APPENDIX C

INSTRUMENTATION
APPENDIX C
INSTRUMENTATION

TABLE OF CONTENTS

| C.1. | GENERAL | C-1 |
| C.2. | OBSERVATION WELLS | C-1 |
| C.3. | VIBRATING WIRE PIEZOMETERS | C-2 |
| C.4. | INCLINOMETERS | C-3 |
| C.5. | REFERENCE | C-3 |

TABLES

C-1 Groundwater Data
C-2 Inclinometer Data

FIGURES

C-1 VWP Calibration Logs (4 sheets)
C-2 Comparison of Precipitation and Groundwater at B-1
C-3 Cumulative Displacement of B-1
C-4 Cumulative Displacement of B-5
C-5 Cumulative Displacement of B-7
C-6 Cumulative Displacement of B-9
C.1. GENERAL

Instrumentation, including observation wells, inclinometers, and vibrating wire piezometers, were installed based on the TOS and discussions with City representatives during exploration activities. Details are presented in the following sections.

Shannon & Wilson collected groundwater data during drilling and after installation of four vibrating wire piezometers (VWPs) and three observation wells. Additional groundwater data from the IT (1996) report for borings MW-5, MW-6, and MW-7 is also included. These observations are shown in Table C-1. The VWP and well installation details are shown on the boring logs in Appendix A.

C.2. OBSERVATION WELLS

Two 2-inch diameter PVC well casings were installed in borings B-6 and B-8, and one 8-inch PVC well casing was installed in the completed bucket auger boring B-3. The observation well locations are shown on Plates 1 and 2.

Sonic boreholes in which wells were installed were done so through the drill string outer pipe casing with the inner core barrel removed, which leaves a borehole annulus of approximately 6 inches in diameter. The bottom 5 foot of the hole was filled with 8/12 graded silica filter pack sand. The 0.020-inch machined-slotted well screen and blank threaded Schedule 40 PVC riser pipe were then placed within the outer pipe casing and filter pack sand was placed around the well pipe by pouring it from the surface. Depth of the sand placed inside the casing was continuously sounded using a weighted fiberglass tape measure. Sand was placed until it rose 1 to 2 feet inside the casing. Then the casing was retracted, being careful not to bring the bottom of the casing above the top of the sand. This was repeated until the sand had reached a depth of 5 feet above the top of the well screen. The remainder of the hole was backfilled with 10 feet of poured medium bentonite chips and then high solids sodium bentonite grout placed through a tremie pipe. A watertight locking cap was placed on the top of the well casing, and a flush-surface traffic-rated monument cover was placed in concrete over the top of the well.

The construction of the 8-inch well was completed in a 24 inch bucket auger hole, B-3. The bottom 5 foot of the hole was filled with Monterey #3 graded silica filter pack sand. The
0.020-inch machined-slotted well screen and blank threaded Schedule 80 PVC riser pipe were then placed between 110 and 40 below ground surface. The Monterey #3 filter pack sand was placed around the well pipe by pouring it from the surface. Depth of the sand placed inside the casing was continuously sounded using a weighted fiberglass tape measure. This was repeated until the sand had reached a depth of 5 feet above the top of the well screen. The remainder of the hole was backfilled with 5 feet of poured medium bentonite chips, which were then hydrated. A high solids sodium bentonite grout was placed through a tremie pipe to approximately 2 feet below ground surface. A watertight locking cap was placed on the top of the well casing, and a flush-surface traffic-rated monument cover was placed in concrete over the top of the well.

**C.3. VIBRATING WIRE PIEZOMETERS**

The 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. During installation, the transducer and low air entry filter is saturated at the ground surface and subsequently taped to the outside of the inclinometer casing and grouted into place at a specified depth. The transducer is connected to a signal cable that is routed up the borehole to the ground surface. The readout device processes the signal, applies calibration factors, and displays a reading in the required engineering unit. The measured values and calibration information were then used to calculate water pressure acting on the transducer. All VWPs used were Geokon Model No. 4500S.

VWPs were placed in borings B-1, B-5, B-7 and B-9 thus allowing water level readings at each location. In conjunction with the observation well locations at borings B-3, B-6 and B-8, it will allow a total of seven points water level monitoring points throughout the site. Groundwater measurements using VWPs are presented in Figure C-1. A comparison between the precipitation and reflection in the groundwater elevation is graphically displayed in Figure C-2.

Groundwater measurements were generally taken during a specific instant in time; however, in boring B-1, we installed a single-channel datalogger for periods of several weeks. The datalogger captures the groundwater hourly for the duration of the installation. We used a Geokon Single-Channel Datalogger Model 8002-1A (LC-2A). It is designed to read both the vibrating wire element and the integral thermistor of the vibrating wire sensor. It records the datalogger ID, day (Julian or month/day format), time (HHMM), seconds, main battery voltage, datalogger temperature, vibrating wire sensor reading (in engineering units), the sensor temperature, and array number.
C.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. One high-impact, 2.75-inch outside diameter (O.D.) and two 3.34-inch ABS plastic inclinometer pipes, or casings, manufactured by the Durham Geo Slope Indicator Company were installed in vertical boreholes. The 2.75-inch O.D. casing was installed in boring B-1, and the 3.34 inch O.D. casing was installed in Borings B-5, B-7 and B-9.

The purpose of the inclinometer casings is to permit periodic monitoring of the slope to detect hillside 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 slope movement.

Each reading consists of two sets of data. Data Set “A” measures deviation from the baseline reading in the down-slope direction, referred to as the “A axis.” Data set B measures deviation from the baseline reading at 90 degrees to the down-slope direction, the “B axis.” The baseline readings were taken on December 28, 2010. The subsequent data sets can be plotted as incremental or cumulative change from the baseline reading. The inclinometer plots of the incremental change are shown in Table C-2 and Figures C-3 through C-6 for the individual borings.

C.5. REFERENCE

## Table C-1

### Groundwater Data

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<th>Well/VWP</th>
<th>B-1</th>
<th>B-2</th>
<th>B-3</th>
<th>B-4</th>
<th>B-5</th>
<th>B-6</th>
<th>B-7</th>
<th>B-8</th>
<th>B-9</th>
<th>MW-5</th>
<th>MW-6</th>
<th>MW-7</th>
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<td>VWP Elev. = 14 ft.</td>
<td>Screened Elev. = 84.14 to 14.14</td>
<td>Screened Elev. = 100.78 to 26.68</td>
<td>VWP Elev. = 6.41</td>
<td>VWP Elev. = 7.31</td>
<td>VWP Elev. = 9.85 to 17.55</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Water Depth1 (ft.)</td>
<td>Water Depth2 (ft.)</td>
<td>Water Depth1 (ft.)</td>
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<td>Water Elevation (ft.)</td>
<td>Water Elevation (ft.)</td>
<td>Water Elevation (ft.)</td>
<td>Water Elevation (ft.)</td>
<td>Water Elevation (ft.)</td>
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<td>Water Elevation (ft.)</td>
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### Notes:

1. Measured using vibrating wire piezometer.

---

5/31/2012, Tables.xlsx, JXM Page 1 of 1

51-1-10052-011
### Table C-2
Inclinometer Data

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<th>Inclinometer Reading Date</th>
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<td>3/2/2012</td>
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<td>5/28/2012</td>
<td>&lt;0.1</td>
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</tbody>
</table>

Notes:
1. Measured using inclinometer.
   Baseline: Three series of measurements to determine starting point used for comparisons.
# Vibrating Wire Pressure Transducer Calibration Report

**Type:** S  
**Date of Calibration:** January 7, 2011  
**Temperature:** 24.1 °C  
**Barometric Pressure:** 976.9 mbar

**Serial Number:** 1040564  
**Pressure Range:** 700 kPa

## Calibration Data

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<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>
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</table>

(kPa) Linear Gage Factor (G): 0.1823  (kPa/ digit)  
Polynomial Gage Factors: A: -7.783E-07  B: -0.1715  C: 1582.6

Thermal Factor (K): 0.0010  (kPa/ °C)

## Pressure Calculations

- **Linear:** $P = G(R_0 - R_1) + K(T_1 - T_0)(S_1 - S_0)^{**}$  
- **Polynomial:** $P = AR_0^3 + BR_0^2 + C + K(T_1 - T_0)(S_1 - S_0)^{**}$

Barometric pressures are absolute. Barometric compensation is not required with vented and differential pressure transducers.

## Factory Zero Reading

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<tr>
<th>GK-401 Pos. B or F(R0)</th>
<th>Temp(T0)</th>
<th>Date: January 20, 2011</th>
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</thead>
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<td>8863</td>
<td>23.2 °C</td>
<td>992.9 mbar</td>
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<tr>
<td>$D_f\gamma$</td>
<td>22.2</td>
<td>976.9 mbar</td>
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</tbody>
</table>

**Note:** Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used, the field value of C must be calculated by plugging the initial zero reading into the polynomial equation with the value of P set to zero.

---

*The above instrument was found to be in tolerance to all operating ranges.  
The above sealed instrument has been calibrated by comparison with standards traceable to the NIST, in accordance with ASME B40.1-2000.*

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# Vibrating Wire Pressure Transducer Calibration Report

**Type:** S  
**Date of Calibration:** January 7, 2011

**Serial Number:** 1040580  
**Temperature:** 24.1 °C

**Pressure Range:** 700 kPa  
**Barometric Pressure:** 976.9 mbar

**Calibration Instruction:** VW Pressure Transducers

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<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>
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<td>699.8</td>
<td>-0.02</td>
<td>699.9</td>
<td>-0.02</td>
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</table>

(kPa) Linear Gage Factor (G): 0.1804  
(kPa/ digit)  

Regression Zero: 8630

Polynomial Gage Factors:  
A: 2.406E-08  
B: -0.1807  
C: 1557.6

Thermal Factor (K): 0.0375 (kPa/°C)

(ksi) Linear Gage Factor (G): 0.02616 (ksi/ digit)

Polynomial Gage Factors:  
A: 3.48964E-09  
B: -0.02621  
C: 225.91

Thermal Factor (K): 0.00544 (ksi/°C)

Calculated Pressures:  
Linear, P = G(R_0 - R_1) + K(T_1 - T_0)(S_1 - S_0)

Polynomial, P = AR_0^2 + BR_0 + C + K(T_1 - T_0)(S_1 - S_0)

†Barometric pressures are absolute. Barometric compensation is not required with vented and differential pressure transducers.

Factory Zero Reading:  
GK-401 Pos. B or F(R_0): 8620  
Temp(T_0): 23.6 °C  
†Barometric Pressure: 992.9 mbar  
Date: January 20, 2011

*Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used, the field value of °C must be calculated by plugging the initial zero reading into the polynomial equation with the value of P set to zero.

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.  
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# Vibrating Wire Pressure Transducer Calibration Report

**Type:** S  
**Serial Number:** 1040576  
**Pressure Range:** 700 kPa  
**Date of Calibration:** January 7, 2011  
**Temperature:** 24.1 °C  
**Barometric Pressure:** 976.9 mbar  
**Calibration Instruction:** VW Pressure Transducers  
**Technician:** [Signature]

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<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>
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**(kPa) Linear Gage Factor (G):** 0.1751  
**Regression Zero:** 8880

**Polynomial Gage Factors:**  
A: -6.061E-07  
B: -0.1667  
C: 1528.5  
**Thermal Factor (K):** 0.0187 (kPa/°C)

**(psi) Linear Gage Factor (G):** 0.02539  
**Polynomial Gage Factors:**  
A: -8.7909E-08  
B: -0.02418  
C: 221.69  
**Thermal Factor (K):** 0.00271 (psi/°C)

**Calculated Pressures:**  
Linear, \( P = G(R_4 - R_1) + K(T_1 - T_0) + (S_1 - S_0)^* \)  
Polynomial, \( P = AR_1^2 + BR_1 + C + K(T_1 - T_0) + (S_1 - S_0)^* \)

†Barometric pressures are absolute. Barometric compensation is not required with vented and differential pressure transducers.

**Factory Zero Reading:**  
GK-401 Pos. B OR F(R4): 8873  
Temp \( T_0 \): 23.3 °C  
†Baro \( S_0 \): 992.9 mbar  
Date: January 20, 2011

*Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used the field value of \( C \) must be calculated by plugging the initial zero reading into the polynomial equation with the value of \( P \) set to zero.

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.

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Vibrating Wire Pressure Transducer Calibration Report

**Type:** S  
**Serial Number:** 1040566  
**Pressure Range:** 700 kPa

Date of Calibration: January 7, 2011  
Temperature: 24.1 °C  
†Barometric Pressure: 976.9 mbar

**Calibration Instruction:** VW Pressure Transducers  
**Technician:**

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<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>8851</td>
<td>8851</td>
<td>8851</td>
<td>1.800</td>
<td>0.26</td>
<td>0.121</td>
<td>0.02</td>
</tr>
<tr>
<td>140.0</td>
<td>8071</td>
<td>8071</td>
<td>8071</td>
<td>139.6</td>
<td>-0.06</td>
<td>139.9</td>
<td>-0.01</td>
</tr>
<tr>
<td>280.0</td>
<td>7286</td>
<td>7286</td>
<td>7286</td>
<td>278.3</td>
<td>-0.25</td>
<td>279.6</td>
<td>-0.05</td>
</tr>
<tr>
<td>420.0</td>
<td>6490</td>
<td>6490</td>
<td>6490</td>
<td>419.0</td>
<td>-0.14</td>
<td>420.5</td>
<td>0.06</td>
</tr>
<tr>
<td>560.0</td>
<td>5693</td>
<td>5693</td>
<td>5693</td>
<td>559.7</td>
<td>-0.04</td>
<td>560.1</td>
<td>0.01</td>
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<tr>
<td>700.0</td>
<td>4890</td>
<td>4890</td>
<td>4890</td>
<td>701.6</td>
<td>0.22</td>
<td>699.9</td>
<td>-0.02</td>
</tr>
</tbody>
</table>

(kPa) Linear Gage Factor (G): 0.1767 (kPa/digit)  
Regression Zero: 8861

Polynomial Gage Factors:  
A: -8.088E-07  
B: -0.1655  
C: 1528.8  
Thermal Factor (K): 0.0367 (kPa/°C)

(psi) Linear Gage Factor (G): 0.02562 (psi/digit)  
Polynomial Gage Factors:  
A: -1.17307E-07  
B: -0.02401  
C: 221.73  
Thermal Factor (K): 0.00533 (psi/°C)

Calculated Pressures:
- **Linear,** \( P = G(R_0 - R_t) + K(T_1 - T_0)(S_1 - S_0) \)**
- **Polynomial,** \( P = A R_t^2 + B R_t + C + K(T_1 - T_0)(S_1 - S_0) \)**

†Barometric pressures are absolute. Barometric compensation is not required with vented and differential pressure transducers.

**Factory Zero Reading:**  
GK-401 Pos. B or F(R_0): 8845  
Temp(T_0): 23.5 °C  
†Baro(S_0): 992.9 mbar  
Date: January 20, 2011

*Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used the field value of C must be calculated by plugging the initial zero reading into the polynomial equation with the value of \( P \) set to zero.*

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.  
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Comparison of Precipitation and Groundwater at B-1

Precipitation, in.

- Cumulative Precipitation

Datalogger Groundwater Elevation, ft.

Graph shows the comparison of precipitation and groundwater levels from December 6, 2011, to June 3, 2012.