APPENDIX D

INSTRUMENTATION
APPENDIX D

INSTRUMENTATION

TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.1. GENERAL</td>
<td>D-1</td>
</tr>
<tr>
<td>D.2. VIBRATING WIRE PIEZOMETERS</td>
<td>D-1</td>
</tr>
<tr>
<td>D.3. DATALOGGERS</td>
<td>D-1</td>
</tr>
<tr>
<td>D.4. INCLINOMETERS</td>
<td>D-2</td>
</tr>
</tbody>
</table>

FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-1</td>
<td>VWP and Datalogger Calibration Logs (5 sheets)</td>
</tr>
<tr>
<td>D-2</td>
<td>Measured Piezometer Levels in B-12 (1 sheet)</td>
</tr>
<tr>
<td>D-3</td>
<td>Inclinometer Measurements in B-12 (1 sheet)</td>
</tr>
</tbody>
</table>
APPENDIX D
INSTRUMENTATION

D.1. GENERAL

Instrumentation, including inclinometer casing and vibrating wire piezometers (VWP), were installed based on the Task Order Solicitation, discussions with City representatives during exploration activities, and observations of B-12. Details are presented in the following sections. The VWP locations and installation details are shown on the boring logs in Appendix B.

D.2. VIBRATING WIRE PIEZOMETERS

Three Geokon Model No. 4500 VWPs were placed in boring B-12 at depths of approximately 76, 101, and 131 feet to measure the groundwater pore pressure. Including the previous installed VWPs, a total of 16 water level or pore pressure monitoring points are present throughout the site. VWP calibration logs are presented in Figure D-1, while the most recent data are illustrated in Figure D-2.

VWPs are typically grouted in place with a lean bentonite cement grout. The grout is permeable enough to transmit changes in the groundwater pressure through the grout to the instrument. Geokon recognizes grouting VWPs in-place as an acceptable form of installation.

A VWP 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. When excited by the electromagnetic coil, the wire vibrates at its natural frequency. The vibration of the wire near the coil generates a frequency signal that is transmitted to the readout device. The readout device processes the signal, applies calibration factors, and displays a reading in the required engineering unit.

D.3. DATALOGGERS

A Geokon Four Channel Datalogger Model LC-2x4 was installed in B-12. The datalogger calibration log is presented in Figure D-1. For this project, the datalogger is programmed to take readings hourly; the readings are periodically, manually downloaded to a computer for processing.

A datalogger is a measurement instrument designed to read and record VWP sensors. Dataloggers store arrays of information consisting of datalogger ID; timestamp of the year, date,
time, and seconds when the reading was taken; battery voltage; datalogger temperature; the VWP reading (transducer frequency and temperature); and the array number in memory.

**D.4. INCLINOMETERS**

Inclinometers are devices for monitoring deformation normal to the axis of a pipe by means of a portable probe passing through the pipe. The inside of the pipe contains two sets of grooves at 90 degrees to each other so that the probe can track up and down the casing without rotating. The casing is usually installed so that one set of grooves is aligned in the down-slope direction. The probe contains a gravity sensing transducer designed to measure inclination with respect to the vertical. High-impact, 2.75-inch O.D. inclinometer pipes, or casings, manufactured by the Durham Geo Slope Indicator Company were installed in boring B-12.

The purpose of the inclinometer casings is to permit periodic monitoring of the subsurface to detect horizontal or near horizontal differential movements. The inclinometer measurements can define the location of deforming zone(s) and allow an evaluation of that zone as time progresses. Baseline (or “initial”) readings from each inclinometer are taken in the casings and then subsequent readings are taken at intervals and compared to the initial readings. Deviations from the initial readings may indicate subsurface movement.

Each reading consists of two sets of data. Data Set “A” measures deviation from the initial reading generally in the down-slope direction, referred to as the “A axis.” Data set B measures deviation from the initial reading at 90 degrees to the down-slope direction, the “B axis.” The initial readings are considered the “baseline” readings and are typically not plotted. The subsequent data sets can be plotted as incremental or cumulative change. The most recent inclinometer measurements are presented on Figure D-3.
8002 Calibration Data Sheet

Calibration Date: August 28, 2012
Calibration Recall: August 28, 2013
Serial Number: 1225324

Calibration Instruction: CI-8002

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Actual Freq. Counter Reading (Hz)</th>
<th>Computed Reading (Digits $F^2$ /1000)</th>
<th>Actual 8002 Reading (Digits)</th>
<th>Error (Digits)*</th>
<th>Allowable Error (Digits) ($\pm 0.05$ of $F$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500.0</td>
<td>500.00</td>
<td>250.00</td>
<td>249.9</td>
<td>0.1</td>
<td>$\pm 7.9$</td>
</tr>
<tr>
<td>2225.0</td>
<td>2225.00</td>
<td>4950.63</td>
<td>4952.4</td>
<td>-1.8</td>
<td>$\pm 7.9$</td>
</tr>
<tr>
<td>4000.0</td>
<td>4000.00</td>
<td>16000.00</td>
<td>16004.0</td>
<td>-4.0</td>
<td>$\pm 7.9$</td>
</tr>
</tbody>
</table>

*Error = Computed Reading - Actual Reading

Control Number: 033

This certifies the above named instrument has been calibrated by comparison with standards traceable to the National Institute of Standards and Technology (NIST) in compliance with ANSI/NCSL Z540-1 and is in tolerance as found.

This certificate shall not be reproduced, except in full, without written permission of Geokon, Inc.

8002 cal rev: A

Notes: 8002-4-1 Software Version 3.1.1
# Vibrating Wire Pressure Transducer Calibration Report

**Model Number:** 43000-350 kPa  
**Serial Number:** 1220479  
**Date of Calibration:** July 18, 2012  
**Temperature:** 23.8 °C  
**Calibration Instruction:** VW Pressure Transducers  
**Barometric Pressure:** 989.2 mbar  
**Cable Length:** 80 feet  
**Technician:** [Signature]  

<table>
<thead>
<tr>
<th>Applied Pressure (kPa)</th>
<th>1st Cycle Reading</th>
<th>2nd Cycle Reading</th>
<th>Average Reading</th>
<th>Calculated Pressure (Linear)</th>
<th>Error Linear (kPa/°F)</th>
<th>Calculated Pressure (Polynomial)</th>
<th>Error Polynomial (kPa/°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>8855</td>
<td>8856</td>
<td>8856</td>
<td>0.618</td>
<td>0.18</td>
<td>0.021</td>
<td>0.01</td>
</tr>
<tr>
<td>70.0</td>
<td>8240</td>
<td>8241</td>
<td>8241</td>
<td>69.74</td>
<td>-0.07</td>
<td>69.89</td>
<td>-0.02</td>
</tr>
<tr>
<td>139.9</td>
<td>7620</td>
<td>7620</td>
<td>7620</td>
<td>139.5</td>
<td>-0.12</td>
<td>140.0</td>
<td>0.03</td>
</tr>
<tr>
<td>280.0</td>
<td>6998</td>
<td>6998</td>
<td>6998</td>
<td>200.4</td>
<td>0.16</td>
<td>200.9</td>
<td>0.06</td>
</tr>
<tr>
<td>349.9</td>
<td>6372</td>
<td>6372</td>
<td>6372</td>
<td>279.7</td>
<td>-0.06</td>
<td>279.9</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>5742</td>
<td>5742</td>
<td>5742</td>
<td>350.5</td>
<td>0.18</td>
<td>349.9</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(kPa) Linear Gage Factor \( G \): \(-0.1124\) (kPa/ digit)  

Polynomial Gage factors:  
\( A: -4.856E-07 \)  
\( B: -0.1053 \)  
\( C: \)  

Thermal Factor \( K \): \(-0.04107\) (kPa/°C)  

Regression Zero: 8861

Calculate \( C \) by setting \( P=0 \) and \( R_1 = \) initial field zero reading into the polynomial equation

\[ \text{(psi) Linear Gage Factor (G): } -0.01630 \text{ (psi/ digit)} \]

Polynomial Gage Factors:  
\( A: -7.043E-08 \)  
\( B: -0.01527 \)  
\( C: \)  

Thermal Factor \( K \): \(-0.005956\) (psi/°C)  

Calculate \( C \) by setting \( P=0 \) and \( R_1 = \) initial field zero reading into the polynomial equation

### Calculated Pressures:

- **Linear,** \( P = G(R_1 - R_0) + K(T_1 - T_0)(S_1 - S_0) \)**

- **Polynomial,** \( P = AR_1 + BR_1 + C + K(T_1 - T_0)(S_1 - S_0) \)**

\*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

---

The above instrument was found to be in tolerance in all operating ranges.

This report shall not be reproduced except in full without written permission of GeoKon Inc.

\[ B = 2840.5 \text{ / } 16.2 \]

\[ W_2 = 2832.0 \text{ / } 16.0 \]
Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa  
Serial Number: 1307483  
Temperature: 23.1 °C  
Barometric Pressure: 986.2 mbar  
Cable Length: 110 feet  

<table>
<thead>
<tr>
<th>Applied Pressure (kPa)</th>
<th>Gage Reading 1st Cycle</th>
<th>Gage Reading 2nd Cycle</th>
<th>Average Gage Reading</th>
<th>Calculated Pressure (Linear)</th>
<th>Error Linear (%FS)</th>
<th>Calculated Pressure (Polynomial)</th>
<th>Error Polynomial (%FS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>8853</td>
<td>8853</td>
<td>8853</td>
<td>0.363</td>
<td>0.10</td>
<td>0.033</td>
<td>0.01</td>
</tr>
<tr>
<td>70.0</td>
<td>8278</td>
<td>8278</td>
<td>8278</td>
<td>69.89</td>
<td>-0.03</td>
<td>69.91</td>
<td>-0.02</td>
</tr>
<tr>
<td>140.0</td>
<td>7699</td>
<td>7700</td>
<td>7700</td>
<td>139.8</td>
<td>-0.04</td>
<td>140.0</td>
<td>0.02</td>
</tr>
<tr>
<td>210.0</td>
<td>7121</td>
<td>7121</td>
<td>7121</td>
<td>209.8</td>
<td>-0.05</td>
<td>210.0</td>
<td>0.00</td>
</tr>
<tr>
<td>280.0</td>
<td>6541</td>
<td>6541</td>
<td>6541</td>
<td>279.9</td>
<td>-0.01</td>
<td>280.0</td>
<td>0.00</td>
</tr>
<tr>
<td>349.9</td>
<td>5959</td>
<td>5960</td>
<td>5960</td>
<td>350.3</td>
<td>0.09</td>
<td>349.9</td>
<td>0.00</td>
</tr>
</tbody>
</table>

(kPa) Linear Gage Factor (G): -0.1209 (kPa/digit)  
Polynomial Gage factors:  
A: -2.59E-07  
B: -0.1171  
C: __________  
Thermal Factor (K): 0.02505 (kPa/°C)

Regression Zero: 8856

Calculate C by setting P=0 and R₁ = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G): -0.01754 (psi/digit)  
Polynomial Gage Factors:  
A: -3.757E-08  
B: -0.01698  
C: __________  
Thermal Factor (K): 0.003633 (psi/°C)

Calculate C by setting P=0 and R₁ = initial field zero reading into the polynomial equation

Calculated Pressures:  
Linear, P = G(R₁ - R₂) + K(T₁ - T₂) - (S₁ - S₂)  
Polynomial, P = AR₁² + BR₁ + C + K(T₁ - T₂) - (S₁ - S₂)  
*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

The above named instrument was found to be in tolerance to all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI 2540-1.

This report shall not be reproduced except in full without written permission of Geokon Inc.

\[ D = 28845.3 \div 15.9 \]
\[ \omega = 8837.4 \div 16.1 \]
# Vibrating Wire Pressure Transducer Calibration Report

**Model Number:** 4500S-350 kPa  
**Date of Calibration:** April 02, 2015  
**Serial Number:** 1207481  
**Temperature:** 23.1 °C  
**Calibration Instruction:** VW Pressure Transducers  
**Barometric Pressure:** 986.2 mbar

<table>
<thead>
<tr>
<th>Applied Pressure (kPa)</th>
<th>Gage Reading 1st Cycle</th>
<th>Gage Reading 2nd Cycle</th>
<th>Average Gage Reading</th>
<th>Calculated Pressure (Linear)</th>
<th>Error Linear (%FS)</th>
<th>Calculated Pressure (Polynomial)</th>
<th>Error Polynomial (%FS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>8738</td>
<td>8739</td>
<td>8739</td>
<td>0.306</td>
<td>0.09</td>
<td>-0.067</td>
<td>-0.02</td>
</tr>
<tr>
<td>70.0</td>
<td>8169</td>
<td>8170</td>
<td>8170</td>
<td>69.97</td>
<td>0.00</td>
<td>70.10</td>
<td>0.03</td>
</tr>
<tr>
<td>140.0</td>
<td>7600</td>
<td>7601</td>
<td>7601</td>
<td>139.6</td>
<td>-0.10</td>
<td>140.0</td>
<td>0.01</td>
</tr>
<tr>
<td>210.0</td>
<td>7030</td>
<td>7030</td>
<td>7030</td>
<td>209.6</td>
<td>-0.12</td>
<td>209.9</td>
<td>-0.02</td>
</tr>
<tr>
<td>280.0</td>
<td>6456</td>
<td>6456</td>
<td>6456</td>
<td>279.8</td>
<td>-0.05</td>
<td>279.9</td>
<td>-0.02</td>
</tr>
<tr>
<td>349.9</td>
<td>5879</td>
<td>5880</td>
<td>5880</td>
<td>350.4</td>
<td>0.12</td>
<td>350.0</td>
<td>0.02</td>
</tr>
</tbody>
</table>

(kPa) Linear Gage Factor (G) = -0.1224  
Polynomial Gage Factors:  
\[ A = -3.825 \times 10^{-6}, \quad B = -0.1168, \quad C = \_ \]  
Thermal Factor (K) = 0.06725 (kPa/°C)  
Regression Zero: 8741

Calculate C by setting \( P = 0 \) and \( R_1 \) = initial field zero reading into the polynomial equation

(psi) Linear Gage Factor (G) = -0.01776  
Polynomial Gage Factors:  
\[ A = -5.548 \times 10^{-6}, \quad B = -0.01695, \quad C = \_ \]  
Thermal Factor (K) = 0.009753 (psi/°C)  
Calculate C by setting \( P = 0 \) and \( R_1 \) = initial field zero reading into the polynomial equation

Calculated Pressures:  
Linear, \( P = G(R_1 - R_0) + K(T_1 - T_0)(S_1 - S_0) \)  
Polynomial, \( P = AR_1^2 + BR_1 + C + K(T_1 - T_0)(S_1 - S_0) \)  
*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

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

This report shall not be reproduced except in full without written permission of Geokon Inc.
**VWP Construction Log**

**BORING NO:** BR-12

**APPROX. GROUND ELEV.:**

**LOCATION:**

**INSPECTOR:**

**INSTALL DATE:** 4/1/2013

**ECOL. TAG NO.:**

**TOTAL DRILLED DEPTH:** 150 feet

**TOTAL SAMPL. DEPTH:** 130 feet

**DRILLING METHOD:** Pnu. Coring (HSA, Mud Rotary, act.)

**DRILLING FLUID USED:** Bentonite (Bentonite, Polymer, act.)

**BOREHOLE DIAMETER:** 6 1/4 inches

**DEDICATED TREME:** YES ☐ NO ☐

**DRIL RMKS:** Flushed with clear water

### VWP INSTALLATION DETAILS

<table>
<thead>
<tr>
<th>VWP No.</th>
<th>Pressure Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>WVP #1</td>
<td>122.04 psi</td>
</tr>
<tr>
<td>WVP #2</td>
<td>120.24 psi</td>
</tr>
<tr>
<td>WVP #3</td>
<td>118.34 psi</td>
</tr>
<tr>
<td>WVP #4</td>
<td>116.1 psi</td>
</tr>
<tr>
<td>WVP #5</td>
<td>114.0 psi</td>
</tr>
<tr>
<td>WVP #6</td>
<td>112.3 psi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VWP No.</th>
<th>Reading Type</th>
<th>Zero Reading</th>
<th>Zero Temp</th>
<th>Date and Time of Reading</th>
<th>Readout Box SN</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Natural</td>
<td>3840.5</td>
<td>116.2</td>
<td>4/1/2013</td>
<td>122.04</td>
<td>120.24</td>
</tr>
<tr>
<td>#2 Natural</td>
<td>3830.0</td>
<td>116.0</td>
<td>4/1/2013</td>
<td>122.04</td>
<td>120.24</td>
</tr>
<tr>
<td>#3 Natural</td>
<td>3824.5</td>
<td>114.0</td>
<td>4/1/2013</td>
<td>122.04</td>
<td>120.24</td>
</tr>
<tr>
<td>#4 Natural</td>
<td>3819.7</td>
<td>112.0</td>
<td>4/1/2013</td>
<td>122.04</td>
<td>120.24</td>
</tr>
<tr>
<td>#5 Natural</td>
<td>3815.0</td>
<td>110.0</td>
<td>4/1/2013</td>
<td>122.04</td>
<td>120.24</td>
</tr>
<tr>
<td>#6 Natural</td>
<td>3810.0</td>
<td>108.0</td>
<td>4/1/2013</td>
<td>122.04</td>
<td>120.24</td>
</tr>
</tbody>
</table>

**Depth to Water Before Installation:** 0 feet

**Depth to Water After Installation:** 10 feet

**SAND:** 0 feet

**CEMENT:** 10 feet

**BENTONITE POWDER:** 5 feet

**BENT. CHIPS / PELLETS:** 5 feet

**RI ANK PVC:** 8 feet

**BORING NO:** BR-12
FIG. D-2

B-12 GROUNDWATER FROM VIBRATING WIRE PIEZOMETERS

White Point Landslide
San Pedro District
Los Angeles, California

July 2014

VAP Piezometric Elevation, ft.

51-1-10079-028

51-1-10079-028
FIG. D-3

B-12 INCLINOMETER
CUMULATIVE DISPLACEMENT

White Point Landslide
San Pedro District
Los Angeles, California

July 2014

51-1-10079-028

FIG. D-3