AMEC Earth & Environmental
A division of AMEC Americas Limited
610 Richard Road, Prince George, BC
Canada V2K 4L3
Tel   +1 (250) 564-3243
Fax  +1 (250) 562-7045

# PILOT DEWATERING WELL TEST
# WEST QUESNEL LAND STABILITY STUDY
# QUESNEL, BRITISH COLUMBIA

Submitted To:
**City of Quesnel**
410 Kinchant Street
Quesnel, British Columbia
V2J 7J5

Submitted By:

**AMEC Earth & Environmental**
**Prince George, B.C.**

28 May 2004
Project No. KX04397

## EXECUTIVE SUMMARY

AMEC Earth & Environmental, a division of AMEC Americas Limited (AMEC), has completed a dewatering well test in the West Quesnel District of Quesnel, B.C. Previous studies by AMEC have identified a large, slow-moving, ancient landslide underlying a large portion of the West Quesnel area. AMEC has also identified that dewatering (groundwater pressure reduction) in the slide mass was considered the most cost-effective means for reducing slide movements to manageable levels. The objectives of the dewatering well test were as follows:

- to further understand soil and groundwater conditions underlying a selected area known to be affected by the landslide; and
- to assess the feasibility of conventional pumped wells as a means for stabilizing the landslide.

Two pumping wells (PW03-1 and PW03-2) and nine observation wells (piezometers) were installed in a test area bounded by Flamingo St., Abbott Drive, Blair Street, and Lark Avenue. The pumping wells were completed to depths of 55 and 61 m below ground at two different locations. PVC slotted pipe was installed at each pumping well location at depths ranging between 30 and 55 m below ground. Observation wells were installed at three different locations. At each location, three different wells were completed (each at its own distinct depth) to depths ranging between 23 and 88 m below ground level.

Generally, the stratigraphy encountered within the dewatering well test area consisted of fill overlying silt followed by a sand or gravel layer. ). There was only limited horizontal continuity in stratigraphy between drill holes. The upper silt and granular layer was underlain by clay, locally interbedded with thin (less than 0.6 m) lignite (coal) layers, followed by dense weathered volcanic bedrock. The weathered volcanic bedrock has the consistency of silt or clay. Within the dewatering well test area, the slide surface was inferred to exist within the clay and lignite layers at depths ranging between 38 and 50 m below ground surface.

Significant flows of water were not encountered during the actual drilling installation of the wells. However, water levels at most locations slowly rose over time to within a few metres of the ground surface, confirming the high groundwater pressures encountered during earlier investigation.

Short-term pumping tests were performed in PW03-1 (October 9 to November 5, 2003) and PW03-2 (November 6 to December 15, 2003). A longer term pumping test was then conducted in PW03-01 (December 15, 2003 to March 8, 2004). While the wells were pumped, the volume of water removed and the water levels in neighbouring observation wells, were recorded. The results and conclusions of the pumping tests are summarized below:

1. Both pumping wells were pumped dry in less than 30 minutes and it took approximately three days for water levels to recover to the point where pumping could resume. Less than 9,000 litres of groundwater was removed during each pumping test and pumps operated only intermittently.

2. The observation wells generally indicated only small or negligible water level drops during pumping of the test wells.

3. The small volume of water removed and poor response of observation wells indicated that the stratigraphic zone containing the slide surface at the pumping well transmits groundwater poorly. This is likely due to the fine-grained nature of the soils, lensing in the soils such that there is little lateral continuity, and few continuous fractures in the soils.

4. The capacity of the stratigraphic units to transmit groundwater at or near the slide surface is variable. Dewatering directly from the slide plane is judged unlikely to be cost-effective in lowering the groundwater pressures acting on the slide surface. Based on conditions observed to date, pumping wells drawing from the slide plane would need to be spaced no more than 10 m apart to have any significant impact on slide movement.

5. Of the stratigraphic units encountered, the sand and gravel units (although likely discontinuous) overlying the slide plane offer the best potential to transmit groundwater. The overlying, saturated, sand and gravel units likely transmit the failure zone.

Subsurface conditions within the dewatering test area may not be representative of subsurface conditions elsewhere in the slide area. To further explore the potential for reducing groundwater levels in the slide area, AMEC recommends the following scope of work:

- In four different areas within the West Quesnel study area, assessment of the saturated sand and gravel units overlying the stratigraphy containing the slide surface for their continuity and capacity to transmit groundwater.

- Pump testing and hydrogeologic assessment in at least four different areas within the West Quesnel study area.

- Testing of innovative methods for dewatering such as vacuum enhancement of pumping wells, as a means to enhance flow rates in any future dewatering in the area.

- Use of fast response vibrating wire piezometers should be used rather than conventional standpipe observation wells for water level monitoring.

To further understand the geological and groundwater conditions in the study area, with a view to implementing a long-term management plan for the study area, AMEC makes the following recommendations (some of which are re-iterated) from our 2002 report:

- Implementation of a comprehensive surface water management plan that will reduce groundwater infiltration within the study area.

- Direct measurement of precipitation in the study area via a dedicated weather station.

- Continued monitoring and characterization of subsurface conditions throughout West Quesnel via additional drilling, groundwater instrumentation, and possible use of indirect geophysical methods (e.g. electrical resistivity tomography).

- Continued monitoring of ground movements via continued GPS surveys, installation of additional slope indicator casings, and the possible use of innovative satellite based remote sensing techniques (e.g. InSAR).

## TABLE OF CONTENTS

Page #

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF APPENDICES

## 1.0 INTRODUCTION

AMEC Earth & Environmental, a division of AMEC Americas Limited, (AMEC) has completed a pilot dewatering well test in the West Quesnel area of Quesnel, B.C. (Figure 1). This report provides the results of the pilot dewatering well tests and provides recommendations for the next stage of dewatering/depressurization efforts in West Quesnel.

## 2.0 BACKGROUND

Since 1997, the presence of large-scale landslide features in a suburban area of West Quesnel has been postulated by various geotechnical assessments. These assessments were largely based on airphoto interpretation, surface reconnaissance, and a review of reported utility breaks. Subsequently, lateral movements of up to 250 mm were reported at GPS monitoring hubs installed in West Quesnel by BC Gas (now Terasen). Due largely to the absence of detailed subsurface information, reviews of past work had been unsuccessful at documenting the clear existence of a deep-seated landslide.

Between September 2000 and July 2002, AMEC conducted a sub-surface geotechnical investigation in a portion of the affected area of West Quesnel. The findings of the investigation were presented in a report entitled *West Quesnel Land Stability Study, Quesnel, B.C.* dated 25 October, 2002. Based on subsurface information collected from seven slope indicator installations, two 50 mm diameter monitoring wells and two vibrating wire piezometers, AMEC concluded that a large, deep-seated, active but slow moving landslide underlies part of the West Quesnel area. Relatively high (in some places artesian) groundwater levels were evident in the slide area. AMEC's report concluded that potentially the most practical and cost effective way of improving the stability of the area (reducing movement rates to manageable levels or possibly stopping further movement) would likely be via extensive surface and sub-surface drainage measures focused on dewatering and/or reduction of groundwater pressures within the slide area. A slope stability analysis presented in the report of October 25, 2002 presented factors of safety against sliding (F) and correlated these factors of safety to arbitrary decreases in groundwater elevation. It was concluded that in order to be effective, drainage measures would need to draw down the groundwater levels by some 10 to 20 m over the inferred area of the slide.

AMEC's study also concluded that in addition to surface drainage measures, subsurface drainage via pumped dewatering wells would also probably be required. However, prior to design and installation of a full dewatering well system, it was recommended that the City of Quesnel consider a pilot dewatering well test program to further characterize the hydrogeological conditions in the slide area, determine parameters required for design of a well dewatering system, and to get a preliminary indication of the effectiveness and possible configuration of a final dewatering well system. This report summarizes the results of the pilot program to date.

## 3.0 OBJECTIVE AND SCOPE OF WORK

The objective of the pilot dewatering well test was to characterize the hydrogeological conditions underlying a select location within the overall area known to be affected by the land instability and to assess the feasibility of effectively dewatering this area. For purposes of discussion, it is assumed later in this report that the conditions at the site of the pilot study are similar to those over the entire slide area. However, the investigations to date cover only a narrow corridor across the slide and the conditions underlying most of the area are not known. It is likely that the conditions vary appreciably across the area.

To achieve the stated objective, AMEC has completed the following scope of work:

- Collected soil samples and recorded soil stratigraphy in six piezometer boreholes drilled at three different general locations (BH03-2AB, BH03-2C, BH03-3A, BH03-3BC, BH03-4AB and BH03-4C).
- Based on the stratigraphy observed at each location, specified completion of three nested standpipe piezometers with screened intervals between 0.6 m and 1.5 m long set at three different depths (for example at BH03-2, piezometers BH03-2A, BH03-2B, and BH03-2C have been completed where A is the deepest piezometer and C is the shallowest piezometer).
- Completed single well response (slug) tests in each piezometer to assess local hydraulic conductivities.
- Collected soil samples and recorded stratigraphy in two 150 mm diameter boreholes completed as 100 mm diameter groundwater pumping wells (PW03-1 and PW03-2).
- In cooperation with Ingram Well and Pump Service (IWPS), conducted a short-term pumping test on each production well and a long-term pumping test on PW03-1.
- Collected two groundwater samples and submitted each sample for laboratory testing of general chemistry and dissolved metals parameters.
- Compiled and interpreted data collected from the single-well response tests, short and long-term pumping tests
- Completed this report.

Authorization to proceed was provided by City of Quesnel purchase order number 303574 dated June 11, 2003. Generally, the scope of work was completed in accordance with AMEC's proposal dated June 2, 2003. Due to difficult drilling conditions encountered by the drill rig used at BH03-3 and BH03-4, a borehole at the proposed location of BH03-1 was not completed. This change in scope of work was outlined in a memorandum to the City of Quesnel dated 12 August, 2003.

## 4.0 SITE DESCRIPTION

The proposed pilot dewatering well test area and the inferred extent of the West Quesnel landslide was defined in Figure 9 of AMEC's 2002 report. Rationale for the selection of the pilot dewatering test well area was as follows:

- subsurface information had been previously collected at BH-3A, BH-4A and SI-5, at the periphery of the proposed dewatering well test area; and
- there were accessible, vacant parcels of land within the proposed dewatering well test area to allow access for the drill rig to complete the piezometers and pumping wells.

Based on the completed pumping well and piezometer locations, the pilot dewatering well test area was modified from that presented in the 2002 AMEC report (Figure 2). The pilot dewatering well test area finally chosen was bounded to the north by Lark Avenue; to the west by Blair Street; to the south by Abbott Drive; and to the west by Flamingo Street (Figure 2). The area was transected by Bettcher Street. Each of the roads in the test area was surfaced with asphalt pavement.

Generally, the area sloped downward toward the south and southeast. The maximum elevation of the area was approximately 527 m above mean sea level (amsl) at the southeast corner of the intersection of Flamingo Street and Lark Avenue. The minimum elevation of the area was approximately 498 m amsl at the northwest corner of the intersection of Blair Street and Abbott Road. A City of Quesnel stormwater retention pond (known as the Lower Flamingo Pond) was located within the dewatering area, approximately 40 m east of Flamingo Road. The bottom of the retention pond was unlined and at an approximate elevation of 513 m amsl.

Residential homes were located along the south side of Lark Avenue, the north side of Abbott Road, east side of Bettcher Street and the west side of Blair Street. A Pentecostal church occupied the lot at the southeast corner of the intersection of Lark Avenue and Flamingo Street. A gravel surfaced lane was located between the south boundary of the Pentecostal Church and Lower Flamingo Pond.

Several undeveloped lots are located along the west side of Bettcher Street. Only the two southernmost lots on the west side of Bettcher street have been developed. Along the undeveloped lots on the west side of Bettcher Street, a City of Quesnel stormwater overflow right-of-way (ROW) has been subdivided approximately mid-way between Lark Avenue and Abbott Road.

The church and each of the residences are serviced by a City of Quesnel sanitary sewage distribution system. Stormwater from areas north and northwest of the study area are allowed to flow overland, following topographic gradients. There were no catch basins north and west of the study area. Some components of the stormwater drainage from these areas are directed into a stormwater retention pond (known as the Upper Flamingo Pond) located approximately 100 m west of the study area. The remaining component of stormwater flow is directed along Flamingo Street and into the retention pond 40 m to the east. Overflow from this pond is directed via the overflow ROW and discharged at a wooded location approximately 100 m east of Blair Street. Stormwater flowing overland along Abbott Road and Bettcher Street is directed into a catch basin located at the northeast corner of the intersection of these two streets. Stormwater caught at this catch basin is ultimately discharged at a stormwater retention pond located approximately 100 m southeast of Blair Street and Abbott Road.

## 5.0 DRILLING INVESTIGATIONS

### 5.1 PIEZOMETERS

Between July 8 and July 24, 2003 Geotech Drilling Services (Geotech) completed four boreholes at two locations (BH03-3 and BH03-4) between the Lighthouse Pentecostal Church and the Lower Flamingo Pond using a Silverado air-rotary drill rig. At each location, the paired boreholes were separated by less than 2 m and were considered to occupy effectively one location. Borehole locations are provided in Figure 2. Borehole logs and piezometer completion details are provided in Appendix A.

Borehole stratigraphy was recorded based on observations of disturbed soil grab samples and anecdotal information including drilling difficulty and degree of saturation provided by the driller. Drilling of each of the boreholes completed at the BH03-3 and BH03-4 locations proceeded to the target stratigraphic unit except in cases where the casing drive shoe broke off from the bottom of the casing. Where the casing drive shoe broke off from the bottom of the casing before achieving the target stratigraphic unit, either a second, deeper borehole was drilled within 2 m of the first, or the most permeable (based on recorded stratigraphy) unit(s) intersected were selected for completion of a piezometer.

Due to drilling difficulties encountered by the drilling system used by Geotech, Cariboo Water Wells (CWW) was retained to complete the two boreholes at the BH03-2 location. The boreholes were completed between August 3 and August 8, 2003 immediately adjacent to the City of Quesnel ROW using an Ingersoll-Rand TH-60 air-rotary drill rig (Figure 2).

Generally, soil grab samples were collected from cuttings blown from the borehole at intervals ranging between 0.6 m and 3.0 m, depending on the extent of layering observed in the stratigraphy. Seven soil samples were collected from the upper 18.4 m at BH03-3 using a split-spoon sampler at 3.0 m intervals. Four soil samples were collected from the upper 16.8 m at BH03-4 using a split-spoon sampler at 3.0 m intervals. An additional split-spoon sample was collected from 41 m below grade at BH03-4. No soil samples were collected from BH03-2 using the split-spoon sampler. Soil samples were collected into a labelled polyethylene bag and shipped to AMEC's Kamloops office for review and future reference.

The first borehole drilled at each location was completed with two 33.4 mm diameter PVC standpipes having 0.6 m to 1.5 m lengths of machine-slotted pipe set at the measurement intervals. The second borehole drilled at each location was completed with a single 33.4 mm diameter PVC standpipe having a 0.6 m length of machine-slotted pipe set at the third selected monitoring interval for that location. The width of slot openings at each piezometer was 0.25 mm.

The annulus between the slotted section of each piezometer and the borehole wall was backfilled with silica sand to a height of 0.6 m above the slotted section of pipe. At BH03-3 and BH03-4, a 0.3 m to 0.9 m thick layer of coated bentonite pellets was placed over the silica sand. Using a grout mixer and tremie pipe, a bentonite-cement grout mixture was placed in the annulus over the bentonite pellets to either the ground surface or to the bottom elevation of the second piezometer to be installed in the borehole.

At BH03-2, bentonite chips were poured into the borehole annulus over the silica sand and subsequently hydrated. Clean, imported 19 mm minus sand and gravel was used to backfill the borehole annulus either to grade or to the desired completion depth of the upper piezometer. In the latter case, an additional layer of hydrated bentonite chips was used to cap the sand and gravel.

Each borehole was completed at grade with a 200 mm diameter steel or cast iron bolt-down well cover set flush to grade. Each piezometer was capped slightly below grade with a PVC well cap that had been cut at four points on its wall to facilitate the removal and placement of the well cap and also to allow air pressure within the piezometer to equilibrate to atmospheric conditions. At each piezometer, an arbitrary point at the top of the PVC pipe was marked with a black indelible marker. The point is considered to be the measuring reference point at each piezometer.

The City of Quesnel completed a geodetic survey of each of the piezometers relative to a survey monument located on Lark Avenue. The ground level elevation adjacent to each piezometer and the elevation of the measuring reference point was recorded. Also the location of each piezometer was recorded relative to the NAD 83 coordinate system.

A summary of the elevations and depths of each piezometer are provided in Table 1. At each borehole location, piezometers were labelled such that piezometer ‘A’ was set at the lowest elevation and piezometer ‘C’ was set at the highest elevation.

## Table 1
## Piezometer Completion Summary

| Location | Piezometer | Elevation of Slotted Interval (m amsl) | | Elevation of Annular Silica Sand Backfill (m amsl) | |
|---|---|---|---|---|---|
| | | Top | Bottom | Top | Bottom |
| **BH03-2** | **A** | 429.6 | 428.1 | 431.2 | 426.1 |
| | **B** | 469.1 | 468.3 | 470.2 | 467.7 |
| | **C** | 491.2 | 490.6 | 491.8 | 490.3 |
| **BH03-3** | **A** | 469.2 | 468.6 | 470.0 | 468.3 |
| | **B** | 480.4 | 478.9 | 481.0 | 478.9 |
| | **C** | 487.1 | 485.6 | 487.7 | 485.6 |
| **BH03-4** | **A** | 471.0 | 470.4 | 471.6 | 470.1 |
| | **B** | 481.1 | 480.5 | 481.7 | 479.6 |
| | **C** | 497.0 | 496.4 | 497.8 | 496.3 |

Static water levels were recorded in each of the piezometers on at least two separate dates during August using a calibrated electric sounder. All static water levels recorded using a calibrated electric sounder, and the dates recorded are presented in Appendix B.

On August 15 and 16, 2004 AMEC developed each of the piezometers, with the exception of piezometer BH03-2A. On the day that development was to take place (eight days following completion of piezometer BH03-2A), this piezometer was not developed since it was dry.

The purpose of the development process was to restore the aquifer properties immediately adjacent the annular silica sand backfill to their original condition before the borehole was drilled. Piezometer development was performed by pumping a volume of groundwater out of the well bore using a Waterra® polyethylene tubing and foot valve reciprocating pump system. The reciprocating pump system allows for some flow of water back and forth across the slotted section of pipe and consequently across the annular sand pack. Initially, the discharged groundwater is clear as the standing groundwater in the piezometer is removed. As pumping continues, the discharged water typically becomes laden with suspended silt and some fine sand (finer than the slot opening in the slotted section of pipe). Removal of this suspended sediment and sand is intended to restore the aquifer properties to their original condition. Upon further pumping, the sand component of the discharged water typically is no longer observed and the suspended silt content is reduced to some constant level. After pumping for a period of time with no observed change in the suspended sediment component in the discharged groundwater, pumping is stopped and the development process is complete. The results of the development process are summarized on Table 2.

## Table 2
## Piezometer Development Summary

| Well | Date Developed | Pumping Duration (minutes) | Volume Discharged (L) | Discharge Water Quality on Completion |
|---|---|---|---|---|
| **BH03-2C** | August 16 | 45 | 47 | White, turbid and silty |
| **BH03-2B** | August 16 | 48 | 2 | Dark brown, turbid and silty |
| **BH03-3C** | August 15 | 32 | 52 | Turbid with suspended white sediment, effervescent |
| **BH03-3B** | August 15 | 27 | 27 | Cloudy with trace fine sand and dark brown suspended sediment |
| **BH03-3A** | August 15 | 34 | 15 | Cloudy with trace fine sand and dark brown suspended sediment |
| **BH03-4C** | August 15 | 29 | 12 | Cloudy with trace fine sand and dark brown suspended sediment |
| **BH03-4B** | August 16 | 34 | 12 | Dark brown, turbid ad some silt, some effervescence |
| **BH03-4A** | August 16 | 46 | 12 | Turbid with trace fine sand; effervescent upon discharge |

### 5.2 PUMPING WELLS

Between September 15 and 18, 2003 CWW completed two 150 mm diameter boreholes for pumping wells (PW03-1 and PW03-2) to depths of 54.9 m and 61.0 m, respectively. Pumping well locations were selected based on the accessibility for the drill rig, proximity to piezometer locations, and results of the single-well response testing (described below). Borehole locations are provided in Figure 2. Soil grab samples were collected at 1.5 m intervals from cuttings blown out of the borehole. Borehole stratigraphy was recorded based on observations of the grab samples and anecdotal information including drilling difficulty and degree of saturation provided by the driller.

Generally, the borehole stratigraphy observed at PW03-1 comprised fine to medium grained sand followed by well-graded silt, overlying interbedded layers of blue-grey clay and lignite. The lignite was underlain by weathered green volcanic bedrock. This weathered green volcanic bedrock unit was of sufficient density to allow CWW to drill without casing below 42.7 m at both borehole locations. The stratigraphy observed at PW03-2 was similar except that the interbedded layers of blue-grey clay and lignite were not detected.

Based on observations recorded during drilling, AMEC specified completion of each pumping well with a 100 mm diameter PVC liner with a machine-slotted section set between 48.8 m and 30.5 m below grade (at PW03-1) and 54.9 m and 30.5 m below grade (at PW03-2). The width of slot openings at each pumping well was 0.25 mm. No annular backfill was placed within either borehole. At each location after the PVC liner was installed, the steel casing was pulled back to expose the entire length of slotted PVC liner. A summary of pumping well completion details is provided in Table 3.

### Table 3
### Pumping Well Completion Summary

| Well | Depth (m) | Elevation of Slotted Interval (m amsl) | | Elevation of Steel Casing Bottom (m amsl) |
|---|---|---|---|---|
| | | Top | Bottom | |
| **PW03-1** | 54.9 | 488.9 | 470.7 | 489.5 |
| **PW03-2** | 61.0 | 472.0 | 447.6 | 472.6 |

Upon completion of each of the pumping wells, the water levels were observed to recover very slowly, thus indicating slow groundwater recharge to the wells. Due to the slow rate of recharge, the pumping wells were not developed using the drill rig, but rather during the short-term pumping test (described in Section 7.0).

Using the survey coordinates provided by the City of Quesnel, AMEC calculated the distances from each piezometer to each pumping well. The calculated distances are presented in Table 4.

### Table 4
### Distances Between Pumping Wells and Piezometers

| Pumping Well | Piezometer | Calculated Distance (m) |
|---|---|---|
| PW03-1 | BH03-2A | 216 |
| | BH03-2B | 216 |
| | BH03-2C | 219 |
| | BH03-3A | 13.2 |
| | BH03-3B | 12.0 |
| | BH03-3C | 12.0 |
| | BH03-4A | 48.7 |
| | BH03-4B | 48.7 |
| | BH03-4C | 50.7 |
| PW03-2 | BH02-3A | 8.0 |
| | BH03-2A | 161 |
| | BH03-2B | 161 |
| | BH03-2C | 160 |
| | BH03-3A | 318 |
| | BH03-3B | 319 |
| | BH03-3C | 319 |
| | BH03-4A | 298 |
| | BH03-4B | 298 |
| | BH03-4C | 297 |

## 6.0 SINGLE-WELL RESPONSE TESTING

Single-well response testing comprised the following scope of work:

- Two rising head tests performed on BH03-2B and BH03-4A; and
- Six slug tests (falling head tests) performed on BH03-2C, BH03-3A, BH03-3B, BH03-3C, BH03-4B and BH03-4C.

Single-well response testing was not performed at BH03-2A since it remained dry throughout the test period (August 16 to September 3, 2003).

Based on the slow groundwater recharge to piezometers BH03-2B and BH03-4A observed during the development process, non-vented pressure transducers and dataloggers were installed in these piezometers immediately following their development to allow measurements over a longer period of time. Since the pressure transducers are non-vented and record both atmospheric pressure and water pressure, a pressure transducer dedicated to recording only atmospheric pressure was suspended 2 m below the top of the PVC pipe within BH03-2A. Using the pressure transducers and dataloggers, the recovery of water levels within these piezometers was recorded at 30 minute (BH03-2B) and I minute (BH03-4A) intervals, between August 16 and September 3, 2003.

After water levels in each piezometer had been given some time to recover to their static condition following development, AMEC returned to the site on September 3, 2003 to perform slug tests. The slug tests were performed to estimate the hydraulic conductivity of the stratigraphic formations exposed to the sand pack around the slotted interval at each piezometer. Due to the slow groundwater recharge observed at piezometers BH03-2B and BH03-4A, slug tests were not performed on these piezometers.

Each slug test was performed by initially recording the static water level within the piezometer. A pressure transducer and datalogger was installed in the piezometer at least 3 m below the static water level and not more than the manufacturer-defined pressure rating of the transducer. After the pressure transducer had been set within the piezometer, the static water level was recorded once again. A 15.9 mm diameter copper pipe (the slug), sealed at both ends, was lowered into the piezometer so that its top was set at a depth immediately below the recorded static water level. When lowered beneath the static water level, the slug causes instantaneous displacement of a volume of water within the piezometer. As soon as the displacement begins, the water level begins to equilibrate to static conditions. The rate at which the water level equilibrates to static conditions is recorded by the pressure transducer and datalogger. Recovery of static water levels was recorded for a period ranging between 10 minutes (BH03-2C) to one hour (BH03-4B, and BH03-3B).

The results of the slug tests are discussed in Section 8.0.

## 7.0 PUMPING TESTS

Pumping tests performed in the dewatering well test area are summarized in Table 5.

**Table 5**
**Pumping Test Summary**

| Pumping Test | Period Conducted | Piezometers Monitored |
|---|---|---|
| PW03-1 Short Term | October 9 – November 5, 2003 | BH03-3C, BH03-3B, BH03-4B |
| PW03-2 Short Term | November 6 – December 15, 2003 | BH02-3A, BH03-2B, BH03-2B, BH03-4B |
| PW03-1 Long Term | December 15, 2003 – March 8, 2004 | BH03-2C, BH03-3B, BH03-3C, BH03-4B |

Ingram Well & Pump Service (IWPS) of Quesnel, B.C. installed a 0.5 horsepower 7S05-11 Grundfos 115 Volt submersible pump with a 25 mm diameter schedule 80 drop pipe and a 25 mm diameter schedule 40 PVC sounding tube in each pumping well. At pumping well PW03-1, the pump intake was set at 50.3 m below the top of the top of the well casing. At pumping well PW03-2, the pump intake was set at 53.8 m below the top of the well casing. A flow meter, installed at the top of the drop pipe at each pumping well, recorded the cumulative volume of water discharged from the well.

Immediately prior to the start of the test, static water levels were recorded in each of the piezometers and in PW03-2. Based on the recorded hydraulic conductivity at each piezometer and its proximity to the pumping well, pressure transducers and dataloggers were installed in selected piezometers (Table 5). Also, a pressure transducer and datalogger was installed in PW03-1. A datalogger suspended in air 2 m below the top of the PVC pipe at BH03-2A continued to record atmospheric pressure. Static water levels were confirmed following installation of the dataloggers and prior to the start of the pumping test.

After the water level in PW03-1 had recovered to its static water level (2.4 m below the top of the casing), the short-term pumping test was started on October 9, 2003. The pump installed in PW03-1, powered by a portable generator, was turned on at 9:15 AM. After the pump had operated for a period of 16 minutes, 430 litres of groundwater had been discharged from PW03-1 and the water level had been drawn down to the level of the pump intake. The pump was turned off and the water level was allowed to recover over a period of approximately 3 days. Groundwater from the well was discharged into the Lower Flamingo Pond. After 3 days, and prior to the water level having reached its static water level, IWPS returned with a portable generator and discharged the accumulated column of water. After pumping down the accumulated column of water, IWPS recorded water levels using a calibrated electric sounder, in the six closest piezometers to the pumping well. This pumping cycle continued over the duration of the test.

A similar procedure was used in the completion of the PW03-2 short term test and the PW03-1 long-term test. During the PW03-2 short term pumping test, groundwater discharge was directed into the catch basin at the northeast corner of the intersection of Abbott Road and Bettcher Street. During the PW03-1 long-term pumping test, groundwater was discharged into a polyethylene holding tank mounted on a vehicle. After pumping the column of water out of the pumping well, the water in the holding tank was transported to the catch basin at the northeast corner of the intersection of Abbott Road and Bettcher Street and discharged. Also prior to the start of the PW03-1 long-term pumping test, the City of Quesnel installed a calibrated guage in the Lower Flamingo Pond, in order to record water level fluctuations in the pond during the long term pumping test. Recorded pumping volume data and inferred flow rates are provided in Appendix C. The discharge location and total volume pumped during each of the pumping tests is provided in Table 6.

**Table 6**
**Total Volume Discharged from Pumping Wells**

| Test | Volume Discharged (L) | Discharge Location |
|---|---|---|
| PW03-1 Short-Term | 3082 | Lower Flamingo Pond |
| PW03-2 Short-Term | 2936 | Abbott and Bettcher Catch Basin |
| PW03-1 Long-Term | 8055 | Abbott and Bettcher Catch Basin |

The pond level data recorded during the PW03-1 long-term pumping test did not show any reduction in pond levels during the test interval. However, had the total volume of water discharged from PW03-1 during the long-term test been pumped directly from the Lower Flamingo Pond, it is unlikely that the water levels in the pond would have been affected. Consequently, water discharged directly into the Lower Flamingo Pond during the short-term test is unlikely to have affected the results of the test.

Volumes provided in Table 6 and flow rates provided in Appendix C are considered to be low. In order to put the numbers into context, consider that the typical flow rate to a household is 2,273 litres/day. Flows presented in Appendix C are equivalent to less than 114 L/day or less than 5 % of the flow required to service a household.

During the final pumping event of each short-term pumping test, a groundwater sample was collected from the pumped well. On November 6, 2003 a groundwater sample was collected from PW03-1 and on December 15, 2003 a groundwater sample was collected from PW03-2. Each sample was collected into a 1 litre polyethylene sample bottle (to be analysed for general chemistry) and into a 250 millilitre polyethylene sample bottle having a 1:1 nitric acid preservative (to be analyzed for dissolved metals). The dissolved metals samples were passed through a 0.45 $\mu$ filter before being placed in the bottle.

## 8.0 DATA INTERPRETATION

### 8.1 SINGLE-WELL RESPONSE TESTS

Each of the single-well response tests were interpreted using the following equation (Hvorslev, 1951):

$$K=r^2 \ln(L/R)/2LT_O \qquad \text{where } L/R >8.$$

K is the hydraulic conductivity, r is the radius of the slotted section of PVC piezometer pipe, L is the length of the annular sand pack adjacent the slotted pipe, R is the radius of the borehole and $T_O$ is the basic time lag. Hydraulic conductivity is a measure of the potential rate of flow along a line. Each of these parameters can be determined from information provided in

Appendix A. $T_O$ is determined graphically from a graph of elapsed time *versus* log((H-h)/(H-$H_O$)). H is the static water level of the piezometer, $H_O$ is the water level recorded following an instantaneous change in water level (caused by the insertion of the slug), and h is the water level recorded during the recovery of the water level to its static condition. $T_O$ is defined as the elapsed time when the log((H-h)/(H-$H_O$)) of a straight-line projection of the early time recovery data is equal to 0.37. Elapsed time *versus* log((H-h)/(H-$H_O$)) graphs for each piezometer tested are provided in Appendix D.

The estimated hydraulic conductivities at each piezometer tested for the test intervals indicated are presented in Table 7.

**Table 7**
**Estimated Hydraulic Conductivities**

| Piezometer | Test Interval (m amsl) | | Estimated Hydraulic Conductivity (m/sec) |
|---|---|---|---|
| | Top | Bottom | |
| BH03-2C | 491.8 | 490.3 | $8.5 \times 10^{-6}$ |
| BH03-2B | 470.2 | 467.7 | $2.6 \times 10^{-10}$ |
| BH03-3A | 470.1 | 468.4 | $2.4 \times 10^{-7}$ |
| BH03-3B | 481.0 | 478.9 | $2.1 \times 10^{-7}$ |
| BH03-3C | 488.7 | 485.6 | $5.4 \times 10^{-6}$ |
| BH03-4A | 471.6 | 470.4 | $2.0 \times 10^{-10}$ |
| BH03-4B | 481.7 | 478.9 | $3.5 \times 10^{-8}$ |
| BH03-4C | 497.6 | 496.4 | $1.8 \times 10^{-7}$ |

Hydraulic conductivities on the order of $1 \times 10^{-6}$ m/sec are considered to be at the practical limit adequate for groundwater dewatering using conventional pumped well systems. Higher values (eg., $1 \times 10^{-5}$ m/sec) are considered preferable. The lower hydraulic conductivities, measured at most of the piezometers are considered to be too low for adequate groundwater dewatering. To put the figures in context, if the water table was sloped at a gradient equal to the ground surface within the pilot dewatering test area, the maximum hydraulic conductivity presented in Table 7 ($8.5 \times 10^{-6}$ m/sec) would allow movement of groundwater at a rate of 55 m/year. Similarly, the minimum hydraulic conductivity presented in Table 7 ($2.0 \times 10^{-10}$ m/sec) allows movement of groundwater at a rate of 1.7 mm/year for the same gradient.

## 8.2 WATER LEVEL ELEVATIONS

Water levels recorded in each piezometer using a calibrated electric sounder are presented graphically in Figure 4. The operational periods for each of the pumping tests are also shown on Figure 4. The recorded groundwater level elevations are presented in Appendix B.

The following observations are made from Figure 4:

- Water levels in BH03-3B and BH03-3C appear to be affected by pumping from PW03-1.
- Water levels recorded at BH03-2A, BH03-2C, BH03-3A, BH03-4A, BH03-4B, and BH03-4C were unaffected by pumping from either PW03-1 or PW03-2. The sudden increase in water levels in BH03-3A, BH03-4B, and BH03-4A observed after February 25, 2004 (during the latter part of the long-term test) may be due to leakage of surficially ponded water within the surface protector into the top of the piezometer.
- It is uncertain if the increase in water level elevation recorded at BH03-2B after February 19, 2004 is a response to one of the pumping tests or due to leakage of surficially ponded water into the top of the piezometer.
- Water levels recorded in BH03-2A, BH03-2B, and BH03-4A have been recovering (rising) since their completion, and did not achieve equilibrium before the end of the long-term test on March 8, 2004.
- Under both static and pumping conditions, there was a consistent upward vertical hydraulic gradient between the zones monitored by BH03-4B and BH03-4C.
- Under both static and pumping conditions there was a consistent downward vertical hydraulic gradient across each of the piezometers installed at BH03-2.
- Under static conditions, there was a downward vertical hydraulic gradient across each of the piezometers installed at BH03-3. However, while pumping from PW03-1 there was an induced upward vertical gradient across each of the piezometers installed at BH03-3. The start of the PW03-1 short-term pumping test created an instantaneous upward vertical gradient across BH03-3B and BH03-3C. However, the induced upward hydraulic gradient from BH03-3A was not created until 17 days following the start of the short-term test.

Water level elevations recorded using the calibrated electric sounder presented in Figure 4 and the recorded piezometric responses to pumping conditions were in general agreement with the piezometer estimated hydraulic conductivities presented in Table 7.

The overall conclusion from the water level observations was that the pressures were not influenced by the pumping tests, except at BH03-3A and BH03-3B. This is in accordance with the low hydraulic conductivies that appear to be present. Moreover, the very low hydraulic conductivity values determined during the slug tests indicate that the standpipe piezometer response would also be very slow.

## 8.3 PUMPING TEST INTERPRETATION

The following data is presented graphically in Appendix D:

- Water levels recorded in PW03-1 during the short-term test;
- Atmospheric pressures recorded at BH03-2A during each of the short-term tests and the PW03-1 long-term test; and
- Water levels recorded in selected piezometers (listed in Table 5) during each test.

### 8.1.1 General Observations

During the PW03-1 short-term pumping test, 1 m of drawdown was recorded in BH03-3B and 3 m of drawdown was recorded at BH03-3C, located 12 m from PW03-1. The drawdown recorded at these locations did not reach equilibrium during the short-term test. The water level recorded in BH03-4B (48.7 m from PW03-1) was not affected by pumping from PW03-1. Small (less than 15 cm) fluctuations in water levels recorded at BH03-4B correlate with recorded atmospheric pressure variations.

During the PW03-2 short-term pumping test, a limited drawdown effect was recorded in BH02-3A, located 8 m from PW03-2. The water level at BH02-3A drew down approximately 0.8 m before reaching equilibrium. Water levels recorded in BH03-2C and BH03-2B (160 m from PW03-2) and in BH03-4B (298 m from PW03-2) were not affected by pumping from PW03-2. Water levels recorded in BH03-2B continued to recover during the PW03-2 short-term test and never achieved equilibrium. Small (less than 30 cm at BH03-2C and BH02-3 A, less than 15 cm at BH03-4B, and less than 10 cm at BH03-2B) fluctuations in water levels recorded in each of the piezometers monitored correlate with recorded atmospheric pressure variations. This correlation was closest at BH02-3A, where the vibrating wire piezometer from AMEC's previous investigation work was installed. Some time lag in the correlation was observed in the PVC piezometers.

Observations made from the PW03-1 long-term test data were similar to those made for the PW03-1 short term test data. Approximately 2.8 m of drawdown was recorded in BH03-3B and 5.8 m of drawdown was recorded at BH03-3C, Water levels recorded at BH03-3C and BH03-3B did not reach equilibrium during the long-term test.

### 8.1.2 Transmissivity and Storativity

Drawdown has been plotted versus the log of elapsed time on a semi-logarithmic graph for BH03-3C and BH03-3B during both the PW03-1 short and long-term tests. A straight-line projection of the end of the pumping test curve has been made. The transmissivity (T in $m^2$/day) of the formations adjacent BH03-3C and BH03-3B have been calculated using the Cooper-Jacob method:

$$T=0.183Q/\Delta s$$

where Q is the flow rate (in $m^3$/day) pumped from PW03-1 and $\Delta s$ is determined graphically as the drawdown (m) over one log cycle from a straight-line projection of the end of the pumping test curve on the semi-logarithmic graph.

Storativity (S) has been calculated using the following equation:

$$S=2.25Tt_O/r^2$$

Where T is the transmissivity (in $m^2$/day), $t_O$ is the time (in days) at the intercept of zero drawdown of the straight line projection of the end of the pumping test curve, r is the distance (m) from the piezometer to the pumped well.

Using the methods described above and the pumping test curves presented in Appendices E and G, the transmissivty and storativity values presented in Table 8 have been calculated for the formations adjacent the slotted sections of BH03-3C and BH03-3B.

**Table 8**
**BH03-3C and BH03-3B Estimated Transmissivity and Storativity**

| Well | Test Interval (m) | | PW03-1 Short Term Test | | PW03-1 Long Term Test | |
|---|---|---|---|---|---|---|
| | Top | Bottom | Transmissivity ($m^2$/day) | Storativity | Transmissivity ($m^2$/day) | Storativity |
| **BH03-3C** | 488.7 | 485.6 | 0.0039 | $5.1 \times 10^{-4}$ | 0.0029 | $4.8 \times 10^{-4}$ |
| **BH03-3B** | 481.0 | 478.9 | 0.0083 | $1.5 \times 10^{-3}$ | 0.0045 | $1.3 \times 10^{-3}$ |

Data presented in Table 8 shows good consistency between the estimated storativities and adequate consistency between the estimated transmissivities. Table 8 also shows that transmissivities calculated for the BH03-3B are greater than those calculated for BH03-3C. This does not agree with the estimated hydraulic conductivities presented in Table 7 nor with the response of the piezometers observed in the field. Estimated storativities calculated for BH03-3C were less than those calculated for BH03-3B. This agrees with information provided in the borehole log.

### 8.1.3 Time-Drawdown Projections

The responses of the piezometers show that the influence of the pumping on the nearby piezometers was small or negligible. Due to the poor transmissivity of the formations intersected, the response times of the majority of the standpipe piezometers were too slow to obtain accurate pore pressure responses to pumping.

The test results indicate that the transmissivities recorded at BH03-3B and BH03-3C are probably not representative of the overall transmissivities within the stratigraphic units in the dewatering test area (i.e., the transmissivities are higher than average). As they are the only piezometers where any drawdown was recorded, they have been used to develop an estimate of minimum period to achieve the minimum required drawdowns. The drawdowns calculated from these piezometers thus represent a “Best Case” that probably could not be realized in actual practice.

Table 21 of AMEC’s 2002 report presented a summary of the slope stability analysis and lists specific drawdown targets to achieve specific factors of safety against sliding (F). Achieving the drawdown targets listed in Table 21 requires the following conditions to be true:

- Target drawdowns in each pumping well should exceed the target drawdown over the slide area to obtain the necessary factors of safety between wells; and
- In order to achieve the necessary interference drawdown effect between wells, the spacing between pumping wells should vary based on variations in transmissivity between stratigraphic units.
- The reductions shown would have to occur over the entire slope or area.

Using the semi-logarithmic time-drawdown plots for BH03-3C and BH03-3B presented in Appendix G, the projected pumping periods required to achieve the drawdowns presented In Table 21 (AMEC, 2002) were calculated and presented in Table 9.

**Table 9**
**Projected Pumping Periods to Achieve Increased**
**Factor of Safety Against Sliding (F)**

| Required Drawdown (m) | F | Projected Pumping Period | |
|---|---|---|---|
| | | BH03-3C | BH03-3B |
| 5 | 1.17 | 63 days | 330 days |
| 10 | 1.30 | 420 days | 19 years |
| 15 | 1.43 | 7.6 years | 442 years |
| 20 | 1.55 | 51 years | 9500 years |

Table 9 shows that using conventional submersible pumps and wells, achieving a drawdown of 10 m (and a factor of safety against sliding of 1.30) at BH03-3C by pumping from PW03-1 (12 m away) is projected to take approximately 420 days. Achieving a similar drawdown at BH03-3B by pumping from PW03-1 (12 m away) is projected to take 19 years. Generally, achieving drawdowns greater than 10 m at BH03-3B and greater than 15 m at BH03-3C is not considered realistically feasible from a well pumping 12 m away, screened at similar depths.

Achieving the required drawdowns at other piezometers completed as part of this study is not considered to be realistically feasible using conventional submersible pumps and wells.

Therefore, the overall conclusion of the work to date is that the sedimentary sequence within which the shear surface occurs is not suitable for dewatering/depressurization using conventional pumped wells.

## 8.4 ANALYTICAL CHEMISTRY RESULTS

A groundwater sample was collected from each pumping well at the end of the short term test. A review of major ion concentrations suggests that the groundwater discharged from PW03-1 is of a different geochemical origin than the groundwater discharged from PW03-2. Groundwater discharged from PW03-1 was a sodium-bicarbonate type groundwater, while groundwater discharged from PW03-2 was a sodium-sulfate type.

Recorded general chemistry parameter concentrations and dissolved metals concentrations in both groundwater samples are presented in Table 10. Laboratory chemistry reports are presented in Appendix H. For comparative purposes, the analytical chemistry results are compared to the Health Canada *Guidelines for Canadian Drinking Water Quality* (GCDWQ) and the Ministry of Water Land and Air Protection (MWLAP) B.C. Approved Water Quality Guidelines (AWQG).

Total iron and manganese concentrations and dissolved manganese concentrations in both samples exceeded both the GCDWQ and AWQG. The dissolved iron concentration in PW03-1 exceeded both the GCDWQ and the AWQG. Turbidity levels in both samples exceeded the GCDWQ and AWQG. The total dissolved solids concentration in the sample collected from PW03-2 exceeded both the GCDWQ and the AWQG. The dissolved aluminium concentration in the sample collected from PW03-1 exceeded the AWQG. All other parameter concentrations analysed were less than the GCDWQ and AWQG.

The results of the tests indicate that surface disposal of appreciable quantities of groundwater from the pumped zone might be a concern.

## 9.0 CONCLUSIONS

Two wells and nine piezometers have been completed at five different locations within the pilot dewatering test area. Generally the stratigraphy within the test area consisted of fill overlying residual volcanogenic silt overlying a granular layer locally described as either sand or gravel. The granular layer is underlain by volcanogenic high plastic clay locally interbedded with thin (less than 0.6 m) lignite layers followed by dense weathered volcanic bedrock. Within the pilot dewatering test area, the failure zone is inferred to exist within the plastic clay locally interbedded with thin lignite layers.

The transmissivity data shows that the influence of pumping within the high plastic clay/lignite zone on piezometers was considered to be small or negligible. Due to the poor transmissivity of the formations intersected, the response times of the majority of the standpipe piezometers were too slow to obtain accurate pore pressure responses to pumping. The intersection of sufficient continuous transmissive zones within the volcanogenic stratigraphic units within the failure zone is considered to be the limiting factor to effective reduction of pore pressures within the dewatering test area.

The test results show that conventional dewatering from the slide surface and/or immediately surrounding strata is unlikely to be successful. Although local permeable stratigraphic units were encountered during drilling, the more permeable strata are evidently not laterally continuous, severely limiting the extent of groundwater drawdown. The test results further indicate that, assuming homogeneous stratigraphy having transmissivities as high as those recorded at BH03-3B, and BH03-3C, pumping well spacings of not more than 10 m would be required to achieve groundwater level reductions sufficient (minimum 10 m reduction over the study area) to effectively improve stability. Given that the stratigraphy observed in completed boreholes was not homogeneous or continuous and that transmissivities over most of the area tested appears to be considerably less than those recorded at BH03-3B and BH03-3C, then effective reduction of pore pressures is not considered to be feasible by conventional submersible pumps and wells pumping from near the failure zone.

The hydrogeological conditions of the stratigraphic units overlying the clay/lignite zone may be more conducive to dewatering, although these strata are likely still discontinuous. Based on static vertical groundwater gradients observed in the various piezometers, the saturated overlying stratigraphic units are considered to locally recharge the failure zone. Thus, dewatering within the sediments overlying the clay/lignite sequence may offer a potential “secondary” means of reduction of groundwater pressures along the failure zone.

## 10.0 RECOMMENDATIONS

Due to the poor transmissivities encountered within stratigraphy located at or near the depth of the failure zone it is apparent that further hydrogeologic investigation is required to assess the potential for direct sub-surface reduction of groundwater levels in the slide area. AMEC recommends further hydrogeologic exploratory work proceed on two fronts:

1. Exploration and hydrogeologic assessment of the transmissivity of the saturated stratigraphic units overlying the failure zone to determine whether dewatering of the overlying strata is feasible and whether a suitable pressure response can be induced along the failure surface.

2. Testing of innovative methods for dewatering such as vacuum enhancement of pumping wells, to determine whether this would assist the economics of future dewatering/depressurization. Vacuum dewatering has been applied in several cases to sub-horizontal drain systems with good success and has also been applied in a few cases to well installations. Previous experience with the method has been very good in some instances. The method is potentially applicable to hydraulic conductivities in the range of $10^{-6}$ to $10^{-7}$ m/s, which is within the range determined by the testing to date.

If further exploration and assessment is undertaken, the following additional preliminary recommendations for the wells and monitoring piezometers are made:

3. AMEC recommends that one of assessment areas be located within close proximity to the most recent test area, another be located further upslope along the axis of known information (Section shown on Figure 7 of AMEC's 2002 report), and that at least two more test areas be located in areas of unknown subsurface information (i.e. north of the existing information).

4. Each 150 mm diameter pumping well should be completed with a 100 mm diameter PVC pipe slotted over the entire saturated area of the borehole. The wells should extend down below the sand/gravel layer to the depth of failure.

5. A 6 m to 10 m long bentonite slurry or cement surface seal should be installed to seal the wells, in order to allow application of a vacuum to enhance flow rates discharged from the stratigraphy.

6. Due to the expected low permeability of the formations, fast response vibrating wire piezometers should be used for observation wells rather than standpipe piezometers. Piezometer distribution should include three piezometers: one in upper formations, one in the sand/gravel layer and one near the shear surface.

Effective direct sub-surface dewatering is one part of an overall long term management plan for the study area. Given that it will take additional time and resources to fully explore effective pumping well options, AMEC recommends the following (some of which have been re-iterated from our 2002 report):

7. Implementation of a comprehensive surface water management plan that will reduce groundwater infiltration within the study area. Containment of stormwater runoff through development of a closed stormwater management plan should be undertaken for West Quesnel. Infiltration from the existing system may be creating increased pore pressures along the failure surfaces, which in turn would be expected to result in increased movement rates.

8. In conjunction with implementation of a comprehensive storm water management plan, direct information on actual precipitation in the study area would be useful. Installation of a dedicated weather station in West Quesnel should be considered.

9. Continue to monitor groundwater levels and ground movements via the existing instrumentation (wells, piezometers and slope inclinometers) and GPS hub surveys.

10. Determination of more detail on slide movements via installation of additional slope inclinometers, more surface monitoring GPS hubs and/or satellite methods would allow determination of zones of extension and compression which would be of great assistance in the operation of utilities and determination of critical areas within the study area. Interferometry applied to satellite based synthetic aperture radar images (InSAR) is a newer method for determining surface movements that should be considered.

11. Additional characterization of subsurface stratigraphy throughout West Quesnel is required. Specifically, information about stratigraphy is generally only known along one section through the slide. There may be substantial lateral variation in material properties that could affect future decision-making. Additional drilling and coring locations are required. Further, AMEC recommends that a geophysical survey (such as electrical resistivity tomography) be considered as a potential tool to identify sub-surface stratigraphy and zones of higher transmissivity. The geophysical survey could potentially be used to optimise the location of the additional drill holes and possible future pumping wells.

## 11.0 CLOSURE

Recommendations presented herein are based on a geotechnical evaluation of the findings of the site investigation noted. The geotechnical sampling and testing was conducted in accordance with industry standard practices and the proposed scope of work for this project. If conditions other than those reported are noted during subsequent phases of the project, AMEC should be notified and be given the opportunity to review and revise the current recommendations, if necessary. The general limitations of this report are specified in Appendix I.

This report has been prepared for the exclusive use of the City of Quesnel for specific application to the area within this report. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. AMEC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. It has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

We trust that this information meets your current requirements. If you have any questions or concerns, please contact the undersigned at your convenience.

Recommendations presented herein may not be valid if an adequate level of review or inspection is not provided during construction.
Respectfully submitted,

**AMEC Earth & Environmental**

Scott Green

Scott Green, P.Eng.
Hydrogeologist

Reviewed by:

Drum Cavers, M.Eng.,P.Eng.,P.Geo.
Principal Geotechnical Engineer

Nick Polysou, P.Eng.
Senior Geotechnical Engineer

SG:NP/rmm
KX04397final.rpt.doc

# APPENDIX A
# BOREHOLE LOGS AND PIEZOMETER COMPLETION DETAILS

# APPENDIX B
# WATER LEVEL MONITORING DATA

# APPENDIX C

## RECORDED PUMPING VOLUME DATA AND INFERRED FLOW RATES

# APPENDIX D
# SINGLE-WELL RESPONSE TEST CURVES

# APPENDIX E
# PW03-1 SHORT-TERM PUMPING TEST CURVES

# APPENDIX F
# PW03-2 SHORT-TERM PUMPING TEST CURVES

# APPENDIX G
# PW03-1 LONG-TERM PUMPING TEST CURVES

# APPENDIX H
# ANALYTICAL CHEMISTRY REPORT

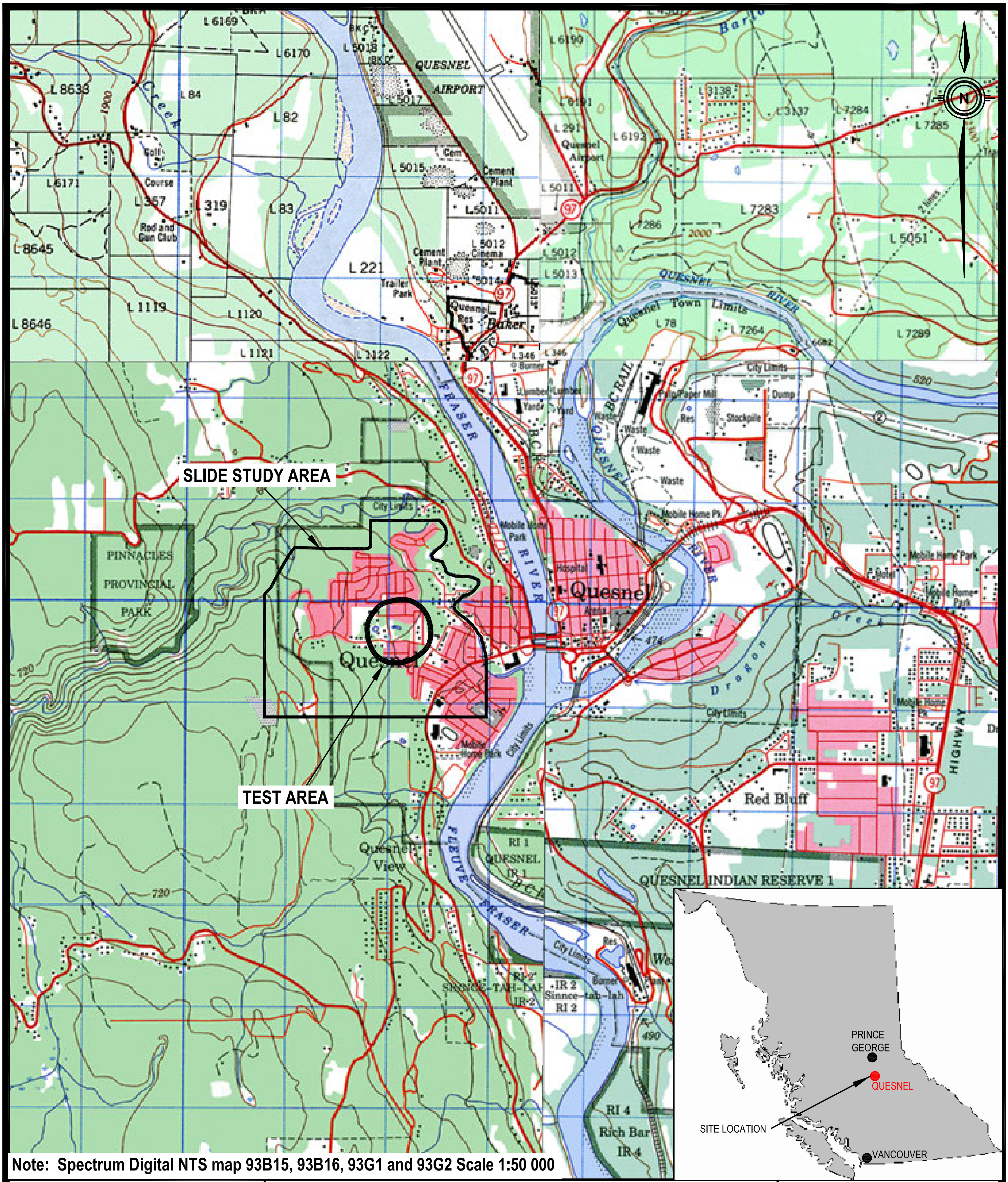
# APPENDIX I
# GENERAL LIMITATIONS

## Table 10: West Quesnel Pilot Dewatering Test, Analytical Chemistry Results

| **Parameter** | Concentration (mg/L) | | B.C.Approved Water Quality Guidelines (2001) | Guidelines for Canadian Drinking Water Quality (2001) |
|---|---|---|---|---|
| | November 6, 2003 | December 15, 2003 | | |
| | **PW03-1** | **PW03-2** | | |
| **General Chemistry** | | | | |
| Calcium | 24.3 | 74.1 | ns | ns |
| Magnesium | 10 | 27.3 | ns | ns |
| Potassiuum | 5.5 | 8.4 | ns | ns |
| Sodium | 112 | 127 | ns | ns |
| Total Iron | **17** | **1.75** | 0.3 | 0.3 |
| Total Manganese | **0.21** | **0.16** | 0.05 | 0.05 |
| Bicarbonate | 385 | 215 | ns | ns |
| Carbonate | <1 | <1 | ns | ns |
| Chloride | 7.0 | 7.3 | 250 | 250 |
| Fluoride | 0.47 | 0.18 | 1.5 | 1.5 |
| Hydroxide | <1 | <1 | ns | ns |
| Nitrate | <0.05 | <0.05 | 10 | 10 |
| Nitrite | <0.05 | <0.05 | ns | 3.2 |
| Sulphate | 34.9 | 391 | 500 | 500 |
| Conductivity (µS/cm) | 627 | 1,080 | ns | ns |
| pH | 8.29 | 8.08 | 6.5-8.5 | 6.5-8.5 |
| Turbidity (NTU) | **660** | **43** | 1 | 1 |
| Total Alkalinity | 316 | 176 | ns | ns |
| Total Dissolved Solids | 288 | **716** | 500 | 500 |
| Total Hardness | 100 | 297 | 500 | ns |
| **Dissolved Metals** | | | | |
| Aluminum | *1.31* | 0.12 | 0.1 | ns |
| Antimony | <0.002 | 0.005 | 0.006 | 0.006 |
| Arsenic | 0.006 | 0.008 | 0.025 | 0.025 |
| Barium | 0.35 | 0.14 | 1.0 | 1.0 |
| Beryllium | <0.0005 | <0.0005 | ns | ns |
| Boron | 0.1 | <0.1 | 5 | 5 |
| Cadmium | 0.0002 | <0.0001 | 0.005 | 0.005 |
| Calcium | 27.9 | 73.4 | ns | ns |
| Chromium | 0.002 | <0.001 | 0.05 | 0.05 |
| Cobalt | <0.001 | <0.001 | ns | ns |
| Copper | 0.011 | 0.003 | 1 | 1.0 |
| Iron | **1.95** | 0.25 | 0.3 | 0.3 |
| Lead | 0.006 | <0.001 | 0.010 | 0.010 |
| Magnesium | 10 | 26.2 | ns | ns |
| Manganese | **0.075** | **0.139** | 0.05 | 0.05 |
| Mercury | <0.0002 | <0.0002 | 0.001 | 0.001 |
| Molybdenum | 0.052 | 0.106 | ns | ns |
| Nickel | 0.018 | 0.022 | ns | ns |
| Selenium | <0.005 | 0.006 | 0.01 | 0.01 |
| Silver | <0.0005 | <0.0005 | ns | ns |
| Sodium | 94.8 | 128 | 200 | 200 |
| Thallium | <0.002 | <0.002 | ns | ns |
| Titanium | 0.032 | 0.007 | ns | ns |
| Uranium | <0.01 | <0.01 | 0.1 | 0.02 |
| Vanadium | 0.005 | <0.001 | ns | ns |
| Zinc | 0.091 | 0.077 | 5.0 | 5.0 |

**Notes:**

| | |
|---|---|
| mg/L | milligrams per litre equivalent to parts per million by volume |
| µS/cm | microSiemens per centimetre |
| NTU | Nephelometric Turbidity Units |
| < | less than analytical detection limit indicated |
| ns | no listed standard |
| **Bold** | indicates concentration exceeds Guidelines for Canadian Drinking Water Quality and B.C. Approved Water quality Guidelines |
| *Italics* | indicates concentration exceeds B.C. Approved Water Quality Guidelines |



Note: Spectrum Digital NTS map 93B15, 93B16, 93G1 and 93G2 Scale 1:50 000

amec

CLIENT:
CITY OF QUESNEL

TITLE:
# TEST AREA LOCATION

PROJECT:
WEST QUESNEL PILOT DE-WATERING WELL TEST
QUESNEL, BC

DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: SANDE
PROJECT MGR: SG
CAD FILE: DRAFTING\KX04397\FIGURE1.DWG
FIGURE #: FIGURE 1

## LEGEND:

BH-2A AMEC BOREHOLE (2001)

BH03-4B,C AMEC BOREHOLE WITH PIEZOMETER (2003)

PW03-1 AMEC PUMPING WELL (2003)

0m 40 80 120 160

1 : 4000

NOTE: ORIGINAL BASE MAP PRODUCED FROM DATA PROVIDED BY MCELHANNEY CONSULTING AND SERVICES LTD. AND CADASTERAL MAPPING PROVIDED BY BC GAS UTILITY LTD. CONTOURS AT 2.5m INTERVALS. DIGITAL IMAGE IS SCANNED FROM BCC97136 NO.73 (1997)

amec

CLIENT:

CITY OF QUESNEL

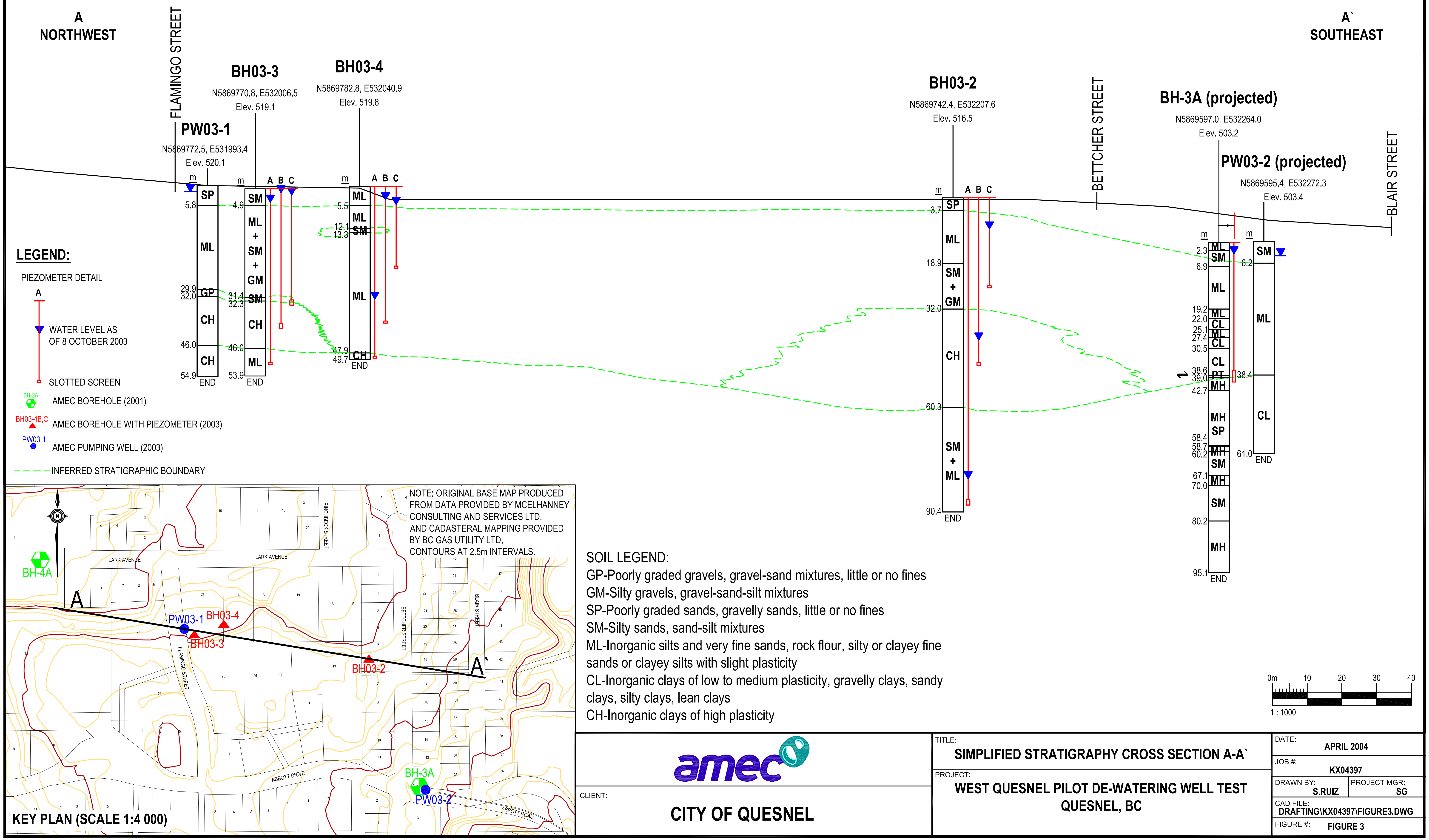
TITLE:

SITE PLAN

PROJECT:

WEST QUESNEL PILOT DE-WATERING WELL TEST
QUESNEL, BC

| | |
|---|---|
| DATE: | MARCH 2004 |
| JOB #: | KX04397 |
| DRAWN BY: S.RUIZ | PROJECT MGR: SG |
| CAD FILE: | DRAFTING\KX04397\FIGURE2.DWG |
| FIGURE #: | FIGURE 2 |



NOTE: ORIGINAL BASE MAP PRODUCED FROM DATA PROVIDED BY MCELHANNEY CONSULTING AND SERVICES LTD. AND CADASTERAL MAPPING PROVIDED BY BC GAS UTILITY LTD. CONTOURS AT 2.5m INTERVALS.

SOIL LEGEND:
GP-Poorly graded gravels, gravel-sand mixtures, little or no fines
GM-Silty gravels, gravel-sand-silt mixtures
SP-Poorly graded sands, gravelly sands, little or no fines
SM-Silty sands, sand-silt mixtures
ML-Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
CL-Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
CH-Inorganic clays of high plasticity

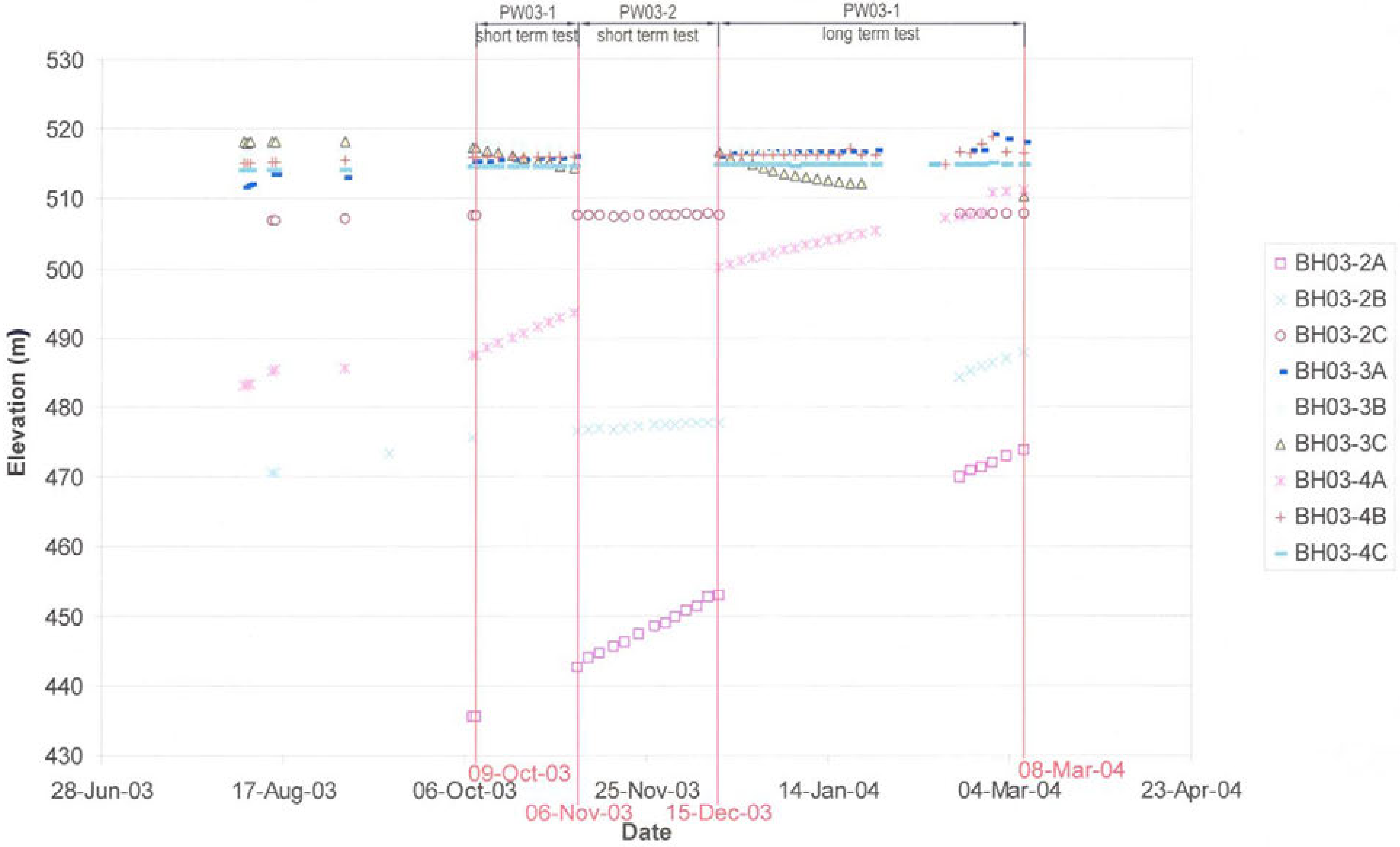
CLIENT:
**CITY OF QUESNEL**

TITLE:
**SIMPLIFIED STRATIGRAPHY CROSS SECTION A-A`**

PROJECT:
**WEST QUESNEL PILOT DE-WATERING WELL TEST**
**QUESNEL, BC**

DATE: APRIL 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CAD FILE: DRAFTING\KX04397\FIGURE3.DWG
FIGURE #: FIGURE 3

**West Quesnel Pilot De-Watering Project**
**Water Elevations Recorded in Piezometers using Calibrated Electric Sounder**



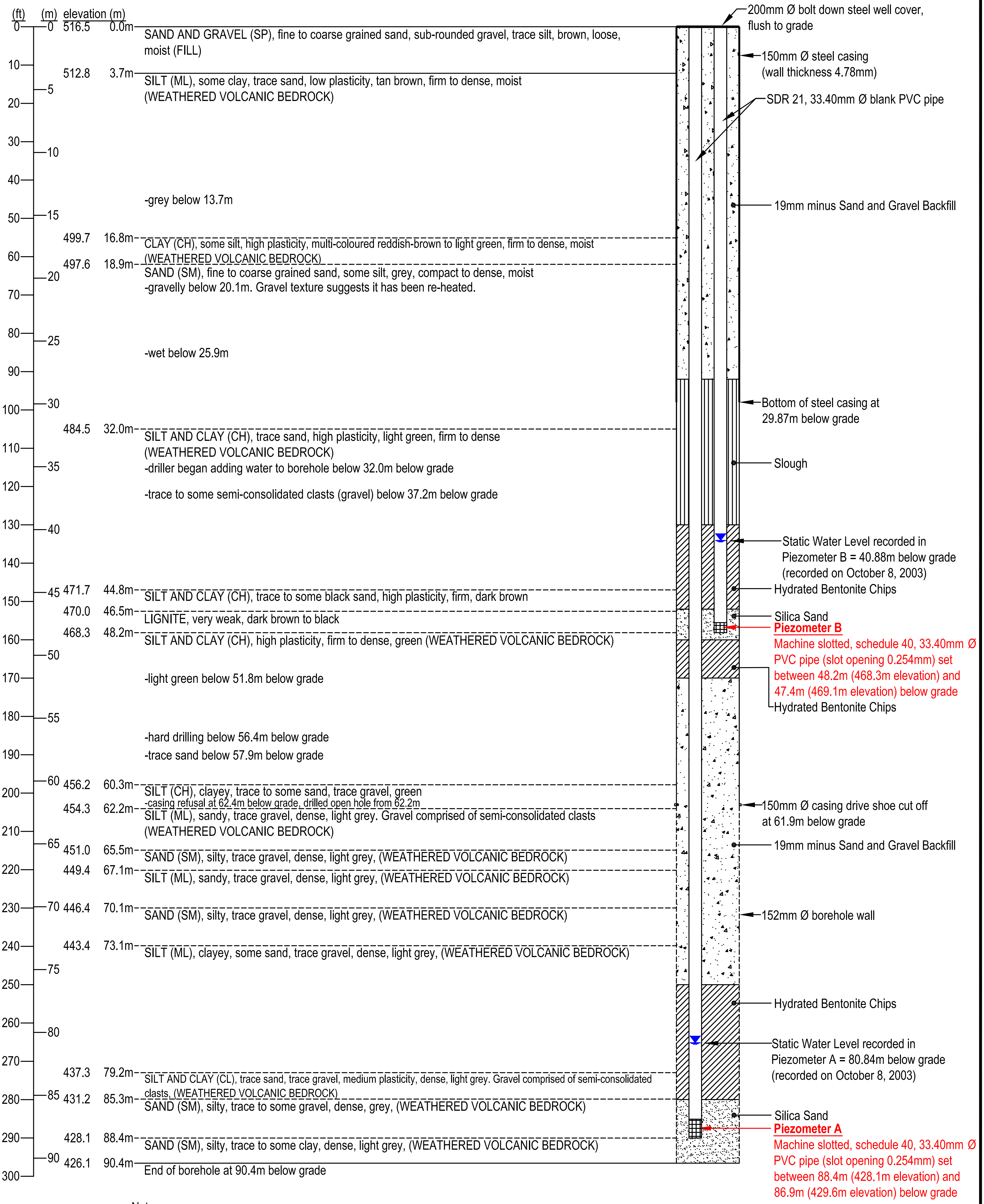
**amec**

CLIENT:
CITY OF QUESNEL

TITLE:
PIEZOMETRIC GROUNDWATER ELEVATIONS

PROJECT:
WEST QUESNEL PILOT DE-WATERING TEST
QUESNEL, BC

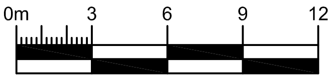
DATE: APRIL 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CAD FILE: DRAFTING\KX04397\FIG4.DWG
FIGURE #: FIGURE 4



| elevation (m) | | |
|---|---|---|
| 516.5 | 0.0m | SAND AND GRAVEL (SP), fine to coarse grained sand, sub-rounded gravel, trace silt, brown, loose, moist (FILL) |
| 512.8 | 3.7m | SILT (ML), some clay, trace sand, low plasticity, tan brown, firm to dense, moist (WEATHERED VOLCANIC BEDROCK)<br>-grey below 13.7m |
| 499.7 | 16.8m | CLAY (CH), some silt, high plasticity, multi-coloured reddish-brown to light green, firm to dense, moist (WEATHERED VOLCANIC BEDROCK) |
| 497.6 | 18.9m | SAND (SM), fine to coarse grained sand, some silt, grey, compact to dense, moist<br>-gravelly below 20.1m. Gravel texture suggests it has been re-heated.<br>-wet below 25.9m |
| 484.5 | 32.0m | SILT AND CLAY (CH), trace sand, high plasticity, light green, firm to dense (WEATHERED VOLCANIC BEDROCK)<br>-driller began adding water to borehole below 32.0m below grade<br>-trace to some semi-consolidated clasts (gravel) below 37.2m below grade |
| 471.7 | 44.8m | SILT AND CLAY (CH), trace to some black sand, high plasticity, firm, dark brown |
| 470.0 | 46.5m | LIGNITE, very weak, dark brown to black |
| 468.3 | 48.2m | SILT AND CLAY (CH), high plasticity, firm to dense, green (WEATHERED VOLCANIC BEDROCK)<br>-light green below 51.8m below grade<br>-hard drilling below 56.4m below grade<br>-trace sand below 57.9m below grade |
| 456.2 | 60.3m | SILT (CH), clayey, trace to some sand, trace gravel, green<br>-casing refusal at 62.4m below grade, drilled open hole from 62.2m |
| 454.3 | 62.2m | SILT (ML), sandy, trace gravel, dense, light grey. Gravel comprised of semi-consolidated clasts (WEATHERED VOLCANIC BEDROCK) |
| 451.0 | 65.5m | SAND (SM), silty, trace gravel, dense, light grey, (WEATHERED VOLCANIC BEDROCK) |
| 449.4 | 67.1m | SILT (ML), sandy, trace gravel, dense, light grey, (WEATHERED VOLCANIC BEDROCK) |
| 446.4 | 70.1m | SAND (SM), silty, trace gravel, dense, light grey, (WEATHERED VOLCANIC BEDROCK) |
| 443.4 | 73.1m | SILT (ML), clayey, some sand, trace gravel, dense, light grey, (WEATHERED VOLCANIC BEDROCK) |
| 437.3 | 79.2m | SILT AND CLAY (CL), trace sand, trace gravel, medium plasticity, dense, light grey. Gravel comprised of semi-consolidated clasts, (WEATHERED VOLCANIC BEDROCK) |
| 431.2 | 85.3m | SAND (SM), silty, trace to some gravel, dense, grey, (WEATHERED VOLCANIC BEDROCK) |
| 428.1 | 88.4m | SAND (SM), silty, trace to some clay, dense, light grey, (WEATHERED VOLCANIC BEDROCK) |
| 426.1 | 90.4m | End of borehole at 90.4m below grade |

Notes:
BH03-2AB drilled and completed between August 3 and August 7, 2003 using an Ingersoll-Rand TH-60 air-rotary drill rig provided by Cariboo Water Wells.
BH03-2AB logged by Homan Arabshahi, P.Eng and reviewed by Scott Green, P.Eng, soil samples collected along 1.5m intervals.
None of the soil samples collected from BH03-2AB have been subject to laboratory testing.
Ground Surface Elevation = 516.479m
Piezometer 2A = 532207.573East, 5869742.429North; Elevation of measuring datum = 516.389m
Piezometer 2B = 532207.564East, 5869742.394North; Elevation of measuring datum = 516.371m
Elevations relative to Geodatic Datum NAD 83

**Vertical Scale:**



1:300

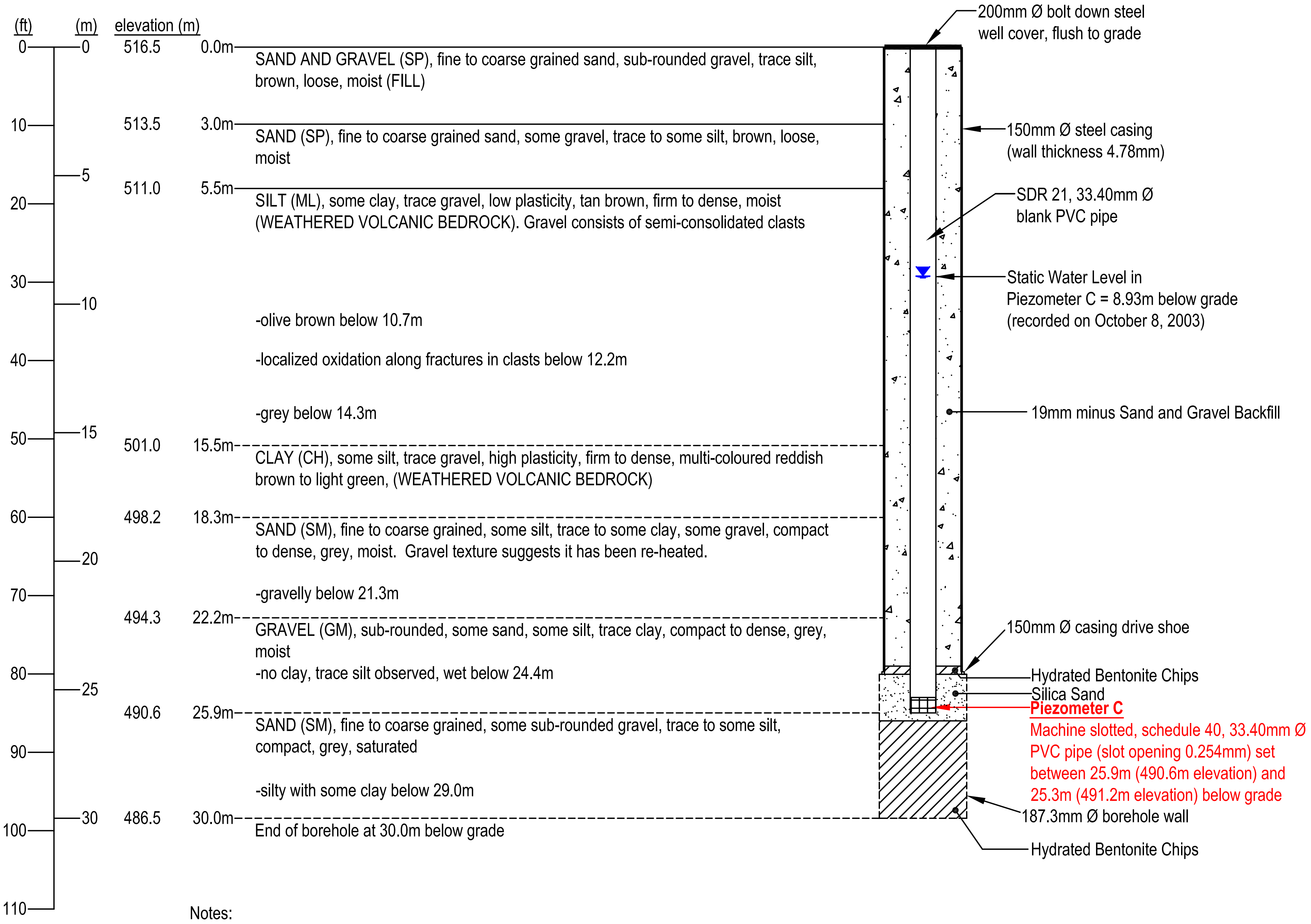
amec

CLIENT:
**CITY OF QUESNEL**

TITLE:
## BH03-2A,B Borehole Log and Piezometer Completion Details

PROJECT:
**WEST QUESNEL PILOT DE-WATERING WELL TEST**
**QUESNEL, BC**

DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CADFILE: DRAFTING\KX04397\BH03-2AB.DWG
FIGURE #: BH03-2A,B



| elevation (m) | depth | |
|---|---|---|
| 516.5 | 0.0m | SAND AND GRAVEL (SP), fine to coarse grained sand, sub-rounded gravel, trace silt, brown, loose, moist (FILL) |
| 513.5 | 3.0m | SAND (SP), fine to coarse grained sand, some gravel, trace to some silt, brown, loose, moist |
| 511.0 | 5.5m | SILT (ML), some clay, trace gravel, low plasticity, tan brown, firm to dense, moist (WEATHERED VOLCANIC BEDROCK). Gravel consists of semi-consolidated clasts<br>-olive brown below 10.7m<br>-localized oxidation along fractures in clasts below 12.2m<br>-grey below 14.3m |
| 501.0 | 15.5m | CLAY (CH), some silt, trace gravel, high plasticity, firm to dense, multi-coloured reddish brown to light green, (WEATHERED VOLCANIC BEDROCK) |
| 498.2 | 18.3m | SAND (SM), fine to coarse grained, some silt, trace to some clay, some gravel, compact to dense, grey, moist. Gravel texture suggests it has been re-heated.<br>-gravelly below 21.3m |
| 494.3 | 22.2m | GRAVEL (GM), sub-rounded, some sand, some silt, trace clay, compact to dense, grey, moist<br>-no clay, trace silt observed, wet below 24.4m |
| 490.6 | 25.9m | SAND (SM), fine to coarse grained, some sub-rounded gravel, trace to some silt, compact, grey, saturated<br>-silty with some clay below 29.0m |
| 486.5 | 30.0m | End of borehole at 30.0m below grade |

Notes:

BH03-2C drilled and completed between August 7 and August 8, 2003 using an Ingersoll-Rand TH-60 air-rotary drill rig provided by Cariboo Water Wells.

BH03-2C logged by Scott Green, P.Eng, Soil samples collected along 1.5m intervals.

None of the soil samples collected from BH03-2C have been subject to laboratory testing.

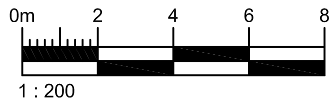
Ground Surface Elevation = 516.514m

Water Level Measuring Reference Elevation = 516.416m

Piezometer 2C = 532210.041East, 5869742.276North

Elevations relative to Geodatic Datum NAD 83

**Vertical Scale:**



amec

CLIENT:

**CITY OF QUESNEL**

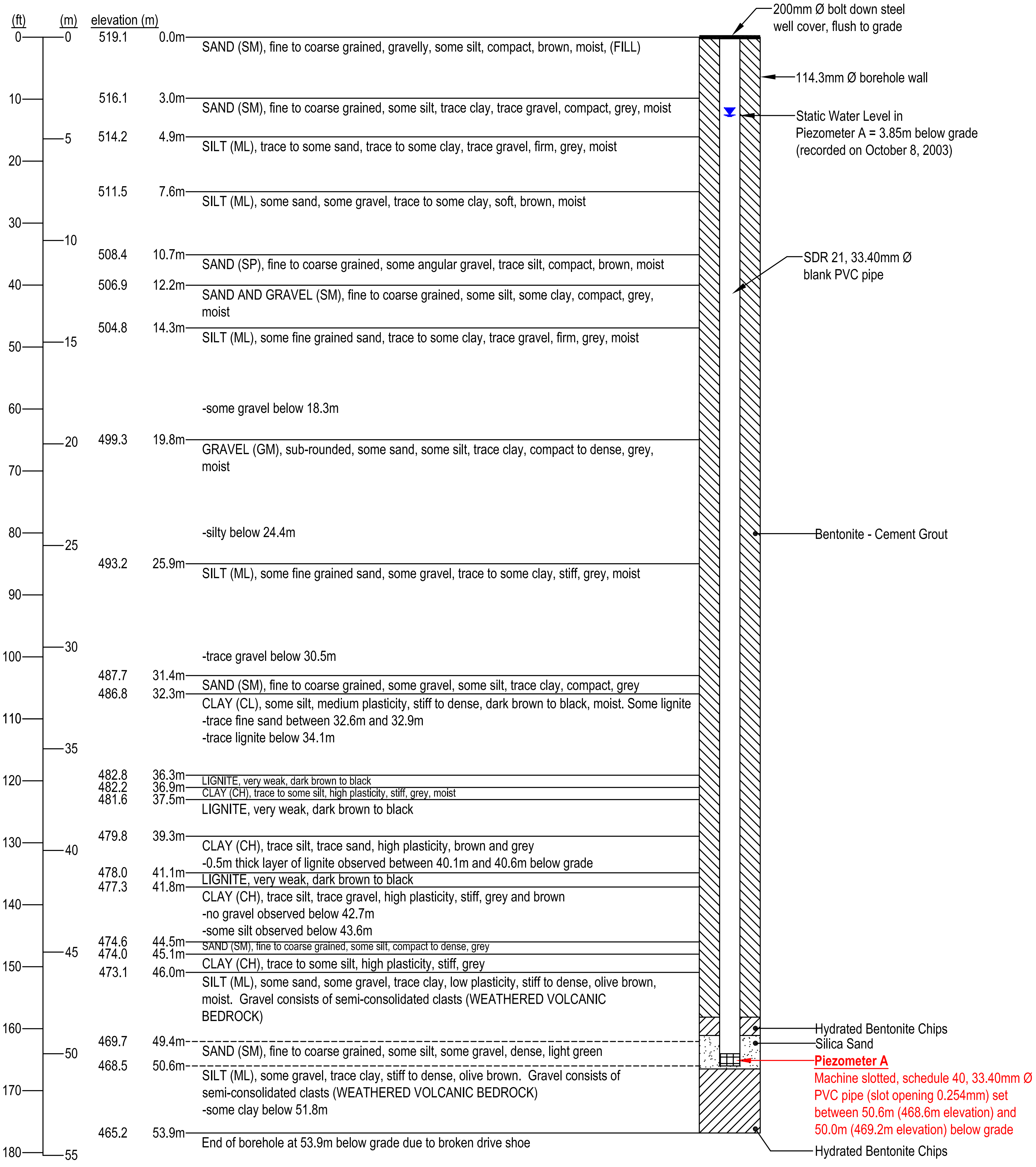
TITLE:

**BH03-2C Borehole Log and Piezometer Completion Details**

PROJECT:

**WEST QUESNEL PILOT DE-WATERING WELL TEST**
**QUESNEL, BC**

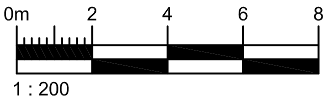
DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CADFILE: DRAFTING\KX04397\BH03-2C.DWG
FIGURE #: BH03-2C



| elevation (m) | | |
|---|---|---|
| 519.1 | 0.0m | SAND (SM), fine to coarse grained, gravelly, some silt, compact, brown, moist, (FILL) |
| 516.1 | 3.0m | SAND (SM), fine to coarse grained, some silt, trace clay, trace gravel, compact, grey, moist |
| 514.2 | 4.9m | SILT (ML), trace to some sand, trace to some clay, trace gravel, firm, grey, moist |
| 511.5 | 7.6m | SILT (ML), some sand, some gravel, trace to some clay, soft, brown, moist |
| 508.4 | 10.7m | SAND (SP), fine to coarse grained, some angular gravel, trace silt, compact, brown, moist |
| 506.9 | 12.2m | SAND AND GRAVEL (SM), fine to coarse grained, some silt, some clay, compact, grey, moist |
| 504.8 | 14.3m | SILT (ML), some fine grained sand, trace to some clay, trace gravel, firm, grey, moist<br>-some gravel below 18.3m |
| 499.3 | 19.8m | GRAVEL (GM), sub-rounded, some sand, some silt, trace clay, compact to dense, grey, moist<br>-silty below 24.4m |
| 493.2 | 25.9m | SILT (ML), some fine grained sand, some gravel, trace to some clay, stiff, grey, moist<br>-trace gravel below 30.5m |
| 487.7 | 31.4m | SAND (SM), fine to coarse grained, some gravel, some silt, trace clay, compact, grey |
| 486.8 | 32.3m | CLAY (CL), some silt, medium plasticity, stiff to dense, dark brown to black, moist. Some lignite<br>-trace fine sand between 32.6m and 32.9m<br>-trace lignite below 34.1m |
| 482.8 | 36.3m | LIGNITE, very weak, dark brown to black |
| 482.2 | 36.9m | CLAY (CH), trace to some silt, high plasticity, stiff, grey, moist |
| 481.6 | 37.5m | LIGNITE, very weak, dark brown to black |
| 479.8 | 39.3m | CLAY (CH), trace silt, trace sand, high plasticity, brown and grey<br>-0.5m thick layer of lignite observed between 40.1m and 40.6m below grade |
| 478.0 | 41.1m | LIGNITE, very weak, dark brown to black |
| 477.3 | 41.8m | CLAY (CH), trace silt, trace gravel, high plasticity, stiff, grey and brown<br>-no gravel observed below 42.7m<br>-some silt observed below 43.6m |
| 474.6 | 44.5m | SAND (SM), fine to coarse grained, some silt, compact to dense, grey |
| 474.0 | 45.1m | CLAY (CH), trace to some silt, high plasticity, stiff, grey |
| 473.1 | 46.0m | SILT (ML), some sand, some gravel, trace clay, low plasticity, stiff to dense, olive brown, moist. Gravel consists of semi-consolidated clasts (WEATHERED VOLCANIC BEDROCK) |
| 469.7 | 49.4m | SAND (SM), fine to coarse grained, some silt, some gravel, dense, light green |
| 468.5 | 50.6m | SILT (ML), some gravel, trace clay, stiff to dense, olive brown. Gravel consists of semi-consolidated clasts (WEATHERED VOLCANIC BEDROCK)<br>-some clay below 51.8m |
| 465.2 | 53.9m | End of borehole at 53.9m below grade due to broken drive shoe |

Notes:
BH03-3A drilled and completed between July 22 and July 24, 2003 using a Silverado air-rotary drill rig equipped with a ROTAX rig bit provided by Geotech Drilling Services Ltd.
BH03-3A logged by Homan Arabshahi, P.Eng and reviewed by Scott Green, P.Eng, soil samples collected along 1.5m intervals.
None of the soil samples collected from BH03-3A have been subject to laboratory testing.
Ground Surface Elevation = 519.148m
Water Level Measuring Reference Elevation = 519.098m
Piezometer 3A = 532006.533East, 5869770.816North
Elevations relative to Geodatic Datum NAD 83

**Vertical Scale:**



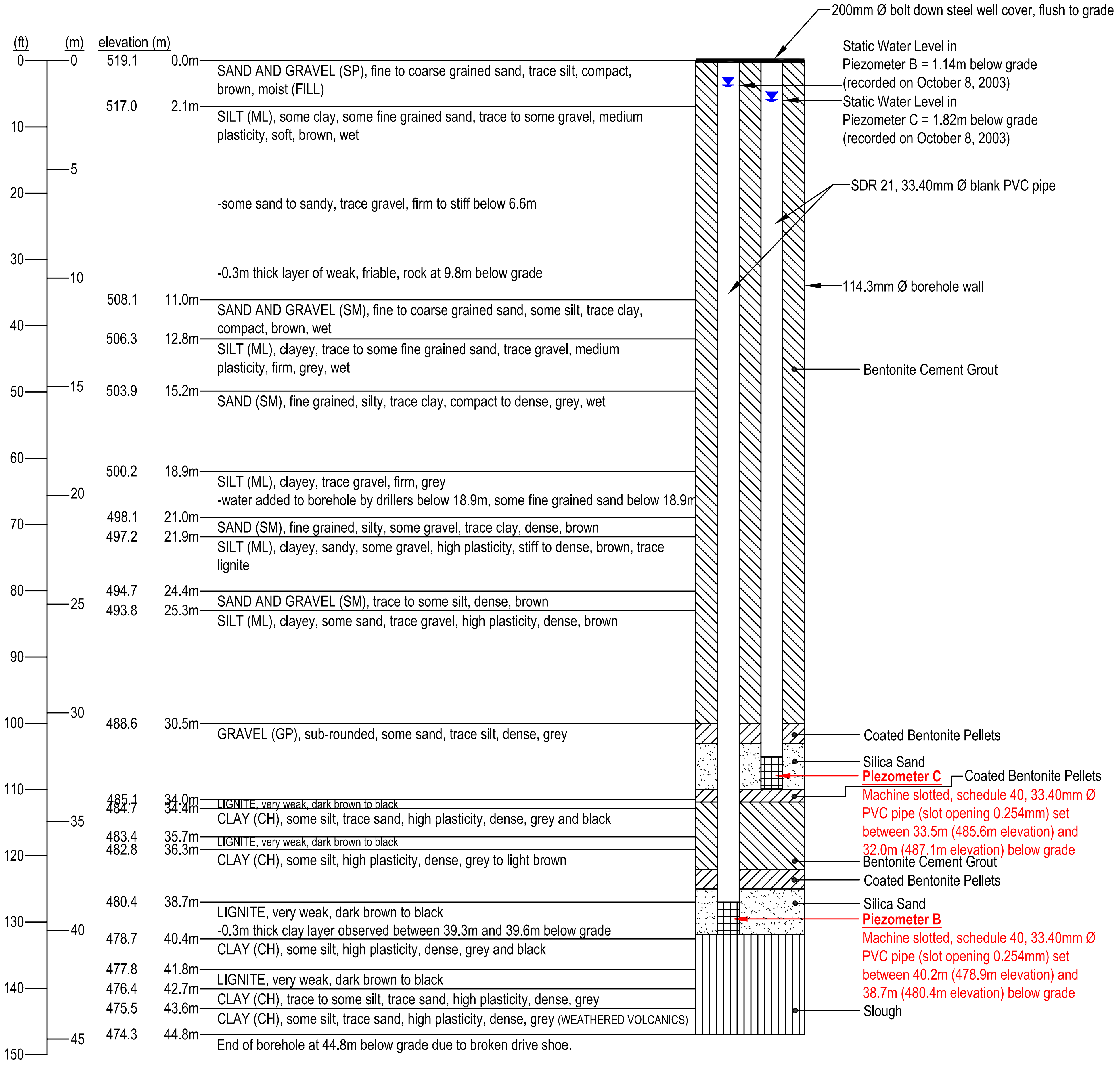
amec

CLIENT: **CITY OF QUESNEL**

TITLE: **BH03-3A Borehole Log and Piezometer Completion Details**

PROJECT: **WEST QUESNEL PILOT DE-WATERING WELL TEST QUESNEL, BC**

DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CADFILE: DRAFTING\KX04397\BH03-2C.DWG
FIGURE #: BH03-3A



| elevation (m) | | |
|---|---|---|
| 519.1 | 0.0m | SAND AND GRAVEL (SP), fine to coarse grained sand, trace silt, compact, brown, moist (FILL) |
| 517.0 | 2.1m | SILT (ML), some clay, some fine grained sand, trace to some gravel, medium plasticity, soft, brown, wet<br>-some sand to sandy, trace gravel, firm to stiff below 6.6m<br>-0.3m thick layer of weak, friable, rock at 9.8m below grade |
| 508.1 | 11.0m | SAND AND GRAVEL (SM), fine to coarse grained sand, some silt, trace clay, compact, brown, wet |
| 506.3 | 12.8m | SILT (ML), clayey, trace to some fine grained sand, trace gravel, medium plasticity, firm, grey, wet |
| 503.9 | 15.2m | SAND (SM), fine grained, silty, trace clay, compact to dense, grey, wet |
| 500.2 | 18.9m | SILT (ML), clayey, trace gravel, firm, grey<br>-water added to borehole by drillers below 18.9m, some fine grained sand below 18.9m |
| 498.1 | 21.0m | SAND (SM), fine grained, silty, some gravel, trace clay, dense, brown |
| 497.2 | 21.9m | SILT (ML), clayey, sandy, some gravel, high plasticity, stiff to dense, brown, trace lignite |
| 494.7 | 24.4m | SAND AND GRAVEL (SM), trace to some silt, dense, brown |
| 493.8 | 25.3m | SILT (ML), clayey, some sand, trace gravel, high plasticity, dense, brown |
| 488.6 | 30.5m | GRAVEL (GP), sub-rounded, some sand, trace silt, dense, grey |
| 485.1 | 34.0m | LIGNITE, very weak, dark brown to black |
| 484.7 | 34.4m | CLAY (CH), some silt, trace sand, high plasticity, dense, grey and black |
| 483.4 | 35.7m | LIGNITE, very weak, dark brown to black |
| 482.8 | 36.3m | CLAY (CH), some silt, high plasticity, dense, grey to light brown |
| 480.4 | 38.7m | LIGNITE, very weak, dark brown to black<br>-0.3m thick clay layer observed between 39.3m and 39.6m below grade |
| 478.7 | 40.4m | CLAY (CH), some silt, high plasticity, dense, grey and black |
| 477.8 | 41.8m | LIGNITE, very weak, dark brown to black |
| 476.4 | 42.7m | CLAY (CH), trace to some silt, trace sand, high plasticity, dense, grey |
| 475.5 | 43.6m | CLAY (CH), some silt, trace sand, high plasticity, dense, grey (WEATHERED VOLCANICS) |
| 474.3 | 44.8m | End of borehole at 44.8m below grade due to broken drive shoe. |

200mm Ø bolt down steel well cover, flush to grade

Static Water Level in
Piezometer B = 1.14m below grade
(recorded on October 8, 2003)

Static Water Level in
Piezometer C = 1.82m below grade
(recorded on October 8, 2003)

SDR 21, 33.40mm Ø blank PVC pipe

114.3mm Ø borehole wall

Bentonite Cement Grout

Coated Bentonite Pellets

Silica Sand

**Piezometer C**

Coated Bentonite Pellets

Machine slotted, schedule 40, 33.40mm Ø PVC pipe (slot opening 0.254mm) set between 33.5m (485.6m elevation) and 32.0m (487.1m elevation) below grade

Bentonite Cement Grout

Coated Bentonite Pellets

Silica Sand

**Piezometer B**

Machine slotted, schedule 40, 33.40mm Ø PVC pipe (slot opening 0.254mm) set between 40.2m (478.9m elevation) and 38.7m (480.4m elevation) below grade

Slough

Notes:
BH03-3B,C drilled and completed between July 18 and July 22, 2003 using a Silverado air-rotary drill rig equipped with an ODEX drill bit provided by Geotech Drilling Services Ltd.
BH03-3B,C logged by Shiloh Jorgensen, EIT and reviewed by Scott Green, P.Eng.
Soil samples collected along 1.5m intervals.
None of the soil samples collected from BH03-3B,C have been subject to laboratory testing.
Ground Surface Elevation = 519.132m
Piezometer 3B = 522005.235East, 5869720.439North; Elevation of measuring datum = 519.065m.
Piezometer 3C = 532005.199East, 5869770.423North; Elevation of measuring datum = 519.107m
Elevations relative to Geodatic Datum NAD 83

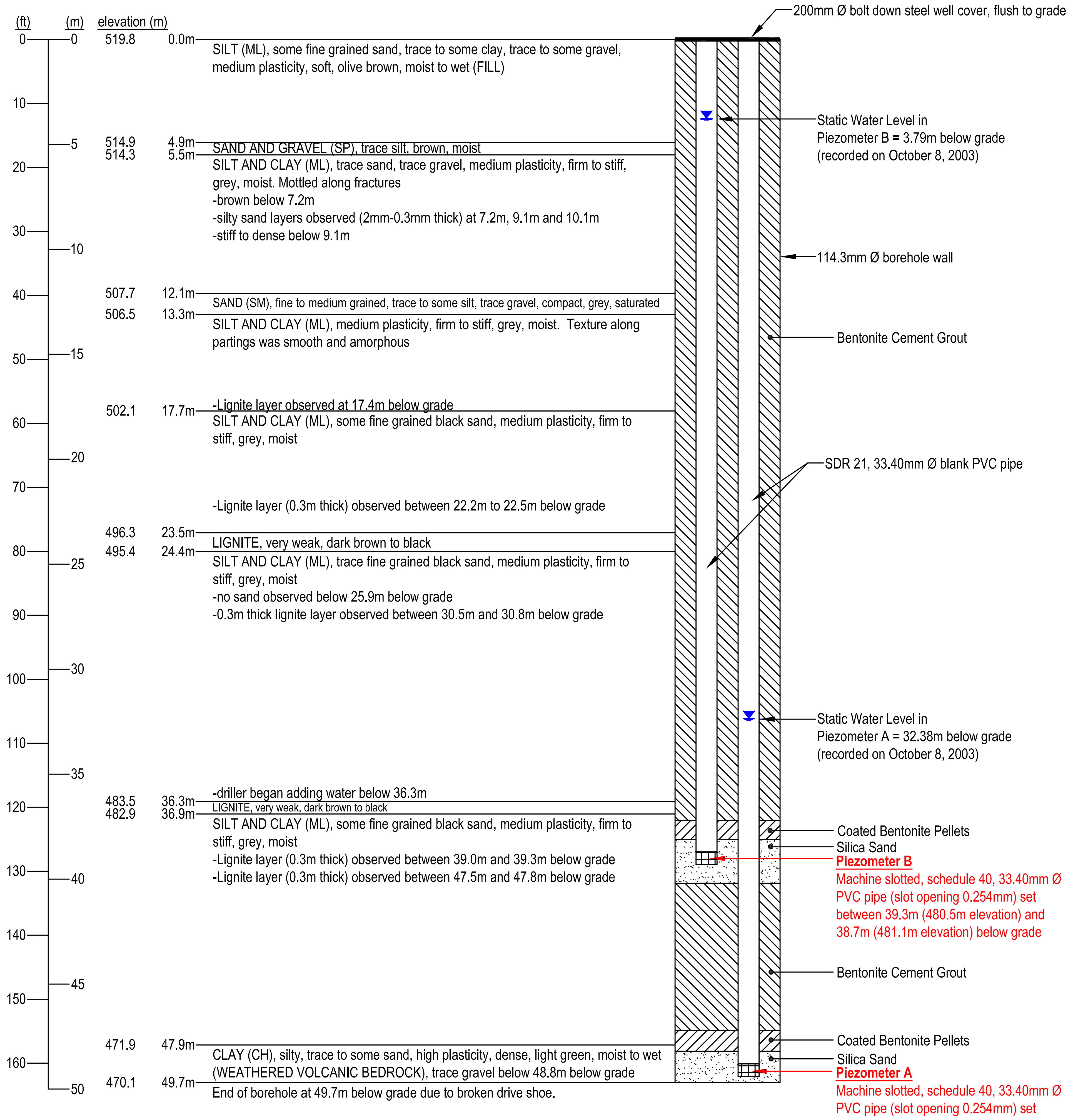
**Vertical Scale:**
0m 2 4 6 8
1 : 200

CLIENT:
**CITY OF QUESNEL**

TITLE:
**BH03-3B,C Borehole Log and Piezometer Completion Details**

PROJECT:
**WEST QUESNEL PILOT DE-WATERING WELL TEST**
**QUESNEL, BC**

DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CADFILE: DRAFTING\KX04397\BH03-3BC.DWG
FIGURE #: **BH03-3B,C**



| elevation (m) | | |
|---|---|---|
| 519.8 | 0.0m | SILT (ML), some fine grained sand, trace to some clay, trace to some gravel, medium plasticity, soft, olive brown, moist to wet (FILL) |
| 514.9 | 4.9m | SAND AND GRAVEL (SP), trace silt, brown, moist |
| 514.3 | 5.5m | SILT AND CLAY (ML), trace sand, trace gravel, medium plasticity, firm to stiff, grey, moist. Mottled along fractures<br>-brown below 7.2m<br>-silty sand layers observed (2mm-0.3mm thick) at 7.2m, 9.1m and 10.1m<br>-stiff to dense below 9.1m |
| 507.7 | 12.1m | SAND (SM), fine to medium grained, trace to some silt, trace gravel, compact, grey, saturated |
| 506.5 | 13.3m | SILT AND CLAY (ML), medium plasticity, firm to stiff, grey, moist. Texture along partings was smooth and amorphous<br>-Lignite layer observed at 17.4m below grade |
| 502.1 | 17.7m | SILT AND CLAY (ML), some fine grained black sand, medium plasticity, firm to stiff, grey, moist<br>-Lignite layer (0.3m thick) observed between 22.2m to 22.5m below grade |
| 496.3 | 23.5m | LIGNITE, very weak, dark brown to black |
| 495.4 | 24.4m | SILT AND CLAY (ML), trace fine grained black sand, medium plasticity, firm to stiff, grey, moist<br>-no sand observed below 25.9m below grade<br>-0.3m thick lignite layer observed between 30.5m and 30.8m below grade<br>-driller began adding water below 36.3m |
| 483.5 | 36.3m | LIGNITE, very weak, dark brown to black |
| 482.9 | 36.9m | SILT AND CLAY (ML), some fine grained black sand, medium plasticity, firm to stiff, grey, moist<br>-Lignite layer (0.3m thick) observed between 39.0m and 39.3m below grade<br>-Lignite layer (0.3m thick) observed between 47.5m and 47.8m below grade |
| 471.9 | 47.9m | CLAY (CH), silty, trace to some sand, high plasticity, dense, light green, moist to wet (WEATHERED VOLCANIC BEDROCK), trace gravel below 48.8m below grade |
| 470.1 | 49.7m | End of borehole at 49.7m below grade due to broken drive shoe. |

200mm Ø bolt down steel well cover, flush to grade

Static Water Level in
Piezometer B = 3.79m below grade
(recorded on October 8, 2003)

114.3mm Ø borehole wall

Bentonite Cement Grout

SDR 21, 33.40mm Ø blank PVC pipe

Static Water Level in
Piezometer A = 32.38m below grade
(recorded on October 8, 2003)

Coated Bentonite Pellets
Silica Sand
**Piezometer B**
Machine slotted, schedule 40, 33.40mm Ø PVC pipe (slot opening 0.254mm) set between 39.3m (480.5m elevation) and 38.7m (481.1m elevation) below grade

Bentonite Cement Grout

Coated Bentonite Pellets
Silica Sand
**Piezometer A**
Machine slotted, schedule 40, 33.40mm Ø PVC pipe (slot opening 0.254mm) set between 49.4m (470.4m elevation) and 48.8m (471.0m elevation) below grade

Notes:
BH03-4A,B drilled and completed between July 8 and July 17, 2003 using a Silverado air-rotary drill rig equipped with an ODEX drill bit provided by Geotech Drilling Services Ltd.
BH03-4A,B logged by Shiloh Jorgensen, EIT and reviewed by Scott Green, P.Eng.
Soil samples collected along 1.5m intervals.
None of the soil samples collected from BH03-4A,B have been subject to laboratory testing.
Ground Surface Elevation = 519.773m
Piezometer 4A = 532040.983East, 5869782.793North; Elevation of measuring datum = 519.723m.
Piezometer 4B = 532041.022East, 5869782.830North; Elevation of measuring datum = 519.716m.
Elevations relative to Geodatic Datum NAD 83

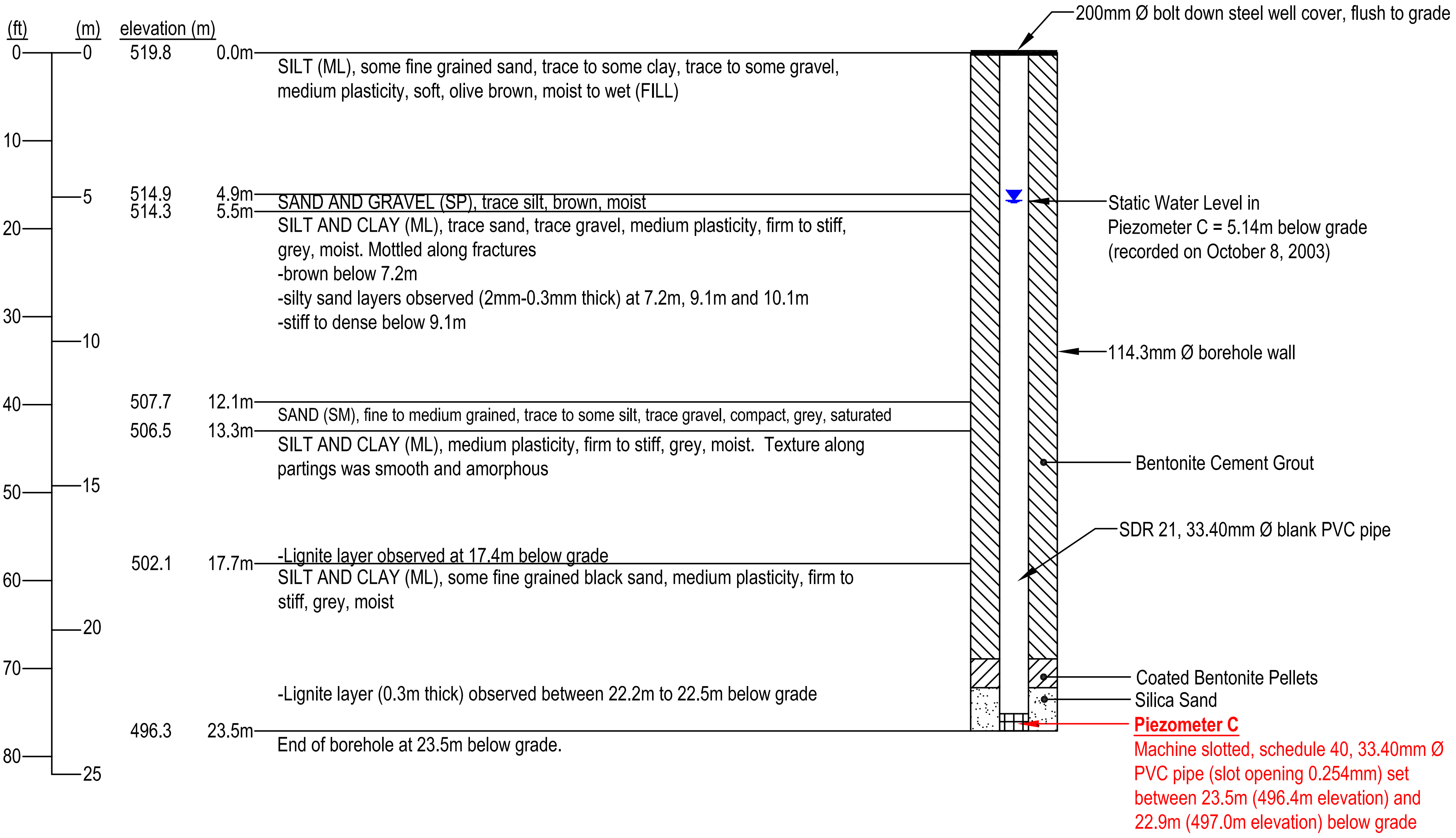
**Vertical Scale:**
0m 2 4 6 8
1 : 200

CLIENT:
**CITY OF QUESNEL**

TITLE:
**BH04A,B Borehole Log and Piezometer Completion Details**

PROJECT:
**WEST QUESNEL PILOT DE-WATERING WELL TEST**
**QUESNEL, BC**

DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CADFILE: DRAFTING\KX04397\BH03-4AB.DWG
FIGURE #: **BH03-4A,B**



| elevation (m) | | |
|---|---|---|
| 519.8 | 0.0m | SILT (ML), some fine grained sand, trace to some clay, trace to some gravel, medium plasticity, soft, olive brown, moist to wet (FILL) |
| 514.9 | 4.9m | SAND AND GRAVEL (SP), trace silt, brown, moist |
| 514.3 | 5.5m | SILT AND CLAY (ML), trace sand, trace gravel, medium plasticity, firm to stiff, grey, moist. Mottled along fractures<br>-brown below 7.2m<br>-silty sand layers observed (2mm-0.3mm thick) at 7.2m, 9.1m and 10.1m<br>-stiff to dense below 9.1m |
| 507.7 | 12.1m | SAND (SM), fine to medium grained, trace to some silt, trace gravel, compact, grey, saturated |
| 506.5 | 13.3m | SILT AND CLAY (ML), medium plasticity, firm to stiff, grey, moist. Texture along partings was smooth and amorphous<br>-Lignite layer observed at 17.4m below grade |
| 502.1 | 17.7m | SILT AND CLAY (ML), some fine grained black sand, medium plasticity, firm to stiff, grey, moist<br>-Lignite layer (0.3m thick) observed between 22.2m to 22.5m below grade |
| 496.3 | 23.5m | End of borehole at 23.5m below grade. |

200mm Ø bolt down steel well cover, flush to grade

Static Water Level in Piezometer C = 5.14m below grade (recorded on October 8, 2003)

114.3mm Ø borehole wall

Bentonite Cement Grout

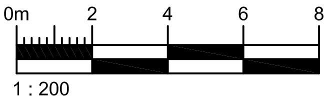
SDR 21, 33.40mm Ø blank PVC pipe

Coated Bentonite Pellets

Silica Sand

**Piezometer C**
Machine slotted, schedule 40, 33.40mm Ø PVC pipe (slot opening 0.254mm) set between 23.5m (496.4m elevation) and 22.9m (497.0m elevation) below grade

Notes:
BH03-4C drilled and completed between July 17 and July 18, 2003 using a Silverado air-rotary drill rig equipped with an ODEX drill bit provided by Geotech Drilling Services Ltd.
BH03-4C log is based on samples collected from BH03-4A, B, located 20m northeast of BH03-4A, B.
Ground Surface Elevation = 519.827m
Water Level Measuring Reference Elevation = 519.765m
Piezometer 4C = 532042.934East, 5869783.479North
Elevations relative to Geodatic Datum NAD 83

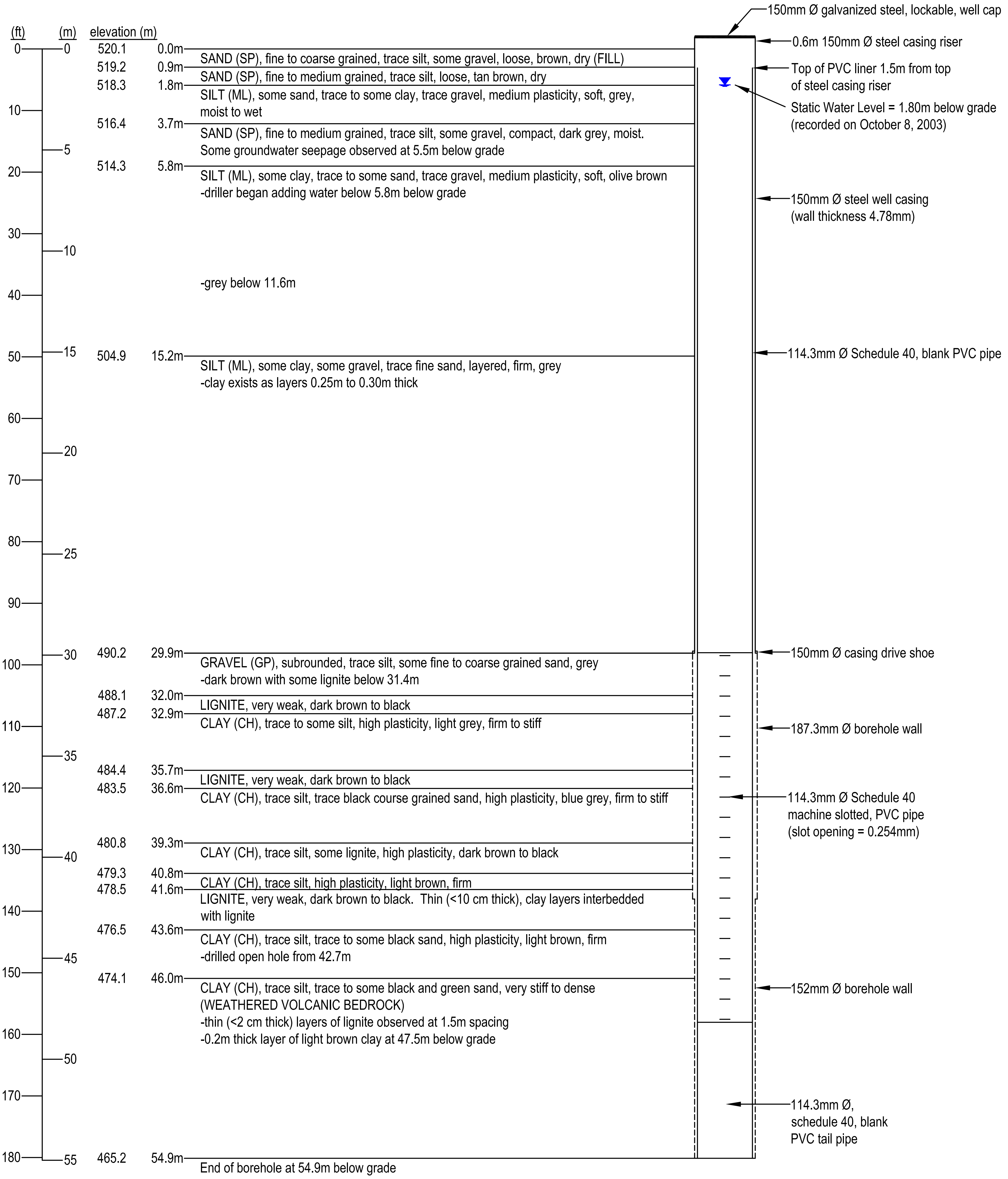
**Vertical Scale:**


CLIENT:
CITY OF QUESNEL

TITLE:
BH04C Borehole Log and
Piezometer Completion Details

PROJECT:
WEST QUESNEL PILOT DE-WATERING WELL TEST
QUESNEL, BC

DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CADFILE: DRAFTING\KX04397\BH03-4C.DWG
FIGURE #: BH03-4C



| elevation (m) | | |
|---|---|---|
| 520.1 | 0.0m | SAND (SP), fine to coarse grained, trace silt, some gravel, loose, brown, dry (FILL) |
| 519.2 | 0.9m | SAND (SP), fine to medium grained, trace silt, loose, tan brown, dry |
| 518.3 | 1.8m | SILT (ML), some sand, trace to some clay, trace gravel, medium plasticity, soft, grey, moist to wet |
| 516.4 | 3.7m | SAND (SP), fine to medium grained, trace silt, some gravel, compact, dark grey, moist.<br>Some groundwater seepage observed at 5.5m below grade |
| 514.3 | 5.8m | SILT (ML), some clay, trace to some sand, trace gravel, medium plasticity, soft, olive brown<br>-driller began adding water below 5.8m below grade<br>-grey below 11.6m |
| 504.9 | 15.2m | SILT (ML), some clay, some gravel, trace fine sand, layered, firm, grey<br>-clay exists as layers 0.25m to 0.30m thick |
| 490.2 | 29.9m | GRAVEL (GP), subrounded, trace silt, some fine to coarse grained sand, grey<br>-dark brown with some lignite below 31.4m |
| 488.1 | 32.0m | LIGNITE, very weak, dark brown to black |
| 487.2 | 32.9m | CLAY (CH), trace to some silt, high plasticity, light grey, firm to stiff |
| 484.4 | 35.7m | LIGNITE, very weak, dark brown to black |
| 483.5 | 36.6m | CLAY (CH), trace silt, trace black course grained sand, high plasticity, blue grey, firm to stiff |
| 480.8 | 39.3m | CLAY (CH), trace silt, some lignite, high plasticity, dark brown to black |
| 479.3 | 40.8m | CLAY (CH), trace silt, high plasticity, light brown, firm |
| 478.5 | 41.6m | LIGNITE, very weak, dark brown to black. Thin (<10 cm thick), clay layers interbedded with lignite |
| 476.5 | 43.6m | CLAY (CH), trace silt, trace to some black sand, high plasticity, light brown, firm<br>-drilled open hole from 42.7m |
| 474.1 | 46.0m | CLAY (CH), trace silt, trace to some black and green sand, very stiff to dense (WEATHERED VOLCANIC BEDROCK)<br>-thin (<2 cm thick) layers of lignite observed at 1.5m spacing<br>-0.2m thick layer of light brown clay at 47.5m below grade |
| 465.2 | 54.9m | End of borehole at 54.9m below grade |

Notes:
PW03-1 drilled and completed between September 15 and September 16, 2003 using an Ingersall-Rand TH-60 air-rotary drill rig provided by Cariboo Water Wells.
PW03-1 logged by Scott Green, P.Eng, soil samples collected along 1.5m intervals.
None of the soil samples collected from PW03-1 have been subject to laboratory testing.
Ground Surface Elevation = 520.068m
Water Level Measuring Reference Elevation = 520.710m
Northing = 5869772.498
Easting = 531993.423
Elevations relative to Geodatic Datum NAD 83

**Vertical Scale:**
0m 2 4 6 8
1 : 200

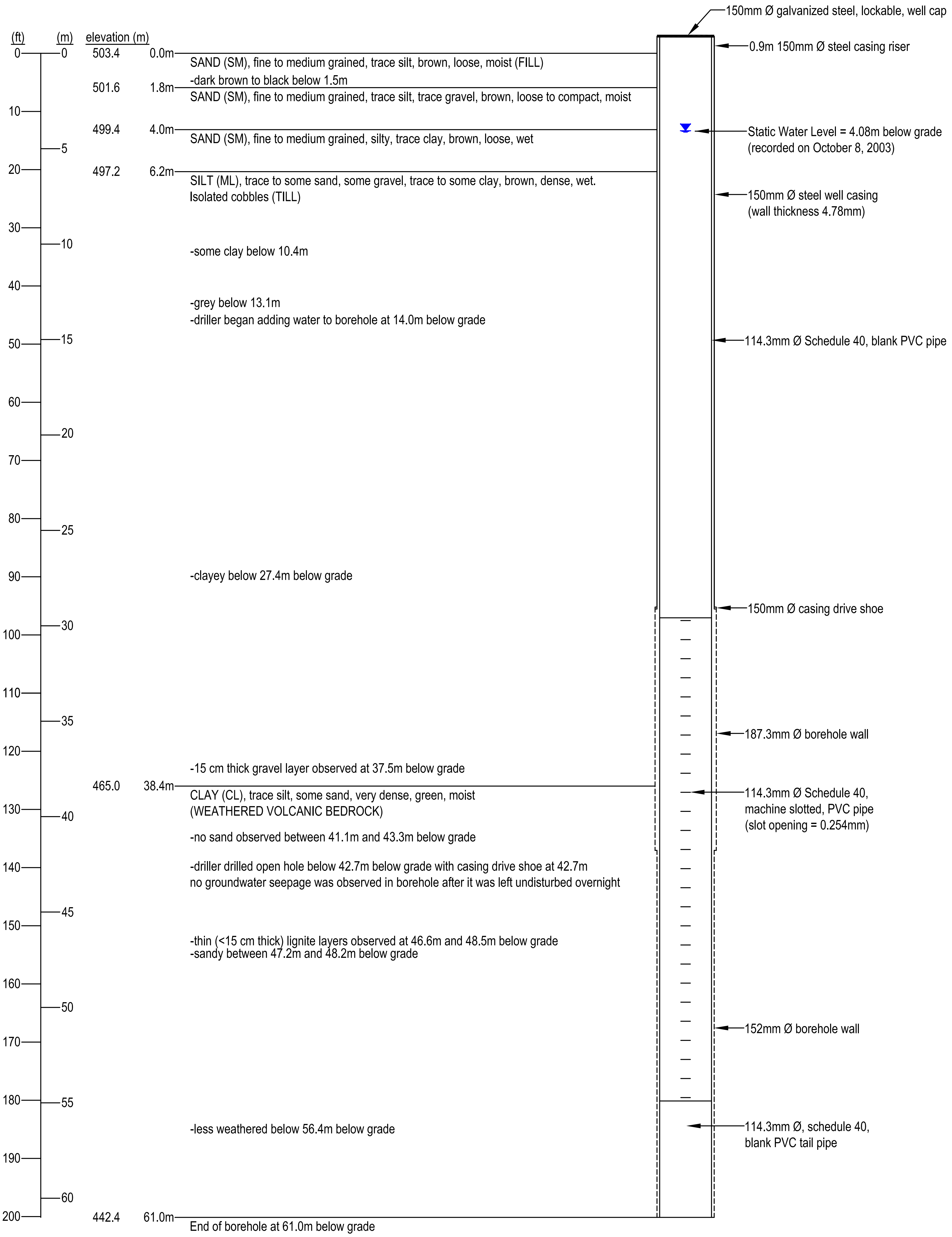
amec

CLIENT:
**CITY OF QUESNEL**

TITLE:
**PW03-1 Borehole Log and Well Completion Details**

PROJECT:
**WEST QUESNEL PILOT DE-WATERING WELL TEST**
**QUESNEL, BC**

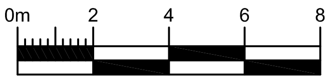
DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CADFILE: DRAFTING\KX04397\PW03-1.DWG
FIGURE #: **PW03-1**



| elevation (m) | | |
|---|---|---|
| 503.4 | 0.0m | SAND (SM), fine to medium grained, trace silt, brown, loose, moist (FILL)<br>-dark brown to black below 1.5m |
| 501.6 | 1.8m | SAND (SM), fine to medium grained, trace silt, trace gravel, brown, loose to compact, moist |
| 499.4 | 4.0m | SAND (SM), fine to medium grained, silty, trace clay, brown, loose, wet |
| 497.2 | 6.2m | SILT (ML), trace to some sand, some gravel, trace to some clay, brown, dense, wet. Isolated cobbles (TILL)<br>-some clay below 10.4m<br>-grey below 13.1m<br>-driller began adding water to borehole at 14.0m below grade<br>-clayey below 27.4m below grade<br>-15 cm thick gravel layer observed at 37.5m below grade |
| 465.0 | 38.4m | CLAY (CL), trace silt, some sand, very dense, green, moist (WEATHERED VOLCANIC BEDROCK)<br>-no sand observed between 41.1m and 43.3m below grade<br>-driller drilled open hole below 42.7m below grade with casing drive shoe at 42.7m no groundwater seepage was observed in borehole after it was left undisturbed overnight<br>-thin (<15 cm thick) lignite layers observed at 46.6m and 48.5m below grade<br>-sandy between 47.2m and 48.2m below grade<br>-less weathered below 56.4m below grade |
| 442.4 | 61.0m | End of borehole at 61.0m below grade |

Notes:
PW03-2 drilled and completed between September 17 and September 18, 2003 using an Ingersall-Rand TH-60 air-rotary drill rig provided by Cariboo Water Wells.
PW03-2 logged by Scott Green, P.Eng, soil samples collected along 1.5m intervals.
None of the soil samples collected from PW03-2 have been subject to laboratory testing.
Ground Surface Elevation = 503.409m
Water Level Measuring Reference Elevation = 504.278m
Northing = 5869595.405
Easting = 532272.268
Elevations relative to Geodatic Datum NAD 83

**Vertical Scale:**



1 : 200

CLIENT:
**CITY OF QUESNEL**

TITLE:
**PW03-2 Borehole Log and Well Completion Details**

PROJECT:
**WEST QUESNEL PILOT DE-WATERING WELL TEST**
**QUESNEL, BC**

DATE: MARCH 2004
JOB #: KX04397
DRAWN BY: S.RUIZ
PROJECT MGR: SG
CADFILE: DRAFTING\KX04397\PW03-2.DWG
FIGURE #: PW03-2

**Water Level Monitoring Data - West Quesnel Pilot Dewatering Test**

| Monitor | Top of Casing Elevation (m) | | Relative Elevation (m) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 06-Aug-03 | 07-Aug-03 | 08-Aug-03 | 14-Aug-03 | 15-Aug-03 | 03-Sep-03 | 15-Sep-03 | 01-Oct-03 | 02-Oct-03 | 06-Oct-03 | 08-Oct-03 | 09-Oct-03 | 12-Oct-03 | 15-Oct-03 | 19-Oct-03 | 22-Oct-03 | 26-Oct-03 |
| BH03-2A | 516.39 | DTW | | | | dry | dry | dry | | | | | 80.75 | 80.63 | | | | | |
| | | WL | | | | | | | | | | | 435.64 | 435.76 | | | | | |
| BH03-2B | 516.37 | DTW | | | | 45.65 | 45.56 | | 42.82 | | | | 40.77 | | | | | | |
| | | WL | | | | 470.72 | 470.81 | | 473.55 | | | | 475.60 | | | | | | |
| BH03-2C | 516.42 | DTW | | | | 9.55 | 9.52 | 9.17 | | | | | 8.83 | 8.86 | | | | | |
| | | WL | | | | 506.87 | 506.90 | 507.25 | | | | | 507.59 | 507.55 | | | | | |
| BH03-3A | 519.02 | DTW | 7.40 | 7.18 | 6.87 | 5.64 | 5.54 | 6.05 | | | | | 3.80 | 3.78 | 3.69 | 3.60 | 3.52 | 3.44 | 3.36 |
| | | WL | 511.62 | 511.84 | 512.15 | 513.38 | 513.48 | 512.97 | | | | | 515.22 | 515.24 | 515.32 | 515.42 | 515.50 | 515.58 | 515.66 |
| BH03-3B | 519.07 | DTW | 2.54 | 2.51 | 2.33 | 1.65 | 1.60 | 1.66 | | | | | 1.07 | 1.03 | 1.13 | 1.19 | 1.32 | 1.46 | 1.66 |
| | | WL | 516.53 | 516.56 | 516.74 | 517.42 | 517.47 | 517.41 | | | | | 518.00 | 518.04 | 517.93 | 517.88 | 517.75 | 517.61 | 517.40 |
| BH03-3C | 519.11 | DTW | 0.98 | 0.99 | 0.96 | 0.82 | 0.81 | 0.97 | | | | | 1.79 | 1.75 | 2.15 | 2.41 | 2.91 | 3.26 | 3.77 |
| | | WL | 518.13 | 518.12 | 518.15 | 518.29 | 518.30 | 518.14 | | | | | 517.32 | 517.36 | 516.96 | 516.69 | 516.20 | 515.84 | 515.33 |
| BH03-4A | 519.72 | DTW | 36.62 | 36.50 | 36.23 | 34.48 | 34.32 | 34.04 | | | | | 32.33 | 32.16 | 31.11 | 30.43 | 29.68 | 29.03 | 28.16 |
| | | WL | 483.10 | 483.22 | 483.49 | 485.24 | 485.40 | 485.68 | | | | | 487.40 | 487.56 | 488.62 | 489.29 | 490.04 | 490.70 | 491.56 |
| BH03-4B | 519.72 | DTW | 4.55 | 4.62 | 4.60 | 4.41 | 4.36 | 4.10 | | | | | 3.73 | 3.69 | 3.75 | 3.78 | 3.80 | 3.74 | 3.75 |
| | | WL | 515.17 | 515.10 | 515.12 | 515.31 | 515.36 | 515.62 | | | | | 515.99 | 516.03 | 515.97 | 515.94 | 515.92 | 515.97 | 515.96 |
| BH03-4C | 519.77 | DTW | 5.60 | 5.68 | 5.66 | 5.56 | 5.55 | 5.60 | | | | | 5.08 | 5.08 | 5.13 | 5.11 | 5.11 | 5.10 | 5.15 |
| | | WL | 514.17 | 514.09 | 514.11 | 514.21 | 514.22 | 514.17 | | | | | 514.68 | 514.68 | 514.64 | 514.65 | 514.65 | 514.66 | 514.61 |
| PW03-1 | 520.07 | DTW | | | | | | | | 5.07 | 4.03 | 2.48 | 2.44 | 2.42 | | | | | |
| | | WL | | | | | | | | 515.00 | 516.04 | 517.59 | 517.63 | 517.64 | | | | | |
| PW03-2 | 503.41 | DTW | | | | | | | | 13.57 | 2.95 | 4.88 | 4.95 | 4.95 | | | | | |
| | | WL | | | | | | | | 489.84 | 500.46 | 498.53 | 498.46 | 498.46 | | | | | |
| POND | 510.00 | RDG | | | | | | | | | | | | | | | | | |
| | | WL | | | | | | | | | | | | | | | | | |

- denotes no data

| | |
|---|---|
| DTW | Depth to Water from Top of PVC Casing (m) |
| WL | Water Elevation (m) |
| RDG | Stake Reading |

# Water Level Monitoring Data - West Quesnel Pilot Dewatering Test

| Monitor | Top of Casing Elevation (m) | | Relative Elevation (m) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 29-Oct-03 | 01-Nov-03 | 05-Nov-03 | 06-Nov-03 | 09-Nov-03 | 12-Nov-03 | 16-Nov-03 | 19-Nov-03 | 23-Nov-03 | 27-Nov-03 | 30-Nov-03 | 03-Dec-03 | 06-Dec-03 | 09-Dec-03 | 12-Dec-03 | 15-Dec-03 | 18-Dec-03 |
| BH03-2A | 516.39 | DTW | | | | 73.67 | 72.37 | 71.64 | 70.80 | 70.13 | 68.87 | 67.91 | 67.28 | 66.50 | 65.64 | 64.83 | 63.62 | 63.25 | |
| | | WL | | | | 442.72 | 444.02 | 444.75 | 445.58 | 446.26 | 447.52 | 448.48 | 449.10 | 449.88 | 450.75 | 451.56 | 452.77 | 453.14 | |
| BH03-2B | 516.37 | DTW | | | | 39.66 | 39.44 | 39.37 | 39.46 | 39.42 | 39.06 | 38.96 | 38.93 | 38.85 | 38.70 | 38.73 | 38.56 | 38.59 | |
| | | WL | | | | 476.71 | 476.93 | 477.00 | 476.91 | 476.95 | 477.31 | 477.41 | 477.44 | 477.52 | 477.67 | 477.65 | 477.81 | 477.78 | |
| BH03-2C | 516.42 | DTW | | | | 8.82 | 8.75 | 8.78 | 8.99 | 9.05 | 8.73 | 8.75 | 8.80 | 8.78 | 8.69 | 8.76 | 8.67 | 8.726 | |
| | | WL | | | | 507.60 | 507.67 | 507.63 | 507.42 | 507.36 | 507.69 | 507.66 | 507.62 | 507.64 | 507.72 | 507.66 | 507.74 | 507.69 | |
| BH03-3A | 519.02 | DTW | 3.26 | 3.21 | 3.14 | | | | | | | | | | | | | 3.07 | 2.48 |
| | | WL | 515.76 | 515.81 | 515.88 | | | | | | | | | | | | | 515.95 | 516.53 |
| BH03-3B | 519.07 | DTW | 1.79 | 1.94 | 2.11 | | | | | | | | | | | | | 1.485 | 2.04 |
| | | WL | 517.28 | 517.13 | 516.95 | | | | | | | | | | | | | 517.58 | 517.02 |
| BH03-3C | 519.11 | DTW | 4.11 | 4.39 | 4.77 | | | | | | | | | | | | | 2.47 | 3.32 |
| | | WL | 515.00 | 514.72 | 514.33 | | | | | | | | | | | | | 516.64 | 515.79 |
| BH03-4A | 519.72 | DTW | 27.49 | 26.89 | 26.12 | | | | | | | | | | | | | 19.479 | 19.06 |
| | | WL | 492.24 | 492.83 | 493.60 | | | | | | | | | | | | | 500.24 | 500.66 |
| BH03-4B | 519.72 | DTW | 3.69 | 3.69 | 3.68 | | | | | | | | | | | | | 3.57 | 3.60 |
| | | WL | 516.02 | 516.03 | 516.03 | | | | | | | | | | | | | 516.15 | 516.12 |
| BH03-4C | 519.77 | DTW | 5.10 | 5.10 | 5.09 | | | | | | | | | | | | | 4.976 | 5.00 |
| | | WL | 514.66 | 514.67 | 514.67 | | | | | | | | | | | | | 514.79 | 514.77 |
| PW03-1 | 520.07 | DTW | | | | | | | | | | | | | | | | | |
| | | WL | | | | | | | | | | | | | | | | | |
| PW03-2 | 503.41 | DTW | | | | | | | | | | | | | | | | | |
| | | WL | | | | | | | | | | | | | | | | | |
| POND | 510.00 | RDG | | | | | | | | | | | | | | | | 3.826 | |
| | | WL | | | | | | | | | | | | | | | | 513.83 | |

- denotes no data

| | |
|---|---|
| DTW | Depth to Water from Top of PVC Casing (m) |
| WL | Water Elevation (m) |
| RDG | Stake Reading |

## Water Level Monitoring Data - West Quesnel Pilot Dewatering Test

| Monitor | Top of Casing Elevation (m) | | Relative Elevation (m) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 21-Dec-03 | 24-Dec-03 | 27-Dec-03 | 30-Dec-03 | 02-Jan-04 | 05-Jan-04 | 08-Jan-04 | 11-Jan-04 | 14-Jan-04 | 17-Jan-04 | 20-Jan-04 | 23-Jan-04 | 27-Jan-04 | 31-Jan-04 | 03-Feb-04 | 06-Feb-04 | 09-Feb-04 |
| BH03-2A | 516.39 | DTW | | | | | | | | | | | | | | | | | |
| | | WL | | | | | | | | | | | | | | | | | |
| BH03-2B | 516.37 | DTW | | | | | | | | | | | | | | | | | |
| | | WL | | | | | | | | | | | | | | | | | |
| BH03-2C | 516.42 | DTW | | | | | | | | | | | | | | | | | |
| | | WL | | | | | | | | | | | | | | | | | |
| BH03-3A | 519.02 | DTW | 2.47 | 2.44 | 2.45 | 2.42 | 2.41 | 2.41 | 2.36 | 2.35 | 2.32 | 2.36 | 2.34 | 2.34 | 2.15 | | | | |
| | | WL | 516.54 | 516.58 | 516.57 | 516.60 | 516.61 | 516.61 | 516.66 | 516.67 | 516.70 | 516.66 | 516.68 | 516.67 | 516.86 | | | | |
| BH03-3B | 519.07 | DTW | 2.14 | 2.26 | 2.41 | 2.56 | 2.45 | 2.84 | 2.95 | 3.09 | 3.21 | 3.17 | 3.25 | 3.06 | | | | | |
| | | WL | 516.93 | 516.80 | 516.66 | 516.51 | 516.61 | 516.22 | 516.11 | 515.98 | 515.86 | 515.90 | 515.82 | 516.00 | | | | | |
| BH03-3C | 519.11 | DTW | 3.78 | 4.24 | 4.75 | 5.16 | 5.55 | 5.91 | 6.11 | 6.40 | 6.61 | 6.78 | 6.97 | 7.08 | | | | | |
| | | WL | 515.33 | 514.87 | 514.35 | 513.95 | 513.55 | 513.19 | 513.00 | 512.70 | 512.49 | 512.33 | 512.13 | 512.03 | | | | | |
| BH03-4A | 519.72 | DTW | 18.68 | 18.28 | 17.91 | 17.52 | 17.16 | 16.81 | 16.48 | 16.14 | 15.81 | 15.45 | 15.04 | 14.73 | 14.35 | | | | |
| | | WL | 501.04 | 501.45 | 501.81 | 502.21 | 502.56 | 502.92 | 503.24 | 503.58 | 503.91 | 504.27 | 504.68 | 504.99 | 505.37 | | | | |
| BH03-4B | 519.72 | DTW | 3.57 | 3.54 | 3.57 | 3.55 | 3.55 | 3.59 | 3.51 | 3.51 | 3.49 | 3.58 | 2.72 | 3.60 | 3.54 | | | | |
| | | WL | 516.15 | 516.18 | 516.15 | 516.17 | 516.17 | 516.12 | 516.21 | 516.20 | 516.23 | 516.13 | 517.00 | 516.12 | 516.17 | | | | |
| BH03-4C | 519.77 | DTW | 4.99 | 4.96 | 4.97 | 4.97 | 4.98 | 5.04 | 4.98 | 4.97 | 4.95 | 4.94 | 4.97 | 4.96 | 4.96 | | | | |
| | | WL | 514.77 | 514.81 | 514.79 | 514.79 | 514.78 | 514.73 | 514.78 | 514.79 | 514.82 | 514.82 | 514.80 | 514.80 | 514.80 | | | | |
| PW03-1 | 520.07 | DTW | | | | | | | | | | | | | | | | | |
| | | WL | | | | | | | | | | | | | | | | | |
| PW03-2 | 503.41 | DTW | | | | | | | | | | | | | | | | | |
| | | WL | | | | | | | | | | | | | | | | | |
| POND | 510.00 | RDG | | | | | | | | | 3.84 | | | | | | | | |
| | | WL | | | | | | | | | 513.84 | | | | | | | | |

- denotes no data

| | |
|---|---|
| DTW | Depth to Water from Top of PVC Casing (m) |
| WL | Water Elevation (m) |
| RDG | Stake Reading |

# Water Level Monitoring Data - West Quesnel Pilot Dewatering Test

| Monitor | Top of Casing Elevation (m) | | Relative Elevation (m) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 12-Feb-04 | 15-Feb-04 | 19-Feb-04 | 22-Feb-04 | 25-Feb-04 | 28-Feb-04 | 03-Mar-04 | 08-Mar-04 |
| BH03-2A | 516.39 | DTW | | | 46.28 | 45.54 | 44.89 | 44.26 | 43.40 | 42.47 |
| | | WL | | | 470.11 | 470.84 | 471.49 | 472.13 | 472.99 | 473.92 |
| BH03-2B | 516.37 | DTW | | | 32.06 | 31.15 | 30.51 | 29.96 | 29.26 | 28.50 |
| | | WL | | | 484.31 | 485.22 | 485.86 | 486.41 | 487.11 | 487.87 |
| BH03-2C | 516.42 | DTW | | | 8.70 | 8.66 | 8.65 | 8.68 | 8.62 | 8.66 |
| | | WL | | | 507.72 | 507.76 | 507.77 | 507.74 | 507.80 | 507.76 |
| BH03-3A | 519.02 | DTW | | | | 2.10 | 2.09 | -0.03 | 0.66 | 0.99 |
| | | WL | | | | 516.92 | 516.93 | 519.05 | 518.36 | 518.03 |
| BH03-3B | 519.07 | DTW | | | | | | | | 4.51 |
| | | WL | | | | | | | | 514.55 |
| BH03-3C | 519.11 | DTW | | | | | | | | 8.86 |
| | | WL | | | | | | | | 510.25 |
| BH03-4A | 519.72 | DTW | | 12.69 | 12.35 | 12.12 | 11.89 | 8.88 | 8.70 | 8.50 |
| | | WL | | 507.04 | 507.37 | 507.61 | 507.83 | 510.84 | 511.02 | 511.23 |
| BH03-4B | 519.72 | DTW | | 4.87 | 3.11 | 3.29 | 1.88 | 0.80 | 3.13 | 3.39 |
| | | WL | | 514.85 | 516.60 | 516.43 | 517.84 | 518.91 | 516.59 | 516.33 |
| BH03-4C | 519.77 | DTW | 4.89 | | 4.85 | 4.84 | 4.83 | 4.76 | 4.83 | 4.85 |
| | | WL | 514.88 | | 514.91 | 514.92 | 514.94 | 515.00 | 514.93 | 514.91 |
| PW03-1 | 520.07 | DTW | | | | | | | | |
| | | WL | | | | | | | | |
| PW03-2 | 503.41 | DTW | | | | | | | | |
| | | WL | | | | | | | | |
| POND | 510.00 | RDG | | | | | | | | 3.863 |
| | | WL | | | | | | | | 513.86 |

- denotes no data

| | |
|---|---|
| DTW | Depth to Water from Top of PVC Casing (m) |
| WL | Water Elevation (m) |
| RDG | Stake Reading |

## Flamingo Road (PW03-1)- Short Term Pumping Test

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading (m3) | Cumulative Discharge (m3) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| October 9, 2003 | 9:15 | 0 | 0 | 6993.500 | 0 | 0 | 0 | 0 | 0 |
| | 9:16 | 1 | 0.02 | 6993.560 | 0.060 | 60 | 13.205 | 13.205 | 60.000 |
| | 9:18 | 3 | 0.05 | 6993.613 | 0.113 | 113 | 24.869 | 8.290 | 37.667 |
| | 9:20 | 5 | 0.08 | 6993.800 | 0.300 | 300 | 66.024 | 13.205 | 60.000 |
| | 9:22 | 7 | 0.12 | 6993.831 | 0.331 | 331 | 72.846 | 10.407 | 47.286 |
| | 9:28 | 13 | 0.22 | 6993.850 | 0.350 | 350 | 77.028 | 5.925 | 26.923 |
| | 9:30 | 15 | 0.25 | 6993.920 | 0.420 | 420 | 92.434 | 6.162 | 28.000 |
| | 9:31 | 16 | 0.27 | 6993.930 | 0.430 | 430 | 94.634 | 5.915 | 26.875 |
| October 12, 2003 | 16:08 | 4733 | 78.88 | 6993.930 | 0.430 | 430 | 94.634 | 0.020 | 0.091 |
| | 16:09 | 4734 | 78.90 | | | | | | |
| | 16:11 | 4736 | 78.93 | | | | | | |
| | 16:12 | 4737 | 78.95 | 6994.090 | 0.590 | 590 | 129.847 | 0.027 | 0.125 |
| | 16:17 | 4742 | 79.03 | 6994.200 | 0.700 | 700 | 154.056 | 0.032 | 0.148 |
| | 16:23 | 4748 | 79.13 | | | | | | |
| | 16:24 | 4749 | 79.15 | 6994.310 | 0.810 | 810 | 178.265 | 0.038 | 0.171 |
| October 15, 2003 | 9:35 | 8660 | 144.33 | 6994.310 | 0.810 | 810 | 178.265 | 0.021 | 0.094 |
| | 9:36 | 8661 | 144.35 | 6994.341 | 0.841 | 841 | 185.087 | 0.021 | 0.097 |
| | 9:38 | 8663 | 144.38 | 6994.400 | 0.900 | 900 | 198.072 | 0.023 | 0.104 |
| | 9:42 | 8667 | 144.45 | 6994.512 | 1.012 | 1012 | 222.721 | 0.026 | 0.117 |
| | 9:44 | 8669 | 144.48 | 6994.562 | 1.062 | 1062 | 233.725 | 0.027 | 0.123 |
| | 9:45 | 8670 | 144.50 | | | | | | |
| | 9:46 | 8671 | 144.52 | 6994.611 | 1.111 | 1111 | 244.509 | 0.028 | 0.128 |
| | 9:47 | 8672 | 144.53 | 6994.634 | 1.134 | 1134 | 249.571 | 0.029 | 0.131 |
| | 9:48 | 8673 | 144.55 | 6994.649 | 1.149 | 1149 | 252.872 | 0.029 | 0.132 |
| October 19, 2003 | 15:08 | 14753 | 245.88 | 6994.649 | 1.149 | 1149 | 252.872 | 0.017 | 0.078 |
| | 15:10 | 14755 | 245.92 | | | | | | |
| | 15:12 | 14757 | 245.95 | 6994.760 | 1.260 | 1260 | 277.301 | 0.019 | 0.085 |
| | 15:14 | 14759 | 245.98 | 6994.812 | 1.312 | 1312 | 288.745 | 0.020 | 0.089 |
| | 15:17 | 14762 | 246.03 | 6994.900 | 1.400 | 1400 | 308.112 | 0.021 | 0.095 |
| | 15:19 | 14764 | 246.07 | 6994.940 | 1.440 | 1440 | 316.915 | 0.021 | 0.098 |
| | 15:20 | 14765 | 246.08 | 6994.982 | 1.482 | 1482 | 326.159 | 0.022 | 0.100 |
| October 22, 2003 | 12:13 | 18898 | 314.97 | 6994.982 | 1.482 | 1482 | 326.159 | 0.017 | 0.078 |
| | 12:14 | 18899 | 314.98 | 6995.012 | 1.512 | 1512 | 332.761 | 0.018 | 0.080 |
| | 12:15 | 18900 | 315.00 | 6995.046 | 1.546 | 1546 | 340.244 | 0.018 | 0.082 |
| | 12:16 | 18901 | 315.02 | 6995.073 | 1.573 | 1573 | 346.186 | 0.018 | 0.083 |
| | 12:18 | 18903 | 315.05 | 6995.131 | 1.631 | 1631 | 358.950 | 0.019 | 0.086 |
| | 12:22 | 18907 | 315.12 | 6995.239 | 1.739 | 1739 | 382.719 | 0.020 | 0.092 |
| | 12:23 | 18908 | 315.13 | 6995.258 | 1.758 | 1758 | 386.901 | 0.020 | 0.093 |
| | 12:24 | 18909 | 315.15 | 6995.290 | 1.790 | 1790 | 393.943 | 0.021 | 0.095 |
| | 12:25 | 18910 | 315.17 | 6995.301 | 1.801 | 1801 | 396.364 | 0.021 | 0.095 |
| October 26, 2003 | 10:30 | 24555 | 409.25 | 6995.301 | 1.801 | 1801 | 396.364 | 0.016 | 0.073 |
| | 10:31 | 24556 | 409.27 | 6995.330 | 1.830 | 1830 | 402.746 | 0.016 | 0.075 |
| | 10:32 | 24557 | 409.28 | 6995.361 | 1.861 | 1861 | 409.569 | 0.017 | 0.076 |
| | 10:33 | 24558 | 409.30 | 6995.391 | 1.891 | 1891 | 416.171 | 0.017 | 0.077 |
| | 10:34 | 24559 | 409.32 | 6995.421 | 1.921 | 1921 | 422.774 | 0.017 | 0.078 |
| | 10:35 | 24560 | 409.33 | 6995.450 | 1.950 | 1950 | 429.156 | 0.017 | 0.079 |
| | 10:38 | 24563 | 409.38 | 6995.530 | 2.030 | 2030 | 446.762 | 0.018 | 0.083 |
| | 10:39 | 24564 | 409.40 | 6995.558 | 2.058 | 2058 | 452.925 | 0.018 | 0.084 |
| | 10:40 | 24565 | 409.42 | 6995.586 | 2.086 | 2086 | 459.087 | 0.019 | 0.085 |
| | 10:41 | 24566 | 409.43 | 6995.609 | 2.109 | 2109 | 464.149 | 0.019 | 0.086 |
| | 10:42 | 24567 | 409.45 | 6995.635 | 2.135 | 2135 | 469.871 | 0.019 | 0.087 |
| October 29, 2003 | 14:52 | 29137 | 485.62 | 6995.635 | 2.135 | 2135 | 469.871 | 0.016 | 0.073 |
| | 14:53 | 29138 | 485.63 | 6995.664 | 2.164 | 2164 | 476.253 | 0.016 | 0.074 |
| | 14:54 | 29139 | 485.65 | 6995.698 | 2.198 | 2198 | 483.736 | 0.017 | 0.075 |
| | 14:55 | 29140 | 485.67 | 6995.726 | 2.226 | 2226 | 489.898 | 0.017 | 0.076 |
| | 14:56 | 29141 | 485.68 | 6995.754 | 2.254 | 2254 | 496.060 | 0.017 | 0.077 |
| | 14:57 | 29142 | 485.70 | 6995.832 | 2.332 | 2332 | 513.227 | 0.018 | 0.080 |
| | 15:00 | 29145 | 485.75 | 6995.868 | 2.368 | 2368 | 521.149 | 0.018 | 0.081 |
| | 15:01 | 29146 | 485.77 | 6995.898 | 2.398 | 2398 | 527.752 | 0.018 | 0.082 |
| | 15:02 | 29147 | 485.78 | 6995.918 | 2.418 | 2418 | 532.153 | 0.018 | 0.083 |
| | 15:03 | 29148 | 485.80 | 6995.940 | 2.440 | 2440 | 536.995 | 0.018 | 0.084 |
| | 15:04 | 29149 | 485.82 | 6995.964 | 2.464 | 2464 | 542.277 | 0.019 | 0.085 |
| November 1, 2003 | 12:33 | 33318 | 555.30 | 6995.964 | 2.464 | 2464 | 542.277 | 0.016 | 0.074 |
| | 12:34 | 33319 | 555.32 | 6995.990 | 2.490 | 2490 | 547.999 | 0.016 | 0.075 |
| | 12:35 | 33320 | 555.33 | 6996.020 | 2.520 | 2520 | 554.602 | 0.017 | 0.076 |
| | 12:36 | 33321 | 555.35 | 6996.052 | 2.552 | 2552 | 561.644 | 0.017 | 0.077 |
| | 12:37 | 33322 | 555.37 | 6996.081 | 2.581 | 2581 | 568.026 | 0.017 | 0.077 |
| | 12:39 | 33324 | 555.40 | 6996.090 | 2.590 | 2590 | 570.007 | 0.017 | 0.078 |
| | 12:40 | 33325 | 555.42 | 6996.168 | 2.668 | 2668 | 587.173 | 0.018 | 0.080 |
| | 12:41 | 33326 | 555.43 | 6996.190 | 2.690 | 2690 | 592.015 | 0.018 | 0.081 |
| | 12:42 | 33327 | 555.45 | 6996.216 | 2.716 | 2716 | 597.737 | 0.018 | 0.081 |
| | 12:44 | 33329 | 555.48 | 6996.264 | 2.764 | 2764 | 608.301 | 0.018 | 0.083 |
| November 5, 2003 | 9:01 | 38834 | 647.23 | 6996.264 | 2.764 | 2764 | 608.301 | 0.016 | 0.071 |
| | 9:02 | 38835 | 647.25 | 6996.292 | 2.792 | 2792 | 614.463 | 0.016 | 0.072 |
| | 9:03 | 38836 | 647.27 | 6996.322 | 2.822 | 2822 | 621.066 | 0.016 | 0.073 |
| | 9:04 | 38837 | 647.28 | 6996.352 | 2.852 | 2852 | 627.668 | 0.016 | 0.073 |
| | 9:05 | 38838 | 647.30 | 6996.382 | 2.882 | 2882 | 634.271 | 0.016 | 0.074 |
| | 9:08 | 38841 | 647.35 | 6996.466 | 2.966 | 2966 | 652.757 | 0.017 | 0.076 |
| | 9:09 | 38842 | 647.37 | 6996.490 | 2.990 | 2990 | 658.039 | 0.017 | 0.077 |
| | 9:10 | 38843 | 647.38 | 6996.512 | 3.012 | 3012 | 662.881 | 0.017 | 0.078 |
| | 9:12 | 38845 | 647.42 | 6996.536 | 3.036 | 3036 | 668.163 | 0.017 | 0.078 |
| | 9:13 | 38846 | 647.43 | 6996.582 | 3.082 | 3082 | 678.287 | 0.017 | 0.079 |

## Abbott Road (PW03-2) - Short Term Pumping Test

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading ($m^3$) | Cumulative Discharge ($m^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| November 6, 2003 | 9:52 | 0 | 0 | 6996.583 | 0 | 0 | 0 | 0 | 0 |
| | 9:53 | 1 | 0.02 | 6996.613 | 0.030 | 30 | 6.602 | 6.602 | 30.000 |
| | 9:54 | 2 | 0.03 | 6996.648 | 0.065 | 65 | 14.305 | 7.153 | 32.500 |
| | 9:55 | 3 | 0.05 | 6996.679 | 0.096 | 96 | 21.128 | 7.043 | 32.000 |
| | 9:56 | 4 | 0.07 | 6996.711 | 0.128 | 128 | 28.170 | 7.043 | 32.000 |
| | 9:57 | 5 | 0.08 | 6996.756 | 0.173 | 173 | 38.074 | 7.615 | 34.600 |
| | 9:58 | 6 | 0.10 | 6996.776 | 0.193 | 193 | 42.475 | 7.079 | 32.167 |
| | 9:59 | 7 | 0.12 | 6996.803 | 0.220 | 220 | 48.418 | 6.917 | 31.429 |
| | 10:00 | 8 | 0.13 | 6996.829 | 0.246 | 246 | 54.140 | 6.767 | 30.750 |
| | 10:01 | 9 | 0.15 | 6996.855 | 0.272 | 272 | 59.862 | 6.651 | 30.222 |
| | 10:02 | 10 | 0.17 | 6996.881 | 0.298 | 298 | 65.584 | 6.558 | 29.800 |
| | 10:03 | 11 | 0.18 | 6996.906 | 0.323 | 323 | 71.086 | 6.462 | 29.364 |
| | 10:04 | 12 | 0.20 | 6996.931 | 0.348 | 348 | 76.588 | 6.382 | 29.000 |
| | 10:05 | 13 | 0.22 | 6996.958 | 0.375 | 375 | 82.530 | 6.348 | 28.846 |
| | 10:06 | 14 | 0.23 | 6996.98 | 0.397 | 397 | 87.372 | 6.241 | 28.357 |
| | 10:07 | 15 | 0.25 | 6997.006 | 0.423 | 423 | 93.094 | 6.206 | 28.200 |
| | 10:08 | 16 | 0.27 | 6997.026 | 0.443 | 443 | 97.495 | 6.093 | 27.688 |
| | 10:10 | 18 | 0.30 | 6997.049 | 0.466 | 466 | 102.557 | 5.698 | 25.889 |
| | 10:11 | 19 | 0.32 | 6997.071 | 0.488 | 488 | 107.399 | 5.653 | 25.684 |
| November 9, 2003 | 14:52 | 4620 | 77.00 | 6997.094 | 0.488 | 488 | 107.399 | 0.023 | 0.106 |
| | 14:53 | 4621 | 77.02 | 6997.120 | 0.514 | 514 | 113.121 | 0.024 | 0.111 |
| | 14:54 | 4622 | 77.03 | 6997.148 | 0.542 | 542 | 119.283 | 0.026 | 0.117 |
| | 14:55 | 4623 | 77.05 | 6997.176 | 0.570 | 570 | 125.446 | 0.027 | 0.123 |
| | 14:56 | 4624 | 77.07 | 6997.200 | 0.594 | 594 | 130.728 | 0.028 | 0.128 |
| | 14:57 | 4625 | 77.08 | 6997.224 | 0.618 | 618 | 136.009 | 0.029 | 0.134 |
| | 14:58 | 4626 | 77.10 | 6997.250 | 0.644 | 644 | 141.732 | 0.031 | 0.139 |
| | 14:59 | 4627 | 77.12 | 6997.276 | 0.670 | 670 | 147.454 | 0.032 | 0.145 |
| | 15:00 | 4628 | 77.13 | 6997.299 | 0.693 | 693 | 152.515 | 0.033 | 0.150 |
| | 15:01 | 4629 | 77.15 | 6997.320 | 0.714 | 714 | 157.137 | 0.034 | 0.154 |
| | 15:02 | 4630 | 77.17 | 6997.346 | 0.740 | 740 | 162.859 | 0.035 | 0.160 |
| | 15:03 | 4631 | 77.18 | 6997.362 | 0.756 | 756 | 166.380 | 0.036 | 0.163 |

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading (m$^3$) | Cumulative Discharge (m$^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| November 12, 2003 | 15:01 | 8949 | 149.15 | 6997.362 | 0.756 | 756 | 166.380 | 0.019 | 0.084 |
| | 15:02 | 8950 | 149.17 | 6997.388 | 0.782 | 782 | 172.103 | 0.019 | 0.087 |
| | 15:03 | 8951 | 149.18 | 6997.412 | 0.806 | 806 | 177.384 | 0.020 | 0.090 |
| | 15:04 | 8952 | 149.20 | 6997.440 | 0.834 | 834 | 183.547 | 0.021 | 0.093 |
| | 15:05 | 8953 | 149.22 | 6997.464 | 0.858 | 858 | 188.829 | 0.021 | 0.096 |
| | 15:06 | 8954 | 149.23 | 6997.490 | 0.884 | 884 | 194.551 | 0.022 | 0.099 |
| | 15:07 | 8955 | 149.25 | 6997.514 | 0.908 | 908 | 199.833 | 0.022 | 0.101 |
| | 15:08 | 8956 | 149.27 | 6997.538 | 0.932 | 932 | 205.115 | 0.023 | 0.104 |
| | 15:09 | 8957 | 149.28 | 6997.562 | 0.956 | 956 | 210.396 | 0.023 | 0.107 |
| | 15:10 | 8958 | 149.30 | 6997.587 | 0.981 | 981 | 215.898 | 0.024 | 0.110 |
| November 16, 2003 | 13:41 | 14629 | 243.82 | 6997.587 | 0.981 | 981 | 215.898 | 0.015 | 0.067 |
| | 13:42 | 14630 | 243.83 | 6997.614 | 1.008 | 1008 | 221.841 | 0.015 | 0.069 |
| | 13:43 | 14631 | 243.85 | 6997.642 | 1.036 | 1036 | 228.003 | 0.016 | 0.071 |
| | 13:44 | 14632 | 243.87 | 6997.670 | 1.064 | 1064 | 234.165 | 0.016 | 0.073 |
| | 13:45 | 14633 | 243.88 | 6997.694 | 1.088 | 1088 | 239.447 | 0.016 | 0.074 |
| | 13:46 | 14634 | 243.90 | 6997.720 | 1.114 | 1114 | 245.169 | 0.017 | 0.076 |
| | 13:47 | 14635 | 243.92 | 6997.748 | 1.142 | 1142 | 251.331 | 0.017 | 0.078 |
| | 13:48 | 14636 | 243.93 | 6997.772 | 1.166 | 1166 | 256.613 | 0.018 | 0.080 |
| | 13:49 | 14637 | 243.95 | 6997.796 | 1.190 | 1190 | 261.895 | 0.018 | 0.081 |
| | 13:50 | 14638 | 243.97 | 6997.820 | 1.214 | 1214 | 267.177 | 0.018 | 0.083 |
| | 13:51 | 14639 | 243.98 | 6997.844 | 1.238 | 1238 | 272.459 | 0.019 | 0.085 |
| | 13:52 | 14640 | 244.00 | 6997.863 | 1.257 | 1257 | 276.641 | 0.019 | 0.086 |
| November 19, 2003 | 15:05 | 19033 | 317.22 | 6997.863 | 1.257 | 1257 | 276.641 | 0.015 | 0.066 |
| | 15:06 | 19034 | 317.23 | 6997.884 | 1.278 | 1278 | 281.262 | 0.015 | 0.067 |
| | 15:07 | 19035 | 317.25 | 6997.906 | 1.300 | 1300 | 286.104 | 0.015 | 0.068 |
| | 15:08 | 19036 | 317.27 | 6997.934 | 1.328 | 1328 | 292.266 | 0.015 | 0.070 |
| | 15:09 | 19037 | 317.28 | 6997.960 | 1.354 | 1354 | 297.988 | 0.016 | 0.071 |
| | 15:10 | 19038 | 317.30 | 6997.984 | 1.378 | 1378 | 303.270 | 0.016 | 0.072 |
| | 15:11 | 19039 | 317.32 | 6998.010 | 1.404 | 1404 | 308.992 | 0.016 | 0.074 |
| | 15:12 | 19040 | 317.33 | 6998.034 | 1.428 | 1428 | 314.274 | 0.017 | 0.075 |
| | 15:13 | 19041 | 317.35 | 6998.058 | 1.452 | 1452 | 319.556 | 0.017 | 0.076 |
| | 15:14 | 19042 | 317.37 | 6998.082 | 1.476 | 1476 | 324.838 | 0.017 | 0.078 |
| November 20, 2003 | 13:42 | 20390 | 339.83 | 6998.082 | 1.476 | 1476 | 324.838 | 0.016 | 0.072 |
| | 13:43 | 20391 | 339.85 | 6998.106 | 1.500 | 1500 | 330.120 | 0.016 | 0.074 |
| | 13:44 | 20392 | 339.87 | 6998.136 | 1.530 | 1530 | 336.722 | 0.017 | 0.075 |
| | 13:45 | 20393 | 339.88 | 6998.162 | 1.556 | 1556 | 342.444 | 0.017 | 0.076 |
| | 13:46 | 20394 | 339.90 | 6998.190 | 1.584 | 1584 | 348.607 | 0.017 | 0.078 |
| | 13:47 | 20395 | 339.92 | 6998.214 | 1.608 | 1608 | 353.889 | 0.017 | 0.079 |
| | 13:48 | 20396 | 339.93 | 6998.242 | 1.636 | 1636 | 360.051 | 0.018 | 0.080 |
| | 13:49 | 20397 | 339.95 | 6998.268 | 1.662 | 1662 | 365.773 | 0.018 | 0.081 |
| | 13:50 | 20398 | 339.97 | 6998.293 | 1.687 | 1687 | 371.275 | 0.018 | 0.083 |
| | 13:51 | 20399 | 339.98 | 6998.316 | 1.710 | 1710 | 376.337 | 0.018 | 0.084 |
| | 13:52 | 20400 | 340.00 | 6998.340 | 1.734 | 1734 | 381.619 | 0.019 | 0.085 |
| | 13:53 | 20401 | 340.02 | 6998.358 | 1.752 | 1752 | 385.580 | 0.019 | 0.086 |

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading (m$^3$) | Cumulative Discharge (m$^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| November 27, 2003 | 15:04 | 30552 | 509.20 | 6998.358 | 1.752 | 1752 | 385.580 | 0.013 | 0.057 |
| | 15:05 | 30553 | 509.22 | 6998.384 | 1.778 | 1778 | 391.302 | 0.013 | 0.058 |
| | 15:06 | 30554 | 509.23 | 6998.414 | 1.808 | 1808 | 397.905 | 0.013 | 0.059 |
| | 15:07 | 30555 | 509.25 | 6998.444 | 1.838 | 1838 | 404.507 | 0.013 | 0.060 |
| | 15:08 | 30556 | 509.27 | 6998.470 | 1.864 | 1864 | 410.229 | 0.013 | 0.061 |
| | 15:09 | 30557 | 509.28 | 6998.496 | 1.890 | 1890 | 415.951 | 0.014 | 0.062 |
| | 15:10 | 30558 | 509.30 | 6998.522 | 1.916 | 1916 | 421.673 | 0.014 | 0.063 |
| | 15:11 | 30559 | 509.32 | 6998.550 | 1.944 | 1944 | 427.836 | 0.014 | 0.064 |
| | 15:12 | 30560 | 509.33 | 6998.576 | 1.970 | 1970 | 433.558 | 0.014 | 0.064 |
| | 15:13 | 30561 | 509.35 | 6998.598 | 1.992 | 1992 | 438.399 | 0.014 | 0.065 |
| | 15:14 | 30562 | 509.37 | 6998.624 | 2.018 | 2018 | 444.121 | 0.015 | 0.066 |
| | 15:15 | 30563 | 509.38 | 6998.648 | 2.042 | 2042 | 449.403 | 0.015 | 0.067 |
| | 15:16 | 30564 | 509.40 | 6998.662 | 2.056 | 2056 | 452.484 | 0.015 | 0.067 |
| November 30, 2003 | 8:45 | 34493 | 574.88 | 6998.662 | 2.056 | 2056 | 452.484 | 0.013 | 0.060 |
| | 8:46 | 34494 | 574.90 | 6998.690 | 2.084 | 2084 | 458.647 | 0.013 | 0.060 |
| | 8:47 | 34495 | 574.92 | 6998.714 | 2.108 | 2108 | 463.929 | 0.013 | 0.061 |
| | 8:48 | 34496 | 574.93 | 6998.740 | 2.134 | 2134 | 469.651 | 0.014 | 0.062 |
| | 8:49 | 34497 | 574.95 | 6998.768 | 2.162 | 2162 | 475.813 | 0.014 | 0.063 |
| | 8:50 | 34498 | 574.97 | 6998.792 | 2.186 | 2186 | 481.095 | 0.014 | 0.063 |
| | 8:51 | 34499 | 574.98 | 6998.814 | 2.208 | 2208 | 485.937 | 0.014 | 0.064 |
| | 8:52 | 34500 | 575.00 | 6998.842 | 2.236 | 2236 | 492.099 | 0.014 | 0.065 |
| | 8:53 | 34501 | 575.02 | 6998.866 | 2.260 | 2260 | 497.381 | 0.014 | 0.066 |
| | 8:54 | 34502 | 575.03 | 6998.883 | 2.277 | 2277 | 501.122 | 0.015 | 0.066 |
| December 3, 2003 | 12:17 | 39025 | 650.42 | 6998.883 | 2.277 | 2277 | 501.122 | 0.013 | 0.058 |
| | 12:18 | 39026 | 650.43 | 6998.908 | 2.302 | 2302 | 506.624 | 0.013 | 0.059 |
| | 12:19 | 39027 | 650.45 | 6998.938 | 2.332 | 2332 | 513.227 | 0.013 | 0.060 |
| | 12:20 | 39028 | 650.47 | 6998.966 | 2.360 | 2360 | 519.389 | 0.013 | 0.060 |
| | 12:21 | 39029 | 650.48 | 6998.992 | 2.386 | 2386 | 525.111 | 0.013 | 0.061 |
| | 12:22 | 39030 | 650.50 | 6999.017 | 2.411 | 2411 | 530.613 | 0.014 | 0.062 |
| | 12:23 | 39031 | 650.52 | 6999.042 | 2.436 | 2436 | 536.115 | 0.014 | 0.062 |
| | 12:24 | 39032 | 650.53 | 6999.068 | 2.462 | 2462 | 541.837 | 0.014 | 0.063 |
| | 12:25 | 39033 | 650.55 | 6999.093 | 2.487 | 2487 | 547.339 | 0.014 | 0.064 |
| | 12:26 | 39034 | 650.57 | 6999.115 | 2.509 | 2509 | 552.181 | 0.014 | 0.064 |
| | 12:27 | 39035 | 650.58 | 6999.133 | 2.527 | 2527 | 556.142 | 0.014 | 0.065 |

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading ($m^3$) | Cumulative Discharge ($m^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| December 6, 2003 | 12:01 | 43329 | 722.15 | 6999.133 | 2.527 | 2527 | 556.142 | 0.013 | 0.058 |
| | 12:02 | 43330 | 722.17 | 6999.158 | 2.552 | 2552 | 561.644 | 0.013 | 0.059 |
| | 12:03 | 43331 | 722.18 | 6999.188 | 2.582 | 2582 | 568.247 | 0.013 | 0.060 |
| | 12:04 | 43332 | 722.20 | 6999.211 | 2.605 | 2605 | 573.308 | 0.013 | 0.060 |
| | 12:05 | 43333 | 722.22 | 6999.235 | 2.629 | 2629 | 578.590 | 0.013 | 0.061 |
| | 12:06 | 43334 | 722.23 | 6999.260 | 2.654 | 2654 | 584.092 | 0.013 | 0.061 |
| | 12:07 | 43335 | 722.25 | 6999.287 | 2.681 | 2681 | 590.034 | 0.014 | 0.062 |
| | 12:08 | 43336 | 722.27 | 6999.310 | 2.704 | 2704 | 595.096 | 0.014 | 0.062 |
| | 12:08 | 43336 | 722.27 | 6999.330 | 2.724 | 2724 | 599.498 | 0.014 | 0.063 |
| December 9, 2003 | 15:12 | 47840 | 797.33 | 6999.330 | 2.724 | 2724 | 599.498 | 0.013 | 0.057 |
| | 15:13 | 47841 | 797.35 | 6999.356 | 2.750 | 2750 | 605.220 | 0.013 | 0.057 |
| | 15:14 | 47842 | 797.37 | 6999.382 | 2.776 | 2776 | 610.942 | 0.013 | 0.058 |
| | 15:15 | 47843 | 797.38 | 6999.406 | 2.800 | 2800 | 616.224 | 0.013 | 0.059 |
| | 15:16 | 47844 | 797.40 | 6999.432 | 2.826 | 2826 | 621.946 | 0.013 | 0.059 |
| | 15:17 | 47845 | 797.42 | 6999.460 | 2.854 | 2854 | 628.108 | 0.013 | 0.060 |
| | 15:18 | 47846 | 797.43 | 6999.484 | 2.878 | 2878 | 633.390 | 0.013 | 0.060 |
| | 15:19 | 47847 | 797.45 | 6999.508 | 2.902 | 2902 | 638.672 | 0.013 | 0.061 |
| | 15:20 | 47848 | 797.47 | 6999.532 | 2.926 | 2926 | 643.954 | 0.013 | 0.061 |
| | 15:20 | 47848 | 797.47 | 6999.542 | 2.936 | 2936 | 646.155 | 0.014 | 0.061 |
| December 12, 2003 | 15:43 | 52191 | 869.85 | 6999.542 | 2.936 | 2936 | 646.155 | 0.012 | 0.056 |

## Flamingo Road (PW03-1) - Long Term Pumping Test

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading ($m^3$) | Cumulative Discharge ($m^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| December 15, 2003 | 16:17 | 0 | 0 | 6999.544 | 0 | 0 | 0 | 0 | 0 |
| | 16:18 | 1 | 0.02 | 6999.576 | 0.032 | 32 | 7.043 | 7.043 | 32.000 |
| | 16:19 | 2 | 0.03 | 6999.606 | 0.062 | 62 | 13.645 | 6.822 | 31.000 |
| | 16:20 | 3 | 0.05 | 6999.640 | 0.096 | 96 | 21.128 | 7.043 | 32.000 |
| | 16:21 | 4 | 0.07 | 6999.670 | 0.126 | 126 | 27.730 | 6.933 | 31.500 |
| | 16:22 | 5 | 0.08 | 6999.700 | 0.156 | 156 | 34.332 | 6.866 | 31.200 |
| | 16:23 | 6 | 0.10 | 6999.728 | 0.184 | 184 | 40.495 | 6.749 | 30.667 |
| | 16:24 | 7 | 0.12 | 6999.756 | 0.212 | 212 | 46.657 | 6.665 | 30.286 |
| | 16:25 | 8 | 0.13 | 6999.786 | 0.242 | 242 | 53.259 | 6.657 | 30.250 |
| | 16:26 | 9 | 0.15 | 6999.810 | 0.266 | 266 | 58.541 | 6.505 | 29.556 |
| | 16:27 | 10 | 0.17 | 6999.840 | 0.296 | 296 | 65.144 | 6.514 | 29.600 |
| | 16:28 | 11 | 0.18 | 6999.864 | 0.320 | 320 | 70.426 | 6.402 | 29.091 |
| | 16:29 | 12 | 0.20 | 6999.886 | 0.342 | 342 | 75.267 | 6.272 | 28.500 |
| | 16:30 | 13 | 0.22 | 6999.910 | 0.366 | 366 | 80.549 | 6.196 | 28.154 |
| | 16:31 | 14 | 0.23 | 6999.936 | 0.392 | 392 | 86.271 | 6.162 | 28.000 |
| | 16:31 | 14 | 0.23 | 6999.940 | 0.396 | 396 | 87.152 | 6.225 | 28.286 |
| December 18, 2003 | 15:03 | 4246 | 70.77 | 7000.038 | 0.494 | 494 | 108.720 | 0.026 | 0.116 |
| | 15:04 | 4247 | 70.78 | 7000.068 | 0.524 | 524 | 115.322 | 0.027 | 0.123 |
| | 15:05 | 4248 | 70.80 | 7000.098 | 0.554 | 554 | 121.924 | 0.029 | 0.130 |
| | 15:06 | 4249 | 70.82 | 7000.130 | 0.586 | 586 | 128.967 | 0.030 | 0.138 |
| | 15:07 | 4250 | 70.83 | 7000.158 | 0.614 | 614 | 135.129 | 0.032 | 0.144 |
| | 15:08 | 4251 | 70.85 | 7000.188 | 0.644 | 644 | 141.732 | 0.033 | 0.151 |
| | 15:09 | 4252 | 70.87 | 7000.216 | 0.672 | 672 | 147.894 | 0.035 | 0.158 |
| | 15:10 | 4253 | 70.88 | 7000.244 | 0.700 | 700 | 154.056 | 0.036 | 0.165 |
| | 15:11 | 4254 | 70.90 | 7000.270 | 0.726 | 726 | 159.778 | 0.038 | 0.171 |
| | 15:12 | 4255 | 70.92 | 7000.296 | 0.752 | 752 | 165.500 | 0.039 | 0.177 |
| | 15:13 | 4256 | 70.93 | 7000.320 | 0.776 | 776 | 170.782 | 0.040 | 0.182 |
| | 15:14 | 4257 | 70.95 | 7000.344 | 0.800 | 800 | 176.064 | 0.041 | 0.188 |
| | 15:15 | 4258 | 70.97 | 7000.368 | 0.824 | 824 | 181.346 | 0.043 | 0.194 |
| | 15:16 | 4259 | 70.98 | 7000.390 | 0.846 | 846 | 186.188 | 0.044 | 0.199 |
| December 21, 2003 | 10:51 | 8314 | 138.57 | 7000.390 | 0.846 | 846 | 186.188 | 0.022 | 0.102 |
| | 10:57 | 8320 | 138.67 | 7000.404 | 0.860 | 860 | 189.269 | 0.023 | 0.103 |
| | 10:58 | 8321 | 138.68 | 7000.434 | 0.890 | 890 | 195.871 | 0.024 | 0.107 |
| | 10:59 | 8322 | 138.70 | 7000.464 | 0.920 | 920 | 202.474 | 0.024 | 0.111 |
| | 11:00 | 8323 | 138.72 | 7000.496 | 0.952 | 952 | 209.516 | 0.025 | 0.114 |
| | 11:01 | 8324 | 138.73 | 7000.522 | 0.978 | 978 | 215.238 | 0.026 | 0.117 |
| | 11:02 | 8325 | 138.75 | 7000.55 | 1.006 | 1006 | 221.400 | 0.027 | 0.121 |
| | 11:03 | 8326 | 138.77 | 7000.576 | 1.032 | 1032 | 227.123 | 0.027 | 0.124 |
| | 11:04 | 8327 | 138.78 | 7000.604 | 1.060 | 1060 | 233.285 | 0.028 | 0.127 |
| | 11:05 | 8328 | 138.80 | 7000.630 | 1.086 | 1086 | 239.007 | 0.029 | 0.130 |
| | 11:06 | 8329 | 138.82 | 7000.654 | 1.110 | 1110 | 244.289 | 0.029 | 0.133 |
| | 11:07 | 8330 | 138.83 | 7000.678 | 1.134 | 1134 | 249.571 | 0.030 | 0.136 |
| | 11:08 | 8331 | 138.85 | 7000.700 | 1.156 | 1156 | 254.412 | 0.031 | 0.139 |
| | 11:09 | 8332 | 138.87 | 7000.713 | 1.169 | 1169 | 257.274 | 0.031 | 0.140 |

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading ($m^3$) | Cumulative Discharge ($m^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| December 24, 2003 | 12:39 | 12742 | 212.37 | 7000.714 | 1.170 | 1170 | 257.494 | 0.020 | 0.092 |
| | 12:40 | 12743 | 212.38 | 7000.744 | 1.200 | 1200 | 264.096 | 0.021 | 0.094 |
| | 12:41 | 12744 | 212.40 | 7000.774 | 1.230 | 1230 | 270.698 | 0.021 | 0.097 |
| | 12:42 | 12745 | 212.42 | 7000.804 | 1.260 | 1260 | 277.301 | 0.022 | 0.099 |
| | 12:43 | 12746 | 212.43 | 7000.834 | 1.290 | 1290 | 283.903 | 0.022 | 0.101 |
| | 12:44 | 12747 | 212.45 | 7000.862 | 1.318 | 1318 | 290.065 | 0.023 | 0.103 |
| | 12:45 | 12748 | 212.47 | 7000.888 | 1.344 | 1344 | 295.788 | 0.023 | 0.105 |
| | 12:46 | 12749 | 212.48 | 7000.914 | 1.370 | 1370 | 301.510 | 0.024 | 0.107 |
| | 12:47 | 12750 | 212.50 | 7000.940 | 1.396 | 1396 | 307.232 | 0.024 | 0.109 |
| | 12:48 | 12751 | 212.52 | 7000.970 | 1.426 | 1426 | 313.834 | 0.025 | 0.112 |
| | 12:49 | 12752 | 212.53 | 7000.990 | 1.446 | 1446 | 318.236 | 0.025 | 0.113 |
| | 12:50 | 12753 | 212.55 | 7001.010 | 1.466 | 1466 | 322.637 | 0.025 | 0.115 |
| | 12:51 | 12754 | 212.57 | 7001.036 | 1.492 | 1492 | 328.359 | 0.026 | 0.117 |
| December 27, 2003 | 10:32 | 16935 | 282.25 | 7001.038 | 1.494 | 1494 | 328.800 | 0.019 | 0.088 |
| | 10:33 | 16936 | 282.27 | 7001.066 | 1.522 | 1522 | 334.962 | 0.020 | 0.090 |
| | 10:34 | 16937 | 282.28 | 7001.094 | 1.550 | 1550 | 341.124 | 0.020 | 0.092 |
| | 10:35 | 16938 | 282.30 | 7001.124 | 1.580 | 1580 | 347.726 | 0.021 | 0.093 |
| | 10:36 | 16939 | 282.32 | 7001.152 | 1.608 | 1608 | 353.889 | 0.021 | 0.095 |
| | 10:37 | 16940 | 282.33 | 7001.178 | 1.634 | 1634 | 359.611 | 0.021 | 0.096 |
| | 10:38 | 16941 | 282.35 | 7001.204 | 1.660 | 1660 | 365.333 | 0.022 | 0.098 |
| | 10:39 | 16942 | 282.37 | 7001.230 | 1.686 | 1686 | 371.055 | 0.022 | 0.100 |
| | 10:40 | 16943 | 282.38 | 7001.254 | 1.710 | 1710 | 376.337 | 0.022 | 0.101 |
| | 10:41 | 16944 | 282.40 | 7001.280 | 1.736 | 1736 | 382.059 | 0.023 | 0.102 |
| | 10:42 | 16945 | 282.42 | 7001.300 | 1.756 | 1756 | 386.460 | 0.023 | 0.104 |
| | 10:43 | 16946 | 282.43 | 7001.324 | 1.780 | 1780 | 391.742 | 0.023 | 0.105 |
| | 10:44 | 16947 | 282.45 | 7001.348 | 1.804 | 1804 | 397.024 | 0.023 | 0.106 |
| | 10:45 | 16948 | 282.47 | 7001.354 | 1.810 | 1810 | 398.345 | 0.024 | 0.107 |
| December 30, 2003 | 14:02 | 21465 | 357.75 | 7001.354 | 1.810 | 1810 | 398.345 | 0.019 | 0.084 |
| | 14:03 | 21466 | 357.77 | 7001.382 | 1.838 | 1838 | 404.507 | 0.019 | 0.086 |
| | 14:04 | 21467 | 357.78 | 7001.412 | 1.868 | 1868 | 411.109 | 0.019 | 0.087 |
| | 14:05 | 21468 | 357.80 | 7001.444 | 1.900 | 1900 | 418.152 | 0.019 | 0.089 |
| | 14:06 | 21469 | 357.82 | 7001.472 | 1.928 | 1928 | 424.314 | 0.020 | 0.090 |
| | 14:07 | 21470 | 357.83 | 7001.498 | 1.954 | 1954 | 430.036 | 0.020 | 0.091 |
| | 14:08 | 21471 | 357.85 | 7001.526 | 1.982 | 1982 | 436.199 | 0.020 | 0.092 |
| | 14:09 | 21472 | 357.87 | 7001.554 | 2.010 | 2010 | 442.361 | 0.021 | 0.094 |
| | 14:10 | 21473 | 357.88 | 7001.578 | 2.034 | 2034 | 447.643 | 0.021 | 0.095 |
| | 14:11 | 21474 | 357.90 | 7001.602 | 2.058 | 2058 | 452.925 | 0.021 | 0.096 |
| | 14:12 | 21475 | 357.92 | 7001.626 | 2.082 | 2082 | 458.207 | 0.021 | 0.097 |
| | 14:13 | 21476 | 357.93 | 7001.650 | 2.106 | 2106 | 463.488 | 0.022 | 0.098 |
| | 14:14 | 21477 | 357.95 | 7001.668 | 2.124 | 2124 | 467.450 | 0.022 | 0.099 |

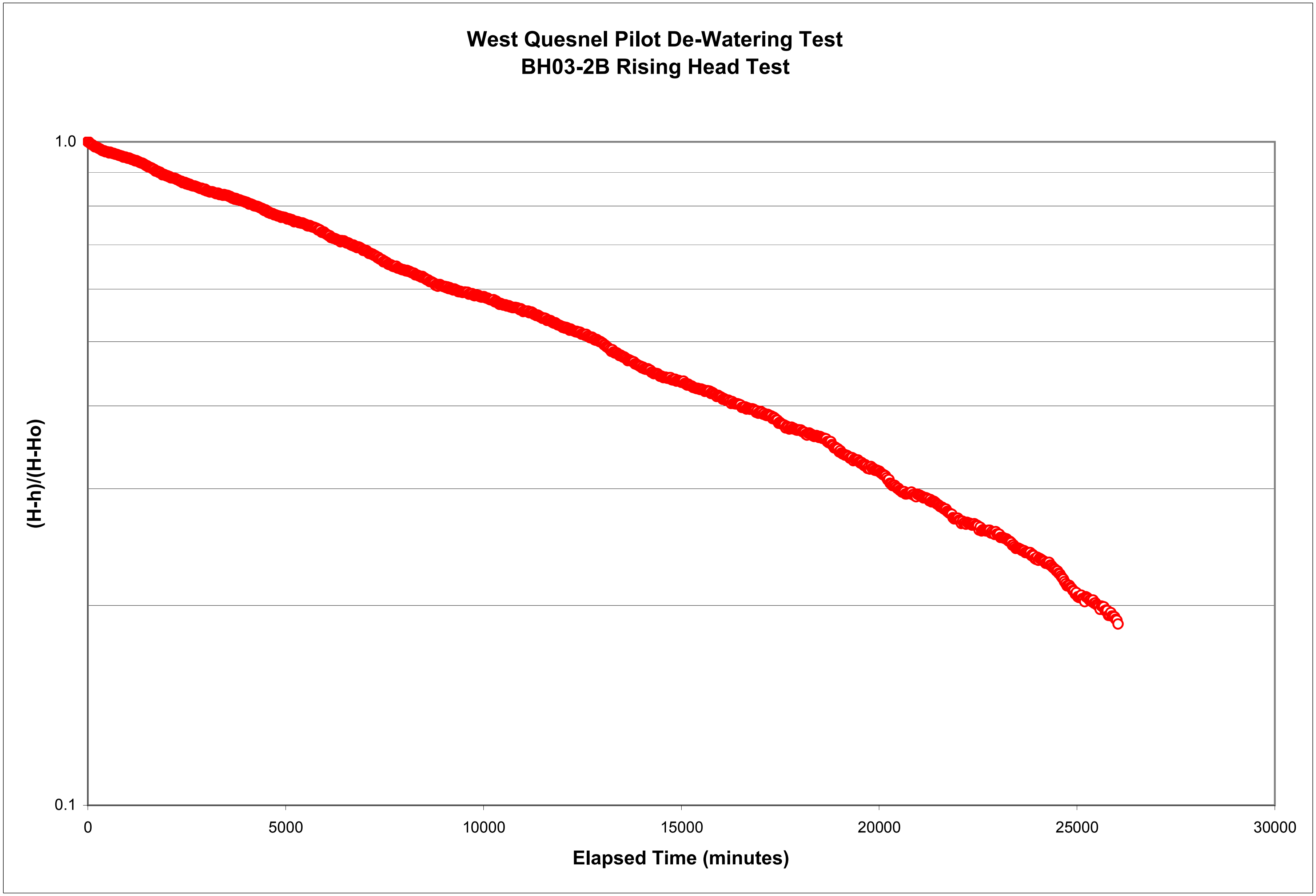
| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading ($m^3$) | Cumulative Discharge ($m^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| January 2, 2004 | 12:40 | 25703 | 428.38 | 7001.67 | 2.126 | 2126 | 467.890 | 0.018 | 0.083 |
| | 12:41 | 25704 | 428.40 | 7001.698 | 2.154 | 2154 | 474.052 | 0.018 | 0.084 |
| | 12:42 | 25705 | 428.42 | 7001.728 | 2.184 | 2184 | 480.655 | 0.019 | 0.085 |
| | 12:43 | 25706 | 428.43 | 7001.758 | 2.214 | 2214 | 487.257 | 0.019 | 0.086 |
| | 12:44 | 25707 | 428.45 | 7001.786 | 2.242 | 2242 | 493.419 | 0.019 | 0.087 |
| | 12:45 | 25708 | 428.47 | 7001.814 | 2.270 | 2270 | 499.582 | 0.019 | 0.088 |
| | 12:46 | 25709 | 428.48 | 7001.842 | 2.298 | 2298 | 505.744 | 0.020 | 0.089 |
| | 12:47 | 25710 | 428.50 | 7001.868 | 2.324 | 2324 | 511.466 | 0.020 | 0.090 |
| | 12:48 | 25711 | 428.52 | 7001.892 | 2.348 | 2348 | 516.748 | 0.020 | 0.091 |
| | 12:49 | 25712 | 428.53 | 7001.916 | 2.372 | 2372 | 522.030 | 0.020 | 0.092 |
| | 12:50 | 25713 | 428.55 | 7001.940 | 2.396 | 2396 | 527.312 | 0.021 | 0.093 |
| | 12:51 | 25714 | 428.57 | 7001.964 | 2.420 | 2420 | 532.594 | 0.021 | 0.094 |
| | 12:52 | 25715 | 428.58 | 7001.976 | 2.432 | 2432 | 535.235 | 0.021 | 0.095 |
| January 5, 2004 | 12:54 | 30037 | 500.62 | 7001.976 | 2.432 | 2432 | 535.235 | 0.018 | 0.081 |
| | 12:55 | 30038 | 500.63 | 7002.004 | 2.460 | 2460 | 541.397 | 0.018 | 0.082 |
| | 12:56 | 30039 | 500.65 | 7002.036 | 2.492 | 2492 | 548.439 | 0.018 | 0.083 |
| | 12:57 | 30040 | 500.67 | 7002.064 | 2.520 | 2520 | 554.602 | 0.018 | 0.084 |
| | 12:58 | 30041 | 500.68 | 7002.094 | 2.550 | 2550 | 561.204 | 0.019 | 0.085 |
| | 12:59 | 30042 | 500.70 | 7002.120 | 2.576 | 2576 | 566.926 | 0.019 | 0.086 |
| | 13:00 | 30043 | 500.72 | 7002.148 | 2.604 | 2604 | 573.088 | 0.019 | 0.087 |
| | 13:01 | 30044 | 500.73 | 7002.174 | 2.630 | 2630 | 578.810 | 0.019 | 0.088 |
| | 13:02 | 30045 | 500.75 | 7002.198 | 2.654 | 2654 | 584.092 | 0.019 | 0.088 |
| | 13:03 | 30046 | 500.77 | 7002.224 | 2.680 | 2680 | 589.814 | 0.020 | 0.089 |
| | 13:04 | 30047 | 500.78 | 7002.248 | 2.704 | 2704 | 595.096 | 0.020 | 0.090 |
| | 13:05 | 30048 | 500.80 | 7002.270 | 2.726 | 2726 | 599.938 | 0.020 | 0.091 |
| | 13:06 | 30049 | 500.82 | 7002.280 | 2.736 | 2736 | 602.139 | 0.020 | 0.091 |
| January 8, 2004 | 8:41 | 34104 | 568.40 | 7002.28 | 2.736 | 2736 | 602.139 | 0.018 | 0.080 |
| | 8:42 | 34105 | 568.42 | 7002.306 | 2.762 | 2762 | 607.861 | 0.018 | 0.081 |
| | 8:43 | 34106 | 568.43 | 7002.334 | 2.790 | 2790 | 614.023 | 0.018 | 0.082 |
| | 8:44 | 34107 | 568.45 | 7002.362 | 2.818 | 2818 | 620.185 | 0.018 | 0.083 |
| | 8:45 | 34108 | 568.47 | 7002.388 | 2.844 | 2844 | 625.908 | 0.018 | 0.083 |
| | 8:46 | 34109 | 568.48 | 7002.412 | 2.868 | 2868 | 631.189 | 0.019 | 0.084 |
| | 8:47 | 34110 | 568.50 | 7002.438 | 2.894 | 2894 | 636.912 | 0.019 | 0.085 |
| | 8:48 | 34111 | 568.52 | 7002.464 | 2.920 | 2920 | 642.634 | 0.019 | 0.086 |
| | 8:49 | 34112 | 568.53 | 7002.486 | 2.942 | 2942 | 647.475 | 0.019 | 0.086 |
| | 8:50 | 34113 | 568.55 | 7002.510 | 2.966 | 2966 | 652.757 | 0.019 | 0.087 |
| | 8:51 | 34114 | 568.57 | 7002.532 | 2.988 | 2988 | 657.599 | 0.019 | 0.088 |
| | 8:52 | 34115 | 568.58 | 7002.554 | 3.010 | 3010 | 662.441 | 0.019 | 0.088 |
| | 8:53 | 34116 | 568.60 | 7002.576 | 3.032 | 3032 | 667.283 | 0.020 | 0.089 |
| January 11, 2004 | 8:36 | 38419 | 640.32 | 7002.576 | 3.032 | 3032 | 667.283 | 0.017 | 0.079 |
| | 8:37 | 38420 | 640.33 | 7002.605 | 3.061 | 3061 | 673.665 | 0.018 | 0.080 |
| | 8:38 | 38421 | 640.35 | 7002.634 | 3.090 | 3090 | 680.047 | 0.018 | 0.080 |
| | 8:40 | 38423 | 640.38 | 7002.690 | 3.146 | 3146 | 692.372 | 0.018 | 0.082 |
| | 8:41 | 38424 | 640.40 | 7002.719 | 3.175 | 3175 | 698.754 | 0.018 | 0.083 |
| | 8:42 | 38425 | 640.42 | 7002.744 | 3.200 | 3200 | 704.256 | 0.018 | 0.083 |
| | 8:43 | 38426 | 640.43 | 7002.770 | 3.226 | 3226 | 709.978 | 0.018 | 0.084 |
| | 8:44 | 38427 | 640.45 | 7002.793 | 3.249 | 3249 | 715.040 | 0.019 | 0.085 |
| | 8:45 | 38428 | 640.47 | 7002.817 | 3.273 | 3273 | 720.322 | 0.019 | 0.085 |
| | 8:46 | 38429 | 640.48 | 7002.846 | 3.302 | 3302 | 726.704 | 0.019 | 0.086 |
| | 8:47 | 38430 | 640.50 | 7002.864 | 3.320 | 3320 | 730.666 | 0.019 | 0.086 |
| | 8:48 | 38431 | 640.52 | 7002.880 | 3.336 | 3336 | 734.187 | 0.019 | 0.087 |

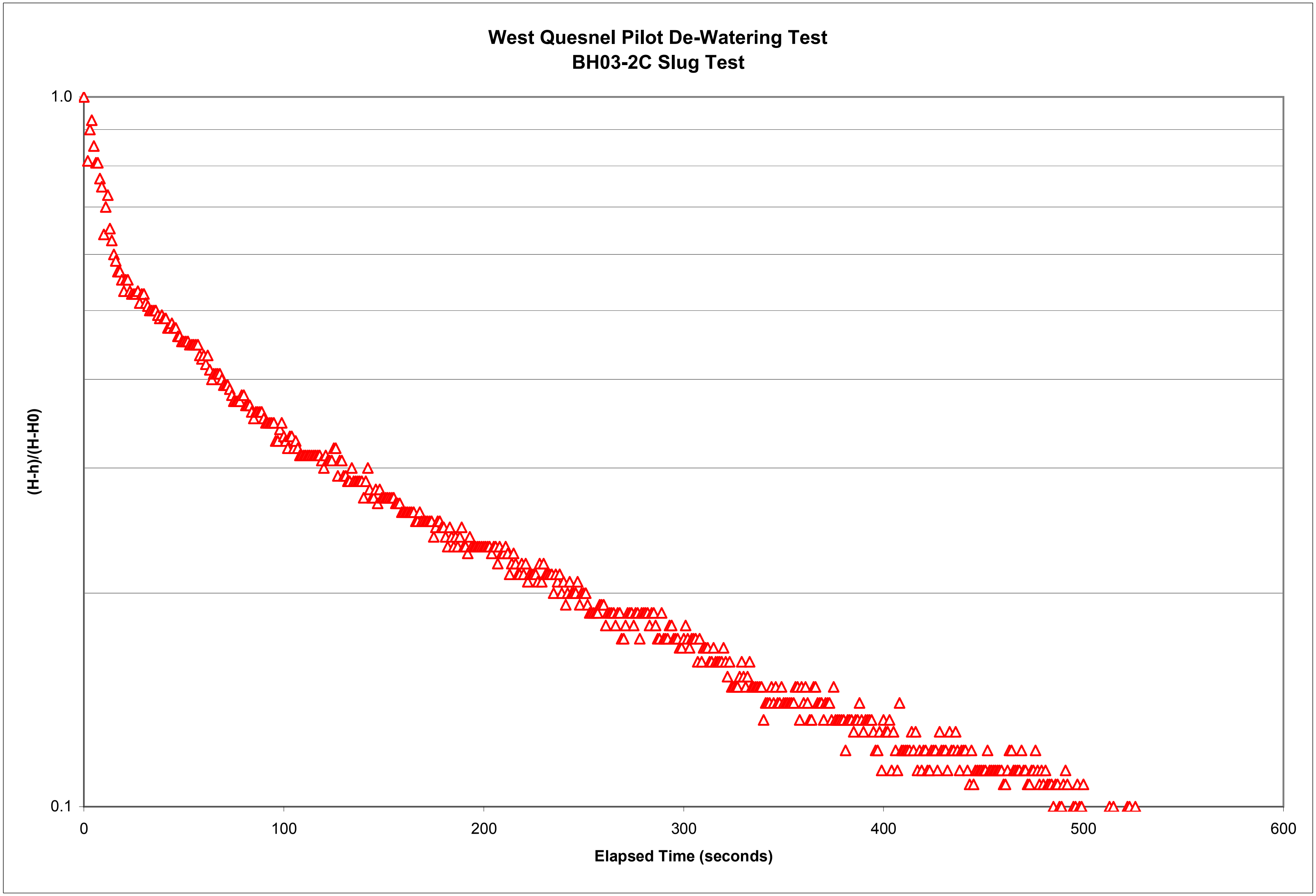
| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading ($m^3$) | Cumulative Discharge ($m^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| January 14, 2004 | 9:01 | 42764 | 712.73 | 7002.88 | 3.336 | 3336 | 734.187 | 0.017 | 0.078 |
| | 9:02 | 42765 | 712.75 | 7002.905 | 3.361 | 3361 | 739.689 | 0.017 | 0.079 |
| | 9:03 | 42766 | 712.77 | 7002.936 | 3.392 | 3392 | 746.511 | 0.017 | 0.079 |
| | 9:04 | 42767 | 712.78 | 7002.963 | 3.419 | 3419 | 752.454 | 0.018 | 0.080 |
| | 9:05 | 42768 | 712.80 | 7002.991 | 3.447 | 3447 | 758.616 | 0.018 | 0.081 |
| | 9:06 | 42769 | 712.82 | 7003.018 | 3.474 | 3474 | 764.558 | 0.018 | 0.081 |
| | 9:07 | 42770 | 712.83 | 7003.043 | 3.499 | 3499 | 770.060 | 0.018 | 0.082 |
| | 9:08 | 42771 | 712.85 | 7003.069 | 3.525 | 3525 | 775.782 | 0.018 | 0.082 |
| | 9:09 | 42772 | 712.87 | 7003.093 | 3.549 | 3549 | 781.064 | 0.018 | 0.083 |
| | 9:10 | 42773 | 712.88 | 7003.118 | 3.574 | 3574 | 786.566 | 0.018 | 0.084 |
| | 9:11 | 42774 | 712.90 | 7003.140 | 3.596 | 3596 | 791.408 | 0.019 | 0.084 |
| | 9:12 | 42775 | 712.92 | 7003.158 | 3.614 | 3614 | 795.369 | 0.019 | 0.084 |
| January 17, 2004 | 14:46 | 47429 | 790.48 | 7003.158 | 3.614 | 3614 | 795.369 | 0.017 | 0.076 |
| | 14:47 | 47430 | 790.50 | 7003.186 | 3.642 | 3642 | 801.531 | 0.017 | 0.077 |
| | 14:48 | 47431 | 790.52 | 7003.214 | 3.670 | 3670 | 807.694 | 0.017 | 0.077 |
| | 14:49 | 47432 | 790.53 | 7003.244 | 3.700 | 3700 | 814.296 | 0.017 | 0.078 |
| | 14:50 | 47433 | 790.55 | 7003.272 | 3.728 | 3728 | 820.458 | 0.017 | 0.079 |
| | 14:51 | 47434 | 790.57 | 7003.300 | 3.756 | 3756 | 826.620 | 0.017 | 0.079 |
| | 14:52 | 47435 | 790.58 | 7003.324 | 3.780 | 3780 | 831.902 | 0.018 | 0.080 |
| | 14:53 | 47436 | 790.60 | 7003.352 | 3.808 | 3808 | 838.065 | 0.018 | 0.080 |
| | 14:54 | 47437 | 790.62 | 7003.376 | 3.832 | 3832 | 843.347 | 0.018 | 0.081 |
| | 14:55 | 47438 | 790.63 | 7003.400 | 3.856 | 3856 | 848.628 | 0.018 | 0.081 |
| | 14:56 | 47439 | 790.65 | 7003.422 | 3.878 | 3878 | 853.470 | 0.018 | 0.082 |
| | 14:57 | 47440 | 790.67 | 7003.446 | 3.902 | 3902 | 858.752 | 0.018 | 0.082 |
| | 14:58 | 47441 | 790.68 | 7003.464 | 3.920 | 3920 | 862.714 | 0.018 | 0.083 |
| January 20, 2004 | 15:41 | 51804 | 863.40 | 7003.464 | 3.920 | 3920 | 862.714 | 0.017 | 0.076 |
| | 15:42 | 51805 | 863.42 | 7003.492 | 3.948 | 3948 | 868.876 | 0.017 | 0.076 |
| | 15:43 | 51806 | 863.43 | 7003.520 | 3.976 | 3976 | 875.038 | 0.017 | 0.077 |
| | 15:44 | 51807 | 863.45 | 7003.55 | 4.006 | 4006 | 881.640 | 0.017 | 0.077 |
| | 15:45 | 51808 | 863.47 | 7003.576 | 4.032 | 4032 | 887.363 | 0.017 | 0.078 |
| | 15:46 | 51809 | 863.48 | 7003.602 | 4.058 | 4058 | 893.085 | 0.017 | 0.078 |
| | 15:47 | 51810 | 863.50 | 7003.630 | 4.086 | 4086 | 899.247 | 0.017 | 0.079 |
| | 15:48 | 51811 | 863.52 | 7003.654 | 4.110 | 4110 | 904.529 | 0.017 | 0.079 |
| | 15:49 | 51812 | 863.53 | 7003.680 | 4.136 | 4136 | 910.251 | 0.018 | 0.080 |
| | 15:50 | 51813 | 863.55 | 7003.702 | 4.158 | 4158 | 915.093 | 0.018 | 0.080 |
| | 15:51 | 51814 | 863.57 | 7003.726 | 4.182 | 4182 | 920.375 | 0.018 | 0.081 |
| | 15:52 | 51815 | 863.58 | 7003.748 | 4.204 | 4204 | 925.216 | 0.018 | 0.081 |
| | 15:53 | 51816 | 863.60 | 7003.763 | 4.219 | 4219 | 928.518 | 0.018 | 0.081 |
| January 23, 2004 | 14:50 | 56073 | 934.55 | 7003.763 | 4.219 | 4219 | 928.518 | 0.017 | 0.075 |
| | 14:51 | 56074 | 934.57 | 7003.790 | 4.246 | 4246 | 934.460 | 0.017 | 0.076 |
| | 14:52 | 56075 | 934.58 | 7003.820 | 4.276 | 4276 | 941.062 | 0.017 | 0.076 |
| | 14:53 | 56076 | 934.60 | 7003.852 | 4.308 | 4308 | 948.105 | 0.017 | 0.077 |
| | 14:54 | 56077 | 934.62 | 7003.878 | 4.334 | 4334 | 953.827 | 0.017 | 0.077 |
| | 14:55 | 56078 | 934.63 | 7003.904 | 4.360 | 4360 | 959.549 | 0.017 | 0.078 |
| | 14:56 | 56079 | 934.65 | 7003.930 | 4.386 | 4386 | 965.271 | 0.017 | 0.078 |
| | 14:57 | 56080 | 934.67 | 7003.956 | 4.412 | 4412 | 970.993 | 0.017 | 0.079 |
| | 14:58 | 56081 | 934.68 | 7003.980 | 4.436 | 4436 | 976.275 | 0.017 | 0.079 |
| | 14:59 | 56082 | 934.70 | 7003.004 | 3.460 | 3460 | 761.477 | 0.014 | 0.062 |
| | 15:00 | 56083 | 934.72 | 7003.028 | 3.484 | 3484 | 766.759 | 0.014 | 0.062 |
| | 15:01 | 56084 | 934.73 | 7003.050 | 3.506 | 3506 | 771.600 | 0.014 | 0.063 |
| | 15:02 | 56085 | 934.75 | 7003.060 | 3.516 | 3516 | 773.801 | 0.014 | 0.063 |

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading (m$^3$) | Cumulative Discharge (m$^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| January 27, 2004 | 15:19 | 61862 | 1031.03 | 7004.060 | 4.516 | 4516 | 993.881 | 0.016 | 0.073 |
| | 15:20 | 61863 | 1031.05 | 7004.088 | 4.544 | 4544 | 1000.044 | 0.016 | 0.073 |
| | 15:21 | 61864 | 1031.07 | 7004.118 | 4.574 | 4574 | 1006.646 | 0.016 | 0.074 |
| | 15:22 | 61865 | 1031.08 | 7004.146 | 4.602 | 4602 | 1012.808 | 0.016 | 0.074 |
| | 15:23 | 61866 | 1031.10 | 7004.174 | 4.630 | 4630 | 1018.970 | 0.016 | 0.075 |
| | 15:24 | 61867 | 1031.12 | 7004.202 | 4.658 | 4658 | 1025.133 | 0.017 | 0.075 |
| | 15:25 | 61868 | 1031.13 | 7004.228 | 4.684 | 4684 | 1030.855 | 0.017 | 0.076 |
| | 15:26 | 61869 | 1031.15 | 7004.254 | 4.710 | 4710 | 1036.577 | 0.017 | 0.076 |
| | 15:27 | 61870 | 1031.17 | 7004.278 | 4.734 | 4734 | 1041.859 | 0.017 | 0.077 |
| | 15:28 | 61871 | 1031.18 | 7004.300 | 4.756 | 4756 | 1046.700 | 0.017 | 0.077 |
| | 15:29 | 61872 | 1031.20 | 7004.326 | 4.782 | 4782 | 1052.423 | 0.017 | 0.077 |
| | 15:30 | 61873 | 1031.22 | 7004.350 | 4.806 | 4806 | 1057.704 | 0.017 | 0.078 |
| | 15:31 | 61874 | 1031.23 | 7004.370 | 4.826 | 4826 | 1062.106 | 0.017 | 0.078 |
| January 31, 2004 | 12:23 | 67446 | 1124.10 | 7004.370 | 4.826 | 4826 | 1062.106 | 0.016 | 0.072 |
| | 12:24 | 67447 | 1124.12 | 7004.398 | 4.854 | 4854 | 1068.268 | 0.016 | 0.072 |
| | 12:25 | 67448 | 1124.13 | 7004.428 | 4.884 | 4884 | 1074.871 | 0.016 | 0.072 |
| | 12:26 | 67449 | 1124.15 | 7004.458 | 4.914 | 4914 | 1081.473 | 0.016 | 0.073 |
| | 12:27 | 67450 | 1124.17 | 7004.486 | 4.942 | 4942 | 1087.635 | 0.016 | 0.073 |
| | 12:28 | 67451 | 1124.18 | 7004.514 | 4.970 | 4970 | 1093.798 | 0.016 | 0.074 |
| | 12:29 | 67452 | 1124.20 | 7004.540 | 4.996 | 4996 | 1099.520 | 0.016 | 0.074 |
| | 12:30 | 67453 | 1124.22 | 7004.566 | 5.022 | 5022 | 1105.242 | 0.016 | 0.074 |
| | 12:31 | 67454 | 1124.23 | 7004.590 | 5.046 | 5046 | 1110.524 | 0.016 | 0.075 |
| | 12:32 | 67455 | 1124.25 | 7004.614 | 5.070 | 5070 | 1115.806 | 0.017 | 0.075 |
| | 12:33 | 67456 | 1124.27 | 7004.638 | 5.094 | 5094 | 1121.088 | 0.017 | 0.076 |
| | 12:34 | 67457 | 1124.28 | 7004.662 | 5.118 | 5118 | 1126.369 | 0.017 | 0.076 |
| | 12:35 | 67458 | 1124.30 | 7004.681 | 5.137 | 5137 | 1130.551 | 0.017 | 0.076 |
| February 3, 2004 | 14:59 | 71922 | 1198.70 | 7004.681 | 5.137 | 5137 | 1130.551 | 0.016 | 0.071 |
| | 15:00 | 71923 | 1198.72 | 7004.710 | 5.166 | 5166 | 1136.933 | 0.016 | 0.072 |
| | 15:01 | 71924 | 1198.73 | 7004.740 | 5.196 | 5196 | 1143.536 | 0.016 | 0.072 |
| | 15:02 | 71925 | 1198.75 | 7004.766 | 5.222 | 5222 | 1149.258 | 0.016 | 0.073 |
| | 15:03 | 71926 | 1198.77 | 7004.796 | 5.252 | 5252 | 1155.860 | 0.016 | 0.073 |
| | 15:04 | 71927 | 1198.78 | 7004.822 | 5.278 | 5278 | 1161.582 | 0.016 | 0.073 |
| | 15:05 | 71928 | 1198.80 | 7004.850 | 5.306 | 5306 | 1167.744 | 0.016 | 0.074 |
| | 15:06 | 71929 | 1198.82 | 7004.876 | 5.332 | 5332 | 1173.467 | 0.016 | 0.074 |
| | 15:07 | 71930 | 1198.83 | 7004.900 | 5.356 | 5356 | 1178.748 | 0.016 | 0.074 |
| | 15:08 | 71931 | 1198.85 | 7004.924 | 5.380 | 5380 | 1184.030 | 0.016 | 0.075 |
| | 15:09 | 71932 | 1198.87 | 7004.948 | 5.404 | 5404 | 1189.312 | 0.017 | 0.075 |
| | 15:10 | 71933 | 1198.88 | 7004.970 | 5.426 | 5426 | 1194.154 | 0.017 | 0.075 |
| | 15:11 | 71934 | 1198.90 | 7004.982 | 5.438 | 5438 | 1196.795 | 0.017 | 0.076 |
| February 6, 2004 | 15:01 | 76244 | 1270.73 | 7004.982 | 5.438 | 5438 | 1196.795 | 0.016 | 0.071 |
| | 15:02 | 76245 | 1270.75 | 7005.010 | 5.466 | 5466 | 1202.957 | 0.016 | 0.072 |
| | 15:03 | 76246 | 1270.77 | 7005.040 | 5.496 | 5496 | 1209.560 | 0.016 | 0.072 |
| | 15:04 | 76247 | 1270.78 | 7005.068 | 5.524 | 5524 | 1215.722 | 0.016 | 0.072 |
| | 15:05 | 76248 | 1270.80 | 7005.096 | 5.552 | 5552 | 1221.884 | 0.016 | 0.073 |
| | 15:06 | 76249 | 1270.82 | 7005.122 | 5.578 | 5578 | 1227.606 | 0.016 | 0.073 |
| | 15:07 | 76250 | 1270.83 | 7005.148 | 5.604 | 5604 | 1233.328 | 0.016 | 0.073 |
| | 15:08 | 76251 | 1270.85 | 7005.174 | 5.630 | 5630 | 1239.050 | 0.016 | 0.074 |
| | 15:09 | 76252 | 1270.87 | 7005.200 | 5.656 | 5656 | 1244.772 | 0.016 | 0.074 |
| | 15:10 | 76253 | 1270.88 | 7005.224 | 5.680 | 5680 | 1250.054 | 0.016 | 0.074 |
| | 15:11 | 76254 | 1270.90 | 7005.246 | 5.702 | 5702 | 1254.896 | 0.016 | 0.075 |
| | 15:12 | 76255 | 1270.92 | 7005.270 | 5.726 | 5726 | 1260.178 | 0.017 | 0.075 |
| | 15:13 | 76256 | 1270.93 | 7005.276 | 5.732 | 5732 | 1261.499 | 0.017 | 0.075 |

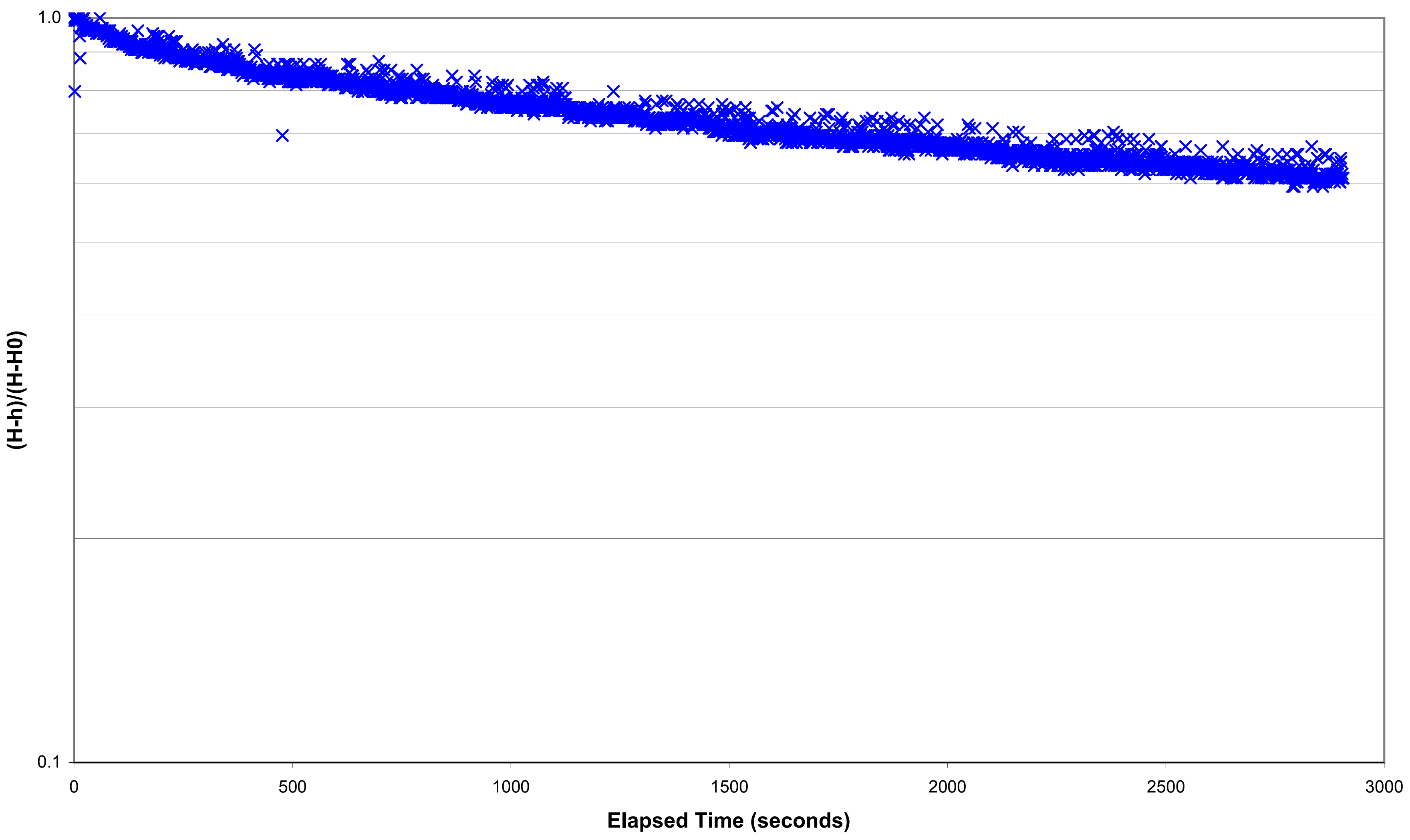
| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading ($m^3$) | Cumulative Discharge ($m^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| February 9, 2004 | 14:54 | 80557 | 1342.62 | 7005.276 | 5.732 | 5732 | 1261.499 | 0.016 | 0.071 |
| | 14:56 | 80559 | 1342.65 | 7005.336 | 5.792 | 5792 | 1274.703 | 0.016 | 0.072 |
| | 14:57 | 80560 | 1342.67 | 7005.363 | 5.819 | 5819 | 1280.646 | 0.016 | 0.072 |
| | 14:58 | 80561 | 1342.68 | 7005.394 | 5.850 | 5850 | 1287.468 | 0.016 | 0.073 |
| | 14:59 | 80562 | 1342.70 | 7005.423 | 5.879 | 5879 | 1293.850 | 0.016 | 0.073 |
| | 15:00 | 80563 | 1342.72 | 7005.445 | 5.901 | 5901 | 1298.692 | 0.016 | 0.073 |
| | 15:01 | 80564 | 1342.73 | 7005.469 | 5.925 | 5925 | 1303.974 | 0.016 | 0.074 |
| | 15:02 | 80565 | 1342.75 | 7005.493 | 5.949 | 5949 | 1309.256 | 0.016 | 0.074 |
| | 15:03 | 80566 | 1342.77 | 7005.518 | 5.974 | 5974 | 1314.758 | 0.016 | 0.074 |
| | 15:04 | 80567 | 1342.78 | 7005.542 | 5.998 | 5998 | 1320.040 | 0.016 | 0.074 |
| | 15:05 | 80568 | 1342.80 | 7005.561 | 6.017 | 6017 | 1324.221 | 0.016 | 0.075 |
| | 15:06 | 80569 | 1342.82 | 7005.567 | 6.023 | 6023 | 1325.542 | 0.016 | 0.075 |
| February 12, 2004 | 13:20 | 84783 | 1413.05 | 7005.567 | 6.023 | 6023 | 1325.542 | 0.016 | 0.071 |
| | 13:21 | 84784 | 1413.07 | 7005.594 | 6.050 | 6050 | 1331.484 | 0.016 | 0.071 |
| | 13:22 | 84785 | 1413.08 | 7005.624 | 6.080 | 6080 | 1338.086 | 0.016 | 0.072 |
| | 13:23 | 84786 | 1413.10 | 7005.653 | 6.109 | 6109 | 1344.469 | 0.016 | 0.072 |
| | 13:24 | 84787 | 1413.12 | 7005.680 | 6.136 | 6136 | 1350.411 | 0.016 | 0.072 |
| | 13:25 | 84788 | 1413.13 | 7005.707 | 6.163 | 6163 | 1356.353 | 0.016 | 0.073 |
| | 13:26 | 84789 | 1413.15 | 7005.734 | 6.190 | 6190 | 1362.295 | 0.016 | 0.073 |
| | 13:27 | 84790 | 1413.17 | 7005.759 | 6.215 | 6215 | 1367.797 | 0.016 | 0.073 |
| | 13:28 | 84791 | 1413.18 | 7005.782 | 6.238 | 6238 | 1372.859 | 0.016 | 0.074 |
| | 13:29 | 84792 | 1413.20 | 7005.807 | 6.263 | 6263 | 1378.361 | 0.016 | 0.074 |
| | 13:30 | 84793 | 1413.22 | 7005.830 | 6.286 | 6286 | 1383.423 | 0.016 | 0.074 |
| | 13:31 | 84794 | 1413.23 | 7005.854 | 6.310 | 6310 | 1388.705 | 0.016 | 0.074 |
| February 15, 2005 | 10:56 | 93279 | 1554.65 | 7005.854 | 6.310 | 6310 | 1388.705 | 0.015 | 0.068 |
| | 10:57 | 93280 | 1554.67 | 7005.882 | 6.338 | 6338 | 1394.867 | 0.015 | 0.068 |
| | 10:58 | 93281 | 1554.68 | 7005.912 | 6.368 | 6368 | 1401.469 | 0.015 | 0.068 |
| | 10:59 | 93282 | 1554.70 | 7005.940 | 6.396 | 6396 | 1407.632 | 0.015 | 0.069 |
| | 11:00 | 93283 | 1554.72 | 7005.968 | 6.424 | 6424 | 1413.794 | 0.015 | 0.069 |
| | 11:01 | 93284 | 1554.73 | 7005.993 | 6.449 | 6449 | 1419.296 | 0.015 | 0.069 |
| | 11:02 | 93285 | 1554.75 | 7006.020 | 6.476 | 6476 | 1425.238 | 0.015 | 0.069 |
| | 11:03 | 93286 | 1554.77 | 7006.046 | 6.502 | 6502 | 1430.960 | 0.015 | 0.070 |
| | 11:04 | 93287 | 1554.78 | 7006.069 | 6.525 | 6525 | 1436.022 | 0.015 | 0.070 |
| | 11:05 | 93288 | 1554.80 | 7006.092 | 6.548 | 6548 | 1441.084 | 0.015 | 0.070 |
| | 11:06 | 93289 | 1554.82 | 7006.115 | 6.571 | 6571 | 1446.146 | 0.016 | 0.070 |
| | 11:07 | 93290 | 1554.83 | 7006.132 | 6.588 | 6588 | 1449.887 | 0.016 | 0.071 |
| February 19, 2004 | 14:04 | 97787 | 1629.78 | 7006.132 | 6.588 | 6588 | 1449.887 | 0.015 | 0.067 |
| | 14:05 | 97788 | 1629.80 | 7006.161 | 6.617 | 6617 | 1456.269 | 0.015 | 0.068 |
| | 14:06 | 97789 | 1629.82 | 7006.190 | 6.646 | 6646 | 1462.652 | 0.015 | 0.068 |
| | 14:07 | 97790 | 1629.83 | 7006.220 | 6.676 | 6676 | 1469.254 | 0.015 | 0.068 |
| | 14:08 | 97791 | 1629.85 | 7006.249 | 6.705 | 6705 | 1475.636 | 0.015 | 0.069 |
| | 14:09 | 97792 | 1629.87 | 7006.274 | 6.730 | 6730 | 1481.138 | 0.015 | 0.069 |
| | 14:10 | 97793 | 1629.88 | 7006.300 | 6.756 | 6756 | 1486.860 | 0.015 | 0.069 |
| | 14:11 | 97794 | 1629.90 | 7006.328 | 6.784 | 6784 | 1493.023 | 0.015 | 0.069 |
| | 14:12 | 97795 | 1629.92 | 7006.353 | 6.809 | 6809 | 1498.525 | 0.015 | 0.070 |
| | 14:13 | 97796 | 1629.93 | 7006.374 | 6.830 | 6830 | 1503.146 | 0.015 | 0.070 |
| | 14:14 | 97797 | 1629.95 | 7006.399 | 6.855 | 6855 | 1508.648 | 0.015 | 0.070 |
| | 14:15 | 97798 | 1629.97 | 7006.422 | 6.878 | 6878 | 1513.710 | 0.015 | 0.070 |
| | 14:16 | 97799 | 1629.98 | 7006.434 | 6.890 | 6890 | 1516.351 | 0.016 | 0.070 |

| Date | Time | Elapsed Time (minutes) | Elapsed Time (hours) | Meter Reading (m$^3$) | Cumulative Discharge (m$^3$) | Cumulative Discharge (Litres) | Cumulative Discharge (Igal.) | Flow Rate (Igpm) | Flow Rate (L/min) |
|---|---|---|---|---|---|---|---|---|---|
| February 22, 2004 | 16:28 | 102251 | 1704.18 | 7006.434 | 6.890 | 6890 | 1516.351 | 0.015 | 0.067 |
| | 16:29 | 102252 | 1704.20 | 7006.465 | 6.921 | 6921 | 1523.174 | 0.015 | 0.068 |
| | 16:30 | 102253 | 1704.22 | 7006.493 | 6.949 | 6949 | 1529.336 | 0.015 | 0.068 |
| | 16:31 | 102254 | 1704.23 | 7006.522 | 6.978 | 6978 | 1535.718 | 0.015 | 0.068 |
| | 16:32 | 102255 | 1704.25 | 7006.549 | 7.005 | 7005 | 1541.660 | 0.015 | 0.069 |
| | 16:33 | 102256 | 1704.27 | 7006.576 | 7.032 | 7032 | 1547.603 | 0.015 | 0.069 |
| | 16:34 | 102257 | 1704.28 | 7006.603 | 7.059 | 7059 | 1553.545 | 0.015 | 0.069 |
| | 16:35 | 102258 | 1704.30 | 7006.629 | 7.085 | 7085 | 1559.267 | 0.015 | 0.069 |
| | 16:36 | 102259 | 1704.32 | 7006.653 | 7.109 | 7109 | 1564.549 | 0.015 | 0.070 |
| | 16:37 | 102260 | 1704.33 | 7006.670 | 7.126 | 7126 | 1568.290 | 0.015 | 0.070 |
| | 16:38 | 102261 | 1704.35 | 7006.692 | 7.148 | 7148 | 1573.132 | 0.015 | 0.070 |
| | 16:39 | 102262 | 1704.37 | 7006.718 | 7.174 | 7174 | 1578.854 | 0.015 | 0.070 |
| | 16:40 | 102263 | 1704.38 | 7006.724 | 7.180 | 7180 | 1580.174 | 0.015 | 0.070 |
| February 25, 2004 | 12:29 | 106332 | 1772.20 | 7006.724 | 7.180 | 7180 | 1580.174 | 0.015 | 0.068 |
| | 12:30 | 106333 | 1772.22 | 7006.754 | 7.210 | 7210 | 1586.777 | 0.015 | 0.068 |
| | 12:31 | 106334 | 1772.23 | 7006.782 | 7.238 | 7238 | 1592.939 | 0.015 | 0.068 |
| | 12:32 | 106335 | 1772.25 | 7006.810 | 7.266 | 7266 | 1599.101 | 0.015 | 0.068 |
| | 12:33 | 106336 | 1772.27 | 7006.839 | 7.295 | 7295 | 1605.484 | 0.015 | 0.069 |
| | 12:34 | 106337 | 1772.28 | 7006.865 | 7.321 | 7321 | 1611.206 | 0.015 | 0.069 |
| | 12:35 | 106338 | 1772.30 | 7006.890 | 7.346 | 7346 | 1616.708 | 0.015 | 0.069 |
| | 12:36 | 106339 | 1772.32 | 7006.916 | 7.372 | 7372 | 1622.430 | 0.015 | 0.069 |
| | 12:37 | 106340 | 1772.33 | 7006.941 | 7.397 | 7397 | 1627.932 | 0.015 | 0.070 |
| | 12:38 | 106341 | 1772.35 | 7006.964 | 7.420 | 7420 | 1632.994 | 0.015 | 0.070 |
| | 12:39 | 106342 | 1772.37 | 7006.987 | 7.443 | 7443 | 1638.055 | 0.015 | 0.070 |
| | 12:40 | 106343 | 1772.38 | 7007.008 | 7.464 | 7464 | 1642.677 | 0.015 | 0.070 |
| | 12:41 | 106344 | 1772.40 | 7007.012 | 7.468 | 7468 | 1643.557 | 0.015 | 0.070 |
| February 28, 2004 | 15:14 | 110817 | 1846.95 | 7007.012 | 7.468 | 7468 | 1643.557 | 0.015 | 0.067 |
| | 15:15 | 110818 | 1846.97 | 7007.040 | 7.496 | 7496 | 1649.720 | 0.015 | 0.068 |
| | 15:16 | 110819 | 1846.98 | 7007.068 | 7.524 | 7524 | 1655.882 | 0.015 | 0.068 |
| | 15:17 | 110820 | 1847.00 | 7007.096 | 7.552 | 7552 | 1662.044 | 0.015 | 0.068 |
| | 15:18 | 110821 | 1847.02 | 7007.124 | 7.580 | 7580 | 1668.206 | 0.015 | 0.068 |
| | 15:19 | 110822 | 1847.03 | 7007.153 | 7.609 | 7609 | 1674.589 | 0.015 | 0.069 |
| | 15:20 | 110823 | 1847.05 | 7007.176 | 7.632 | 7632 | 1679.651 | 0.015 | 0.069 |
| | 15:21 | 110824 | 1847.07 | 7007.204 | 7.660 | 7660 | 1685.813 | 0.015 | 0.069 |
| | 15:22 | 110825 | 1847.08 | 7007.227 | 7.683 | 7683 | 1690.875 | 0.015 | 0.069 |
| | 15:23 | 110826 | 1847.10 | 7007.252 | 7.708 | 7708 | 1696.377 | 0.015 | 0.070 |
| | 15:24 | 110827 | 1847.12 | 7007.275 | 7.731 | 7731 | 1701.438 | 0.015 | 0.070 |
| | 15:25 | 110828 | 1847.13 | 7007.296 | 7.752 | 7752 | 1706.060 | 0.015 | 0.070 |
| | 15:26 | 110829 | 1847.15 | 7007.302 | 7.758 | 7758 | 1707.381 | 0.015 | 0.070 |
| March 3, 2004 | 14:00 | 116503 | 1941.72 | 7007.302 | 7.758 | 7758 | 1707.381 | 0.015 | 0.067 |
| | 14:01 | 116504 | 1941.73 | 7007.331 | 7.787 | 7787 | 1713.763 | 0.015 | 0.067 |
| | 14:02 | 116505 | 1941.75 | 7007.360 | 7.816 | 7816 | 1720.145 | 0.015 | 0.067 |
| | 14:03 | 116506 | 1941.77 | 7007.388 | 7.844 | 7844 | 1726.308 | 0.015 | 0.067 |
| | 14:04 | 116507 | 1941.78 | 7007.416 | 7.872 | 7872 | 1732.470 | 0.015 | 0.068 |
| | 14:05 | 116508 | 1941.80 | 7007.444 | 7.900 | 7900 | 1738.632 | 0.015 | 0.068 |
| | 14:06 | 116509 | 1941.82 | 7007.469 | 7.925 | 7925 | 1744.134 | 0.015 | 0.068 |
| | 14:07 | 116510 | 1941.83 | 7007.494 | 7.950 | 7950 | 1749.636 | 0.015 | 0.068 |
| | 14:08 | 116511 | 1941.85 | 7007.520 | 7.976 | 7976 | 1755.358 | 0.015 | 0.068 |
| | 14:09 | 116512 | 1941.87 | 7007.544 | 8.000 | 8000 | 1760.640 | 0.015 | 0.069 |
| | 14:10 | 116513 | 1941.88 | 7007.568 | 8.024 | 8024 | 1765.922 | 0.015 | 0.069 |
| | 14:11 | 116514 | 1941.90 | 7007.588 | 8.044 | 8044 | 1770.324 | 0.015 | 0.069 |
| | 14:12 | 116515 | 1941.92 | 7007.599 | 8.055 | 8055 | 1772.744 | 0.015 | 0.069 |

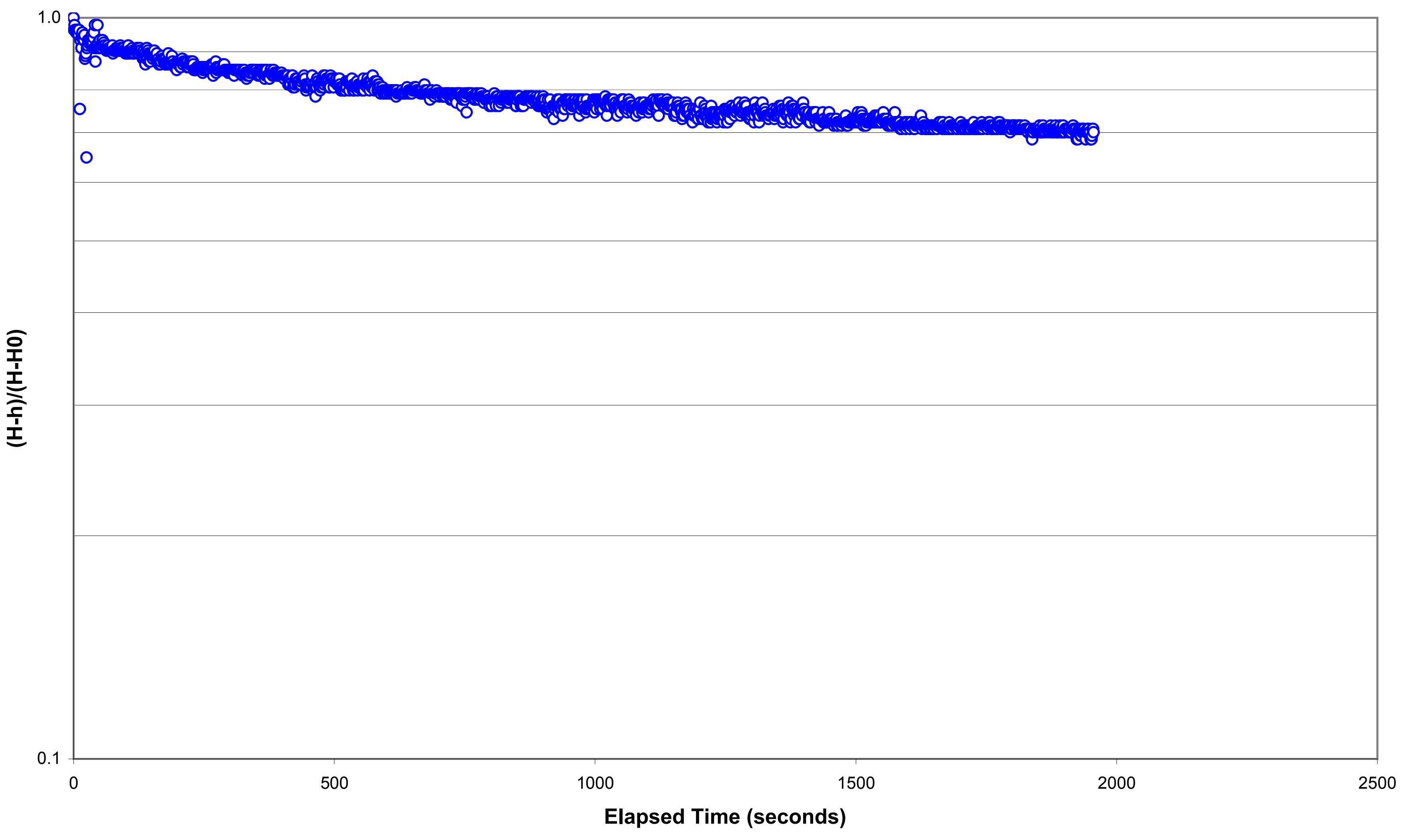

West Quesnel Pilot De-Watering Test
BH03-2B Rising Head Test
(H-h)/(H-Ho)
1.0
0.1
0
5000
10000
15000
20000
25000
30000
Elapsed Time (minutes)

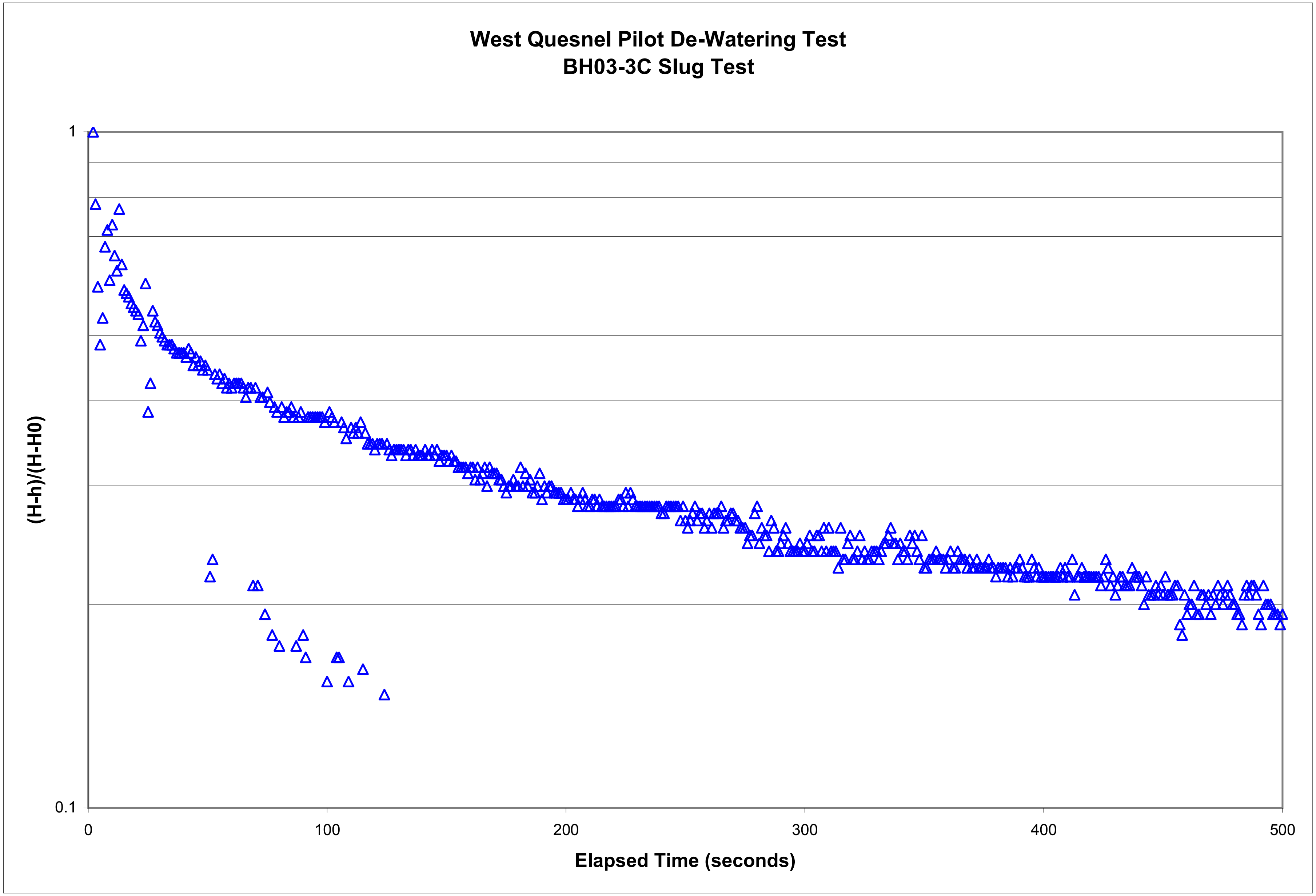

West Quesnel Pilot De-Watering Test
BH03-2C Slug Test
(H-h)/(H-H0)
1.0
0.1
0
100
200
300
400
500
600
Elapsed Time (seconds)

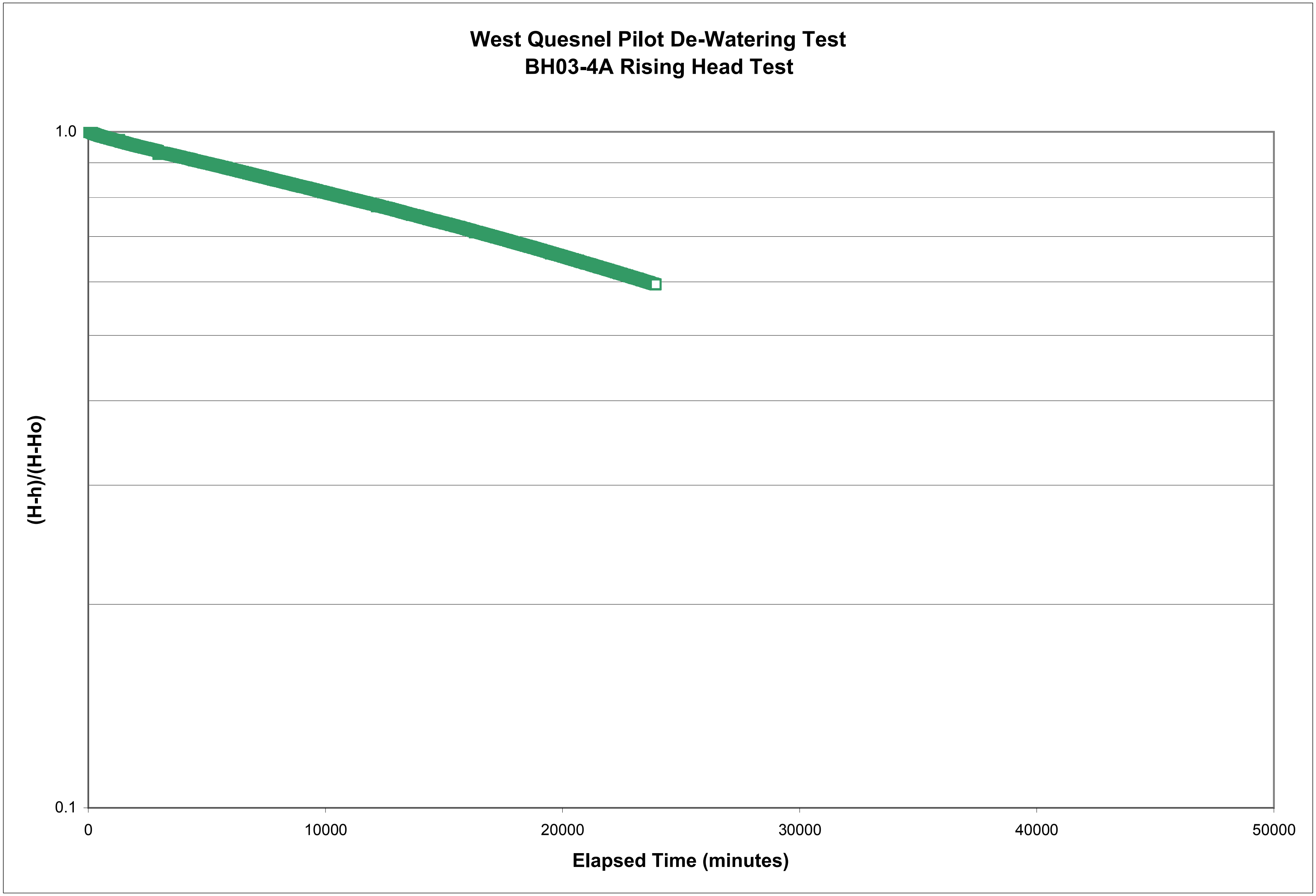
## West Quesnel Pilot De-Watering Test
## BH03-3A Slug Test



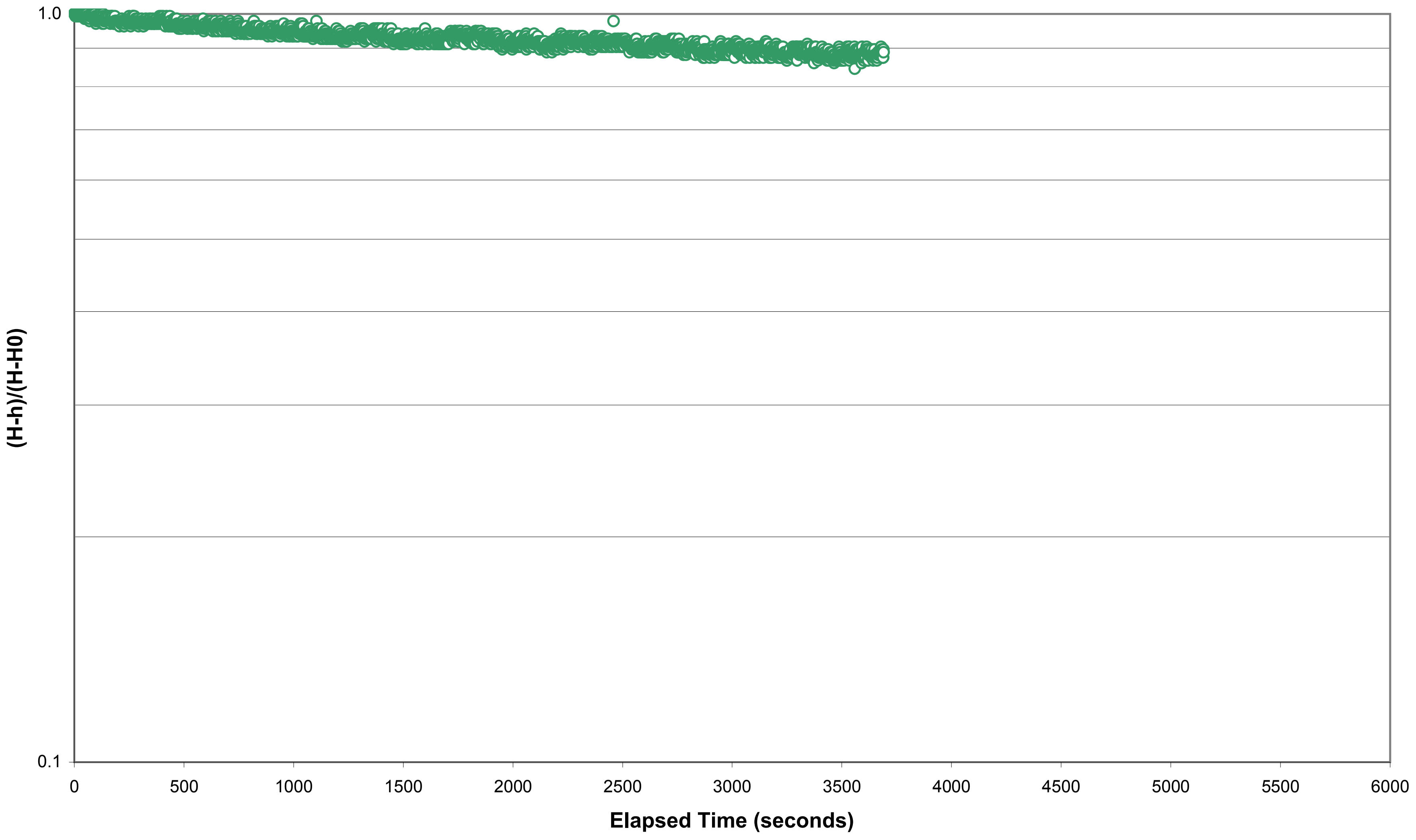
# West Quesnel Pilot De-Watering Test
## BH03-3B Slug Test

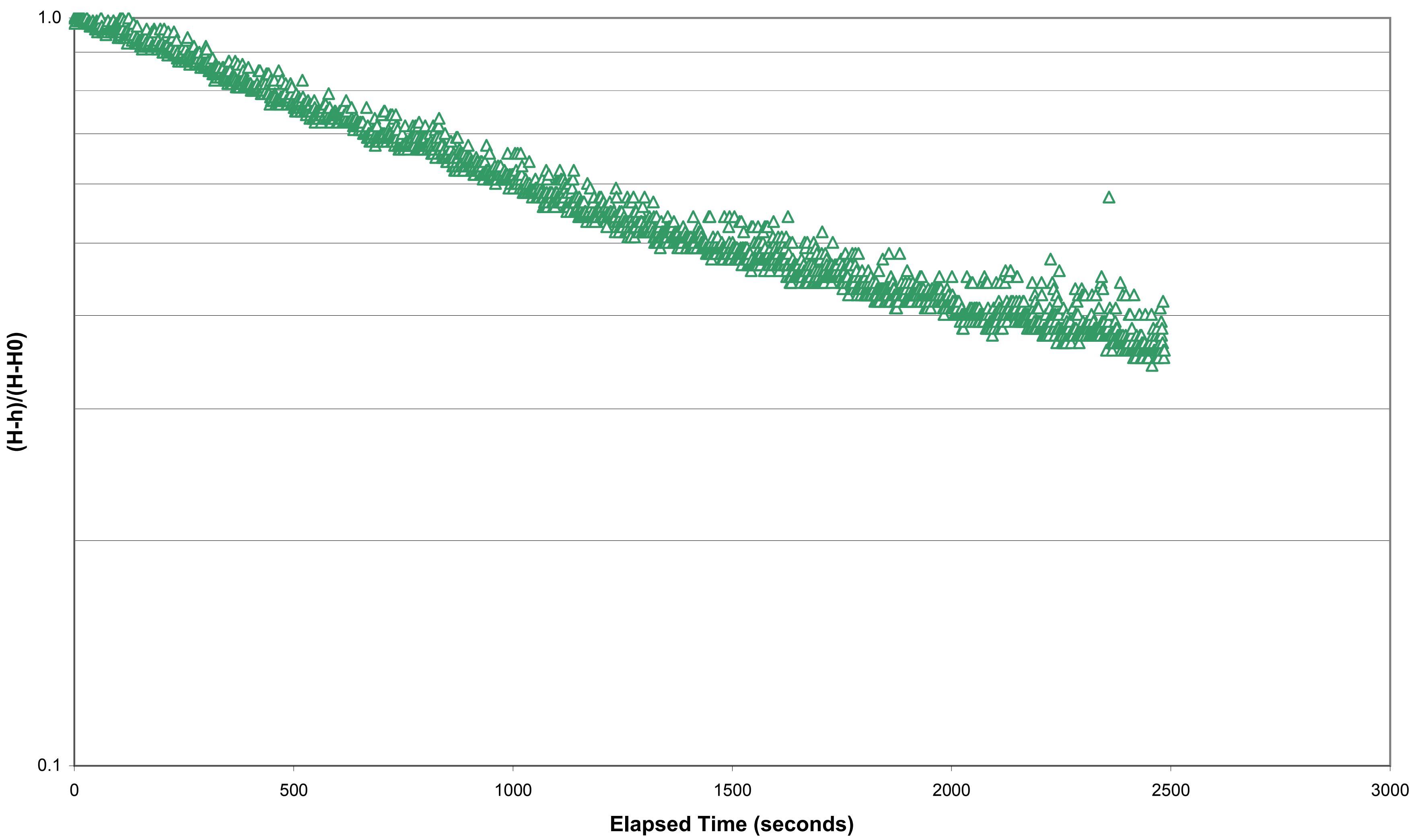



West Quesnel Pilot De-Watering Test
BH03-3C Slug Test
(H-h)/(H-H0)
1
0.1
0
100
200
300
400
500
Elapsed Time (seconds)


West Quesnel Pilot De-Watering Test
BH03-4A Rising Head Test
(H-h)/(H-Ho)
1.0
0.1
0
10000
20000
30000
40000
50000
Elapsed Time (minutes)

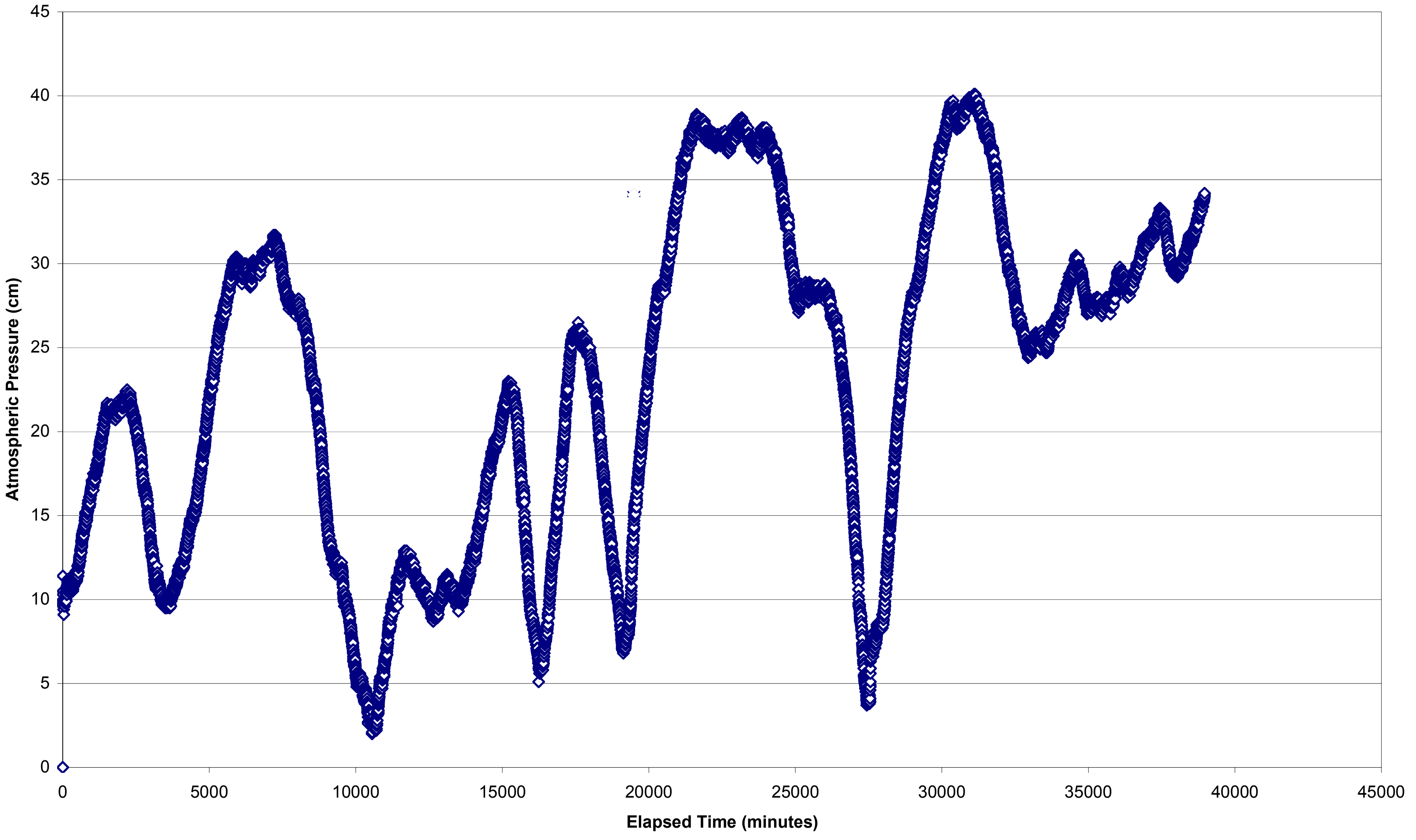
# West Quesnel Pilot De-Watering Test
# BH03-4B Slug Test



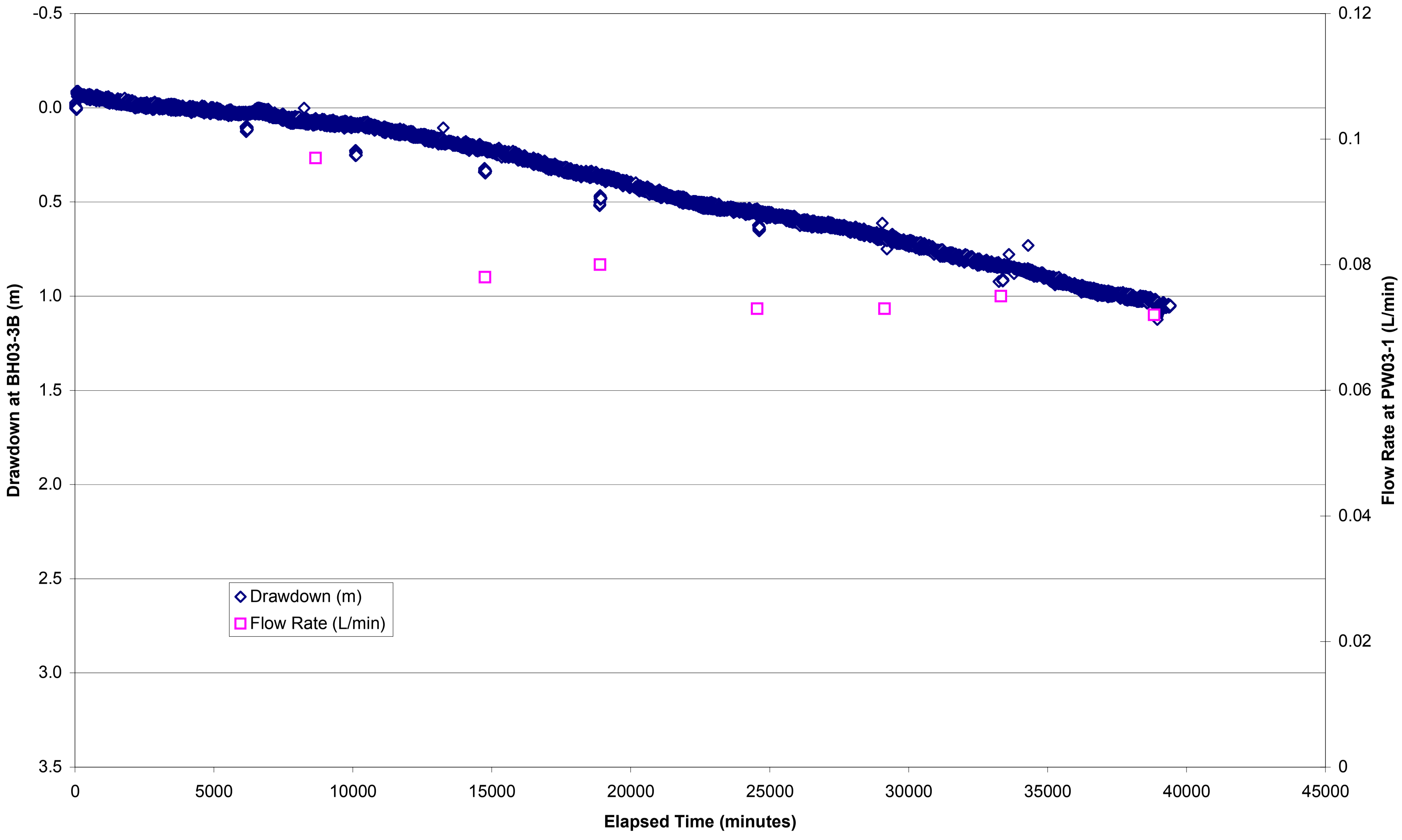


West Quesnel Pilot De-Watering Test
BH03-4C Slug Test

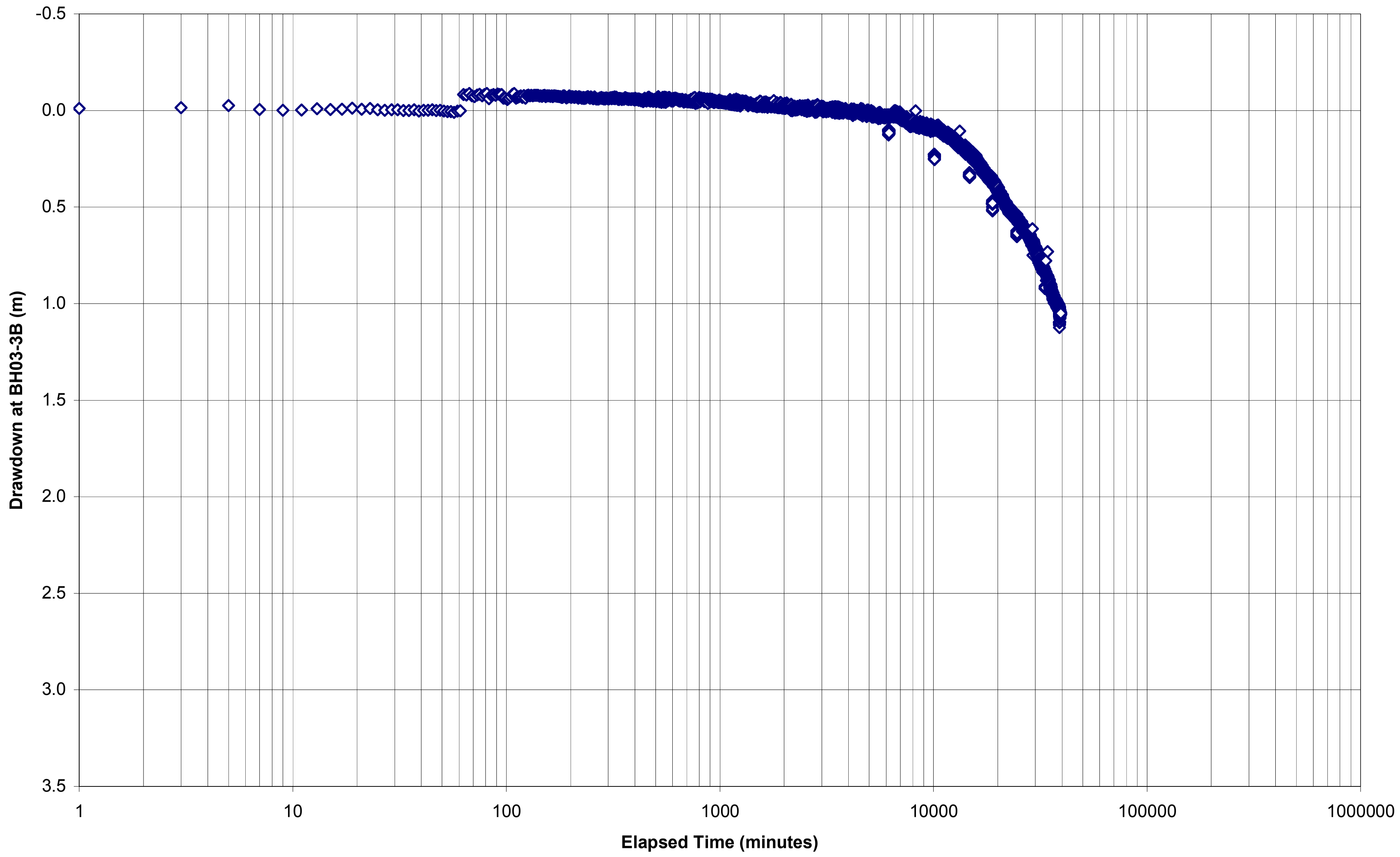
## West Quesnel PW03-1 Short Term Pumping Test
## Atmospheric Pressure



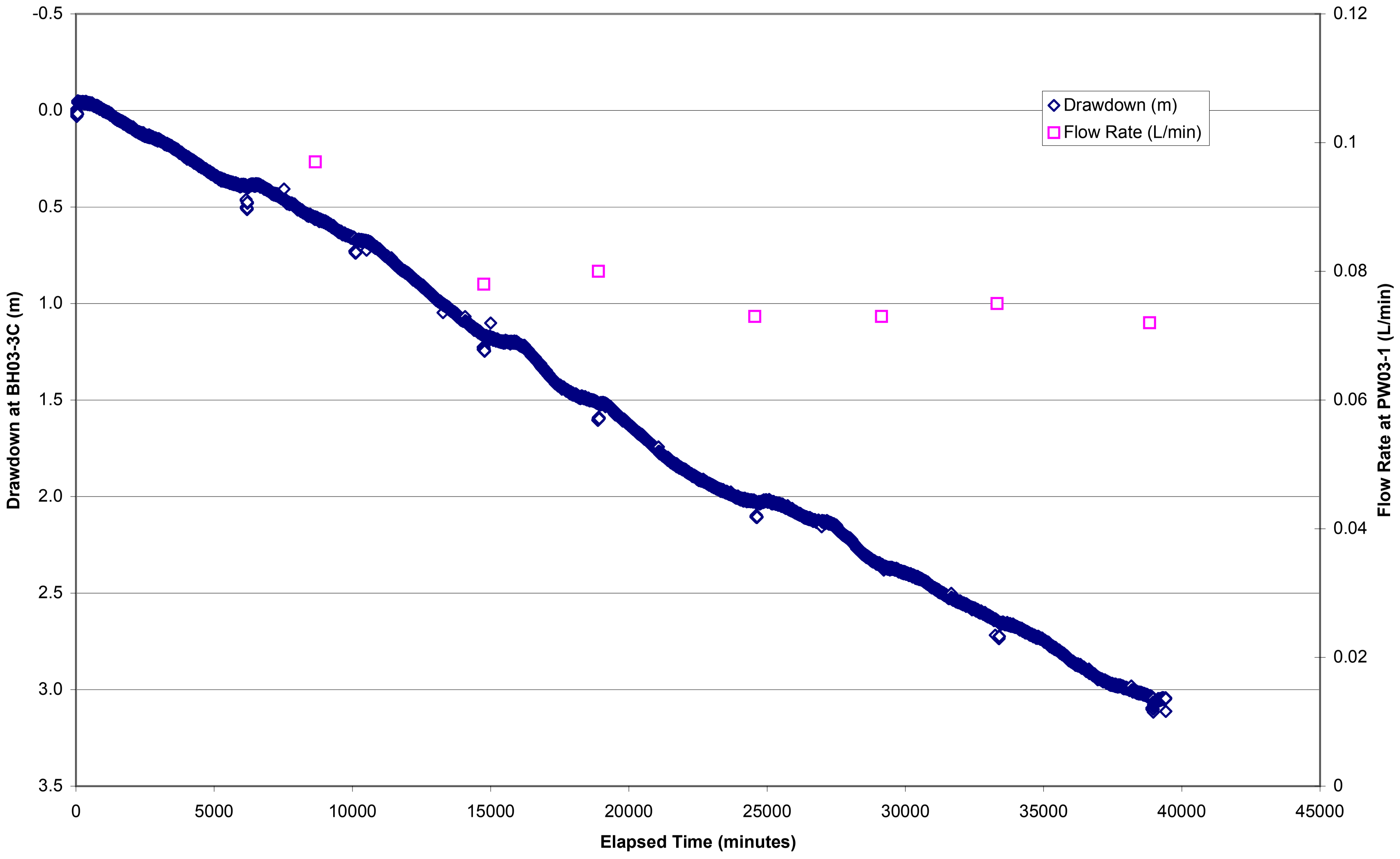
**West Quesnel PW03-1 Short Term Test**
**Drawdown at BH03-3B**



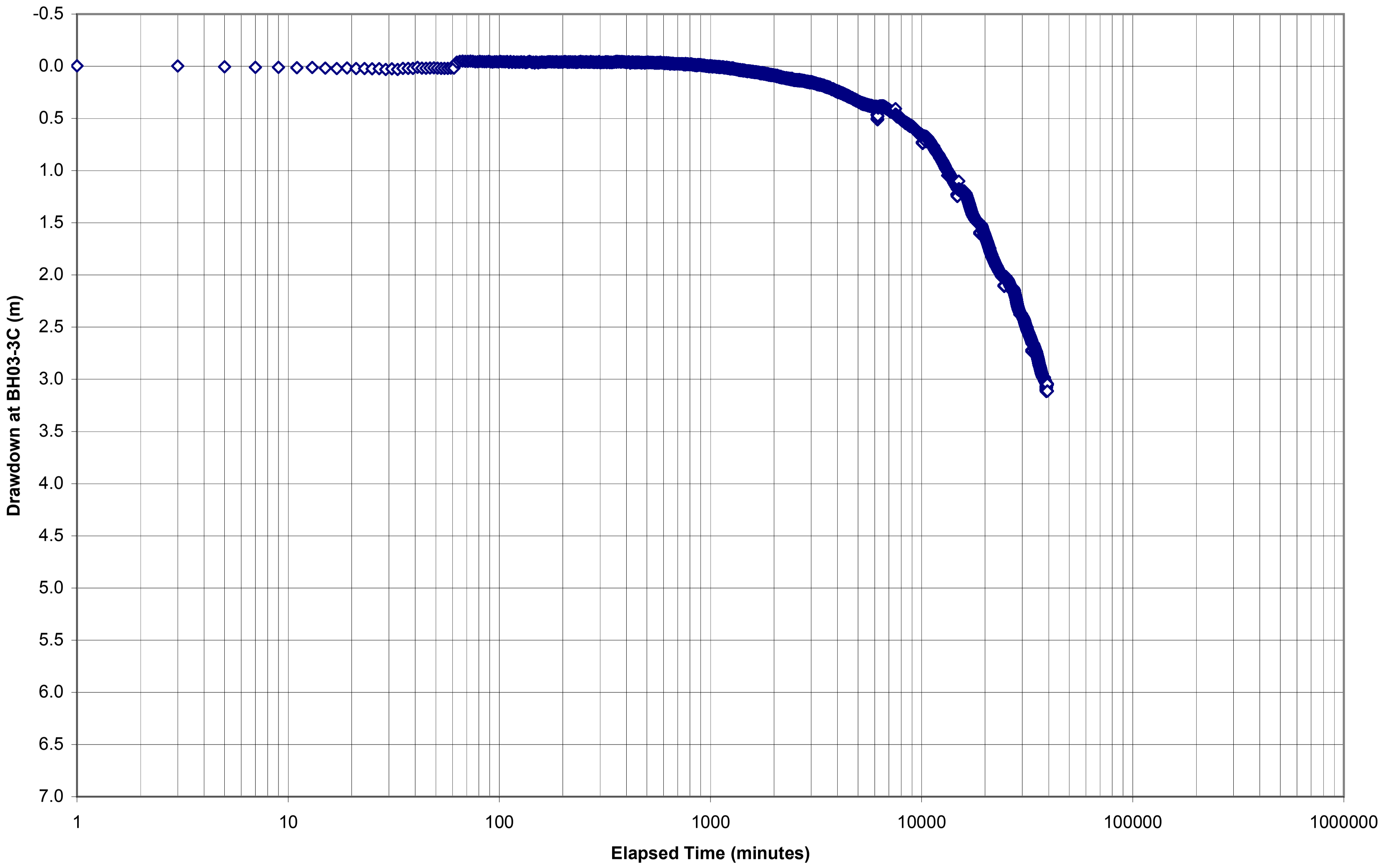
## West Quesnel PW03-1 Short Term Test
## Drawdown at BH03-3B



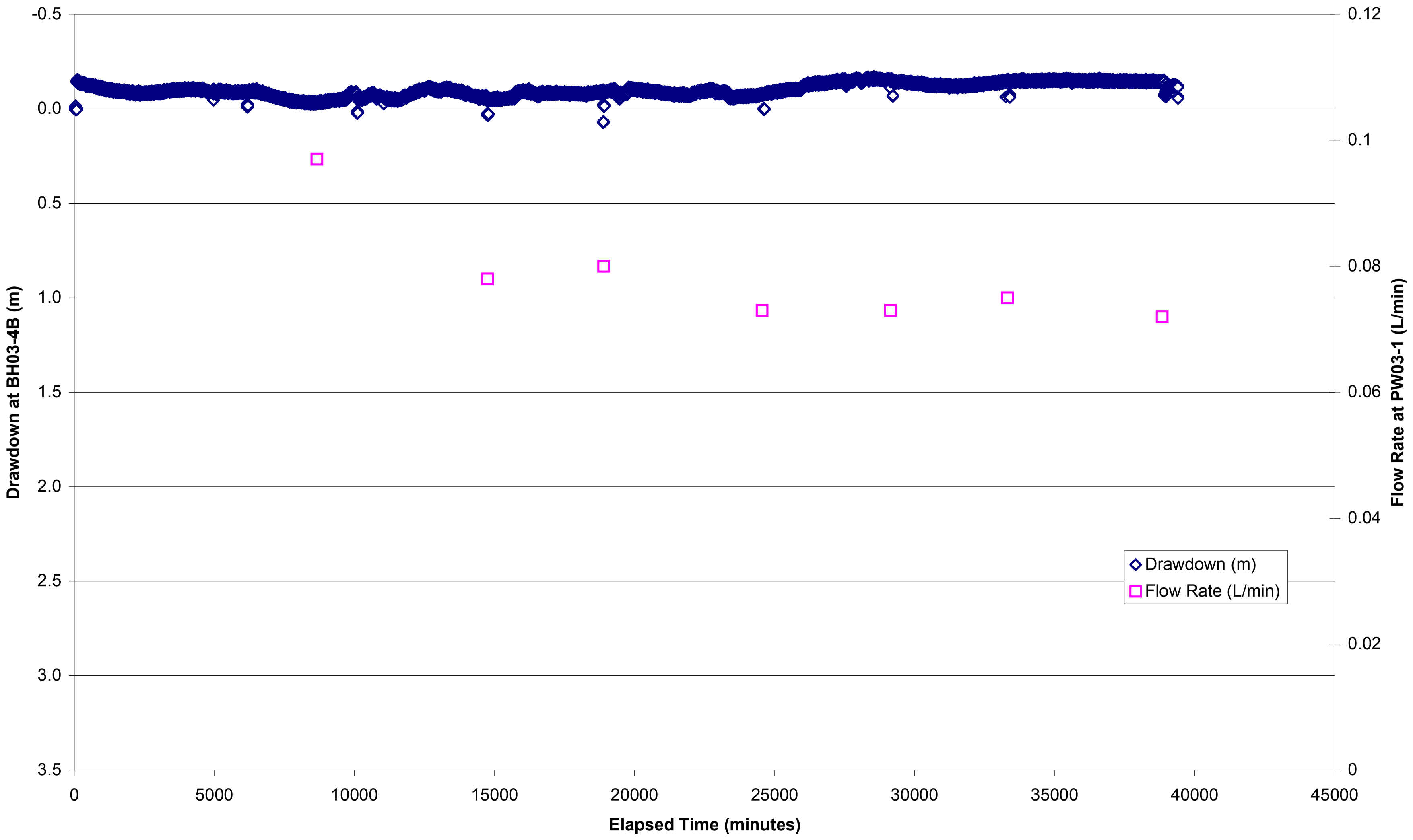
## West Quesnel PW03-1 Short Term Test
## Drawdown at BH03-3C

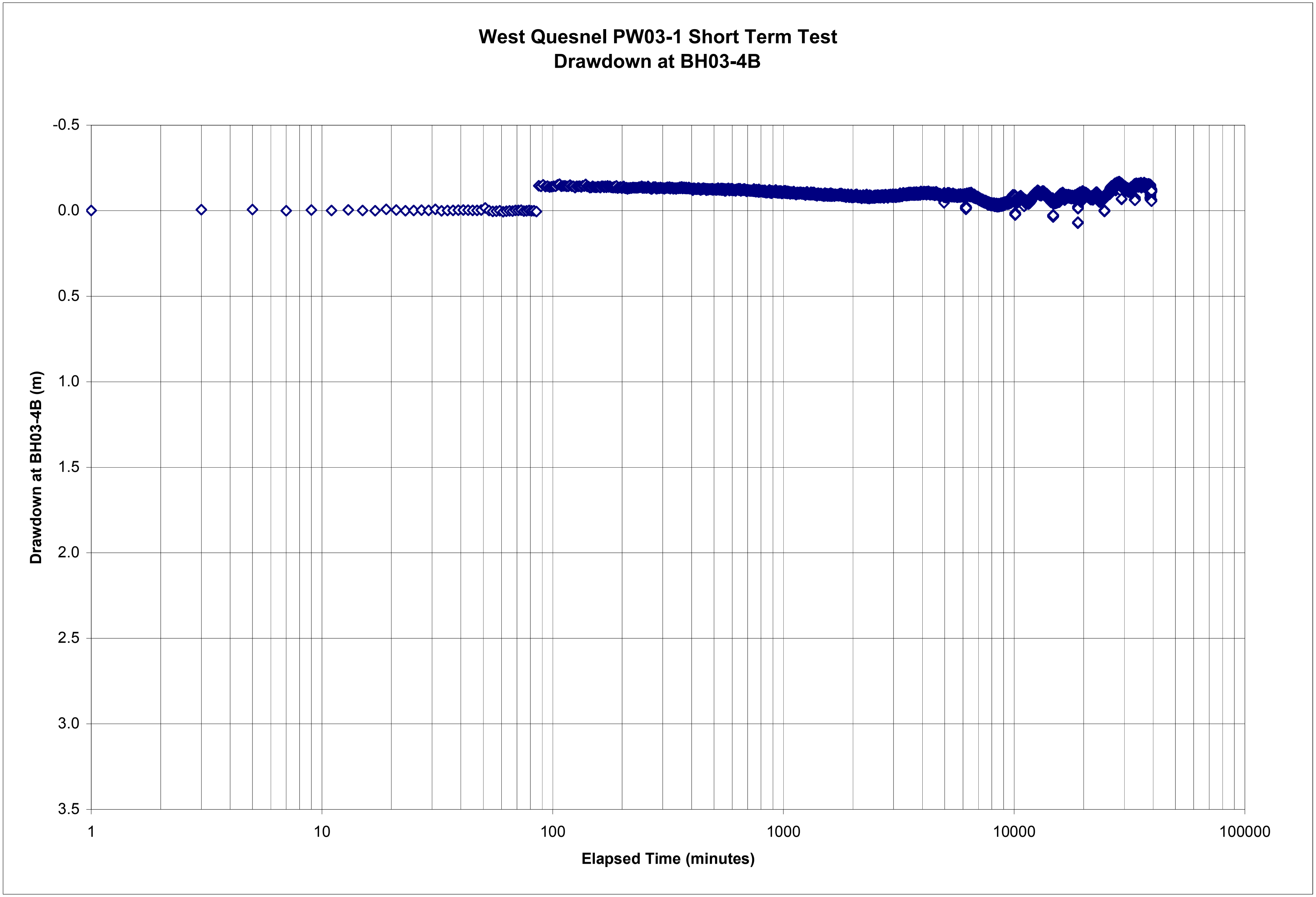


## West Quesnel PW03-1 Short Term Test
## Drawdown at BH03-3C



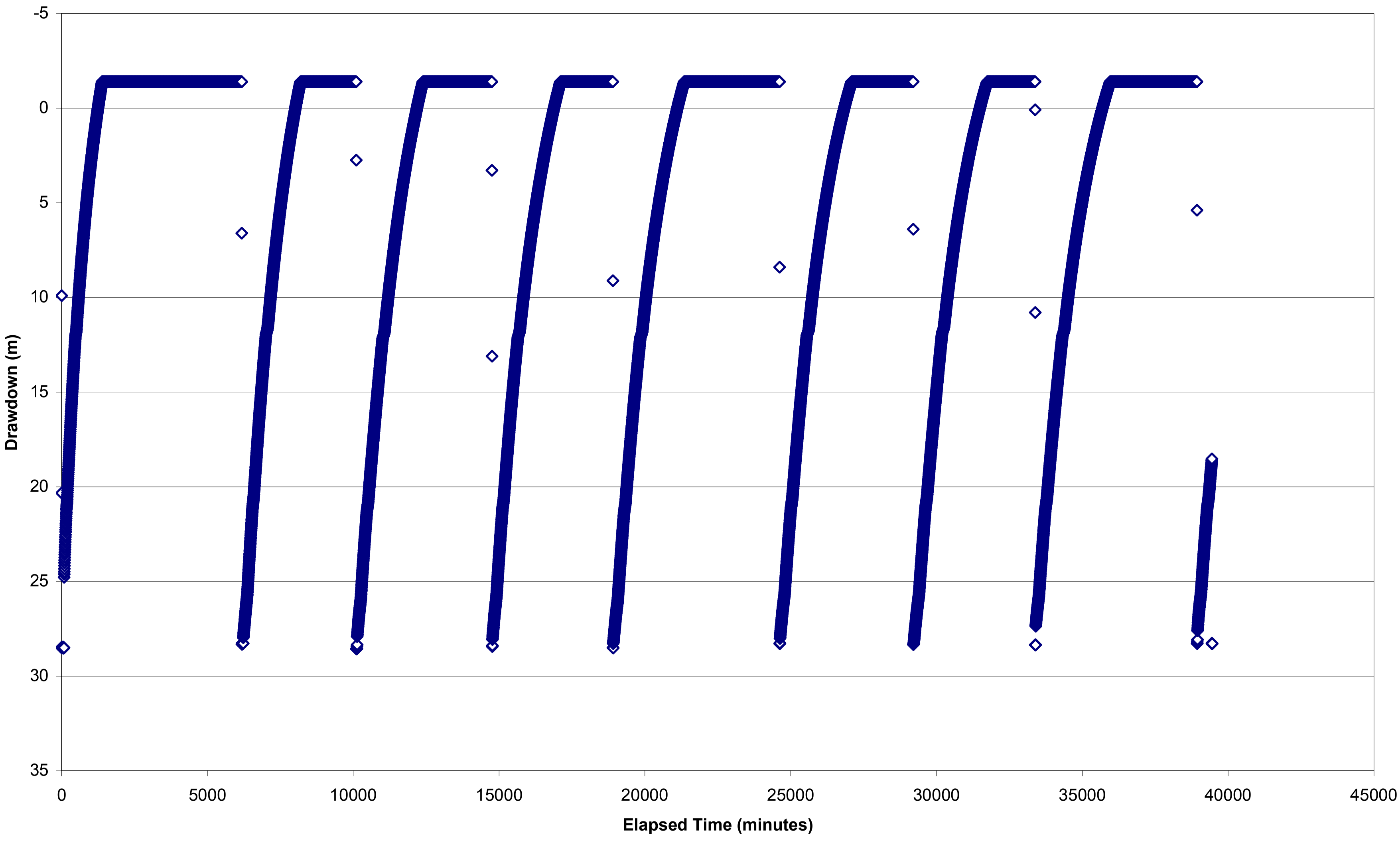
## West Quesnel PW03-1 Short Term Test
## Drawdown at BH03-4B



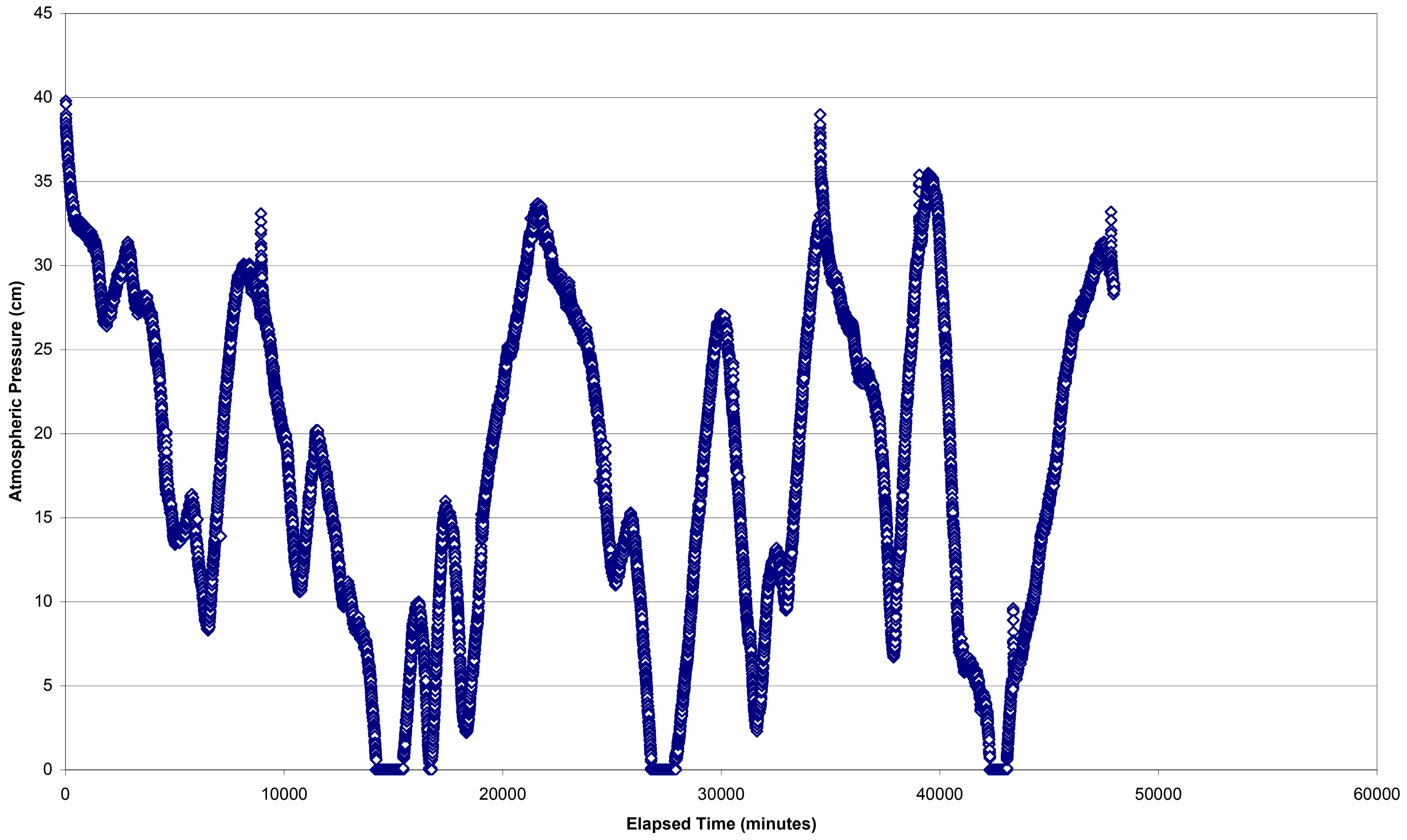


West Quesnel PW03-1 Short Term Test
Drawdown at BH03-4B

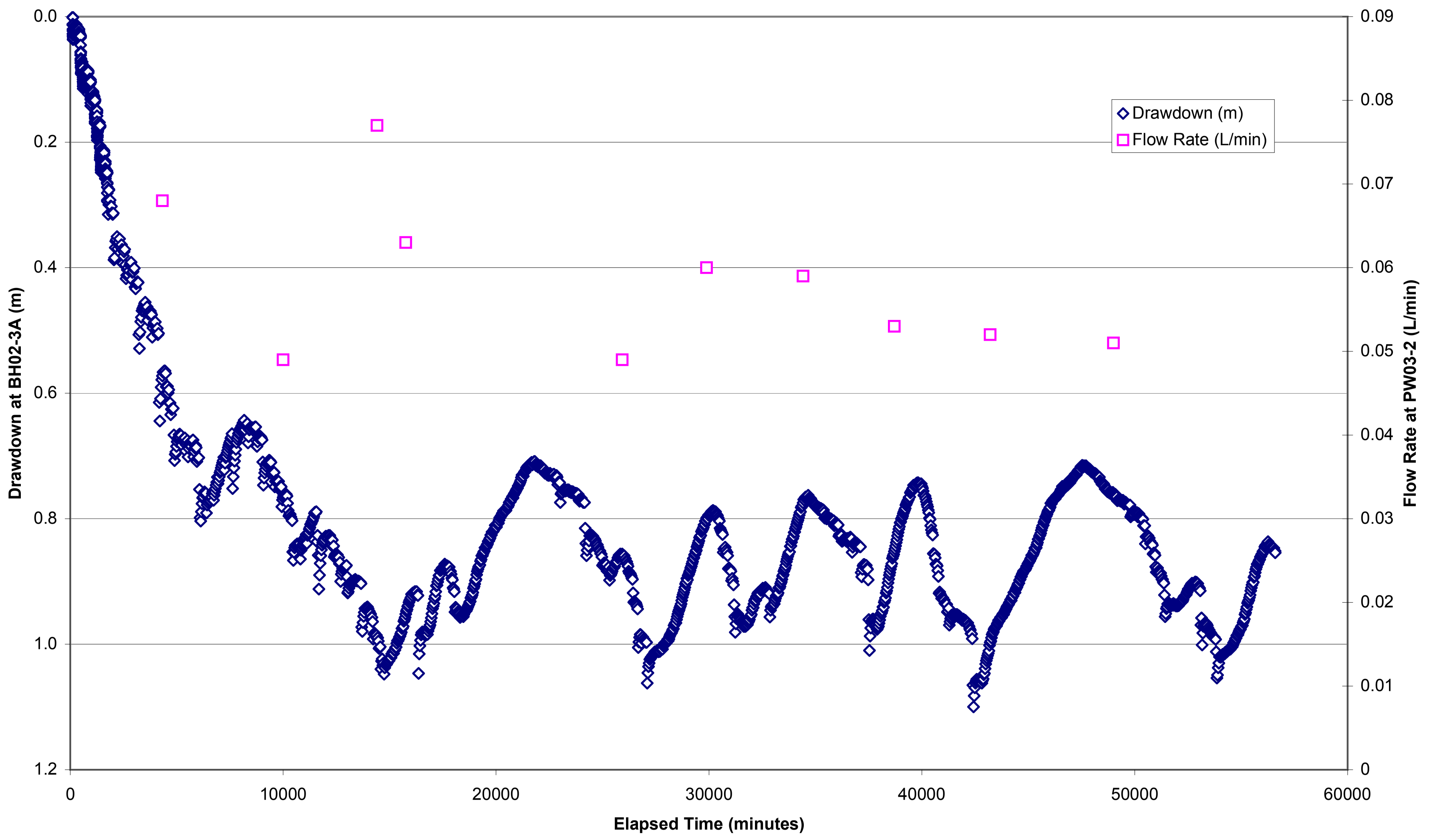
## West Quesnel Pilot PW03-1 Short-Term Pumping Test
## Drawdown at PW03-1

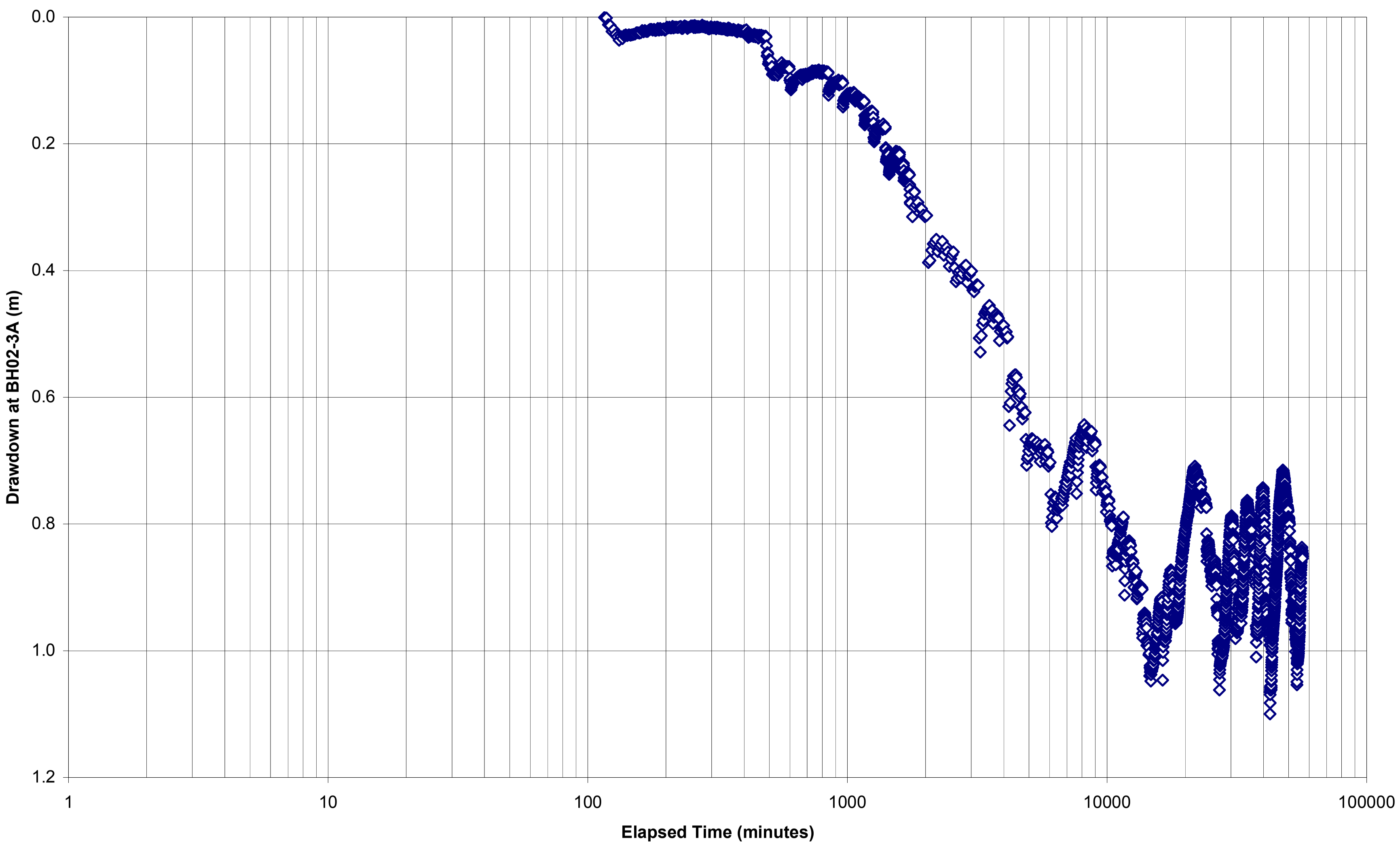


## West Quesnel PW03-2 Short Term Pumping Test
## Atmospheric Pressure

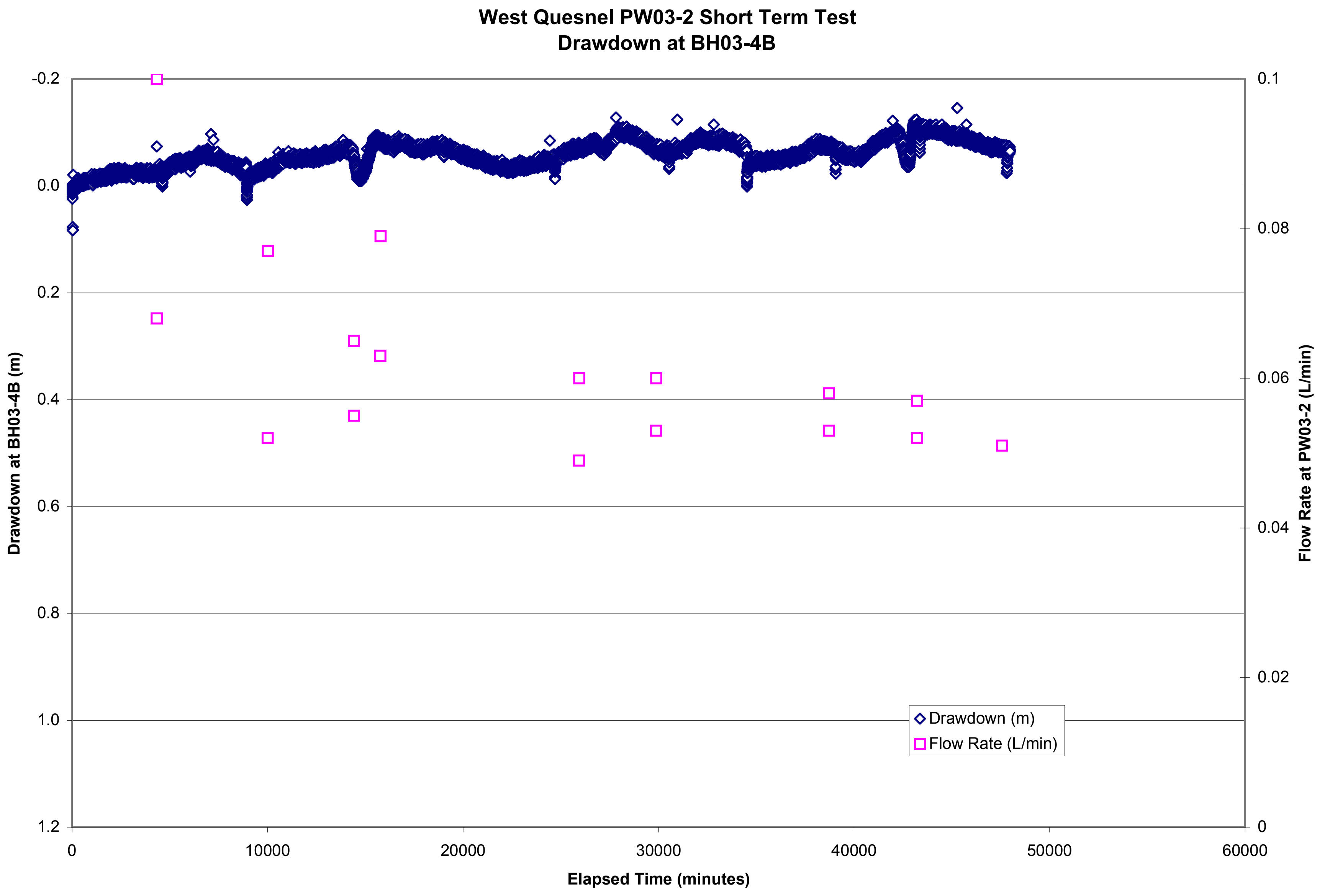


## West Quesnel PW03-2 Short Term Test
## Drawdown at BH02-3A

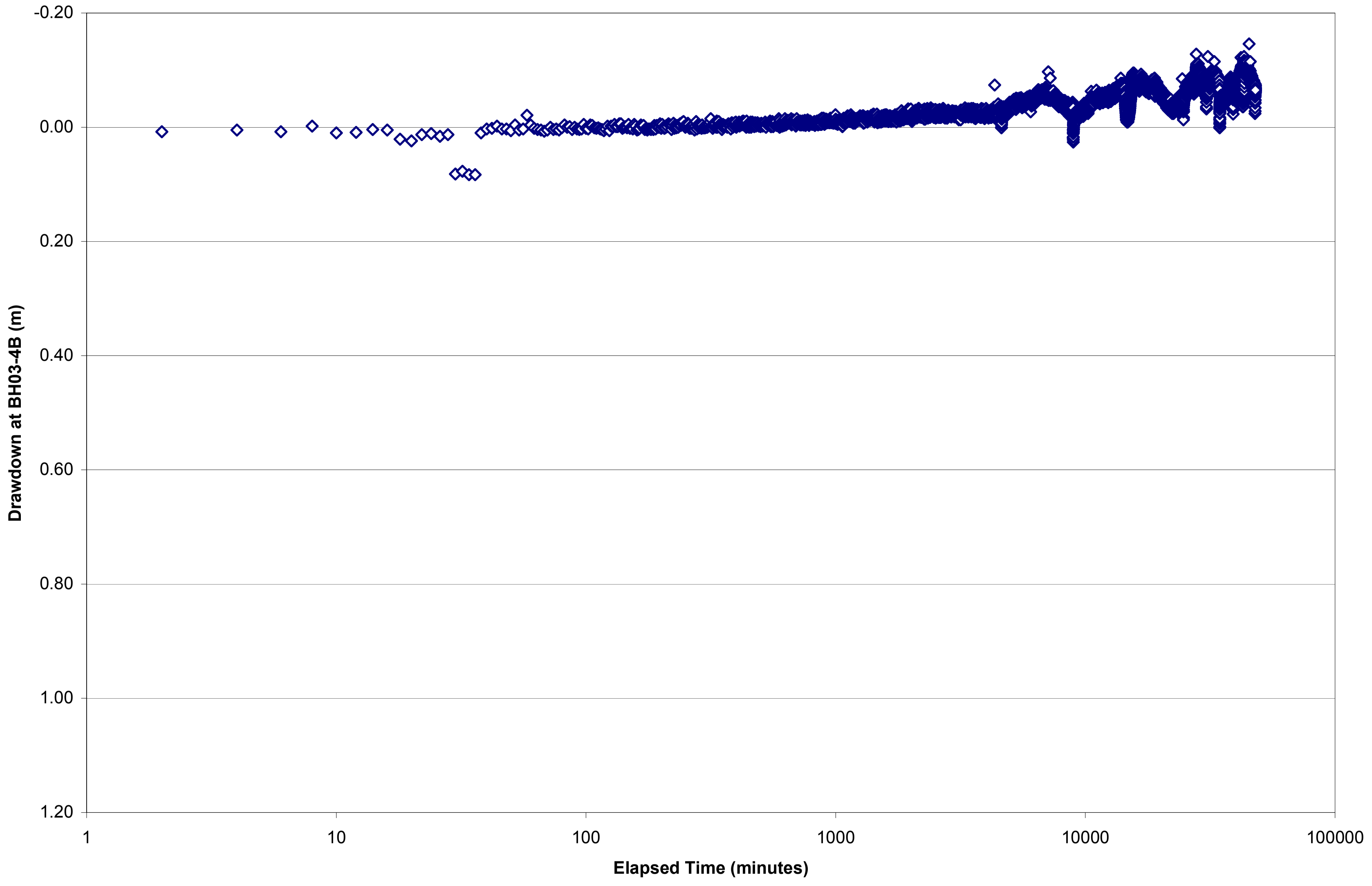




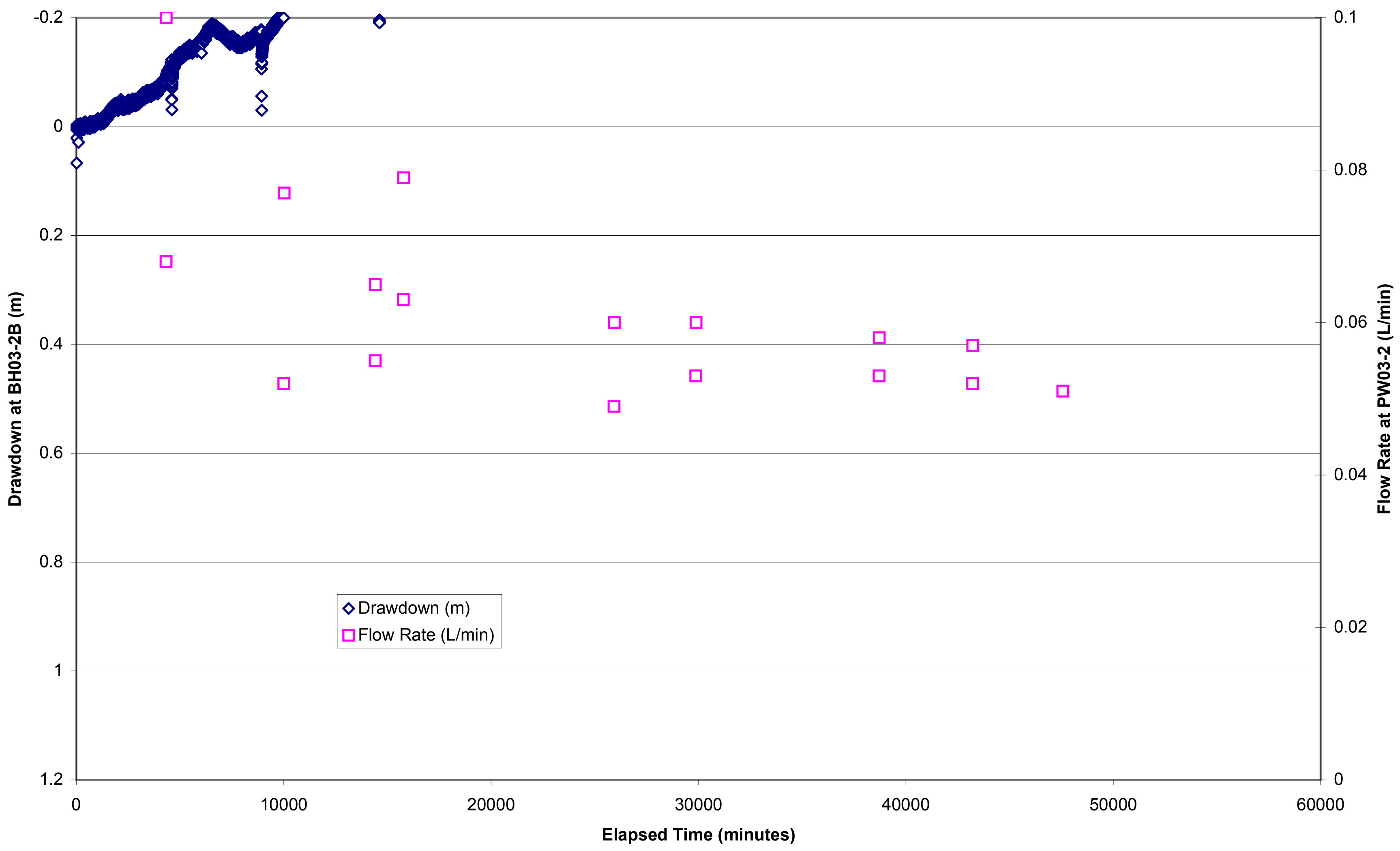
West Quesnel PW03-2 Short Term Test
Drawdown at BH02-3A

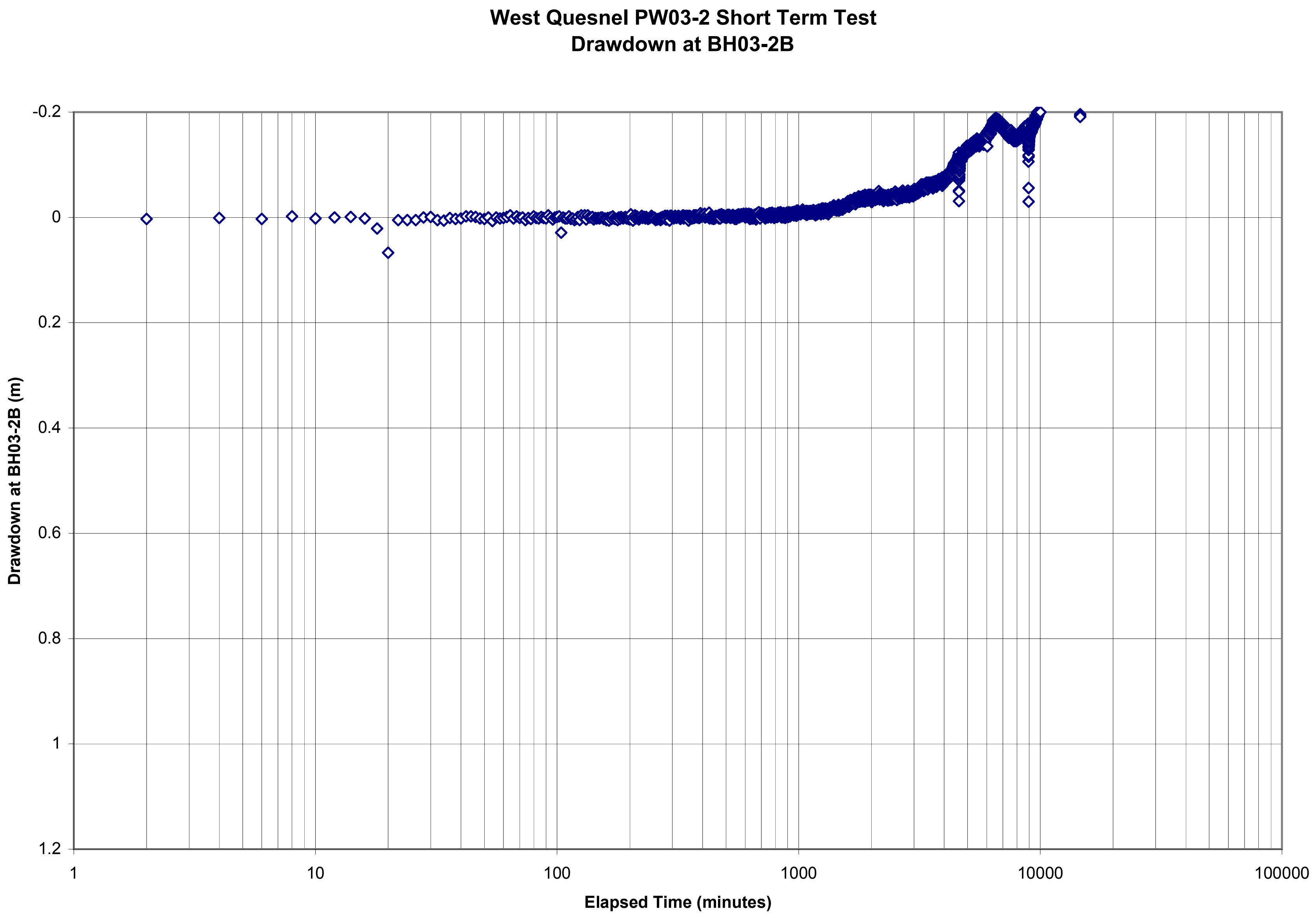

West Quesnel PW03-2 Short Term Test
Drawdown at BH03-4B
Drawdown at BH03-4B (m)
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Flow Rate at PW03-2 (L/min)
0.1
0.08
0.06
0.04
0.02
0
Elapsed Time (minutes)
0
10000
20000
30000
40000
50000
60000
◇ Drawdown (m)
□ Flow Rate (L/min)

# West Quesnel PW03-2 Short Term Test
## Drawdown at BH03-4B



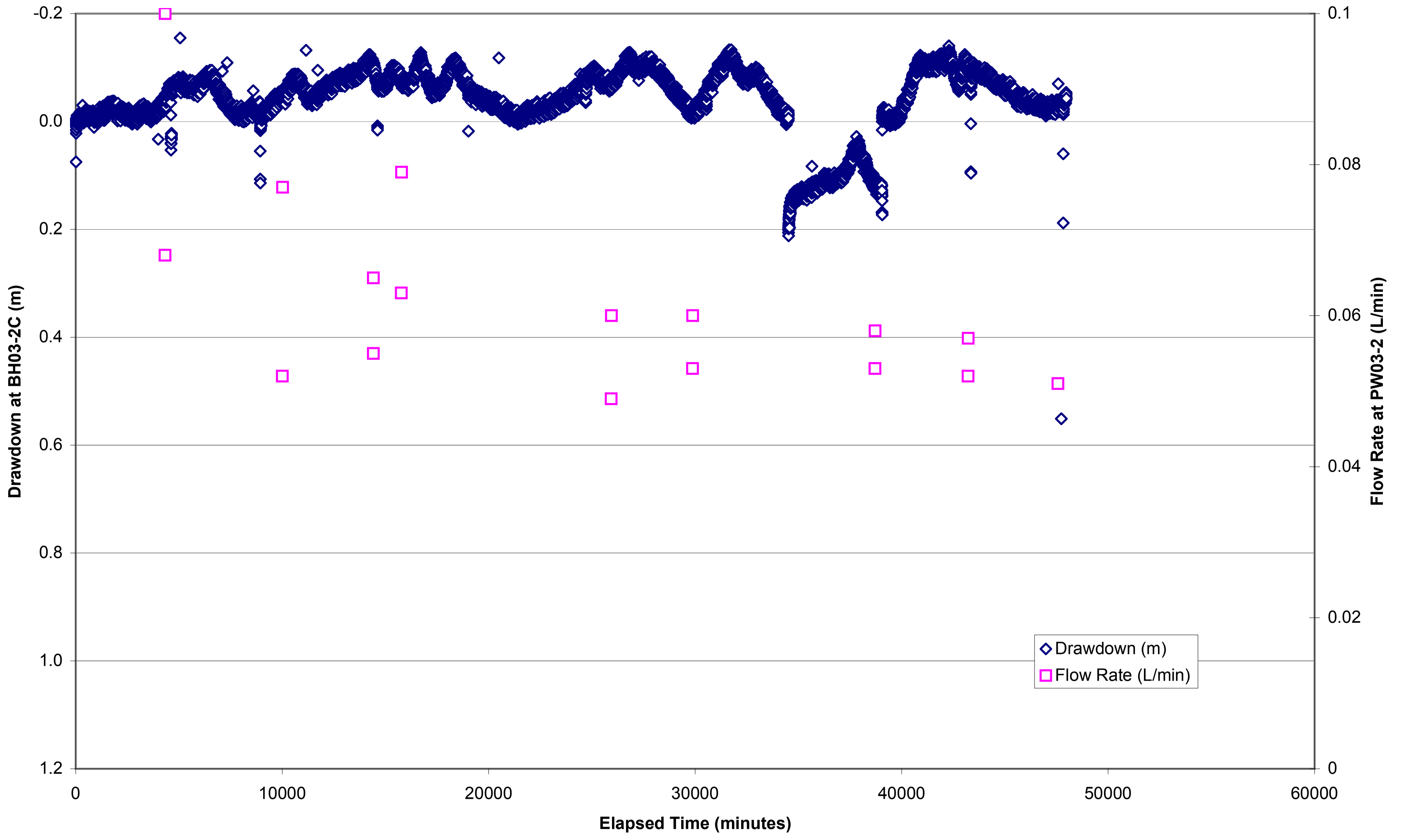
## West Quesnel PW03-2 Short Term Test
## Drawdown at BH03-2B



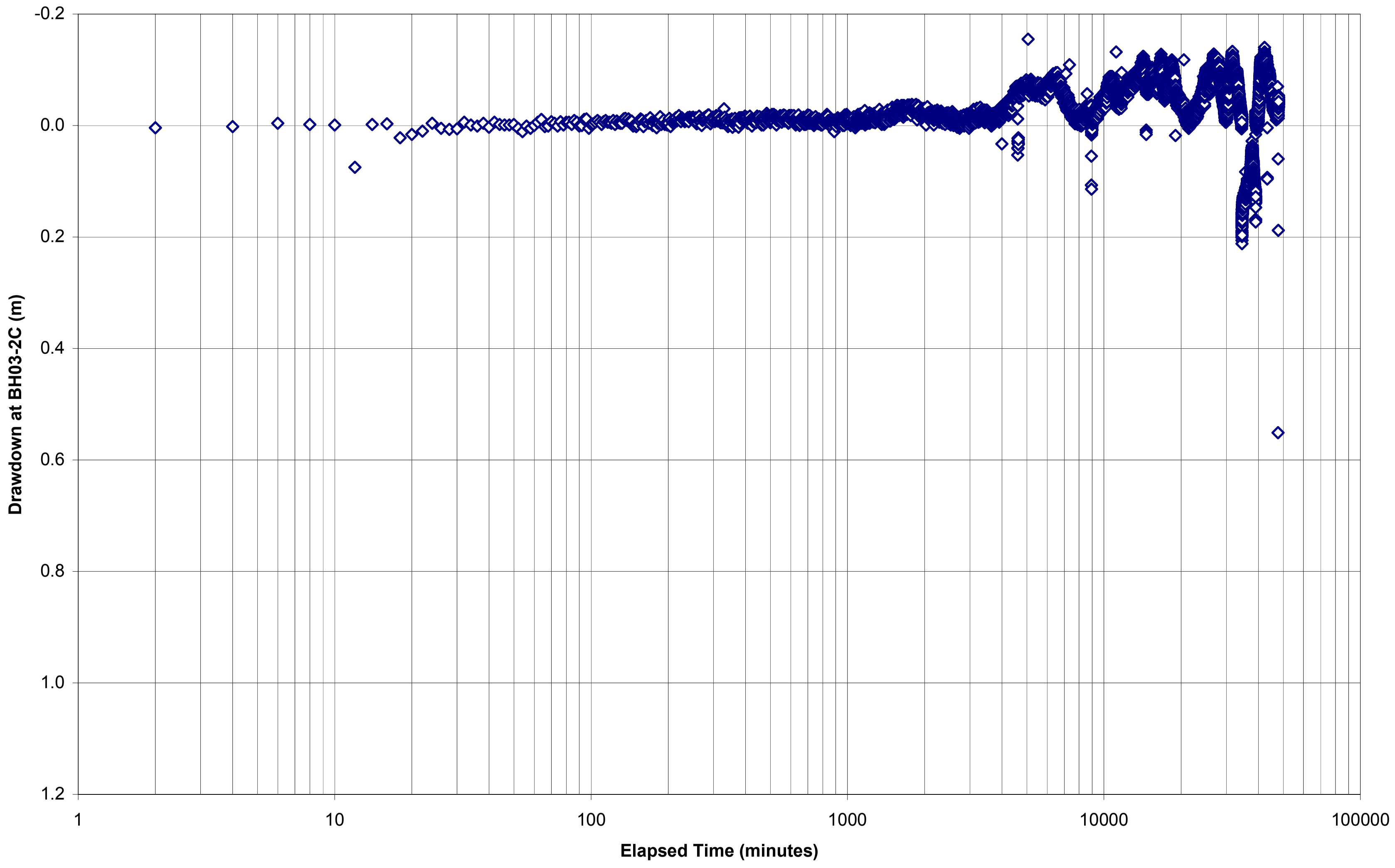


West Quesnel PW03-2 Short Term Test
Drawdown at BH03-2B

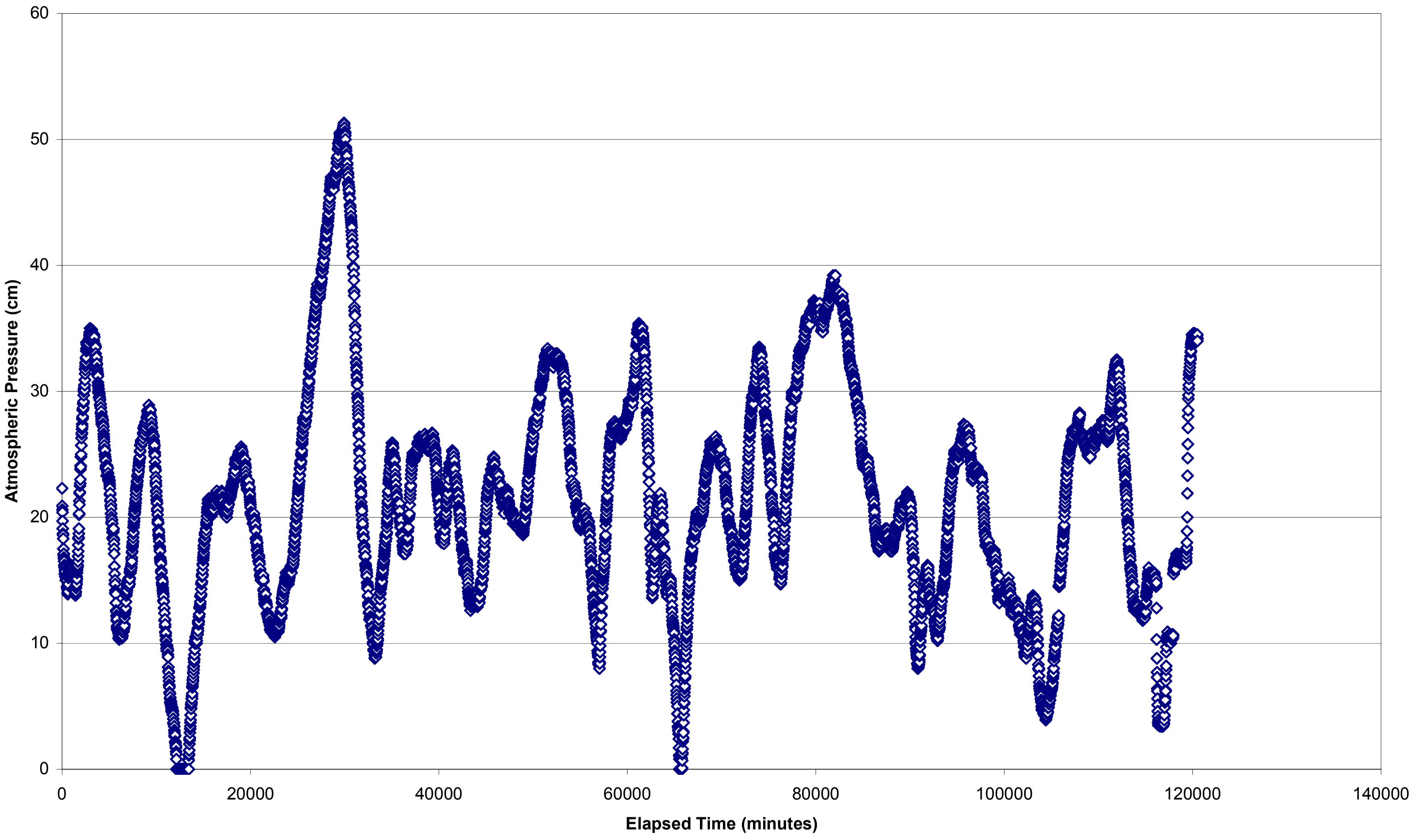
# West Quesnel PW03-2 Short-Term Test
## Drawdown at BH03-2C



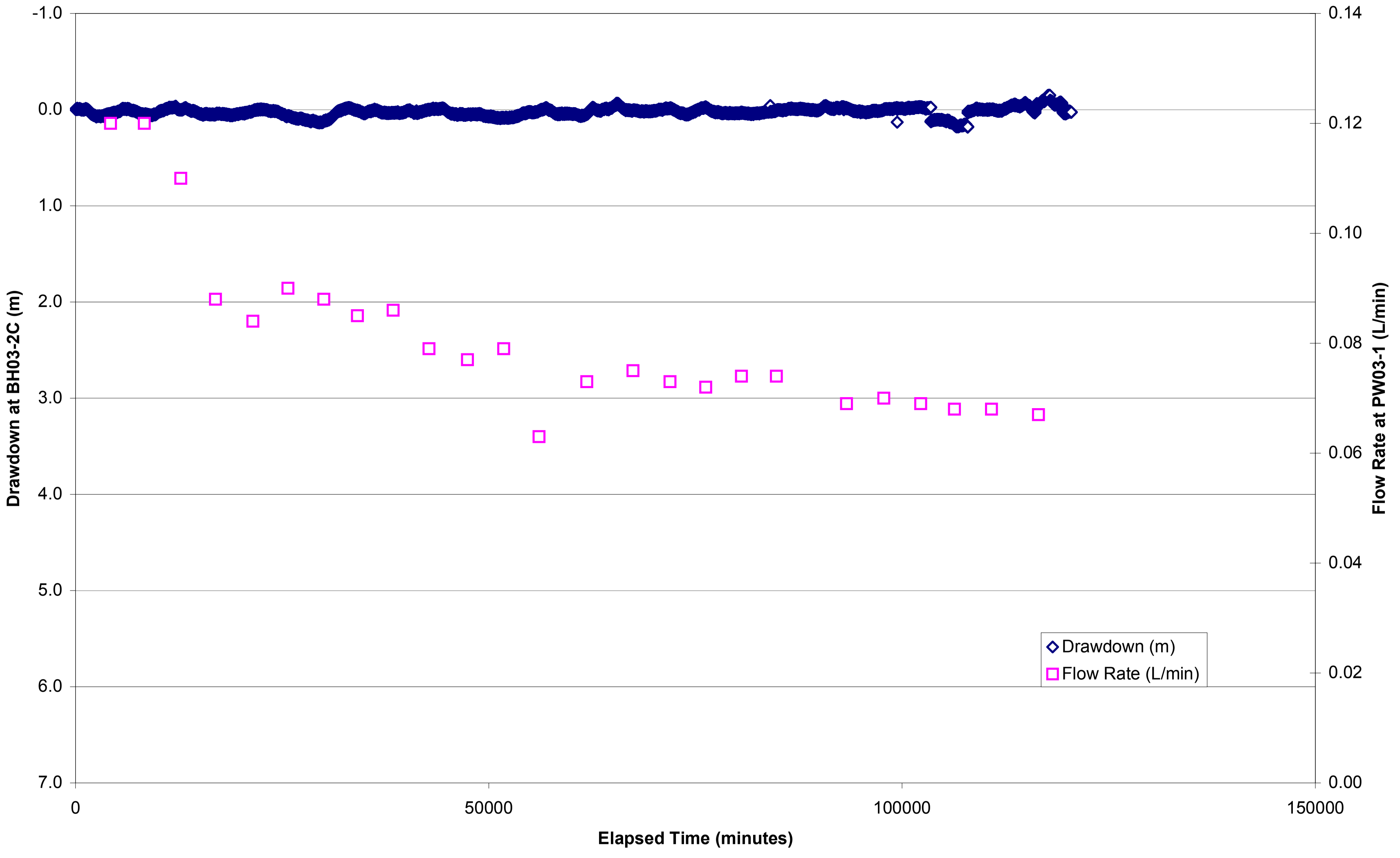
# West Quesnel PW03-2 Short-Term Test
## Drawdown at BH03-2C



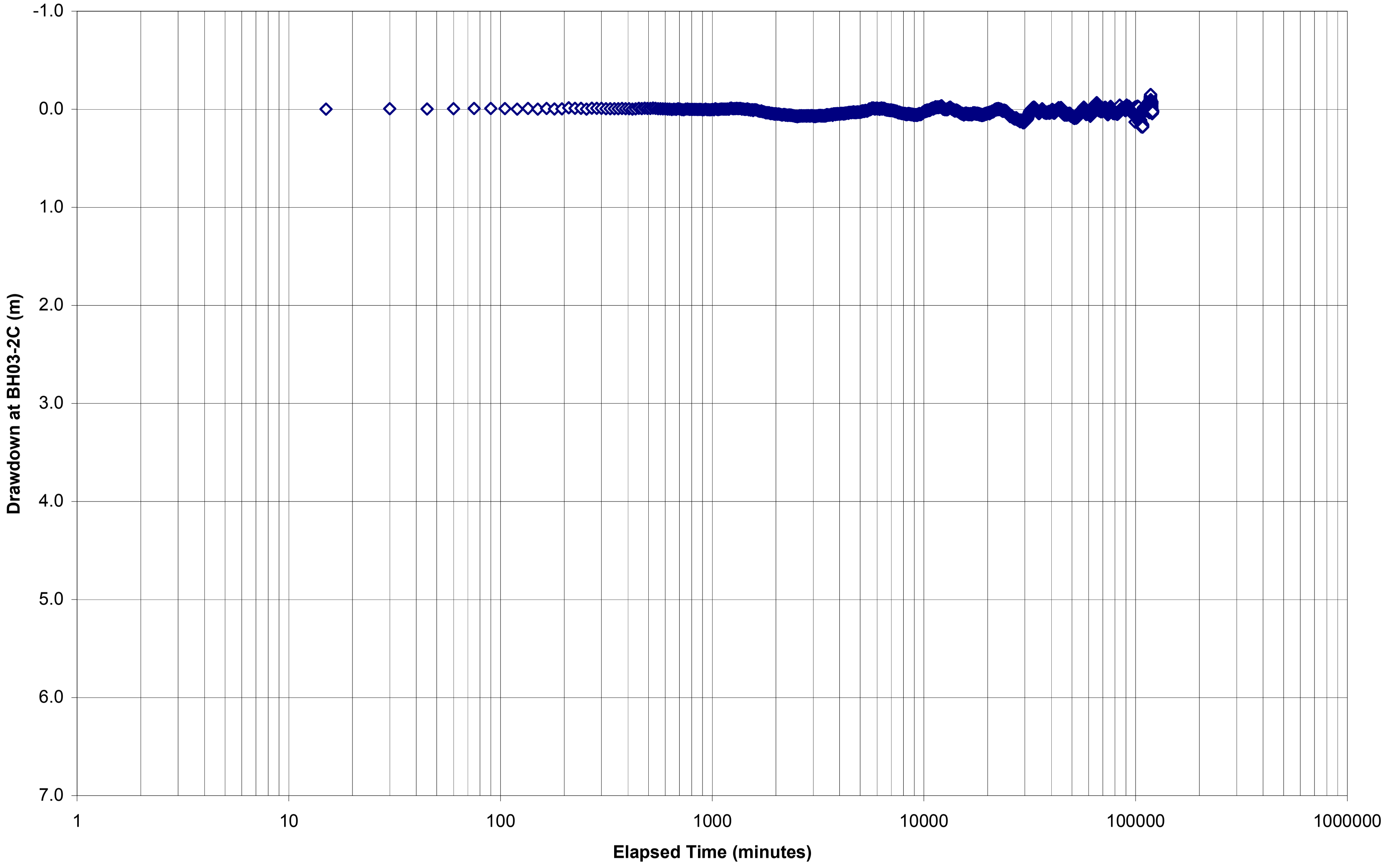
## West Quesnel PW03-1 Long-Term Pumping Test
## Atmospheric Pressure

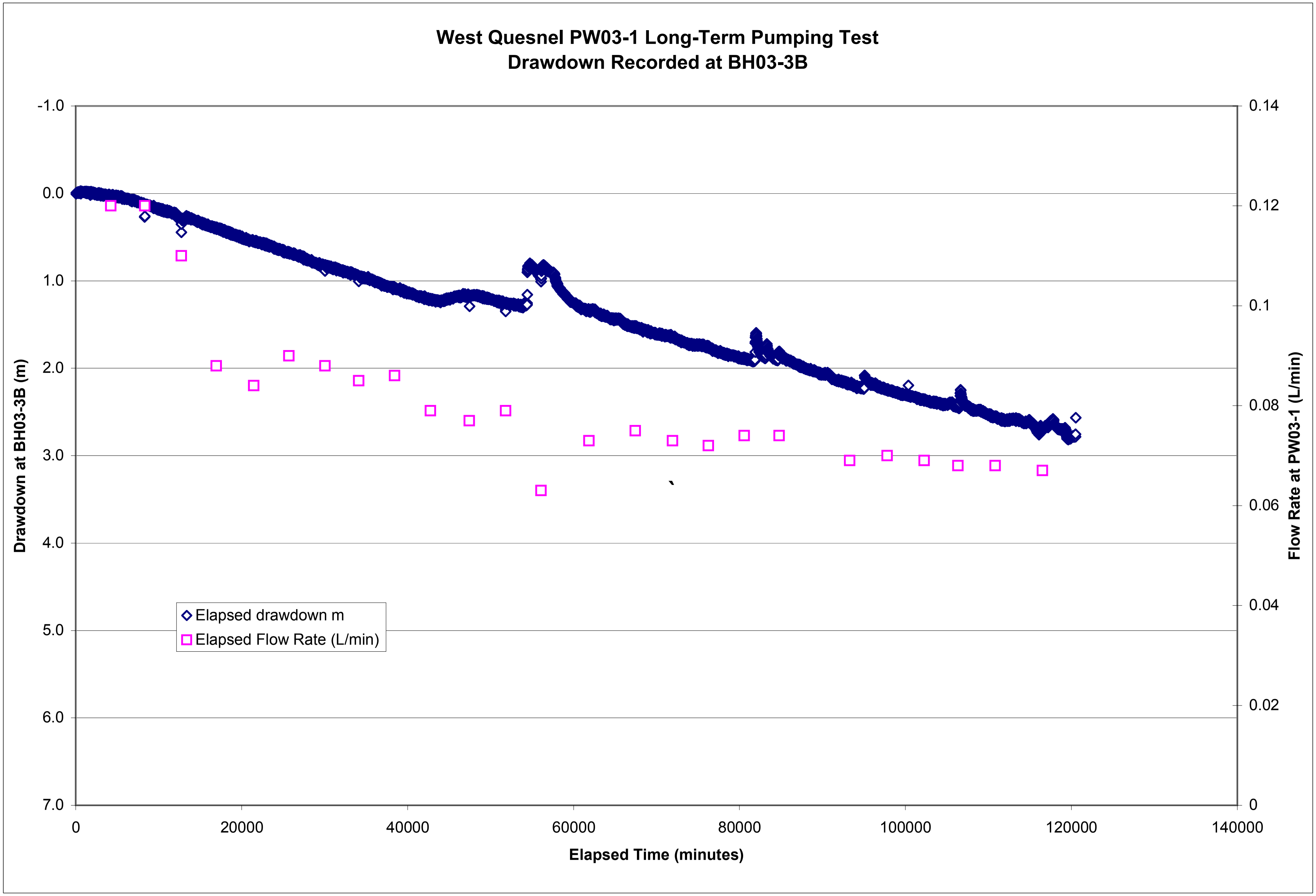


## West Quesnel PW03-1 Long-Term Pumping Test
## Drawdown at BH03-2C



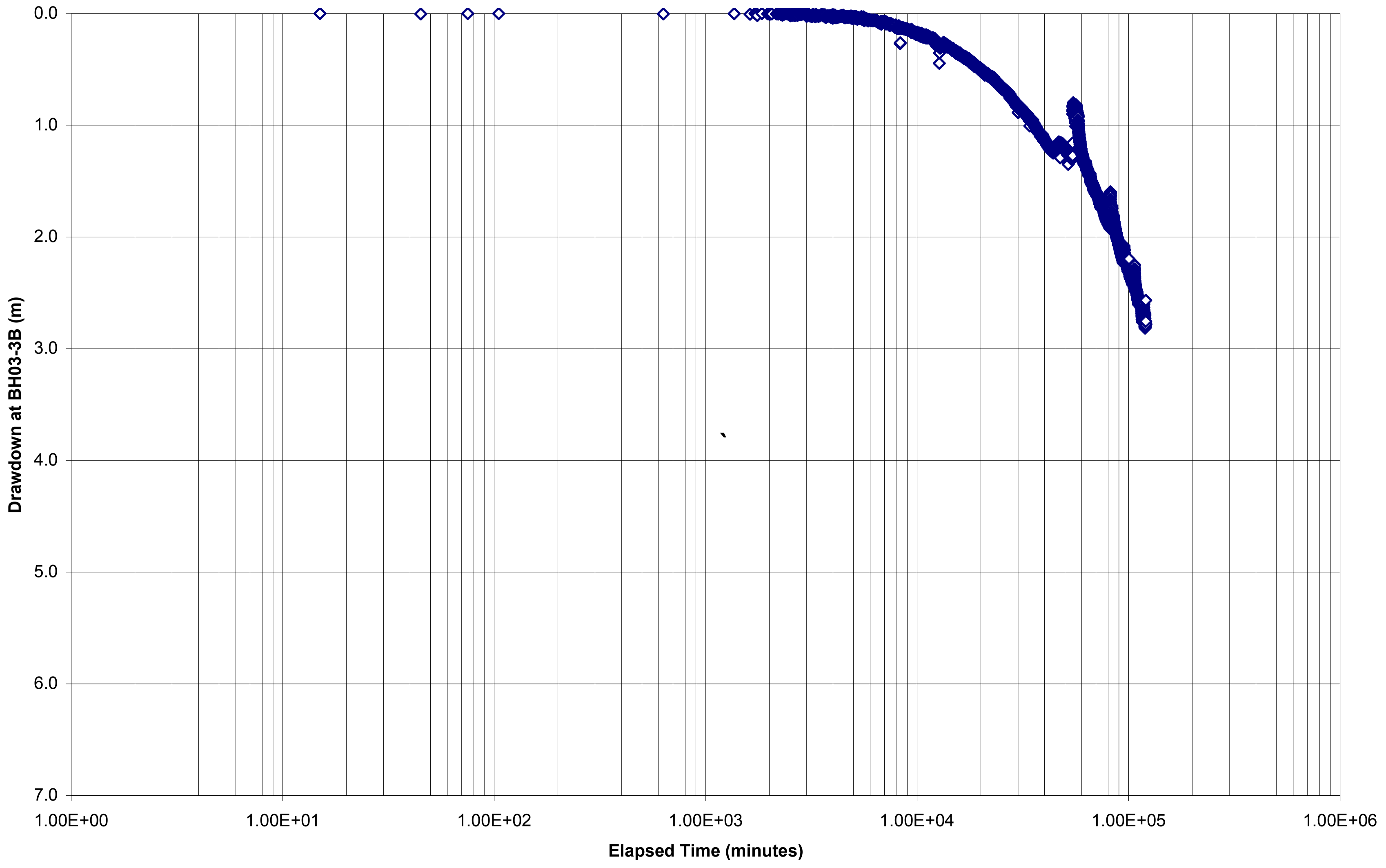
## West Quesnel PW03-1 Long-Term Pumping Test
## Drawdown at BH03-2C



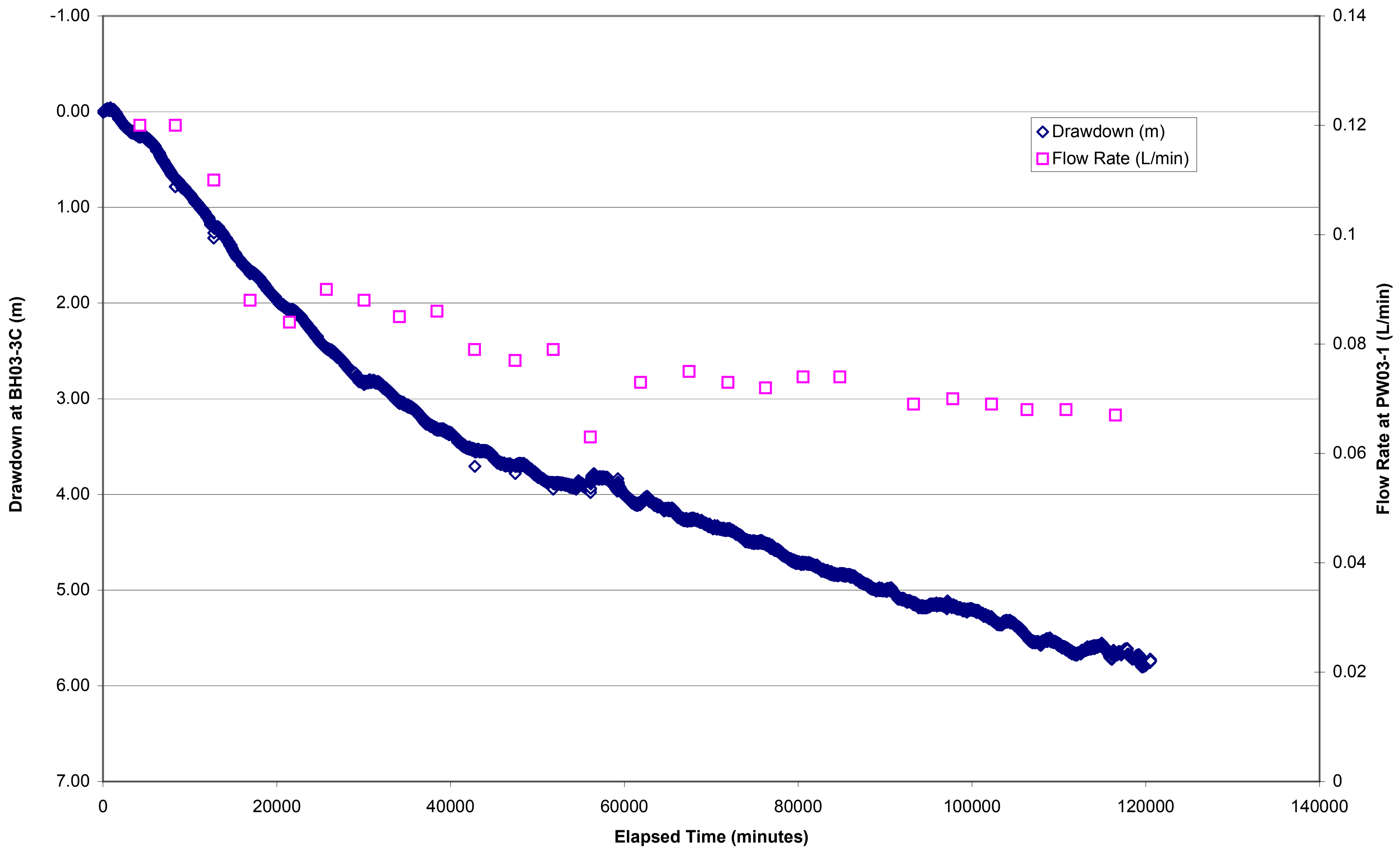


West Quesnel PW03-1 Long-Term Pumping Test
Drawdown Recorded at BH03-3B

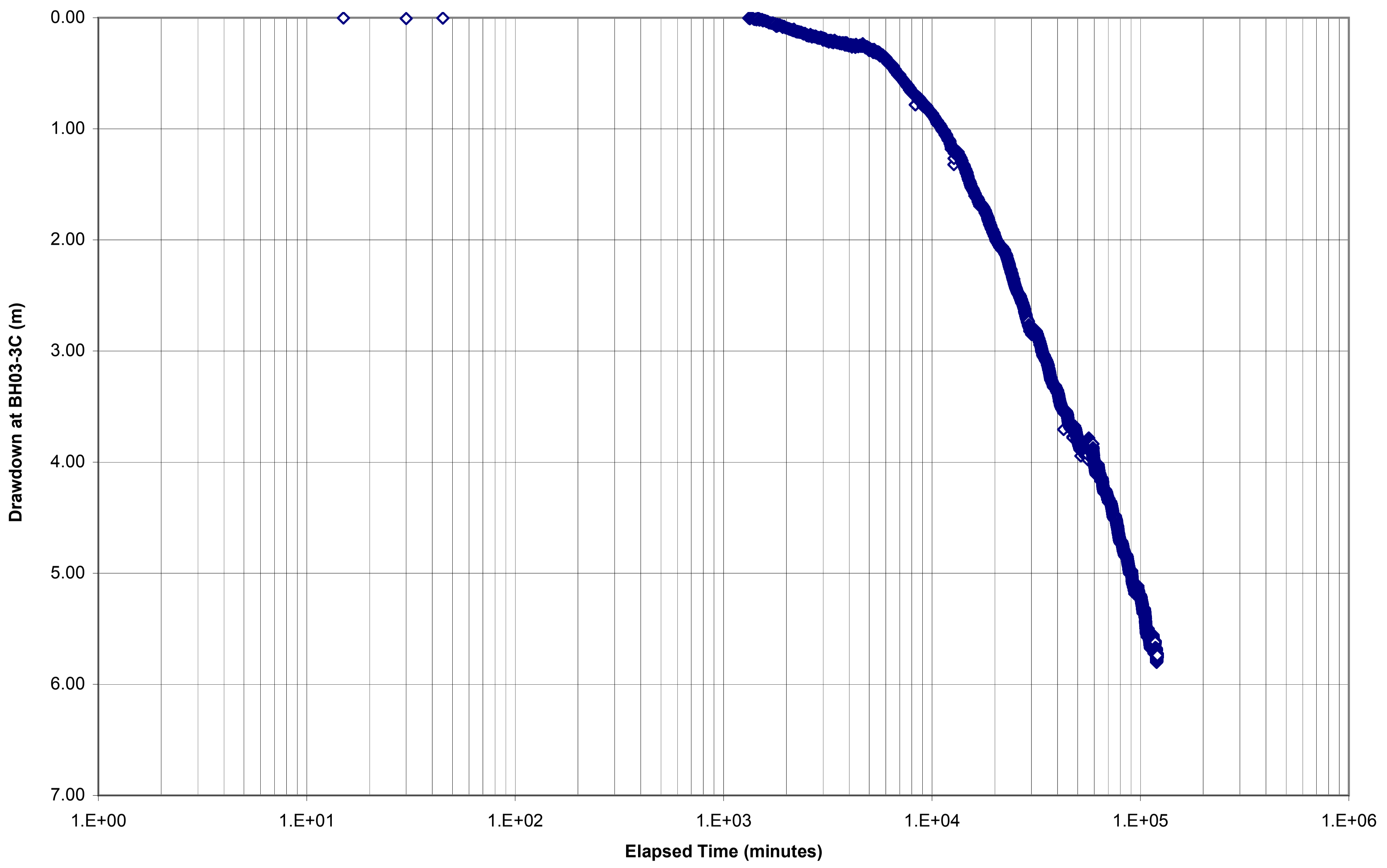
## West Quesnel PW03-1 Long-Term Pumping Test
## Drawdown Recorded at BH03-3B

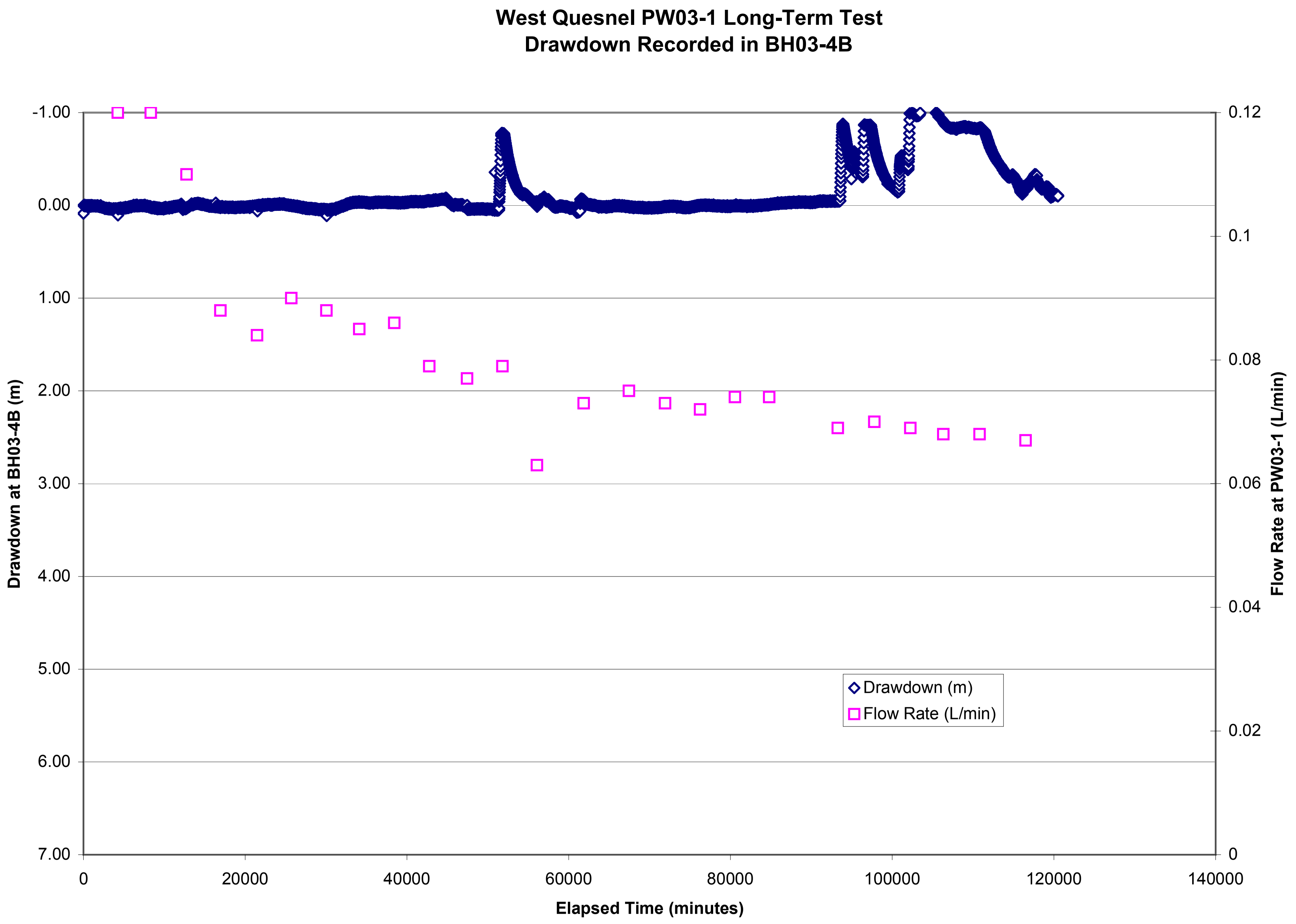


## West Quesnel PW03-1 Long-Term Pumping Test
## Drawdown Recorded at BH03-3C

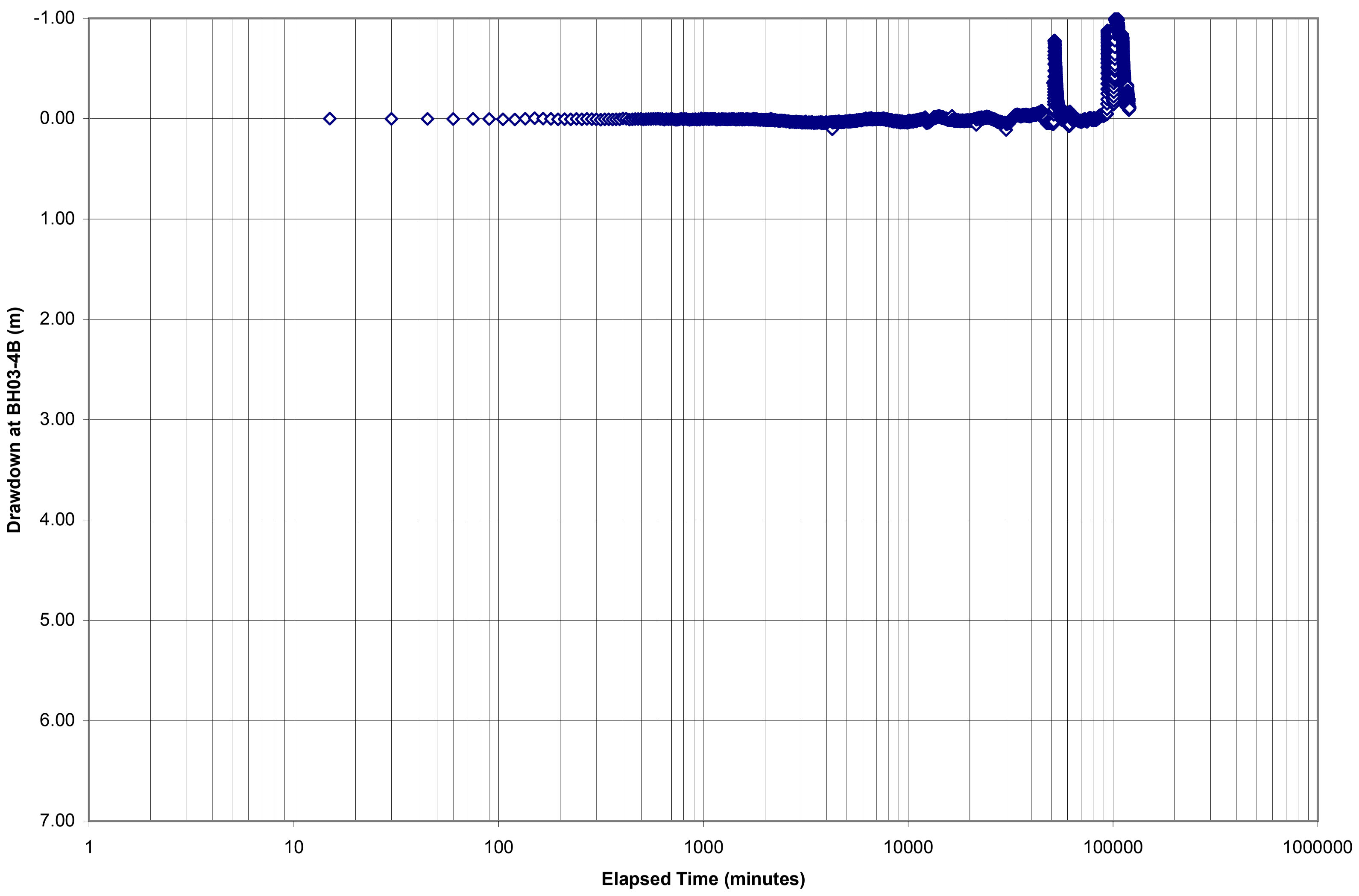


## West Quesnel PW03-1 Long-Term Pumping Test
## Drawdown Recorded at BH03-3C




West Quesnel PW03-1 Long-Term Test
Drawdown Recorded in BH03-4B
Drawdown at BH03-4B (m)
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Flow Rate at PW03-1 (L/min)
0.12
0.1
0.08
0.06
0.04
0.02
0
0
20000
40000
60000
80000
100000
120000
140000
Elapsed Time (minutes)
◇ Drawdown (m)
□ Flow Rate (L/min)

# West Quesnel PW03-1 Long-Term Test
## Drawdown Recorded in BH03-4B



4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

## ANALYTICAL REPORT

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date Received:** 2003/11/14
**Date Sampled:** 2003/11/06
**Date of Report:** 2003/11/27

# Water Analysis

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46103

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | 03-12377 PW03-1 |
|---|---|---|---|---|---|---|
| AD | 2003/11/14 | Calcium | mg/L (ppm) | APHA 3120 | 0.5 | 24.3 |
| AD | 2003/11/14 | Magnesium | mg/L (ppm) | APHA 3120 | 0.5 | 9.6 |
| AD | 2003/11/14 | Potassium | mg/L (ppm) | APHA 3120 | 0.5 | 5.5 |
| AD | 2003/11/14 | Sodium | mg/L (ppm) | APHA 3120 | 0.5 | 112 |
| AD | 2003/11/17 | Iron (Total) | mg/L (ppm) | APHA 3030e/3120 | 0.10 | 17.0 |
| AD | 2003/11/17 | Manganese (Total) | mg/L (ppm) | APHA 3030e/3120 | 0.01 | 0.21 |
| RM | 2003/11/14 | Bicarbonate | mg/L (ppm) | APHA 2320 | 1 | 385 |
| RM | 2003/11/14 | Carbonate | mg/L (ppm) | APHA 2320 | 1 | < 1 |
| RM | 2003/11/15 | Chloride | mg/L (ppm) | APHA 4110 | 0.1 | 7.0 |
| RM | 2003/11/14 | Fluoride | mg/L (ppm) | APHA 4500F-c | 0.02 | 0.47 |
| RM | 2003/11/14 | Hydroxide (as CaCO3) | mg/L (ppm) | APHA 2320 | 1 | < 1 |
| RM | 2003/11/14 | Nitrate - Nitrogen | mg/L (ppm) | APHA 4110 | 0.05 | < 0.05 |
| RM | 2003/11/14 | Nitrite - Nitrogen | mg/L (ppm) | APHA 4110 | 0.05 | < 0.05 |
| RM | 2003/11/15 | Sulphate | mg/L (ppm) | APHA 4110 | 0.5 | 34.9 |
| RM | 2003/11/14 | Conductivity @ 25°C | mS/cm | APHA 2510 | 0.001 | 0.627 |
| RM | 2003/11/14 | pH @ 25°C | -- | APHA 4500H | 0.01 | 8.29 |
| RM | 2003/11/14 | Turbidity | NTU | APHA 2130-b | 1 | 660 |
| RM | 2003/11/14 | T-Alkalinity as CaCO3 | mg/L (ppm) | APHA 2320 | 1 | 316 |
| RM | 2003/11/18 | T-Dissolved Solids105°C | mg/L (ppm) | APHA 2540-c | 2 | 288 |
|  |  | T-Hardness as CaCO3 | mg/L (ppm) | APHA 2340-b | 6.0 | 100 |
|  |  | Balance (+ions/-ions) | Ratio | APHA 1030-e | 0.01 | 0.97 |

All Analytical results pertain to samples analyzed as received.
APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.
MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

## ANALYTICAL REPORT

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date Received:** 2003/11/14
**Date Sampled:** 2003/11/06
**Date of Report:** 2003/11/27

# Water Analysis - Dissolved Metals

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46103

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | 03-12377 PW03-1 |
|---|---|---|---|---|---|---|
| AD | 2003/11/18 | Aluminum | mg/L (ppm) | APHA 3120 | 0.02 | 1.31 |
| AD | 2003/11/18 | Antimony | mg/L (ppm) | APHA 3120 | 0.002 | < 0.002 |
| AD | 2003/11/18 | Arsenic | mg/L (ppm) | APHA 3120 | 0.005 | 0.006 |
| AD | 2003/11/18 | Barium | mg/L (ppm) | APHA 3120 | 0.03 | 0.35 |
| AD | 2003/11/18 | Beryllium | mg/L (ppm) | APHA 3120 | 0.0005 | < 0.0005 |
| AD | 2003/11/18 | Boron | mg/L (ppm) | APHA 3120 | 0.1 | 0.1 |
| AD | 2003/11/18 | Cadmium | mg/L (ppm) | APHA 3120 | 0.0001 | 0.0002 |
| AD | 2003/11/18 | Calcium | mg/L (ppm) | APHA 3120 | 0.2 | 27.9 |
| AD | 2003/11/18 | Chromium | mg/L (ppm) | APHA 3120 | 0.001 | 0.002 |
| AD | 2003/11/18 | Cobalt | mg/L (ppm) | APHA 3120 | 0.001 | < 0.001 |
| AD | 2003/11/18 | Copper | mg/L (ppm) | APHA 3120 | 0.002 | 0.011 |
| AD | 2003/11/18 | Iron | mg/L (ppm) | APHA 3120 | 0.01 | 1.95 |
| AD | 2003/11/18 | Lead | mg/L (ppm) | APHA 3120 | 0.001 | 0.006 |
| AD | 2003/11/18 | Magnesium | mg/L (ppm) | APHA 3120 | 0.5 | 10.0 |
| AD | 2003/11/18 | Manganese | mg/L (ppm) | APHA 3120 | 0.001 | 0.075 |
| AD | 2003/11/22 | Mercury | mg/L (ppm) | APHA 3112 | 0.0002 | < 0.0002 |
| AD | 2003/11/18 | Molybdenum | mg/L (ppm) | APHA 3120 | 0.001 | 0.052 |
| AD | 2003/11/18 | Nickel | mg/L (ppm) | APHA 3120 | 0.002 | 0.018 |
| AD | 2003/11/18 | Selenium | mg/L (ppm) | APHA 3120 | 0.005 | < 0.005 |
| AD | 2003/11/18 | Silver | mg/L (ppm) | APHA 3120 | 0.0005 | < 0.0005 |
| AD | 2003/11/18 | Sodium | mg/L (ppm) | APHA 3120 | 0.5 | 94.8 |
| AD | 2003/11/18 | Thallium | mg/L (ppm) | APHA 3120 | 0.002 | < 0.002 |
| AD | 2003/11/18 | Titanium | mg/L (ppm) | APHA 3120 | 0.001 | 0.032 |

All Analytical results pertain to samples analyzed as received.
APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.
MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

**ANALYTICAL REPORT**

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date Received:** 2003/11/14
**Date Sampled:** 2003/11/06
**Date of Report:** 2003/11/27

# Water Analysis - Dissolved Metals

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46103

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | 03-12377 PW03-1 |
|---|---|---|---|---|---|---|
| AD | 2003/11/18 | Uranium | mg/L (ppm) | APHA 3120 | 0.01 | < 0.01 |
| AD | 2003/11/18 | Vanadium | mg/L (ppm) | APHA 3120 | 0.001 | 0.005 |
| AD | 2003/11/18 | Zinc | mg/L (ppm) | APHA 3120 | 0.002 | 0.091 |
| AD | 2003/11/18 | pH @ 25°C | -- | APHA 4500H | 0.01 | --- |
|  |  | T-Hardness as CaCO3 | mg/L (ppm) | APHA 2340-b | 6.0 | 111 |

All Analytical results pertain to samples analyzed as received.
APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.
MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

**ANALYTICAL REPORT**

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date of Report:** 2003/11/27

# Quality Control Standard

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46103

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | Analyzed Value | Advisory Range | Target Value | Reference No. |
|---|---|---|---|---|---|---|---|---|---|
| AD | 2003/11/14 | Calcium | mg/L (ppm) | APHA 3120 | 0.5 | 49.3 | 43.3-55.9 | 49.60 | P-CAT-01041 |
| AD | 2003/11/14 | Magnesium | mg/L (ppm) | APHA 3120 | 0.5 | 29.9 | 26.2-34.4 | 30.30 | P-CAT-01041 |
| AD | 2003/11/14 | Potassium | mg/L (ppm) | APHA 3120 | 0.5 | 27.3 | 22.1-29.7 | 25.90 | P-CAT-01041 |
| AD | 2003/11/14 | Sodium | mg/L (ppm) | APHA 3120 | 0.5 | 79.3 | 67.7-82.8 | 75.20 | P-CAT-01041 |
| AD | 2003/11/17 | Iron (Total) | mg/L (ppm) | APHA 3030e/3120 | 0.10 | 0.18 | 0.17-0.23 | 0.20 | P-TM01050 |
| AD | 2003/11/17 | Manganese (Total) | mg/L (ppm) | APHA 3030e/3120 | 0.01 | 0.37 | 0.35-0.43 | 0.39 | P-TM01050 |
| RM | 2003/11/15 | Chloride | mg/L (ppm) | APHA 4110 | 0.1 | 2.8 | 2.7-3.3 | 3.00 | cc-anion-60 |
| RM | 2003/11/14 | Fluoride | mg/L (ppm) | APHA 4500F-c | 0.02 | 5.21 | 4.45-5.44 | 4.94 | W-MIN01110 |
| RM | 2003/11/14 | Nitrate - Nitrogen | mg/L (ppm) | APHA 4110 | 0.05 | 2.21 | 2.03-2.48 | 2.26 | cc-anion-60 |
| RM | 2003/11/15 | Sulphate | mg/L (ppm) | APHA 4110 | 0.5 | 14.1 | 13.5-16.5 | 15.00 | cc-anion-60 |
| RM | 2003/11/14 | Conductivity @ 25°C | mS/cm | APHA 2510 | 0.001 | 0.443 | 0.387-0.473 | 0.04 | W-MIN01110 |
| RM | 2003/11/14 | pH @ 25°C | --- | APHA 4500H | 0.01 | 6.00 | 5.95-6.05 | 6.00 | cc-pH-79 |
| RM | 2003/11/14 | Turbidity | NTU | APHA 2130-b | 1 | 15 | 13.9-18.7 | 16.30 | T-Turb01041 |
| RM | 2003/11/14 | T-Alkalinity as CaCO3 | mg/L (ppm) | APHA 2320 | 1 | 57 | 51-62 | 56.00 | W-MIN01110 |
| RM | 2003/11/18 | T-Dissolved Solids105°C | mg/L (ppm) | ASTM2540c | 1 | 1030 | 805-1345 | 1,075.00 | W-SLD01121 |

All Analytical results pertain to samples analyzed as received.
APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.
MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

## ANALYTICAL REPORT

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date of Report:** 2004/01/07

# Quality Control Standard

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46303

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | Analyzed Value | Advisory Range | Target Value | Reference No. |
|---|---|---|---|---|---|---|---|---|---|
| AD | 2003/12/18 | Aluminum | mg/L (ppm) | APHA 3120 | 0.02 | 0.30 | 0.25-0.35 | 0.30 | P-TM01050 |
| AD | 2003/12/18 | Antimony | mg/L (ppm) | APHA 3120 | 0.002 | 0.076 | 0.055-0.097 | 0.08 | P-TM01050 |
| AD | 2003/12/18 | Arsenic | mg/L (ppm) | APHA 3120 | 0.005 | 0.051 | 0.044-0.067 | 0.06 | P-TM01050 |
| AD | 2003/12/18 | Barium | mg/L (ppm) | APHA 3120 | 0.03 | 0.37 | 0.32-0.38 | 0.35 | P-TM01050 |
| AD | 2003/12/18 | Beryllium | mg/L (ppm) | APHA 3120 | 0.0005 | 0.0593 | 0.0510-0.0690 | 0.06 | P-TM01050 |
| AD | 2003/12/18 | Boron | mg/L (ppm) | APHA 3120 | 0.1 | 0.4 | 0.30-0.45 | 0.38 | P-TM01050 |
| AD | 2003/12/18 | Cadmium | mg/L (ppm) | APHA 3120 | 0.0001 | 0.0875 | 0.076-0.104 | 0.09 | P-TM01050 |
| AD | 2003/12/18 | Calcium | mg/L (ppm) | APHA 3120 | 0.2 | 26.7 | 22.9-29.7 | 26.30 | P-CAT01042 |
| AD | 2003/12/18 | Chromium | mg/L (ppm) | APHA 3120 | 0.001 | 0.334 | 0.280-0.402 | 0.34 | P-TM01050 |
| AD | 2003/12/18 | Cobalt | mg/L (ppm) | APHA 3120 | 0.001 | 0.389 | 0.348-0.452 | 0.40 | P-TM01050 |
| AD | 2003/12/18 | Copper | mg/L (ppm) | APHA 3120 | 0.002 | 0.311 | 0.298-0.351 | 0.33 | P-TM01050 |
| AD | 2003/12/18 | Iron | mg/L (ppm) | APHA 3120 | 0.01 | 0.20 | 0.17-0.23 | 0.20 | P-TM01050 |
| AD | 2003/12/18 | Lead | mg/L (ppm) | APHA 3120 | 0.001 | 0.256 | 0.224-0.307 | 0.27 | P-TM01050 |
| AD | 2003/12/18 | Magnesium | mg/L (ppm) | APHA 3120 | 0.5 | 12.6 | 10.7-14.1 | 12.40 | P-CAT01042 |
| AD | 2003/12/18 | Manganese | mg/L (ppm) | APHA 3120 | 0.010 | 0.376 | 0.353-0.429 | 0.39 | P-TM01050 |
| AD | 2003/12/22 | Mercury | mg/L (ppm) | APHA 3112 | 0.0002 | 0.0343 | 0.0256-0.0424 | 0.03 | P-TM01052 |
| AD | 2003/12/18 | Molybdenum | mg/L (ppm) | APHA 3120 | 0.001 | 0.358 | 0.308-0.432 | 0.37 | P-TM01050 |
| AD | 2003/12/18 | Nickel | mg/L (ppm) | APHA 3120 | 0.002 | 0.307 | 0.282-0.347 | 0.32 | P-TM01050 |
| AD | 2003/12/18 | Selenium | mg/L (ppm) | APHA 3120 | 0.005 | 0.092 | 0.072-0.118 | 0.10 | P-TM01050 |
| AD | 2003/12/18 | Silver | mg/L (ppm) | APHA 3120 | 0.0005 | 0.0601 | 0.0530-0.0720 | 0.06 | P-TM01050 |
| AD | 2003/12/18 | Sodium | mg/L (ppm) | APHA 3120 | 0.5 | 19.9 | 17.6-22.1 | 19.80 | P-TM01042 |
| AD | 2003/12/18 | Thallium | mg/L (ppm) | APHA 3120 | 0.002 | 0.048 | 0.040-0.061 | 0.05 | P-TM01050 |
| AD | 2003/12/18 | Titanium | mg/L (ppm) | APHA 3120 | 0.001 | 0.102 | 0.090-0.110 | 0.10 | QCP-QCS-2 |
| AD | 2003/12/18 | Vanadium | mg/L (ppm) | APHA 3120 | 0.001 | 0.266 | 0.237-0.306 | 0.27 | P-TM01050 |
| AD | 2003/12/18 | Zinc | mg/L (ppm) | APHA 3120 | 0.002 | 0.332 | 0.293-0.376 | 0.34 | P-TM01050 |

All Analytical results pertain to samples analyzed as received.

APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.

MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

## ANALYTICAL REPORT

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date Received:** 2003/12/17
**Date Sampled:** 2003/12/15
**Date of Report:** 2004/01/07

# Water Analysis

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46303

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | 03-13678 PW03-2 |
|---|---|---|---|---|---|---|
| AD | 2003/12/19 | Calcium | mg/L (ppm) | APHA 3120 | 0.5 | 74.1 |
| AD | 2003/12/18 | Magnesium | mg/L (ppm) | APHA 3120 | 0.5 | 27.3 |
| AD | 2003/12/18 | Potassium | mg/L (ppm) | APHA 3120 | 0.5 | 8.4 |
| AD | 2003/12/19 | Sodium | mg/L (ppm) | APHA 3120 | 0.5 | 127 |
| AD | 2003/12/19 | Iron (Total) | mg/L (ppm) | APHA 3030e/3120 | 0.10 | 1.75 |
| AD | 2003/12/19 | Manganese (Total) | mg/L (ppm) | APHA 3030e/3120 | 0.01 | 0.16 |
| RM | 2003/12/17 | Bicarbonate | mg/L (ppm) | APHA 2320 | 1 | 215 |
| RM | 2003/12/17 | Carbonate | mg/L (ppm) | APHA 2320 | 1 | < 1 |
| RM | 2003/12/17 | Chloride | mg/L (ppm) | APHA 4110 | 0.1 | 7.3 |
| RM | 2003/12/17 | Fluoride | mg/L (ppm) | APHA 4500F-c | 0.02 | 0.18 |
| RM | 2003/12/17 | Hydroxide (as CaCO3) | mg/L (ppm) | APHA 2320 | 1 | < 1 |
| RM | 2003/12/17 | Nitrate - Nitrogen | mg/L (ppm) | APHA 4110 | 0.05 | < 0.05 |
| RM | 2003/12/17 | Nitrite - Nitrogen | mg/L (ppm) | APHA 4110 | 0.05 | < 0.05 |
| RM | 2003/12/19 | Sulphate | mg/L (ppm) | APHA 4110 | 0.5 | 391 |
| RM | 2003/12/17 | Conductivity @ 25°C | mS/cm | APHA 2510 | 0.001 | 1.08 |
| RM | 2003/12/17 | pH @ 25°C | -- | APHA 4500H | 0.01 | 8.08 |
| RM | 2003/12/17 | Turbidity | NTU | APHA 2130-b | 1 | 43 |
| RM | 2003/12/17 | T-Alkalinity as CaCO3 | mg/L (ppm) | APHA 2320 | 1 | 176 |
| RM | 2003/12/19 | T-Dissolved Solids105°C | mg/L (ppm) | APHA 2540-c | 2 | 716 |
| AD | 2003/12/19 | T-Hardness as CaCO3 | mg/L (ppm) | APHA 2340-b | 6.0 | 297 |
| AD | 2003/12/19 | Balance (+ions/-ions) | Ratio | APHA 1030-e | 0.01 | 0.98 |

All Analytical results pertain to samples analyzed as received.
APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.
MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

## ANALYTICAL REPORT

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date Received:** 2003/12/17
**Date Sampled:** 2003/12/15
**Date of Report:** 2004/01/07

# Water Analysis - Dissolved Metals

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46303

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | 03-13678 PW03-2 |
|---|---|---|---|---|---|---|
| AD | 2003/12/18 | Aluminum | mg/L (ppm) | APHA 3120 | 0.02 | 0.12 |
| AD | 2003/12/18 | Antimony | mg/L (ppm) | APHA 3120 | 0.002 | 0.005 |
| AD | 2003/12/18 | Arsenic | mg/L (ppm) | APHA 3120 | 0.005 | 0.008 |
| AD | 2003/12/18 | Barium | mg/L (ppm) | APHA 3120 | 0.03 | 0.14 |
| AD | 2003/12/18 | Beryllium | mg/L (ppm) | APHA 3120 | 0.0005 | < 0.0005 |
| AD | 2003/12/18 | Boron | mg/L (ppm) | APHA 3120 | 0.1 | < 0.1 |
| AD | 2003/12/18 | Cadmium | mg/L (ppm) | APHA 3120 | 0.0001 | < 0.0001 |
| AD | 2003/12/18 | Calcium | mg/L (ppm) | APHA 3120 | 0.2 | 73.4 |
| AD | 2003/12/18 | Chromium | mg/L (ppm) | APHA 3120 | 0.001 | < 0.001 |
| AD | 2003/12/18 | Cobalt | mg/L (ppm) | APHA 3120 | 0.001 | < 0.001 |
| AD | 2003/12/18 | Copper | mg/L (ppm) | APHA 3120 | 0.002 | 0.003 |
| AD | 2003/12/18 | Iron | mg/L (ppm) | APHA 3120 | 0.01 | 0.25 |
| AD | 2003/12/18 | Lead | mg/L (ppm) | APHA 3120 | 0.001 | < 0.001 |
| AD | 2003/12/18 | Magnesium | mg/L (ppm) | APHA 3120 | 0.5 | 26.2 |
| AD | 2003/12/18 | Manganese | mg/L (ppm) | APHA 3120 | 0.001 | 0.139 |
| AD | 2003/12/22 | Mercury | mg/L (ppm) | APHA 3112 | 0.0002 | < 0.0002 |
| AD | 2003/12/18 | Molybdenum | mg/L (ppm) | APHA 3120 | 0.001 | 0.106 |
| AD | 2003/12/18 | Nickel | mg/L (ppm) | APHA 3120 | 0.002 | 0.022 |
| AD | 2003/12/18 | Selenium | mg/L (ppm) | APHA 3120 | 0.005 | 0.006 |
| AD | 2003/12/18 | Silver | mg/L (ppm) | APHA 3120 | 0.0005 | < 0.0005 |
| AD | 2003/12/18 | Sodium | mg/L (ppm) | APHA 3120 | 0.5 | 128 |
| AD | 2003/12/18 | Thallium | mg/L (ppm) | APHA 3120 | 0.002 | < 0.002 |
| AD | 2003/12/18 | Titanium | mg/L (ppm) | APHA 3120 | 0.001 | 0.007 |

All Analytical results pertain to samples analyzed as received.
APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.
MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

## ANALYTICAL REPORT

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date Received:** 2003/12/17
**Date Sampled:** 2003/12/15
**Date of Report:** 2004/01/07

# Water Analysis - Dissolved Metals

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46303

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | 03-13678 PW03-2 |
|---|---|---|---|---|---|---|
| AD | 2003/12/18 | Uranium | mg/L (ppm) | APHA 3120 | 0.01 | < 0.01 |
| AD | 2003/12/18 | Vanadium | mg/L (ppm) | APHA 3120 | 0.001 | < 0.001 |
| AD | 2003/12/18 | Zinc | mg/L (ppm) | APHA 3120 | 0.002 | 0.077 |
| AD | 2003/12/18 | pH @ 25°C | -- | APHA 4500H | 0.01 | --- |
| AD | 2003/12/19 | T-Hardness as CaCO3 | mg/L (ppm) | APHA 2340-b | 6.0 | 291 |

All Analytical results pertain to samples analyzed as received.
APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.
MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

**ANALYTICAL REPORT**

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date of Report:** 2004/01/07

# Quality Control Standard

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46303

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | Analyzed Value | Advisory Range | Target Value | Reference No. |
|---|---|---|---|---|---|---|---|---|---|
| AD | 2003/12/19 | Calcium | mg/L (ppm) | APHA 3120 | 0.2 | 28.2 | 22.9-29.7 | 26.30 | P-CAT01042 |
| AD | 2003/12/18 | Magnesium | mg/L (ppm) | APHA 3120 | 0.5 | 12.9 | 10.7-14.1 | 12.40 | P-CAT01042 |
| AD | 2003/12/18 | Potassium | mg/L (ppm) | APHA 3120 | 0.5 | 16.4 | 14.7-20.0 | 17.40 | P-CAT01042 |
| AD | 2003/12/19 | Sodium | mg/L (ppm) | APHA 3120 | 0.5 | 19.8 | 17.6-22.1 | 19.80 | P-TM01042 |
| AD | 2003/12/19 | Iron (Total) | mg/L (ppm) | APHA 3030e/3120 | 0.10 | 0.19 | 0.17-0.23 | 0.20 | P-TM01050 |
| AD | 2003/12/19 | Manganese (Total) | mg/L (ppm) | APHA 3030e/3120 | 0.01 | 0.37 | 0.35-0.43 | 0.39 | P-TM01050 |
| RM | 2003/12/17 | Chloride | mg/L (ppm) | APHA 4110 | 0.1 | 3.1 | 2.7-3.3 | 3.00 | cc-anion-60 |
| RM | 2003/12/17 | Fluoride | mg/L (ppm) | APHA 4500F-c | 0.02 | 5.10 | 4.45-5.44 | 4.94 | W-MIN01110 |
| RM | 2003/12/17 | Nitrate - Nitrogen | mg/L (ppm) | APHA 4110 | 0.05 | 2.25 | 2.03-2.48 | 2.26 | cc-anion-60 |
| RM | 2003/12/19 | Sulphate | mg/L (ppm) | APHA 4110 | 0.5 | 14.2 | 13.5-16.5 | 15.00 | cc-anion-60 |
| RM | 2003/12/17 | Conductivity @ 25°C | mS/cm | APHA 2510 | 0.001 | 0.440 | 0.387-0.473 | 0.04 | W-MIN01110 |
| RM | 2003/12/17 | pH @ 25°C | -- | APHA 4500H | 0.01 | 6.02 | 5.95-6.05 | 6.00 | cc-pH-60 |
| RM | 2003/12/17 | Turbidity | NTU | APHA 2130-b | 1 | 14 | 13.9-18.7 | 16.30 | T-Turb01041 |
| RM | 2003/12/17 | T-Alkalinity as CaCO3 | mg/L (ppm) | APHA 2320 | 1 | 55 | 51-62 | 56.00 | W-MIN01110 |
| RM | 2003/12/19 | T-Dissolved Solids105°C | mg/L (ppm) | ASTM2540c | 1 | 1010 | 805-1345 | 1,075.00 | W-SLD01121 |

All Analytical results pertain to samples analyzed as received.

APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.

MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

4810 - 93 Street
Edmonton, Alberta
Canada T6E 5M4
Tel: (780) 436-2152
Fax: (780) 435-8425

amec

**ANALYTICAL REPORT**

**AMEC Earth & Environmental Ltd**
**913 Laval Crescent**
**Kamloops, BC V2C 5P4**

**Date of Report:** 2003/11/27

# Quality Control Standard

**Attention:** Green, Scott

**Project No.** KX04397

**File No.:** EC-46103

| Analyst | Date of Analysis (yyyy/m/d) | Analytical Parameter | Units | Reference Method | MDL | Analyzed Value | Advisory Range | Target Value | Reference No. |
|---|---|---|---|---|---|---|---|---|---|
| AD | 2003/11/18 | Aluminum | mg/L (ppm) | APHA 3120 | 0.02 | 0.29 | 0.25-0.35 | 0.30 | P-TM01050 |
| AD | 2003/11/18 | Antimony | mg/L (ppm) | APHA 3120 | 0.002 | 0.087 | 0.055-0.097 | 0.08 | P-TM01050 |
| AD | 2003/11/18 | Arsenic | mg/L (ppm) | APHA 3120 | 0.005 | 0.052 | 0.044-0.067 | 0.06 | P-TM01050 |
| AD | 2003/11/18 | Barium | mg/L (ppm) | APHA 3120 | 0.03 | 0.40 | 0.32-0.38 | 0.35 | P-TM01050 |
| AD | 2003/11/18 | Beryllium | mg/L (ppm) | APHA 3120 | 0.0005 | 0.0578 | 0.0510-0.0690 | 0.06 | P-TM01050 |
| AD | 2003/11/18 | Boron | mg/L (ppm) | APHA 3120 | 0.1 | 0.4 | 0.30-0.45 | 0.38 | P-TM01050 |
| AD | 2003/11/18 | Cadmium | mg/L (ppm) | APHA 3120 | 0.0001 | 0.0850 | 0.076-0.104 | 0.09 | P-TM01050 |
| AD | 2003/11/18 | Calcium | mg/L (ppm) | APHA 3120 | 0.5 | 48.5 | 43.3-55.9 | 49.60 | P-CAT-01041 |
| AD | 2003/11/18 | Chromium | mg/L (ppm) | APHA 3120 | 0.001 | 0.324 | 0.280-0.402 | 0.34 | P-TM01050 |
| AD | 2003/11/18 | Cobalt | mg/L (ppm) | APHA 3120 | 0.001 | 0.376 | 0.348-0.452 | 0.40 | P-TM01050 |
| AD | 2003/11/18 | Copper | mg/L (ppm) | APHA 3120 | 0.002 | 0.309 | 0.298-0.351 | 0.33 | P-TM01050 |
| AD | 2003/11/18 | Iron | mg/L (ppm) | APHA 3120 | 0.01 | 0.18 | 0.17-0.23 | 0.20 | P-TM01050 |
| AD | 2003/11/18 | Lead | mg/L (ppm) | APHA 3120 | 0.001 | 0.249 | 0.224-0.307 | 0.27 | P-TM01050 |
| AD | 2003/11/18 | Magnesium | mg/L (ppm) | APHA 3120 | 0.5 | 29.4 | 26.2-34.4 | 30.30 | P-CAT-01041 |
| AD | 2003/11/18 | Manganese | mg/L (ppm) | APHA 3120 | 0.010 | 0.369 | 0.353-0.429 | 0.39 | P-TM01050 |
| AD | 2003/11/22 | Mercury | mg/L (ppm) | APHA 3112 | 0.0002 | 0.0197 | 0.0164-0.0276 | 0.02 | P-TM01051 |
| AD | 2003/11/18 | Molybdenum | mg/L (ppm) | APHA 3120 | 0.001 | 0.362 | 0.308-0.432 | 0.37 | P-TM01050 |
| AD | 2003/11/18 | Nickel | mg/L (ppm) | APHA 3120 | 0.002 | 0.299 | 0.282-0.347 | 0.32 | P-TM01050 |
| AD | 2003/11/18 | Selenium | mg/L (ppm) | APHA 3120 | 0.005 | 0.099 | 0.072-0.118 | 0.10 | P-TM01050 |
| AD | 2003/11/18 | Silver | mg/L (ppm) | APHA 3120 | 0.0005 | 0.0589 | 0.0530-0.0720 | 0.06 | P-TM01050 |
| AD | 2003/11/18 | Sodium | mg/L (ppm) | APHA 3120 | 0.5 | 77.6 | 67.7-82.8 | 75.20 | P-CAT-01041 |
| AD | 2003/11/18 | Thallium | mg/L (ppm) | APHA 3120 | 0.002 | 0.047 | 0.040-0.061 | 0.05 | P-TM01050 |
| AD | 2003/11/18 | Titanium | mg/L (ppm) | APHA 3120 | 0.001 | 0.103 | 0.090-0.110 | 0.10 | QCP-QCS-2 |
| AD | 2003/11/18 | Uranium | mg/L (ppm) | APHA 3120 | 0.01 | 0.11 | 0.090-0.110 | 0.10 | T-U01056 |
| AD | 2003/11/18 | Vanadium | mg/L (ppm) | APHA 3120 | 0.001 | 0.261 | 0.237-0.306 | 0.27 | P-TM01050 |
| AD | 2003/11/18 | Zinc | mg/L (ppm) | APHA 3120 | 0.002 | 0.319 | 0.293-0.376 | 0.34 | P-TM01050 |

All Analytical results pertain to samples analyzed as received.

APHA: Standard Method for the Examination of Water and Wastewater, 1998. 20th Ed. American Public Health Association.

MDL - Method Detection Limit

Report reviewed by:

James A. LeBlanc, B.Sc., P.Chem.
QA/QC Manager
Laboratory Services

Brenda Chomin, P.Chem.
Manager
Laboratory Services

AMEC Earth & Environmental Limited has been certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. for specific tests registered with the Association.

** All samples will be disposed of after 30 days following analysis. Please contact the lab if you require additional sample storage time. (Samples deemed hazardous will be returned to the client at their own expense or disposal will be arranged.) **

## Limitations

1. The work performed in this report was carried out in accordance with the Standard Terms and Conditions made part of our contract. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract.

2. The report has been prepared in accordance with generally accepted engineering practices. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our contract and included in this report.

3. The services performed and outlined in this report were based upon interpretation of data collected at ten piezometers and two pumping wells. Interpretations made from data collected at these locations are for these locations. Our opinion cannot be extended to portions of the site not investigated.

4. The objective of this report was to assess hydrogeological conditions at the location indicated, within the context of our contract and generally accepted engineering principles.

5. Our observations relating to the subsurface conditions at the site are described in this report. It should be noted that subsurface conditions other than those described in this report could be present.

6. The conclusions of this report are based in part on the information provided by others. The possibility remains that unexpected subsurface conditions may be encountered at the site in locations not specifically investigated. Should such an event occur, AMEC Earth & Environmental must be notified in order that we may determine if modifications to our conclusions are necessary.