APPENDIX E
GEOTECHNICAL MONITORING PLAN

GEOTECHNICAL MONITORING PLAN

TAILINGS IMPOUNDMENT
FORMER CALLAHAN MINE SUPERFUND SITE
BROOKSVILLE, MAINE

Prepared for:

State of Maine Department of Transportation
16 State House Station
Augusta, ME 04333

Prepared by:

AMEC Environment & Infrastructure, Inc.
511 Congress Street
Portland, Maine 04101

December 2014

Project No. 3612-11-2201

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1.0 INTRODUCTION

AMEC Environment and Infrastructure, Inc. (AMEC) has prepared this Geotechnical Monitoring Plan as part of the Draft Final Design to describe the geotechnical instrumentation to be installed, the monitoring to be performed, and the data compilation and reporting to be conducted to support the remedy of the Operable Unit 3 (OU3) Tailings Impoundment at the Callahan Mine Superfund Site in Brooksville, Maine.

The impoundment contains fine sand, silt, and clay-sized rock particles (i.e., tailings) from the Callahan-era mining operations. The tailings are contained by a three-sided dam constructed against a sloping hillside. The strata within, beneath, and/or at the toe of the Tailings Impoundment consist of the following principal strata:

- Tailings;
- Clay (Fill/Re-Work);
- Organic Silt/Clay, Peat, and Clay (Estuarine);
- Clay (Presumpscot Formation);
- Glacial Till; and
- Bedrock.

The thickness of the tailings ranges from about 5 to 60 feet, and the thickness generally increases from west to east. Highly compressible tailing “slimes” dominate central portions of the impoundment. The slimes consist almost exclusively of silt and clay-sized particles with trace amounts of fine sand. Conversely, tailings “sands”, consisting primarily of loose silty fine-grained sand, dominate the perimeter of the impoundment (i.e., in close proximity to the dam). A zone of highly stratified and/or laminated tailings is generally found in between the slimes and the sands.

Based on the remedy and the subsurface conditions, AMEC identified concerns regarding the stability of the Tailings Impoundment that might occur during remedial construction. The remedy calls for the installation of prefabricated vertical drains (PVDs), hereafter referred to as EQ Drains, to accelerate construction (which consists primarily of filling atop slimes) and promote consolidation-induced strength gain, and in-turn stability. Consequently, geotechnical monitoring will be required during dewatering and construction earthwork operations in order to assess the performance of the remedy.

AMEC recommends the installation of geotechnical instrumentation in in “Phase 1” of the remedial construction, in conjunction with the installation of horizontal drains, and immediately following construction of the working surface and installation of EQ Drains. The instrumentation is intended to monitor the Tailings Impoundment response, and to utilize the data to adjust the rates of fill placement during construction to promote local and global stability.

1.1 SITE DESCRIPTION

The former Callahan Mine property, an elongated 120-acre property oriented north-south, is located approximately 15 miles west of the Town of Blue Hill and 35 miles west of the Town of Bar Harbor on the northwest side of the Cape Rosier peninsula on Penobscot Bay.

The former Callahan Mine was a hard-rock, open-pit mine developed in Goose Pond, a shallow tidal estuary of approximately 75 acres. Between approximately 1968 and 1972, approximately 5,000,000 tons of waste rock was mined to access and remove approximately 800,000 tons of ore-bearing rock at the Site. Rock was blasted from inside the open pit and hauled out in trucks. Ore-grade rock was taken directly to on-site processing or to an ore storage area. Waste rock was either disposed of or used for construction projects, such as the construction of on-site containment dams at the Tailings Impoundment. Tailings from the flotation mill were pumped as slurry to the Tailings Impoundment.

The Tailings Impoundment is located at the southern end of the Site, adjacent to a Salt Marsh at the edge of South Goose Pond. The impoundment encompasses an approximately 17-acre trapezoidal-shaped footprint. The impoundment contains fine sand, silt, and clay-sized rock particles (i.e., tailings) from the Callahan-era mining operations. The tailings are contained by a three-sided dam constructed against a sloping hillside. The existing ground surface is roughly elevation +75 feet along the crest of the dam and about elevation +70 feet in central portions of the impoundment. The impoundment surface is concave and surface water ponds in the middle. The existing ground surface averages about elevation +15 feet along the eastern toe. The dam is constructed of waste rock, and is a maximum of about 60 feet high and has an average slope of about 1.3H-1.5H to 1V (horizontal to vertical). East of the toe, the existing ground surface slopes down gradually to the edge of the Salt Marsh/Goose Pond floodplain (at approximately elevation +7 feet).

The existing features and topography of the Tailings Impoundment are depicted in Figure E-1.

1.2 PROPOSED REMEDY

The remedy of the Tailings Impoundment includes the following major components:

- Installation of horizontal drains (for pre-construction and long-term dewatering purposes);
- Installation/construction of a working surface atop the tailings slimes to allow for equipment access and instrumentation installation, as necessary;
- Installation of EQ Drains in proposed fill areas;
- Installation of geotechnical monitoring instrumentation;
- Re-grading the Tailings Impoundment to design elevations (includes cuts near the impoundment perimeter and fills within the impoundment interior); and
- Placement of a low-permeability cover system.

1.3 PURPOSE AND SCOPE OF MONITORING

The purpose of the geotechnical monitoring plan is to monitor the response of the Tailings Impoundment to dewatering, and to monitor stability, locally and globally, during construction. The main components of the monitoring include the following:

- Visually observe and document conditions within and around the impoundment during construction;
- Monitor horizontal/lateral deformation within the impoundment, along the impoundment fill slope toe, and along the outer perimeter/toe of the impoundment dam;
- Monitor phreatic surface elevation head within the tailings prior to and, to a lesser extent, during construction;
- Monitor pore pressure generation/dissipation in the tailings during fill placement;
- Monitor vertical settlement in the tailings during fill placement;
- Utilize the geotechnical monitoring data in conjunction with the visual observations to evaluate the response of the Tailings Impoundment during dewatering and construction and to adjust the rate of fill placement, as necessary, to promote stability.

The Tailings Impoundment currently contains installed instrumentation. It is anticipated that the existing instrumentation will be utilized during dewatering and will be abandoned/removed in proposed cut areas during construction operations. AMEC recommends that existing instrumentation be utilized during geotechnical monitoring, where possible. The existing instrumentation, within and at the toe of the impoundment, consists of monitoring wells, observation wells, standpipe piezometers, and vibrating wire piezometers (VWPs).

The following supplemental/additional instrumentation will be installed in support of the plan objectives and are listed as follows:

- 10 Slope Inclinometers;
- 7 Standpipe Piezometers;
- 6 VWP Locations (consisting of multi-level/“nested” pairs of VWPs); and
- 8 Settlement Platforms.

Existing and proposed instrumentation locations are presented in Figure E-1.

2.0 VISUAL INSPECTIONS

Visual inspection of the impoundment should be performed during construction. The inspections should be conducted once daily, at a minimum. Specific areas of focus should include the following:

- Outer perimeter/toe of the Tailings Impoundment;
- Crest and impoundment dam face;
- Fill areas; and
- Cut areas.

Focus areas and the frequency of inspection may be adjusted as construction progresses and as monitoring data becomes available.

The inspections should note observations of any signs of potential slope instability, including, but not limited to, cracking, depressions, bulging, and seepage breakout. At a minimum, daily reporting should consist of a notation that an inspection was made and that no anomalies were noted. If anomalies are observed, the daily report should document and include the following information, at a minimum:

- A narrative description of the anomaly;
- The approximate location(s)/coordinates of the anomaly;
- The construction activities that have occurred in that area over the previous few days; and
- Digital photographs showing the observed conditions.

A sample visual inspection report is provided in Attachment E-1. At a minimum, the frequency of monitoring events will be increased if anomalies are observed. Additional actions, including a reduction in fill placement rates, a temporary cessation of cutting/filling operations, or removal of existing fill may also be considered.

3.0 HORIZONTAL DEFORMATION

Horizontal deformation/deflection will be monitored by the use of vertical slope inclinometers.

3.1 SLOPE INCLINOMETERS

A total of ten (10) slope inclinometers should be installed along the impoundment fill slope toe and along the outer perimeter/toe of the Tailings Impoundment in critical areas. The proposed inclinometer locations are depicted on Figure E-1. The inclinometer locations should be field adjusted, as necessary.

3.1.1 Installation

Installation of inclinometers will be performed by a conventional drilling rig and will be conducted as follows:

- The drill rig should be leveled and mast erected vertically prior to the start of drilling such that the inclination of the boring will be no more than 3 degrees from vertical.
- Drilling for inclinometer installation should be completed via rotary wash drilling methods utilizing 6-inch inside diameter (ID) flush-joint steel casing (driven), potable water, and/or mud rotary methods using drilling “mud”.
- As the borings are advanced, Standard Penetration Tests (SPTs) will be conducted, as directed by the on-site engineer, and soil samples will be obtained via 2-inch diameter split-spoon samplers. SPTs will be conducted in general accordance with ASTM D 1586.

  A 3-inch diameter split spoon sampler should be on-site and available for use.
- Borings (and inclinometer casing) will extend a minimum of 20 feet into dense glacial till and/or bedrock.
- Inclinometer casing should consist of 3.34-inch outside diameter (OD) Quick Connect (QC)-type inclinometer casing supplied by Durham Geo Slope Indicator (Slope Indicator) or equal. Product information for the inclinometer casing is provided in Attachment E-2a.
- Inclinometer casing should be assembled and installed in general accordance with Slope Indicator’s installation guidelines. The QC Casing Installation Guide is provided in Attachment E-2b.
- Inclinometer casing should be filled with potable water to counteract buoyancy in the boring.
- The casing should be installed such that the grooves should be installed perpendicular and parallel with the slope.
- During grouting (see below), down force should be applied at the bottom of the casing (i.e., to the bottom cap) via extra drilling rods.

- Inclinometer casing will be fully-grouted with cement-bentonite grout via tremie methods. All grouting will be performed in two stages, using a solid polyvinyl chloride (PVC) tremie pipe:

  During Stage 1 grouting, the inclinometer annulus should be grouted from the bottom of the borehole up. Stage 1 grout should be utilized for the bottom 20 feet of the inclinometer (grouted in dense glacial till and/or bedrock). Stage 1 grout should consist of 94 pounds of Portland cement (Type I or II), 69 pounds of water (8.3 gallons), and about 5 pounds of bentonite.

  During Stage 2 grouting, the inclinometer should be grouted from the top of Stage 1 grout up. Stage 2 grout should be utilized for the remainder of the inclinometer. Stage 2 grout should consist of 94 pounds of Portland cement (Type I or II), 625 pounds of water (75 gallons), and about 39 pounds of bentonite.

- Protective steel casing should be installed around the above ground portion of the inclinometers.

The locations and elevations (ground surface and top of casing) for each inclinometer should be surveyed after the grout has fully cured (approximately 48 hours). Survey accuracy should be as follows:

- Horizontal location to the nearest 0.01 foot; and
- Vertical elevation to the nearest 0.01 foot.

Protective boundaries (5-foot radius, minimum) should be placed around each inclinometer with high-visibility fence, flagging, or equivalent during construction.

3.1.2 Monitoring

After the grout has cured (48 hours, minimum), three initial readings should be conducted to establish a baseline profile for each inclinometer. Baseline readings should be made within one week of installation.

The inclinometers within the impoundment should be initially monitored one (1) time per week during filling. The inclinometers at the outer toe of the impoundment dam should be monitored at least two (2) times per month. The frequency of the monitoring events will be adjusted as monitoring data becomes available. At a minimum, the frequency of monitoring events may be increased if movement occurs as described in Section 3.1.4.

During each monitoring event, a Digitilt inclinometer probe and a Digitilt DataMate II data recorder, or equal system, should be used to “read” each inclinometer. Product information for the inclinometer system is provided in Attachment E-2c.

3.1.3 Data Compilation and Reporting

DigiPro inclinometer software (or equal) should be utilized to compile and plot the inclinometer data recorded by the inclinometer probe and data recorder. The inclinometer software reports for each inclinometer shall include cumulative and incremental displacement in both the A and B axes, and shear strain in 2-foot zones of the A-axis at suspected areas of high movement. Sample inclinometer data reports are provided in Attachment E-2d.

3.1.4 Action levels

The frequency of monitoring of the inclinometers will be once per week during the initial filling for those inclinometers installed at the toe of the fill operations within the impoundment and two times per month for those inclinometers installed at the outer toe of the impoundment. These frequencies may be increased or decreased depending on the rate of cumulative displacement and shear strain measured during site filling.

The monitoring of the inclinometers will also be increased should movements exceed certain guidance criteria for lateral cumulative displacement and shear strain as follows:

<u>Cumulative Displacement</u>: If the cumulative displacement exceeds 0.08 inches per month at the maximum point of movement in the inclinometer plot, the Owner and Design Engineer will be notified, and the following actions will be taken:

- An additional inclinometer survey will be made to verify the exceedance;
- The monitoring frequency will be increased to weekly or to a frequency at which the 30 percent the guidance criteria would be measured at the current rate of movement. For instance, if the cumulative displacement is measured at a rate of 0.24 inches per month (adjusted for a 30 day period), the frequency of readings will be increased to (0.08 x 30 %)/0.24 x 30 or 3 days between readings. If the calculated frequency of readings is greater than 7-days, the frequency of readings will be limited to once per week;
- The monitoring frequency will continue until the rate of cumulative displacement drops below 0.08 inches per month, and for three consecutive readings thereafter; and
- If the displacement measurements indicate an <u>*acceleration*</u> of movement, the fill placement operations will be ceased at that location, and further actions will be implemented, which might include further increasing the monitoring frequency, stability analyses, placement of berms, a longer waiting period before additional fill placement or removal of fill.

<u>Shear Strain</u>: If the shear strain exceeds 0.04 percent per month in identified zones of shear displacement, the owner and Design Engineer will be notified, and the following actions will be taken:

- An additional inclinometer survey will be made to verify the exceedance;
- The monitoring frequency will be increased to a frequency at which 30 percent of the guidance criteria would be measured. For instance, if the rate of shear strain is measured at a rate of 0.12 percent per month (adjusted for a 30 day period), the frequency of readings will be increased to (0.04 x 30 %)/0.12 x 30 or 3 days

between readings. If the calculated frequency of readings is greater than 7-days, the frequency of readings will be limited to once per week;

- The monitoring frequency will continue until the rate of shear strain drops to below 0.04 percent per month, and for three consecutive readings thereafter under the guidance criteria is met; and
- If the shear strain measurements indicate an *acceleration* in the rate of shear strain, the filling operations will be ceased at that location, and further actions will be implemented, which might include further increasing the monitoring frequency, stability analyses, placement of berms, or removal of fill.

Cumulative Shear Strain: Total cumulative shear strain will be monitored at each inclinometer in zones of suspected shear type deflection. The significance of shear strain is that the soft tailings may exhibit strain softening during shear failure. Strain softening denotes a loss in strength with increasing strain after peak strength values are reached. For the purposes of this plan, a total cumulative shear strain of 4 percent or greater for any 2-foot long zone measured may trigger other actions, depending on other site data measurements.

Several measures may be considered to assess the rate of shear strain and its long-term impact on the stability of the facility. These measures may include the following:

- *Installation of piezometers at, above, and below suspected zones of shear*. If excessive shear strain occurs, it is expected that the pore pressures in the shear zone will increase. Piezometers placed just above and/or below the zone of shearing, and within the zone can help assess if excessive shear strain is occurring;
- *Installation of additional inclinometers*. If a shear type failure develops, it should be evident along a vertical section through the filled portion of the site. Additional inclinometers can be installed in a section perpendicular to the slope beneath the crest of the fill slope to assess the continuity of the suspected zone of shearing. A single span of casing without settlement couplings should be installed across the suspected zone of shear with settlement couplings above and below the zone; and
- *Vane shear testing or con penetration testing (CPT) at suspected zones of shear strain*: Vane shear or CPT testing could be performed at suspected shear zones to assess if a loss of strength occurs. The testing would have to be performed at very short intervals across the suspected zone in order to detect the loss in strength.

The decision to implement such measures at the site would be based on the overall progress of the site filling, acceleration or deceleration of movements, as well as other site monitoring data from the piezometers and settlement platforms.

4.0 PHREATIC SURFACE ELEVATION HEAD

Phreatic surface elevation head should be monitored during dewatering and construction operations to verify that the horizontal drains are functioning as intended/designed.

4.1 Installation

Seven (7) additional standpipe piezometers should be installed within the Tailings Impoundment to specifically target anticipated bottom of tailings "low spots" where the tailings could potentially remain saturated below the proposed horizontal drains. The standpipe piezometers should have a target screened interval slightly above the bottom of the tailings. The standpipe piezometers should be installed as follows:

- Drilling for standpipe piezometers should be completed using a conventional drill rig using rotary wash drilling methods utilizing 6-inch inside diameter (ID) flush-joint steel casing (driven), potable water, and/or mud rotary methods using drilling "mud".
- As the borings are advanced, SPTs will be conducted, as directed by the on-site engineer, to identify bottom of tailings, and soil samples will be obtained via 2-inch diameter split-spoon samplers. SPTs will be conducted in general accordance with ASTM D 1586.
- Piezometer screen and riser materials should consist of 1-inch diameter flush-joint schedule 40 PVC.
- PVC screen shall be new, machine slotted, with a 0.010-inch slot size. Piezometers should be constructed with 10- to 20-foot long screened intervals, as determined by the on-site engineer.
- The bottom of the screen should be approximately 1 to 2 feet above the bottom of the tailings.
- The screened interval should be backfilled with filter sand (#1), which shall extend at least 2 feet above the top of the screen.
- A bentonite seal (bentonite chips) should be installed to approximately 3 feet (minimum) above the top of the sand pack. Bentonite chips should be hydrated prior to grouting.
- The remainder of the piezometer should then be grouted from the bottom up via a tremie-pipe and cement-bentonite grout.
- The grout mix shall consist of 94 pounds of Portland cement (Type I or II), 69 pounds of water (8.3 gallons), and about 5 pounds of bentonite.

Protective boundaries (5-foot radius, minimum) should be established around each piezometer (existing and newly installed) with high-visibility fence, flagging, or equivalent. During subsequent earthwork activities, shovels and hand-operated walk-behind compaction equipment shall be used to place and compact fill within a 5-foot radius (minimum) of the piezometers.

4.2 Monitoring

AMEC recommends monitoring phreatic surface elevation head within the Tailings Impoundment during dewatering and construction operations. The phreatic surface elevation head should be monitored one (1) time per month during dewatering and one (1) time per week during construction, at a minimum. A sample phreatic surface elevation head field data sheet is presented in Attachment E-3a.

4.3 Data Reporting and Compilation

Data should be compiled, tabulated, and plotted for each monitoring point following each monitoring event. A sample phreatic surface elevation head data report is provided in Attachment E-3b.

4.4 Action Levels

The Tailings Impoundment should be dewatered, per the design, prior to construction. If the impoundment does not respond as anticipated, additional actions, such as installation of additional horizontal drains, should be considered.

Action levels will be established prior to dewatering and construction operations. Additional actions, including a reduction in fill placement rates, a temporary cessation of filling operations, or removal of existing fill should also be considered during construction.

Action levels may be adjusted during construction depending on actual site conditions, as necessary/applicable.

5.0 PORE PRESSURE

The generation and dissipation of excess pore pressure in the tailings induced by fill placement should be monitored via VWPs.

5.1 VIBRATING WIRE PIEZOMETERS

VWPs should be installed at six (6) locations within the Tailings Impoundment as shown on Figure E-1. Each location will consist of up to two (2) VWPs at approximately 10 to 15 foot vertical spacing.

5.1.1 Installation

Installation of VWPs should be conducted as follows:

- The VWPs should be installed after the PVDs have been installed. At each VWP location, the VWP drill hole shall be centered between a cluster of three (3) EQ Drains.
- Drilling for VWP installation should be completed using a conventional drilling rig using rotary wash drilling methods utilizing 4-inch ID flush-joint steel casing (driven), potable water, and/or mud rotary methods using drilling "mud".
- SPTs should be conducted, at the direction of the on-site engineer, and soil samples should be obtained via 2-inch diameter split-spoon samplers as the borings are advanced. SPTs should be conducted in general accordance with ASTM D 1586.
- Borings are anticipated to extend to depths ranging from approximately 15 to 40 feet bgs.
- VWPs should consist of standard 50 psi units and be checked and prepared (saturated) in accordance with the manufacturer's specifications and/or recommendations.
- The VWPs should be attached to a 1-inch ID PVC tremie pipe, via duct tape and zip ties, and lowered to the targeted depths (determined by the on-site engineer). The tip of the VWP shall be saturated and checked, in accordance with manufacturer recommendations, prior to installing in the borehole.
- VWPs (and tremie pipe) should be fully-grouted from the bottom up, using the 1-inch ID tremie pipe, with cement-bentonite grout.

  The grout mix shall consist of 94 pounds of Portland cement (Type I or II), 415 pounds (50 gallons) of water, and about 30-39 pounds of bentonite.
- The lead wires for each VWP shall be routed to the adjacent settlement platform and raised as the platform riser pipe is raised during filling.

The coordinates and ground surface elevation at each VWP location should be surveyed after the grout has fully cured (approximately 48 hours). Survey accuracy should be as follows:

- Horizontal location to the nearest 0.01 foot; and
- Vertical elevation to the nearest 0.01 foot.

Protective boundaries (5-foot radius, minimum) should be installed around each VWP location with high-visibility fence, flagging, or equivalent. During earthwork activities, shovels and hand-operated walk-behind compaction equipment shall be used to place and compact fill within a 5-foot radius (minimum) of the VWPs.

5.1.2 Monitoring

After the grout has cured, at least two initial readings should be taken to establish a baseline for each VWP. Baseline readings should be made within one week of installation and prior to placement of any fill above the working platform.

The VWPs should be monitored after each lift of fill is placed (maximum of once per day), or a minimum of three (3) times per week during fill placement, and one (1) time per week following completion of construction. Barometric pressures should also be recorded. Product information for the VWPs and data readout box/data logger is provided in Attachments E-4a and E-4b, respectively. A sample VWP field data report is provided in Attachment E-4c.

5.1.3 Data Compilation and Reporting

Data should be compiled, tabulated, and plotted for each VWP after each monitoring event. A sample VWP data report is provided in Attachment E-4d.

5.1.4 Action levels

The information obtained from the VWPs will be used in conjunction with settlement platform data, vane shear test data and laboratory shear test results to predict strength gains resulting from consolidation of the tailings.

A secondary purpose of the piezometers will be to monitor potential instability. As fill is placed over the slimes, it is expected that the initial pore pressure increases measured by piezometers will be directly related to the weight of the fill placed above it. During no-load situations it is expected that these pore pressures will slowly dissipate, and consolidation will occur. However, a sudden rise in the pore pressure measured by a piezometer located in a potential shear failure zone (as determined by stability analyses and inclinometer monitoring) would be indicative of excessive shear deformation and potential slope instability.

The following guidance levels will be established for active loading and no loading conditions:

> <u>Active loading conditions</u>: During active loading of an area, the piezometers installed within that area (within a 50 foot radius) will be monitored 2-times per week. Piezometers in other areas located within 200 feet of the loading will be measured once per week. For active loading conditions, the pore pressure readings will be compared to the theoretical pore pressure increase computed based on stress distribution and an

estimated weight of fill placed in the vicinity of the piezometer. If the measured pore pressure increase exceeds 90 percent of the theoretical increase (based on our understanding of the fill unit weight from density measurements), the frequency of measurements will be increased to three times per week. The following measures will also be taken:

- The fill unit weight will be scrutinized;
- Daily readings will continue until the pore pressures subside to below 90 percent of theoretical maximum pore pressure; and
- Additional readings of nearby instrumentation may be implemented.

If the pore pressures exceed 100 percent of the theoretical values, the following actions will be taken:

- The fill unit weight will be scrutinized;
- Daily readings will continue until the pore pressures subside to below 90 percent of the theoretical maximum value;
- Additional inclinometer readings may be implemented;
- Additional instrumentation may be installed to verify the readings; and
- Fill placement in that area may be suspended or delayed until pore pressures dissipate.

<u>No loading conditions</u>. During no loading conditions, the pore pressure readings will be evaluated with respect to the expected dissipation rate and/or rainfall/snowmelt events. If an unexplained increase greater than 10 percent of the pore pressure measured during the previous monitoring event is detected, a guidance level will be triggered and one or more of the following actions will be taken:

- The monitoring frequency will be increased to daily and continued until the increase can be explained; and
- Based upon the findings of the evaluation, additional actions, including increasing the monitoring frequencies of other instruments, performing additional analyses, and adding additional monitoring instrumentation may be necessary.

6.0 VERTICAL SETTLEMENT

Settlement platforms will be utilized to measure the magnitude and time-rate of vertical settlement. The installation and monitoring of eight (8) settlement platforms is planned, as described in the subsections below.

6.1 SETTLEMENT PLATFORMS

Six (6) settlement platforms should be installed in fill areas within the Tailings Impoundment, adjacent to proposed VWP locations, and two (2) platforms should be installed in the fill areas adjacent to existing VWP locations. Proposed settlement platform locations are depicted on Figure E-1.

Vertical deflections at the platforms will be measured to monitor settlement of the tailings. Measurements will also be used to assess the time-rate of settlement at each location and to estimate the percentage of primary consolidation that occurs during fill placement.

6.1.1 Installation

Settlement platforms should be installed such that the bottom of the platform is in direct contact with tailings or an installed working surface.

The locations and elevations (ground surface and reference clamp) of each platform should be surveyed prior to earthwork operations. Survey accuracy will be as follows:

- Horizontal location to the nearest 0.01 foot; and
- Vertical elevation to the nearest 0.01 foot.

Protective boundaries (10-foot radius, minimum) should be established around each platform with high-visibility fence, flagging, or equivalent. During subsequent earthwork activities, shovels and hand-operated walk-behind compaction equipment shall be used to place and compact fill within a 10-foot radius (minimum) of the settlement platforms. The reference clamp should be raised, as necessary, as fill height increases.

Additional settlement platform details are provided in Attachment E-5a.

6.1.2 Monitoring

The settlement platforms should be monitored once per week or after each lift of fill is placed, whichever is more frequent, with a maximum of one reading per day. During each monitoring event, the vertical elevations of both the platform reference clamp and the ground surface should be surveyed to the nearest 0.01 foot at each location. A sample settlement platform field data report is provided in Attachment E-5b.

6.1.3 Data Compilation and Reporting

Settlement and fill thickness data will be compiled, tabulated, and plotted for each settlement platform after each monitoring event. A sample settlement platform data report is provided in Attachment E-5c.

6.1.4 Action Levels

No action levels or limiting criteria for total settlement or the time-rate of settlement at the platform locations are recommended. Settlement trends will be developed during the monitoring period. Substantial deviations from established trends will be cause for increased frequency of monitoring. These measurements are intended to supplement other measurements from the piezometers and inclinometers.

FIGURES

Prepared/Date: BJB 07/31/14
Checked/Date: TCC 07/31/14

NOT FOR CONSTRUCTION

90% BASIS OF DESIGN REPORT
TAILINGS IMPOUNDMENT
CALAHAN MINE SUPERFUND SITE
BROOKSVILLE, MAINE

amec

GEOTECHNICAL
INSTRUMENTATION PLAN
Project 3612-11-2201
Figure E-1

ATTACHMENT E-1

Sample Visual Inspection Report

amec	Project: Location: Client: Job No.:	**Visual Inspection Report**

Date:

Report By:

Weather:

DESCRIPTION AND AREAS OF WORK

INSTRUMENTS READ

GENERAL OBSERVATIONS

ANOMALIES (excess settlement, tension cracks, falling rock, etc.)

Signed By: **Date:**

ATTACHMENT E-2

Slope Inclinometers

ATTACHMENT E-2a

QC Casing Product Information

Inclinometer Casing

Inclinometer Casing

Inclinometer casing is a special purpose, grooved pipe used in inclinometer installations. It is typically installed in boreholes, but can also be embedded in fills, cast into concrete, or attached to structures.

Inclinometer casing provides access for the inclinometer probe, allowing it to obtain subsurface measurements. Grooves inside the casing control the orientation of the probe and provide a surface from which repeatable tilt measurements can be obtained.

Choosing Inclinometer Casing

Although Slope Indicator casing is competitively priced, price should never be the deciding factor in choosing inclinometer casing. The cost of casing is quite small relative to the cost of mobilizing a drill rig, and very small relative to the cost of a failed installation.

This page summarizes the most important factors to consider when choosing casing.

Casing Diameter

The useful life of the casing ends when ground movement pinches or shears the casing, preventing the probe from passing through. Larger diameter casing generally provides longer life.

85mm (3.34") Casing is suitable for landslides and long term monitoring. It is also appropriate for monitoring multiple shear zones or very narrow shear zones, and it is required for the horizontal Digitilt inclinometer probe.

70mm (2.75") Casing is suitable for construction projects. It can also be used for slope stability monitoring when only a moderate degree of deformation is anticipated.

48mm (1.9") Casing is suitable for applications where small deformations are distributed over broad zones. It is generally not installed in soils.

Casing Grooves

Measurement accuracy is directly influenced by the quality of casing grooves. Slope Indicator optimizes casing grooves for the wheels of the Digitilt inclinometer probe, providing a flat surface for the wheels and also the extra width needed when the probe must pass through cross-axis curvature. Groove spiral is also tightly controlled.

Casing Strength

In borehole installations, the annular space around the casing is usually backfilled with grout. The grouting process can generate pressure high enough to cause the casing to collapse. In deep installations, the pressure of grout must be controlled by stage grouting, but in other cases, the casing must be strong enough to withstand the normal pressure of grouting. Slope Indicator uses thick-walled pipe and carefully controls the depth of the grooves.

Sealable Couplings

If casing joints are not adequately sealed, grout can force its way into the casing and later prevent the probe from reaching its intended depth.

Slope Indicator offers several types of couplings and casings, all of which can be sealed easily and consistently. Our newest designs feature O-ring seals, and our older designs feature tight-fitting surfaces that are fused together with solvent cement.

Assembly

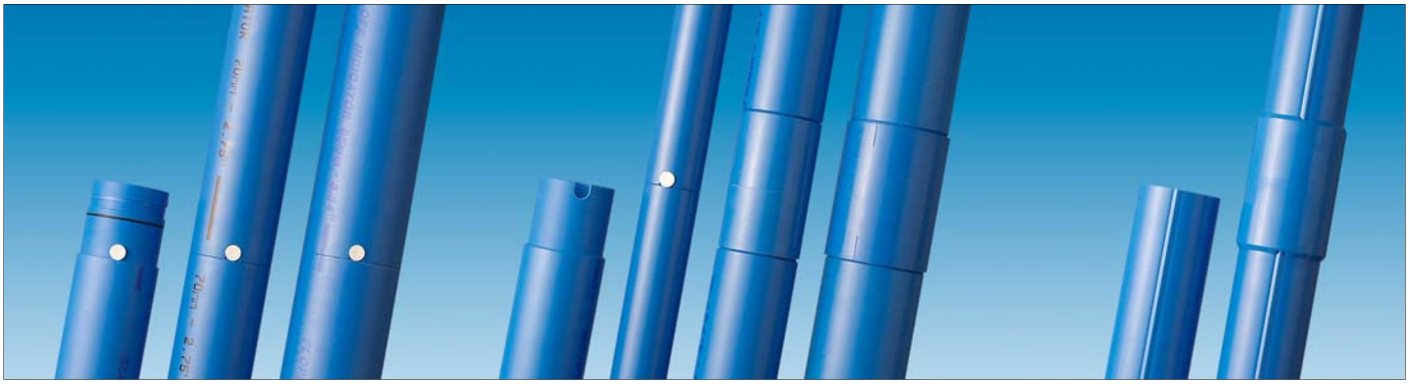
Inclinometer casing should be easy to assemble, even with an untrained crew. Slope Indicator's QC casing, which snaps together, is the current leader in quick and easy assembly. Other types of casing are assembled with shear wires or with solvent cement.

Casing Materials

Slope Indicator uses only ABS plastic for its casing for several reasons. ABS plastic retains its shape and flexibility over a wider range of temperatures than PVC plastic. ABS plastic is much easier to handle and seal than fiberglass casing. Finally, ABS plastic is suitable for long term contact with all types of soils, grouts, and ground water, unlike aluminum casing, which is no longer recommended for any application.

Installation Information

Visit the technical support section at www.slopeindicator.com to find recommended grout mixes, ways to counter casing buoyancy, and notes on other installation issues.



QC CASING

QC (Quick Connect) casing features snap-together convenience and strong, flush joints.

Grooves: Grooves are machine broached for excellent control of width, chamfer, depth, straightness, and spiral.

Sealing: O-ring seals prevent entry of grout.

Coupling: Built-in couplings snap together to make a flush joint. Unique locking mechanism engages full inner circumference of casing, providing much stronger joints than other snap-type casings.

Assembly: Press casing sections together until joint snaps closed. The resulting joint is strong, flush, and grout-proof. Solvent cement, rivets, or tape are not required. O-ring lubricant is applied at factory. Extra O-rings and lubricant are supplied with each box of casing.

Best for: General use.

QC Casing 85mm · 3.34"

Casing OD: 85 mm, 3.34 inches.
Casing ID: 73 mm, 2.87 inches.
Collapse Rating: 12.4 bar, 180 psi.
Load Rating: 635 kg, 1400 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: $\leq$ 0.33° per 3m or 10' section.

QC Casing 70mm · 2.75"

Casing OD: 70 mm, 2.75 inches.
Casing ID: 59 mm, 2.32 inches.
Collapse Rating: 16.5 bar, 240 psi.
Load Rating: 635 kg, 1400 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: $\leq$ 0.33° per 3m or 10' section.

STANDARD CASING

Slope Indicator's traditional inclinometer casing features high-strength, flush joints and is available in three diameters.

Grooves: Grooves are machine broached for excellent control of width, chamfer, depth, straightness, and spiral.

Sealing: Solvent cement and tape.

Coupling: Precision molded couplings have interference fit for high-strength bonding. Small diameter version has integral couplings.

Assembly: Casing and couplings are glued together with ABS solvent cement, riveted, and wrapped with tape.

Best for: General use. The extra-strong joints are helpful in very deep boreholes and oversize boreholes in which casing is not well supported.

Standard Casing 85mm · 3.34"

Coupling OD: 89 mm, 3.51 inches.
Casing OD: 85 mm, 3.34 inches.
Casing ID: 73 mm, 2.87 inches.
Collapse Rating: 10.6 bar, 155 psi.
Load Rating: 320 kg, 700 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: $\leq$ 0.33° per 3m or 10' section.

Standard Casing 70mm · 2.75"

Coupling OD: 70 mm, 2.75 inches.
Casing OD: 70 mm, 2.75 inches.
Casing ID: 59 mm, 2.32 inches.
Collapse Rating: 15 bar, 220 psi.
Load Rating: 320 kg, 700 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: $\leq$ 0.33° per 3 m or 10' section.

Standard Casing 48mm · 1.9"

Casing OD: 48 mm, 1.9 inches.
Casing ID: 38 mm, 1.5 inches.
Collapse Rating: 24 bar, 350 psi.
Load Rating: 320 kg, 700 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: $\leq$ 0.33° per 3 m or 10' section.

EPIC CASING

EPIC casing is an economical casing that can be cut and coupled at any point along its length.

Grooves: Grooves are formed during extrusion and are less precise than broached grooves.

Sealing: Solvent cement, mastic, and tape.

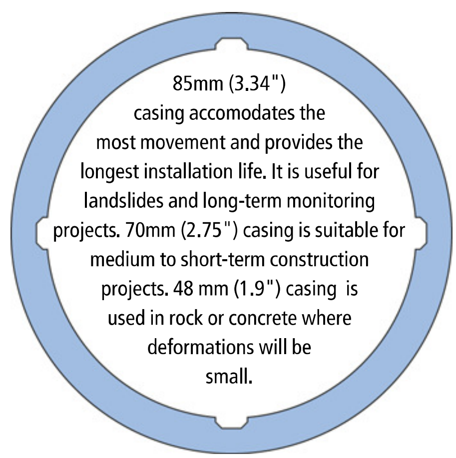
Coupling: Oversize couplings make very strong joints.

Assembly: Casing and couplings are glued together with ABS solvent cement. The joint must then be sealed with mastic and tape.

Best for: General use. Some care must be taken to seal the coupling.

EPIC Casing 70mm · 2.75" Only

Coupling OD: 78 mm, 3.07 inches.
Casing OD: 70 mm, 2.75 inches.
Casing ID: 60 mm, 2.32 inches.
Collapse Rating: 15 bar, 220 psi.
Load Rating: 320 kg, 700 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: $\leq$ 0.5° per 3m or 10' section.



CPI CASING

CPI casing features quick assembly and disassembly and is available in 3 diameters.

Grooves: Grooves are machine broached for excellent control of width, chamfer, depth, straightness, and spiral.

Sealing: O-ring seals prevent entry of grout.

Coupling: Oversize couplings and shear wires make high strength joint.

Assembly: Apply grease to O-rings, press coupling onto casing, and insert shear wire.

Best for: Cold weather assembly or temporary installations that involve repeated disassembly.

CPI Casing 85mm · 3.34"

Coupling OD: 94 mm, 3.7 inches.
Casing OD: 85 mm, 3.34 inches.
Casing ID: 73 mm, 2.87 inches.
Collapse Rating: 11 bar, 155 psi.
Load Rating: 635 kg, 1400 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: ≤ 0.33° per 3m or 10' section.

CPI Casing 70mm ·2.75"

Coupling OD: 76 mm, 3 inches.
Casing OD: 70 mm, 2.75 inches.
Casing ID: 59 mm, 2.32 inches.
Collapse Rating: 15 bar, 220 psi.
Load Rating: 400 kg, 900 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: ≤ 0.33° per 3m or 10' section.

CPI Casing, 48mm · 1.9"

Coupling OD: 54 mm, 2.12 inches.
Casing OD: 48 mm, 1.9 inches.
Casing ID: 38 mm, 1.5 inches.
Collapse Rating: 24 bar, 350 psi.
Load Rating: 320 kg, 900 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: ≤ 0.33° per 3 m or 10' section.

SHEAR-WIRE CASING

Shear-Wire casing features flush joints that can be assembled easily in cold weather.

Grooves: Grooves are machine broached for excellent control of width, chamfer, depth, straightness, and spiral.

Sealing: O-ring seals prevent entry of grout.

Coupling: Built-in couplings lock together with removable nylon shear wire to make flush joint.

Assembly: Press casing sections together, then insert shear wire. The result is a flush, grout-proof joint. Solvent cement, rivets, and tape are not required. O-ring lubricant is applied at the factory. Extra O-rings, lubricant, and shear wires are supplied with each box of casing.

Best for: Easy assembly in weather that is too cold for solvent cement or snap-together joints. Generally used in water-filled boreholes.

Shear Wire Casing 85mm · 3.34"

Casing OD: 85 mm, 3.34 inches.
Casing ID: 73 mm, 2.87 inches.
Collapse Rating: 12.4 bar, 180 psi.
Load Rating: 225 kg, 500 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: ≤ 0.33° per 3m or 10' section.

Shear Wire Casing 70mm · 2.75"

Casing OD: 70 mm, 2.75 inches.
Casing ID: 59 mm, 2.32 inches.
Collapse Rating: 16.5 bar, 240 psi.
Load Rating: 225 kg, 500 lb.
Temp rating: -29 to 88 °C, -20 to 190 °F.
Spiral: ≤ 0.33° per 3m or 10' section.

GROUT VALVES

Grout valves allow placement of grout backfill in boreholes that cannot accommodate an external grout pipe. The one-way valve is installed in the bottom section of casing. A grout pipe is lowered through the casing to mate with the grout valve and deliver the grout.

TELESCOPING SECTIONS

Optional telescoping sections accommodate 150 mm (6 inches) of compression or extension. Fully extended, each telescoping section adds 0.76 m (2.5 feet) of length to the casing

CASING ANCHORS

In its fluid state, grout exerts an uplift force that can push even water-filled casing out of the borehole. Holding the casing down from the top has unfortunate side-effects: the casing goes into compression and snakes from side to side in the borehole. Thus casing curvature is present from the start, and slight variations in the positioning of the probe are more likely to produce reading errors..

The casing anchor, installed in place of the bottom cap, provides a convenient way to counter casing buoyancy and reduces casing curvature, since the casing self-centers in the borehole. The anchor has spring loaded arms that are activated when a pin is pulled. Anchors are available for 70 mm and 85 mm casing.

QC CASING 85MM · 3.34"

Casing Section, 10' (3.05 m)	51150310
Casing Section, 5' (1.52 m)	51150311
Section, Telescoping	51150320
Cap, Bottom	51150330
Cap, Bottom, Heavy Duty	51100520
Grout Valve, Gasket Type	51100830
Cap, Top	51100500
Cap, Locking	51100550
Splice Kit, Male	51150350
Splice Kit, Female	51150351

QC CASING 70mm · 2.75"

Casing Section,10' (3.05 m)	51150210
Casing Section, 5' (1.52 m)	51150211
Section, Telescoping	51150220
Cap, Bottom	51150230
Cap, Bottom, Heavy Duty	51101520
Grout Valve, Gasket Type	51100820
Cap, Top	51101500
Cap, Locking	51101550
Splice Kit, Male	51150250
Splice Kit, Female	51150251

STANDARD CASING 85mm · 3.34"

Casing Section, 10' (3.05 m)	51100100
Casing Section, 5' (1.52 m)	51100105
Telescoping Section	51106400
Coupling	51100200
Cap, Bottom, Heavy Duty	51100520
Grout Valve, Gasket Type	51100830
Cap	51100500
Cap, Locking	51100550
Pop Rivet AD44H	51103301

STANDARD CASING 70mm · 2.75"

Casing Section, 10' (3.05 m)	51101100
Casing Section, 5' (1.52 m)	51101105
Telescoping Section	51107400
Coupling	51101200
Cap, Bottom, Heavy Duty	51101520
Grout Valve, Gasket Type	51100820
Cap	51101500
Locking Cap with Padlock	51101550
Pop Rivet AD42H	51003303

STANDARD CASING 48mm · 1.9"

Casing Section, 5' (1.52 m)	51102305
Cap	51102500
Locking Cap with Padlock	51102550
Grout Valve, Gasket Type	51104000

EPIC CASING 70mm · 2.75"

Casing Section, 10' (3.05 m)	51111100
Coupling	51111200
Telescoping Coupling	51111400
Cap, Bottom, Heavy Duty	51101520
Grout Valve, Gasket Type	51100820
Cap	51111500
Locking Cap with Padlock	51101550
Pop Rivet AD46H	51003310
Lubricant for Telescoping Coupling	57504000

CPI CASING 85mm · 3.34"

Casing Section, 10' (3.05 m)	57500100
Casing Section, 5' (1.52 m)	57500105
Telescoping Section	57506400
Coupling with 2 Shear Wires	57500200
Cap with Shear Wire	57500500
Cap, Bottom, Heavy Duty	51100520
Grout Valve, Gasket Type	51100830
Cap, Top	51100500
Spare Nylon Shear Wire	57500700
O-Ring Lubricant	57504000

CPI CASING 70mm · 2.75"

Casing Section, 10' (3.05 m)	57501100
Casing Section, 5' (1.52 m)	57501105
Telescoping Section	57507400
Coupling with 2 Shear Wires	57501200
Cap with Shear Wire	57501500
Cap, Bottom, Heavy Duty	51101520
Grout Valve, Gasket Type	51100820
Cap, Top	51101500
Spare Nylon Shear Wire	57501700
O-Ring Lubricant	57504000

CPI CASING 48mm · 1.9"

Casing Section, 5' (1.52 m)	57502105
Coupling with 2 Shear Wires	57502200
Cap with Shear Wire	57502500
Grout Valve, Gasket Type	57503700
Cap, Top	51102500
Spare Nylon Shear Wire	57502700
O-Ring Lubricant	57504000

SHEAR WIRE CASING 85mm · 3.34"

10' (3.05 m) Casing Section	51160310
5' (1.52 m) Casing Section	51160311
Section, Telescoping	51160320
Cap, Bottom	51160330
Cap, Bottom, Heavy Duty	51100520
Grout Valve, Gasket Type	51100830
Cap, Top	51100500
Cap, Locking	51100550

SHEAR WIRE CASING 70mm · 2.75"

Casing Section, 10' (3.05 m)	51160210
Casing Section, 5' (1.52 m)	51160211
Section, Telescoping	51160220
Cap, Bottom	51160230
Cap, Bottom, Heavy Duty	51101520
Grout Valve, Gasket Type	51100820
Cap, Top	51101500
Cap, Locking	51101550

CASING ANCHORS

Casing Anchor, 85 mm (3.34")	51104385
Casing Anchor, 70 mm (2.75")	51104370
Anchor + Grout Valve, 85mm(3.34")	51104485
Anchor + Grout Valve, 70mm(2.75")	51104470

INSTALLATION ACCESSORIES

Mastic Sealing Tape	51003800
Vinyl Tape	51003900
Duct Tape	51004000
ABS Solvent Cement, 1/2 pint	51103401
ABS Solvent Cement, 1 pint	51103402
Pop Rivet Gun	50100202
Casing Clamp	50100200

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CE

ATTACHMENT E-2b

QC Casing Installation Guide

QC Inclinometer Casing Installation Guide

51150099

Inclinometer casing should be installed by technically-qualified personnel. This publication is provided as a guide only and is not intended to substitute for the expertise of a qualified engineer or to supersede project specifications or instruction manuals.

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SLOPE INDICATOR

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Contents

1

Introduction

Notes

The Advantages of QC Inclinometer Casing

QC inclinometer casing combines the quality and precision of Slope Indicator's traditional inclinometer casing with a patented* coupling system that saves time and virtually eliminates assembly mistakes.

The patented QC coupling system provides snap-together convenience and creates strong, flush joints without glue, rivets, or tape. The QC joint won't pull part. It won't twist out of alignment. It won't break if you bend it. And it won't leak or collapse under the pressure of grout.

Quality and precision are easily seen in the spiral-free, machine-broached guide grooves. The shape of the grooves promotes repeatable positioning of the inclinometer probe. The uniform depth of the grooves prevents weak spots along the casing wall that could fail under the pressure of grout.

If you're an engineer who requires accurate inclinometer data, or if you are installer who needs reliable casing that installs quickly, you'll like the way QC inclinometer casing performs.

*US Patent #5,015,014

QC Casing Part Numbers

85 mm (3.34 inch) Casing	Part No.
10-Foot Section	51150310
5-Foot Section	51150311
Telescoping Section	51150320
Bottom Cap	51150330
Top Cap	51100500
Locking Cap with Padlock	51100550
Splice Kit, Male	51150350
Splice Kit, Female	51150351
85 mm Grout Valve, Gasket-Type	51150335
85 mm Grout Valve, Quick-Connect	51150340
Pipe Clamp	50100200

70 mm (2.75inch) Casing	Part No.
10-Foot Section	51150210
5-Foot Section	51150211
Telescoping Section	51150220
Bottom Cap	51150230
Top Cap	51101500
Locking Cap with Padlock	51101550
Splice Kit, Male	51150250
Splice Kit, Female	51150251
70 mm Grout Valve, Gasket-Type	51150235
70 mm Grout Valve, Quick-Connect	51150240
Pipe Clamp	50100200

QC Casing Performance Tests

During the development of QC casing, Slope Indicator established a series of tests to quantify and improve the strength of QC coupling system. The final testing of QC casing was observed by Pacific Testing Laboratories and the results of the testing were certified in a report entitled "Engineering Review of Inclinometer Casing Strength Tests." Please contact Slope Indicator if you are interested in obtaining a copy of the PTL report.

Pull Test

Purpose: To test the performance of QC casing joints under tensile loads.

Materials: QC casing section samples, loading frame, and NIST-traceable equipment including a calibrated hydraulic ram and pressure gauge.

Procedure: The casing section samples were assembled and mounted in the loading frame. The samples were loaded until the casing joints failed.

Results: Both 85 mm (3.34 inch) and 70 mm (2.75 inch) casing sample joints withstood 635 kg (1400 lb) of tension.

Torque Test

Purpose: To test the performance of QC casing joints under twisting forces that could cause misalignment of casing grooves.

Materials: QC casing section samples, torque test frame with lever arm, NIST Class F traceable weights.

Procedure: The casing section samples were assembled and mounted in the torque test frame. The weight suspended from the lever arm was increased until the casing joints failed.

Results: Both 85 mm (3.34 inch) and 70 mm (2.75 inch) casing sample joints withstood 33 N.m (25 ft.lb) of torque.

Bending Test

Purpose: To test the performance of QC casing joints under bending moments.

Materials: QC casing sections, a test frame, and NIST Class F traceable weights.

Procedure: Casing sections were assembled and then supported at opposite ends, with the unsupported joint in the middle. Weights were suspended from the casing sections on both sides of the joint to create a bending moment across the joint. Weight was then increased until the joint failed.

Results: Both 85 mm (3.34 inch) and 70 mm (2.75 inch) casing joints withstood a bending moment of 186 N.m (140 ft.lb).

Pressure Test

Purpose: To test the O-ring seals and the collapse strength of the QC joint by subjecting them to compressive forces.

Materials: QC casing sections, a water-filled pressure vessel, and an NIST-traceable pressure gauge.

Procedure: Casing sections were assembled and placed in the pressure vessel, which was designed to apply pressure to the casing wall and joint, but not to casing ends, which were left open to atmosphere. Water pressure was increased until the casing failed.

Results: The 85 mm (3.34 inch) casing joints withstood a minimum of 12.4 bar (180 psi). The 70 mm (2.75 inch) casing joints withstood 16.5 bar (240 psi).

2

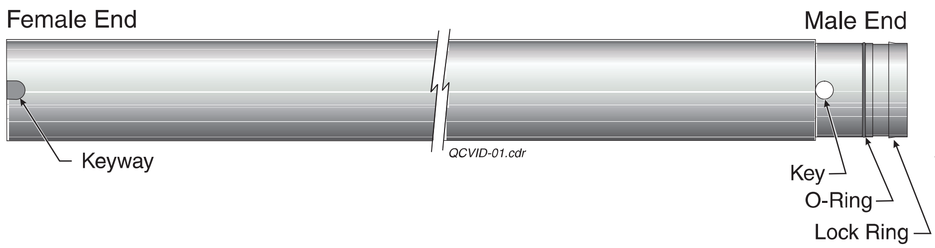
Assembling QC Casing

Notes

Assembling QC Casing

QC Casing Sections

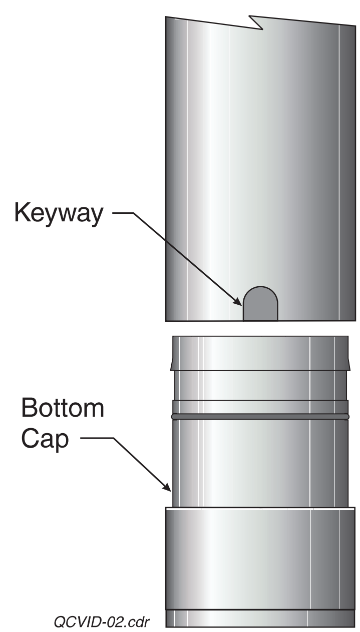
Each section of casing has a male end with an alignment key, an O-ring, and a lock ring, and a female end with a keyway. It takes about 30 pounds to snap two sections of casing together.



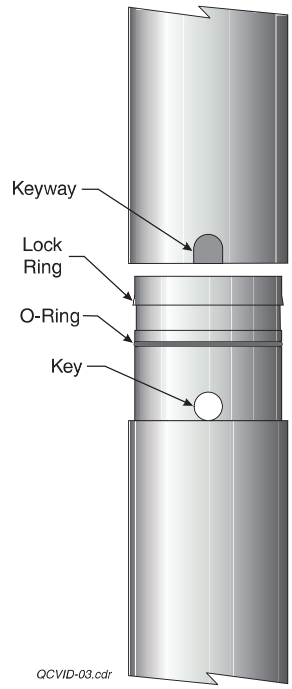
The O-ring and lock-ring are greased at the factory and protected by a cap. At assembly time, remove the cap and check that the O-ring and lock ring are still greased. Be sure to keep casing ends clean.

Installing a Bottom Cap or Grout Valve

1. Remove protective cap.
2. Place bottom cap or grout valve on ground with male end up.
3. Push female end of casing section onto bottom cap or grout valve. You will hear a “snap” as the lock ring is seated.

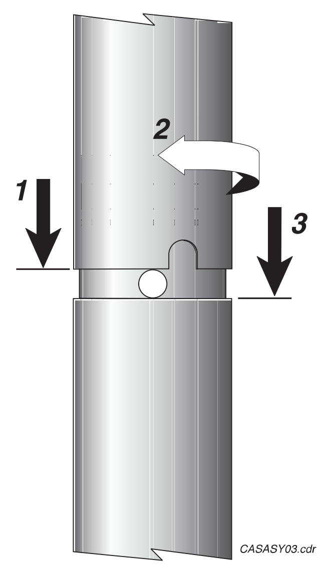


Assembling Casing Sections



1. Remove protective caps and check that O-ring and lock ring are greased.
2. Align the key and keyway of the two sections.
3. Push the sections together until the joint snaps closed. If the O-ring is caught in the keyway, pull the sections apart and start again.

Speed Hint



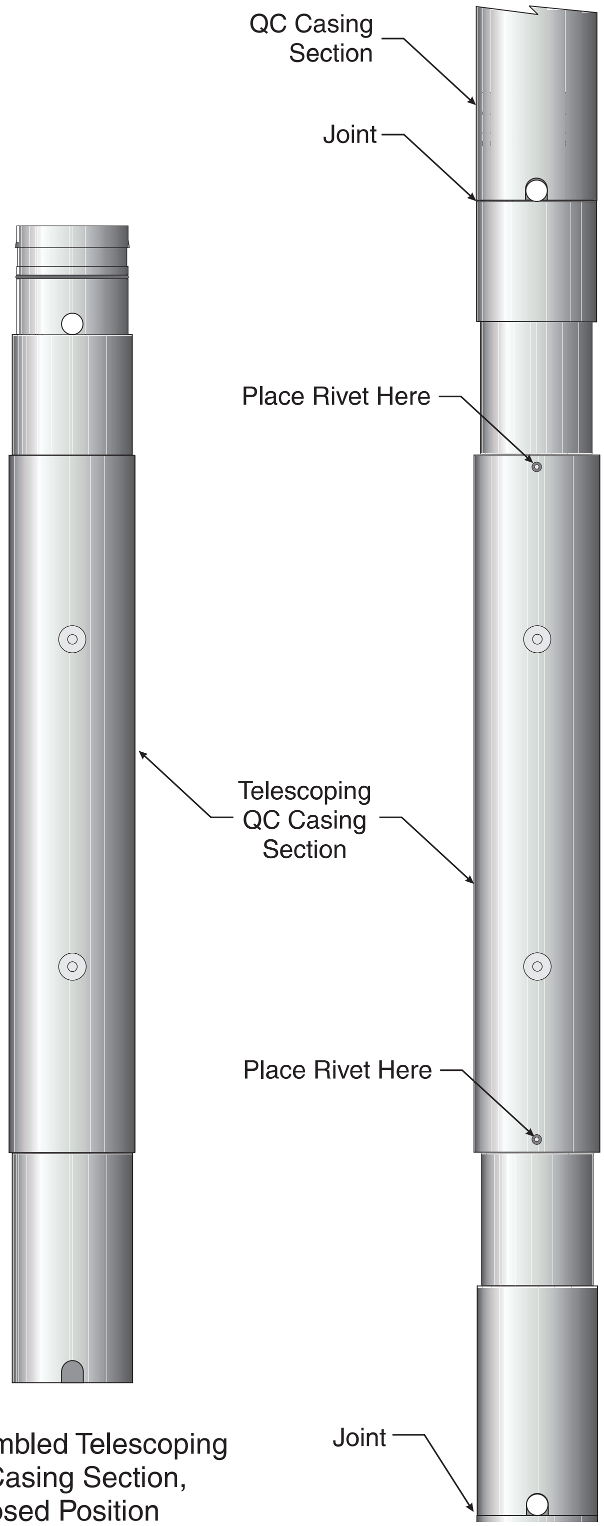
You may find this alternative assembly procedure easier:

1. Push the sections together until the end of the casing touches the alignment key.
2. Turn the casing into alignment.
3. Snap the joint closed.

Assembling Telescoping Sections

Each QC telescoping section allows six inches of compression or extension. The sliding sleeves of the section are equipped with QC ends, allowing the telescoping section to be inserted between two QC casing sections.

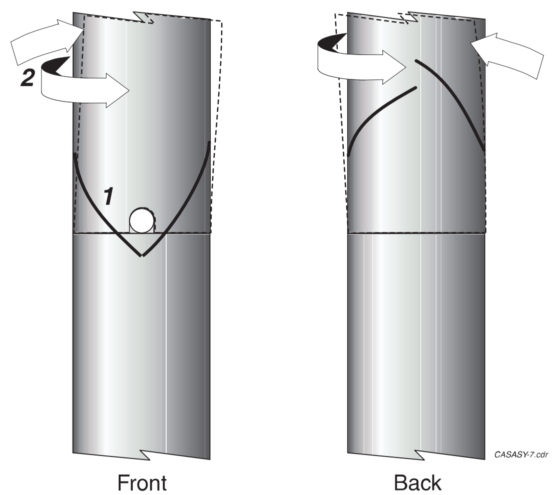
To accommodate settlement, the telescoping sections should be installed with sleeves extended. Use one rivet to hold each sleeve. Place the rivet about 1/2 inch from the edge of the section body and aligned with the key and keyway (see drawing on the next page). To counter buoyancy, be sure to apply a down force to the bottom of the casing. The single rivets may not hold if you apply a down force from the top.



Unassembled Telescoping QC Casing Section, Closed Position

Taking Apart QC Casing

1. Use a hacksaw to cut the casing. Start cutting just below the alignment key. End the cut about 3½ to 4 inches above the joint as shown in the drawing. Cut through the first layer of casing only. Do not allow cuts to intersect.
2. Pry the casing loose, starting at the key. Then bend the casing until you can remove it.



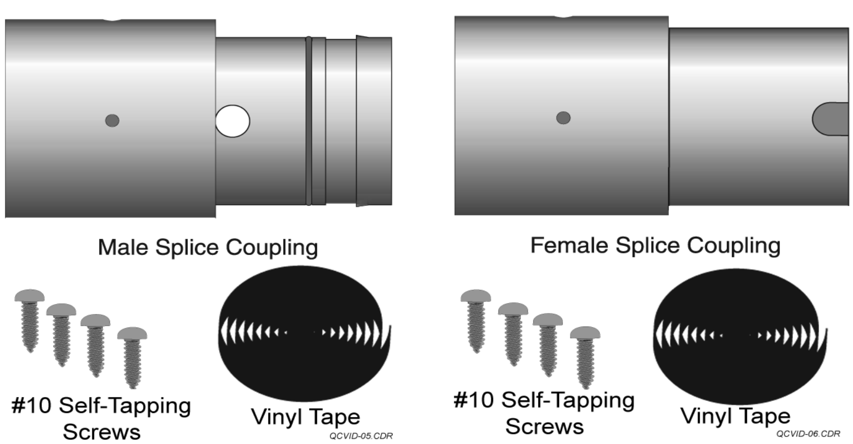
Reassembling QC Casing

1. Remove burrs and rough edges.
2. Glue and rivet the reassembled joint. Place rivets at 90 degree intervals around the joint, starting the first rivet just above the keyway.
3. Seal the entire joint with tape.

Splicing QC Casing

Damaged QC casing can be repaired using a QC casing splice kit. Splice kits include a male or female coupling, self-tapping screws, and vinyl tape. You will need a hack-saw, drill, and screwdriver.

1. Cut off damaged casing. Remove burrs.
2. Slide the splice coupling onto the end of the casing and align it with the grooves in the casing.
3. Drill holes in the casing using the pre-drilled holes on the splice coupling as a guide. Use drill size 5/32" or 4.0 mm on self-tapping screws.
4. Insert the self-tapping screws into the pre-drilled holes and screw them into the casing.
5. Seal the joint with vinyl tape.
6. The casing section now has a good QC end and can be used normally.



3

Installing QC Casing

Notes

Installation Concerns

How to Store Casing

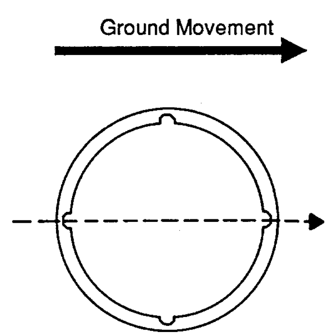
Casing should be supported evenly so that it does not warp or bend during storage. In the field, keep casing in the shade, if possible, since prolonged exposure to the heat of direct sunlight can cause deformation.

Check Borehole Depth

Check the depth of the borehole before you begin installing the casing. Also consider that grout valves or external weights may require a deeper borehole.

Align Grooves with Direction of Movement

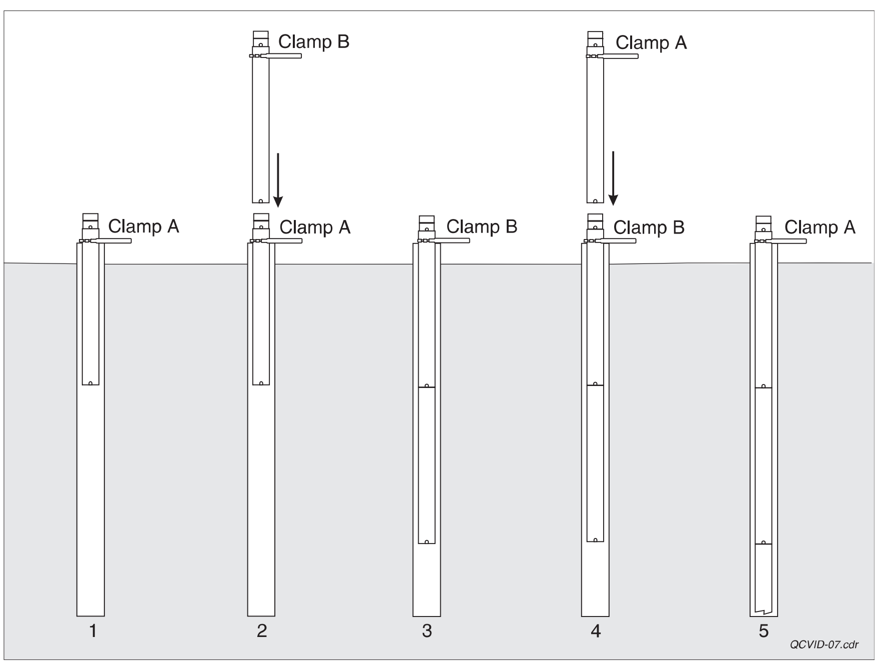
It is important to align one set of casing grooves with the expected direction of movement (see drawing below). A guide line is printed on the casing to help you maintain this orientation.



Using Pipe Clamps

Use pipe clamps to hold the casing at the borehole collar while you add the next section of casing. In dry boreholes or in situations where down hole problems seem likely, rig a safety line to provide extra security and a way to retrieve the casing, if necessary.

1. Attach Clamp A to the top of the first section of casing. Lower the casing into the borehole until the clamp rests on the borehole collar.
2. Attach Clamp B to the top of the next section. After you snap the new section onto the casing, remove Clamp A and lower the new section into the borehole until Clamp B rests on the borehole collar.
3. Now attach Clamp A to the next section of casing, make the joint and lower it into the borehole. Continue alternating Clamp A and clamp B on successive sections of casing.



Casing Buoyancy

Casing will float in water-filled boreholes, so you must fill it with water to install it down hole. However, when you pump grout into the borehole, the water-filled casing becomes buoyant again, because the grout is denser than water.

To counter this buoyancy, you should apply a down force at the bottom of the casing. You can lower a steel pipe to the bottom of the casing or you can suspend a non-retrievable weight from the bottom of the casing when you install it. A suspended weight requires a deeper borehole and may require use of a safety line.

Note that a down force applied at the top of the casing is likely to distort the casing profile. For this reason, we recommend that you do not park a drill rig over the casing or apply any other top-down method of counteracting buoyancy.

Grouting

You will need a mixer, a grout pump, a pipe or hose for delivering the grout, and optionally, a grout valve installed in the bottom section of the casing. We recommend that you do not mix the grout by hand. We also recommend that you do not use a water pump to place the grout, since pumping grout would damage it.

Properly mixed grout should be free of lumps. It has to be thin enough to pump but thick enough to set in a reasonable length of time. If the mixture is too watery, it will shrink excessively, leaving the upper portion of the borehole ungrouted. Also, avoid the use of admixtures and grouts that cure at high temperature since these may damage the casing.

Grouting continued

Ideally, the grout should be mixed to match the strength and deformation characteristics of the ground around the borehole. In practice, the main consideration is to use a grout that allows the casing to move with the surrounding soil.

If you have no other guidance, try one of the following "general purpose" mixtures. The compressive strength of these mixtures is about 500 lb/ft^2 at a 28 day cure time. The bentonite mixture swells to seal the borehole, but the lime mixture does not.

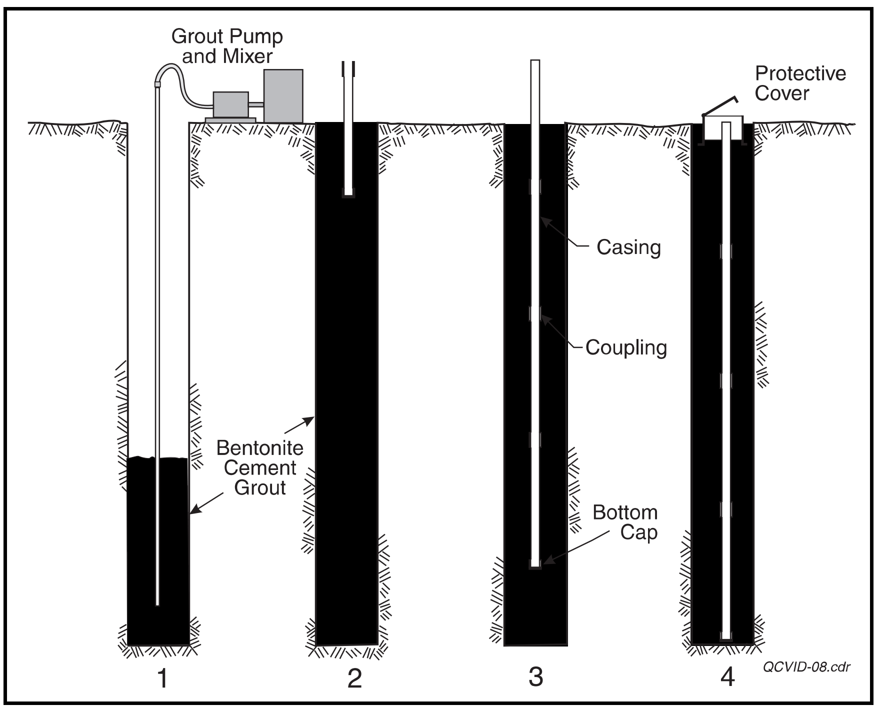
Bentonite-Cement Grout		
Materials	Weight	Percent
Portland Cement	94 lb (1 bag)	15%
Bentonite*	39 lb	6%
Water	75 gallons	79%
*Mix bentonite with water first, then with the cement		

Lime-Cement Grout		
Materials	Weight	Percent
Portland Cement	94 lb (1 bag)	15%
Hydrated LIme	150 lb	33%
Water	25 to 30 gallons	46%

Installation Methods

Pre-Grouting the Borehole

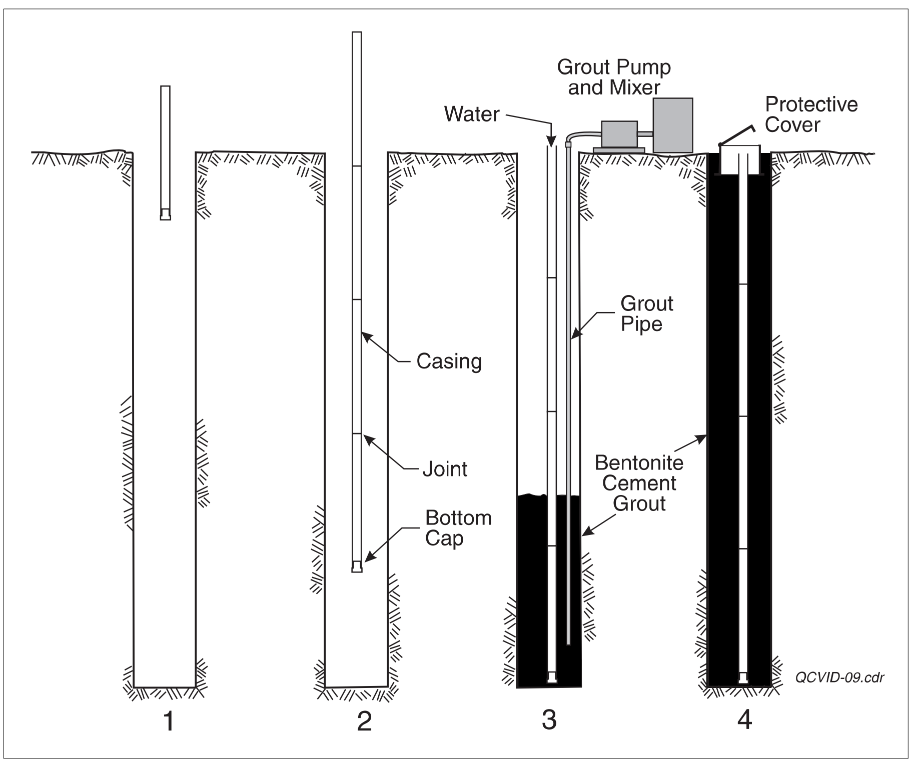
1. Clear the borehole of debris. Check the borehole depth. Lower the grout pipe to the bottom of the borehole. Pump in the grout and then retrieve the grout pipe.
2. Attach the bottom cap to the bottom section of casing.
3. Install casing to the specified depth. Keep casing filled with water to counteract buoyancy.
4. Lower a steel bar or drill pipe to the bottom of the casing to counteract buoyancy. Allow the grout to set. Later, top off the borehole with grout and install a protective cover.



Using an External Grout Pipe

This method is used in boreholes that have room for a grout pipe (or hose) in the annulus between the casing and the borehole wall.

1. Clear the borehole of debris. Check the borehole depth. Attach bottom cap. Attach grout hose, if used.
2. Install casing to the specified depth. Lower pipe to the bottom of the casing to counteract buoyancy. Cap the casing to prevent entry of grout.
3. Lower the grout pipe to the bottom of the borehole and pump in grout. You may have to "jet" the pipe into place by pumping a mixture of grout and water. Then pump in grout and retrieve the grout pipe.
4. Allow the grout to set. Later, top off the borehole with grout and install a protective cover.



Using a Grout Valve

Grout valves are used when casing is installed in small diameter boreholes that do not allow use of an external grout pipe. The grout valve is a one-way valve installed in the bottom cap of the casing. A grout pipe is lowered through the casing to mate with the grout valve and deliver grout.

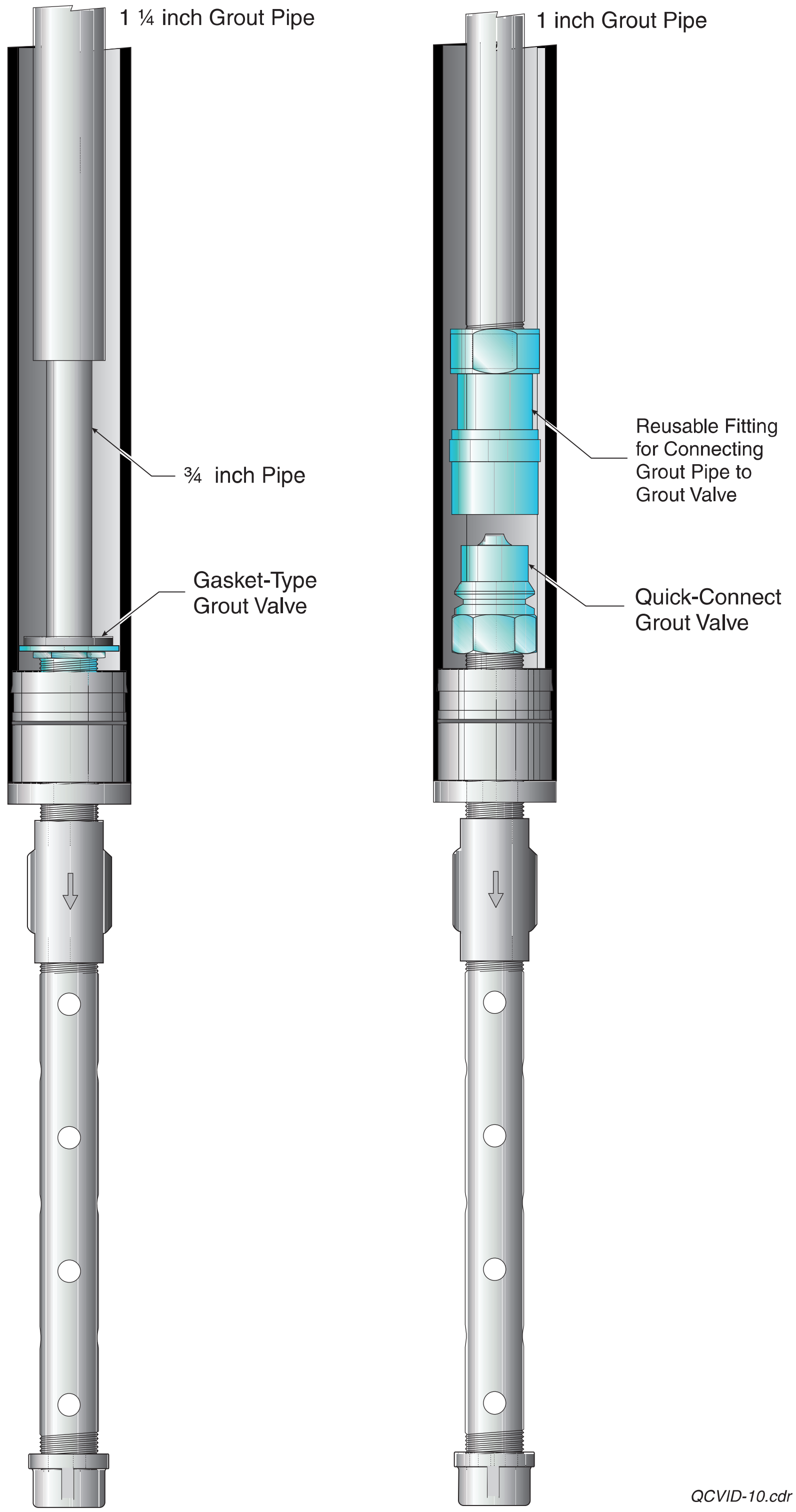
Grout valves add about two feet to the effective length of the casing, so the borehole should be about two feet deeper to compensate.

Types of Grout Valves

Grout valves are illustrated on the next page.

The gasket-type grout valve couples with the grout pipe via a straight pipe with a rubber gasket at its base. The grout pipe is lowered onto the grout valve rest on the gasket. This prevents grout from entering the casing. However, when the grout pipe is withdrawn, grout spills out of the pipe into the casing and must be flushed out with water.

The quick-connect grout valve has a quick connect fitting that mates with another quick-connect fitting that is attached to the grout pipe. When the grout pipe is withdrawn, very little grout leaks into the casing. However, as you are retrieving the pipe, you must be careful not to spill grout into the casing, since you will have to flush it out.


1 ¼ inch Grout Pipe
¾ inch Pipe
Gasket-Type Grout Valve
1 inch Grout Pipe
Reusable Fitting for Connecting Grout Pipe to Grout Valve
Quick-Connect Grout Valve
QCVID-10.cdr

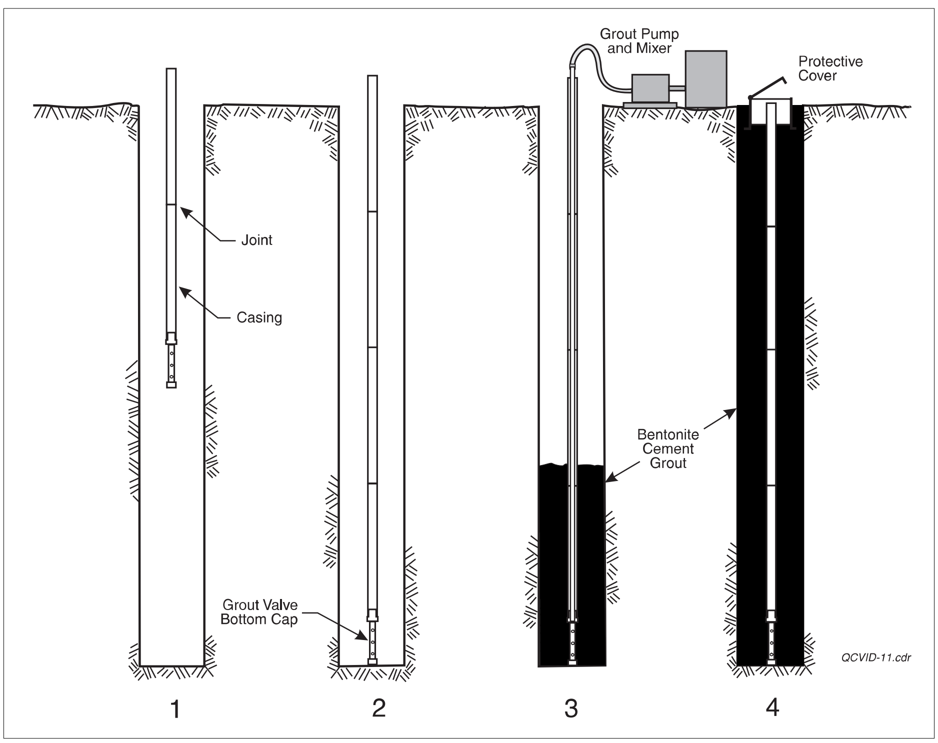
Using a Grout Valve

1. Install grout valve on bottom section of casing. Install casing to the required depth.
2. Lower the grout pipe into the casing until it contacts the grout valve. Rotate the pipe until it slips onto the grout valve connector. Successful coupling can be tested by pumping water through the grout pipe. If the water level inside the casing rises, reposition the pipe and test again.
3. Pump in grout until it spills out at the surface. The weight of the grout pipe will keep the casing from floating. Note: If you installed dry casing, pump water into the casing as the grout level rises.
4. When you retrieve the grout pipe, the casing will float upwards, so you must be prepared to hold the casing down as you retrieve the pipe. Follow either of the two procedures below:
   - **Gasket-type valve:** If you are using the gasket-type grout valve, raise the grout pipe well above the grout valve and pump water into the casing to flush out the grout. When clean water spills out at the surface, gradually lower the pipe and continue to flush until you have flushed grout from the bottom of the casing. Then disconnect the pipe at the surface and leave it in the casing to counteract buoyancy. When the grout sets, withdraw the pipe.

Using a Grout Valve continued

- **Quick-connect valve:** If you are using a quick-connect grout valve, retrieve the grout pipe and flush it with water. Then lower pipe into the casing to counteract buoyancy. You must avoid contact with the quick-connect valve, since it can be opened easily. You can fabricate a bracket that fits over the quick-connect valve (the quick connect fitting stands about 3 inches off the bottom of the casing) or you can use a 1.5-inch schedule 40 water pipe (which has ID of about 1.6 inches), which will slip over the quick-connect valve. After the grout sets, withdraw the pipe.

5. Finally, top off the borehole with grout and install a protective cover.



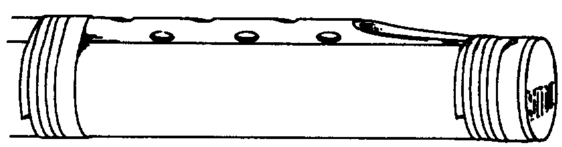
Stage Grouting

In stage grouting, grout backfill is placed in stages, so that the pressure of grout never exceeds the collapse strength of the casing. In general, you should consider stage grouting when the depth of the borehole exceeds 200 feet.

- Grout can be delivered by hose or pipe. Hose must be installed with the casing, but it is disposable and can be left in place after grouting.
- Stage grouting with hoses requires at least two hoses. The first pipe should extend to the bottom of the bore-hole. The next pipe should extend to bottom of the the next stage, and so on.
- Be sure to label or color-code each grout pipe to avoid accidentally pumping grout or water down the wrong pipe.
- Make some provision to counter buoyancy of the casing. This is best done by applying a down force at the bottom of the casing.

Overview of Stage Grouting with Hoses

1. Hoses are fixed to the casing as shown in the drawing below. In Stage 1, calculate the volume of grout needed to backfill the borehole above the end of the Stage 2 grout hose. Pump in that volume of grout plus about 30%. Leave the Stage 1 grout hose in place.
2. Pump water through the Stage 2 grout hose. The bottom of the Stage 2 hose should be below the surface of the grout, and pumping in water should flush grout from the borehole. If no grout appears, pump more grout through the Stage 1 hose and then test again. Using this method, you can be relatively certain that Stage 1 is grouted
satisfactorily. Continue pumping water through the Stage 2 hose until "clear" water flushes from the borehole. This ensures that the Stage 2 hose will be clear for use later.
3. When the State 1 grout has set, grout Stage 2. Since the bottom of the casing is now grouted in place, buoyancy will no longer be a problem.



To prepare a polyethylene hose for grouting, cut a wedge-shaped end and several additional holes. Then tape the hose to the casing.

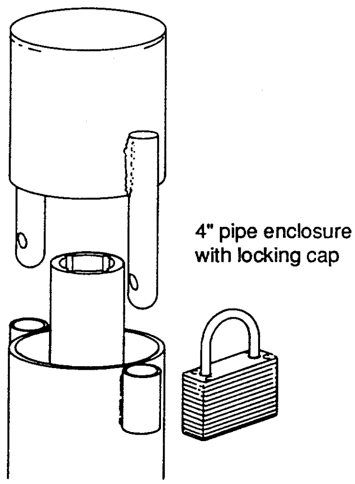
4

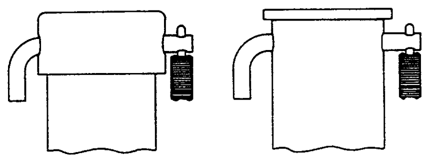
Termination

Notes

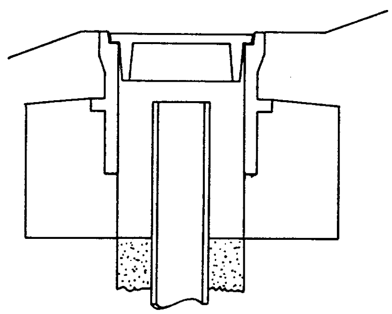
Protective Caps and Enclosures

Project specifications usually require that the installation be protected from traffic, vandalism, and debris. In some locations, a locked cap may provide sufficient protection. In other locations, a locking steel enclosure or a monument case may be required.





Locking Caps



Monument Case

Accommodating a Pulley Assembly

Keep in mind that the inclinometer user will want to attach a pulley assembly to the top of the casing. If the top of the casing is deep inside a protective pipe, the user will not be able to attach the pulley. Ideally, the enclosure should be installed so that the top of the enclosure is only an inch or two above the top of the casing. When the top of the casing is deeper, the enclosure must provide a 10 inch clearance around the casing if the pulley is to be attached directly to the casing.

Notes

ATTACHMENT E-2c

Inclinometer System Product Information

Digitilt Classic Inclinometer System

Digitilt Classic System

Slope Indicator's classic inclinometer system has a world-wide reputation for durability, high precision, and rapid response.

The classic system includes the Digitilt probe, heavy-duty control cable, the DataMate II readout, and DigiPro2 software.

Applications

Inclinometers are used to monitor subsurface movements in landslides, embankments, dams, and deep excavations.

Inclinometer casing is installed in a vertical borehole that passes through suspected zones of movement into stable ground.

The Digitilt Classic system is used to survey the casing. The first survey establishes the initial profile of the casing. Changes in the profile, revealed by comparing subsequent surveys to the initial, indicate that ground movement has occurred.

Plots of inclinometer data show the magnitude, direction, and rate of ground movement.

Operation

To start a survey, the operator selects an inclinometer from a list stored in the DataMate. The DataMate displays a starting depth for the survey.

The operator positions the probe and watches the DataMate for a "ready" signal that indicates that the reading is stable. To record the reading, the operator clicks the hand switch. The DataMate confirms with a beep and displays the next depth.

The operator repositions the probe, watches for the ready signal, and records the reading, repeating these steops until the survey is complete.

If display depth and probe depth get out of sync, the operator can scroll to the required depth, reposition the probe, and continue the survey from that point.

When all readings have been taken, the operator can display checksum statistics to validate the survey.

On return to the office, the operator transfers surveys from the DataMate to the PC using DigiPro2 software. Afterwards, DigiPro2 can process and plot the surveys.

Advantages

Proven Performance: The classic system features the time-tested Digitilt analog probe designed and manufactured by Slope Indicator.

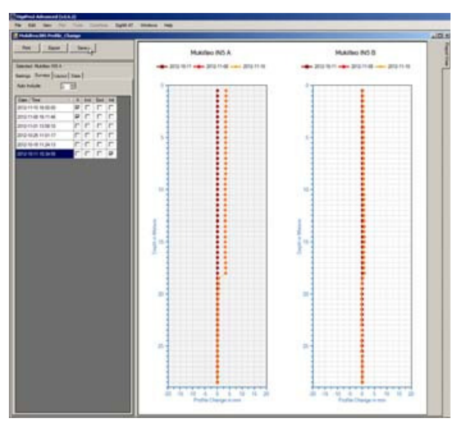
Repeatable Tracking: The Digitilt probe is equipped with robust wheel carriages, sealed wheel bearings, and specially designed wheels to ensure consistent tracking in all types of casing.

Reliable Control Cable: Digitilt control cable is durable and easy to handle. The cable has excellent dimensional stability, and its rubber depth marks are vulcanized to the cable jacket and cannot slip.

Ergonomic Operation: Surveys require just one person, since the cable and hand switch can be gripped at the same time. The pulley also takes the weight of the cable while the reading stabilizes.

Versatile: The Digitilt Classic system includes a horizontal probe, a spiral probe, a portable tiltmeter, slip-ring reels, and other accessories.

DigiPro2 Software: DigiPro2 makes short work of data management and plotting. Its advanced mode provides routines for identifying and correcting errors, reusable reports and many other features.



DIGITILT INCLINOMETER PROBE

Metric-Unit Probe 50302510
English-Unit Probe 50302500

Probe includes stainless steel carrying case. Control cable, reel, pulley, and DataMate are ordered by separate part numbers.

	Metric	English
Sensor Type	Analog force-balanced servo-accelerometers x 2	
Wheel Base	500 mm	24 inch
Cal Range*	±30°	±30°
Sys Resolution*	0.01 mm	0.0006"
Sys Accuracy*	±6 mm / 25m	±0.3"/ 100'
Precision	±0.01% FS	
Temp	-20 to +50 °C	-4 to +122 °F
Material	Stainless Steel	

Calibrated Range: Metric and English unit probes are calibrated to ±30° and have an over-range to ±53° and ±42° respectively.

System Resolution: The resolution derived from a two-pass survey converted to mm and inches per standard interval.

System Accuracy: Specifications were derived empirically from the analysis of a large number of surveys and include errors introduced by casing, probe, cable, readout, and operator. Casing was installed within 3 degrees of vertical. Operators followed recommended survey practices. After correcting for systematic errors, the best accuracy obtainable is ±1.4 mm per 50 readings with metric systems and ±0.05 inch per 50 readings with English systems.

CONTROL CABLE

30m Control Cable 50601030
50m Control Cable 50601050
100m Control Cable 50601100

100 ft Control Cable 50601002
150 ft Control Cable 50601003
300 ft Control Cable 50601004

Depth Marks: Metric cable has 0.5m depth marks English cable has 2 foot marks. Marks are molded onto the cable jacket and cannot slip.

Construction: Cable is supplied with no splices or surface defects. Kevlar core provides tensile strength. Dacron torsion braid counters twist and provides dimensional stability. Polyurethane jacket resists chemicals and abrasions and stays flexible in cold temperatures.

Custom Length Cables: Lengths up to 300m (1000 ft) are available on special order. Extension cables are also available.

DIGITILT DATAMATE READOUT

Digitilt DataMate II 50310900

Readout includes hand switch, battery charger with international plugs, and USB cable for PC.

Compatibility: Digitilt probes, both vertical and horizontal, Digitilt tiltmeters, and spiral sensors.

Survey Types: 2-pass surveys for inclinometer probes; 4-pass surveys for spiral sensors.

Minimum Reading Interval: 0.5 m for metric systems and 12 inches for English systems.

Display: Two line backlit LCD shows readings in traditional sine units: 25000 sine (angle) for metric systems and 20000 sine (angle) for English.

Memory Capacity: 160 installations and 32000 A & B axis readings.

Battery: 6 volt, 6 Ah, lead-acid gell cell powers readout and probe up to 16 hours per charge.

Temp Rating: -20 to 50°C (-4 to 122°F).

Case: Aluminum case is splash proof. Connectors are waterproof when capped or in use.

Size & Weight: 127 x 178 x 178 mm at 3 kg. (5 x 7 x 7" at 6.5 lb).

DIGIPR02 SOFTWARE

DigiPro2 Software . . . . Download
DigiPro2 License Key 50310101

DigiPro2 software is an essential component of the classic system. It has two modes, basic and advanced.

DigiPro2 Basic is free to use and provides all the functions necessary to retrieve surveys from the DataMate and make simple plots.

DigiPro2 Advanced provides correction routines, reports, and many other features that enabled by purchase of a license key. Features are described in a separate datasheet and on the website.

DUMMY PROBE

Metric Wheel Base 50304810
English Wheel Base 50304800
Reel & Line for Dummy Probe . . . 50304900

Dummy probe for testing continuity of casing and grooves and for detecting obstructions or severe distortions of casing that could hinder retrieval of Digitilt probe and control cable.

Dummy probe is stainless steel and has dimensions and wheels identical to those of Digitilt probe. Reel with 60 m (200') of nylon line is used to lower and retrieve dummy probe.

PULLEY ASSEMBLY

Small Pulley. 51104604
Large Pulley 51104606

Pulley assembly fits clamps onto top of casing. Cable hold serves as reference for depth marks. Wheel removes for easy insertion of probe. Order small pulley for 48 or 70 mm casing. Order large pulley for 70 or 85mm casing.

CABLE STORAGE REEL

30m (100') capacity. 50502030
70 m (230') capacity 50502050
100 m (360') capacity 50502110

Sturdy storage reels with large diameter hubs keep cable neat when not in use.

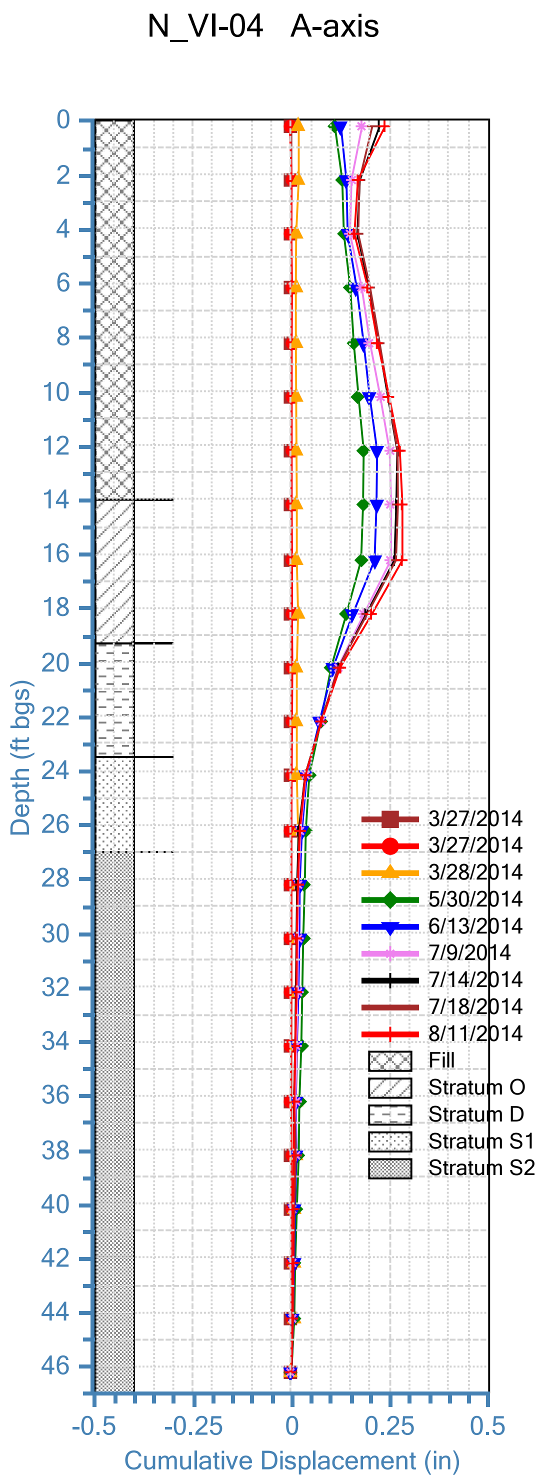
SLIP-RING REEL

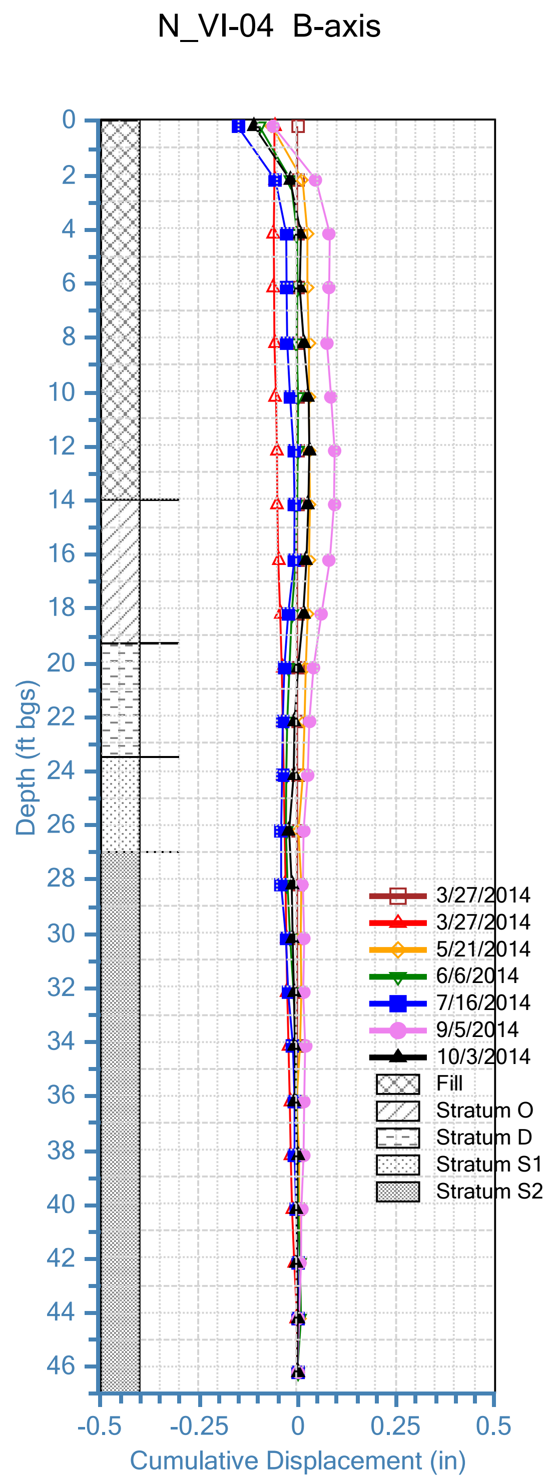
200 m (650') capacity 50503100
300 m (1150') capacity 50503300

Slip-ring cable reel allows the readout to remain connected while the reel is operated. Includes jumper cable to connect reel to readout.

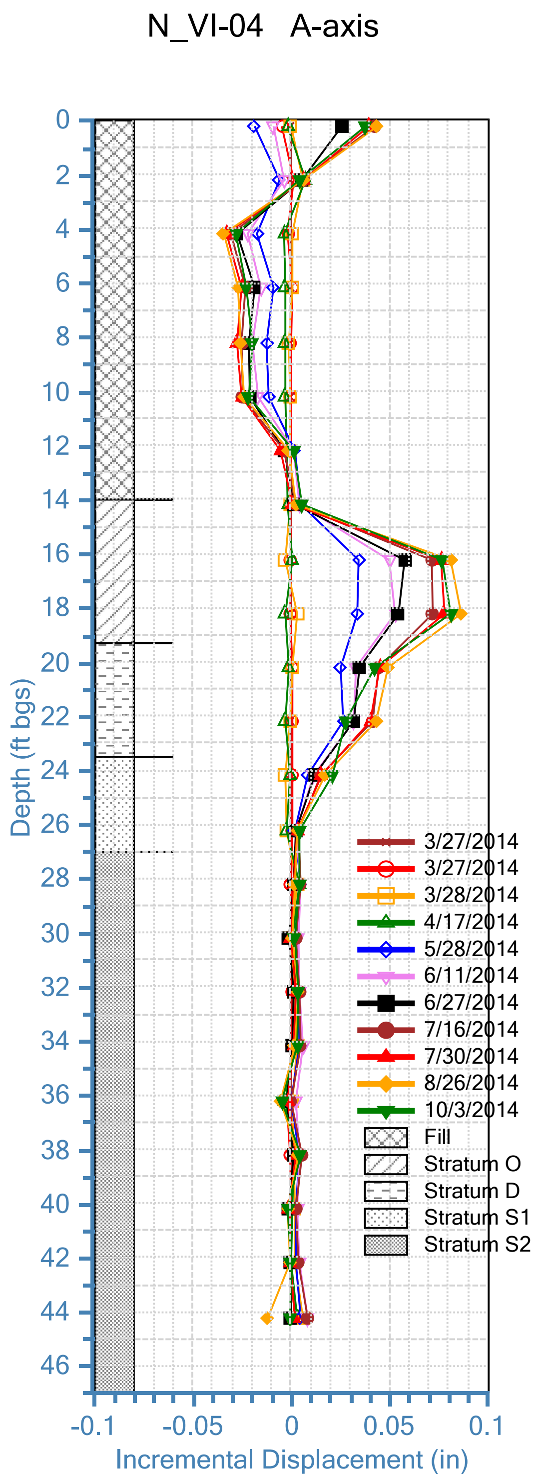
ATTACHMENT E-2d

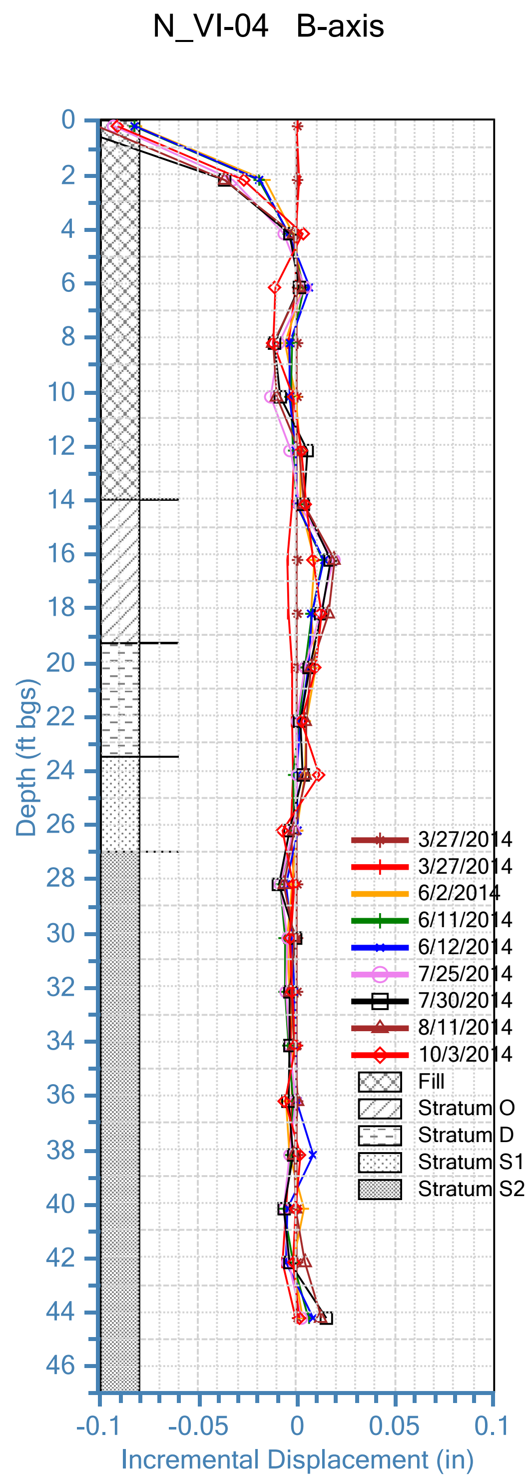
Sample Data Reports





amec	Client:	N_VI-04
	Project:	Inclinometer Data Summary
	Project No.:	Cumulative Displacement





Client:	N_VI-04
Project:	Inclinometer Data Summary
Project No.:	Incremental Displacement

ATTACHMENT E-3

Piezometric Elevation Head

ATTACHMENT E-3a

Sample Field Data Report

	Project:		STANDPIPE PIEZOMETER #
	Location:		
	Client:		

STANDPIPE PIEZOMETER - FIELD DATA SHEET

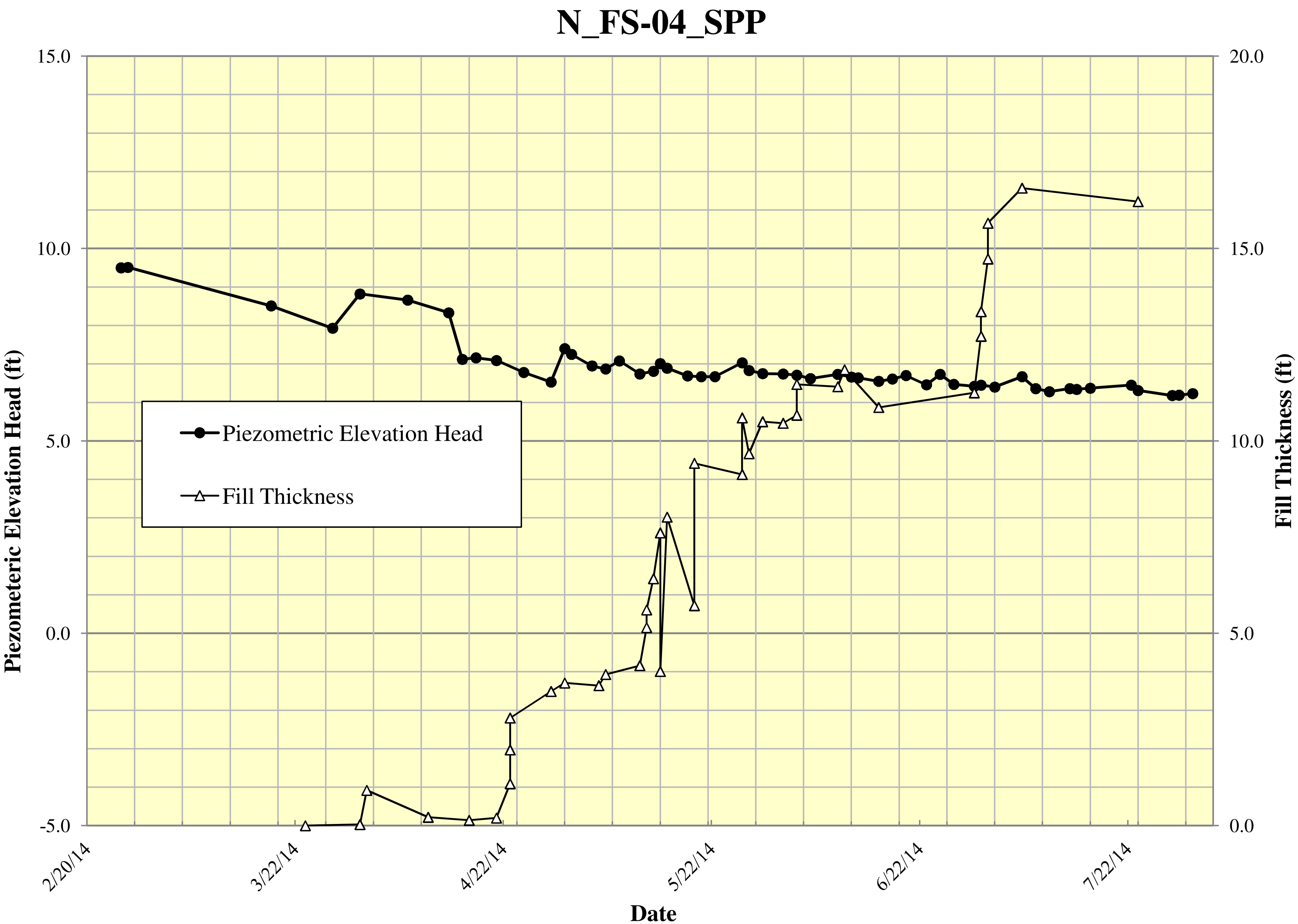
Date	Recorded By	Depth to Water [1] (ft btor)	Riser Added Today? (Yes/No)	Depth to Water [1, 2] (ft btor)	Riser Surveyed? [3] (Yes/No)	Riser Elevation [4] (ft)

Notes:

1. Measure/record groundwater depths to the nearest 0.01 feet.
2. If riser is added on this date, re-measure the depth to water after adding riser.
3. **Measure/record TOR elev. periodically.**
4. Measure/record elevations to the nearest 0.01 feet.

ATTACHMENT E-3b

Sample Data Report


N_FS-04_SPP
Piezometric Elevation Head (ft)
Fill Thickness (ft)
Date
Piezometric Elevation Head
Fill Thickness
15.0
10.0
5.0
0.0
-5.0
20.0
15.0
10.0
5.0
0.0
2/20/14
3/22/14
4/22/14
5/22/14
6/22/14
7/22/14

ATTACHMENT E-4

Vibrating Wire Piezometers

ATTACHMENT E-4a

Vibrating Wire Piezometer Product Information

Vibrating Wire Piezometers

Applications

VW piezometers are used to monitor pore-water pressure. They can also be used to monitor water levels. Typical applications include:

- Monitoring pore water pressures to determine safe rates of fill or excavation.
- Monitoring pore water pressures to determine slope stability.
- Monitoring the effects of dewatering systems used for excavations.
- Monitoring the effects of ground improvement systems such as vertical drains and sand drains.
- Monitoring pore pressures to check the performance of earth fill dams and embankments.
- Monitoring pore pressures to check containment systems at land fills and tailings dams.
- Monitoring water levels in stilling basins and weirs.

Operation

The VW piezometer converts water pressure to a frequency signal via a diaphragm, a tensioned steel wire, and an electromagnetic coil.

The piezometer is designed so that a change in pressure on the diaphragm causes a change in tension of the wire. An electro-magnetic coil is used to excite the wire, which then vibrates at its natural frequency. The vibration of the wire in the proximity of the coil generates a frequency signal that is transmitted to the readout device.

The readout or data logger stores the reading in Hz. Calibration factors are then applied to the reading to arrive at a pressure in engineering units.

VW Piezometers: Standard, Heavy Duty, and Push-In (bottom)

Types of VW Piezometers

Standard: The standard piezometer is suitable for most applications. It operates equally well in fully-grouted boreholes or sand-filter zones.

Heavy-Duty: The heavy-duty model has a strong, double-wall housing and is supplied with armored cable.

Push-In: The push-in piezometer can be pushed a short distance into soft soils using a EW drill rod.

Multi-Level: The multi-level piezometer system system provides an easy way to install multiple sensors in a borehole. See separate datasheet.

Low-Pressure: The low-pressure piezometer can monitor very small changes in pore-water pressure.

Vented: The vented piezometer is used to monitor water levels in open standpipes and wells.

Corrosion Resistant: A titanium body protects from corrosive environments.

Advantages

Groutable: VW piezometers can be installed in fully-grouted boreholes and do not require sand filter zones. This greatly simplifies the installation of multiple sensors in the same borehole. It also makes it possible to install piezometers with inclinometer casing within the same borehole.

High Resolution: VW piezometers provide a resolution of 0.025% FS.

High Accuracy: Slope Indicator's automated, precision calibration system ensures that these sensors meet or exceed specifications.

Rapid Response: VW piezometers respond very quickly to changes in pore-water pressure.

Reliable Signal Transmission: With properly shielded cable, signals from the VW piezometer can be transmitted long distances.

STANDARD VW PIEZOMETERS

3.5 bar (50 psi) Piezometer 52611020
7 bar (100 psi) Piezometer 52611030
17 bar (250 psi) Piezometer 52611040
35 bar (500 psi) Piezometer 52611050
Signal Cable 50613524

The standard VW piezometer is suitable for most applications. The piezometer can be installed without a sand filter when the borehole is back-filled with bentonite-cement grout.

VW PIEZOMETERS WITH CABLE

Standard VW Piezometers, 3.5 bar (50 psi)
with 15 m (50') cable 52611028
with 30 m (100') cable 52611024
with 45 m (150') cable 52611027
with 60 m (200') cable 52611026

Standard VW Piezometers, 7 bar (100 psi)
with 30 m (100') cable 52611033
with 45 m (150') cable 52611034
with 60 m (200') cable 52611035
with 90 m (300') cable 52611036

PUSH-IN VW PIEZOMETERS

3.5 bar (50 psi) Piezometer 52621020
7 bar (100 psi) Piezometer 52621030
17 bar (250 psi) Piezometer 52621040
35 bar (500 psi) Piezometer 52621050
Signal Cable 50613524
Adapter for EW Drill Rod 50718042
EW Coupling 50718010

The push-in piezometer has a special housing that allows it to be pushed a short distance into soft, cohesive soils.

Adaptor for EW drill rod extends the length of the piezometer by 0.6m and provides a left-hand thredad for easy disconnect of the drill rod. Order one adapter per piezometer.

Coupling (pin) threads into the drill rod and has a left-hand thread for easy disconnect from the adaptor. Coupling can be reused, so only one is needed.

HEAVY-DUTY VW PIEZOMETERS

3.5 bar (50 psi) Piezometer 52610520
7 bar (100 psi) Piezometer 52610530
17 bar (250 psi) Piezometer 52610540
35 bar (500 psi) Piezometer 52610550
Signal Cable, Armored 50613586

This piezometer features a strong double wall housing and is normally supplied with armored signal cable.

LOW-PRESSURE VW PIEZOMETERS

0.7 bar (10 psi) Piezometer 52611610
1.8 bar (25 psi) Piezometer 52611625
Signal Cable 50613524

The low-pressure piezometer is designed to monitor very small changes in pore-water pressure. It can also be used to monitor water levels.

CORROSION-RESISTANT VW PIEZO

7 bar (100 psi) Piezometer 52621230
17 bar (250 psi) Piezometer 52621240
PVC Signal Cable 50613824

The body of the corrosion-resistant VW piezometer is manufactured of titanium while the filter and diaphragm are protected by a heat-bonded PTFE coating and a PVC housing. PVC signal cable has four 22-gauge conductors. Consult factory if other configurations are required.

VW PIEZOMETER SPECIFICATIONS

Sensor Type: Pluck-type vibrating wire sensor with built-in thermistor or RTD.

Range: Standard ranges are listed at left. Custom calibration ranges are available.

Resolution: 0.025%FS.

Accuracy: ±0.1% FS for 0.7 - 7 bar sensors, ±0.3% FS for 17 and 35 bar sensors.

Maximum Pressure: 1.5 x rated range.

Filter: 50-micron, sintered stainless steel. Add y part 92611065 for 1-bar high-air-entry filter.

Temperature Coefficient: < 0.04% FS per °C).

Materials: Stainless steel.

Size: Standard: 19 x 155 mm (0.75 x 6.10")
Low-Pressure: 29 x 191 mm (1.125 x 7.5").
Heavy-Duty: 29 x 191 mm (1.125 x 7.5").
Push-In: 35 x 270 mm (1.385 x 10.5").
Corrosion-Resistant: 29x191mm (1.125 x 7.5").

Weight: Standard: 0.16 kg (0.3 lb).
Low-pressure: 0.45 kg (1 lb).
Heavy-Duty: 0.8 kg (1.75 lb).
Push-in: 1.2 kg (2.75 lb).

SIGNAL CABLE SPECIFICATIONS

Standard Signal Cable 50613524

Shielded cable with four 22-gauge tinned-copper conductors and polyurethane jacket.

Armored Signal Cable 50613586

Shield cable with four 22-gauge tinned-copper conductors, inner polyurethane jacket, steel braid armor, and outer high-density, polyethylene jacket. For heavy duty piezometer only.

READOUT & TERMINAL BOXES

VW Data Recorder 52613500
Jumper Cable for Terminal Box . . 52613557
Terminal Box for 6 sensors 57711606
Terminal Box for 12 Sensors 57711600
Terminal Box for 24 Sensors 97711624

See separate datasheet for VW Data Recorder. Terminal boxes provide terminals for 6, 12, or 24 sensors. Sensors are selected by rotary switch. 6-sensor box is 240 x 190 x 120 mm (9.5 x 7.5 x 4.75"). 12 and 24-sensor boxes are 290 x 345 x 135 mm (11.5 x 13.5 x 5.25").

DATA LOGGERS

VW MiniLogger for 1 Sensor 52613310
VW Quattro Logger for 4 Sensors 52614000
Campbell Scientific Data Loggers

VW piezometers connect directly to the VW MIniLogger and Quattro Logger. The CR1000 requires an AVW200 vibrating wire adaptor.

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ATTACHMENT E-4b

Readout Box Information

VW Data Recorder

Applications

The VW Data Recorder is a recording readout for pluck-type vibrating wire sensors, RTDs, and thermistors.

The VW Data Recorder is simple to operate, stores up to 8000 readings, and can transfer the readings to a PC for processing.

Basic Operation

The VW Data Recorder has just three controls: an on/off switch, an Enter key, and a Change key.

To take a reading, switch on the power, connect the sensor, and press the Enter key. The reading appears.

To save a reading, press Enter twice more, once to confirm a sensor ID, and once to record the reading.

Settings

To change a setting, press the Change key. You can set the display to show Hz, Hz^2 or microstrain and choose thermistor or RTD for the type of temperature device built into your sensor. The Change key also lets you set a sensor ID when you save a reading.

Transferring Readings to a PC

Connect the VW Data Recorder to your PC and run Logger Manager software. Specify a file name and location for the readings, and two mouse clicks later, the data is on your PC, ready for your spreadsheet program.

Advantages

Wide Compatibility: The VW Data Recorder reads any pluck-type VW sensor from any manufacturer.

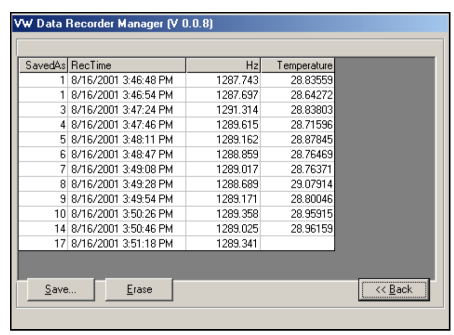
Simple Operation: Learn how to use the VW Data Recorder in just a few minutes. Most operations are performed by pressing a single key. Data retrieval is just as easy.

Reliable: Readings are stored in secure, non-volatile memory that keeps data even when batteries are fully discharged.

Spreadsheet Friendly: Logger Manager software retrieves readings and from the logger stores them in ASCII file, ready to open and process with your spreadsheet program.

No Setup: The VW Data Recorder is always ready to use. There are no sensor lists or calibration factors to load.

No Special Parts: The VW Data Recorder uses standard cables and batteries. Built-in terminals eliminate the need for a jumper cable. The serial interface cable can be replaced at any computer store, and the standard D-cell batteries eliminate the need for a charger.



SavedAs	RecTime	Hz	Temperature
1	8/16/2001 3:46:48 PM	1287.743	28.83559
1	8/16/2001 3:46:54 PM	1287.697	28.64272
3	8/16/2001 3:47:24 PM	1291.314	28.83803
4	8/16/2001 3:47:46 PM	1289.615	28.71596
5	8/16/2001 3:48:11 PM	1289.162	28.87845
6	8/16/2001 3:48:47 PM	1288.859	28.76469
7	8/16/2001 3:49:08 PM	1289.017	28.76371
8	8/16/2001 3:49:28 PM	1288.689	29.07914
9	8/16/2001 3:49:54 PM	1289.171	28.80046
10	8/16/2001 3:50:26 PM	1289.358	28.95915
14	8/16/2001 3:50:46 PM	1289.025	28.96159
17	8/16/2001 3:51:18 PM	1289.341	

Retrieving Readings with Manager Software

VW DATA RECORDER

VW Data Recorder. 52613500

The VW Data Recorder includes batteries and an interface cable.

Sensor Compatibility: Reads any pluck-type vibrating wire sensor that operates between 450 and 6000 Hz. Also reads thermistor and RTD temperature sensors.

Range: 450 to 6000 Hz.

Resolution: 0.01% FS.

Accuracy: ±0.02% of Hz reading.

Temperature Measurement: -20 to 120 °C with ±1°C accuracy.

Displayed Units: Hz, Hz^2, microstrain, degrees C. Microstrain units are dedicated to VW spot-weldable strain gauge.

Sensor IDs: Stored readings are identified by date, time, and sensor ID, which is a number between 0 and 31. User assigns ID when saving a reading.

Memory Capacity: 8000 readings with ID, date, and time.

LCD: 2 line x 20 character, high contrast LCD with extended temperature rating.

Controls: On/Off switch with auto-off timer, keypad with two keys.

Connectors: Panel-mounted terminal for sensor cables, DB9 connector for serial interface cable.

Interface Cable: Included part 50306869 is a modem-type serial interface cable with DB9 connectors on either end.

Batteries: Two 1.5 volt alkaline D-cells provide about 60 hours of continuous use at 20 °C.

Environmental Limits: -20 to 50 °C.

Dimensions: 235 x 190 x 108 (9.25 x 7.5 x 4.25").

Weight: 1.5 kg (3.3 lb.).

LOGGER MANAGER SOFTWARE

Logger Manager. . . . . Download

Logger Manager software can be downloaded from www.slopeindicator.com.

System Requirements: Windows computer with serial port. If no serial port is available, a USB to serial adaptor is required.

Settings: Synchronize recorder's internal clock with PC or specify different date and time; set default sweep frequency; set default type of temperature sensor.

Data Retrieval: Choose to retrieve all readings or a selected range of readings. Readings are stored in ASCII format ready for import into a spreadsheet. VW readings are stored in Hz or Hz^2. VW spot-weldable strain gauge readings are stored in microstrain or Hz. Temperature readings are stored in degrees C.

OPTIONAL JUMPER CABLES

Jumper to Terminal Box 52613557
Jumper with Alligator Clips 52613550

Jumper to terminal box is required if sensors are terminated at universal terminal box 57711600. Approximately 2 m (6') long.

Jumper with alligator clips is useful for locations where the signal cable from the sensor is not easily connected to the terminals on the panel. Approximately 2 m (6') long.

TERMINAL BOXES

Terminal Box for 6 sensors 57711606
Terminal Box for 12 Sensors 57711600
Terminal Box for 24 Sensors 97711624

Provides rotary switch for selecting sensors. Small 6-sensor box measures 240x190x120 mm (9.5 x7.5x 4.75"). 12 and 24 sensor boxes measure 290 x 345 x 135 mm (11.5 x 13.5 x 5.25").

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VW MiniLogger

MiniLogger Advantages

Economical: It is possible to deploy four or five MiniLoggers for less than the cost of a full-size logger. Cable costs are also reduced, since the MiniLogger can be placed near each sensor.

Simple to Use: Learn how to use the MiniLogger in minutes, not hours. There are no programs to write, no switches to set, and only four wires to connect.

Reliable: The MiniLogger is rated for temperatures from -20 to +50°C. Its encapsulated electronics are impervious to humidity and condensation. Readings are stored in secure, non-volatile memory.

Spreadsheet Friendly: Logger Manager software retrieves readings and applies calibration factors, if present, to generate data files that contain both raw and processed readings. Thus data can be used immediately in the spreadsheet.

Wireless Option: The wireless option provides easy data retrieval when access to the logger is difficult or when frequent retrieval is required.

VW MiniLogger Applications

The VW MiniLogger is a reliable, low-cost data logger designed to monitor a single vibrating wire sensor, such as a VW piezometer or crackmeter. Typical applications include:

- Monitoring small projects, where only a few sensors are installed. Note that one MiniLogger is required for each sensor.
- Monitoring single sensors that are too far away to connect to a centralized data acquisition system.
- Monitoring single sensors in areas where heavy traffic or electrical noise prevents use of long cables.
- Monitoring single sensors during early phase of construction when centralized data acquisition system is not ready.

Overview of Operation

The MiniLogger is simple to use and takes only a few minutes to set up.

Connect the MiniLogger to your PC and run Logger Manager software to specify a start time and reading interval for data logging.

On site, connect the sensor signal cable to the MiniLogger and walk away. D-cell batteries provide power for up to six months in temperatures as low as -20° C.

Return to the site with your PC and run Logger Manager to retrieve the readings and save them in a file that is ready for your spreadsheet.

Finally, open the file with your spreadsheet for processing and plotting.

VW MINILOGGER

VW MiniLogger 52613310

VW MiniLogger includes interface cable and two D-cell batteries.

Sensor Compatibility: Reads VW sensors operating in the range of 450 to 6000 Hz. Also reads temperature sensors (RTD and thermistor).

Data Storage: Stores 8,000 records in secure, non-volatile memory. Each record includes a VW reading, a temperature reading, and the time and date. When memory is full, recording either stops or continues by overwriting the earliest readings, according to user preference.

Logger Settings: Assign a logger ID, specify whether to stop when memory is full or to overwrite earliest readings.

Sensor Settings: Assign a sensor ID, set sweep range for excitation, store calibration factors, and set temperature sensor to RTD or thermistor.

Reading Schedule Starts recording on power up or at specified date and time. Records readings at intervals from one reading every two seconds to one reading per week.

Logging Schedule: Set logger to start recording on power up or at a specific date and time (to synchronize readings with other MiniLoggers or data loggers). Set reading intervals to day, hour, minute, and second.

Power: Two D-cell batteries provide power for approximately six months at temperatures from -20 to +50°C, assuming readings are taken every half-hour.

Weatherproofing: MiniLogger electronics are completely encapsulated in waterproof resin. Polycarbonate box has O-ring seal and cable gland for signal cable.

Dimensions: 100 x 100 x 90 mm high (4 x 4 x 3.5").

Data Retrieval: Readings are retrieved via RS-232 serial connection or by wireless link to computer running Logger Manager.

2.4 GHZ WIRELESS OPTION

Radio Lid, 2.4 Ghz 52613360
Radio Base Station, 2.4 Ghz 52613455

Radio lid replaces standard lid of MiniLogger and includes spread-spectrum radio, interface cable, and half-wave antenna.

Base station works with PC and includes spread-spectrum radio, USB cable, half-wave antenna, and CD.

Frequency: 2.4 Ghz.

Radio Type: Spread Spectrum.

Transmission Power: 40 mW.

Range: Up to 0.6 km (0.4 miles) line of sight.

Power: Powered from MiniLogger's batteries. Average life is about 2 months, assuming 4-daily downloads. Base station is powered by computer's USB port.

WIRELESS ACCESSORIES

Advanced Programming Cable. . . 52613340

Optional cable allows user to change configuration of radio lid. Works with both 900 Mhz and 2.4Ghz radios.

LOGGER MANAGER SOFTWARE

Logger Manager Software . . . . . Download

Logger Manager is used to set MiniLogger's reading schedule and to retrieve recorded readings. Readings can be stored in a Campbell Scientific compatible format or in a spreadsheet-ready format.

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VW Quattro Logger

Applications

The VW Quattro Logger is a compact data logger designed to monitor four vibrating wire sensors. Typical applications include:

- Monitoring small projects, where only a few sensors are installed.
- Monitoring multilevel piezometers, multipoint rod extensometers, or crackmeters.
- Monitoring sensors that are too far away to connect to a centralized data acquisition system.
- Monitoring critical sensors during early phases of construction when the centralized data acquisition system is not ready.

Overview of Operation

The Quattro Logger is simple to use and set up takes only a few minutes.

Connect the logger to your computer and use Logger Manager software to specify a start time and reading schedule.

On site, connect sensor signal cables to the logger. You can view readings in real time if you have a PC with you. Then close the logger and walk away. Three D-cell batteries power the logger for up to 6 months.

Return to the site to retrieve readings with your PC. Logger Manager saves the readings in an ASCII file, ready for your spreadsheet.

Finally, import the file into your spreadsheet for processing and plotting.

Quattro Logger Advantages

Cost-Effective: Quattro Loggers are the right size for many projects. Two or three Quattro Loggers can be deployed for less than the cost of a single full size, centralized logger.

Simple to Use: Learn how to use the Quattro Logger in minutes, not hours. There are no programs to write and no switches to set.

Reliable: The Quattro Logger is rated for temperatures from -20 to +70°C, and its encapsulated electronics are impervious to humidity and condensation. Readings are stored in secure, non-volatile memory.

Spreadsheet Friendly: Logger Manager software retrieves readings and applies calibration factors, if present, to generate data files that contain both raw and processed readings. Thus data can be used immediately in the spreadsheet.

LOGGER SPECIFICATIONS

VW Quattro Logger 52614000
VW Quattro Logger, External USB . . . 52614020

USB interface cable and batteries are included with the logger. Download manual and software from www.slopeindicator.com.

Measurement Range: Reads VW sensors operating in the range of 450 to 6000 Hz. Reads thermistors or RTDs in the range of -20 to 120 °C.

Logger Resolution: 0.01% FS for vibrating wire sensors, 0.1 °C for temperature sensors.

Logger Accuracy: ±0.02 % of Hz reading for vibrating wire sensors, ± 1 °C for temperature sensors.

Data Storage: Stores 43,000 records for each sensor in secure, non-volatile memory. Each record includes a VW reading, a temperature reading, and the time and date. When memory is full, recording either stops or continues by overwriting the earliest readings, according to user preference.

Logger Settings: Date, time, and memory mode. Memory mode determines if logging stops when memory is full or if logging continues by overwriting earliest readings.

Logging Schedule: Logger start time can be set to a specific date and time so that readings are synchronized with other loggers. Reading intervals can be specified by day, hour, minute, and second. Maximum interval is days. Minimum interval is 20 seconds.

Sensor Settings: Sensor ID, serial number, calibration factors, and sweep range for each sensor. Choice of thermistor or RTD for temperature channels.

Power: Three D-cell batteries provide power for six months in moderate temperatures, assuming readings are taken every hour.

Weatherproofing: Quattro Logger electronics are encapsulated in waterproof resin and housed in an IPC66 metal box. Plugs are provided for unused cable ports.

Interface Cable: Male A/B USB 2.0 cable, the same cable commonly used for USB printers. 2m length (6 feet).

Dimensions: 240 x 160 x 81 mm (9.5 x 6.3 x 3.2 inches).

LOGGER MANAGER SOFTWARE

Logger Manager. . . . . Download

Logger Manager software is used to set up the logger and later to retrieve data from the logger. Download from www.slopeindicator.com.

Choice of output file formats: ASCII format ready for import into a spreadsheet or in format that is compatible with the CR1000 data logger.

Automatic Engineering Units: The Quattro Logger stores readings in Hz. It also stores calibration factors for each sensor. Logger Manager retrieves the calibration factors along with the readings, then applies the calibration factors to generate a reading in engineering units (both raw and generated readings are stored in the file). Temperature readings are stored in degrees C only.

Real-Time View of Logging: Logger Manager can show real-time readings when the PC is connected to the logger. This is useful to verify that sensors, connections, and loggers are working properly.

Clock Syncronization: The Manager program can synchronize the logger's clock to the clock in the PC.

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ATTACHMENT E-4c

Sample Field Data Report

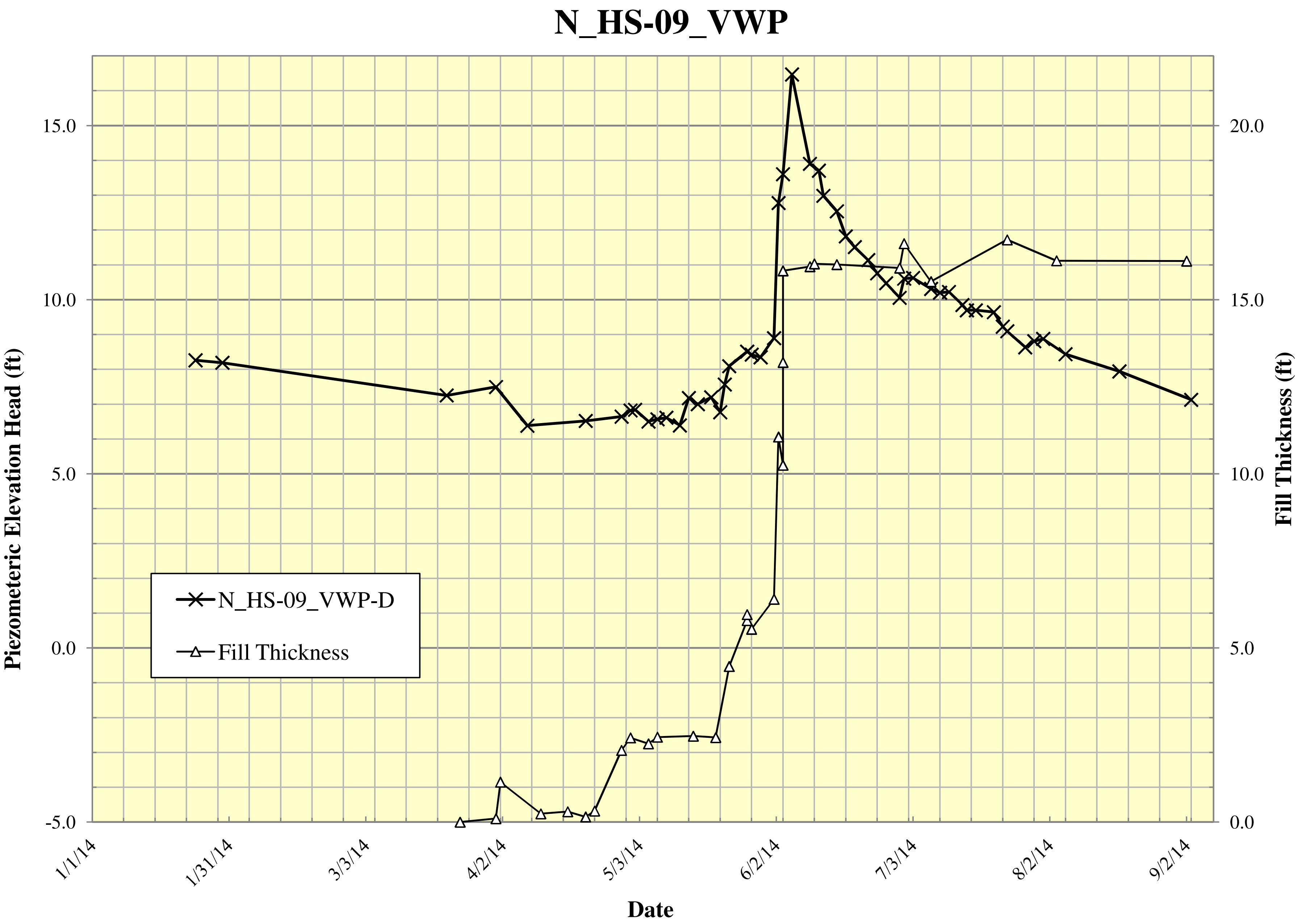
amec	Project:		VWP Location #
	Location:		
	Client:		

VIBRATING WIRE PIEZOMETERS - FIELD DATA SHEET

VWP Readings												
VWP Designation:												Notes
VWP Serial No.:												
Date	Recorded By:	Frequency (Hz)	Temp. (deg C)	Frequency (Hz)	Temp. (deg C)	Frequency (Hz)	Temp. (deg C)	Frequency (Hz)	Temp. (deg C)	Frequency (Hz)	Temp. (deg C)	

ATTACHMENT E-4d

Sample Data Report

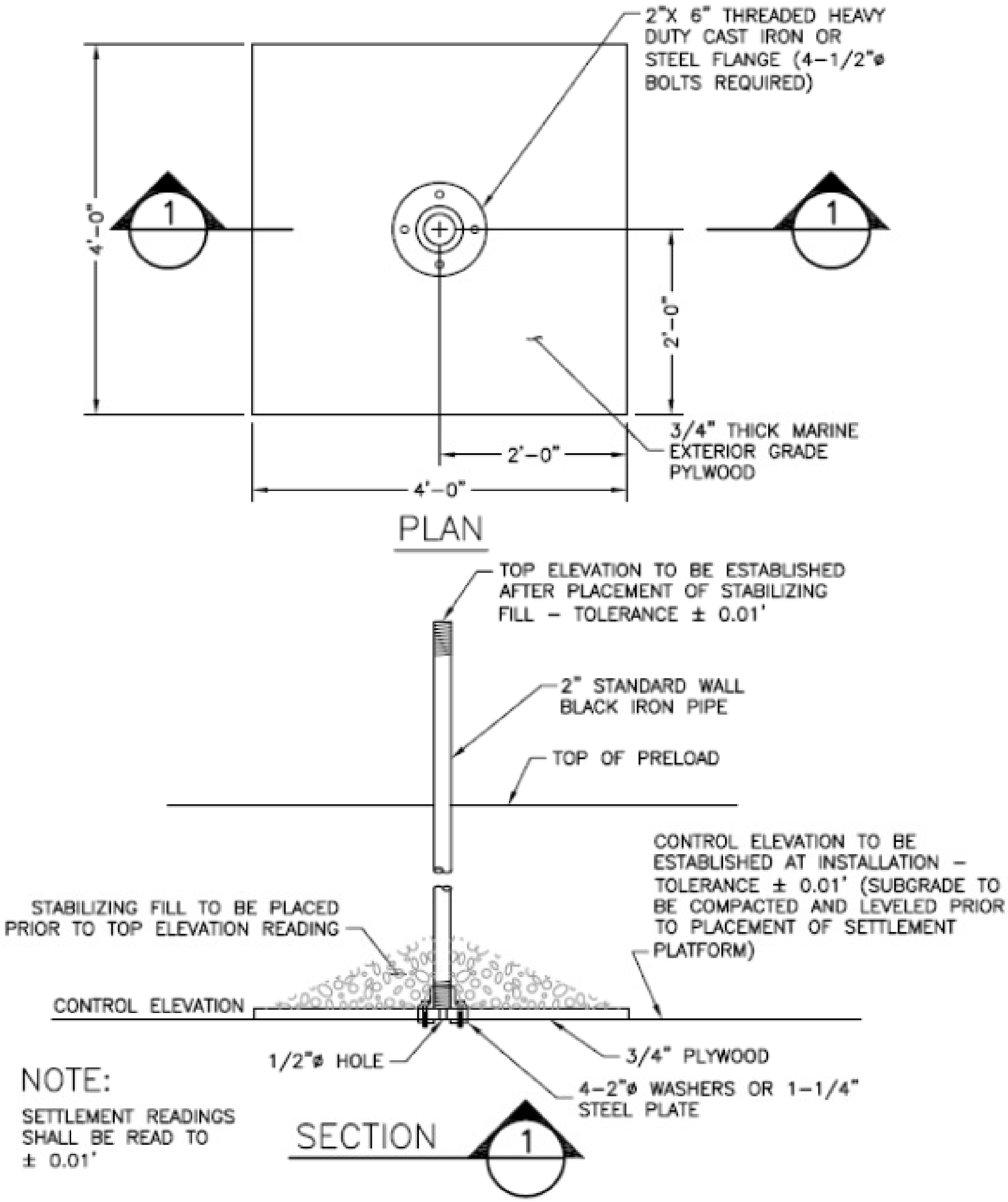

N_HS-09_VWP
Piezometeric Elevation Head (ft)
Fill Thickness (ft)
Date
N_HS-09_VWP-D
Fill Thickness
15.0
10.0
5.0
0.0
-5.0
20.0
15.0
10.0
5.0
0.0
1/1/14
1/31/14
3/3/14
4/2/14
5/3/14
6/2/14
7/3/14
8/2/14
9/2/14

ATTACHMENT E-5

Settlement Platforms

ATTACHMENT E-5a

Installation Details



SETTLEMENT PLATFORM

NTS

Prepared/Date: RJR 08/03/10
Checked/Date: TCC 08/03/10

ATTACHMENT E-5b

Sample Field Data Report

amec	Project:		SETTLEMENT PLATFORM #
	Location:		
	Client:		

SETTLEMENT PLATFORM - FIELD DATA SHEET

Baseline Location	
Northing:	
Easting:	
Date/Recorded By:	

Baseline Elevations	
Existing Ground Surface Elev.[1,2] (ft):	
Initial Reference Clamp Elev.[1] (ft):	
Date/Recorded By:	

Survey the Reference Clamp Elevation
BEFORE and AFTER adding riser pipe!

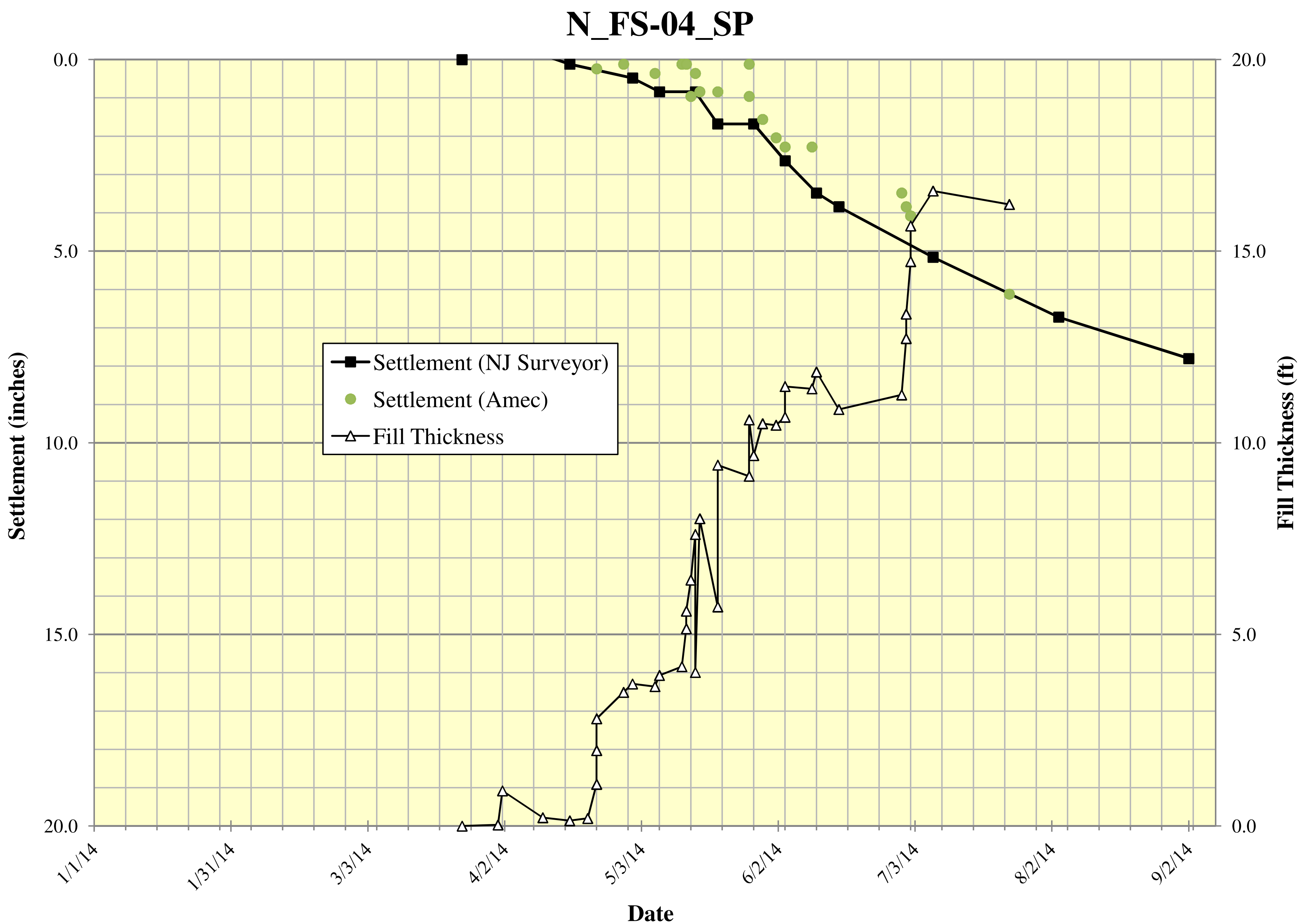
Date	Recorded by	Settlement Platform	Fill Placement	Notes
		Reference Clamp Elevation[1] (ft)	Ground Surface Elevation[1,3] (ft)	(note when riser pipe is added)

Notes:

1. Measure/record elevations to the nearest 0.01 feet.
2. At installation, record existing ground surface elev. at/proximate to the installed platform; for determining fill thickness above existing grade.
3. During surcharge fill placement/monitoring period, record existing ground surface elev. (i.e., top of fill) at/proximate to the installed platform.

ATTACHMENT E-5c

Sample Data Report


N_FS-04_SP
Settlement (NJ Surveyor)
Settlement (Amec)
Fill Thickness
Settlement (inches)
Fill Thickness (ft)
Date
0.0
5.0
10.0
15.0
20.0
20.0
15.0
10.0
5.0
0.0
1/1/14
1/31/14
3/3/14
4/2/14
5/3/14
6/2/14
7/3/14
8/2/14
9/2/14