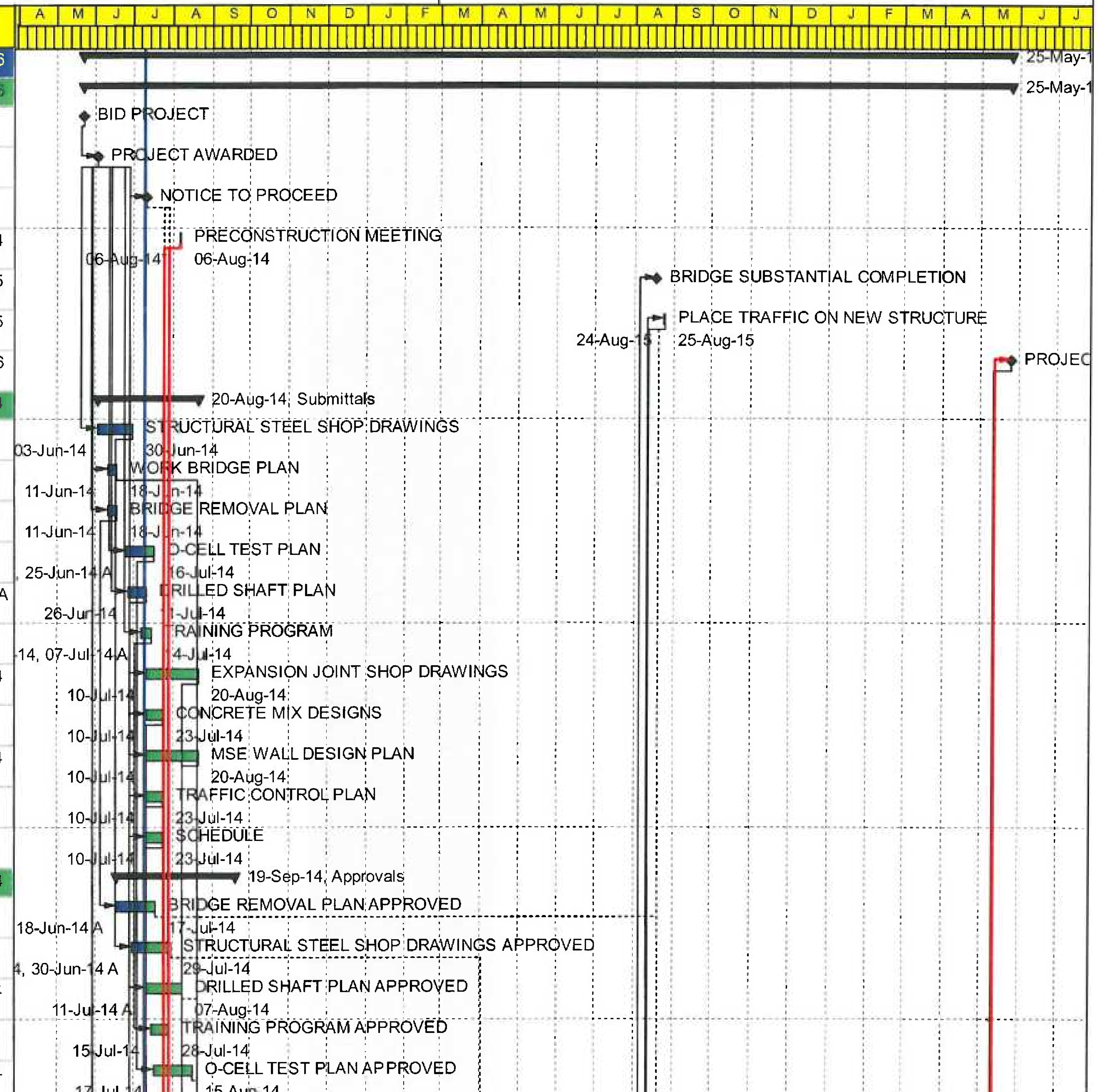
UPN NUMBER 4039

DRAWING NO. 22057

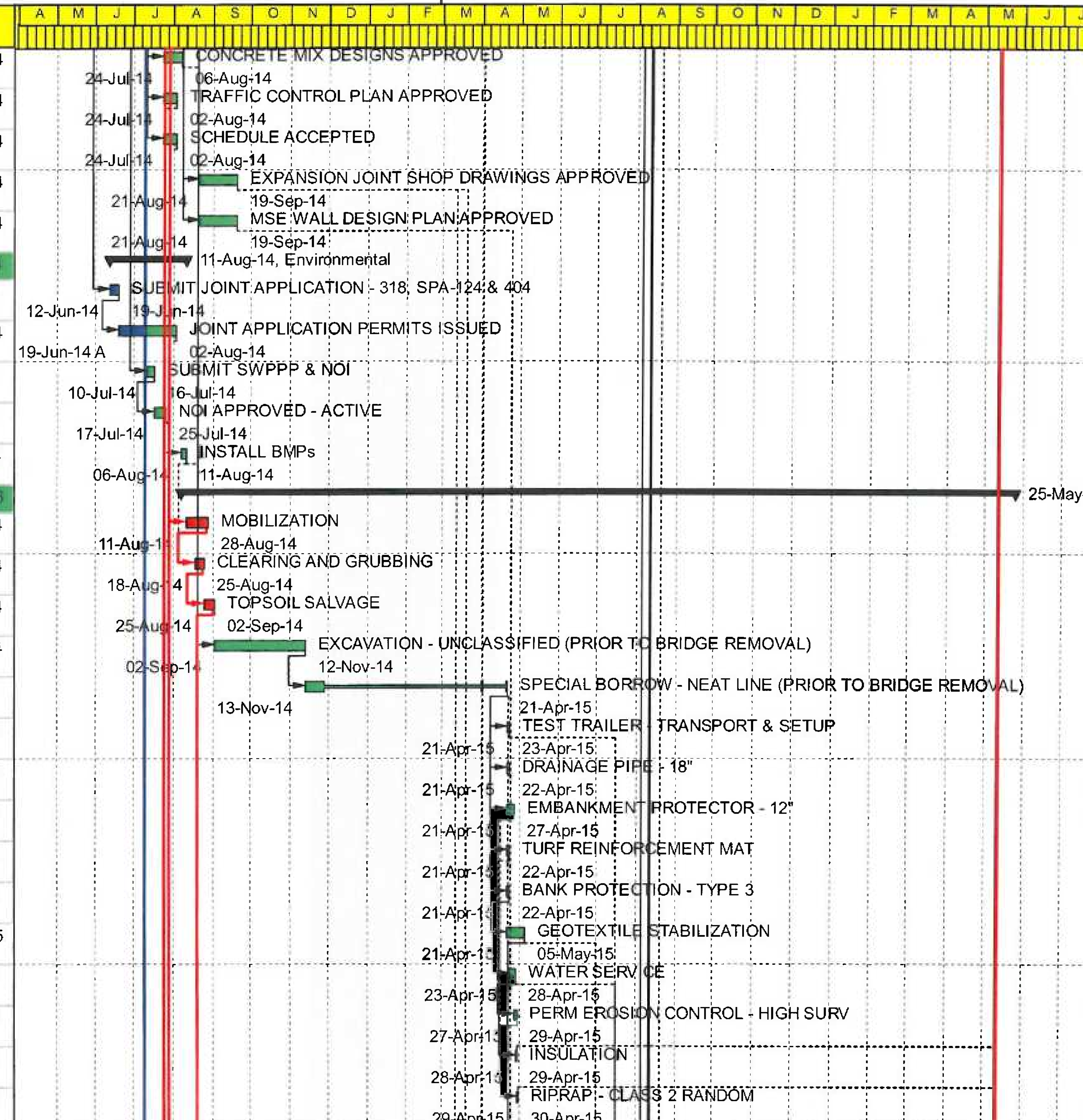
Activity ID	Added Date	Activity Name	Original Duration	Start	Finish
Thompson River Bridge			388	22-May-1	25-May-16
General			379	22-May-1	25-May-16
G1000	10-Jul-14	BID PROJECT	0	22-May-14 A	
G1010	10-Jul-14	PROJECT AWARDED	0	03-Jun-14 A	
G1020	10-Jul-14	NOTICE TO PROCEED	0	10-Jul-14	
G1060	10-Jul-14	PRECONSTRUCTION MEETING	1	06-Aug-14*	06-Aug-14
G1040		BRIDGE SUBSTANTIAL COMPLETION	0		18-Aug-15
G1050	10-Jul-14	PLACE TRAFFIC ON NEW STRUCTURE	1	24-Aug-15	25-Aug-15
G1030		PROJECT COMPLETE	0		25-May-16
Submittals			39	03-Jun-14	20-Aug-14
S1040	10-Jul-14	STRUCTURAL STEEL SHOP DRAWINGS	30	03-Jun-14 A	30-Jun-14 A
S1030	10-Jul-14	WORK BRIDGE PLAN	15	11-Jun-14 A	18-Jun-14 A
S1070	10-Jul-14	BRIDGE REMOVAL PLAN	15	11-Jun-14 A	18-Jun-14 A
S1080	10-Jul-14	O-CELL TEST PLAN	25	25-Jun-14 A	16-Jul-14
S1020	10-Jul-14	DRILLED SHAFT PLAN	15	26-Jun-14 A	11-Jul-14 A
S1000	10-Jul-14	TRAINING PROGRAM	15	07-Jul-14 A	14-Jul-14
S1050	10-Jul-14	EXPANSION JOINT SHOP DRAWINGS	30	10-Jul-14	20-Aug-14
S1060	10-Jul-14	CONCRETE MIX DESIGNS	10	10-Jul-14	23-Jul-14
S1090	10-Jul-14	MSE WALL DESIGN PLAN	30	10-Jul-14	20-Aug-14
S1100	10-Jul-14	TRAFFIC CONTROL PLAN	10	10-Jul-14	23-Jul-14
S1110	10-Jul-14	SCHEDULE	10	10-Jul-14	23-Jul-14
Approvals			51	18-Jun-14	19-Sep-14
A1060	10-Jul-14	BRIDGE REMOVAL PLAN APPROVED	30	18-Jun-14 A	17-Jul-14
A1030	10-Jul-14	STRUCTURAL STEEL SHOP DRAWINGS APPROVED	30	30-Jun-14 A	29-Jul-14
A1020	10-Jul-14	DRILLED SHAFT PLAN APPROVED	30	11-Jul-14 A	07-Aug-14
A1000	10-Jul-14	TRAINING PROGRAM APPROVED	14	15-Jul-14	28-Jul-14
A1070	10-Jul-14	O-CELL TEST PLAN APPROVED	30	17-Jul-14	15-Aug-14



Actual Work | Critical Remaining Work | Summary | Remaining Work | Milestone

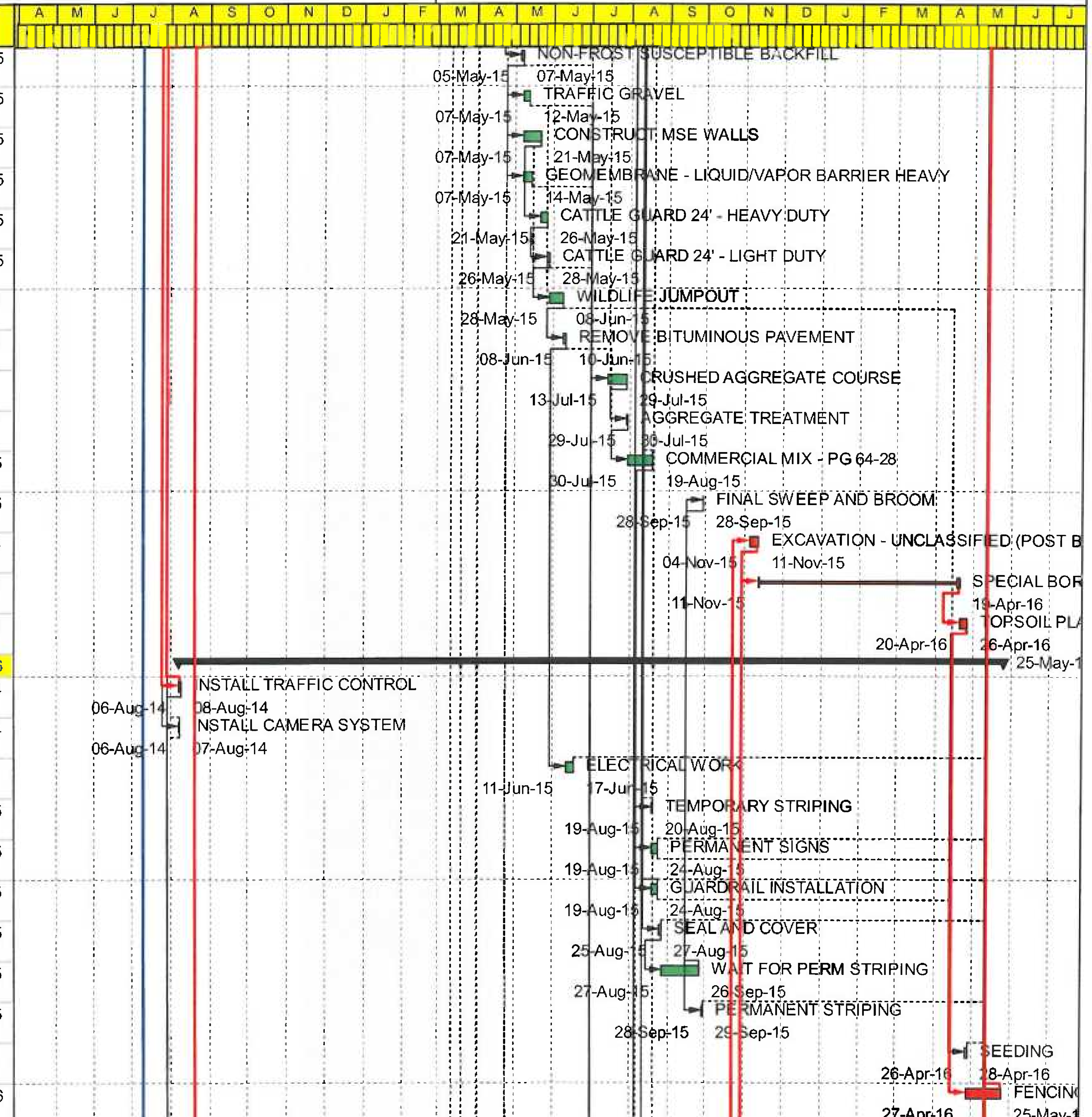
Sletten COMPANIES

Activity ID	Added Date	Activity Name	Original Duration	Start	Finish
A1050	10-Jul-14	CONCRETE MIX DESIGNS APPROVED	14	24-Jul-14	06-Aug-14
A1090	10-Jul-14	TRAFFIC CONTROL PLAN APPROVED	10	24-Jul-14	02-Aug-14
A1100	10-Jul-14	SCHEDULE ACCEPTED	10	24-Jul-14	02-Aug-14
A1040	10-Jul-14	EXPANSION JOINT SHOP DRAWINGS APPROVED	30	21-Aug-14	19-Sep-14
A1080	10-Jul-14	MSE WALL DESIGN PLAN APPROVED	30	21-Aug-14	19-Sep-14
Environmental			51	12-Jun-14	11-Aug-14
E1000	10-Jul-14	SUBMIT JOINT APPLICATION - 318, SPA-124 & 404	20	12-Jun-14 A	19-Jun-14 A
E1010	10-Jul-14	JOINT APPLICATION PERMITS ISSUED	45	19-Jun-14 A	02-Aug-14
E1020	10-Jul-14	SUBMIT SWPPP & NOI	5	10-Jul-14	16-Jul-14
E1030	10-Jul-14	NOI APPROVED - ACTIVE	7	17-Jul-14	25-Jul-14
E1040	10-Jul-14	INSTALL BMPs	2	06-Aug-14	11-Aug-14
Road (LHC)			360	06-Aug-14	25-May-16
R1000	10-Jul-14	MOBILIZATION	14	11-Aug-14	28-Aug-14
R1010	10-Jul-14	CLEARING AND GRUBBING	5	18-Aug-14	25-Aug-14
R1050	10-Jul-14	TOPSOIL SALVAGE	6	25-Aug-14	02-Sep-14
R1030	10-Jul-14	EXCAVATION - UNCLASSIFIED (PRIOR TO BRIDGE REMOVAL)	50	02-Sep-14	12-Nov-14
R1040	10-Jul-14	SPECIAL BORROW - NEAT LINE (PRIOR TO BRIDGE REMOVAL)	12	13-Nov-14	21-Apr-15
R1060	10-Jul-14	TEST TRAILER - TRANSPORT & SETUP	3	21-Apr-15	23-Apr-15
R1150	10-Jul-14	DRAINAGE PIPE - 18"	2	21-Apr-15	22-Apr-15
R1160	10-Jul-14	EMBANKMENT PROTECTOR - 12"	4	21-Apr-15	27-Apr-15
R1170	10-Jul-14	TURF REINFORCEMENT MAT	2	21-Apr-15	22-Apr-15
R1220	10-Jul-14	BANK PROTECTION - TYPE 3	2	21-Apr-15	22-Apr-15
R1250	10-Jul-14	GEOTEXTILE STABILIZATION	10	21-Apr-15	05-May-15
R1130	10-Jul-14	WATER SERVICE	3	23-Apr-15	28-Apr-15
R1240	10-Jul-14	PERM EROSION CONTROL - HIGH SURV	2	27-Apr-15	29-Apr-15
R1140	10-Jul-14	INSULATION	1	28-Apr-15	29-Apr-15
R1210	10-Jul-14	RIPRAP - CLASS 2 RANDOM	2	29-Apr-15	30-Apr-15



Actual Work | Critical Remaining Work | Summary
Remaining Work | ◆ Milestone

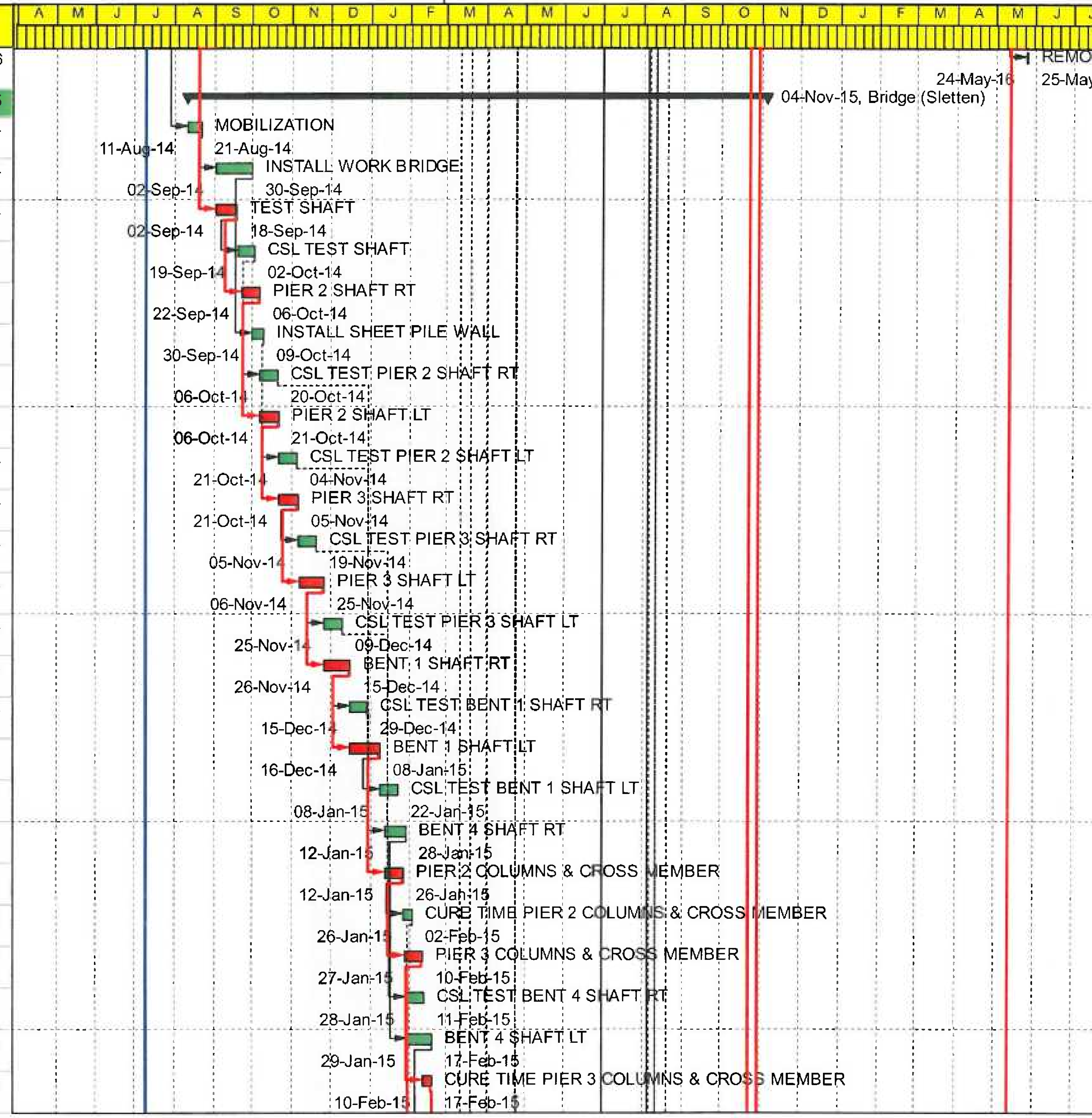
Activity ID	Added Date	Activity Name	Original Duration	Start	Finish
R1090	10-Jul-14	NON-FROST SUSCEPTIBLE BACKFILL	3	05-May-15	07-May-15
R1070	10-Jul-14	TRAFFIC GRAVEL	2	07-May-15	12-May-15
R1230	10-Jul-14	CONSTRUCT MSE WALLS	10	07-May-15	21-May-15
R1260	10-Jul-14	GEOMEMBRANE - LIQUID/VAPOR BARRIER HEAVY	5	07-May-15	14-May-15
R1200	10-Jul-14	CATTLE GUARD 24' - HEAVY DUTY	2	21-May-15	26-May-15
R1190	10-Jul-14	CATTLE GUARD 24' - LIGHT DUTY	3	26-May-15	28-May-15
R1180	10-Jul-14	WILDLIFE JUMPOUT	6	28-May-15	08-Jun-15
R1020	10-Jul-14	REMOVE BITUMINOUS PAVEMENT	3	08-Jun-15	10-Jun-15
R1080	10-Jul-14	CRUSHED AGGREGATE COURSE	12	13-Jul-15	29-Jul-15
R1100	10-Jul-14	AGGREGATE TREATMENT	1	29-Jul-15	30-Jul-15
R1110	10-Jul-14	COMMERCIAL MIX - PG 64-28	14	30-Jul-15	19-Aug-15
R1120	10-Jul-14	FINAL SWEEP AND BROOM	1	28-Sep-15	28-Sep-15
R1035	11-Jul-14	EXCAVATION - UNCLASSIFIED (POST BRIDGE REMOVAL)	5	04-Nov-15	11-Nov-15
R1045	11-Jul-14	SPECIAL BORROW NEAT LINE (POST BRIDGE REMOVAL	4	11-Nov-15	19-Apr-16
R1055	10-Jul-14	TOPSOIL PLACE	4	20-Apr-16	26-Apr-16
Miscellaneous (Highmark / Mild Fence / PMS / Poteet / Quality / Stillwater			**360**	**06-Aug-14**	**25-May-16**
M111(	10-Jul-14	INSTALL TRAFFIC CONTROL	2	06-Aug-14	08-Aug-14
M115(	10-Jul-14	INSTALL CAMERA SYSTEM	1	06-Aug-14	07-Aug-14
M116(	10-Jul-14	ELECTRICAL WORK	5	11-Jun-15	17-Jun-15
M112(	10-Jul-14	TEMPORARY STRIPING	1	19-Aug-15	20-Aug-15
M119(	10-Jul-14	PERMANENT SIGNS	3	19-Aug-15	24-Aug-15
M121(	10-Jul-14	GUARDRAIL INSTALLATION	3	19-Aug-15	24-Aug-15
M113(	10-Jul-14	SEAL AND COVER	2	25-Aug-15	27-Aug-15
M113!	10-Jul-14	WAIT FOR PERM STRIPING	30	27-Aug-15	26-Sep-15
M114(	10-Jul-14	PERMANENT STRIPING	1	28-Sep-15	29-Sep-15
M120(	10-Jul-14	SEEDING	2	26-Apr-16	28-Apr-16
M118(	10-Jul-14	FENCING	20	27-Apr-16	25-May-16



Legend: Actual Work; Critical Remaining Work; Summary; Remaining Work; Milestone

Sletten COMPANIES

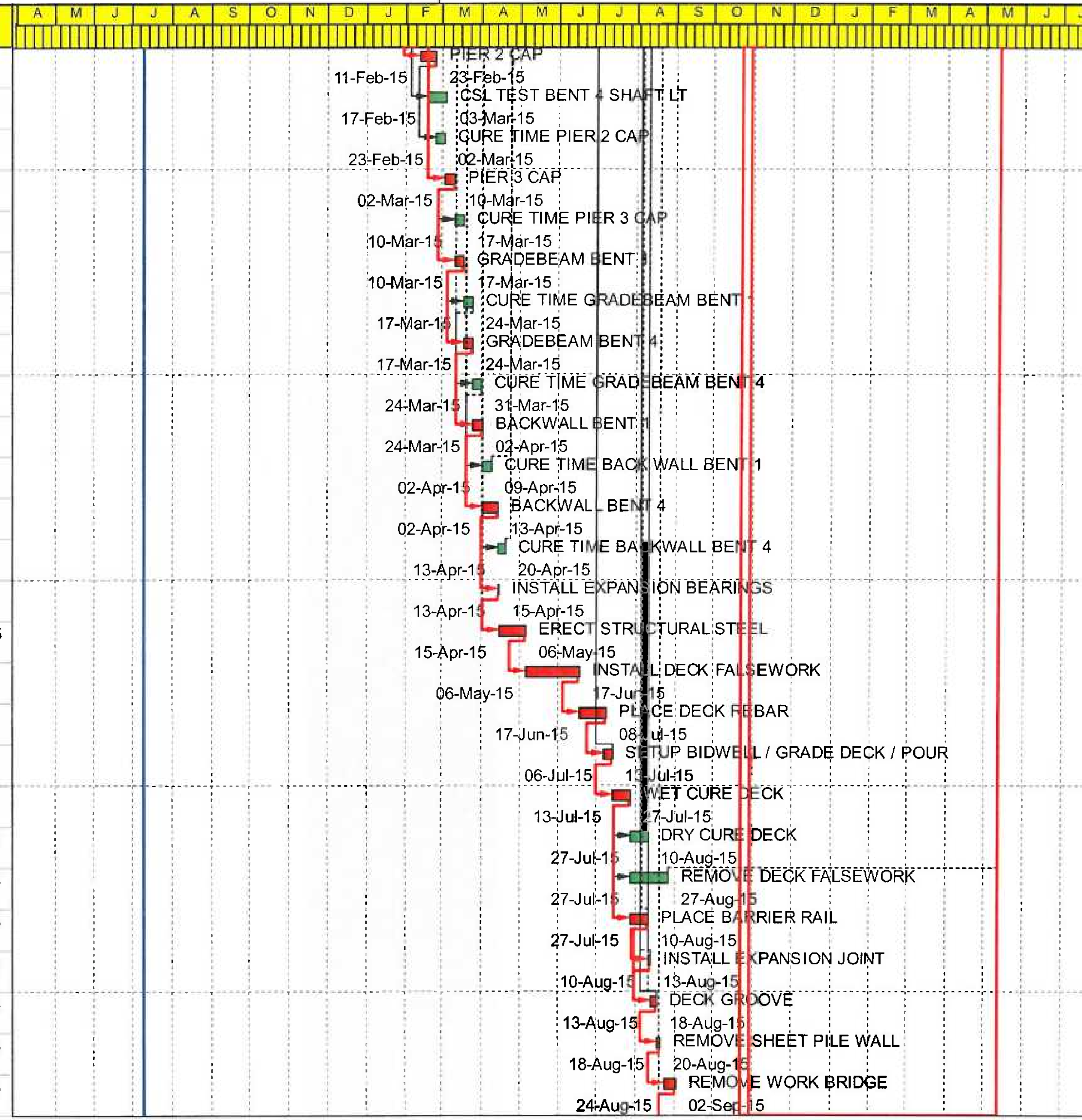
Activity ID	Added Date	Activity Name	Original Duration	Start	Finish
M117(	10-Jul-14	REMOVE CAMERA SYSTEM	1	24-May-16	25-May-16
Bridge (Sletten)			212	11-Aug-14	04-Nov-15
B1000	10-Jul-14	MOBILIZATION	10	11-Aug-14	21-Aug-14
B1010	10-Jul-14	INSTALL WORK BRIDGE	20	02-Sep-14	30-Sep-14
B1020	10-Jul-14	TEST SHAFT	13	02-Sep-14	18-Sep-14
B1040	10-Jul-14	CSL TEST SHAFT	14	19-Sep-14	02-Oct-14
B1050	10-Jul-14	PIER 2 SHAFT RT	11	22-Sep-14	06-Oct-14
B1030	10-Jul-14	INSTALL SHEET PILE WALL	7	30-Sep-14	09-Oct-14
B1060	10-Jul-14	CSL TEST PIER 2 SHAFT RT	14	06-Oct-14	20-Oct-14
B1070	10-Jul-14	PIER 2 SHAFT LT	11	06-Oct-14	21-Oct-14
B1080	10-Jul-14	CSL TEST PIER 2 SHAFT LT	14	21-Oct-14	04-Nov-14
B1090	10-Jul-14	PIER 3 SHAFT RT	11	21-Oct-14	05-Nov-14
B1100	10-Jul-14	CSL TEST PIER 3 SHAFT RT	14	05-Nov-14	19-Nov-14
B1110	10-Jul-14	PIER 3 SHAFT LT	11	06-Nov-14	25-Nov-14
B1120	10-Jul-14	CSL TEST PIER 3 SHAFT LT	14	25-Nov-14	09-Dec-14
B1130	10-Jul-14	BENT 1 SHAFT RT	11	26-Nov-14	15-Dec-14
B1140	10-Jul-14	CSL TEST BENT 1 SHAFT RT	14	15-Dec-14	29-Dec-14
B1150	10-Jul-14	BENT 1 SHAFT LT	11	16-Dec-14	08-Jan-15
B1160	10-Jul-14	CSL TEST BENT 1 SHAFT LT	14	08-Jan-15	22-Jan-15
B1170	10-Jul-14	BENT 4 SHAFT RT	11	12-Jan-15	28-Jan-15
B1210	10-Jul-14	PIER 2 COLUMNS & CROSS MEMBER	9	12-Jan-15	26-Jan-15
B1220	10-Jul-14	CURE TIME PIER 2 COLUMNS & CROSS MEMBER	7	26-Jan-15	02-Feb-15
B1230	10-Jul-14	PIER 3 COLUMNS & CROSS MEMBER	9	27-Jan-15	10-Feb-15
B1180	10-Jul-14	CSL TEST BENT 4 SHAFT RT	14	28-Jan-15	11-Feb-15
B1190	10-Jul-14	BENT 4 SHAFT LT	11	29-Jan-15	17-Feb-15
B1240	10-Jul-14	CURE TIME PIER 3 COLUMNS & CROSS MEMBER	7	10-Feb-15	17-Feb-15



Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

Sletten Companies

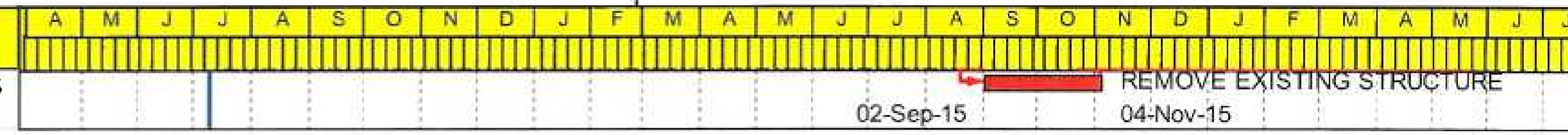
Activity ID	Added Date	Activity Name	Original Duration	Start	Finish
B1250	10-Jul-14	PIER 2 CAP	7	11-Feb-15	23-Feb-15
B1200	10-Jul-14	CSL TEST BENT 4 SHAFT LT	14	17-Feb-15	03-Mar-15
B1260	10-Jul-14	CURE TIME PIER 2 CAP	7	23-Feb-15	02-Mar-15
B1270	10-Jul-14	PIER 3 CAP	7	02-Mar-15	10-Mar-15
B1280	10-Jul-14	CURE TIME PIER 3 CAP	7	10-Mar-15	17-Mar-15
B1290	10-Jul-14	GRADEBEAM BENT 1	5	10-Mar-15	17-Mar-15
B1300	10-Jul-14	CURE TIME GRADEBEAM BENT 1	7	17-Mar-15	24-Mar-15
B1310	10-Jul-14	GRADEBEAM BENT 4	5	17-Mar-15	24-Mar-15
B1320	10-Jul-14	CURE TIME GRADEBEAM BENT 4	7	24-Mar-15	31-Mar-15
B1330	10-Jul-14	BACKWALL BENT 1	7	24-Mar-15	02-Apr-15
B1340	10-Jul-14	CURE TIME BACK WALL BENT 1	7	02-Apr-15	09-Apr-15
B1350	10-Jul-14	BACKWALL BENT 4	7	02-Apr-15	13-Apr-15
B1360	10-Jul-14	CURE TIME BACKWALL BENT 4	7	13-Apr-15	20-Apr-15
B1370	10-Jul-14	INSTALL EXPANSION BEARINGS	2	13-Apr-15	15-Apr-15
B1380	10-Jul-14	ERECT STRUCTURAL STEEL	15	15-Apr-15	06-May-15
B1390	10-Jul-14	INSTALL DECK FALSEWORK	30	06-May-15	17-Jun-15
B1400	10-Jul-14	PLACE DECK REBAR	15	17-Jun-15	08-Jul-15
B1410	10-Jul-14	SETUP BIDWELL / GRADE DECK / POUR	5	06-Jul-15	13-Jul-15
B1420	10-Jul-14	WET CURE DECK	14	13-Jul-15	27-Jul-15
B1430	10-Jul-14	DRY CURE DECK	14	27-Jul-15	10-Aug-15
B1440	10-Jul-14	REMOVE DECK FALSEWORK	24	27-Jul-15	27-Aug-15
B1450	10-Jul-14	PLACE BARRIER RAIL	10	27-Jul-15	10-Aug-15
B1460	10-Jul-14	INSTALL EXPANSION JOINT	3	10-Aug-15	13-Aug-15
B1470	10-Jul-14	DECK GROOVE	3	13-Aug-15	18-Aug-15
B1480	10-Jul-14	REMOVE SHEET PILE WALL	3	18-Aug-15	20-Aug-15
B1490	10-Jul-14	REMOVE WORK BRIDGE	8	24-Aug-15	02-Sep-15



Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

Sletten COMPANIES

Activity ID	Added Date	Activity Name	Original Duration	Start	Finish
B1500	10-Jul-14	REMOVE EXISTING STRUCTURE	45	02-Sep-15	04-Nov-15



Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

SUBMITTAL

BRIDGE OVER THOMPSON RIVER, SANDERS COUNTY, MT

SUBMITTAL (METHOD STATEMENT) FOR INSTALLATION AND LOAD TESTING OF TEST SHAFT TS-1 USING THE OSTERBERG CELL METHOD

This Submittal has been prepared for Loadtest USA's Client:

SLETTEN CONSTRUCTION COMPANY

Loadtest USA Project Number; LT-1074-1

Test Shaft Designation – TS-1

Issue 1, July, 2014

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SUBMITTAL (METHOD STATEMENT) FOR INSTALLATION AND LOAD TESTING OF TEST SHAFT TS-1 USING THE OSTERBERG CELL METHOD

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION:

Osterberg Cell (O-cell) testing has been proposed as the method of choice for the above referenced project. Loadtest will be providing the O-cell testing services. The purpose of the testing is to provide end bearing and side shear information to be used to refine project drilled shaft design parameters.

The Osterberg test method loads the shaft in two directions by hydraulically pressurizing the installed O-cell assembly. Pressurizing the O-cell assembly simultaneously loads the shaft below the O-cell assembly that resists downward movement and loads the shaft above, which resists upward movement (negative shear) (Osterberg, 1989). The load is determined by relating the applied hydraulic pressure to the O-cell calibration. Both a calibrated Bourdon gage and electronic pressure transducer monitor the applied pressure.

The shaft information is summarized as follows:

Designation	Test Type	Shaft Diameter	Shaft Length	Maximum O-cell Load
Test Shaft 1	Dedicated	96 inches	60 feet	3,900 kip

[1]From ground surface. Approximate, see Appendix A.

2.0 O-CELL ASSEMBLY:

The Osterberg cell assembly for the test shaft will consist of the following configuration.

- TS-1 will have one O-cell at a single level.

All O-cells installed by Loadtest USA are calibrated to 3,000 kips. All shipped O-cells are welded closed prior to shipping by American Equipment and Fabricating Corporation. Calibration certificates are made available to the Engineer prior to the installation. The O-cell assembly consists of the specified O-cell configuration (see above) fitted with 2-inch thick steel top and bottom bearing plates. Shop drawings depicting the design of the bearing plates and the rebar cage attachment details are included in Appendix B. The O-cell assembly will be attached to the rebar cage as it lies on the ground in the horizontal position.

2.1 INSTRUMENTATION:

O-cell expansion is measured directly by at least four LVWDTs (Linear Vibrating Wire Displacement Transducers, Geokon Model 4450) attached to the O-cell assembly near the rebar cage and spaced at 90 degree increments. The LVWDT expansion canisters (fixed to the stem of the LVWDTs) are welded to the bottom bearing plate and the shaft of the LVWDT is rigidly fixed to the top bearing plate. The LVWDTs have a travel of at least 6 inches and are read to a 0.001 inch precision.

Compression between the top of shaft and the top of the O-cell assembly is measured with four (4) telltale assemblies, spaced at 90 degree increments, consisting of a ½ inch pipe casing with an inner ¼ inch steel rod. The compression telltale assemblies are monitored by either digital dial indicators (CDI, DPX Series) or LVWDTs (Geokon Model 4450) attached to the top of shaft or embedded within the shaft. The indicators have a travel of at least 1 inch and are read to a 0.0004 inch precision or better. The stems of the indicators are axially aligned with the telltale rod to ensure accurate measurement.

Strain at various elevations is measured using sister bar vibrating wire strain gages (Geokon Model 4911). The gages are installed at multiple levels of four gages per level. The gages on each level will be spaced at 90 degree increments. The sister bar gages have a sensitivity of 0.67 $\mu\varepsilon$ (0.0000007 inch/inch) and an accuracy of 6.7 $\mu\varepsilon$. Strain gages are located as indicated in Appendix A, per the project specifications.

Calibrations for all vibrating wire instrumentation used on this project will be made available to the Engineer prior to installation upon request.

2.2 COMPLETED ASSEMBLY:

The entire assembly will be constructed horizontally on the ground. The rebar cage, wires, hoses, pipes, O-cells and related steel assemblies will be monolithic. The rebar cage will be picked as single piece.

2.3 PROTECTION AND HANDLING OF WIRES, HOSES AND PIPING:

For the test shaft, O-cell hoses, instrumentation and piping will be carefully attached to the rebar cage by approved methods. They shall be attached to hoops and/or verticals as appropriate to allow maximum protection during the picking of the rebar cage, installation of the rebar cage and installation of the tremie pipe and during concreting. Typically, wires, hoses and piping will be attached to rebar hoops at the half way point between two adjacent vertical rebars and usually not in the same space. Wires may be bundled and run in the same space but no more than half of the total wires in any single space.

3.0 CSL PIPING:

CSL testing is required on this project. Our understanding is that all piping will be steel. Continuous steel cannot extend past the O-cell and is not required to extend past the O-cell.

4.0 SHAFT EXCAVATION:

Drilled shaft excavation will proceed under the drilled shaft contractor's work plan as approved by the Engineer. Our understanding is that shaft will be constructed with temporary casings installed to both the plan tip elevation and an intermediate elevation (see Figure A). Drilling of the excavation will be performed using an auger in the dry. Upon reaching the final tip elevation, the shaft bottom is cleaned and approved by the Engineer for concrete placement.

4.1 INSTALLATION AND O-CELL POSITIONING:

The entire assembly will be constructed on the ground. All rebar cage, O-cell assembly, related hydraulic supply, pipes and instrumentation and related steel assemblies will be monolithic and picked as a single piece. Loadtest requires no more than two feet of deflection per 25 feet of rebar cage length. For the test shaft, the O-cell assembly and instrumentation are lowered into the excavation attached to the rebar cage and secured with the assembly at the proper elevation.

4.2 CONCRETE PLACEMENT:

After rebar cage installation, the tremie pipe is lowered into the excavation inside the rebar cage and through the tremie holes and funnel assembly (see Appendix B). The rebar cage and O-cell assembly must be suspended above the base of the excavation with the slick line (tremie) extending below the bottom bearing plate to the tip of the shaft. The slick line should not contain any couplers for the entire length it extends below the any O-cell assembly. Both the tremie and rebar cage should be secured so they can be independently raised and lowed during installation and concreting. The seating layer for the test shaft will be placed below the assembly by pumping concrete through the slick line after the assembly is placed into the shaft.

The assembly must be at least 12 inches above the planned elevation during initial concreting. After the high slump concrete is placed up to the bottom plate of the O-cell assembly as confirmed by taping on multiple sides, the concreting will be stopped or slowed and the assembly lowered 12 inches into the wet concrete to its planned elevation. Concreting then continues as the tremie point of discharge remains below the bottom bearing plate of the O-cell assembly until the concrete level has risen to at least 10 feet above the O-cell assembly. This procedure will ensure complete coverage of the O-cell and plate assembly. Concrete should be delivered slowly as the tremie point of discharge remains below the assembly. The rebar cage should be monitored for movement during concreting so that the O-cell assembly does not rise (float).

The concrete above the O-cell assembly will then be placed to the top of the shaft according to approved procedures. During concrete placement, the tremie or pump line is withdrawn, as per approved concreting procedures.

5.0 FIELD MEASUREMENTS:

Upward top of shaft movement is measured using a pair of automated digital survey levels (Leica, model number NA3000) in accordance with *ASTM D1143 Standard Test Method for Deep Foundations Under Static Axial Compressive Load - Section 7.2.4*. Each survey level will monitor a separate invar rod rigidly mounted to the top of shaft from a minimum distance of at least five shaft diameters from the center of the test shaft. The survey-level / invar-rod reference system has a minimum range of 10 inches and is read to a 0.001 inch precision. Top of shaft displacement monitored in this method does not require a reference beam system and therefore no correction for reference system movement is necessary. A backsight will be used to insure the overall accuracy of the system.

All of the instrumentation is connected to either a Campbell Scientific (Model CR-10) or Datataker (Model DT-615 or DT-85) data acquisition system. A laptop computer will control the data acquisition system. This arrangement allows instrumentation readings to be logged automatically at 60-second intervals during the test. The system provides three levels of backup for all recorded data. The survey level data is also imported into the laptop and stored in two separate locations.

6.0 LOAD TEST PROCEDURES:

The O-cell load test is performed in general accordance with *ASTM D1143 Standard Test Method for Deep Foundations Under Static Axial Compressive Load, procedure a.* Load will be applied utilizing the Quick Load Test Method in increments of no more than 10% of the maximum estimated test load and as approved by the Engineer. The load is maintained constant at each loading increment for eight (8) minutes. An average of one minute is required to increase the O-cell pressure to the next load increment. Unloading of the test shaft will be performed in decrements 25% of the maximum load obtained. The load is maintained constant at each loading decrement for four (4) minutes.

The load test will be carried out in one stage. The lower portion of the shaft will move downward while the upper shear portion of the shaft moves up. The load will be removed as described above and the stage concluded when any of the following situations occur:

Load Test Termination

- The ultimate capacity[1] in the downward direction is reached.
- The ultimate capacity[1] in the upward direction is reached.
- The maximum travel of the O-cells is reached.
- The maximum load capacity of the O-cells is reached.
- At the direction of the Engineer.

6.1 CALCULATION OF MOVEMENTS FOR SINGLE LEVEL TEST SHAFT:

1) **Shaft Compression:** Compression of the shaft above the O-cell assembly will be measured directly from the O-cell assembly top to the top of the shaft using telltales as described above.
2) **Top of Shaft Movement:** The top of shaft or any rigid steel structure in embedded positive contact with the top of shaft will be measured directly using two digital survey levels (Leica NA3001) connected to a laptop computer.
3) **Upward Top of O-cell Movement:** Calculated as sum of shaft compression above the O-cell assembly and top of shaft movement.
4) **O-cell Expansion:** Measured directly using LVWDTs attached to the top and bottom of the

[1] Defined as, "The capacity at which no further loading is possible with the pumping apparatus on site."

O-cell assembly.

5) **Downward Bottom of O-cell Movement:** Calculated as O-cell expansion minus upward top of O-cell movement.

7.0 REPORTING OF TEST RESULTS:

Upon completion of load testing, verbal results and an electronic copy of the raw field data shall be provided to the client. A final report will be issued seven (7) working days after completion of load testing. If requested, preliminary data may be provided within three (3) days.

8.0 DISPOSITION OF TESTED SHAFT:

Dismantling of the test shaft or cutting of any wires, hoses or piping shall not be undertaken prior to formal acceptance of the load test results by the Owner or Owner's Engineer. After the completion of the sacrificial or production load test and with prior approval by the Owner or Owner's Engineer, remove any equipment, material, waste, etc. which are not to be a part of the finished structure.

After each sacrificial load test is approved and accepted by the Engineer, remove the top of the shaft to at least two feet below finished grade. The Contractor shall take ownership and dispose of the cut off section and related material.

9.0 QUALITY ASSURANCE:

The general approach to installation of the O-cell and ancillary equipment is to have zero defects. To this end, each O-cell will have been tested and calibrated to 3,000 kips by the manufacturer and then welded in the closed position prior to shipment. All the hydraulic hose assemblies will be tested to 10,000 psi prior to installation to ensure a leak-free system. All instrumentation are calibrated individually by the manufacturer to ensure proper accuracy and functionality of all devices prior to shipment.

Qualified Loadtest and contractor field personnel with sufficient training and experience to ensure the highest possible quality of workmanship will perform all connections, inspections and supervisions. Generally speaking, Loadtest installation and testing personnel will have successfully completed over twenty projects.

The onsite inspection and checking of the O-cell assembly includes but is not limited to the following:

- The fabrication of the O-cell assembly is supervised and attached perpendicular to the rebar cage.

- All vibrating wire instrumentation systems are checked for functionality and response using a GK401 or GK403 VW readout box, once arriving on site and then checked later for a response following the instrument attachment to the O-cell assembly and rebar cage and prior to installation. Additional checks are made as appropriate or if damage to instrumentation is suspected.

- Tack welds holding the O-cell assembly closed are visually checked to be intact just prior to lifting and placement of the shaft. In most cases, temporary struts will be welded to top and bottom plates for picking and will be cut over the hole.

- Hoisting and lifting of the O-cell assembly and rebar cage from horizontal to vertical is supervised and the rebar cage must deflect as little as possible at all times. It is possible to lift the rebar cage separately and attach it to the O-cell assembly from a vertical position. Consult with Loadtest for details.

- Immediately prior to lowering the O-cell assembly into the hole it is checked to be within acceptable tolerance from vertical. If the criterion is not met initially, suggestive adjustments/procedures will be given to bring the assembly within the acceptable tolerance.

- The concrete must be inspected in order to minimize the possibility of damage and improper seating of the O-cell assembly. Slump and quality must be verified prior to and during concreting.

- In order to minimize the potential problems in the event that damage occurred to the electronic equipment during installation several built in redundancies in the embedded measurement system are installed.

    - The shaft compression is measured by multiple traditional compression telltales.
    - O-cell expansion is measured by a minimum of four LVWDTs (as described above) at 90 degree separation. If any single gage fails, any two remaining gages opposed at 180 degrees would accurately yield O-cell expansion.
    - Bottom plate movement can be measured directly by using telltale rods inserted into the pre-installed vent casings in the event that all expansion LVWDTs fail to function.
    - All external measurement devices used in measuring the shaft head movement, telltale movement, reference beam movement and O-cell pressure can be replaced in case of malfunctioning.

10.0 SAFETY:

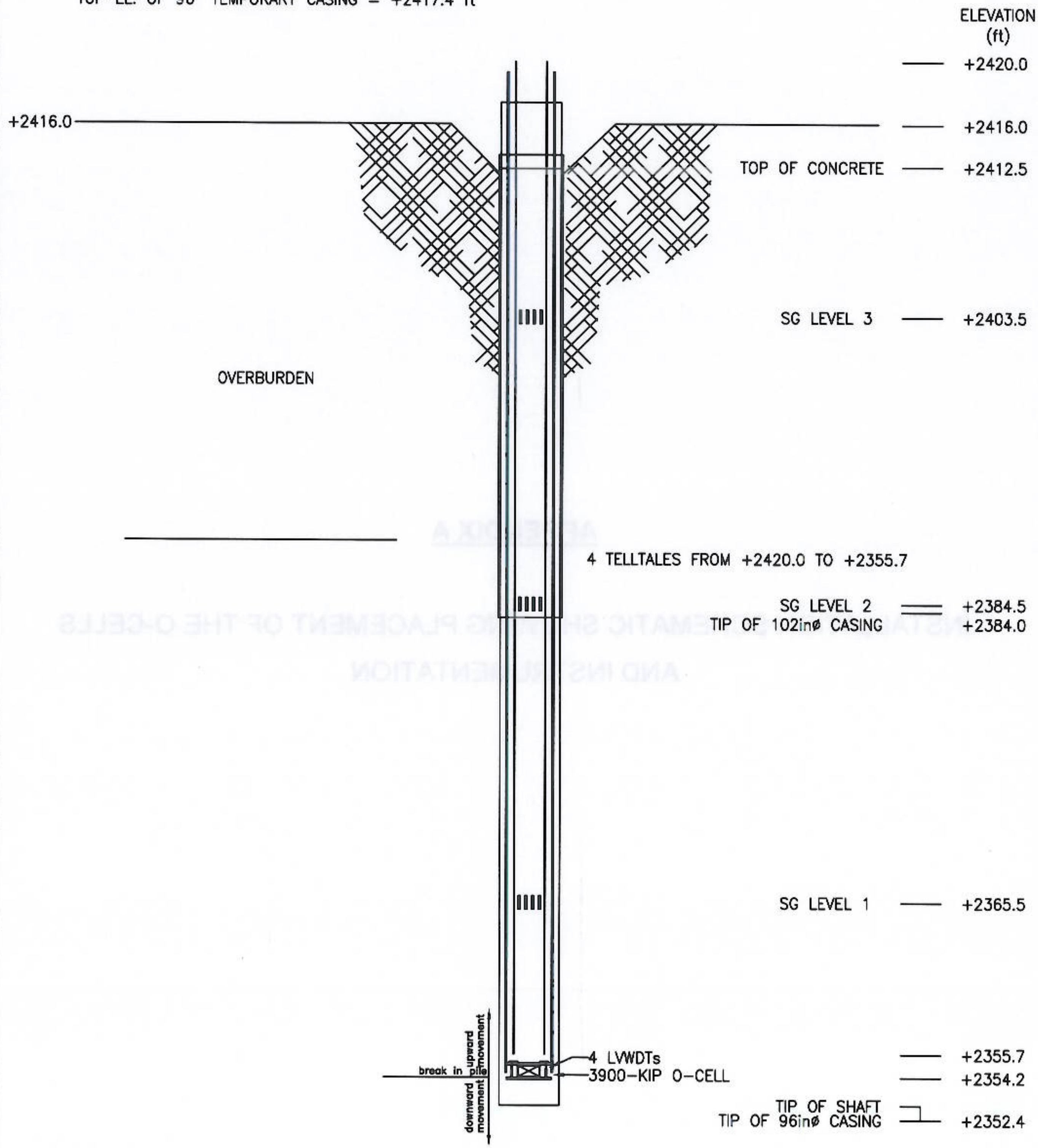
We require a safe working environment for Loadtest personnel to carry out the services proposed herein. Compliance with published OSHA standards and generally accepted safe working procedures are required as a condition of our work. Loadtest reserves the right to suspend work related to our proposed services if our personnel consider that their personal safety on the jobsite is compromised. An AHA form may be submitted separately by Loadtest USA. Loadtest maintains a robust HSE program and all Loadtest personnel have completed OSHA10 or OSHA30 safety training or equivalent.

APPENDIX A

INSTALLATION SCHEMATIC SHOWING PLACEMENT OF THE O-CELLS AND INSTRUMENTATION

NOTE: NOMINAL SHAFT DIAMETER 96"

TOP EL. OF 102" TEMPORARY CASING = +2414.0 ft
TOP EL. OF 96" TEMPORARY CASING = +2417.4 ft



NOTE: SOIL BASED ON BORING # TBD

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SCHEMATIC SECTION OF TEST SHAFT

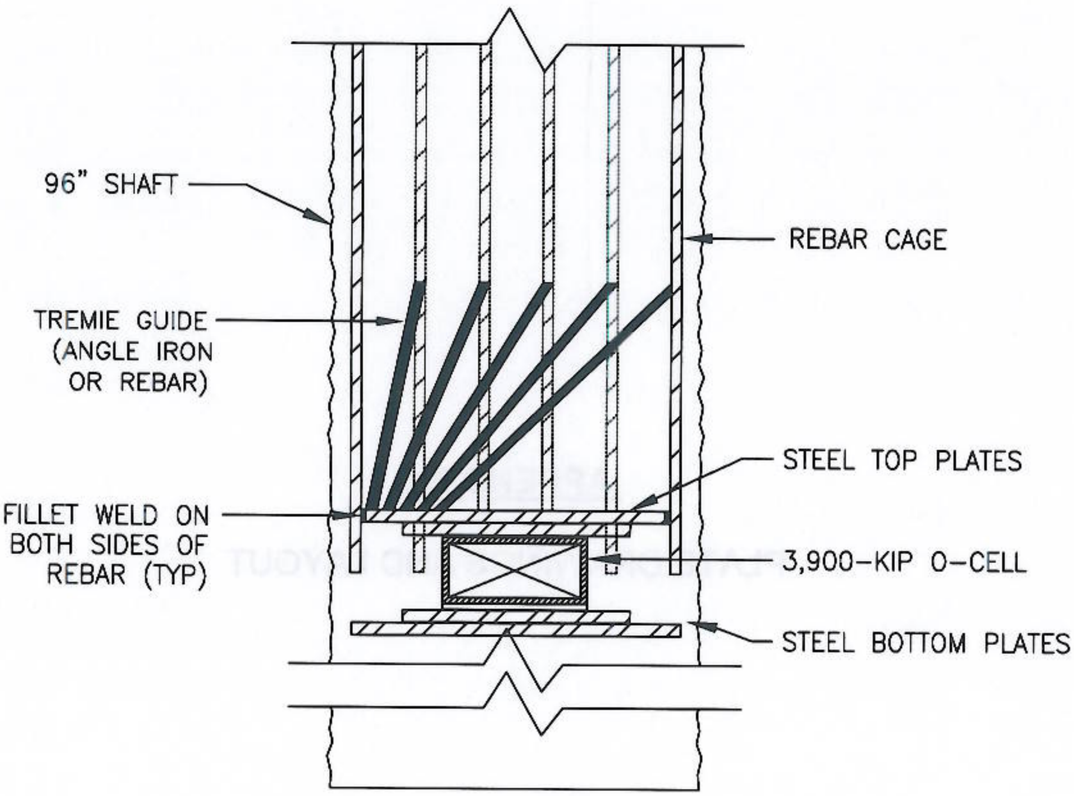
BRIDGE OVER THOMPSON RIVER – SANDERS COUNTY, MT

DWN BY: RCS	DATE: 15 Jul 2014	CHECKED BY: JFU	LT-1074-1
REVISED BY:	DATE:	SCALE: NTS	FIGURE A

APPENDIX B

PLATE DRAWINGS AND LAYOUT

96" SHAFT WITH 3,900-KIP O-CELL



ASSEMBLY STEPS

1. O-CELL FITTED WITH TOP AND BOTTOM STEEL PLATES.
2. TOP PLATE OF O-CELL ASSEMBLY WELDED TO REINFORCING CAGE WITH FILLET WELDS ON BOTH SIDES OF REBARS.
3. IF A TREMIE PIPE IS USED FOR CONCRETE PLACEMENT, A GUIDE IS CONSTRUCTED TO DIRECT THE TREMIE PAST THE O-CELL ASSEMBLY.
4. REINFORCING CAGE IS LOWERED INTO EXCAVATION AND SECURED AT REQUIRED ELEVATION.

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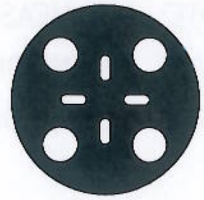
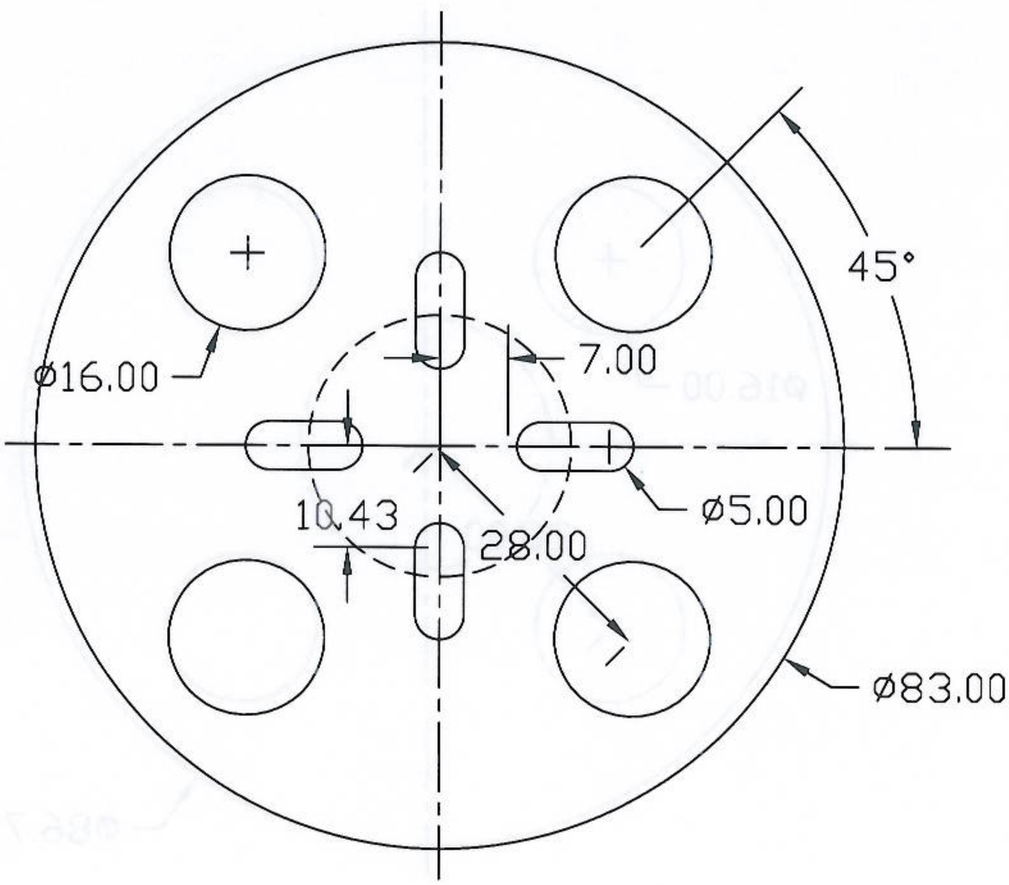
CONCEPTUAL SKETCH OF O-CELL ASSEMBLY BRIDGE OVER THOMPSON RIVER – SANDERS COUNTY, MT			
DWN BY: RCS	DATE: 15 Jul 2014	CHECKED BY: JFU	LT-1074-1
REVISED BY:	DATE:	SCALE: NTS	FIGURE 1

NOTE: ALL MEASUREMENTS IN INCHES (in)
PLATE DIMENSIONS BASED ON A SHAFT DIAMETER OF 96"
CLEAR COVER OF 4", #14 VERTICAL STEEL AND #5 HORZ STEEL



PLAN



1 PER SHAFT WITH 3,900-KIP O-CELL
83" X 2" THICK STEEL PLATE
(OR INSIDE DIA OF REBAR CAGE)

(TOP PLATE: 2,700LB) (ASSEMBLY: 10,300LB)

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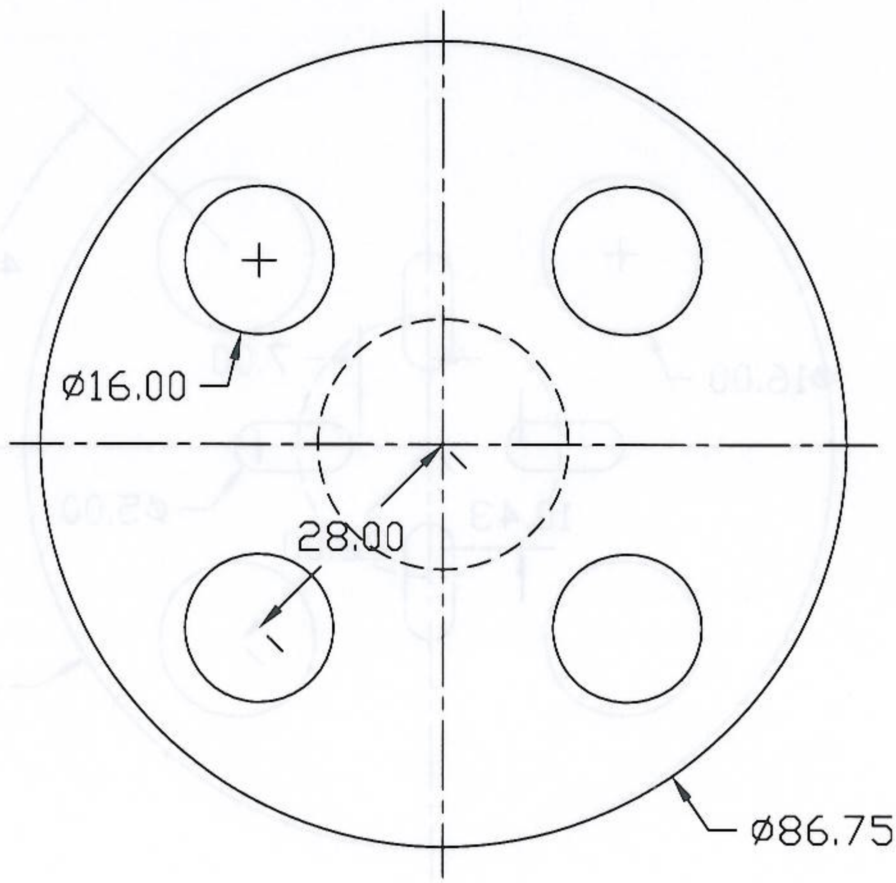
Fax: 352-378-3934

96" SHAFT TOP PLATE LAYOUT BRIDGE OVER THOMPSON RIVER – SANDERS COUNTY, MT			
DWN BY: RCS	DATE: 15 Jul 2014	CHECKED BY: JFU	LT-1074-1
REVISED BY:	DATE:	SCALE: NTS	FIGURE 2

NOTE: ALL MEASUREMENTS IN INCHES (in)
PLATE DIMENSIONS BASED ON A SHAFT DIAMETER OF 96"
CLEAR COVER OF 4", #14 VERTICAL STEEL AND #5 HORIZONTAL STEEL

PLAN



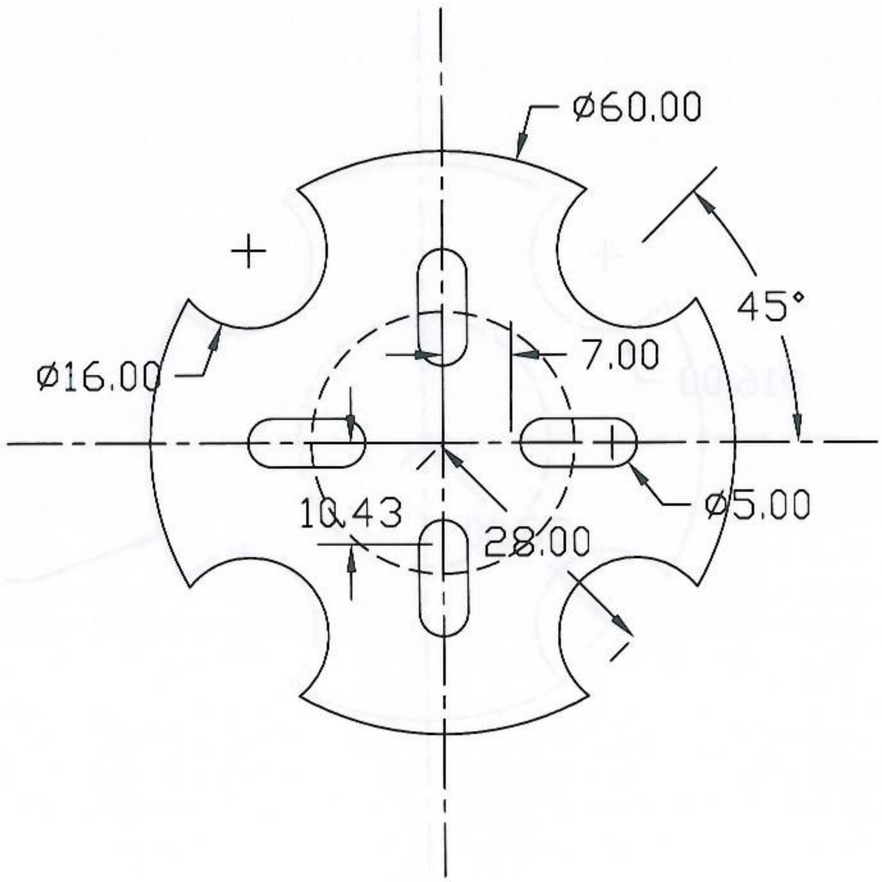
1 PER SHAFT WITH 3,900-KIP O-CELL
86.75" X 2" THICK STEEL PLATE
(OR INSIDE DIA OF REBAR CAGE)

(BOTTOM PLATE: 3,050LB) (ASSEMBLY: 10,300LB)

LOADTEST www.LOADTEST.com	96" SHAFT BOTTOM PLATE LAYOUT BRIDGE OVER THOMPSON RIVER – SANDERS COUNTY, MT			
2631-D NW 41st St. Gainesville, FL, 32606 Phone: 800-368-1138 Fax: 352-378-3934	DWN BY: RCS	DATE: 15 Jul 2014	CHECKED BY:	LT-1074-1
	REVISED BY:	DATE:	SCALE: NTS	FIGURE 3

NOTE: ALL MEASUREMENTS IN INCHES (in)
PLATE DIMENSIONS BASED ON A SHAFT DIAMETER OF 96"
CLEAR COVER OF 4", #14 VERTICAL STEEL AND #5 HORZ STEEL

PLAN



1 PER SHAFT WITH 3,900–KIP O–CELL
60" X 2" THICK STEEL PLATE

(TOP PLATE: 1,400LB) (ASSEMBLY: 10,300LB)

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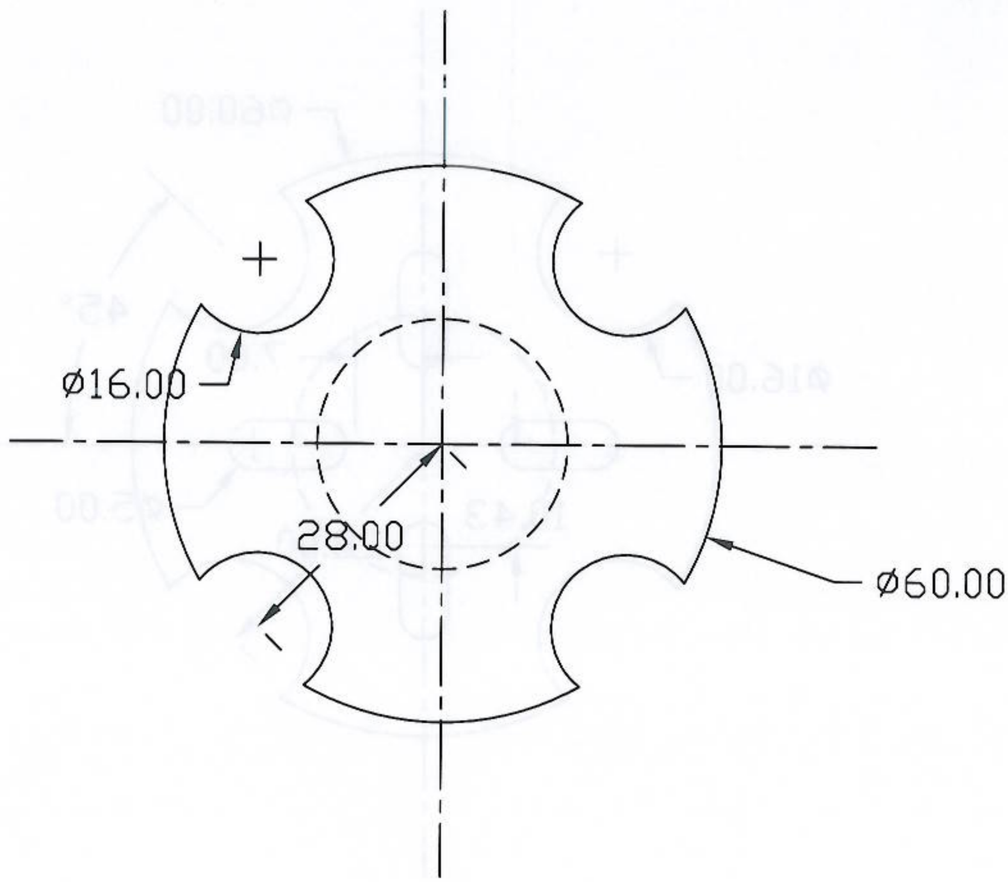
96" SHAFT TOP PLATE LAYOUT
BRIDGE OVER THOMPSON RIVER – SANDERS COUNTY, MT

DWN BY: RCS	DATE: 15 Jul 2014	CHECKED BY:	LT–1074–1
REVISED BY:	DATE:	SCALE: NTS	FIGURE 4

NOTE: ALL MEASUREMENTS IN INCHES (in)
PLATE DIMENSIONS BASED ON A SHAFT DIAMETER OF 96"
CLEAR COVER OF 4", #14 VERTICAL STEEL AND #5 HORIZONTAL STEEL



1 PER SHAFT WITH 3,900-KIP O-CELL
60" X 2" THICK STEEL PLATE
(OR INSIDE DIA OF REBAR CAGE)

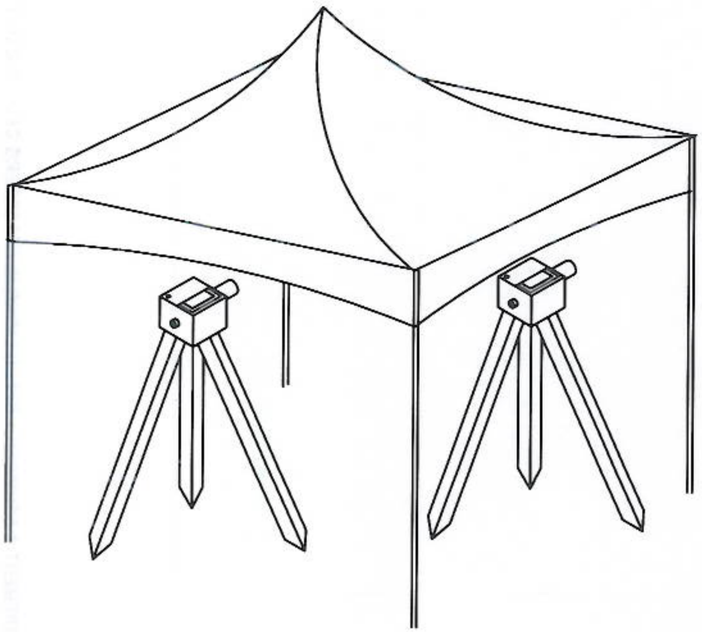
(BOTTOM PLATE: 1,600LB) (ASSEMBLY: 10,300LB)

LOADTEST www.LOADTEST.com	2631-D NW 41st St. Gainesville, FL, 32606 Phone: 800-368-1138 Fax: 352-378-3934	96" SHAFT BOTTOM PLATE LAYOUT BRIDGE OVER THOMPSON RIVER - SANDERS COUNTY, MT		
		DWN BY: RCS	DATE: 15 Jul 2014	CHECKED BY: JFU	LT-1074-1
		REVISED BY:	DATE:	SCALE: NTS	FIGURE 5

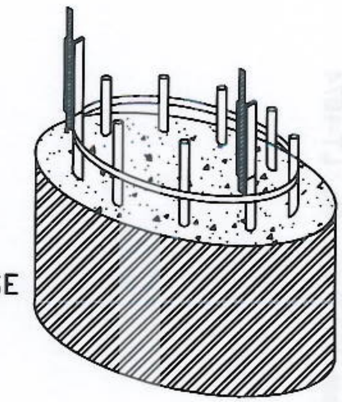
APPENDIX C

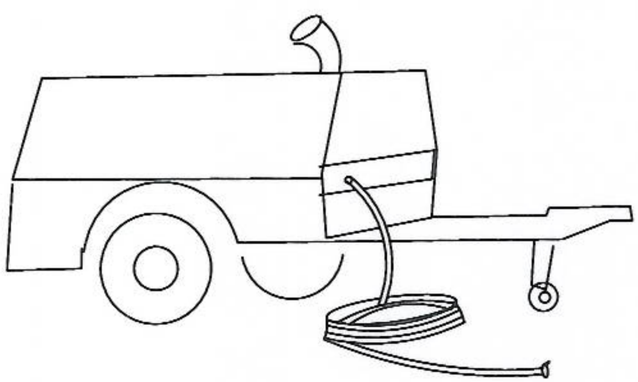
CONTRACTOR WORKSHEET

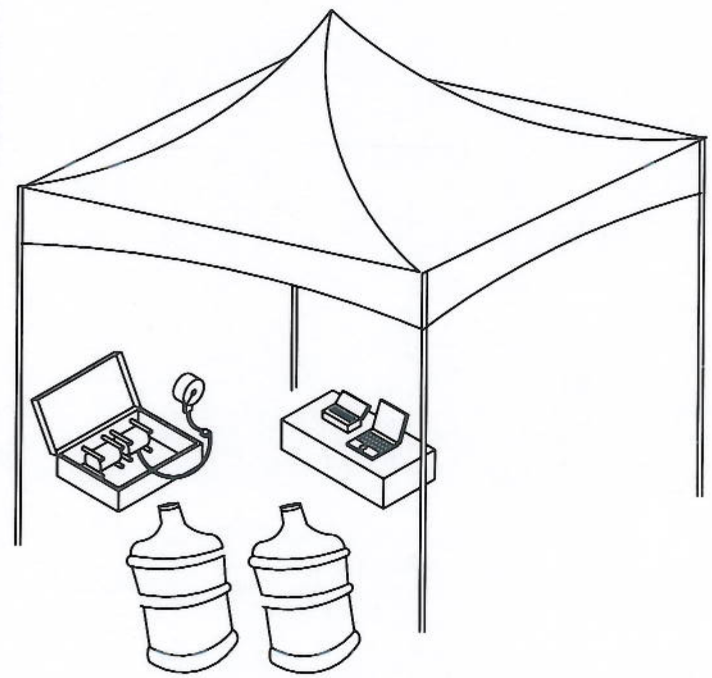
CONTRACTORS WORKSHEET



1.) TWO TENTS TO COVER TESTING INSTRUMENTS
2.) TRIPODS TO MOUNT DIGITAL SURVEY LEVELS
    (LT TO PROVIDE LEVELS)
3.) SUFFICIENTLY FUELED AIR COMPRESSOR & HOSE
    w/ CHICAGO TYPE FITTING
4.) CLEAR POTABLE DRINKING WATER
    CONFIRM QUANTITY WITH LOADTEST







LOADTEST
www.LOADTEST.com
2631-D NW 41st St.
Gainesville, FL 32606
Phone 800-368-1138
FAX 352-378-3934

Loadtest (LT) Contractor's Worksheet

May 5, 2014

PROJECT NAME: Bridge over Thompson River	PROJECT NUMBER: LT-1074
PROJECT LOCATION: Sanders County	STATE: MT
NUMBER OF TESTS ON SITE: 1	PRODUCTION SHAFTS TESTED? No
LOADTEST PROJECT MANAGER: Robert Simpson	CONTRACTOR'S PROJECT MANAGER: Mr. Chad Mares
PHONE: +1-352-219-4367; FAX: +1-352-378-3934	PHONE: 406-761-7920; FAX:
MOBILE PHONE: +1-352-219-4367	EMAIL: cmares@sletteninc.com

FIELD RESPONSIBILITIES FOR INSTALLATION & TESTING

Equipment/Supplies	Contractor	Loadtest	Remarks
Reinforcing Steel Cage	✓		Or Carrying Frame
Steel Bearing Plates	✓		Drawings Provided by LT
½" Iron Pipe: 25 x 21' pieces	✓		Threaded Both Ends
2 x 2 inch Angle Iron	✓		8 X 20 ft. Pieces
Lifting Equipment	✓		
O-cell and Instrumentation		✓	
Welding Personnel	✓		
Welding Equipment & Torches	✓		
Hand Tools	✓	✓	
Air Compressor	✓		
Drinking Water (25 Gallons)	✓		5 Gallon Bottles
Work Platform	✓		If Appropriate
Test Instrumentation		✓	
Test Equipment		✓	
Two Surveyors Tripod(s)	✓		
Weather Protection (sun / rain)	✓		

LOADTEST

Initial______

Loadtest (LT) Contractor's Worksheet			May 5, 2014
PROJECT NAME: Bridge over Thompson River			PROJECT NUMBER: LT-1074
PROJECT LOCATION: Sanders County			STATE MT
NUMBER OF TESTS ON SITE:	1	PRODUCTION SHAFTS TESTED? No	
LOADTEST PROJECT MANAGER: Robert Simpson		CONTRACTOR'S PROJECT MANAGER: Mr. Chad Mares	
PHONE: +1-352-219-4367	FAX: +1-352-378-3934	PHONE: 406-761-7920	FAX:
MOBILE PHONE: +1-352-219-4367		EMAIL: cmares@sletteninc.com	

FIELD RESPONSIBILITIES FOR INSTALLATION & TESTING (CONTINUED)

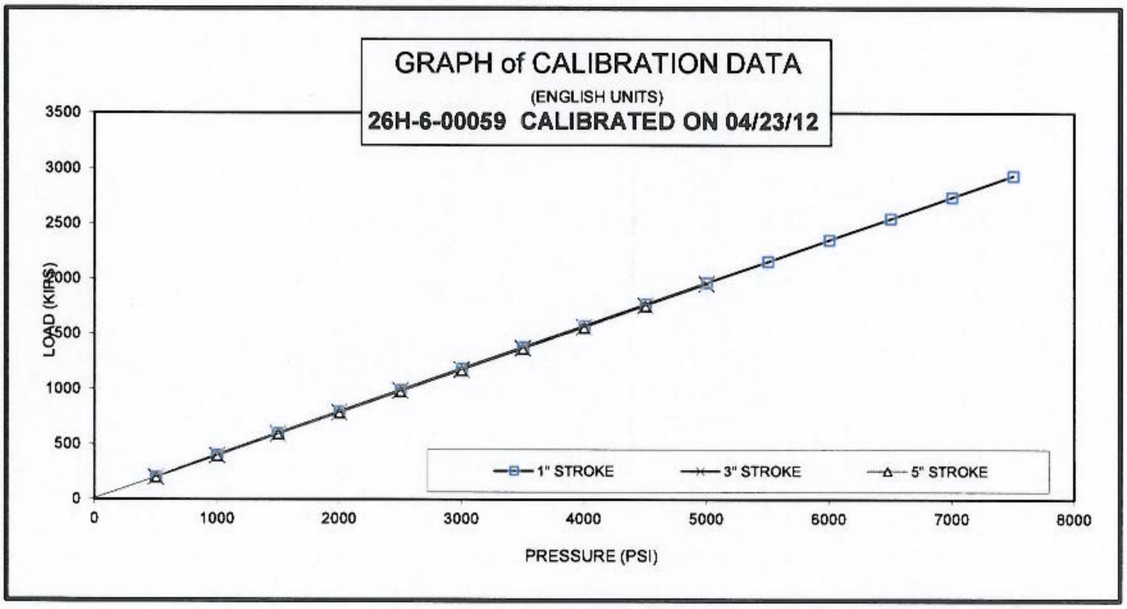
Procedures	Contractor	Loadtest	Remarks
Fabrication of Cage	✓		
Attach O-cell to Cage	✓	LT Observe	
Attach Instruments to Cage		✓	
Excavation of Drilled Shaft	✓		Per Specifications
Inspection of Drilled Shaft	✓		Per Specifications
Quality Control of Shaft	✓		Per Specifications
Placement of O-cell and Cage	✓	LT Observe	Per Specifications
Concrete Placement in Shaft	✓	LT Observe	Per Specifications
Molding of Test Cylinders	✓		
Set up of Weather Protection	✓		
Set up Test Instrumentation		✓	
Operation of Test Equipment		✓	
Recording of Load Test Data		✓	
Submission of Load Test Report		✓	Within 7 working days
Set up of Reference Beam	✓	LT Observe	If Applicable
Post-Test			
Breakdown of Weather Protection	✓		Where Applicable
Breakdown of Work Platform	✓		If Applicable
Post Test Grouting	✓		If Required

LOADTEST

Initial______

APPENDIX D

SAMPLE CALIBRATION SHEETS



26H" O-CELL, SERIAL # 26H-6-00059

STROKE:	1 INCH	3 INCH	5 INCH
PRESSURE PSI	**LOAD KIPS**	**LOAD KIPS**	**LOAD KIPS**
0	0	0	0
500	200	201	200
1000	400	397	396
1500	597	594	592
2000	793	789	785
2500	988	986	978
3000	1183	1177	1171
3500	1377	1372	1365
4000	1572	1564	1558
4500	1767	1759	1752
5000	1961	1954	
5500	2154		
6000	2350		
6500	2544		
7000	2738		
7500	2933		

LOAD CONVERSION FORMULA

LOAD = PRESSURE * 0.3900 + (7.38)
(KIPS) (PSI)

Regression Output:

Constant	7.3776 kips
X Coefficient	0.3900 kip / psi
R Square	1.0000
No. of Observations	34
Degrees of Freedom	32
Std Err of Y Est	4.34
Std Err of X Coeff	0.0004

CALIBRATION STANDARDS:

All data presented are derived from 6" dia. certified hydraulic pressure gauges and electronic load transducer, manufactured and calibrated by the University of Illinois at Champaign, Illinois. All calibrations and certifications are traceable through the Laboratory Master Deadweight Gauges directly to the National Institute of Standards and Technology. No specific guidelines exist for calibration of load test jacks and equipment but procedures comply with similar guidelines for calibration of gages, ANSI specifications B40.1.

* AE & FC CUSTOMER: LOADTEST Inc	* CONTRACTOR.: KIEWIT INFRASTRUCTURE
* AE & FC JOB NO: SO8699	* JOB LOCATION: PORTLAND, OR
* CUSTOMER P.O. NO.: LT-9688-2	* DATED: 04/23/12

SERVICE ENGINEER: [signature] DATE: 4-23-12

GEOKON 48 Spencer St. Lebanon, NH 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 250 mm

Calibration Date: July 10, 2012

Serial Number: 1209157

Temperature: 23.1 °C

Calibration Instruction: CI-4400

Technician: [signature]

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2095	2092	2094	-0.24	-0.10	0.02	0.01
50.0	3023	3022	3023	50.02	0.01	49.95	-0.02
100.0	3952	3951	3952	100.28	0.11	100.05	0.02
150.0	4876	4873	4875	150.21	0.09	149.98	-0.01
200.0	5797	5795	5796	200.07	0.03	200.00	0.00
250.0	6715	6713	6714	249.74	-0.11	250.00	0.00

(mm) Linear Gage Factor (G): 0.05410 (mm/ digit)

Regression Zero: 2098

Polynomial Gage Factors: **A: 9.6155E-08** **B: 0.05326** **C: ________**

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

(inches) Linear Gage Factor (G): 0.002130 (inches/digit)

Polynomial Gage Factors: **A: 3.7856E-09** **B: 0.002097** **C: ________**

Calculate C by setting D = 0 and R_1 = initial field zero reading into the polynomial equation

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St Lebanon, NH 03766 USA

Sister Bar Calibration Report

Model Number: 4911-4

Date of Calibration: January 10, 2013

Serial Number: 1242955

Cable Length: 214 feet

Prestress: 35,000 psi

Regression Zero: 6992

Temperature: 22.0 °C

Technician: [signature]

Calibration Instruction: CI-VW Rebar

Applied Load (pounds)	Readings				Linearity % Max. Load
	Cycle #1	Cycle #2	Average	Change	
100	7051	7043	7047		
1500	7713	7708	7711	664	-0.22
3000	8441	8436	8439	728	-0.10
4500	9173	9165	9169	730	0.09
6000	9895	9891	9893	724	0.07
100	7043	7042	7043		

For conversion factor, load to strain, refer to table C-2 of the Installation Manual

Gage Factor: 0.349 microstrain/ digit (GK-401 Pos. "B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load - Applied Load)/Max. Applied Load) X 100 percent

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

APPENDIX E

PROPOSED LOADING SCHEDULE

Load Test Loading Schedule for Test Shaft 1

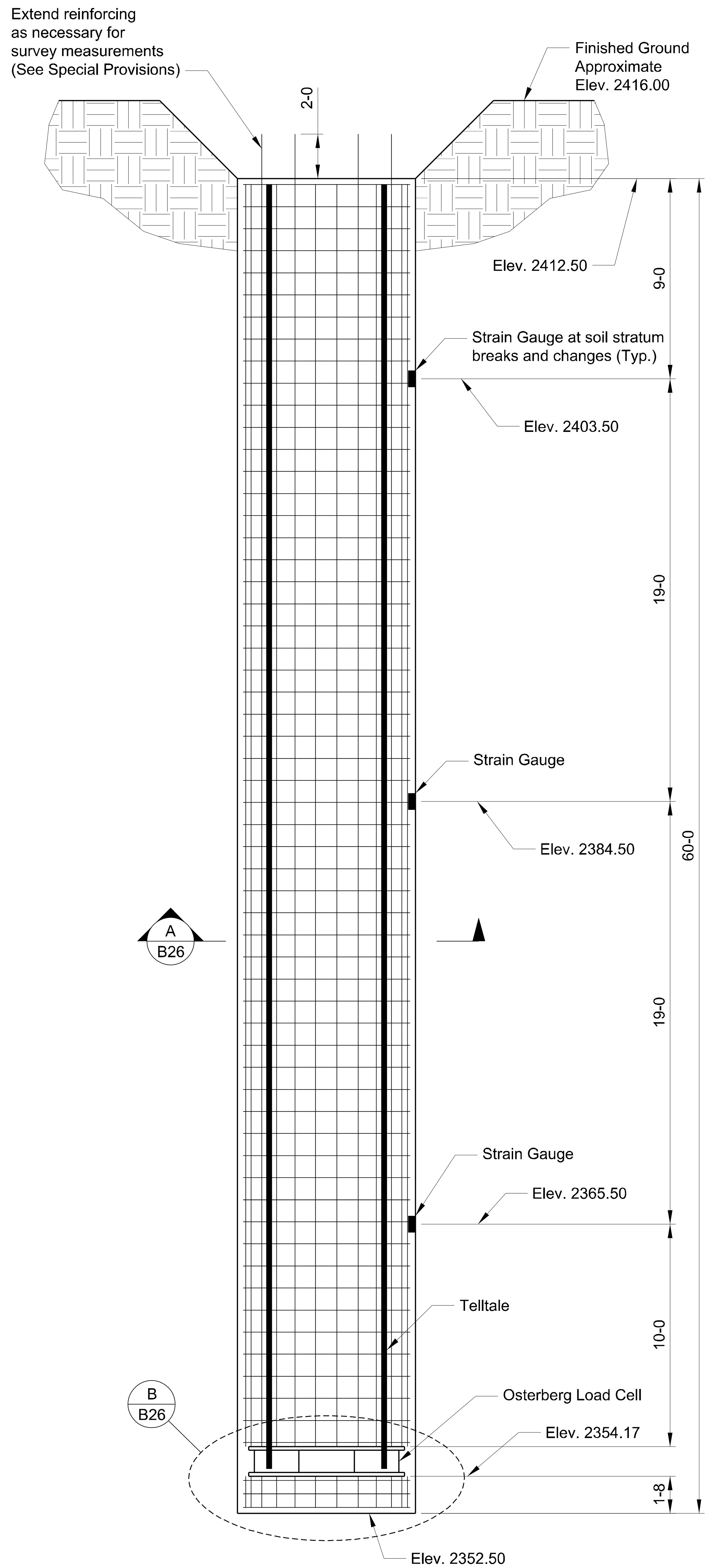
Bridge over Thompson River, Sanders County, MT, LT-1074

	Increment	Applied Pressure (psi)	Applied Gross Load (kips)	Applied Net Load Up (kips)	Total Load (kips)	Hold Time (minutes)
Load Cycle - Load in regular increments - No creep/velocity criteria	1L-0	0	0	0	0	-
	1L-1	500	195	25	220	8
	1L-2	1000	390	220	610	8
	1L-3	1500	585	415	1000	8
	1L-4	2000	780	610	1390	8
	1L-5	2500	975	805	1780	8
	1L-6	3000	1170	1000	2170	8
	1L-7	3500	1365	1195	2560	8
	1L-8	4000	1560	1390	2950	8
	1L-9	4500	1755	1585	3340	8
	1L-10	5000	1950	1780	3730	8
	1L-11	5500	2145	1975	4120	8
	1L-12	6000	2340	2170	4510	8
	1L-13	6500	2535	2365	4900	8
	1L-14	7000	2730	2560	5290	8
	1L-15	7500	2925	2755	5680	8
	1L-16	8000	3120	2950	6070	8

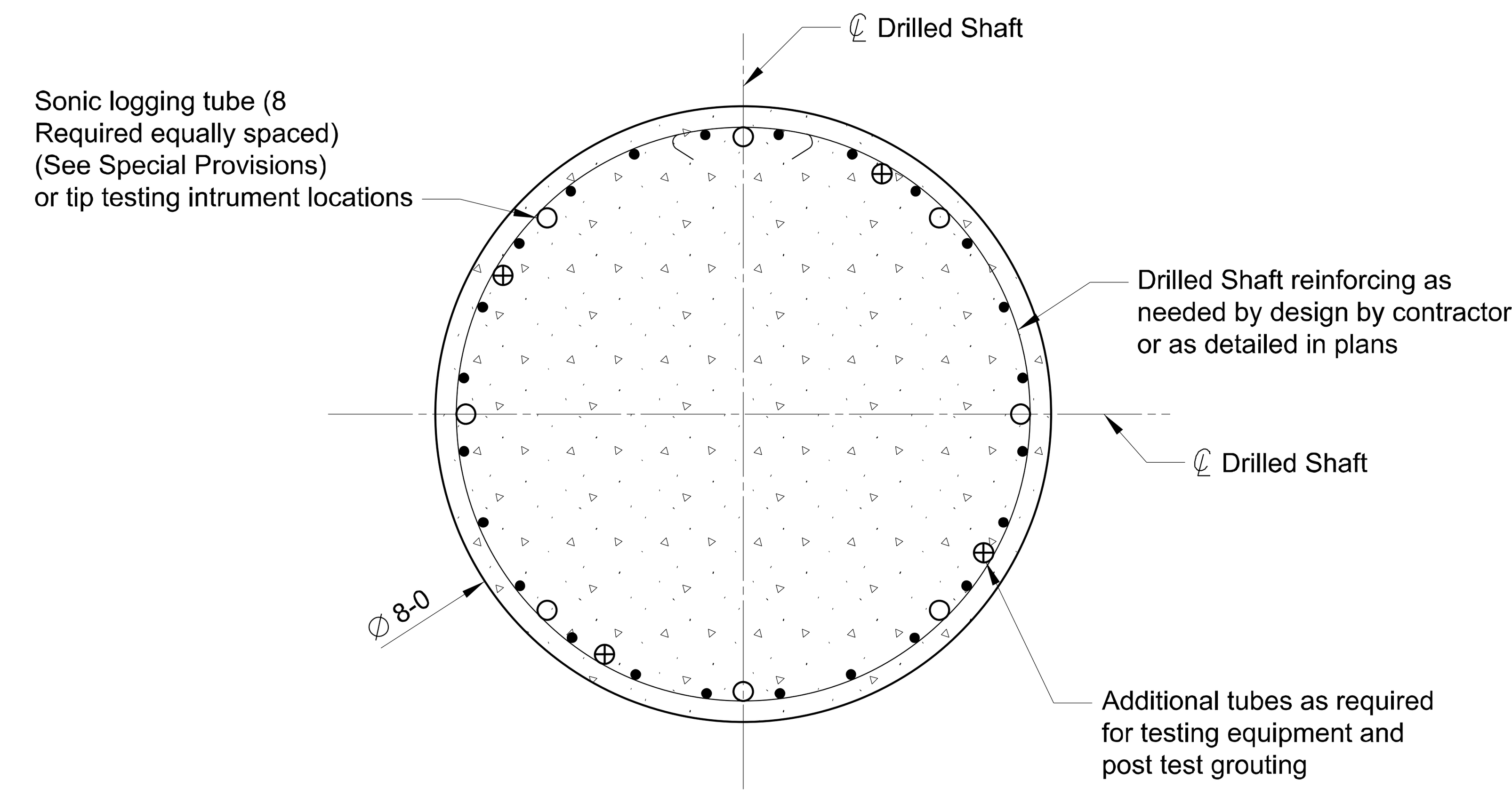
Initial Load Cycle shall continue as long as the pile is not moving excessively or until the the O-cell expansion or load capacity is reached.

	Increment	Applied Pressure (psi)	Applied Gross Load (kips)	Applied Net Load Up (kips)	Total Load (kips)	Hold Time (minutes)
Unload Cycle	1U-1	6400	2496	2326	4822	4
	1U-2	4800	1872	1702	3574	4
	1U-3	3200	1248	1078	2326	4
	1U-4	1600	624	454	1078	4
	1U-5	0	0	0	0	8

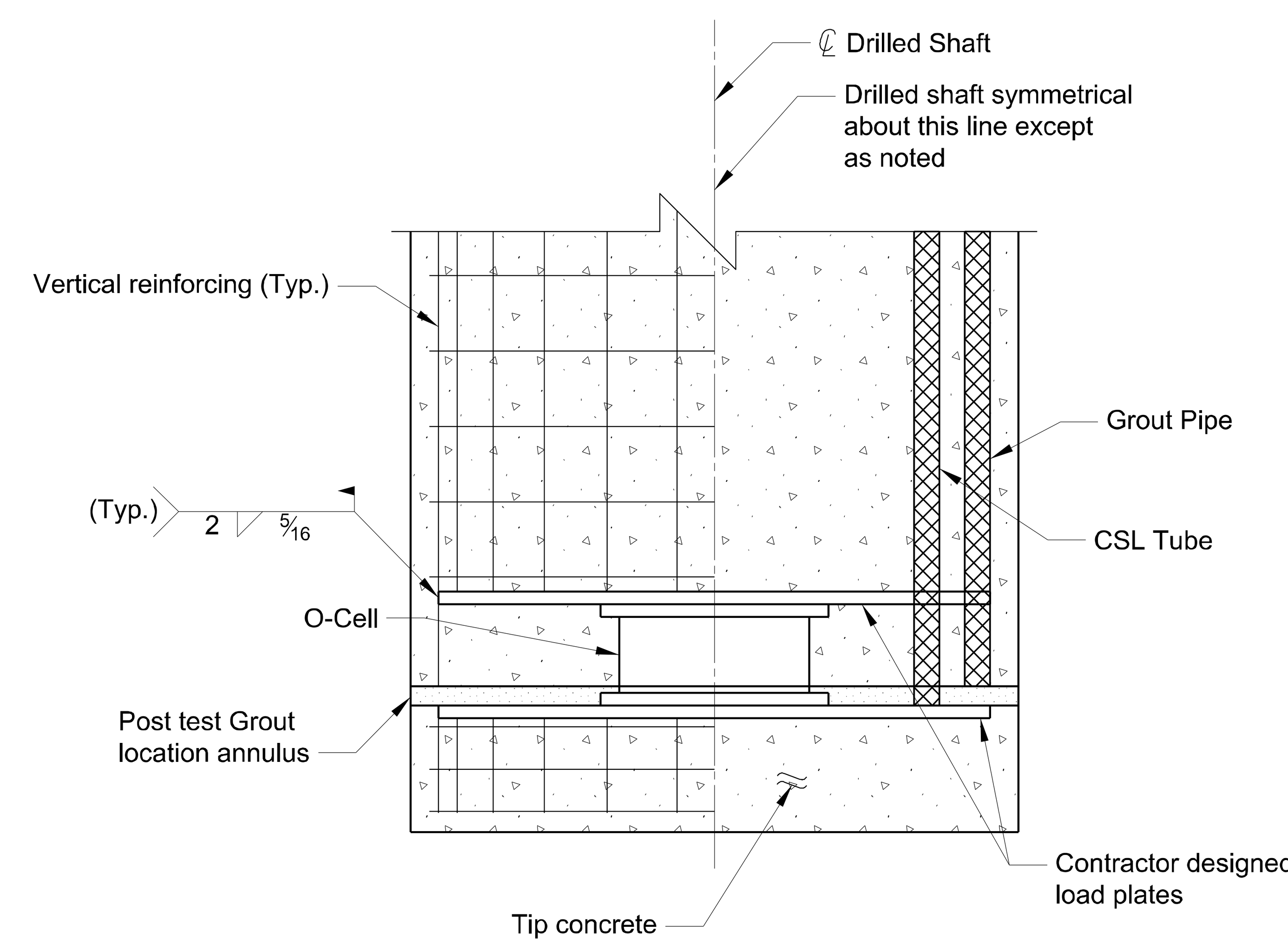
APPENDIX L



TEST DRILLED SHAFT ELEVATION



A
B26
SECTION A
Scale ~ ½" = 1'-0"



B
B26
DETAIL B
Scale ~ ½" = 1'-0"

NOTES

(Sacraficial)	Include all costs associated with furnishing and placing drilled shaft in the unit price bid for Static Load Test - Drilled Shaft.
(Sacraficial & Production)	Include all costs associated with furnishing and performing the Osterberg Load Cell Test in the unit price bid for Static Load Test - Drilled Shaft.
(Sacraficial & Production)	Drilled shaft reinforcing shown on this sheet is for reference only for a sacraficial test shaft. Provide reinforcing as needed by design for load cell test. For a production drilled shaft see details in plan sheets for reinforcing steel.
(Sacraficial & Production)	Design the drilled shaft and conduct the Osterberg Load Cell Test for an ultimate test capacity of 5600 kips
(Sacraficial)	Cut reinforcing steel that is extended out of drilled shaft for survey flush with top of drilled shaft at the completion of the Osterberg Load Cell Test.
(Sacraficial & Production)	Strain gauge locations are approximate. Place gauges as needed to conduct the Osterberg Load Test.
(Sacraficial & Production)	If telescoping casing is used for shaft installation, provide an additional strain guages 1-0 above and below the transition to isolate the transition zone.

SHEET NO.
B26

OSTERBERG LOAD CELL
TEST DETAILS

Scale ~ ¼" = 1'-0" Except As Noted

BRIDGE OVER THOMPSON RIVER

AT STA. 23+20.50

FEDERAL AID PROJECT NO.
STPB-STPP-HSIP 6-1(106)56

SANDERS COUNTY

MDT MONTANA DEPARTMENT OF TRANSPORTATION
BRIDGE BUREAU

REVISED		
REVISED		
REVISED		
REVISED		
CHECKED	2-27-14	C.W.H.
DRAWN	11-25-13	T.J.B.
DESIGNED	11-25-13	T.J.B.
$DATE$	$TIME$	$FILEABBREV$

UPN NUMBER
4039

DRAWING NO.
22075

1. O-CELL LOAD TESTING [560] (SACRIFICIAL SHAFT)

A. Description. This work consists of furnishing all materials, equipment and labor necessary for conducting an Osterberg Cell (O-Cell) Load Test and reporting the results. Supply all material and labor as hereinafter specified and including prior to, during and after the load test. The test shaft is to be constructed at the location shown in the plans and in accordance with the requirements of these special provisions and as outlined elsewhere in the contract.

Employ the services of:

Loadtest USA
2631-D NW 41st Street
Gainsville, FL 32606
Phone (800) 368-1138
(352)378-3717
Fax: (352)378-3934

Loadtest USA must oversee the test shaft installation, instrument installation and operation, and conduct the load test(s) on the drilled shaft(s). The Contractor is to provide auxiliary equipment and services as detailed herein and in coordination with Loadtest USA Loadtest USA has the authority to modify the Contractor's drilled shaft installation methods if deemed detrimental to the O-cell test. Coordinate with Loadtest USA to have a representative on-site as needed during shaft excavation. LoadTest USA must be on-site for O-Cell installation into the re-bar cage, all aspects of instrument installation, and during the placement of the re-bar cage into the accepted shaft excavation. It is encouraged to have a LoadTest USA representative present during the test shaft pour.

No work is allowed on production drilled shafts, before the test shaft has been installed and tested. The test results will be used to set final shaft tip elevations. Re-bar cage construction is allowed at the Contractor's risk, no extra payment will be made for reconfiguring the re-bar cages based on the test shaft results.

It is the responsibility of the Contractor to inform the Project Manager if during the installation of the shaft any occurrences which may affect the quality of the performance of the O-cell test.

Once the project is complete, Research will conduct any necessary ongoing analysis and reporting requirement. The needs for Research may entail interviews with the contractors and applicable staff throughout the course of the project. This will include anecdotal information that may be digitally recorded.

Inform the Project Manager a minimum of 2 weeks prior to the beginning of this experimental feature. Who will contact Craig Abernathy, MDT Research ExPM, avaliable at 444-6269 (cabernathy@mt.gov) 2 weeks prior to the beginning of this project for schedule purposes. Keep the Project Manager informed of any changes in schedule relating to the O-cell test.

1) Preconstruction meeting. The following must attend the Preconstruction meeting:

- A representative from Loadtest USA
- The project Foreman from the Drilled Shaft Contractor.
- Craig Abernathy – Statewide Experimental Program Manager (444-6269) or an experimental program representative.

2) Experience. The Drilled Shaft Foreman must have installed and been a part of at least five successful drilled shafts (8 foot diameter) in the last five years. The Drilled Shaft Foremen must be on-site during all work described in this special provision and related to the test shaft. Submit at the Preconstruction meeting a written narrative with the following information at a minimum:

a) Name of the Drilled Shaft Foreman
b) Project description of previous verifiable drilled shafts including:
(1) Project Name.
(2) Project Location.

(3) Owners Name and contact representative with current address and phone number.

(4) Type and size of test shaft.

(5) O-Cell testing company.

(6) General Description of the O-Cell test conducted and the results.

B. Materials. Furnish all materials required to install the O-Cell, conduct the load test, and remove the load test apparatus as required. Furnish 1 or more O-Cell as required for each load test. The O-Cell(s) to be provided are to have a minimum bi-directional capacity as called for in the project plans or documents and be equipped with all necessary hydraulic lines, fittings, pressure source, pressure gage and telltale devices.

C. Construction Requirements.

1) Submittals. A minimum of 30 days prior to starting the excavation for the test shaft, submit 3 copies of a testing plan with working drawings which outline the test setup, including details of all system elements, instrumentation, materials, data collection system and procedures. Develop the testing submittal in coordination with and submit concurrently with the Drilled Shaft working drawing submittal as required in related specifications found elsewhere in the contract documents. The Department has 20 business days to review and comment on the submittal. Do not begin work on the test shaft or O-Cell until receiving written approval from the Project Manager and Loadtest USA

2) Equipment. Supply equipment and labor required to install the O-Cell, conduct the load test, and remove the load test apparatus as required. Required equipment includes but is not limited to:

a) Fresh, clean, potable water from an approved source to be used as hydraulic fluid to pressurize the O-Cell (typically bottled water or tap water).

b) A minimum of two digital survey levels capable of being read to the nearest 0.001 inch (0.025 mm) division with a minimum range of 10 inches (254 mm).

c) A protected work area (including provisions such as a tent or shed for protection from inclement weather for the load test equipment and personnel) of size and type required by Loadtest USA Protect the work area from cold weather. Do not conduct the O-Cell test below an ambient air temperature of 40°F (4.5°C). If a heater is used to maintain air temperature above 40°F (4.5°C), the heater must be of the type used for heating occupied spaces. Heaters producing large amounts of Carbon Monoxide gas is not allowed.

d) Stable electric power source, as required for lights, welding, instruments, etc.

e) Materials for carrier frame, steel bearing plates and/or other devices needed to attach O-Cell to rebar cage, as required.

f) Welding equipment certified welding personnel and labor, as required, to assemble the test equipment under the supervision of Loadtest USA, attach instrumentation to the O-Cell(s) and prepare the work area.

g) Equipment and labor to construct the steel reinforcing cage and/or placement frame including any steel bearing plates required for the shaft.

h) Equipment and operators for handling the O-Cell, instrumentation and placement frame or steel reinforcing cage during the installation of the O-Cell and during the conduct of the test, including but not limited to a crane or other lifting device, manual labor, and hand tools as required by Loadtest USA

i) Air compressor of sufficient size required by Loadtest USA for pump operation during the load test.

3) Installation and Removal of Load Testing Apparatus. Construct the drilled shaft using the approved shaft installation techniques.

Assemble the O-cell, hydraulic supply lines and other instruments and make ready for installation under the direction of Loadtest USA. Provide a suitable area, adjacent to the test shaft, for installation and assembly of the O-Cell. Construct the steel reinforcing cage required for the test shaft; the O-Cell assembly is to be welded at the appropriate location within the cage or equivalent in conjunction with the construction of the cage. The plane of the bottom plate(s) of the O-Cell(s) are to be set at right angles to the long axis of the cage. Use care in handling the test assembly so as not to damage the instrumentation during installation. Limit the deflection of the cage to 2 feet (610 mm) between pick points while lifting the cage from the horizontal position to vertical. Provide support bracing as needed to maintain the deflection within the specified tolerance. Ensure the O-Cell assembly remains perpendicular to the long axis of the reinforcing cage throughout the lifting and installation process.

When the test shaft excavation has been completed, inspected and accepted by the Project Manager, install the O-Cell assembly and the reinforcing steel. A common method is to install the O-Cell assembly using a pump line or tremie pipe extending through the O-Cell assembly to the base of the shaft. Depending on the configuration of the test assembly, it may be necessary to deliver a seating layer of concrete prior to installing the O-Cell. In this case, the O-Cell assembly would be installed while the concrete or grout at the base is still fluid, under the direction of the Loadtest USA.

After seating the O-Cell, if applicable concrete the remainder of the drilled shaft in the same manner as that approved in the production and test shaft(s) submittal. Make the concrete available for sampling; MDT will sample at least ten (10) concrete test cylinders; more if required by Loadtest USA, in addition to those specified elsewhere from the concrete used in the test shaft, to be tested at the direction of Loadtest USA.

The acceptance criterion and corrective action criterion as detailed in the Drilled Shaft special provision for testing, accepting, and repairing production drilled shafts also applies to the test shaft. CSL tubes must be installed to a minimum depth of the top of the O-Cell. Coordinate with Loadtest USA for installing the CSL tubes and the O-cell testing equipment. The Department will not pay for the installation of the test shaft if the test shaft is deemed “Defective” as detailed in the Drilled Shaft special provision unless repairs satisfactory to Loadtest USA and the Department are performed and accepted.

Do not begin load testing until cylinder break testing has confirmed that the drilled shaft concrete has obtained at least 80% of the compressive strength as called for in the plans or contract documents.

Notify the Geotechnical Section a minimum of 5 business days prior to the beginning of the load test so a representative can observe the load test.

During the load test, no casings may be vibrated into place in the foundation area near the load test. Drilling may not continue within a 300-foot (90 m) radius of the test shaft. If test apparatus shows any interference due to construction activities outside of this perimeter, cease work immediately at the direction of Loadtest USA or the Project Manager.

After the completion of the load test, remove any protruding external equipment, material, waste, etc. which are not to be a part of the finished structure. The load test shaft is not intended to carry service loads. Demolish the load test shaft in accordance with Subsection 202.03.1. Monitor the backfill for the project duration and continue adding material if settlement occurs.

4) Testing and Reporting. Loadtest USA will perform the load testing and reporting. Perform the load testing in compliance with ASTM D1143 using the Quick Load Test Method for Individual Piles. Initially, apply loads in increments equaling 5% to 10% of the maximum test load. The magnitude of the load increments may be increased or decreased depending on the project requirements but cannot be changed during the test.

Direct movement indicator measurements should be made of the following: O-Cell expansion either directly or with telltales (minimum of 4 indicators required), upward top-of-shaft displacement (minimum of 2 levels required) and shaft compression above O-Cell (minimum of 2 indicators required).

Apply loads at the prescribed intervals until the ultimate capacity of the shaft is reached in either end bearing or side shear, until the maximum capacity or maximum stroke of the O-Cell is reached, or unless otherwise directed by the Project Manager.

At each load increment, or decrement, read movement indicators at 1, 2, 4 and 8-minute intervals while the load is held constant.

During unloading cycles, acquire at least 5 data points of the load decrement for the load versus movement curve. Additional cycles of loading and unloading using similar procedures may be required by the Project Manager following the completion of the initial test cycle.

Use digital dial gages, LVDTs, or LVWDTs with a minimum travel of 6 inches (152 mm) and capable of being read to the nearest 0.001 inch (0.025 mm) division to measure O-Cell expansion. Top-of-shaft displacement is required to be measured by a pair of digital survey levels as described in section C.2.b of this special provision. The survey levels must be placed no closer than 5 shaft diameters from the center of the test shaft. When O-Cell expansion is measured directly, or when testing requires the maximum stroke of the O-Cell to be reached, use LVWDTs capable of measuring the full stroke of the O-Cell. Use digital dial gages, LVDTs, or LVWDTs to measure shaft compression that have a minimum travel of 2 inch (50 mm) and are capable of being read to the nearest 0.001 inch (0.025 mm) division.

Supply 6 copies of a report of the load test or one electronic copy in PDF format, as prepared by Loadtest USA coordinate the report with Craig Abernathy and the Project Manager. Provide an initial data report containing the load-movement curves and data tables to the Project Manager within 4 business days of the completion of load testing, to allow evaluation of the test results. Submit a final report on the load testing to the Project Manager within 7 business days after completion of the load testing. As a minimum, include in the final report the following:

a) As-installed location of the test shaft.
b) Logs of the test borings conducted at the test shaft location.
c) Installation records of test shaft showing locations of all instrumentation.
d) Summary of the load test procedure and data collected during load testing.
e) Analysis of unit side adhesion in the test socket and unit end-bearing pressure.
f) Plots of axial load versus displacement at the base of the shaft, and axial load versus displacement and/or strain along the test socket.

5) Upon submission of the final report of the O-cell test, the Department has five business days to evaluate the results of the load test and determine the final depth of the 8 foot diameter productions shafts.

D. Method of Measurement. The “Osterberg Cell Load Testing of Drilled Shaft” will be measured by the Lump Sum for the actual number of shafts tested, and will include any material, labor and equipment necessary for the installation of the drilled shaft(s) and O-Cell load testing of the drilled shaft(s). Include any material, labor and equipment necessary to assemble, install and remove the load test apparatus (if necessary), conduct and report results of the load. All costs associated with the construction of normal production drilled shafts are measured and paid for elsewhere in the contract documents.

E. Basis of Payment. The O-Cell load tests will be paid for at the Lump Sum price for the accepted “Static Load Test – Drilled Shaft.”

Payment at the contract unit price is full compensation for all resources necessary to complete the items of work under the contract. An accepted load test is a test that is conducted in accordance with ASTM D1143 Standard Test Method for Piles under Static Axial Load.

2. SYNTHETIC SLURRY FOR DRILLED SHAFTS (ADDED 4-28-11)

A. Description. Use of synthetic slurry construction methods, meeting the requirements herein, is permissible as an alternative to or in conjunction with temporary casing for drilled shaft excavations.

B. Materials. Do not use Mineral or water slurry. It is only permissible to use Synthetic slurries in conformance with the manufacturer's recommendations, the submitted quality control plan and these Special Provisions. The following synthetic slurries are approved as slurry systems:

Product	Manufacturer
Novagel	Geo-Tech Services, LLC 220 North Zapata Highway, Suite 11A Laredo, TX 78043-4464
ShorePac GCV	CETCO 1500 West Shure Drive Arlington Heights IL, 60004
SlurryPro CDP	KB International, LLC Suite 216, 735 Broad Street Chattanooga, TN 37402-1855
Super Mud*	PDS Company 8140 East Rosecrans Ave. Paramount, CA 90723-2754

*Approval as a product applies to the liquid product only.

Submit other proposed synthetic slurry products for approval. Submit proposed additives for approval.

C. Submittals. As part of the shaft installation plan provide the following:

1) Product name and manufacturer's technical data sheets.

2) Detailed procedures for mixing, using, maintaining, and disposing of the slurry.

3) A detailed mix design (including all additives and their specific purpose in the slurry mix), and a discussion of its suitability to the anticipated subsurface conditions.

4) A detailed plan for quality control of the selected slurry, including tests to be performed, test methods to be used, and minimum and/or maximum property requirements which must be met to ensure that the slurry functions as intended, considering the anticipated subsurface conditions and shaft construction methods, in accordance with the slurry manufacturer's recommendations and these Special Provisions. At a minimum include in the quality control plans the following tests:

Property	Test Method
Density	Mud Weight (Density), API 13B-1, Section 1
Viscosity	Marsh Funnel and Cup, API 13B-1, Section 2.2
PH	Glass Electrode, pH Meter, or pH Paper
Sand Content	Sand, API 13B-1, Section 5

5) Arrange for a representative from the slurry manufacturer to provide technical assistance in the use of the slurry and submit the following to the Project Manager:

a) The name, current phone number and training/experience record of the slurry manufacturer's technical representative assigned to the project, and the frequency of scheduled visits to the project site by the representative.

b) The name(s) of the Contractor's personnel assigned to the project and trained by the slurry manufacturer in the proper use of the slurry. Include a signed training certification letter from the slurry manufacturer for each trained Contractor's employee listed, including the date of the training. If training and certification are to be performed on-site, indicate that in the submittal and furnish the certifications when they are available.

D. Construction.

1) Manufacturer's Representative. The manufacturer's representative described above is required to: Provide technical assistance for the use of the slurry, be at the site prior to introduction of the slurry into the first drilled hole, and remain at the site during the construction and completion of a minimum of one shaft to adjust the slurry mix to the specific site conditions. In the manufacturer's representative absence, the Contractor's employee trained in the use of the slurry, as identified to the Project Manager in accordance with this Special Provision, is required to be present at the site during shaft slurry operations to perform the duties specified above.

2) Slurry installation requirements. Do not begin work until all the required submittals have been approved in writing by the Project Manager. All approvals given by the Project Manager will be subject to trial in the field and do not relieve the Contractor of the responsibility to satisfactorily complete the work.

When using slurry once the excavation operation has been started, perform the excavation in a continuous operation until the excavation of the shaft is completed, except for pauses and stops as noted, using equipment capable of excavating through the type of material expected. .

Pauses, defined as momentary interruptions of the excavation operation, are allowed only for casing splicing, tooling changes, slurry maintenance, and removal of obstructions. Shaft excavation operation interruptions not conforming to this definition are considered stops. Stops for uncased excavations (including partially cased excavations) cannot exceed 16 hours duration. For stops exceeding the 16 hour duration, stabilize the excavation using one or both of the following methods:

a) Install casing in the hole to the depth of the excavation. Provide casing with outside diameter no less than six inches less than either the Plan diameter of the shaft or the actual excavated diameter of the hole, whichever is greater. Prior to removing the casing and resumption of shaft excavation, sound the annular space outside the casing. If the sounding operation indicates that caving has occurred, do not remove the casing or resume shaft excavation until the excavation has been stabilized in accordance with the shaft installation plan conforming to this Special Provision.

b) For both a cased and uncased excavations, backfill the hole with granular material. Backfill the hole to the ground surface, if the excavation is not cased, or to a minimum of five feet above the bottom of casing (temporary or permanent), if the excavation is cased. Backfilling of shafts with casing fully seated into rock, as determined by the Project Manager, will not be required.

Conform to the requirements of this Special Provision regarding the maintenance of the slurry and the minimum level of drilling slurry throughout the stoppage of the shaft excavation operation, and recondition the slurry to the required slurry properties in accordance with the submitted quality control plan and this Special Provision prior to recommencing shaft excavation operations.

Maintain the slurry level in the excavation a minimum of 10 feet above the groundwater level or greater as required to provide and maintain a stable hole. Provide casing, or other means, as necessary to meet these requirements. Maintain slurry above all unstable zones a sufficient distance to prevent bottom heave, caving or sloughing of those zones.

3) Slurry Mixing, Sampling and Testing. Thoroughly mix slurry hydrated in slurry tanks, ponds, storage areas, or as recommended by the Manufacturers technical representative. Draw sample sets from the slurry storage facility and test the samples for conformance with the appropriate specified material properties before beginning slurry placement in the shaft excavation. Conform to the quality control plan included in the shaft installation plan in accordance with this Special Provision and as approved by the project manager. Sample sets are composed of samples taken at mid-height and within two feet of the bottom of the storage area.

Sample and test all slurry in the presence of the project manager, unless otherwise directed. Record the results of the tests and date, time and names of the persons sampling and testing the slurry. Submit a copy of the recorded slurry test results to the project manager at the completion of each shaft, and during construction of each shaft when requested by the project manager.

Take and test sample sets of all slurry, composed of samples taken at mid-height and within two feet of the bottom of the shaft, during drilling as necessary to verify the control of the properties of the slurry. As a minimum, sample sets of synthetic slurry shall be taken and tested at least once every four hours after beginning its use during each shift. Take and test sample sets of all slurry at least once every two hours if the slurry is not re-circulated in the drilled hole or if the previous sample set did not have consistent specified properties. Recirculate or agitate slurry with the drilling equipment, when tests show that the sample sets do not have consistent specified properties.

Take and test sample sets of all slurry, as specified, prior to final cleaning of the bottom of the hole and again just prior to placing concrete. Do not start cleaning of the bottom of the hole and placement of the concrete until tests show that the samples taken at mid-height and within two feet of the bottom of the hole have consistent specified properties.

Clean, recirculate, de-sand, or replace the slurry to maintain the required slurry properties as necessary.

Demonstrate to the satisfaction of the project manager that stable conditions are being maintained. If the project manager determines that stable conditions are not being maintained, immediately take action to stabilize the shaft. Submit a revised shaft installation plan which addresses the problem and prevents future instability. Do not continue with shaft construction until the damage which has already occurred is repaired in accordance with the specifications, and until receiving the Project Managers approval of the revised shaft installation plan.

Dispose of the slurry as specified in the shaft installation plan as approved by the project manager, and in accordance with the Contractor’s permit requirements.

Immediately prior to commencing concrete placement, the shaft excavation and the properties of the slurry must conform to the quality control plan and this Special Provision. The sand content of slurry prior to final cleaning and immediately prior to placing concrete must be less than 2.0 percent, in accordance with API 13B-1, Section 5.

In the event a shaft is determined to be defective do not continue to use slurry construction methods without written approval from the Project Manager. The Project Manager may require amendment and resubmittal of the shaft construction methods.

E. Method of Measurement. Use of slurry for drilling is not measured for payment.

F. Basis of Payment. Include all costs associated with using slurry in bid item for “Drilled Shaft.”

3. DRILLED SHAFTS (REVISED 5-17-2011)

A. Description. This work is constructing reinforced concrete shafts cast in cylindrically excavated holes that extend into soil or rock to support the structure and externally applied loads at the locations and to the lines and grades shown. Shaft depth may be increased by up to 15 feet (4.6 m) based on field conditions by written order from the Project Manager. Be prepared to construct the shaft to the adjusted depth if required.

B. Materials.

1) Drilled Shaft Concrete. Use Drilled Shaft Concrete for all concrete placed between the bottom of the shaft and the top of the casing, unless otherwise shown on the plans.

2) Permanent Drilled Shaft Casing. Furnish casing meeting the size and thickness requirements specified and casing material that meets the requirements of AASHTO M 270 (M 270M), Grade 36 (Grade 250). Casing materials, fabrication and inspection are as specified in Section 556.

C. Construction Requirements.

1) Submittals. Submit four copies of the following information to the Project Manager a minimum of thirty calendar days before start of drilling operations.

a) Drilled Shaft Activities Schedule Chart and Written Narrative outlining:

(1) Bent and shaft construction sequence. If more than one shaft will be worked on at any time, include that information in the submittal.

(2) Method of Shaft Excavation.

(3) Method to Clean Shaft Excavation.

(4) Temporary and Permanent Casing Installation and Removal Methods. Include casing top and bottom elevations and diameters.

(5) Method of Concrete Placement. Include descriptions of methods or devices that will be used to prevent the injection of air or water into the drilled shaft concrete when starting concrete placement and in the event the placement is stopped and restarted.

(6) Time necessary for complete concrete placement.

b) Name and experience record of Contractor, and Superintendent and Driller(s) to that will perform the drilled shaft work on this project. The experience record need only include the last 10 years.

c) List of proposed drilling equipment to be used, including any cranes, drills, augers, bits, temporary casings and cleaning tools. Include diameter of augers and cleaning buckets.

d) Proposed size and location of all reinforcing steel used to support or maintain the shape of the reinforcing steel cage.

2) Shaft pre-construction meeting. Schedule a shaft pre-construction meeting with the Project Manager for a time 7-14 days prior to drilling. The minimum required attendees are the superintendent, concrete supplier, and Project Manager. The purpose of the meeting is to review the requirements of this Provision, discuss the drilled shaft installation plan, and to discuss logistical and contingency plans.

3) Geotechnical logging. The Department will provide a Geotechnical Section representative on-site during drilling and installation operations to log the excavation. Notify the Project Manager at least seven calendar days prior to start of drilled shaft excavation so that the Project Manager can schedule the on-site representative.

4) Shaft Excavation. Use excavation methods that provide contact with firm, undisturbed soil or rock with the sides and bottom of the shaft concrete when the temporary casing is removed. Do not excavate holes larger than the outside diameter of permanent casings to facilitate casing installation.

5) Shaft Locations, Alignment and Tolerances. Drill all shafts to the bottom elevations specified or as directed by the Project Manager. Construct the shaft so the vertical centerline axis of the finished shaft is within 3 inches (75 mm) of the plan location at the top of the shaft. Drill all shafts to within 2 percent of vertical the entire depth of the shaft excavation.

6) Sloughing and Caving. Use construction methods that will ensure no sloughing or caving of the shaft side walls. In the event any sloughing or caving does occur, remove all sloughed material. Ensure that concrete completely fills the shaft. If caving occurs during placement of drilled shaft concrete, immediately stop the flow of concrete and undertake corrective measures to completely remove the sloughed materials from the shaft. If necessary to facilitate material removal, remove the concrete and reinforcing steel already placed in the shaft.

7) Permanent Casing.

a) Description. Furnish and install permanent casing when specified on the plans. Permanent casing remains in place and is included in the design of the drilled shaft. The permanent casing diameter may be oversized up to 3 inches (75 mm) if necessary to facilitate temporary casing installation.

b) Welding. If field welding, submit four copies of the weld procedures to the Project Manager for approval thirty calendar days prior to welding.

c) Corrosion Protection. Provide corrosion protection for all permanent casing. Galvanize the permanent casing to AASHTO M 111 (M 111M) and ASTM A 653 (A 653M) specifications or paint. If painting, meet the following requirements:

(1) Material. Furnish paint meeting the requirements of Subsection 710.02 (B)(3).

(2) Surface Preparation. Prepare the casing surface following the paint manufacturer's recommendations.

(3) Paint Application. Follow the paint manufacturer's recommendations for paint application. Apply paint to the casing before installation, starting 24 inches (610 mm) below ground surface, continuing to the top of exposed steel.

(4) Shop Painting. Apply the first two paint coats to produce a minimum 12 mil (300 μm) dry film thickness. Provide two copies of the painter's certification that the paint was applied following the manufacturer's recommendations and test results showing the paint coat thickness on the casing.

(5) Field Painting. Repair paint damage caused by transport, handling and welding following the paint manufacturer’s recommendations before applying the finish coat.

For the finish coat, use the same paint or paint compatible with the first two coats. Provide a finish coat with a minimum 3 mil (75 μm) dry film thickness. Provide the finish coat paint color as follows:

COLOR	FEDERAL SPECIFICATION 595B PIGMENT CODE
Concrete Gray	36440

8) Temporary Casing. Do not use slurry construction methods as an alternative to or in conjunction with temporary casing on this project unless the Contract contains the Special Provision “Synthetic Slurry for Drilled Shafts”. Use temporary casing to facilitate shaft construction and prevent sloughing and caving of the shaft sidewalls. Full depth temporary casing is required. Refer to the tip elevations on the bridge plans for temporary casing elevation, these elevations are minimum elevations. Place the temporary casing deeper if necessary to prevent material from entering the shaft excavation. Be prepared to provide up to 15 feet (4.6 m) of additional temporary casing in the event that the shaft bottom elevation is lowered during construction. Use casing with an outside diameter no less than the specified diameter of the shaft. Limit the excavation in advance of the casing tip to no more than 10 feet (3 m) unless synthetic slurry is being used. During casing extraction, maintain a sufficient level of fluid in the casing to counteract external hydrostatic pressures but no less than 5 feet of positive head. Maintain an adequate level of concrete within the casing and provide vibration of the temporary casing or the concrete as needed to ensure that fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete. Use equipment and methods capable of extracting temporary casings. Temporary casings that have become bound or fouled during shaft construction and cannot be removed are considered to be a defect in the drilled shaft. Correct defective shafts using approved methods at no cost to the Department. Corrective action may consist of, but is not limited to, the following:

a) Removing the drilled shaft concrete and extending the drilled shaft deeper to compensate for the loss of frictional capacity to the cased zone.

b) Providing straddle drilled shafts to compensate for capacity loss.

c) Providing a replacement drilled shaft.

9) Obstructions. An obstruction is considered a specific object exceeding 50 percent of the shaft diameter that cannot be removed from the drilled shaft excavation using conventional augers or core barrel tools. If an obstruction is encountered, promptly notify the Project Manager. Submit four copies of a proposed obstruction removal method to the Project Manager for approval within two calendar days of encountering the obstruction.

10) Cleaning. Remove all loose or disturbed material from the bottom of the shaft excavation immediately prior to placing reinforcing steel and concrete. After cleaning, 1.0 inch (25 mm) is the maximum thickness of loose or disturbed material permitted in the bottom of the shaft.

11) Installation of Cross-hole Sonic Logging (CSL) Tubes. As shown in the plans, install the CSL access tubes evenly spaced around the reinforcing cage and inside of all hoops and spiral reinforcing steel. Use schedule 40 mild steel standard black pipe conforming to ASTM A 53 (A 53M), Grade A or B, Type E, F or S, 1 ½ inch (38 mm) nominal diameter CSL access tubes that extend the full length of the drilled shaft. Provide an end plug at the lower end of the pipe and make all joints watertight. Fill the CSL access tubes with a 1:1 mixture of potable water and biodegradable antifreeze prior to placing concrete in the drilled shaft. Temporarily cap the top of the tubes to prevent debris or concrete from entering the tubes.

12) Reinforcing Steel. Use “Figure eight” or “Saddle” ties at all intersecting bars. After inspection and approval of the drilled shaft excavation by the Project Manager, place the reinforcing steel cage into the shaft as one unit. Support the steel cage from the top so that racking and distortion are prevented. Remove internal stiffeners as necessary as the steel cage is placed in the excavation to prevent interference with the placement of concrete. Use non–corrosive, roller-type spacers or other non-corrosive devices as approved by the Project Manager along the steel cage length and around the steel cage perimeter to align and maintain clearance from reinforcing cage to edge of casing during concrete placement. Begin placing the drilled shaft concrete immediately after the Project Manager has inspected and approved the cage for location and alignment within the drilled shaft. Remove the steel cage and re-inspect the excavation if the concrete placement is not started within three hours of placing the steel cage in position.

13) Concrete Placement Record. Complete the MDT Drilled Shaft Concrete Placement Log. Accurately record all data required on the form as the concrete is placed. After the drilled shaft concrete has been placed and before the end of the day, give the completed form to the MDT inspector. MDT will provide copies to the Contractor upon request.

14) Drilled Shaft Concrete

15) Place concrete in the drilled shaft as specified for either dry excavations or wet excavations.

a) Dry Excavations. Place concrete by gravity tremie tube or pumping. Concrete may free fall into the shaft if the concrete can be directed so that it does not strike the reinforcing steel, the excavation wall or any other obstruction during the fall.

b) Wet Excavations.

(1) Place all drilled shaft concrete by tremie tube, pumping, or other approved method to avoid separation and segregation of the concrete mix components.

(2) Separate the first concrete placed from the fluid in the excavation using a plug in the tube, or other approved device.

(3) Begin concrete placement in a manner that minimizes mixing of the concrete with the water and material in the shaft.

(4) Continuously place drilled shaft concrete until the tremie tube or pumping pipe is removed from concrete at the top of the shaft. If at any time during concrete placement it is necessary to temporarily stop concrete placement, restart concrete placement in a manner that ensures that air, water, or other undesirable material is not mixed into the concrete or incorporated into the drilled shaft.

(5) Maintain 10 feet of tremie pipe embedment or more if necessary to ensure upward displacement of all contaminated concrete. If at any time during the pour, the tremie pipe orifice is removed from the concrete, stop and restart concrete placement in a manner that ensures that air, water, or other undesirable material is not allowed to be mixed into the concrete or incorporated into the drilled shaft. Concrete that is discharged above the rising concrete level in the shaft is considered undesirable material.

(6) Once concrete has reached the top of the drilled shaft, remove and dispose of the top layer of concrete and any concrete contaminated with mud or fluid from the drilled shaft. Remove sufficient concrete to fully expose sound, homogeneous and uncontaminated concrete in the shaft.

16) Shaft Testing and Acceptance

a) Cross-Hole Sonic Logging. The Project Manager may use CSL to check the structural soundness of any completed drilled shaft(s). The CSL testing will be performed when the concrete has cured sufficiently to give consistent test readings. Schedule construction activities to allow twelve calendar days from the time concrete is placed in the shaft until the shaft is tested. Provide a stable 110-Volt AC or a 12-Volt DC electrical supply if requested. When the CSL testing access tubes are no longer needed for testing, as determined by the Project Manager, cut off the tubes flush with the top surface of the drilled shaft and remove the antifreeze solution to a depth of 4 inches (100 mm) from the top of the tubes. Permanently cap the CSL access tubes to provide a watertight seal that does not interfere with the subsequent construction operations. The Project Manager will accept or reject the shaft based on the CSL testing or a subsequent drilled core sample. For any drilled shaft determined by CSL testing to be of uncertain quality, drill core samples with a minimum diameter of 2.5 inches (65 mm). Drill at locations and to depths specified by the Project Manager, to explore the shaft quality. Use a core drilling method that provides complete core recovery and minimizes abrasion and erosion of the core. Grout all core holes when directed by the Project Manager.

b) Corrective Action. If the CSL or subsequent coring identifies any defect in the shaft that compromises the capacity of the shaft repair the shaft by a method approved by the Project Manager. Submit a repair plan no later than fourteen calendar days after notification. Include four copies of calculations and working drawings, stamped by a Civil Engineer licensed in Montana, to the Project Manager. Furnish all materials and work necessary to correct shaft defects at no cost to the Department. Prior to constructing other shafts, submit four copies of a written proposal to the Project Manager that describes changes in construction methods or materials designed to avoid defects in subsequent drilled shafts.

D. Method of Measurement.

1) Drilled Shaft. Drilled shaft will be measured by the linear foot (meter) of shaft between the actual bottom elevation of the drilled shaft and the top of shaft elevation shown on the plans.

2) Reinforcing Steel. Drilled shaft reinforcing steel will be measured by the pound (kilogram) in accordance with Subsection 555.04.

3) Drilled Shaft Casing. Permanent drilled shaft casing will be measured by the linear foot (meter) of permanent casing installed as shown in the plans or as directed by the Project Manager in writing.

4) Temporary Casing. When the Contract contains the pay item “Temporary Drilled Shaft Casing”, temporary drilled shaft casing will be measured by the linear foot (meter) of temporary casing measured from the higher of the ground or water surface elevation down to the bottom elevation of the installed temporary casing.

5) Cross-hole Sonic Logging (CSL) Tubes and Testing. Include all costs associated with furnishing and installing CSL access tubes and any required extensions and providing a power source in the Drilled Shaft Pay Item. No measurement or payment will be made for construction delays resulting from the initial CSL drilled shaft testing. The Department will extend the contract time by one day for each day over twelve calendar days required to complete the CSL drilled shaft testing. The Department will pay the costs for the initial CSL drilled shaft testing. Pay for all costs associated with coring, engineering design, cost required to correct the defect and any construction delay costs, if a defect is found based on the CSL drilled shaft testing or coring. Pay the costs of CSL drilled shaft retesting of the repaired drilled shafts. If no defect is found in the drilled shaft based on the coring, the Department will pay all costs of coring and any delays necessitated by the coring.

E. Basis of Payment. Payment for the completed and accepted quantities is made under the following:

<u>Pay Item</u>	<u>Pay Unit</u>
Drilled Shaft	Linear Foot (meter)
Reinforcing Steel	Pound (kilogram)
Drilled Shaft Casing	Linear Foot (meter)
Drilled Shaft Concrete	Cubic Yard (cubic meter)

Payment at the contract unit price is full compensation for all resources necessary to complete the item of work under the contract. Temporary casings remain the property of the Contractor.

If the Contract contains the pay item Temporary Drilled Shaft Casing, all costs associated with temporary casing including, but not limited to, procurement, fabrication, transportation, installation and removal, are included in the Pay Item Temporary Drilled Shaft Casing. If the Contract does not contain the pay item Drilled Shaft Temporary Casing, no measurement or payment will be made. Include all costs associated with temporary casing including, but not limited to, fabrication, providing, transporting, installation and removal in the Drilled Shaft pay item.

Obstruction Removal. Payment for work associated with obstruction removal will be made on a Force Account basis.

1. <u>O-CELL LOAD TESTING [560] (PRODUCTION SHAFT)</u>

A. Description. This work consists of furnishing all materials, equipment and labor necessary for conducting an Osterberg Cell (O-Cell) Load Test and reporting the results. Supply all material and labor as hereinafter specified and including prior to, during and after the load test. The test shaft is to be constructed at the location shown in the plans and in accordance with the requirements of these special provisions and as outlined elsewhere in the contract.

Employ the services of:

Loadtest USA
2631-D NW 41st Street
Gainsville, FL 32606
Phone (800) 368-1138
(352)378-3717
Fax: (352)378-3934

Loadtest USA must oversee the test shaft installation, instrument installation and operation, and conduct the load test(s) on the drilled shaft(s). The Contractor is to provide auxiliary equipment and services as detailed herein and in coordination with Loadtest USA Loadtest USA has the authority to modify the Contractor's drilled shaft installation methods if deemed detrimental to the O-cell test. Coordinate with Loadtest USA to have a representative on-site as needed during shaft excavation. LoadTest USA must be on-site for O-Cell installation into the re-bar cage, all aspects of instrument installation, and during the placement of the re-bar cage into the accepted shaft excavation. It is encouraged to have a LoadTest USA representative present during the test shaft pour.

No work is allowed on production drilled shafts, before the test shaft has been installed and tested. The test results will be used to set final shaft tip elevations. Re-bar cage construction is allowed at the Contractor's risk, no extra payment will be made for reconfiguring the re-bar cages based on the test shaft results.

It is the responsibility of the Contractor to inform the Project Manager if during the installation of the shaft any occurrences which may affect the quality of the performance of the O-cell test.

Once the project is complete, Research will conduct any necessary ongoing analysis and reporting requirement. The needs for Research may entail interviews with the contractors and applicable staff throughout the course of the project. This will include anecdotal information that may be digitally recorded.

Inform the Project Manager a minimum of 2 weeks prior to the beginning of this experimental feature. Who will contact Craig Abernathy, MDT Research ExPM, avaliable at 444-6269 (cabernathy@mt.gov) 2 weeks prior to the beginning of this project for schedule purposes. Keep the Project Manager informed of any changes in schedule relating to the O-cell test.

1) Preconstruction meeting. The following must attend the Preconstruction meeting:

- A representative from Loadtest USA
- The project Foreman from the Drilled Shaft Contractor.
- Craig Abernathy – Statewide Experimental Program Manager (444-6269) or an experimental program representative.

2) Experience. The Drilled Shaft Foreman must have installed and been a part of at least five successful drilled shafts (8 foot diameter) in the last five years. The Drilled Shaft Foremen must be on-site during all work described in this special provision and related to the test shaft. Submit at the Preconstruction meeting a written narrative with the following information at a minimum:

a) Name of the Drilled Shaft Foreman
b) Project description of previous verifiable drilled shafts including:
(1) Project Name.
(2) Project Location.

(3) Owners Name and contact representative with current address and phone number.

(4) Type and size of test shaft.

(5) O-Cell testing company.

(6) General Description of the O-Cell test conducted and the results.

B. Materials. Furnish all materials required to install the O-Cell, conduct the load test, and remove the load test apparatus as required. Furnish 1 or more O-Cell as required for each load test. The O-Cell(s) to be provided are to have a minimum bi-directional capacity as called for in the project plans or documents and be equipped with all necessary hydraulic lines, fittings, pressure source, pressure gage and telltale devices.

1) Provide Post Grout tubes as the type as specified by LoadTest USA, install at least a minimum of 2 tubes for drilled shafts of 6.0 ft. in diameter or smaller, and a minimum of 4 tubes for drilled shafts over 6.0 ft.

2) Provide Neat Cement Grout, for post-test grouting of the O-Cell.

C. Construction Requirements.

1) Submittals. A minimum of 30 days prior to starting the excavation for the test shaft, submit 3 copies of a testing plan with working drawings which outline the test setup, including details of all system elements, instrumentation, materials, data collection system and procedures. Develop the testing submittal in coordination with and submit concurrently with the Drilled Shaft working drawing submittal as required in related specifications found elsewhere in the contract documents. The Department has 20 business days to review and comment on the submittal. Do not begin work on the test shaft or O-Cell until receiving written approval from the Project Manager and Loadtest USA

2) Equipment. Supply equipment and labor required to install the O-Cell, conduct the load test, and remove the load test apparatus as required. Required equipment includes but is not limited to:

a) Fresh, clean, potable water from an approved source to be used as hydraulic fluid to pressurize the O-Cell (typically bottled water or tap water).

b) A minimum of two digital survey levels capable of being read to the nearest 0.001 inch (0.025 mm) division with a minimum range of 10 inches (254 mm).

c) A protected work area (including provisions such as a tent or shed for protection from inclement weather for the load test equipment and personnel) of size and type required by Loadtest USA Protect the work area from cold weather. Do not conduct the O-Cell test below an ambient air temperature of 40°F (4.5°C). If a heater is used to maintain air temperature above 40°F (4.5°C), the heater must be of the type used for heating occupied spaces. Heaters producing large amounts of Carbon Monoxide gas are not allowed.

d) Stable electric power source, as required for lights, welding, instruments, etc.

e) Materials for carrier frame, steel bearing plates and/or other devices needed to attach O-Cell to rebar cage, as required.

f) Welding equipment certified welding personnel and labor, as required, to assemble the test equipment under the supervision of Loadtest USA, attach instrumentation to the O-Cell(s) and prepare the work area.

g) Equipment and labor to construct the steel reinforcing cage and/or placement frame including any steel bearing plates required for the shaft.

h) Equipment and operators for handling the O-Cell, instrumentation and placement frame or steel reinforcing cage during the installation of the O-Cell and during the conduct of the test, including but not limited to a crane or other lifting device, manual labor, and hand tools as required by Loadtest USA

i) Air compressor of sufficient size required by Loadtest USA for pump operation during the load test.

3) Installation and Removal of Load Testing Apparatus. Construct the drilled shaft using the approved shaft installation techniques.

Assemble the O-cell, hydraulic supply lines and other instruments and make ready for installation under the direction of Loadtest USA. Provide a suitable area, adjacent to the test shaft, for installation and assembly of the O-Cell. Construct the steel reinforcing cage required for the test shaft; the O-Cell assembly is to be welded at the appropriate location within the cage or equivalent in conjunction with the construction of the cage. The plane of the bottom plate(s) of the O-Cell(s) are to be set at right angles to the long axis of the cage. Use care in handling the test assembly so as not to damage the instrumentation during installation. Limit the deflection of the cage to 2 feet (610 mm) between pick points while lifting the cage from the horizontal position to vertical. Provide support bracing as needed to maintain the deflection within the specified tolerance. Ensure the O-Cell assembly remains perpendicular to the long axis of the reinforcing cage throughout the lifting and installation process.

When the test shaft excavation has been completed, inspected and accepted by the Project Manager, install the O-Cell assembly and the reinforcing steel. A common method is to install the O-Cell assembly using a pump line or tremie pipe extending through the O-Cell assembly to the base of the shaft. Depending on the configuration of the test assembly, it may be necessary to deliver a seating layer of concrete prior to installing the O-Cell. In this case, the O-Cell assembly would be installed while the concrete or grout at the base is still fluid, under the direction of the Loadtest USA.

After seating the O-Cell, if applicable concrete the remainder of the drilled shaft in the same manner as that approved in the production and test shaft(s) submittal. Make the concrete available for sampling; MDT will sample at least twelve (12) concrete test cylinders; more if required by Loadtest USA, in addition to those specified elsewhere from the concrete used in the test shaft, to be tested at the direction of Loadtest USA.

The acceptance criterion and corrective action criterion as detailed in the Drilled Shaft special provision for testing, accepting, and repairing production drilled shafts also applies to the test shaft. CSL tubes must be installed to a minimum depth of the top of the O-Cell. Coordinate with Loadtest USA for installing the CSL tubes and the O-cell testing equipment. The Department will not pay for the installation of the test shaft if the test shaft is deemed “Defective” as detailed in the Drilled Shaft special provision unless repairs satisfactory to Loadtest USA and the Department are performed and accepted.

Do not begin load testing until cylinder break testing has confirmed that the drilled shaft concrete has obtained the compressive strength as called for in the plans or contract documents, and any integrity testing of the concrete has been completed including but not limited to cross hole sonic logging (CSL) and/or thermal image profiling (TIP) testing.

Notify the Geotechnical Section a minimum of 5 business days prior to the beginning of the load test so a representative can observe the load test.

During the load test, no casings may be vibrated into place in the foundation area near the load test. Drilling may not continue within a 1000-foot (90 m) radius of the test shaft. If test apparatus shows any interference due to construction activities inside or outside of this perimeter, cease work immediately at the direction of Loadtest USA or the Project Manager.

After the completion of the load test, grout the O-Cell and annular space around the O-Cell with neat cement grout.

4) Testing and Reporting. Loadtest USA will perform the load testing and reporting. Perform the load testing in compliance with ASTM D1143 using the Quick Load Test Method for Individual Piles. Initially, apply loads in increments equaling 5% to 10% of the maximum test load. The magnitude of the load increments may be increased or decreased depending on the project requirements but cannot be changed during the test.

Direct movement indicator measurements should be made of the following: O-Cell expansion either directly or with telltales (minimum of 4 indicators required), upward top-of-shaft displacement (minimum of 2 levels required) and shaft compression above O-Cell (minimum of 2 indicators required).

Apply loads at the prescribed intervals until the ultimate capacity of the shaft is reached in either end bearing or side shear, until the maximum capacity or maximum stroke of the O-Cell is reached, or unless otherwise directed by the Project Manager.

At each load increment, or decrement, read movement indicators at 1, 2, 4 and 8-minute intervals while the load is held constant.

During unloading cycles, acquire at least 5 data points of the load decrement for the load versus movement curve. Additional cycles of loading and unloading using similar procedures may be required by the Project Manager following the completion of the initial test cycle.

Use digital dial gages, LVDTs, or LVWDTs with a minimum travel of 6 inches (152 mm) and capable of being read to the nearest 0.001 inch (0.025 mm) division to measure O-Cell expansion. Top-of-shaft displacement is required to be measured by a pair of digital survey levels as described in section C.2.b of this special provision. The survey levels must be placed no closer than 5 shaft diameters from the center of the test shaft. When O-Cell expansion is measured directly, or when testing requires the maximum stroke of the O-Cell to be reached, use LVWDTs capable of measuring the full stroke of the O-Cell. Use digital dial gages, LVDTs, or LVWDTs to measure shaft compression that have a minimum travel of 2 inch (50 mm) and are capable of being read to the nearest 0.001 inch (0.025 mm) division.

Supply 6 copies of a report of the load test or one electronic copy in PDF format, as prepared by Loadtest USA coordinate the report with Craig Abernathy and the Project Manager. Provide an initial data report containing the load-movement curves and data tables to the Project Manager within 4 business days of the completion of load testing, to allow evaluation of the test results. Submit a final report on the load testing to the Project Manager within 7 business days after completion of the load testing. As a minimum, include in the final report the following:

a) As-installed location of the test shaft.
b) Logs of the test borings conducted at the test shaft location.
c) Installation records of test shaft showing locations of all instrumentation.
d) Summary of the load test procedure and data collected during load testing.
e) Analysis of unit side adhesion in the test socket and unit end-bearing pressure.
f) Plots of axial load versus displacement at the base of the shaft, and axial load versus displacement and/or strain along the test socket.

5) Upon submission of the final report of the O-cell test, the Department has five business days to evaluate the results of the load test and determine the final depth of the 8 foot diameter productions shafts.

6) Post-Test Grouting Procedures. Note: this section should only be used when the test is to be performed on a production drilled shaft. It should be deleted if the load test is to be performed on a non-production drilled shaft.

During the O-Cell test, the shaft breaks on a horizontal plane separating the upper section above the O-Cell (upper side shear) from the lower section below (combined end bearing and lower side shear). This creates an annular space, the size of which depends on the shaft/O-Cell geometry and the expansion of the O-Cell.

When a production shaft has been tested, the Project Manager may want to include the end bearing component from the lower section in order to obtain sufficient capacity of the production shaft. In such cases the contractor will be required to grout the O-Cell and the annular space around the O-Cell in order to allow load transfer to the lower side shear and end bearing.

The grout must have strength properties equivalent to or better than those of the drilled shaft concrete.

a) Grouting of O-Cells.

i) Produce grout consisting of Portland cement and water only, **NO SAND**. The grout should be fluid and pumpable. An initial mix consisting of 6 to 7 gallons of water per 95-lb. Bag of cement is recommended. Adjust water to obtain desired consistency.

ii) Mix thoroughly to ensure that there are no lumps of dry cement. Pass the grout through a window screen mesh before pumping.

iii) Connect the grout pump outlet to one hydraulic line of the O-Cell. Open the other line and establish a flow of **water** through the system.

iv) Pump the grout through the O-Cell hydraulic line while collecting the effluent from the bleed line. Monitor characteristics of effluent material and when it becomes equivalent to the grout being pumped, stop pumping.

v) Take three (3) samples of the grout for compression testing at 28 days.

Recommended pre-mixed amount of grout for grouting of O-Cell:				
O-Cell Diameter Inches(mm)	13 (330.2)	21 (533.4)	26 (660.4)	34 (863.6)
Grout Volume Cubic Feet (m^3)	4 (0.11)	7 (0.20)	9 (0.25)	13 (0.37)

b) Grouting of Annular Space Around O-Cells.

i) Prepare a fluid grout mix consisting of Portland Cement and water only, no sand. The mixing procedures should be as outlined for grouting the O-Cells. The quantity of grout should be at least three (3) times the theoretical volume required to fill the annular space and grout pipes.

ii) Pump **water** and establish a flow through the grout pipes (two per shaft).

iii) Pump the fluid grout through one of the grout pipes until grout is observed flowing from the second grout pipe or until 1.5 times the theoretical volume has been pumped.

iv) If no return of grout is observed from the second grout pipe, transfer the pump to the second pipe and pump grout through it until 1.5 times the theoretical volume has been pumped.

v) If higher strength grout is deemed necessary, immediately proceed with pumping the higher strength grout (which may be a sand mix). The pumping procedures for this grout will be the same as described above for the initial cement-water grout. The entire grouting operation must be completed before the set time for the initial grout has elapsed.

vi) Take twelve (12) samples of each type of grout for compression testing at 28 days.

Recommended pre-mix amount of grout for grouting of annular space:								
Shaft Diameter Feet (m)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	7 (2.1)	8 (2.4)	9 (2.7)
Grout Volume Cubic Feet (m^3)	25 (0.71)	30 (0.85)	40 (1.13)	50 (1.42)	65 (1.84)	80 (2.27)	100 (2.83)	125 (3.54)

D. Method of Measurement. The “Osterberg Cell Load Testing of Drilled Shaft” will be measured by the Lump Sum for the actual number of shafts tested, and will include any material, labor and equipment necessary for the installation of the drilled shaft(s) and O-Cell load testing of the drilled shaft(s). Include any material, labor and equipment necessary to assemble, install and remove the load test apparatus (if necessary), conduct and report results of the load. All costs associated with the construction of normal production drilled shafts are measured and paid for elsewhere in the contract documents.

E. Basis of Payment. The O-Cell load tests will be paid for at the Lump Sum price for the accepted “Static Load Test – Drilled Shaft.”

Payment at the contract unit price is full compensation for all resources necessary to complete the items of work under the contract. An accepted load test is a test that is conducted in accordance with ASTM D1143 Standard Test Method for Piles under Static Axial Load.

2. SYNTHETIC SLURRY FOR DRILLED SHAFTS (ADDED 4-28-11)

A. Description. Use of synthetic slurry construction methods, meeting the requirements herein, is permissible as an alternative to or in conjunction with temporary casing for drilled shaft excavations.

B. Materials. Do not use Mineral or water slurry. It is only permissible to use Synthetic slurries in conformance with the manufacturer's recommendations, the submitted quality control plan and these Special Provisions. The following synthetic slurries are approved as slurry systems:

Product	Manufacturer
Novagel	Geo-Tech Services, LLC 220 North Zapata Highway, Suite 11A Laredo, TX 78043-4464
ShorePac GCV	CETCO 1500 West Shure Drive Arlington Heights IL, 60004
SlurryPro CDP	KB International, LLC Suite 216, 735 Broad Street Chattanooga, TN 37402-1855
Super Mud*	PDS Company 8140 East Rosecrans Ave. Paramount, CA 90723-2754

*Approval as a product applies to the liquid product only.

Submit other proposed synthetic slurry products for approval. Submit proposed additives for approval.

C. Submittals. As part of the shaft installation plan provide the following:

1) Product name and manufacturer’s technical data sheets.

2) Detailed procedures for mixing, using, maintaining, and disposing of the slurry.

3) A detailed mix design (including all additives and their specific purpose in the slurry mix), and a discussion of its suitability to the anticipated subsurface conditions.

4) A detailed plan for quality control of the selected slurry, including tests to be performed, test methods to be used, and minimum and/or maximum property requirements which must be met to ensure that the slurry functions as intended, considering the anticipated subsurface conditions and shaft construction methods, in accordance with the slurry manufacturer's recommendations and these Special Provisions. At a minimum include in the quality control plans the following tests:

Property	Test Method
Density	Mud Weight (Density), API 13B-1, Section 1
Viscosity	Marsh Funnel and Cup, API 13B-1, Section 2.2
PH	Glass Electrode, pH Meter, or pH Paper
Sand Content	Sand, API 13B-1, Section 5

5) Arrange for a representative from the slurry manufacturer to provide technical assistance in the use of the slurry and submit the following to the Project Manager:

a) The name, current phone number and training/experience record of the slurry manufacturer's technical representative assigned to the project, and the frequency of scheduled visits to the project site by the representative.

b) The name(s) of the Contractor's personnel assigned to the project and trained by the slurry manufacturer in the proper use of the slurry. Include a signed training certification letter from the slurry manufacturer for each trained Contractor's employee listed, including the date of the training. If training and certification are to be performed on-site, indicate that in the submittal and furnish the certifications when they are available.

D. Construction.

1) Manufacturer's Representative. The manufacturer's representative described above is required to: Provide technical assistance for the use of the slurry, be at the site prior to introduction of the slurry into the first drilled hole, and remain at the site during the construction and completion of a minimum of one shaft to adjust the slurry mix to the specific site conditions. In the manufacturer's representative absence, the Contractor's employee trained in the use of the slurry, as identified to the Project Manager in accordance with this Special Provision, is required to be present at the site during shaft slurry operations to perform the duties specified above.

2) Slurry installation requirements. Do not begin work until all the required submittals have been approved in writing by the Project Manager. All approvals given by the Project Manager will be subject to trial in the field and do not relieve the Contractor of the responsibility to satisfactorily complete the work.

When using slurry once the excavation operation has been started, perform the excavation in a continuous operation until the excavation of the shaft is completed, except for pauses and stops as noted, using equipment capable of excavating through the type of material expected. .

Pauses, defined as momentary interruptions of the excavation operation, are allowed only for casing splicing, tooling changes, slurry maintenance, and removal of obstructions. Shaft excavation operation interruptions not conforming to this definition are considered stops. Stops for uncased excavations (including partially cased excavations) cannot exceed 16 hours duration. For stops exceeding the 16 hour duration, stabilize the excavation using one or both of the following methods:

a) Install casing in the hole to the depth of the excavation. Provide casing with outside diameter no less than six inches less than either the Plan diameter of the shaft or the actual excavated diameter of the hole, whichever is greater. Prior to removing the casing and resumption of shaft excavation, sound the annular space outside the casing. If the sounding operation indicates that caving has occurred, do not remove the casing or resume shaft excavation until the excavation has been stabilized in accordance with the shaft installation plan conforming to this Special Provision.

b) For both a cased and uncased excavations, backfill the hole with granular material. Backfill the hole to the ground surface, if the excavation is not cased, or to a minimum of five feet above the bottom of casing (temporary or permanent), if the excavation is cased. Backfilling of shafts with casing fully seated into rock, as determined by the Project Manager, will not be required.

Conform to the requirements of this Special Provision regarding the maintenance of the slurry and the minimum level of drilling slurry throughout the stoppage of the shaft excavation operation, and recondition the slurry to the required slurry properties in accordance with the submitted quality control plan and this Special Provision prior to recommencing shaft excavation operations.

Maintain the slurry level in the excavation a minimum of 10 feet above the groundwater level or greater as required to provide and maintain a stable hole. Provide casing, or other means, as necessary to meet these requirements. Maintain slurry above all unstable zones a sufficient distance to prevent bottom heave, caving or sloughing of those zones.

3) Slurry Mixing, Sampling and Testing. Thoroughly mix slurry hydrated in slurry tanks, ponds, storage areas, or as recommended by the Manufacturers technical representative. Draw sample sets from the slurry storage facility and test the samples for conformance with the appropriate specified material properties before beginning slurry placement in the shaft excavation. Conform to the quality control plan included in the shaft installation plan in accordance with this Special Provision and as approved by the project manager. Sample sets are composed of samples taken at mid-height and within two feet of the bottom of the storage area.

Sample and test all slurry in the presence of the project manager, unless otherwise directed. Record the results of the tests and date, time and names of the persons sampling and testing the slurry. Submit a copy of the recorded slurry test results to the project manager at the completion of each shaft, and during construction of each shaft when requested by the project manager.

Take and test sample sets of all slurry, composed of samples taken at mid-height and within two feet of the bottom of the shaft, during drilling as necessary to verify the control of the properties of the slurry. As a minimum, sample sets of synthetic slurry shall be taken and tested at least once every four hours after beginning its use during each shift. Take and test sample sets of all slurry at least once every two hours if the slurry is not re-circulated in the drilled hole or if the previous sample set did not have consistent specified properties. Recirculate or agitate slurry with the drilling equipment, when tests show that the sample sets do not have consistent specified properties.

Take and test sample sets of all slurry, as specified, prior to final cleaning of the bottom of the hole and again just prior to placing concrete. Do not start cleaning of the bottom of the hole and placement of the concrete until tests show that the samples taken at mid-height and within two feet of the bottom of the hole have consistent specified properties.

Clean, recirculate, de-sand, or replace the slurry to maintain the required slurry properties as necessary.

Demonstrate to the satisfaction of the project manager that stable conditions are being maintained. If the project manager determines that stable conditions are not being maintained, immediately take action to stabilize the shaft. Submit a revised shaft installation plan which addresses the problem and prevents future instability. Do not continue with shaft construction until the damage which has already occurred is repaired in accordance with the specifications, and until receiving the Project Managers approval of the revised shaft installation plan.

Dispose of the slurry as specified in the shaft installation plan as approved by the project manager, and in accordance with the Contractor’s permit requirements.

Immediately prior to commencing concrete placement, the shaft excavation and the properties of the slurry must conform to the quality control plan and this Special Provision. The sand content of slurry prior to final cleaning and immediately prior to placing concrete must be less than 2.0 percent, in accordance with API 13B-1, Section 5.

In the event a shaft is determined to be defective do not continue to use slurry construction methods without written approval from the Project Manager. The Project Manager may require amendment and resubmittal of the shaft construction methods.

E. Method of Measurement. Use of slurry for drilling is not measured for payment.

F. Basis of Payment. Include all costs associated with using slurry in bid item for “Drilled Shaft.”

3. <u>DRILLED SHAFTS (REVISED 5-17-2011)</u>

A. Description. This work is constructing reinforced concrete shafts cast in cylindrically excavated holes that extend into soil or rock to support the structure and externally applied loads at the locations and to the lines and grades shown. Shaft depth may be increased by up to 15 feet (4.6 m) based on field conditions by written order from the Project Manager. Be prepared to construct the shaft to the adjusted depth if required.

B. Materials.

1) Drilled Shaft Concrete. Use Drilled Shaft Concrete for all concrete placed between the bottom of the shaft and the top of the casing, unless otherwise shown on the plans.

2) Permanent Drilled Shaft Casing. Furnish casing meeting the size and thickness requirements specified and casing material that meets the requirements of AASHTO M 270 (M 270M), Grade 36 (Grade 250). Casing materials, fabrication and inspection are as specified in Section 556.

C. Construction Requirements.

1) Submittals. Submit four copies of the following information to the Project Manager a minimum of thirty calendar days before start of drilling operations.

a) Drilled Shaft Activities Schedule Chart and Written Narrative outlining:

(1) Bent and shaft construction sequence. If more than one shaft will be worked on at any time, include that information in the submittal.

(2) Method of Shaft Excavation.

(3) Method to Clean Shaft Excavation.

(4) Temporary and Permanent Casing Installation and Removal Methods. Include casing top and bottom elevations and diameters.

(5) Method of Concrete Placement. Include descriptions of methods or devices that will be used to prevent the injection of air or water into the drilled shaft concrete when starting concrete placement and in the event the placement is stopped and restarted.

(6) Time necessary for complete concrete placement.

b) Name and experience record of Contractor, and Superintendent and Driller(s) to that will perform the drilled shaft work on this project. The experience record need only include the last 10 years.

c) List of proposed drilling equipment to be used, including any cranes, drills, augers, bits, temporary casings and cleaning tools. Include diameter of augers and cleaning buckets.

d) Proposed size and location of all reinforcing steel used to support or maintain the shape of the reinforcing steel cage.

2) Shaft pre-construction meeting. Schedule a shaft pre-construction meeting with the Project Manager for a time 7-14 days prior to drilling. The minimum required attendees are the superintendent, concrete supplier, and Project Manager. The purpose of the meeting is to review the requirements of this Provision, discuss the drilled shaft installation plan, and to discuss logistical and contingency plans.

3) Geotechnical logging. The Department will provide a Geotechnical Section representative on-site during drilling and installation operations to log the excavation. Notify the Project Manager at least seven calendar days prior to start of drilled shaft excavation so that the Project Manager can schedule the on-site representative.

4) Shaft Excavation. Use excavation methods that provide contact with firm, undisturbed soil or rock with the sides and bottom of the shaft concrete when the temporary casing is removed. Do not excavate holes larger than the outside diameter of permanent casings to facilitate casing installation.

5) Shaft Locations, Alignment and Tolerances. Drill all shafts to the bottom elevations specified or as directed by the Project Manager. Construct the shaft so the vertical centerline axis of the finished shaft is within 3 inches (75 mm) of the plan location at the top of the shaft. Drill all shafts to within 2 percent of vertical the entire depth of the shaft excavation.

6) Sloughing and Caving. Use construction methods that will ensure no sloughing or caving of the shaft side walls. In the event any sloughing or caving does occur, remove all sloughed material. Ensure that concrete completely fills the shaft. If caving occurs during placement of drilled shaft concrete, immediately stop the flow of concrete and undertake corrective measures to completely remove the sloughed materials from the shaft. If necessary to facilitate material removal, remove the concrete and reinforcing steel already placed in the shaft.

7) Permanent Casing.

a) Description. Furnish and install permanent casing when specified on the plans. Permanent casing remains in place and is included in the design of the drilled shaft. The permanent casing diameter may be oversized up to 3 inches (75 mm) if necessary to facilitate temporary casing installation.

b) Welding. If field welding, submit four copies of the weld procedures to the Project Manager for approval thirty calendar days prior to welding.

c) Corrosion Protection. Provide corrosion protection for all permanent casing. Galvanize the permanent casing to AASHTO M 111 (M 111M) and ASTM A 653 (A 653M) specifications or paint. If painting, meet the following requirements:

(1) Material. Furnish paint meeting the requirements of Subsection 710.02 (B)(3).

(2) Surface Preparation. Prepare the casing surface following the paint manufacturer's recommendations.

(3) Paint Application. Follow the paint manufacturer's recommendations for paint application. Apply paint to the casing before installation, starting 24 inches (610 mm) below ground surface, continuing to the top of exposed steel.

(4) Shop Painting. Apply the first two paint coats to produce a minimum 12 mil (300 μm) dry film thickness. Provide two copies of the painter's certification that the paint was applied following the manufacturer's recommendations and test results showing the paint coat thickness on the casing.

(5) Field Painting. Repair paint damage caused by transport, handling and welding following the paint manufacturer’s recommendations before applying the finish coat.

For the finish coat, use the same paint or paint compatible with the first two coats. Provide a finish coat with a minimum 3 mil (75 μm) dry film thickness. Provide the finish coat paint color as follows:

COLOR	FEDERAL SPECIFICATION 595B PIGMENT CODE
Concrete Gray	36440

8) Temporary Casing. Do not use slurry construction methods as an alternative to or in conjunction with temporary casing on this project unless the Contract contains the Special Provision “Synthetic Slurry for Drilled Shafts”. Use temporary casing to facilitate shaft construction and prevent sloughing and caving of the shaft sidewalls. Full depth temporary casing is required. Refer to the tip elevations on the bridge plans for temporary casing elevation, these elevations are minimum elevations. Place the temporary casing deeper if necessary to prevent material from entering the shaft excavation. Be prepared to provide up to 15 feet (4.6 m) of additional temporary casing in the event that the shaft bottom elevation is lowered during construction. Use casing with an outside diameter no less than the specified diameter of the shaft. Limit the excavation in advance of the casing tip to no more than 10 feet (3 m) unless synthetic slurry is being used. During casing extraction, maintain a sufficient level of fluid in the casing to counteract external hydrostatic pressures but no less than 5 feet of positive head. Maintain an adequate level of concrete within the casing and provide vibration of the temporary casing or the concrete as needed to ensure that fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete. Use equipment and methods capable of extracting temporary casings. Temporary casings that have become bound or fouled during shaft construction and cannot be removed are considered to be a defect in the drilled shaft. Correct defective shafts using approved methods at no cost to the Department. Corrective action may consist of, but is not limited to, the following:

a) Removing the drilled shaft concrete and extending the drilled shaft deeper to compensate for the loss of frictional capacity to the cased zone.

b) Providing straddle drilled shafts to compensate for capacity loss.

c) Providing a replacement drilled shaft.

9) Obstructions. An obstruction is considered a specific object exceeding 50 percent of the shaft diameter that cannot be removed from the drilled shaft excavation using conventional augers or core barrel tools. If an obstruction is encountered, promptly notify the Project Manager. Submit four copies of a proposed obstruction removal method to the Project Manager for approval within two calendar days of encountering the obstruction.

10) Cleaning. Remove all loose or disturbed material from the bottom of the shaft excavation immediately prior to placing reinforcing steel and concrete. After cleaning, 1.0 inch (25 mm) is the maximum thickness of loose or disturbed material permitted in the bottom of the shaft.

11) Installation of Cross-hole Sonic Logging (CSL) Tubes. As shown in the plans, install the CSL access tubes evenly spaced around the reinforcing cage and inside of all hoops and spiral reinforcing steel. Use schedule 40 mild steel standard black pipe conforming to ASTM A 53 (A 53M), Grade A or B, Type E, F or S, 1 ½ inch (38 mm) nominal diameter CSL access tubes that extend the full length of the drilled shaft. Provide an end plug at the lower end of the pipe and make all joints watertight. Fill the CSL access tubes with a 1:1 mixture of potable water and biodegradable antifreeze prior to placing concrete in the drilled shaft. Temporarily cap the top of the tubes to prevent debris or concrete from entering the tubes.

12) Reinforcing Steel. Use “Figure eight” or “Saddle” ties at all intersecting bars. After inspection and approval of the drilled shaft excavation by the Project Manager, place the reinforcing steel cage into the shaft as one unit. Support the steel cage from the top so that racking and distortion are prevented. Remove internal stiffeners as necessary as the steel cage is placed in the excavation to prevent interference with the placement of concrete. Use non–corrosive, roller-type spacers or other non-corrosive devices as approved by the Project Manager along the steel cage length and around the steel cage perimeter to align and maintain clearance from reinforcing cage to edge of casing during concrete placement. Begin placing the drilled shaft concrete immediately after the Project Manager has inspected and approved the cage for location and alignment within the drilled shaft. Remove the steel cage and re-inspect the excavation if the concrete placement is not started within three hours of placing the steel cage in position.

13) Concrete Placement Record. Complete the MDT Drilled Shaft Concrete Placement Log. Accurately record all data required on the form as the concrete is placed. After the drilled shaft concrete has been placed and before the end of the day, give the completed form to the MDT inspector. MDT will provide copies to the Contractor upon request.

14) Drilled Shaft Concrete

15) Place concrete in the drilled shaft as specified for either dry excavations or wet excavations.

a) Dry Excavations. Place concrete by gravity tremie tube or pumping. Concrete may free fall into the shaft if the concrete can be directed so that it does not strike the reinforcing steel, the excavation wall or any other obstruction during the fall.

b) Wet Excavations.

(1) Place all drilled shaft concrete by tremie tube, pumping, or other approved method to avoid separation and segregation of the concrete mix components.

(2) Separate the first concrete placed from the fluid in the excavation using a plug in the tube, or other approved device.

(3) Begin concrete placement in a manner that minimizes mixing of the concrete with the water and material in the shaft.

(4) Continuously place drilled shaft concrete until the tremie tube or pumping pipe is removed from concrete at the top of the shaft. If at any time during concrete placement it is necessary to temporarily stop concrete placement, restart concrete placement in a manner that

ensures that air, water, or other undesirable material is not mixed into the concrete or incorporated into the drilled shaft.

(5) Maintain 10 feet of tremie pipe embedment or more if necessary to ensure upward displacement of all contaminated concrete. If at any time during the pour, the tremie pipe orifice is removed from the concrete, stop and restart concrete placement in a manner that ensures that air, water, or other undesirable material is not allowed to be mixed into the concrete or incorporated into the drilled shaft. Concrete that is discharged above the rising concrete level in the shaft is considered undesirable material.

(6) Once concrete has reached the top of the drilled shaft, remove and dispose of the top layer of concrete and any concrete contaminated with mud or fluid from the drilled shaft. Remove sufficient concrete to fully expose sound, homogeneous and uncontaminated concrete in the shaft.

16) Shaft Testing and Acceptance

a) Cross-Hole Sonic Logging. The Project Manager may use CSL to check the structural soundness of any completed drilled shaft(s). The CSL testing will be performed when the concrete has cured sufficiently to give consistent test readings. Schedule construction activities to allow twelve calendar days from the time concrete is placed in the shaft until the shaft is tested. Provide a stable 110-Volt AC or a 12-Volt DC electrical supply if requested. When the CSL testing access tubes are no longer needed for testing, as determined by the Project Manager, cut off the tubes flush with the top surface of the drilled shaft and remove the antifreeze solution to a depth of 4 inches (100 mm) from the top of the tubes. Permanently cap the CSL access tubes to provide a watertight seal that does not interfere with the subsequent construction operations. The Project Manager will accept or reject the shaft based on the CSL testing or a subsequent drilled core sample. For any drilled shaft determined by CSL testing to be of uncertain quality, drill core samples with a minimum diameter of 2.5 inches (65 mm). Drill at locations and to depths specified by the Project Manager, to explore the shaft quality. Use a core drilling method that provides complete core recovery and minimizes abrasion and erosion of the core. Grout all core holes when directed by the Project Manager.

b) Corrective Action. If the CSL or subsequent coring identifies any defect in the shaft that compromises the capacity of the shaft repair the shaft by a method approved by the Project Manager. Submit a repair plan no later than fourteen calendar days after notification. Include four copies of calculations and working drawings, stamped by a Civil Engineer licensed in Montana, to the Project Manager. Furnish all materials and work necessary to correct shaft defects at no cost to the Department. Prior to constructing other shafts, submit four copies of a written proposal to the Project Manager that describes changes in construction methods or materials designed to avoid defects in subsequent drilled shafts.

D. Method of Measurement.

1) Drilled Shaft. Drilled shaft will be measured by the linear foot (meter) of shaft between the actual bottom elevation of the drilled shaft and the top of shaft elevation shown on the plans.

2) Reinforcing Steel. Drilled shaft reinforcing steel will be measured by the pound (kilogram) in accordance with Subsection 555.04.

3) Drilled Shaft Casing. Permanent drilled shaft casing will be measured by the linear foot (meter) of permanent casing installed as shown in the plans or as directed by the Project Manager in writing.

4) Temporary Casing. When the Contract contains the pay item “Temporary Drilled Shaft Casing”, temporary drilled shaft casing will be measured by the linear foot (meter) of temporary casing measured from the higher of the ground or water surface elevation down to the bottom elevation of the installed temporary casing.

5) Cross-hole Sonic Logging (CSL) Tubes and Testing. Include all costs associated with furnishing and installing CSL access tubes and any required extensions and providing a power source in the Drilled Shaft Pay Item. No measurement or payment will be made for

construction delays resulting from the initial CSL drilled shaft testing. The Department will extend the contract time by one day for each day over twelve calendar days required to complete the CSL drilled shaft testing. The Department will pay the costs for the initial CSL drilled shaft testing. Pay for all costs associated with coring, engineering design, cost required to correct the defect and any construction delay costs, if a defect is found based on the CSL drilled shaft testing or coring. Pay the costs of CSL drilled shaft retesting of the repaired drilled shafts. If no defect is found in the drilled shaft based on the coring, the Department will pay all costs of coring and any delays necessitated by the coring.

E. Basis of Payment. Payment for the completed and accepted quantities is made under the following:

Pay Item	Pay Unit
Drilled Shaft	Linear Foot (meter)
Reinforcing Steel	Pound (kilogram)
Drilled Shaft Casing	Linear Foot (meter)
Drilled Shaft Concrete	Cubic Yard (cubic meter)

Payment at the contract unit price is full compensation for all resources necessary to complete the item of work under the contract. Temporary casings remain the property of the Contractor.

If the Contract contains the pay item Temporary Drilled Shaft Casing, all costs associated with temporary casing including, but not limited to, procurement, fabrication, transportation, installation and removal, are included in the Pay Item Temporary Drilled Shaft Casing. If the Contract does not contain the pay item Drilled Shaft Temporary Casing, no measurement or payment will be made. Include all costs associated with temporary casing including, but not limited to, fabrication, providing, transporting, installation and removal in the Drilled Shaft pay item.

Obstruction Removal. Payment for work associated with obstruction removal will be made on a Force Account basis.

APPENDIX M

Montana Department of Transportation
Research Programs
January 2013

EXPERIMENTAL PROJECTS WORK PLAN

OSTERBERG (O-CELL) SACRIFICIAL EIGHT FT. DIAMETER DRILLED SHAFT

Location:	Thompson Falls, Sanders County: Highway 200 (P-6/C000006)
Project Name:	Thompson River East
Project Number:	STPP 6-1(87)56
Experimental Project No.	MT-13-02
Type of Project:	Osterberg Cell Test Verification
Principal Investigator:	Craig Abernathy: Experimental Project Manager (ExPM)

Description

The Department is to replace the existing structure over the Thompson River east of Thompson Falls, MT. The project will construct a new 40 ft. wide bridge north of the existing structure on an offset alignment. The proposed structure is 434 ft. long and is three spans. The superstructure is a steel beam with concrete deck. The foundation consists of two six foot diameter drilled shafts at each abutment and two eight foot diameter drilled shafts at the piers.

A load test is proposed for a sacrificial eight foot diameter drilled shaft near pier 2. This location will provide easy access to conduct the load test and still allow for production shafts to be drilled and other work to continue. For this load test it is proposed to use Osterberg Load Cells (O-Cell) from Load Test Inc. The O-Cell is installed in the test shaft at a predetermined location to maximize skin friction or base resistance for verification of design parameters.

The test shaft needs to be installed prior to the shafts on Pier 2. So the planned tip depth can be confirmed or adjusted.

Experimental Design

At this site, the drilled shafts will be founded in loose to medium dense sands and gravels with no clear end bearing strata. Different design methods currently used by the

Geotechnical Section have yielded markedly different results in terms of available end bearing and skin friction which in turn, have produced very different requirements for shaft diameter and length. A conservative design will be expensive and an un-conservative design will carry risk.

An Osterberg load test will not only confirm the skin friction and end bearing that is present at this site, but will also provide valuable insight into how conservative or un-conservative MDT's design methodology is in a more general sense.

Evaluation Procedures

Research will document the installation for best practice and any construction concerns germane to the installation and testing of the O-Cell.

Construction Documentation: Will include information specific to the installation events of the O-Cell. A special provision will be prepared to instruct Load Test project staff to provide Research with a comprehensive report of results in suitable form for inclusion into the construction report.

Post Documentation: All project information will be available on the projects webpage.

Technical Contact for the project is Tyrell Murfitt, tmurfitt@mt.gov or at 444.9259.

Evaluation Schedule

2014: Posting of the Installation/Construction/Cell Test Analysis and Conclusion Report