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TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DRAFT FOR REVIEW

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EXECUTIVE SUMMARY

AMEC Earth & Environmental, a division of AMEC Americas Limited, conducted a trial dewatering test between November 2007 and May 2008 on behalf of the City of Quesnel as part of the ongoing West Quesnel Land Stability Program. The purpose of the trial was to examine dewatering options in two stratigraphic units in the slide area using two different methods: vertical pumping wells and horizontal drains. Findings in previous reporting suggested that regional groundwater pressure reductions on the order of single metres may result in significant reductions in the average slide movement rate.

The vertical pumping well trial involved the installation of two new wells to depths of 31 m and 61 m, and reconfiguration of two existing wells installed to depths of 55 m and 61 m. All wells were instrumented to monitor flow and water levels throughout the tests. Four (4) horizontal drains were installed by a specialty contractor to lengths ranging from 46 m to 136 m, for a combined total length of 294 m. Fifteen (15) additional vibrating wire piezometers (VWP) were installed in holes drilled at nine new sites to supplement the existing instrument network to monitor the progress of the trial dewatering. The entire trial dewatering instrumentation system was connected to dataloggers and the data downloaded remotely via cellular modems.

The trial dewatering test removed a total of almost 5.7 million litres of water through the test period. 90% of the total was extracted by vertical pumping at the PW4 test well on Panagrot Ave, 9% of the total drained by gravity from 2 horizontal drains at the west end of Avery Ave, and the remaining 1% was extracted at the remaining test sites. Observations of drawdown at each pumped well test site were recorded through the monitoring well network, and appeared to have general trends related to stratigraphy and/or location on the slide. Pumping wells in the underlying Tertiary clay near the toe of the slide had only a marginal effect. At distances beyond 500 m from the toe of the slide, however, drawdowns of almost 2 m were achieved at a distance of 50 m from a well in Tertiary sediments. Drawdown and well production in the sand and gravel unit were significant and indicated drawdowns of 2 m could be achieved with the test equipment at a 50 m radius. The variations in drawdown and well production with geology were as expected. Horizontal drains had marginal effects on groundwater pressures, but moved significant volumes of water, and were considered successful.

The results of the tests indicate that a combined pumped well and horizontal drain dewatering system could produce favourable results for a regional depressurization of at least 2 m, using pumps in the upper portions of the slide and horizontal drains in the lower, high-relief areas. Note that the drawdowns observed in the test were not considered to be at equilibrium, and are expected to grow with time. Additional work in future phases of the study will look at overall water balance and evaluate whether the extracted water is stored water, or if it is being recharged.

AMEC recommends that the City of Quesnel proceed with the detailed design of a full-scale production dewatering system. The system should include a phased roll-out of horizontal drains and pumps, complete with monitoring instrumentation and data collection. The full-scale system must also be combined with ongoing monitoring of climate data and higher-resolution (in-place digital equipment) slide movement data to provide comparisons against the projected baseline movement trends.

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1.0 INTRODUCTION

AMEC Earth & Environmental, a division of AMEC Americas Limited, (AMEC) has carried out a trial dewatering program at West Quesnel as part of the ongoing West Quesnel Land Stability Program. The purpose of the trial dewatering program was to investigate potential options for groundwater pressure reductions in the upper fluvial sedimentary sequence and the lower Tertiary sediments in a previously identified landslide area. The investigation focused on evaluating changes in groundwater pressures by:

1. Pumping water from vertical wells installed and sealed in glaciofluvial deposits that overly the Tertiary sediments.
2. Pumping water from vertical wells installed and sealed in Tertiary sediments.
3. Installing a horizontal drain into glaciofluvial deposits that overly the Tertiary sediments.
4. Installing a horizontal drain into the Tertiary sediments.

The results of the trial dewatering program were intended to provide ranges of values, relating to the potential magnitude and rate of change in groundwater pressures that each system may provide so there is a quantitative basis to design a larger scale dewatering system throughout the landslide area. Key parameters in the quantitative analyses include the zone of influence at each test site, rate of depressurization, and the magnitude of potential changes that may be effected in the different geological units.

The following provides the results of the trial dewatering program and provides recommendations for the next stage of dewatering/depressurization efforts in the West Quesnel area.

2.0 BACKGROUND

For detailed background information including geology and project history, the reader is referred to a previous AMEC West Quesnel Land Stability Program Report dated May 2007[1].

3.0 TRIAL DEWATERING PROGRAM DESIGN

3.1 SITE SELECTION

Site selection for the trial vertical pumping wells and horizontal drains was based on topographic and geological requirements, constructability and site access, dewatering method, and proximity to existing infrastructure. Pumping well and horizontal drain locations are shown on Figure 1. Topography generally controlled the allowable locations for the selection of horizontal drain sites. Geology and proximity to suitable services and discharge locations controlled site selection for the vertical pumping wells.

[1] AMEC Earth & Environmental, May 2007. West Quesnel Land Stability Study (2 Volumes) – DRAFT – 47pp.

3.2 METHODS

Two basic methods of water extraction were used in the trial dewatering program: vertical pumping wells (four installations) and horizontal drains (four drains at a total of two locations). Vertical wells consist of standard steel-cased wells with screened sections and well pumps. Such wells can be installed by most local or regional water well contractors with suitable equipment and experience. Horizontal drains consist of small diameter screened PVC pipes installed in near horizontal drill holes that capture water through screened sections (as with wells), but discharge to the surface by gravity. Horizontal drain installations require specialized contractors and equipment not generally locally available in the Quesnel region.

The objective of the trial vertical pumping wells was to maintain a constant minimum drawdown of the water level in the wells and then determine the growth of the zone of influence (drawdown of water pressures around the wells) with time. The zone of influence can also be described as the well capture zone, and can be assumed to be a hyperbolic cone shaped depression in the surrounding groundwater level. The development of the zone of influence allows for estimates of the bulk hydrogeological properties; parameters necessary to establish production well spacing. Monitoring wells completed using grouted-in-place standpipes equipped with vibrating wire piezometers (VWP) or VWP grouted directly in place to provide remote head readouts were located adjacent to the pumping wells to allow measurement of the zone of influence versus time. Well installation details are shown on Figures 2A to 2D, attached.

The objective of the horizontal drains was similar to the vertical wells, although the measurement and interpretation of the zone of influence of a small number of drains is more difficult and uncertain than for vertical wells. Ultimately the monitoring of potential drain production (flow volume) proved to be the most effective evaluation method. Flow was monitored at the drain outlet using paddlewheel flow meters and by taking manual flow measurements. Upstream monitoring wells were installed near the furthest extent of the drains to track changes in groundwater pressures. Horizontal drain installation details are shown on Figures 2E and 2F.

Water discharged from the trial pumping wells and horizontal drains was directed to existing storm or sewer drains to reduce the potential for re-entry of water into the local groundwater system and to keep surface flow patterns as consistent as possible throughout the test period.

Dataloggers were installed at the four pumping well locations and both horizontal drain locations to efficiently collect and store data including flow rates from pumping wells, water levels in the wells, water and air temperature, groundwater pressure at monitoring locations, and barometric pressure. Remote monitoring was enabled by installing cellular modems at the datalogger locations. The remote methods significantly reduced travel and manual data collection expense, reduced trouble-shooting time and expense due to the availability of high quality data, and allowed for near real-time performance evaluations of the system. See Figures 2A to 2F for typical datalogger installation details.

4.0 INSTALLATION OF TRIAL DEWATERING EQUIPMENT

Selected photos of equipment installations are provided in Appendix A.

4.1 PUMPING WELLS

A total of four (4) pumping well sites were evaluated during the trial dewatering program. Two pumping wells, PW1 near Flamingo Street and PW2 near Abbott Drive, were originally drilled for a limited 2003 dewatering test and were re-initiated for the 2007-2008 trial dewatering program. Two new pumping wells, PW4 at Panagrot Street and PW5 at Adams Street, were drilled in June 2007. Well locations are provided on Figure 1. Borehole logs and well completion details are provided in Appendix B. The following discussion provides details for each of the four pumping wells.

4.1.1 PW1

PW1 was drilled to a total depth of 54.9 m by Cariboo Water Wells (CWW) on 16 September 2003. The well includes a screen between 29.9 m and 47.5 m depth across the Tertiary sediments and may also have a hydraulic connection to overlying, younger glaciolacustrine fine grained sediments. Due to ground movements between 2003 and 2007, the well casing had been displaced at a depth of 46.9 m and the original pump that was in place since 2003 was not retrievable. The well was retrofitted with new equipment prior to the start of the trial dewatering program as follows:

- Ingram Well and Pump Service (IWPS) acidized the well on 22 September 2007 to reduce clogging and installed a new 75 mm diameter 0.75 horsepower (hp) pump, above the shear zone at 45 m depth.
- IWPS and City of Quesnel staff connected a 25 mm discharge line from the well into a storm drain located below Flamingo Street.
- IWPS connected electronic level controls at depths of 41.6 m and 44.0 m to activate and terminate pumping cycles and installed an 18.75 mm paddlewheel flow meter, 0.30 m below a pit-less adapter in the well, to monitor flow rates.
- The pump was restricted to a pumping rate of approximately 15 L/min with an inline restrictor installed near the pit-less adaptor.
- A 25 mm diameter PVC casing housing a VWP was installed to a depth of 44.3 m, at the direction of AMEC staff, during the pump installation to monitor water level readings in the pumping well.

Pumping was initiated on 13 December 2007 at this site.

4.1.2 PW2

PW2 was drilled to a total depth of 61.0 m by CWW on 18 September 2003. The well is screened from 30 m to 55 m depth through the Tertiary sediments. The pump originally installed in 2003 was recovered, however, it was deemed unusable by IWPS due to irreparable damage sustained from prolonged submergence in the well without running. As observed at PW1, displacements in the well casing between 2003 and 2007 prevented the use of the well casing below the shear zone at about 45.4 m depth. The well was retrofitted with new equipment prior to the start of the trial dewatering program as follows:

- IWPS acidized the well on 23 September 2007 to reduce clogging and installed a new 75 mm diameter 0.75 hp pump at 43.0 m depth, above the shear zone.

- IWPS and City of Quesnel staff connected a 25 mm discharge line to a storm drain located adjacent to PW2.
- IWPS connected electronic level controls at 39.3m and 42.1 m depths to activate and terminate pumping cycles and installed an 18.75 mm paddlewheel flow meter, 0.46 m below a pit-less adapter in the well, to monitor flow rates.
- The pump was restricted to a pumping rate of approximately 15 L/min with an inline restrictor installed near the pit-less adaptor.
- A 25 mm diameter PVC casing housing a VWP was installed to a depth of 42.4 m, at the direction of AMEC staff, during the pump installation to monitor water level readings in the well.

Pumping was initiated on 23 October 2007 at this site.

4.1.3 PW4

PW4 was drilled to a total depth of 30.5 m by CWW in 27 June 2007 and was completed using 125 mm diameter slotted PVC well screen that was installed between depths of 6.1 m and 30.5 m. The well extended through a previously identified, water-bearing, shallow glaciofluvial sequence and consequently it was expected to produce significant amounts of water due to the coarse grained nature of the geological unit. The well was fitted with equipment intended to handle higher water flows as follows:

- IWPS initially installed a 100 mm diameter, two (2) hp pump at a depth of 29.0 m. The 25 mm diameter PVC discharge pipe was tied into an adjacent sanitary sewer line, as the storm water system did not extend to this area of the neighborhood. IWPS and City of Quesnel staff completed the sewer tie-in. Based on operational conditions at this well, it was determined that additional room for cooling was required between the pump and the well screen. The original 100 mm diameter pump was replaced with a 75 mm diameter model.
- IWPS also connected electronic water level controls at 25.9 m and 28.5 m depths to activate and terminate pumping cycles. A 25 mm diameter inline paddle wheel flow meter was installed in the discharge line, 0.61 m below the pit-less adapter, to monitor flow rates.
- The pump was restricted to a pumping rate of approximately 75 L/min with an inline restrictor installed near the pit-less adaptor.
- A 25 mm diameter PVC casing housing a VWP was installed to a depth of 28.3 m at the direction of AMEC staff, during the pump installation, to monitor water level readings in the well.

Pumping was initiated on 1 January 2008 at this site.

4.1.4 PW5

PW5 was drilled to a total depth of 61.0 m by CWW on 26 June 2007 and was completed using 125 mm slotted PVC well screen between depths of 42.7 m and 61 m. The well extended through near surface glaciofluvial and glaciolacustrine sediments overlying the tertiary sequence. The well was sealed into the underlying tertiary sediments. The well was fitted with equipment suited for the expected low-flow conditions from the tertiary sediments as follows:

- IWPS acidized the well on 23 September 2007 to reduce clogging.
- IWPS followed-up by installing a 100 mm three-quarter (0.75) hp pump at 58.5 m depth and directed the 25 mm diameter PVC discharge line into an adjacent storm drain. IWPS and City of Quesnel staff completed the tie-in to the nearby storm drain.
- IWPS connected electronic water level controls at 55.8 m and 57.6 m depths to activate and terminate pumping cycles and installed an 18.75 mm diameter inline paddle wheel flow meter in the discharge line, 0.61 m below a pit-less adapter in the well, to monitor flow rates.
- The pump was restricted to a pumping rate of approximately 15 L/min with an inline restrictor installed near the pit-less adaptor.
- A 25 mm diameter PVC casing housing a VWP was installed to a depth of 57.9 m, at the direction of AMEC staff, during the pump installation, to monitor water level readings in the well.

Pumping was initiated on 24 October 2007 at this site.

4.2 HORIZONTAL DRAINS

Jensen Drilling Company, of Eugene, Oregon, was retained to drill and install horizontal drains at two test sites (HD1 and HD4). Two horizontal drains were completed at each of the locations between 31 October and 4 November 2007. The completion dates mark the effective start of the trial dewatering program at these sites. See Figure 1 for horizontal drain locations.

Prior to drilling, City of Quesnel staff prepared gravel working pads, drill fluid sumps, and a short vertical face in the ground for drill entry, at each of the test sites. Following the drilling, City staff returned to clean-up and deactivate the sumps and recontour the work area.

4.2.1 HD1

Horizontal drain site HD1 is located west of Lewis Drive near the Sikh Temple. A total of 112.8 m of drain pipe was installed in two drains (HD1A and HD1B).

HD1A was drilled at an azimuth of 271° and inclination of +2° (using a convention where positive inclination indicates up and negative is down) to a total length of 64.0 m, well short of the target length of 111 m. A 37.5 mm diameter slotted PVC pipe was installed in the borehole prior to retracting the drill stem and a bentonite seal was installed at the drain outlet. Difficult drilling in coarse sediments (gravel) is suspected to be the cause of the shorter than expected length.

HD1B was drilled from the same general entry point at an azimuth of 241° at an inclination of +1° with a total drain length of 48.8 m. A 37.5 mm slotted PVC pipe was installed and the outlet was completed as noted above in HD1A. The shorter installation depth was a result of contractual lengths, not ground conditions.

The drain pipes did not produce water and a drain tie-in was not completed. The drain outlets were covered with granular backfill. Future work in the area should tie these drains to a common point in a manhole, to allow for observation in the event that the drains begin producing water.

4.2.2 HD4

Horizontal drain site HD4 is located approximately 30 m southwest of PW5 opposite the west end of Avery Avenue. A total of 181.4 m of drain was installed in two individual horizontal drains (HD4A and HD4B).

HD4A was drilled at an azimuth of 271° and inclination of +2° to a total length of 135.6 m. A 37.5 mm slotted PVC pipe was installed and the outlet was completed as noted above in HD1A.

HD4B was drilled from the same general entry point as HD4A at an azimuth of 271° and an inclination of -2° with a total drain length of 45.7 m. A 37.5 mm slotted PVC pipe was installed and the outlet was completed as noted above in HD1A.

City of Quesnel staff constructed a concrete base and placed concrete manhole barrels at the HD4 drain outlet. A PVC manifold was plumbed and fixed to the two drain outlets to allow for individual and combined flow measurements. A paddle wheel flow meter was installed at the outlet, then and trenched and connected to the datalogger at PW5. 110V electrical power was connected to the drain outlet from PW5 to power heat tape installed at the drain outlet to maintain ice free operations throughout the winter months. The discharge water was connected by City of Quesnel Staff to a sanitary sewer line below Adams Street.

4.3 MONITORING WELLS

A total of 15 VWP's were installed prior to the start of the test program in nine (9) new boreholes (BH-17 through 25), advanced between 6 July and 24 July 2007 by Geotech Drilling Services (Geotech) using ODEX and wet rotary drilling methods. Borehole locations are shown on Figure 1. As noted above, the boreholes were instrumented with vibrating wire piezometers to monitor water level changes during the trial dewatering period. The VWP cables were extended to centralized datalogger locations through underground 25 mm conduits. Trenched conduit locations are included on the detail drawings included on Figures 2A to 2F. Borehole logs and piezometer completion details are provided in Appendix B. Table 1 presents a summary of the new boreholes and related equipment.

TABLE 1 – Summary of New Boreholes and Related Instrumentation

BH #	ASSOCIATED PW OR HD SITE	RELATIVE POSITION FROM HD OR PW, AND/OR LOCATION	VWP DEPTHS		DATALOGGER LOCATION
			A	B	
17	PW5	5.5 m northeast of PW5 on dirt lane	37.7 m	57.4 m	PW5
18	PW5	30.2 m northeast of PW5 on dirt lane	38.2 m	60.1 m	PW5
19	PW4	5.3 m west of PW4 on Panagrot Ave	16.5 m	22.3 m	PW4
20	PW4	48.1 m west of PW4 on Panagrot Ave	21.4 m	N/A	PW4
21	HD4	Near corner of Hawk St and Crane St	12.6 m	21.3 m	BH21
22	HD4	Crane St., 50 m west of BH21	18.3 m	N/A	BH21
23	HD1	Slope crest in lane north of Baity Avenue	22.4 m	33.1 m	BH23
24	HD1	8 m west of BH23 in lane	22.9 m	N/A	BH23
25	HD1	65 m west of BH23 in lane	16.8 m	30.2 m	BH23

Four (4) standpipe piezometers completed in 2003 were retrofitted for the Trial Dewatering Program using small diameter VWP's, such that water level data could be captured by the nearby dataloggers. In addition to the standpipes, the VWP at BH3, originally installed in 2001, was connected to a new datalogger, to provide additional head measurements. Table 2 presents a summary of the retrofitted piezometers included in the evaluation of the trial dewatering program.

TABLE 2 – Summary of Retrofitted Previous Sites and Related Instrumentation

BH #	ASSOCIATED PW OR HD SITE	RELATIVE POSITION FROM HD OR PW, AND/OR LOCATION	VWP DEPTH	ORIGINAL WELL TYPE	DATALOGGER LOCATION
BH3B	PW1	Nested install 12.0 m east of PW1 in lane	40.0 m	Standpipe	PW1
BH3C	PW1	Nested install 12.0 m east of PW1 in lane	31.0 m	Standpipe	PW1
BH4A	PW1	Nested install 48.7 m east of PW1 in lane	40.0 m	Standpipe	PW1
BH4B	PW1	Nested install 48.7 m east of PW1 in lane	23.0 m	Standpipe	PW1
BH3	PW2	Corner of Abbott/Betcher, 8.4 m from PW2	37.5 m	VWP	BH21

4.4 REMOTE MONITORING EQUIPMENT

Dataloggers and cellular phone modems were installed at all four pumping well locations and both of the horizontal drain monitoring locations, to allow collection of data at short sample intervals, pre-processing of frequency-pressure relationships, (reduction of on-site data collection requirements for on-site data collection), and for near real-time monitoring of pumping cycles and water pressures. Access to near real-time data allowed for remote trouble shooting and system reconfigurations throughout the test program that led to significant savings in field engineering time.

Campbell Scientific supplied CR800 and CR1000 dataloggers capable of storing data received from VWP's and flow meters. The dataloggers are housed in plastic cases enclosed in metal boxes supplied by the City of Quesnel. The dataloggers are connected to 110V electrical power with battery back-up power.

Raven cellular modems, supplied by Thinktel Communications of Edmonton, Alberta, were activated on the Bell Mobility Network and connected to the dataloggers. The cellular modems provide an online link via IP addresses and the internet to data stored in the dataloggers. This data can be downloaded automatically from any computer with proper software, from anywhere there is access to the internet.

Electrical components installed in the metal boxes were supplied and installed by Service Electric Ltd., of Quesnel, B.C. Electrical components in each box consist of a circuit breaker panel, up to four 110V power outlets, and pump level controls at pumping well locations.

4.5 ELECTRICAL CONNECTIONS FOR PUMPS & REMOTE MONITORING EQUIPMENT

The City of Quesnel and Service Electric Ltd. worked with BC Hydro to connect 110V electrical power to the four pumping well locations and two horizontal drain monitoring locations.

5.0 DATA AND INTERPRETATION OF HYDROGEOLOGIC PROPERTIES

AMEC reviewed the water level and flow rate data from the pumping wells, collected between 23 October 2007 and 30 April 2008, piezometric response throughout the test period, and flow rates from the horizontal drains. The data collected from the instrumentation network is included in Appendix C, attached. The following presents the results of the program.

5.1 PUMPING TEST SUMMARY

Four wells (PW-1, PW-2, PW-4 and PW-5) were pumped during the test period noted above. Due to the well spacing, each test area affected a local cluster of monitoring wells near each pumping well. This allows for the data from each test site to be interpreted discretely, based on the assumption that drawdown in each monitoring well was created solely by the nearby pumping well and not by other pumping wells in West Quesnel. It was further assumed that the variations in head at the monitoring wells were produced solely by the pumping well. This is considered a suitable assumption, as typical short-term trends in most areas are typically less than 0.5 m. Higher variations occur over long-term data.

A summary of monitoring wells located adjacent to each pumping well and the pumping period is provided in Table 3.

Table 3 - Pumping Test Summary

PUMPING WELL	PUMPING PERIOD			ADJACENT MONITORING WELLS
	From	To	Duration (days)	
PW-1	13 December 2007	30 April 2008	139	BH-3B, BH-3C, BH-4A, BH-4B
PW-2	24 October 2007	30 April 2008	190	BH-3
PW-4	10 January 2008	6 April 2008	87	BH-12A, BH-12B, BH-12C, BH-12D, BH-19A, BH-19B, BH-20
PW-5	25 October 2007	29 April 2008	187	BH-17A, BH-17B, BH-18A, BH-18B

Pumping from PW-1 and PW-2 was characterized by an initial one or two day period of continuous pumping at progressively decreasing pumping rates. During initial pumping the well casing storage was removed and the head in the well was lowered significantly. Thereafter, the pumping rate from PW-1 fluctuated between 108 and 135 litres/day. The pumping rate from PW-2 fluctuated between 33 and 66 litres/day for about 60 days and eventually became constant at about 33 litres/day. Pumping from PW-5 occurred during nine discrete daily pumping events. Approximately 460 litres was discharged from PW-5 during the first day of pumping followed by 46 litres/day during eight subsequent days spaced over the 187 day test period.

Pumping from PW-4 was distinctly different from pumping at the other wells in that the discharge rate was variable and progressively decreased throughout the test period. As a consequence of the variable pumping rate, the data was initially interpreted using the Aron-Scott solution of the modified non-equilibrium equation for pumping, with a progressively decreasing pumping rate. However, this interpretation was not considered representative, as the data did not satisfy the condition ($r^2S/4Tt_n<0.01$), where **r** (m) is the distance between the monitoring well and the pumping well, **S** (unitless) is the aquifer storativity, **T** (m^2/day) is the aquifer transmissivity and $\mathbf{t_n}$ is the elapsed time (days) since pumping began. As such, PW-4 pumping test data was interpreted in the same way as pumping test data collected at PW-1, PW-2, and PW-5.

5.2 INTERPRETATION OF PUMPING TEST RESULTS

5.2.1 Constant Rate Pumping

Pumping test curves for each pumping well and associated monitoring wells are presented in Appendix D. No discernable de-watering trends were observed at the following monitoring wells: BH-4B, adjacent to PW-1; BH-19A; BH-19B (dry prior to the test, due to pumping trials and pre-test equipment operations); BH-12D adjacent to PW-4; and BH-18A, and BH-18B, adjacent to PW-5.

Monitoring wells adjacent to PW-1, PW-2, and PW-5 that showed discernable de-watering trends also showed some water level recovery during the late stages of the test period. The recovery is attributed to general seasonal (spring) groundwater level increases and equipment problems in specific cases, such as PW1. The start time of recorded water level recovery was different for each monitoring well, as presented in Table 4.

Although recovery was also observed in monitoring wells adjacent to PW-4 (BH-12A, BH-12B, BH-12C, and BH-20), these monitoring wells are not included in Table 4, since it is conceivable that the variable pumping rate at this site could have affected some recovery observed in these wells.

Table 4 -Start Time of Recorded Water Level Recovery in Monitoring Wells

MONITORING WELL	ASSOCIATED PUMPING WELL	APPROXIMATE ELAPSED TIME OF START OF RECOVERY (MINUTES)	DATE
BH-3B	PW-1	233280	11 April 2008
BH-3C		221760	3 April 2008
BH-4A		188640	11 March 2008
BH-4B		200160	19 March 2008
BH-3	PW-2	178560	4 March 2008
BH-17A	PW-5	230400	1 April 2008
BH-17B		230400	1 April 2008

The groundwater discharge data collected from the pumping wells, shown in Table 4, suggests that some external influence, other than a change in pumping rate is responsible for the recovery observed in the monitoring wells. The fact that the observed water level recovery took place during March and April, a period when West Quesnel typically experiences warmer air temperatures, suggests that the recovery was a consequence of infiltration of snow melt into the subsurface.

The fact that water level recovery at BH-17A and BH-17B began on the same date (see Table 4), suggests that the vibrating-wire pressure transducers are installed in the same geologic formation or in formations in hydraulic communication with each other.

An average pumping rate was derived for each pumping well by calculating the total volume of groundwater discharged during the test period divided by the number of days in the test period. This was taken as a constant pumping rate in the subsequent analyses. Using this method, the calculated pumping rates are summarized on Table 5.

Table 5 - Calculated Constant Pumping Rates

PUMPING WELL	CALCULATED CONSTANT PUMPING RATES		
	Usgpm	Litres/day	m^3/day
PW-1	0.024	130	0.13
PW-2	0.0062	33	0.033
PW-4	5.5	29,660	29.7
PW-5	0.00096	5.2	0.005

Based on these constant flow rates, the formation transmissivities adjacent to the monitoring wells were estimated using the Cooper-Jacob solution of the modified non-equilibrium equation:

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

T is the transmissivity (m^2/day), **Q** is the pumping rate (m^3/day), and **Δs** is the drawdown (m) over one log cycle, determined graphically from a straight-line projection of the drawdown curve on the semi-logarithmic graph. Interpreted straight-line projections of the drawdown curve are presented for each monitoring well, showing a discernable de-watering trend, in Appendix D.

The aquifer storativity is estimated by the Cooper-Jacob soluction using the following formula:

$$S=(2.25Tt_o)/r^2$$

where **S** (unitless) is the aquifer storativity, **T** is the transmissivity (m^2/day), **r** is the distance (m) between the pumping well and the monitoring well, and $\mathbf{t_0}$ is the time of zero drawdown (days) determined graphically.

5.2.2 Distance-Drawdown Interpretation

Distance-drawdown graphs for constant-discharge test data are presented in Appendix D. An independent interpretation of aquifer transmissivity and storativity can be determined from constant-discharge test data, using distance-drawdown graphs and a transformation of the Cooper-Jacob solution of the following modified non-equilibrium formula.

$$T=0.366Q/\Delta s$$

T is the transmissivity (m^2/day), **Q** is the pumping rate (m^3/day), and $\mathbf{\Delta s}$ is as the drawdown (m) over one log cycle determined graphically from a straight-line projection of the distance-drawdown curve on a semi-logarithmic graph.

An independent interpretation of the aquifer storativity by the Cooper-Jacob solution and the interpreted aquifer storativity from the distance-drawdown data is estimated using the following formula:

$$S=(2.25Tt)/r_0^2$$

S (unitless) is the aquifer storativity, **T** is the transmissivity (m^2/day) interpreted from the distance-drawdown graph, **t** is the time unit since pumping started at which the distance-drawdown graph was generated, $\mathbf{r_0}$ the distance from the pumping well where there is zero drawdown (m), determined graphically from the distance drawdown graph.

5.3 INTERPRETED TRANSMISSIVITIES

Interpreted aquifer transmissivities are presented in Table 6.

Table 6 - Interpreted Aquifer Transmissivities

MONITORING WELL	ASSOCIATED PUMPING WELL	INTERPRETED AQUIFER TRANSMISSIVITY (M^2/DAY)	DATA SET USED
BH-3B	PW-1	0.0034	Time-Drawdown
		0.0025	Distance-Drawdown
BH-3C		0.0029	Time-Drawdown
		0.0042	Distance-Drawdown
BH-4A		0.010	Time-Drawdown
		-	Distance-Drawdown
BH-3	PW-2	0.0086	Time-Drawdown
BH-12A	PW-4	3.4	Time-Drawdown
		1.5	Distance-Drawdown
BH-12B		3.4	Time-Drawdown
		1.5	Distance-Drawdown
BH-12C		3.4	Time-Drawdown
		-	Distance-Drawdown
BH-20		5.9	Time-Drawdown
		-	Distance-Drawdown
BH-17A	PW-5	0.00088	Time-Drawdown
		0.0036	Distance-Drawdown
BH-17B		0.00049	Time-Drawdown
		0.0018	Distance-Drawdown

Where no transmissivity is provided in Table 6, the interpreted transmissivity was either not considered representative or could not be estimated based on the available data set. At BH-3, a representative interpretation of the aquifer transmissivity, based on distance-drawdown data, could not be developed since data was collected from only one monitoring well adjacent to PW-2. The transmissivities interpreted based on time-drawdown data, were generally consistent with transmissivities interpreted based on distance-drawdown data, with the exception of transmissivities interpreted at BH-17B, where the transmissivity between the two data sets differ by almost an order of magnitude. This discrepancy may be related to the low discharge rates at PW-5. Aquifer transmissivities adjacent PW-4 were three orders of magnitude higher than at locations tested elsewhere in West Quesnel.

As might be expected from the formations found during drilling, the aquifer transmissivity is highest adjacent to PW-4 (2.7 m^2/day at BH-20) and lowest adjacent to PW-5 (0.00049 m^2/day at BH-17B).

5.4 INTERPRETED STORATIVITIES

Interpreted aquifer storativities are presented in Table 7.

Table 7 - Interpreted Aquifer Storativities

MONITORING WELL	ASSOCIATED PUMPING WELL	INTERPRETED AQUIFER STORATIVITY (UNITLESS)	DATA SET USED
BH-3B	PW-1	1.7×10^{-4}	Time-Drawdown
		3.3×10^{-4}	Distance-Drawdown
BH-3C		9.7×10^{-4}	Time-Drawdown
		3.4×10^{-4}	Distance-Drawdown
BH-4A		1.3×10^{-4}	Time-Drawdown
		-	Distance-Drawdown
BH-3	PW-2	3.3×10^{-3}	Time-Drawdown
BH-12A	PW-4	8.5×10^{-5}	Time-Drawdown
		1.0×10^{-1}	Distance-Drawdown
BH-12B		4.3×10^{-4}	Time-Drawdown
		1.0×10^{-1}	Distance-Drawdown
BH-12C		1.1×10^{-2}	Time-Drawdown
		-	Distance-Drawdown
BH-20		1.3×10^{-3}	Time-Drawdown
		-	Distance-Drawdown
BH-17A	PW-5	1.4×10^{-3}	Time-Drawdown
		7.0×10^{-4}	Distance-Drawdown
BH-17B		1.1×10^{-3}	Time-Drawdown
		5.2×10^{-4}	Distance-Drawdown

Where no storativity is provided in Table 7, the interpreted storativity was either not considered representative or could not be estimated based on the available data set. At BH-3, a representative interpretation of the aquifer storativity based on distance-drawdown data could not be developed, since data was collected from only one monitoring well, adjacent PW-2.

5.5 SUMMARY OF HORIZONTAL DRAINS

As noted above in Section 4, water production was only observed at test site HD4. The drains at that location were installed on 31 October 2008, marking the start of the test period. This site included drains that were installed at angles both slightly above and below horizontal. Flow was characterized by initially high rates; up to about 25 litres per minute over the first few days (estimated by flow measurements during the work prior to outfall tie-in). After this initial high flow period, the production become steady between 2 and 2.2 litres/minute, resulting in total volumes of between 80,000 and 90,000 litres/month. Drain production was at its lowest during February 2008, with marginal increases in March and in April 2008.

The trends in the upstream monitoring wells at BH21 and BH22 were roughly equal to the production rate variations in the drain, with decreases in head from the start of the test through to the end of February, then marked increases through March and April to the end of the test period. The drains did not appear to significantly decrease the groundwater pressures in the monitoring wells, as the final pressures were higher than those at the outset of the test period; however, the total produced water from the drains was significant enough to consider the technique successful. The production increases observed match the rise in upstream piezometer pressures, and therefore, a hydraulic connection in the same water bearing formation is assumed.

Further analytical work on the results from the horizontal drains was not carried out due to the limited success in being able to differentiate the observed groundwater pressure patterns from background variations.

5.6 WATER QUALITY TESTS

Water quality screening tests were carried out on samples from HD4 and PW4. The tests were carried out to screen for general chemical and major ions and included total metals and total organic carbon. The results of the tests showed that the water, at the sites tested, is suitable for discharge to surface or storm drains. PW1 and PW2 were not tested, due to accessibility problems at the time of testing. PW5 was not tested, due to production sequences (insufficient well water at the time of testing). Potability of the water was not examined at this stage. The results of the testing are included in Appendix E.

6.0 DISCUSSION OF THE RESULTS OF THE TRIAL DEWATERING PROGRAM

This section provides a site-by-site discussion of:

1. The results and if the site should remain in operation,
2. Observations made during the installation and/or operation of the test equipment, as required, and
3. Observed trends across the test sites and how they might relate to the slide mechanics.

6.1 PUMPING WELLS

The results from PW1 showed that the pumping well drawdown that was maintained by the electronic well level controls, led to decreased groundwater pressures of almost 2 m at monitoring wells up to 48 m from the pumping well. The lateral extent of a drawdown cone of this size was considered significant, and the site should remain in operation.

The relatively high production of PW1 in the Tertiary sediments is likely related to the soil macro-structure (fissures, and more permeable seams/lenses) at this location, or a hydraulic connection to an overlying glaciolacustrine unit, or both. As dewatering was noted in observation wells sealed into Tertiary sediments only, the macro-structure flow regime likely monitoring dominates the production. The well is located near the center portion of the slide area, and as noted above, the well screen is installed into the Tertiary sediments, with gravel and some sandy interbeds throughout. A potential hydraulic connection to the overlying glaciolacustrine deposits is also possible. This location is within an area of the landslide mass that is both spreading and subsiding, and as a result, the soil mass is likely in a state of tension. This condition promotes groundwater flow though the soil macro-structure. For spatial reference, this well is 545 m from the toe of the slide. Note that the toe of the landslide referenced here, and throughout the remainder of the report, is defined by the line presented in AMEC's May 2007 report.

The results from PW2 showed, the pumping well drawdown led to a reduction in groundwater pressures in an adjacent monitoring well, although the decrease was only about 0.4 m at 8.4 m distance from the well. The lateral extent of the drawdown cone was not considered significant, as it fell well short of a 2 m drawdown target. Additional observations over at least a 12 month period should be reviewed prior to stopping pumping operations at this site.

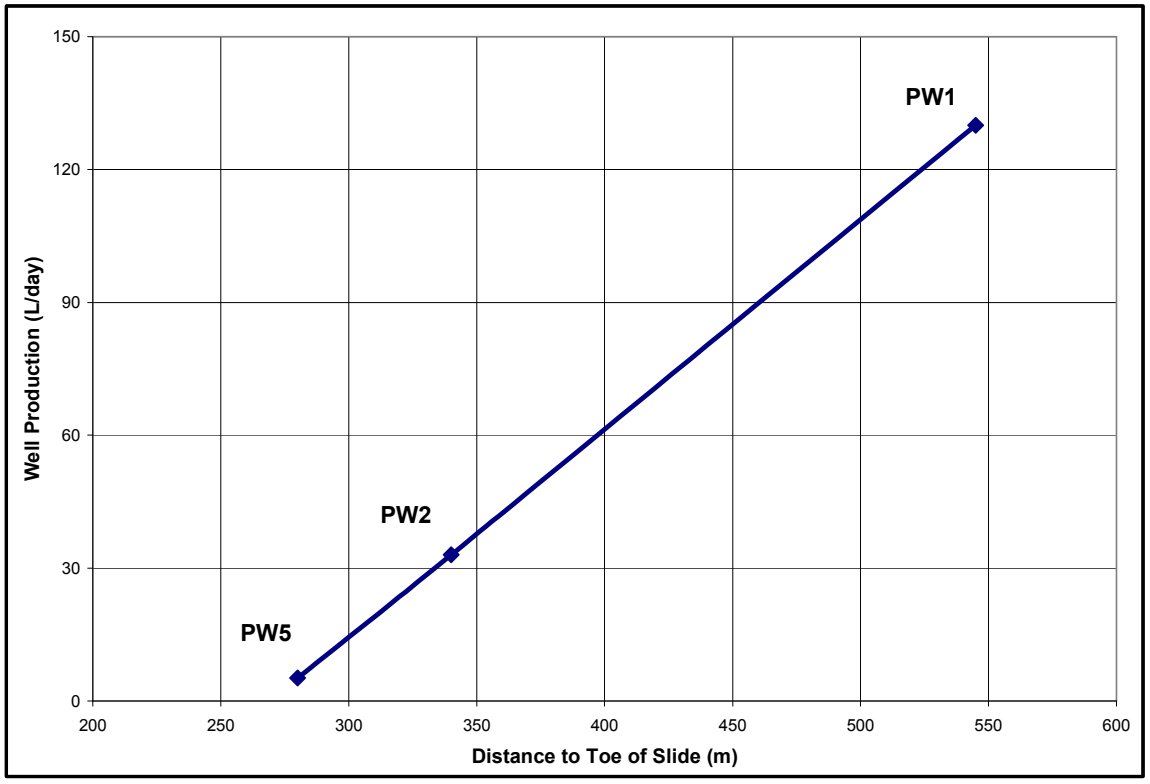
PW2 is located downslope of PW1, with the well screen installed into the Tertiary sediments. This site is much closer to the toe of the landslide and is potentially in an area subject to compression where the toe acts as a restraining boundary for soil mass movement. With this understanding, it would be expected that the soil macro-structure may be much "tighter", or closed, than at PW1 and the macro-structure would play a smaller role in groundwater flow. PW2 is 340 m from the toe of the landslide. The difference between PW1 and PW2 may also be due to a difference in stratigraphy. Specifically, PW1 had a 2 m gravel seam within the screened interval and a more or less continuous silt interval is present in PW2.

In the discussion that follows in this report, PW5 is presented before PW4 due to its relevance to the discussion of Tertiary sediments, well production and relative position within the landslide mass.

PW5 removed very little water throughout the test period, and had little to no effect on the groundwater pressures in monitoring wells near the pumping well. The pumping operations could be discontinued at PW5, if equipment could be used elsewhere. Intermittent (monthly) removal of water could be an alternative. This well, as at PW1 and PW2, is installed and sealed in Tertiary sediments (predominantly clay within the screened interval) that underlie the area, but is much closer to the toe of the landslide. This area is in a zone of compression, a condition where the soil macro-structure would be a closed network of fractures at best and not suitably connected to transmit water. In this case, groundwater flow is controlled by the soil micro-structure, flow through interconnected pore spaces, and would be expected to be very low, considering the fine grained, high plastic nature of the Tertiary sediments. PW5 is located 280 m from the toe of the slide.

Based on the discussion above, it appears that in addition to stratigraphic details (i.e. relative presence of clay, silt and sand proportions in the Tertiary sequence), one control on pumping well production may be the position of the well in relation to the toe of the landslide. Figure 3, below shows the observed relationship between long-term well production and distance from the toe. Note that the relationship is a generalized trend, and does not factor in screen lengths, types, or other contributing factors such as stratigraphy that could influence well production. Figure 3 is provided as a general guideline to help plan effective future dewatering well sites only. Such as, there is also a consistent trend in stratigraphy from, PW1, PW2 to PW5, in terms of variations within the Tertiary sequence with 2 m of gravel at PW1, silt at PW2 and clay at PW5. It is likely that this trend toward finer sediments closer to the toe of the slide, within these three holes, was also a control on well productivity. Further work would be required to determine whether this is a consistent spatial variation or whether it also occurs laterally.

FIGURE 3
PUMP WELL PRODUCTION IN TERTIARY SEDIMENTS
vs.
DISTANCE FROM LANDSLIDE TOE



PW4 was installed in a thick, water bearing sequence of sand and gravel. Pumping removed a significant volume of groundwater, more than 5 million litres of water up to the end of April 2008 and decreased groundwater pressure in the adjacent monitoring wells by almost 2, m at a distance of 48 m from the well. PW4 is believed to be able to sustain pumping rates of more than about 75 litres per minute. The pumping operations should be maintained at this site to continue the dewatering effects, although the discharge should be redirected to a stormwater system instead of the sanitary sewer to reduce long-term costs to the City of Quesnel and demands on the current sewer infrastructure. The high production rates of this well are related to stratigraphic conditions. Stress effects on macro-structure, as mentioned above for the other wells, were not considered to be a significant contributor to the relative well production.

Problems, related to hydraulic restrictions in the temporary well screen used for the test at PW4, were encountered at the start of the pumping trial. To solve the problem through the test period the flow was restricted, a smaller diameter pump was installed, to provide additional space between the pump and the well screen, and a timing switch was retrofitted to the electronic well controls, to prevent short on/off cycles from damaging the pump. Future pumping wells in coarse sediments are planned to have suitable production well screens installed during drilling, not the temporary style screens used in this test. Higher pumping rates would likely be possible with an optimized well installation.

The PW4 test site is in an aquifer, perched well above the valley floor, in the upper portion of the slide mass. The origin of the coarse sediments at this position of the slide could include several potential geologic sources, that will not be discussed in detail for the purposes of this report; however a few geological indicators should be noted with respect to the next phase of production dewatering planning. The almost 30 m thick gravel sequence is located less than about approx. 100 m from the main valley slopes, that extend at steep gradients down to Baker Creek, to the north. The aquifer holds water in the lower 15 m, but if this was a layered sequence or fluvial channel deposit, it likely should have long since drained by gravity to the north. Landslide movements have likely cut off a hydraulic path to the north and consequently, the water trapped in this more permeable deposit likely directly contributes to high groundwater pressures in the underlying Tertiary sequence and landslide failure surface. The extent of the gravel should be delineated and targeted with a production level dewatering program.

6.2 HORIZONTAL DRAINS

After completion of the HD1 drains, (A and B) it was evident that the horizontal drains did not produce any water at the drain outlets. Relatively dry sand, gravels and cobbles were encountered during drilling and drilling water return was minimal or non-existent, as the boreholes, were advanced into the slope. This potentially resulted in accumulation of drill cuttings in the annulus of the borehole that increased drill rod friction and rotation pressure, ultimately leading to refusal of the drill stem prior to the target lengths. Any water being captured from Tertiary sediments, or the sand and gravel unit near the end of the perforated drain pipes, in such conditions would likely re-enter the dry granular sediments, unless a short screened interval isolated by packers; or other isolating means, was installed. In HD1B, the increased rotation pressure, required for drill advancement, resulted in snapping of the drill rods at approximately 34 m depth. Fifteen meters of drill rods remain in the hole. Cased drill methods to advance through the granular soils would be required for future drain installations that advance through such conditions.

HD4 produced significant amounts of water throughout the test program, and was considered to be successful. Initial production was almost 10 times the long term rates observed throughout the program, starting at between 20 and 25 litres/minute, and dropping to a steady rate of about 2 litres/minute. Note that this production level, achieved through gravity drainage and only 2 small drains (less than a standard site production installation), resulted in a total output equal to about 10% of the high flow pumped well at PW4. Drainage by gravity, thus avoiding the complications and expense of pumping, is a further advantage of a horizontal drain. Another less obvious advantage is that if vertical fissures or tension cracks are present, they may be intersected by a drain but would not be intersected by a well.

A key lesson learned from the HD4 test were that paddle wheel flow meters were likely not suitable for this low-flow application, and future flow monitoring instrumentation should avoid in-line moving parts. Electromagnetic sensors would be preferred. Automatic heat tape was used in the collection point to avoid the need for significant burial of the drain outlets, to prevent icing through the winter months. This practice could be continued in future sites where deep burial of the outlets is not practical. Twinned conduits must be installed, to allow for separation of power cables and signal cables from datalogger sites to the manholes.

7.0 CONCLUSIONS & RECOMMENDATIONS

In the May 2007 Geotechnical Report, it was suggested that regional dewatering, on the order of even a few metres, could result in significantly slower displacement rates. This was based on data trends at BH3 (PW2 site) where changes, extended regionally, of even 2 m may correspond to slower movements. Based on the ability to affect pressure changes of this magnitude in a relatively short time (6 months or less), the results of the trial dewatering program indicate that pumping is an effective dewatering method in the mid to upper portions of the slide mass, and that relatively high water production can be achieved using horizontal drains in the lower portions of the slide mass. Note that the success of each system is related to specific geological sequences and details around the installation of each system; however, AMEC considers that the results provide clear guidelines for the path forward to production dewatering of the landslide mass. Some general guidelines proposed for design and implementation of a production dewatering plan are presented below.

The installations were not uniformly successful, due to variations in the stratigraphic conditions. In particular, a well installed into the clay rich Tertiary sediments near the toe was much less successful than wells installed into sequences containing gravel farther up slope. Two drains installed into sand and gravel encountered installation problems and no water was encountered within the shorter than designed length that could be installed. These variations in results can be expected during production scenarios, although, as additional experience is gained, the overall results can be improved.

Table 8 summarizes maximum drawdowns achieved during the pumping test period in monitoring wells having a discernable de-watering trend. Figure 4 is a summary of the discharge volumes and rates over the test period. The cumulative totals to the end of April 2008 were almost 5.7 million litres of water. The relative contributions to the total were about 90% from PW4, 9% from HD4, and 1% from the remaining 3 wells (PW1, 2 and 5).

Table 8 - Maximum Drawdowns

MONITORING WELL	ASSOCIATED PUMPING WELL	MAXIMUM DRAWDOWN (m)
BH-3B	PW-1	11.6
BH-3C		7.0
BH-4A		1.8
BH-3	PW-2	0.4
BH-12A	PW-4	7.2
BH-12B		7.0
BH-12C		3.8
BH-20		1.8
BH-17A	PW-5	0.9
BH-17B		1.4

Based on the results of the pilot de-watering test and the maximum drawdowns, the hydraulic properties within the Tertiary sediments beneath West Quesnel are variable, although, a trend corresponding to relative upslope distance from the toe of the landslide appears to exist. The successful completion of future dewatering wells will depend on the number of continuous saturated fractures intersected by each well (macro-structure flow paths), and/or its relative position within the slide mass (stress effects on the "openness" of the macro-structure). Although we provide a suggested well spacing below, based on the results of this trial dewatering test, the effectiveness of each well at dewatering the subsurface should be expected to be variable and dependent upon the localized stratigrapghy and stress conditions.

To achieve drawdowns in the Tertiary sediments in the mid-portion of the slide mass, similar to between 7 and 12 m that was achieved at BH-3B and BH-3A, assuming the aquifer properties remain consistent for some distance beyond PW-1 (which may, or may not be true), a maximum pumping well spacing of 80 m is suggested. It may also be necessary to maintain a distance from the toe of about 550 m, as suggested by the trends that may indirectly relate stress condition and hydraulic conductivity of the bulk soil mass.

To achieve drawdowns in the fluvial sediments, similar to the approximately 7 m of the drawdown that was achieved at BH-12A and BH-12B, assuming the aquifer properties remain consistent for some distance beyond PW-4 (which may, or may not be true), a pumping well spacing of 110 m is also suggested. An additional control on this spacing would be to maintain well installations within the same perched aquifer. Note that PW-4 drawdown was achieved using a restricted screen and flow volumes, and may under-represent what a full production well could achieve. It is suggested that a 125 to 150 m spacing could be used, although a degree of caution should be exercised in detailed design if this figure is considered. As indicated above, the aim of pumping wells on the upper part of the slide would be to reduce infiltration and recharge affecting the lower elevations portions of the slide.

Drawdown in wells in the lower portions of the landslide area ranged between 0.4 m (BH-3) and 1.4 m (BH-17B) adjacent to two pumping wells within the slide zone. These limited drawdowns infer that the associated pumping wells (PW-2 and PW-5) did not intersect a suitable soil macro -structure, that could achieve the levels of drawdown experienced adjacent PW-1 and PW-4.

The effectiveness of a "string" of wells should be evaluated by installing monitoring points equipped with VWP's in target geological units. The monitoring wells would ideally be placed mid-way between pumping wells, and in selected upstream and downstream locations. Monitoring well sites required would typically be on the order of 1.25 to 1.5 times the number of installed pump wells.

An aggressive program of horizontal drains should be included in the production dewatering plan, and used where topography allows for safe installation under upstream properties. Conceptual drainage fan layouts installed from a common point would include 7 to 9 drains, averaging a minimum of 150 m length, installed at 10° azimuth increments at inclinations of between -5° and +5°. Variable inclinations in a single fan should be used to provide maximum intersection through potential horizontal or perched aquifers. Note that 150 m is not intended to be a fixed length, instead the drains should be drilled to maximum depths possible to capture the largest subsurface zone possible at the time of drilling. Contractual arrangements should be in place to allow for flexibility in total drain lengths, as variable ground conditions are encountered.

Figure 5, shows a conceptual plan for a phased full scale production dewatering system, that uses a combination of dewatering wells and horizontal drains. Detailed design is required prior to initiating construction of such a program, to provide suitable contractual level design drawings and to give due consideration to other project constraints such as private property, construction access, power and storm drainage utility availability, possible environmental impacts, future operational and maintenance considerations. The design phase should include additional small-scale geophysical or borehole investigations to identify the extent of the upper perched aquifer, and generalized conditions in the previously logged but undeveloped area south of Abbott Drive.

The production dewatering program should be focused on phased deployment, with an implementation plan based on strategic and measurable dewatering and monitoring sites. Construction staging and future needs should be defined on the relative success or rate of dewatering from the previous phase (likely requiring annual pauses in construction). Well and horizontal drain production and groundwater drawdown measurement monitoring must be combined with ongoing climate and landslide movement data to measure and confirm the long term effectiveness and operational requirements of a full scale dewatering program. Moving to a continuous, remote, in-place digital system of recording deep landslide movements is considered necessary to complement the groundwater pressure monitoring data as discontinuous slide movement data cannot be suitably matched to specific slide movements and rates.

In conclusion, based on the results of the trial dewatering program monitored to date, it is recommended that the City of Quesnel proceed with the design and implementation of a full scale production dewatering program.

8.0 ACKNOWLEDGMENTS

Considerable efforts from a team of AMEC and City of Quesnel personnel contributed to the success of this work. AMEC would like to thank all the City of Quesnel staff that assisted with the land access and construction phases of the test program. Without the construction support and infrastructure (power drops, trenching, access permissions, water supply, etc) provided by them, the test program would not have been possible. The authors would like to acknowledge the significant efforts of the AMEC team involved in the project and report writing, including the following:

- Ben Pierce, EIT (field program construction, monitoring and reporting);
- Shawn Botten (technical support for automated data collection throughout the program);
- Scott Green, P.Eng. (analysis and reporting of test results);
- Shelley Ruiz, AScT, (visual data presentation).

9.0 CLOSURE

This report has been prepared for the exclusive use of the City of Quesnel and their representatives for specific application to the area described 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.

This report was prepared in accordance with generally accepted geotechnical engineering principles and practice. No other warranty, expressed or implied, is made.

Please do not hesitate to contact the undersigned at (250) 564-3243 should you have any questions or require further information.

AMEC Earth & Environmental
A division of AMEC Americas Limited

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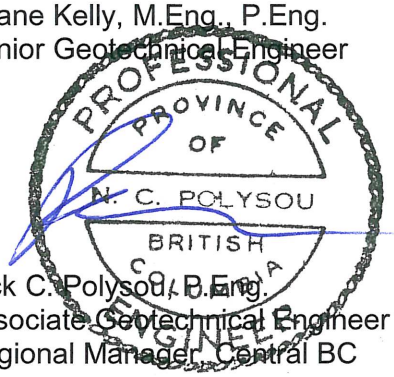
Principal Engineer



Nick C. Polysou, P.Eng.
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Regional Manager, Central BC

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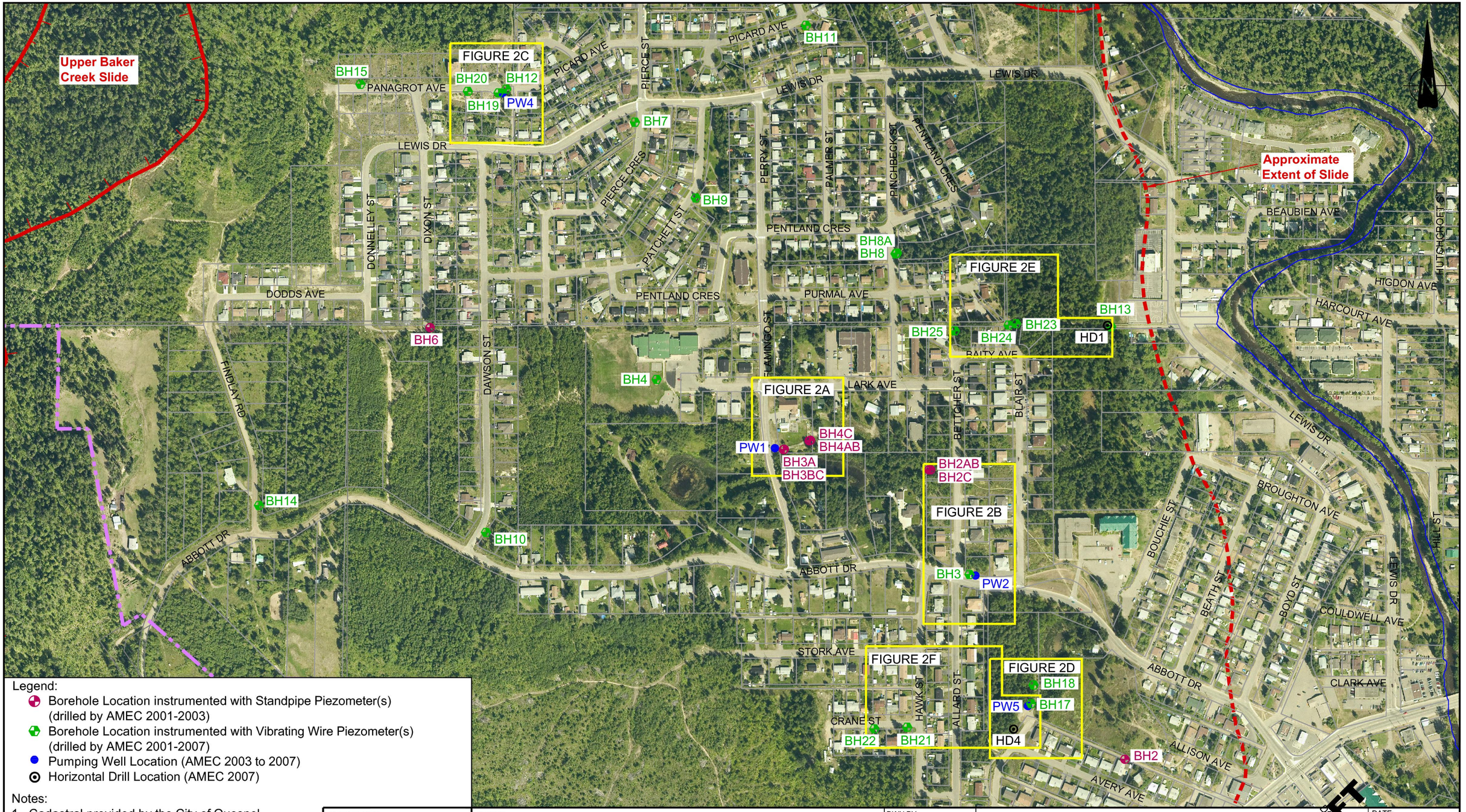
LIST OF FIGURES



Legend:

- Borehole Location instrumented with Standpipe Piezometer(s) (drilled by AMEC 2001-2003)
- Borehole Location instrumented with Vibrating Wire Piezometer(s) (drilled by AMEC 2001-2007)
- Pumping Well Location (AMEC 2003 to 2007)
- Horizontal Drill Location (AMEC 2007)

Notes:

1. Cadastral provided by the City of Quesnel.
2. This drawing must be read in conjunction with AMEC Earth & Environmental Geotechnical Report, "Trial Dewatering Program, West Quesnel Land Stability Study".

0m 50 100 150 200

1 : 5000

CLIENT LOGO

West Quesnel Land Stability Program

CLIENT: CITY OF QUESNEL

AMEC Earth & Environmental
3456 Opie Crescent
Prince George, BC, CANADA V2N 2P9
Tel. (250) 564-3243
Fax (250) 562-7045

DWN BY:	S.Ruiz
CHK'D BY:	S.Kelly
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:5000

TITLE: SITE PLAN WITH PW AND HD LOCATION

DRAFT

PROJECT: TRIAL DEWATERING PROGRAM
WEST QUESNEL LAND STABILITY STUDY
QUESNEL, BC

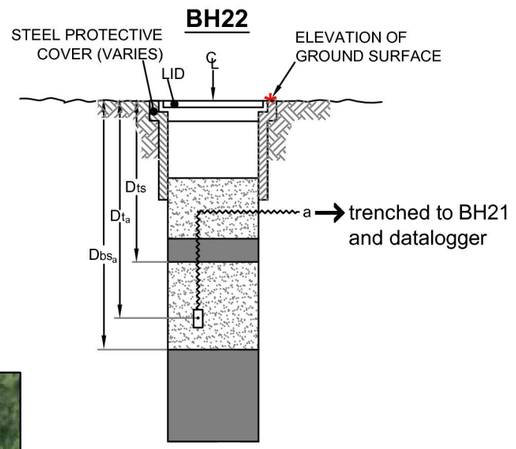
DATE:	MAY 2008
PROJECT NO:	KX0439717
REV. NO.:	A

FIGURE 1

C:_Drafting Working\West Quesnel Slope Stability\KX04397.17-2008 Report-May 2008\KX04397.17-fig1-SITE 11x17.dwg - FIGURE1 - May. 26, 2008 11:26am - shelley.ruiz

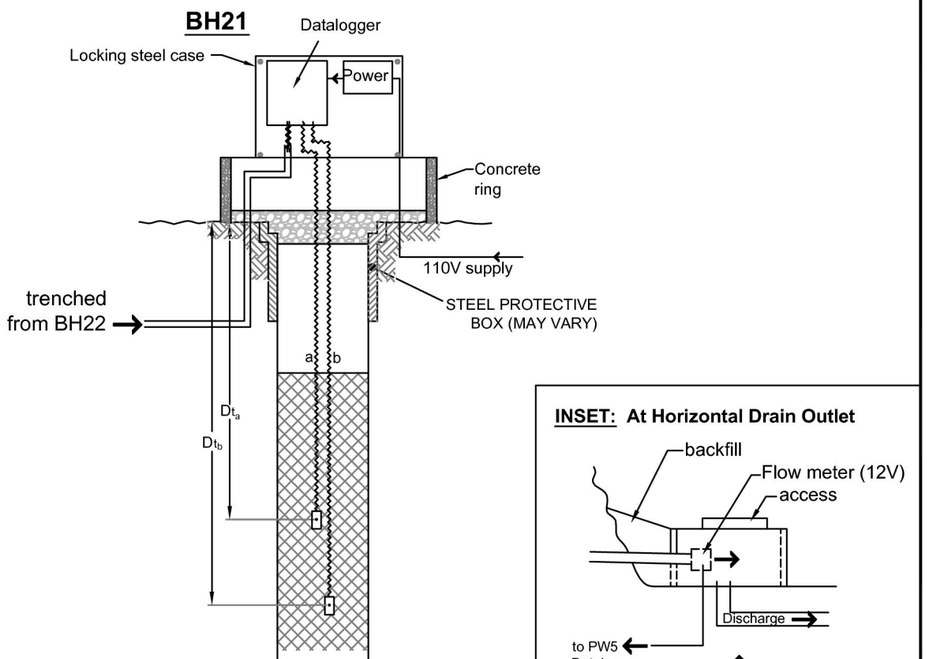
This drawing was originally produced in colour.

STANDPIPE PIEZOMETER / OBSERVATION WELL INSTALLATION DETAIL			
INSTALLATION #	**HD4**	**BH21**	**BH22**
DATE INSTALLED	1 NOVEMBER 2007	11 JULY 2007	24 JULY 2007
SUPERVISED BY AMEC	B.PIERCE	B.PIERCE	B.PIERCE
INSTALL METHOD	HORIZONTAL DRILL	GT-180	B-47
INSTALL DRILLER	JENSON DRILLING	GEOTECH DRILLING	GEOTECH DRILLING
SCREEN / TIP TYPE	SLOTTED	GEOKON MODEL 4500 350 kPa	GEOKON MODEL 4500 350 kPa
PIPE DIAMETER	38mm	N/A - GROUT	N/A - SAND
NORTHING	5869381 (approx)	5869384.67	5869382.30
EASTING	532325 (approx)	532177.32	532131.60
GROUND ELEVATION	481.5 (approx)	505.9	508.7
DEPTH OF HOLE	135.6	24.4	19.8



INSTRUMENT No (i=a, b, c..)	21a		21b		22a	
SERIAL NUMBER	07-13029		07-13028		07-13264	
MANUAL FACTOR A (m H_2O)	-0.000000009557		-0.0000001930		-0.00000007165	
MANUAL FACTOR B (m H_2O)	-0.1015		-0.1031		-0.1084	
MANUAL FACTOR C (m H_2O)	903.26		944.90		966.41	
LINEAR GAGE FACTOR (G) (KPa/digit)	0.1016		0.1060		0.1094	
REGRESSION ZERO	8891		9013		88.64	
	DEPTH (m)	ELEVATION (m)	DEPTH (m)	ELEVATION (m)	DEPTH (m)	ELEVATION (m)
TOP SEAL (D_{tsi})	N/A		N/A		17.4	491.3
TIP (D_{ti})	12.6	493.3	21.3	484.6	18.3	490.4
BOTTOM SEAL (D_{bsi})	N/A		N/A		19.8	488.9

fully grouted



LEGEND:
- Borehole Location
- Horizontal Drain Location
- Horizontal Drain
- Data Cable (trenched)

0m 10 20 30 40
1 : 1000

CLIENT LOGO
West Quesnel Land Stability Program

CLIENT: CITY OF QUESNEL

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DWN BY:	S.Ruiz
CHK'D BY:	S.Kelly
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:1000

TITLE: HD4 TEST SITE DETAIL

DRAFT

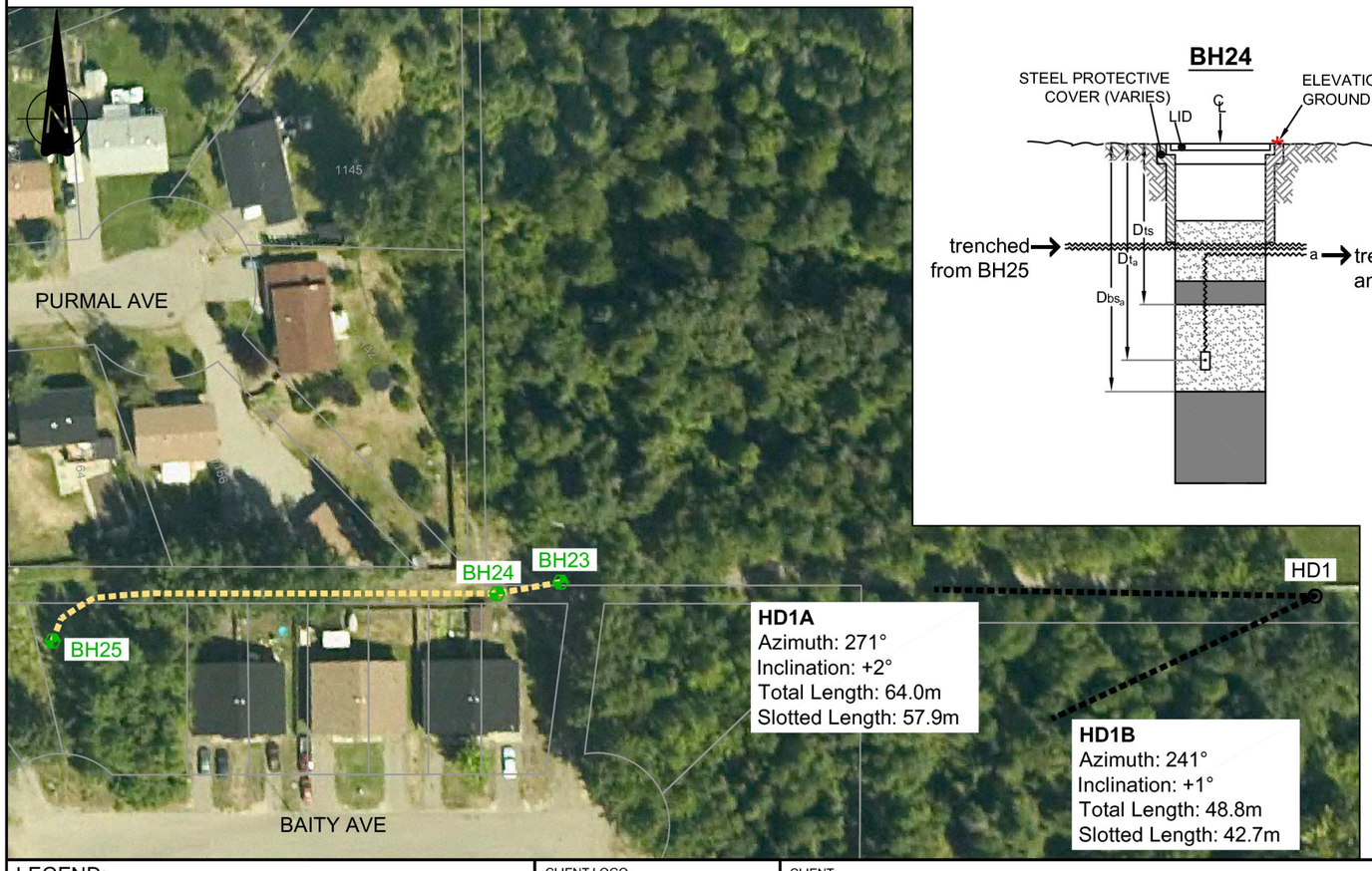
PROJECT: TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE:	MAY 2008
PROJECT NO:	KX0439717
REV. NO.:	A
FIGURE No.	**FIGURE 2F**

C:_Drafting Working\West Quesnel Slope Stability\KX04397.17-2008 Report-May 2008\KX04397.17-fig2F-HD4.dwg – FIGURE2F – May. 30, 2008 9:03am – shelley.ruiz

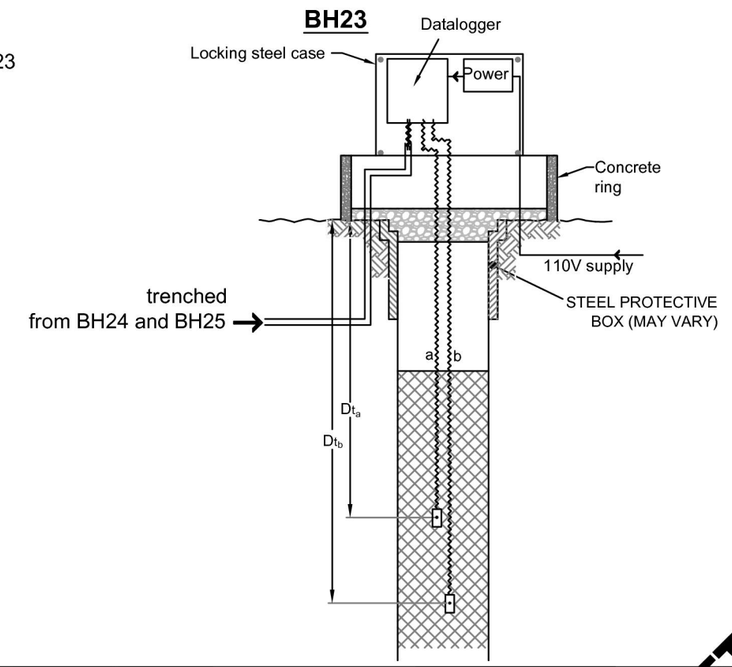
This drawing was originally produced in colour.

STANDPIPE PIEZOMETER / OBSERVATION WELL INSTALLATION DETAIL				
INSTALLATION #	**HD1**	**BH23**	**BH24**	**BH25**
DATE INSTALLED	4 NOVEMBER 2007	11 JULY 2007	12 JULY 2007	12 JULY 2007
SUPERVISED BY AMEC	B.PIERCE	B.PIERCE	B.PIERCE	B.PIERCE
INSTALL METHOD	HORIZONTAL DRILL	B-80	B-80	B-80
INSTALL DRILLER	JENSON DRILLING	GEOTECH DRILLING	GEOTECH DRILLING	GEOTECH DRILLING
SCREEN / TIP TYPE	SLOTTED	GEOKON MODEL 4500 350 kPa	GEOKON MODEL 4500 350 kPa	GEOKON MODEL 4500 350 kPa
PIPE DIAMETER	38mm	N/A - GROUT	N/A - SAND	N/A - GROUT
NORTHING	5869943 (approx)	5869945.47	5869943.54	5869935.58
EASTING	532455 (approx)	532328.98	532318.31	532243.61
GROUND ELEVATION	482.1 (approx)	514.7	515.4	515.2
DEPTH OF HOLE	64.0	33.5	24.4	30.5



INSTRUMENT No (i=a, b, c..)	**23a**		**23b**		**24a**		**25a**		**25b**	
SERIAL NUMBER	07-13025		07-13024		07-13027		07-13033		07-13026	
MANUAL FACTOR A (m H_2O)	-0.0000001376		-0.0000001326		-0.00000003265		-0.0000001229		-0.0000001810	
MANUAL FACTOR B (m H_2O)	-0.1017		-0.1047		-0.1082		-0.0994		-0.1024	
MANUAL FACTOR C (m H_2O)	873.32		932.17		970.34		903.17		923.91	
LINEAR GAGE FACTOR (G) (KPa/digit)	0.1036		0.1066		0.1087		0.1012		0.0997	
REGRESSION ZERO	8493		8803		8941		8984		9169	
	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
TOP SEAL (D_{tsi})	N/A*		N/A*		21.9	493.5	N/A*		N/A*	
TIP (D_{ti})	22.4	492.3	33.1	481.6	22.9	492.5	16.8	498.4	30.2	485.0
BOTTOM SEAL (D_{bsi})	N/A*		N/A*		24.4	491.0	N/A*		N/A*	

fully grouted



LEGEND:
- Borehole Location
- Horizontal Drain Location
- Pumping Well Location
- Borehole Location with Standpipe Piezometers
- Horizontal Drain
- Data Cable (trenched)

0m 10 20 30 40
1 : 1000

CLIENT LOGO

West Quesnel Land Stability Program

CLIENT: CITY OF QUESNEL

AMEC Earth & Environmental
3456 Opie Crescent
Prince George, BC, CANADA V2N 2P9
Tel. (250) 564-3243
Fax (250) 562-7045

amec

DWN BY: S.Ruiz
CHK'D BY: S.Kelly
DATUM: NAD83
PROJECTION: UTM Zone 10
SCALE: 1:1000

TITLE: HD1 TEST SITE DETAIL

DRAFT

PROJECT: TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE: MAY 2008
PROJECT NO: KX0439717
REV. NO.: A
FIGURE No. **FIGURE 2E**

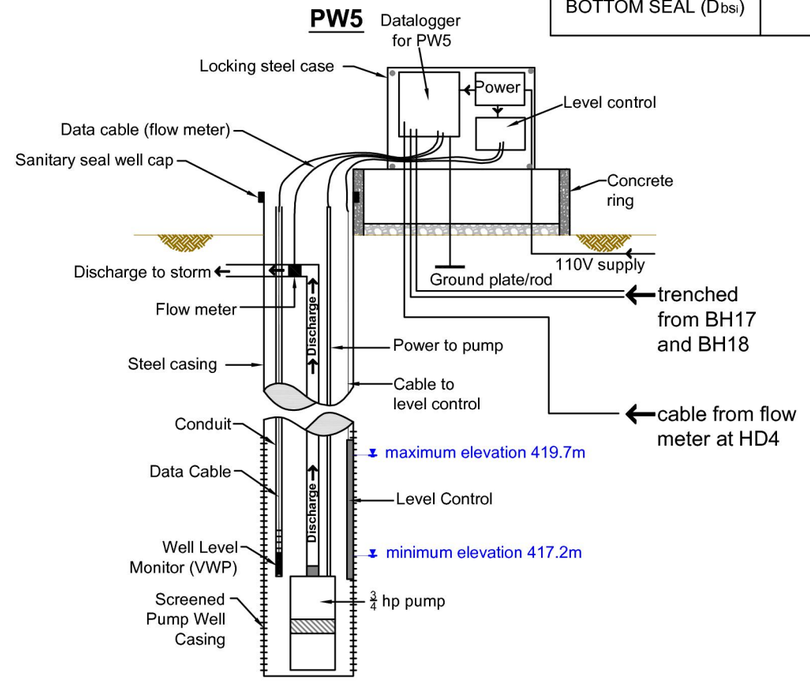
C:_Drafting Working\West Quesnel Slope Stability\KX04397.17-2008 Report-May 2008\KX04397.17-fig2E-HD1.dwg – FIGURE2E – May. 30, 2008 9:00am – shelley.ruiz

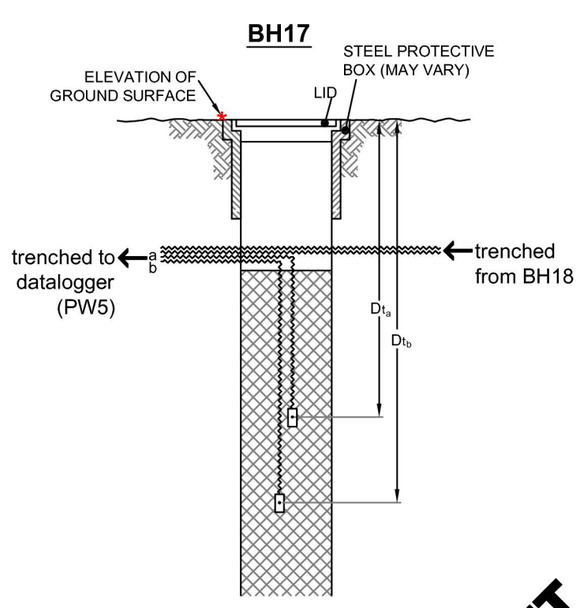
This drawing was originally produced in colour.

STANDPIPE PIEZOMETER / OBSERVATION WELL INSTALLATION DETAIL			
INSTALLATION #	**PW5**	**BH17**	**BH18**
DATE INSTALLED	26 JUNE 2007	7 JULY 2007	9 JULY 2007
SUPERVISED BY AMEC	K.BLACK / N.EKMAN	S.KELLY / B.PIERCE	S.KELLY / B.PIERCE
INSTALL METHOD	TH-60	B-80	B-80
INSTALL DRILLER	CARIBOO WATER WELLS	GEOTECH DRILLING	GEOTECH DRILLING
SCREEN / TIP TYPE	SLOTTED	GEOKON MODEL 4500 350/700 kPa	GEOKON MODEL 4500 350/700 kPa
PIPE DIAMETER	150mm	N/A - GROUT	N/A - GROUT
NORTHING	5869414.08	5869417.38	5869443.27
EASTING	532345.25	532349.64	532352.97
GROUND ELEVATION	481.32	481.2	481.4
DEPTH OF HOLE	61.0	61.0	61.0

INSTRUMENT No (i=a, b, c..)	17a		17b		18a		18b	
SERIAL NUMBER	07-13032		07-12402		07-13030		07-12401	
MANUAL FACTOR A (m H_2O)	-0.0000002198		-0.0000001343		0.00000004057		-0.0000001096	
MANUAL FACTOR B (m H_2O)	-0.1034		-0.1789		-0.0995		-0.1601	
MANUAL FACTOR C (m H_2O)	894.41		1559.3		916.52		1434.3	
LINEAR GAGE FACTOR (G) (KPa/digit)	0.1065		0.1807		0.0989		0.1616	
REGRESSION ZERO	8496		8662		9243		8906	
	DEPTH (m)	ELEVATION (m)	DEPTH (m)	ELEVATION (m)	DEPTH (m)	ELEVATION (m)	DEPTH (m)	ELEVATION (m)
TOP SEAL (D_{tsi})	N/A*		N/A*		N/A*		N/A*	
TIP (D_{ti})	37.7	443.5	57.4	423.8	38.2	443.2	60.1	421.3
BOTTOM SEAL (D_{bsi})	N/A*		N/A*		N/A*		N/A*	

fully grouted





LEGEND:
- Borehole Location
- Pumping Well Location
- Data Cable (trenched)
- Pump Discharge (trenched)

0m 10 20 30 40
1 : 1000

CLIENT LOGO

West Quesnel Land Stability Program

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Prince George, BC, CANADA V2N 2P9
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Fax (250) 562-7045

DWN BY:	S.Ruiz
CHK'D BY:	S.Kelly
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:1000

TITLE: PW5 TEST SITE DETAIL

DRAFT

PROJECT: TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE:	MAY 2008
PROJECT NO:	KX0439717
REV. NO.:	A
FIGURE No.	**FIGURE 2D**

C:_Drafting Working\West Quesnel Slope Stability\KX04397.17-2008 Report-May 2008\KX04397.17-fig2D-PW5.dwg – FIGURE2D – May. 30, 2008 9:22am – shelley.ruiz

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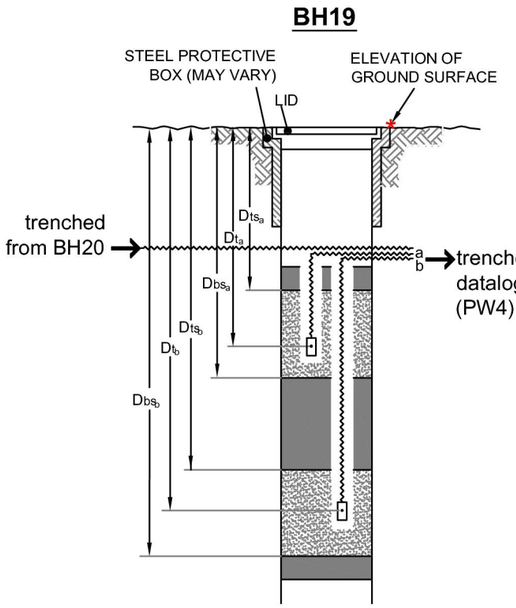
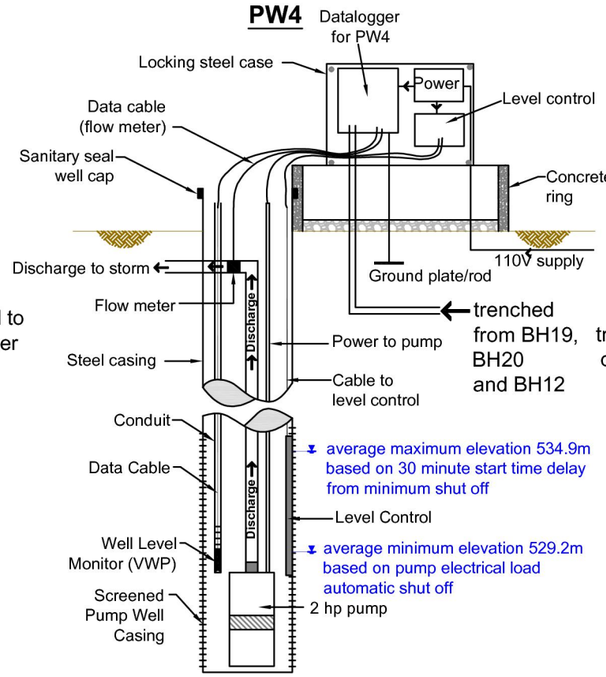
STANDPIPE PIEZOMETER / OBSERVATION WELL INSTALLATION DETAIL

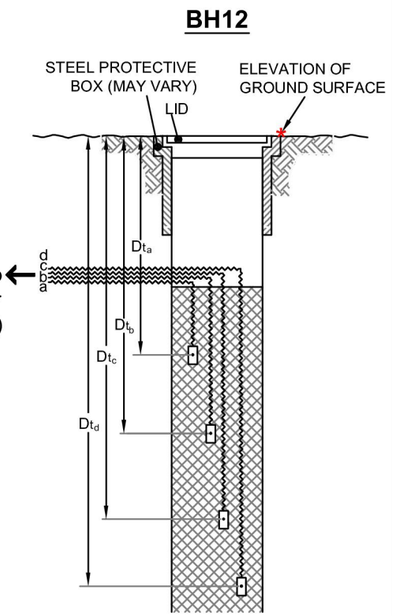
INSTALLATION #	PW4	BH19	BH20	BH12
DATE INSTALLED	27 JUNE 2007	10 JULY 2007	11 JULY 2007	21 JUNE 2005
SUPERVISED BY AMEC	K.BLACK / N.EKMAN	B.PIERCE	B.PIERCE	S.CARLSON / N.EKMAN
INSTALL METHOD	TH-60	B-80	B-80	HC-2000 CORING
INSTALL DRILLER	CARIBOO WATER WELLS	GEOTECH DRILLING	GEOTECH DRILLING	GEOTECH DRILLING
SCREEN / TIP TYPE	SLOTTED	GEOKON MODEL 4500 - 350 kPa	GEOKON MODEL 4500 - 350 kPa	SINCO MODEL 52611020 - 350 kPa
PIPE DIAMETER	150mm	N/A - SAND	N/A - SAND	N/A - GROUT
NORTHING	5870265.93	5870266.21	5870268.36	5870271.58
EASTING	531614.55	531609.22	531566.50	531620.09
GROUND ELEVATION	557.0	557.0	559.24	556.4
DEPTH OF HOLE	30.5	23.8	22.9	70.2

INSTRUMENT No (i=a, b, c..)	19a		19b		20a		12a		12b		12c		12d	
SERIAL NUMBER	07-13034		07-13035		07-13031		82760		82517		82516		82506	
MANUAL FACTOR A (m H_2O)	0.00000006603		-0.00000003364		-0.00000007023		-0.000012275		-0.000012605		-0.000012238		-0.000012076	
MANUAL FACTOR B (m H_2O)	-0.1112		-0.1024		-0.1090		-0.0012922		-0.0028334		0.00036981		0.00035765	
MANUAL FACTOR C (m H_2O)	1002.12		925.13		990.27		118.28		135.80		115.34		117.45	
LINEAR GAGE FACTOR (G) (KPa/digit)	0.1103		0.1029		0.1100		N/A		N/A		N/A		N/A	
REGRESSION ZERO	9057		9012		9037		N/A		N/A		N/A		N/A	
	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
TOP SEAL (D_{tsi})	15.2	541.8	19.2	537.8	18.3	540.94	N/A*		N/A*		N/A*		N/A*	
TIP (D_{ti})	16.5	540.5	22.3	534.7	21.4	537.84	18.0	538.4	22.9	533.5	26.5	529.9	54.9	501.5
BOTTOM SEAL (D_{bsi})	17.5	539.5	23.8	533.20	22.9	536.34	N/A*		N/A*		N/A*		N/A*	

fully grouted







LEGEND:
- Borehole Location
- Pumping Well Location
- Data Cable (trenched)
- Pump Discharge (trenched)

0m 10 20 30 40

1 : 1000

CLIENT LOGO

West Quesnel Land Stability Program

CLIENT: CITY OF QUESNEL

AMEC Earth & Environmental
3456 Opie Crescent
Prince George, BC, CANADA V2N 2P9
Tel. (250) 564-3243
Fax (250) 562-7045

amec

DWN BY:	S.Ruiz
CHK'D BY:	S.Kelly
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:1000

TITLE: PW4 TEST SITE DETAIL

DRAFT

PROJECT: TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

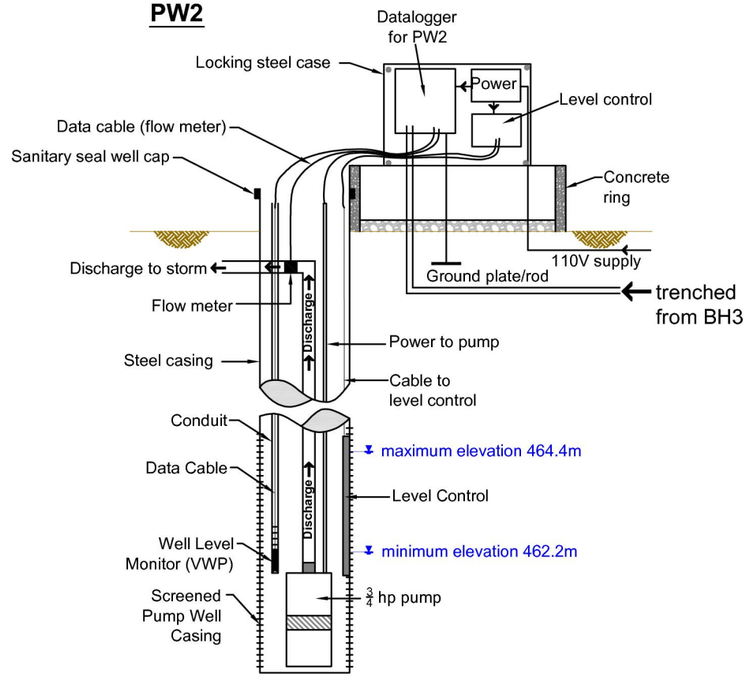
DATE:	MAY 2008
PROJECT NO:	KX0439717
REV. NO.:	A
FIGURE No.	FIGURE 2C

C:_Drafting Working\West Quesnel Slope Stability\KX04397.17–2008 Report–May 2008\KX04397.17–fig2C–PW4.dwg – INSTALLPW4 – May. 30, 2008 9:19am – shelley.ruiz

This drawing was originally produced in colour.

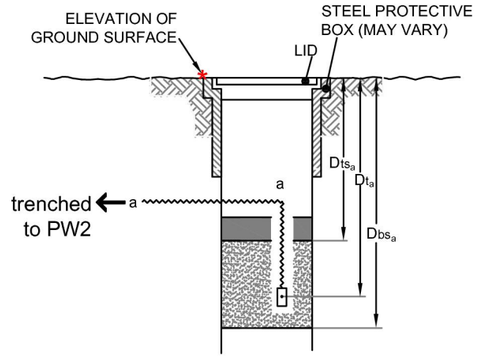
STANDPIPE PIEZOMETER / OBSERVATION WELL INSTALLATION DETAIL		
INSTALLATION #	**PW2**	**BH3**
DATE INSTALLED	17 & 18 SEPTEMBER 2003	15 NOVEMBER 2001
SUPERVISED BY AMEC	S.GREEN	H.ARABSHAHI
INSTALL METHOD	INGERSALL-RAND TH-60	HQ/B-53
INSTALL DRILLER	CARIBOO WATER WELLS	GEOTECH DRILLING
SCREEN / TIP TYPE	SLOTTED	SINCO MODEL 52611030 700 kPa
PIPE DIAMETER	150mm	N/A - SAND
NORTHING	5869595.41	5869597.00
EASTING	532272.27	532264.00
GROUND ELEVATION	503.5	503.2
DEPTH OF HOLE	61.0m	95.1m

PW2



INSTRUMENT No (i=a, b, c..)	**3a**	
SERIAL NUMBER	73153	
MANUAL FACTOR A (m H_2O)	-0.000018148	
MANUAL FACTOR B (m H_2O)	0.0090068	
MANUAL FACTOR C (m H_2O)	143.89	
LINEAR GAGE FACTOR (G) (KPa/digit)	N/A	
REGRESSION ZERO	N/A	
	DEPTH (m)	ELEVATION (m)
TOP SEAL (D_{tsi})	36.9	466.3
TIP (D_{ti})	37.5	465.7
BOTTOM SEAL (D_{bsi})	40	463.0

BH3



LEGEND:
- Borehole Location
- Pumping Well Location
- Data Cable (trenched)
- Pump Discharge (trenched)

0m 10 20 30 40
1 : 1000

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West Quesnel Land Stability Program

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Prince George, BC, CANADA V2N 2P9
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amec

DWN BY:	S.Ruiz
CHK'D BY:	S.Kelly
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:1000

TITLE: PW2 TEST SITE DETAIL

DRAFT

PROJECT: TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

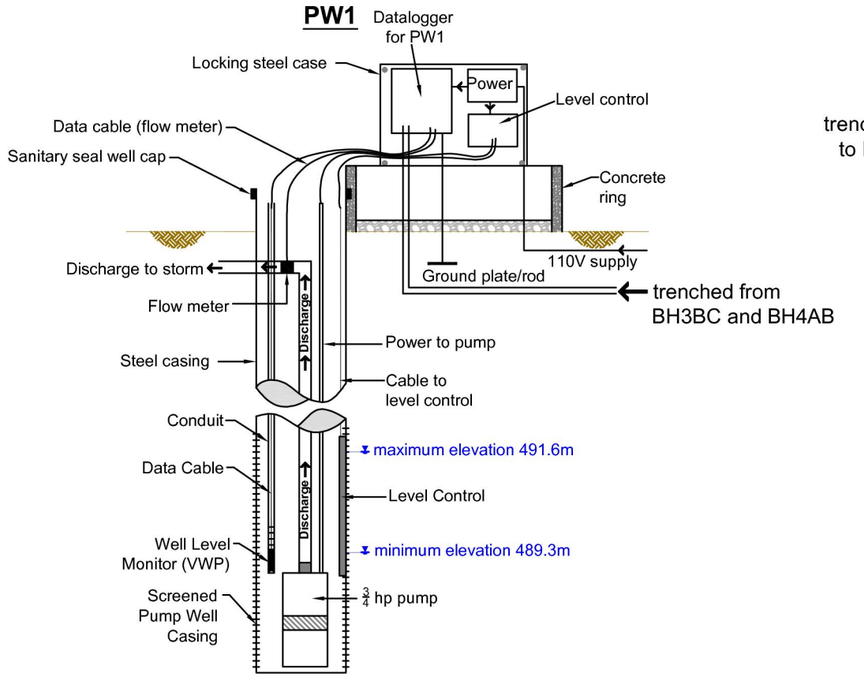
DATE:	MAY 2008
PROJECT NO:	KX0439717
REV. NO.:	A
FIGURE No.	**FIGURE 2B**

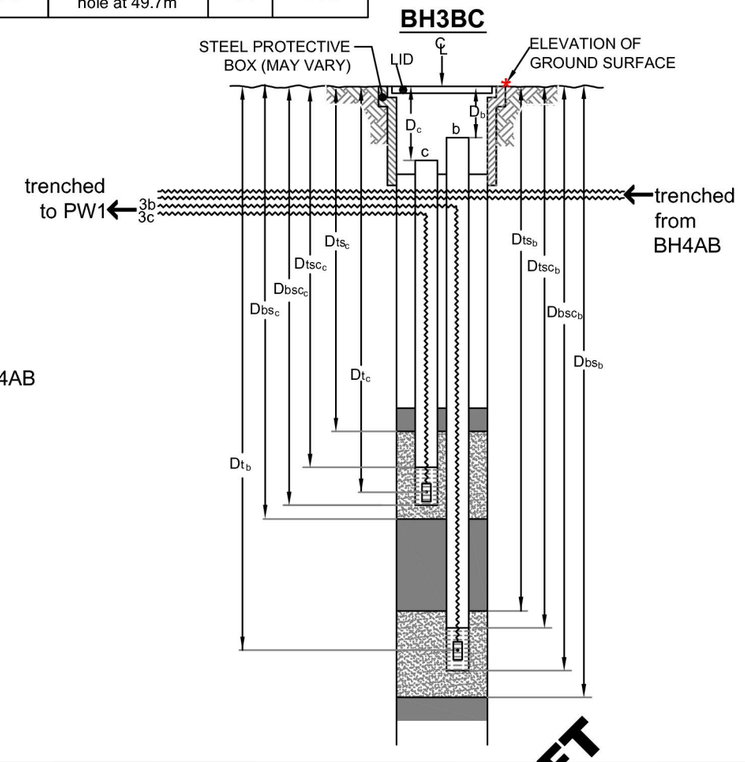
C:_Drafting Working\West Quesnel Slope Stability\KX04397.17-2008 Report-May 2008\KX04397.17-fig2B-PW2.dwg – FIGURE2B – May. 30, 2008 9:09am – shelley.ruiz

This drawing was originally produced in colour.

STANDPIPE PIEZOMETER / OBSERVATION WELL INSTALLATION DETAIL			
INSTALLATION #	**PW1**	**BH3BC**	**BH4AB**
DATE INSTALLED	15 & 16 SEPTEMBER 2003	22 AUGUST 2003	17 JULY 2003
SUPERVISED BY AMEC	S.GREEN	S.GREEN	S.JORGENSON
INSTALL METHOD	INGERSALL-RAND TH60	SILVERADO	SILVERADO
INSTALL DRILLER	CARIBOO WATER WELLS	GEOTECH DRILLING	GEOTECH DRILLING
SCREEN / TIP TYPE	SLOTTED	SLOTTED/GEOKON MODEL 4500 350/700 kPa	SLOTTED/GEOKON MODEL 4500 350/700 kPa
PIPE DIAMETER	150mm	25mm	25mm
NORTHING	5869772.50	5869770.43	5869782.81
EASTING	531993.42	532005.22	532041.00
GROUND ELEVATION	520.1	519.1	519.8
DEPTH OF HOLE	54.9m	44.8m	49.7m

INSTRUMENT No (i=a, b, c..)	**3b**		**3c**		**4a**		**4b**	
SERIAL NUMBER	06-6679		06-23421		06-6678		06-23420	
MANUAL FACTOR A (m H_2O)	0.000000399		0.0000001851		0.0000001573		0.0000001967	
MANUAL FACTOR B (m H_2O)	-0.1606		-0.07585		-0.1659		-0.07553	
MANUAL FACTOR C (m H_2O)	1366.9		649.79		1396.3		644.75	
LINEAR GAGE FACTOR (G) (KPa/digit)	0.1656		0.07813		0.1679		0.07794	
REGRESSION ZERO	8345		8401		8353		8361	
TIP (D_{ti})	40.0		31.0		40.0		23.0	
	DEPTH (m)	ELEVATION (m)	DEPTH (m)	ELEVATION (m)	DEPTH (m)	ELEVATION (m)	DEPTH (m)	ELEVATION (m)
TOP OF PIPE (D_i)	0.03	519.07	0.0	519.1	0.08	519.72	0.08	519.72
TOP SEAL (D_{tsi})	38.3	480.8	31.5	487.6	48.0	471.8	38.1	481.7
TOP SCREEN (D_{tsci})	38.7	480.4	32.0	487.1	48.8	471.0	38.7	481.1
BOTTOM SCREEN (D_{bsci})	40.1	479.0	33.5	485.6	49.4	470.4	40.2	480.4
BOTTOM SEAL (D_{bsi})	SLOUGH to end of hole at 44.8m		33.5	485.6	SAND to end of hole at 49.7m		40.0	479.8





LEGEND:
- Pumping Well Location
- Borehole Location with Standpipe Piezometers
- Data Cable (trenched)
- Pump Discharge (trenched)

0m 10 20 30 40
1 : 1000

CLIENT LOGO
West Quesnel Land Stability Program

CLIENT: CITY OF QUESNEL

AMEC Earth & Environmental
3456 Opie Crescent
Prince George, BC, CANADA V2N 2P9
Tel. (250) 564-3243
Fax (250) 562-7045

DWN BY:	S.Ruiz
CHK'D BY:	S.Kelly
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:1000

TITLE: PW1 TEST SITE DETAIL

DRAFT

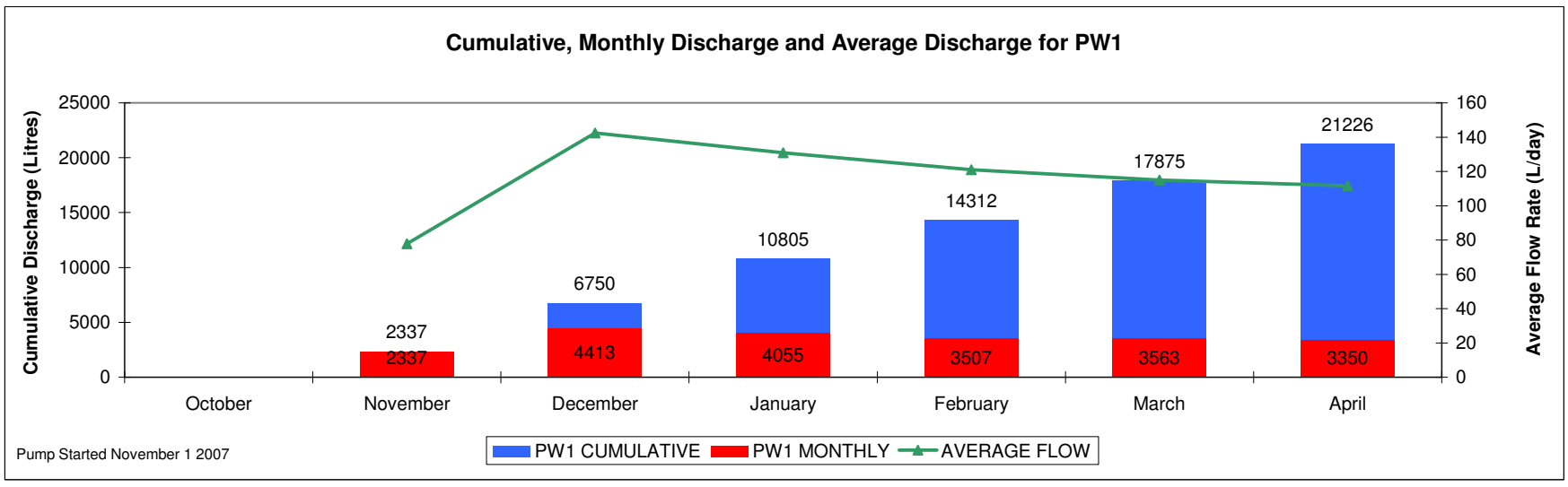
PROJECT: TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

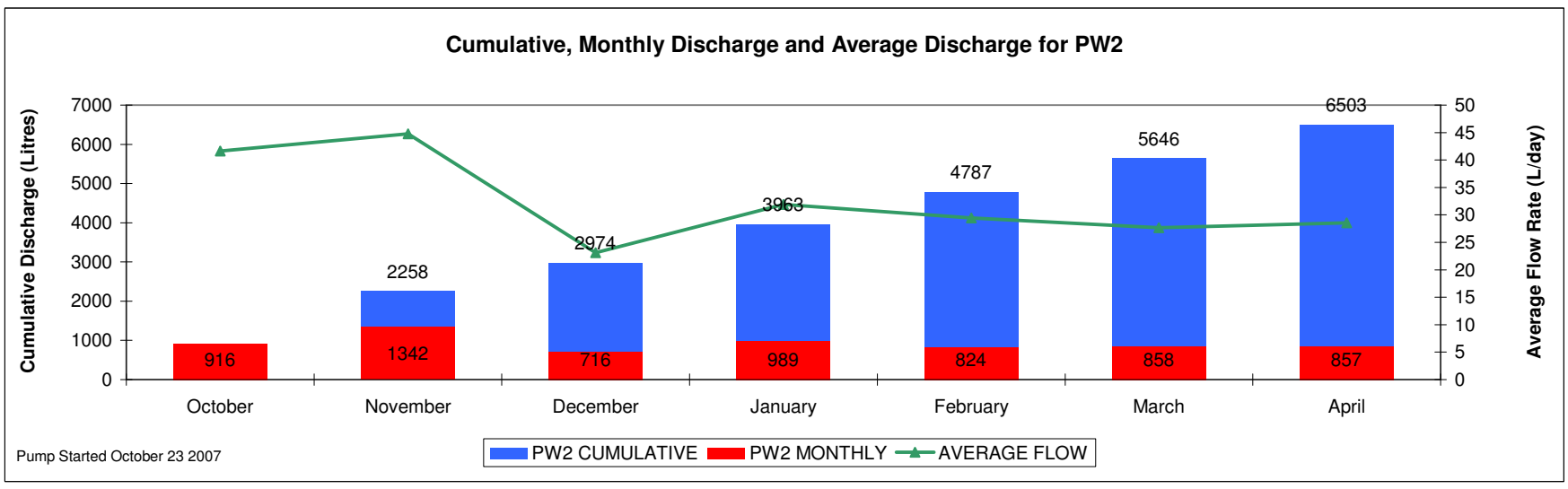
DATE:	MAY 2008
PROJECT NO:	KX0439717
REV. NO.:	A
FIGURE No.	**FIGURE 2A**

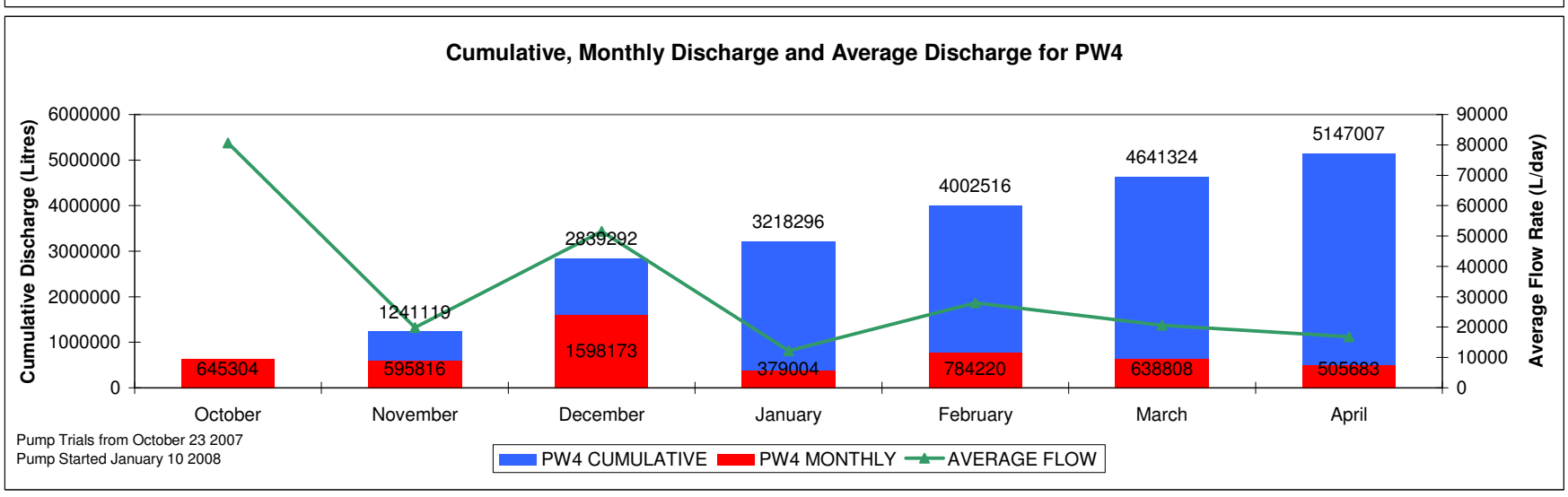
C:_Drafting Working\West Quesnel Slope Stability\KX04397.17-2008 Report-May 2008\KX04397.17-fig2A-PW1.dwg – FIGURE2A – May. 30, 2008 9:06am – shelley.ruiz

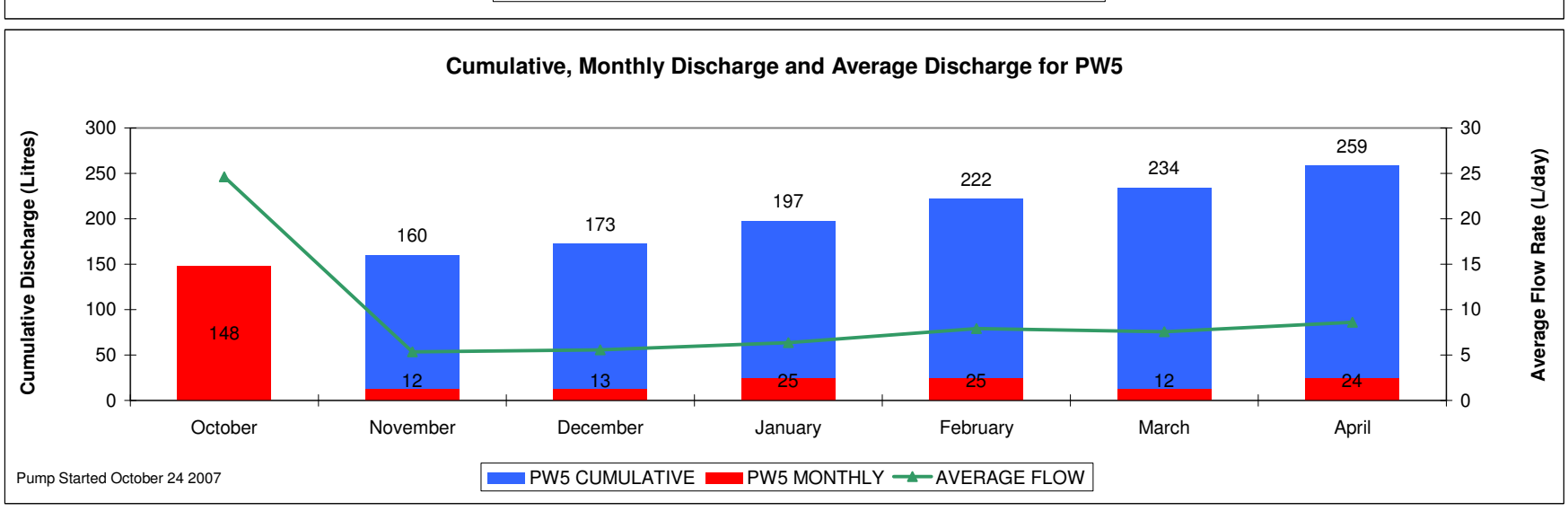
This drawing was originally produced in colour.

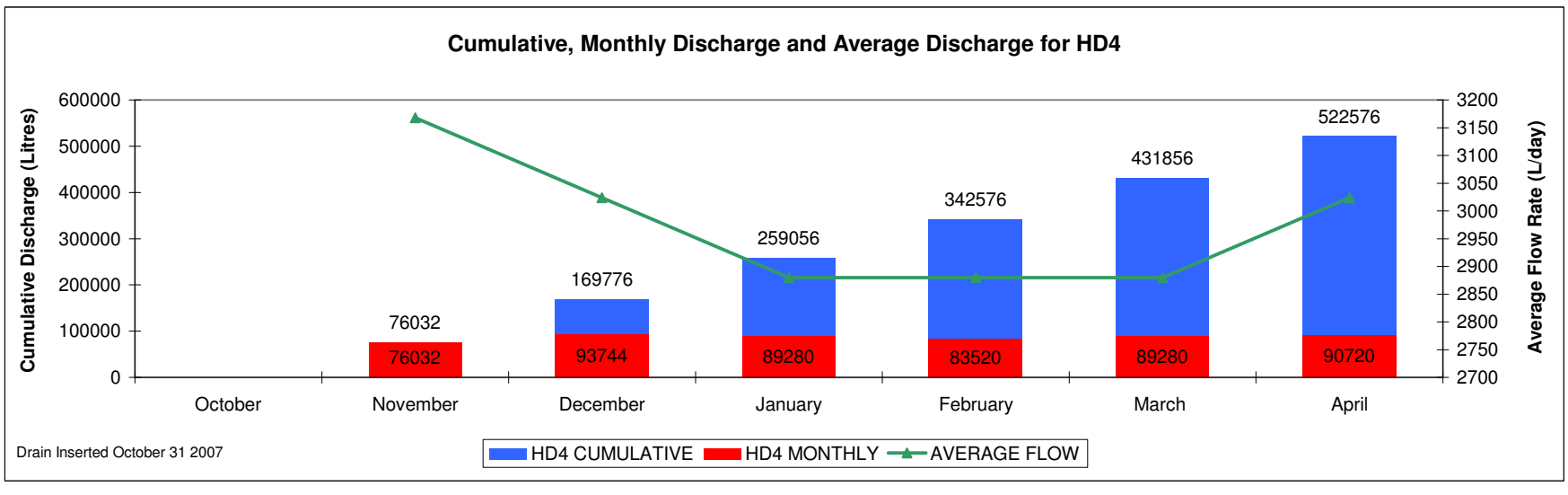
Figure 4
Pumping Wells and Horizontal Drain Flow vs. Time











Upper Baker Creek Slide

CITY OF QUESNEL BOUNDARY

Baker Creek Slide

Approximate Extent of Slide

Approximate 500 meter offset from toe of slide

FRASER RIVER

BAKER CREEK

PW1 PW2 PW4 PW5

PW

HD HD1 HD4

PALEY AVE
PICARD AVE
PANAGROT AVE
LEWIS DR
PIERCE CRES
PENTLAND CRES
PURMAL AVE
DODDS AVE
BAITY AVE
LARK AVE
STORK AVE
CRANE ST
ABBOTT DR
FINDLAY RD
DAWSON ST
BONNELLEY ST
PERRY ST
FERNWOOD ST
BETTNER ST
BLAIR ST
HAWK ST
ALLARD ST
ADAM ST
BOUCHIE ST
BEATH ST
BOYD ST
COULDWELL AVE
CLARK AVE
ALLISON AVE
AVERY AVE
AVISON AVE
ANDERSON DR
DOHERTY DR
WILLIS ST
WINDSOR ST
WEBSTER AVE
WILKINSON ST
RODDIE AVE
RITSON AVE
BAKER DR
BEAUBIEN AVE
FOSTER AVE
HIGDON AVE
HARCOURT AVE
ENGLISH AVE
HARPER AVE
ENEMARK AVE
EARLEY AVE
FULLER AVE
BOWRON AVE
NORTH FRASER DR
HARTLEY ST
HOY ST
ELLIOTT ST
MARSH DR
MALCOLM ST
LEWIS DR
BAKER DR
FRASER DR

Legend:
- Proposed Horizontal Drill Location - Phase 1
- Pumping Well Location (drilled by AMEC 2007) - installed
- Proposed Pumping Well Location - Phase 1
- Proposed Pumping Well Location - Phase 2
- Approximate 500 meter offset from toe of slide (shown in white)

Notes:
1. Cadastral provided by the City of Quesnel.
2. This drawing must be read in conjunction with AMEC Earth & Environmental Geotechnical Report, "Trial Dewatering, West Quesnel Land Stability Program".

0m 50 100 150 200 250 300

1 : 7500

CLIENT LOGO

West Quesnel
Land Stability Program

CLIENT: CITY OF QUESNEL

AMEC Earth & Environmental
3456 Opie Crescent
Prince George, BC, CANADA V2N 2P9
Tel. (250) 564-3243
Fax (250) 562-7045

amec

DWN BY: S.Ruiz
CHK'D BY: S.Kelly
DATUM: NAD83
PROJECTION: UTM Zone 10
SCALE: 1:7500

TITLE: CONCEPTUAL PRODUCTION DEWATERING PLAN

DRAFT

PROJECT: TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE: MAY 2008
PROJECT NO: KX0439717
REV. NO.: A

FIGURE 5

C:_Drafting Working\West Quesnel Slope Stability\KX04397.17-2008 Report-May 2008\KX04397.17-fig5-ZONES 11x17.dwg - figure5 - May. 27, 2008 8:33am - shelley.ruiz

This drawing was originally produced in colour.

Appendix A

Photos

Photo 1: Water well drilling rig at PW4.

Photo 2: Installing well screen at PW4.

Photo 3: Pumping well development at PW4.

Photo 4: Water well drilling rig at PW5.

Photo 5: Installing well casing at PW5.

Photo 6: Well screen installed at PW4 and PW5.

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West Quesnel Land Stability Program

TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE PREPARED: MAY 2008

SCALE: NTS

PREPARED BY: S.RUIZ

PROJECT No: KX0439717

Photos 1 to 6

Taken: June-November 2007

Photo 7: Drilling at BH22.

Photo 8: Drilling at BH25.

Photo 9: PVC conduit running from BH4B/C near PW1.

Photo 10: PVC conduit for VWP cables at BH3A/B, near PW1, looking west.

Photo 11: Installing conduit for VWP cables and electricity at PW1.

Photo 12: VWP cables and electrical conduit installed at PW1.

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West Quesnel Land Stability Program

TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE PREPARED: MAY 2008

SCALE: NTS

PREPARED BY: S.RUIZ

PROJECT No: KX0439717

Photos 7 to 12

Taken: June-November 2007

Photo 13: Trenching at BH21.

Photo 14: Trenching and VWP conduit installation near BH23.

Photo 15: Vibrating wire piezometer installation at BH21

Photo 16: VWP and electrical conduit at BH21.

Photo 17: Datalogger box at BH23.

Photo 18: PW5 with pitless adapter and discharge line.

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TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE PREPARED: MAY 2008

SCALE: NTS

PREPARED BY: S.RUIZ

PROJECT No: KX0439717

Photos 13 to 18

Taken: June-November 2007

Photo 19: Pump discharge line at PW5.

Photo 20: Pump discharge line at manhole barrel and sewer drain at PW4.

Photo 21: Pump prepared for installation at PW5 with power, ground, and shut-off cables visible.

Photo 22: Pump installation at PW5 with flow meter and restrictor visible.

Photo 23: Typical datalogger housing box, PW4 pictured.

Photo 24: Complete datalogger housing with datalogger, pump controls, breaker panel, cellular antenna visible.

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West Quesnel
Land Stability Program

TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE PREPARED: MAY 2008

SCALE: NTS

PREPARED BY: S.RUIZ

PROJECT No: KX0439717

Photos 19 to 24

Taken: June-November 2007

Photo 25: Horizontal drilling rig at HD4.

Photo 26: Horizontal drilling rig at HD4.

Photo 27: Horizontal drilling at HD4.

Photo 28: Horizontal drilling at HD4.

Photo 29: PVC horizontal drain pipe with end cap prior to install.

Photo 30: Installing PVC drain at HD4.

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West Quesnel Land Stability Program

TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE PREPARED: MAY 2008

SCALE: NTS

PREPARED BY: S.RUIZ

PROJECT No: KX0439717

Photos 25 to 30

Taken: June-November 2007

Photo 31: Horizontal drains at HD4 upon completion of drilling.

Photo 32: Horizontal drains at HD4 discharge.

Photo 33: Discharge at HD4 with inline flow meter and heat tape.

Photo 34: Horizontal drilling at HD1.

Photo 35: Broken drill rod at HD1.

Photo 36: Horizontal drains at HD1 upon completion of drilling, note dry conditions.

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West Quesnel
Land Stability Program

TRIAL DEWATERING
WEST QUESNEL LAND STABILITY PROGRAM
QUESNEL, BC

DATE PREPARED: MAY 2008

SCALE: NTS

PREPARED BY: S.RUIZ

PROJECT No: KX0439717

Photos 31 to 36

Taken: June-November 2007

APPENDIX B

Borehole Logs and Well Completion Details

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **PW-1**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: Ingersoll-Rand TH-60/Air Rotary	NORTHING: 5869772.5 EASTING: 531993.42	ELEVATION: 520.1 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND, fine to coarse grained, trace silt, some gravel, loose, brown, dry (fill)				
1		SAND, fine to medium grained, trace silt, loose, tan brown, dry				
2		SILT, some sand, trace to some clay, trace gravel, medium plasticity, soft, grey, moist to wet			Water Level observed at 1.8m below ground surface on October 8, 2003	
3					Pumping well PW-1 (150mm diameter)	
4		SAND, fine to medium grained, trace silt, some gravel, compact, dark grey				
5		note: some groundwater seepage at 5.5m below grade				
6		SILT, some clay, trace to some sand, trace gravel, medium plasticity, soft, olive brown				
7		note: driller began adding water from 5.8m below grade				
8						
9						
10						
11						
12		-grey from 11.6m				
13						
14						
15		-some clay, some gravel, trace fine sand, interbeds of clay 0.25m to 0.30m thick, firm, grey from 15.2m to 29.9m				
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

amec	AMEC Earth & Environmental 3456 Opie Crescent Prince George, British Columbia Canada V2N 2P9	LOGGED BY: SG ENTERED BY: CD	COMPLETION DEPTH: 54.9 m COMPLETION DATE: 9/16/03

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **PW-1**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: Ingersoll-Rand TH-60/Air Rotary	NORTHING: 5869772.5 EASTING: 531993.42	ELEVATION: 520.1 m

SAMPLE TYPE: TUBE; NO RECOVERY; SPLIT SPOON; GRAB; MUD RETURN; CORE RETURN

BACKFILL TYPE: BENTONITE; PEA GRAVEL; SLOUGH; GROUT; DRILL CUTTINGS; SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL	
30		GRAVEL, subrounded, trace silt, some fine to coarse grained sand, grey *(continued)*					489
31		-dark brown with some lignite below 31.4m					488
32		LIGNITE, wery weak, dark brown to black					487
33		CLAY, trace to some silt, firm to stiff, high plasticity, light grey					486
34							485
35							484
36		LIGNITE, wery weak, dark brown to black					483
37		CLAY, trace silt, trace black coarse grained sand, firm to stiff, high plasticity, blue grey					482
38							481
39		-trace silt, some lignite, high plasticity, dark brown to black from 39.3m to 40.8m					480
40							479
41		-trace silt, firm, high plasticity, dark brown from 40.8m to 41.6m					478
42		LIGNITE, clay interbeds <0.10m, very weak, dark brown to black					477
43		-drilled open hole from 42.7m					476
44		CLAY, trace silt, trace to some black sand, firm, high plasticity, light brown					475
45							474
46		CLAY TUFF, trace silt, trace to some black and green sand, very stiff to dense					473
47		-LIGNITE interbeds, thin (<20mm), with 1.5m spacing at 46.5m			Shear zone in well casing (October 2007)		472
48		-shear zone in well casing					471
49		-light brown from 47.5m to 47.7m					470
50							469
51							468
52							467
53							466
54							465
55		End of Borehole 54.9m below grade					464
56							463
57							462
58							461
59							
60							

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LOGGED BY: SG	COMPLETION DEPTH: 54.9 m
ENTERED BY: CD	COMPLETION DATE: 9/16/03

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH3BC**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: Silverado/Air Rotary	NORTHING: 5869720.44 EASTING: 522005.24	ELEVATION: 519.1 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND AND GRAVEL, fine to coarse grained sand, trace silt, compact, brown, moist (fill)				518
2		SILT, some clay, some fine grained sand, trace to some gravel, soft, medium plasticity, brown, wet				517
6		-some sand to sandy, trace gravel, firm to stiff below 6.6m				513
10		-0.3m thick layer of weak, friable, rock at 9.8m				509
11		SAND AND GRAVEL, fine to coarse grained sand, some silt, trace clay, compact, brown, wet				508
13		SILT, clayey, trace to some fine grained sand, trace gravel, firm, medium plasticity, grey, wet				506
15		SAND, fine grained, silty, trace clay, compact to dense, grey, wet				504
19		SILT, clayey, trace gravel, firm, grey				500
21		SAND, fine grained, silty, some gravel, trace clay, dense, brown				498
22		SILT, clayey, sandy, some gravel, stiff to hard, high plasticity, trace lignite inclusions, brown				497
25		SAND AND GRAVEL, trace to some silt, dense, brown				494
26		SILT, clayey, some sand, trace gravel, dense, high plasticity, brown				493
30						490

BOREHOLE LOG KX04397-2003.PUMPING WELLS-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/26/08

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LOGGED BY: SG
ENTERED BY: CD
COMPLETION DEPTH: 44.8 m
COMPLETION DATE: 7/22/03

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH3BC**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: Silverado/Air Rotary	NORTHING: 5869720.44 EASTING: 522005.24	ELEVATION: 519.1 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
30–31		GRAVEL, sub-rounded, some sand, trace silt, dense, grey			-Piezometer C set between 32.0m and 33.5m, static water level measured at 1.82m below grade (October 8, 2003)	488
31–32						487
32–33						486
33–34						485
34–35		LIGNITE, very weak, dark brown to black CLAY, some silt, trace sand, hard, high plasticity, grey and black				484
35–36						483
36–37		LIGNITE, very weak, dark brown to black CLAY, some silt, hard, high plasticity, grey to light brown				482
37–38						481
38–39						480
39–40		LIGNITE, very weak, dark brown to black -0.3m thick clay layer from 39.3m to 39.6m			-Piezometer B set between 38.7m and 40.2m, static water level measured at 1.14m below grade (October 8, 2003)	479
40–41						478
41–42		CLAY, some silt, hard, high plasticity, grey to light brown				477
42–43		LIGNITE, very weak, dark brown to black				476
43–44		CLAY, trace to some silt, hard, high plasticity, grey				475
44–45		CLAY TUFF, some silt, trace sand, dense, high plasticity, grey End of Borehole 44.8m below grade				474
45–46						473
46–47						472
47–48						471
48–49						470
49–50						469
50–51						468
51–52						467
52–53						466
53–54						465
54–55						464
55–56						463
56–57						462
57–58						461
58–59						460
59–60						

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LOGGED BY: SG | COMPLETION DEPTH: 44.8 m

ENTERED BY: CD | COMPLETION DATE: 7/22/03

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH4AB**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: Silverado/Air Rotary	NORTHING: 5869782.79 EASTING: 532040.98	ELEVATION: 519.8 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SILT, some fine grained sand, trace to some clay, trace to some gravel, soft, medium plasticity, olive brown, moist to wet				519
5		SAND AND GRAVEL, trace silt, brown, moist				515
6		SILT AND CLAY, trace sand, trace gravel, firm to stiff, medium plasticity, grey, mottled along fractured, moist -brown below 7.2m -silty sand layers (2mm-30mm thick) at 7.2m, 9.1m and 10.1m -stiff to dense below 9.1m				514
12		SAND, fine to medium grained, trace to some silt, trace gravel, compact, grey, saturated				508
13		SILT AND CLAY, firm to stiff, medium plasticity, grey, moist, texture along partings smooth and amorphous				507
18		SILT AND CLAY, some fine grained black sand, firm to stiff, medium plasticity, grey, moist -LIGNITE layer (0.3m thick) between 22.2m and 22.5m				502
24		LIGNITE, wery weak, dark brown to black				496
25		SILT AND CLAY, trace fine grained black sand, firm to stiff, medium plasticity, grey, moist -no sand from 25.9m				495
30						490

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Canada V2N 2P9

LOGGED BY: SJ
ENTERED BY: CD
COMPLETION DEPTH: 49.7 m
COMPLETION DATE: 7/17/03

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH4AB**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: Silverado/Air Rotary	NORTHING: 5869782.79 EASTING: 532040.98	ELEVATION: 519.8 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
30		SILT AND CLAY, trace fine grained black sand, firm to stiff, medium plasticity, grey, moist *(continued)*				
31		-LIGNITE layer (0.3m thick) from 30.5m to 30.8m				
32						
33						
34						
35						
36		-driller began adding water below 36.3m				
37		LIGNITE, very weak, dark brown to black				
38		SILT AND CLAY, some fine grained black sand, firm to stiff, medium plasticity, grey, moist				
39		-LIGNITE layer (0.3m thick) between 39.0m and 39.3m			-Piezometer B set between 38.7m and 40.2m, static water level measured at 3.79m below grade (October 8, 2003)	
40						
41						
42						
43						
44						
45						
46						
47						
48		-LIGNITE layer (0.3m thick) between 47.5m and 47.8m				
49		CLAY TUFF, trace to some sand, dense, high plasticity, light green, moist to wet -trace gravel from 48.8m			-Piezometer A set between 48.8m and 49.4m, static water level measured at 32.38m below grade (October 8, 2003)	
50		End of Borehole at 49.7m below grade due to broken drive shoe				
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						

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LOGGED BY: SJ
ENTERED BY: CD
COMPLETION DEPTH: 49.7 m
COMPLETION DATE: 7/17/03

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **PW-2**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: Ingersoll-Rand TH-60/Air Rotary	NORTHING: 5869595.41 EASTING: 532272.27	ELEVATION: 503.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND, fine to medium grained, trace silt, brown, loose, moist (fill)				
1						
2		-drak brown to black below 1.5m				
3		SAND, fine to medium grained, trace silt, trace gravel, loose to compact, brown, moist				
4		-fine to medium grained, silty, trace clay, loose, brown, wet from 4.0m to 6.2m			Water Level observed at 4.1m below ground surface on October 8, 2003	
5						
6						
7		SILT, trace to some sand, some gravel, trace to some clay, dense, brown, wet, isolated cobbles				
8						
9						
10						
11		-some clay below 10.4m				
12						
13						
14		-grey below 13.1m -driller began adding water to borehole at 14.0m				
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28		-clayey below 27.4m				
29						
30						
31						
32						
33						

503 502 501 500 499 498 497 496 495 494 493 492 491 490 489 488 487 486 485 484 483 482 481 480 479 478 477 476 475 474 473 472 471

BOREHOLE LOG KX04397-2003.PUMPING WELLS-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/30/08

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LOGGED BY: SG
ENTERED BY: CD
COMPLETION DEPTH: 61.0 m
COMPLETION DATE: 9/18/03

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **PW-2**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: Ingersoll-Rand TH-60/Air Rotary	NORTHING: 5869595.41 EASTING: 532272.27	ELEVATION: 503.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
33		SILT, trace to some sand, some gravel, trace to some clay, dense, brown, wet, isolated cobbles *(continued)*				
34						
35						
36						
37						
38		-GRAVEL layer, 15cm thick, at 37.5m				
39		CLAY TUFF, trace silt, some sand, very dense, green, moist				
40						
41		-no sand from 41.1m to 43.3m				
42						
43		-driller drilled open hole below 42.7m below grade with casing drive shoe at 42.7m no groundwater seepage was observed in borehole after being left undisturbed overnight				
44						
45						
46					Shear zone in well casing (October 2007)	
47		-LIGNITE layers, thin (<15cm), at 46.6m and 48.5m -sandy between 47.2m and 48.2m				
48						
49						
50						
51						
52						
53						
54						
55		-less weathered from 56.4m				
56						
57						
58						
59						
60						
61		End of Borehole 61.0m below grade				
62						
63						
64						
65						
66						

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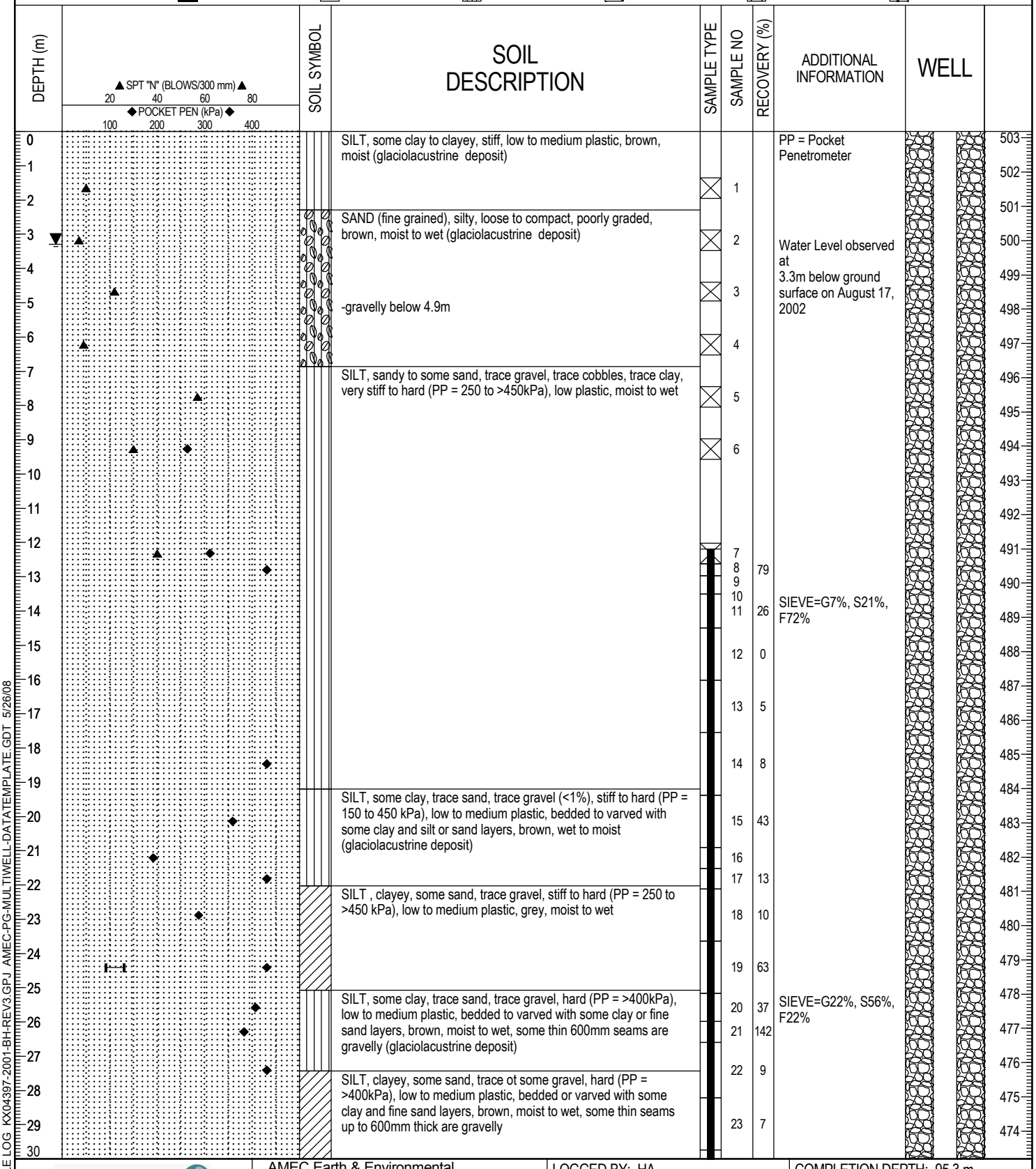
LOGGED BY: SG
ENTERED BY: CD
COMPLETION DEPTH: 61.0 m
COMPLETION DATE: 9/18/03

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH3**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-53 MOBILE/HW CASING	NORTHING: 5869597 EASTING: 532264	ELEVATION: 503.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND



amec	AMEC Earth & Environmental 3456 Opie Crescent Prince George, British Columbia Canada V2N 2P9	LOGGED BY: HA ENTERED BY: SR	COMPLETION DEPTH: 95.3 m COMPLETION DATE: 11/15/01

BOREHOLE LOG KX04397-2001-BH-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/26/08

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH3**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-53 MOBILE/HW CASING	NORTHING: 5869597 EASTING: 532264	ELEVATION: 503.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SPT "N" (BLOWS/300 mm) 20 40 60 80 / POCKET PEN (kPa) 100 200 300 400	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
30								473
31			SILT, clayey, some sand, some gravel, hard to stiff (PP = 250 to >450 kPa), low to medium plastic, grey, wet, some layers of gravel and cobbles excavated (could not confirm depths due to poor recovery) brown to grey soil, gravelly to cobbly (based on drillers comments)		24	0		472
32					25	0		471
33								470
34					26	0		469
35					27	30		468
36			-250mm thick seam of cemented (iron oxide), dense, gravelly sand (medium to fine grained)		28	41	SIEVE=G22%, S30%, F48%	467
37			**-Vibrating Wire Piezometer 3 at 37.5m**		29	14		466
38			-possible slip surface - no recovery across slip surface		30	0		465
39			-possible lignite seam based on black drill water, no recovery		31	5		464
40			TUFF, alternating coarse and fine-grained beds CLAY AND SILT TUFF, hard, high to medium plastic, blue, wet from 39.0m to 42.7m		32	0		463
41					33	5		462
42					34	41		461
43			SILT AND CLAY TUFF, trace sand and gravel (in some thin layers), trace lignite (<1%), hard (PP = >450kPa), medium plastic, green, mottled, moist to wet from 42.7m to 58.4m		35	92	Hydrometer Analysis=SAND 3%, SILT 79%, CLAY 18%	460
44			-230mm thick layer of bedded fine sand, silty with some gravel (in some thin layers), trace lignite (<1%), hard (pp >450kPa), medium plastic, green, mottled, moist to wet		36	100		459
45			-50mm layer of silty sand with trace gravel (clasts mainly rounded clay fragments)		37	80		458
46			-75mm layer of silty sand with trace to some gravel (clasts mainly igneous rock with some clay fragments)					457
47			-200mm thick seam of gravelly (angular, igneous fragments) silt with some sand and trace clay		38	100		456
48			-400mm seam of bedded silt and fine sand with some gravel					455
49			-possible slickensides -trace clay clasts (rounded and gravel size)		39	100		454
50			-300mm thick breccia seam -possible slickensides		40	103	SIEVE=S68%, F32%	453
51			-600mm thick seam of trace to some sand, trace lignite (<1%) -100mm thick sandy silt lense					452
52			-240mm thick silty sand lense -70mm thick silty sand lense		41	100		451
53			-240mm thick silty sand lense		42	100		450
54			-sand and gravel (some silt to silty) 0.4m thick -silt sand/sandy silt lense 1.5m thick		43	59	Artesian water pressure (greater than 5.5m of head above ground surface)	449
55					44	100		448
56			-150mm thick silty sand and gravel lense, trace gravel (rounded clay clasts) -trace lignite (<1%) -possible slickensides		45	100	Artesian water pressure (flow was approx. 0.5L/min)	447
57			-silty sand and gravel lense, trace gravel sized clay clasts, brown, 0.9m thick					446
58					46	100		445
59			-SANDSTONE, brown from 58.4m to 58.7m SILT AND CLAY TUFF, trace to some sand, trace to some clay fragments (gravel size), trace lignite (<1%), hard, medium to high		47	100		444
60								

BOREHOLE LOG KX04397-2001-BH-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/26/08

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3456 Opie Crescent
Prince George, British Columbia
Canada V2N 2P9

LOGGED BY: HA | COMPLETION DEPTH: 95.3 m
ENTERED BY: SR | COMPLETION DATE: 11/15/01

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH3**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-53 MOBILE/HW CASING	NORTHING: 5869597 EASTING: 532264	ELEVATION: 503.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	▲SPT "N" (BLOWS/300 mm)▲ 20 40 60 80 ◆POCKET PEN (kPa)◆ 100 200 300 400	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL	
60			plastic, green from 58.7m to 60.2m				SIEVE=G25%, S52%, F23%		443
61			-300mm thick lense of silty sand with clay clasts (rounded and gravel size)		48	80			442
62			TUFF, alternating coarse and fine-grained beds *(continued)*						441
63			SAND TUFF, some gravel to gravelly, some silt to silty, some clay clasts (rounded and gravel size), very dense, green from 58.7m to 67.1m		49	100			440
64			-easier penetration from 60.7m to 61m -silt and clay, trace lignite (<1%), hard, medium to high plastic, green, from 61.9m to 63.1m		50	67			439
65			-silt and clay, trace lignite (<1%), hard, medium to high plastic, green, from 64.8m to 65.4m		51	52			438
66									437
67			-silt and clay, trace lignite (<1%), hard, medium to high plastic, green, from 66.3m to 66.8m		52	114			436
68			SILT TUFF, some clay to clayey, trace to some sand with isolated sand and gravel lenses, trace to some clay fragments (rounded and gravel size), hard, low to high plastic, green from 67.1m to 70.0m		53	58			435
69					54	92			434
70			-600mm thick lense of sand with some gravel to gravelly, some silt, some clay clasts (rounded and gravel size), very dense, green -450mm thick lense of silt and clay		55	103			433
71			-gravelly, silty sand seam with clay clasts (rounded and gravel size)				SIEVE=G3%, S72%, F25%		432
72			SAND TUFF, some gravel to gravelly, some silt to silty, trace to some clay, some clay clasts (rounded and gravel size), trace lignite (<1%), very dense, green from 70.0m to 80.2m		56	93			431
73			-silt and clay lenses interbedded within the stratum below 70.7m		57	97			430
74			-150mm thick breccia seam						429
75					58	100			428
76					59	75			427
77									426
78					60	78			425
79					61	87			424
80			-300mm thick sandstone seam						423
81			SILT AND CLAY TUFF, trace sand, trace gravel, hard, medium to high plastic, green from 80.2m to 95.1m		62	107			422
82					63	92			421
83			-trace lignite						420
84			-silty sand and gravel lenses with clay fragments		64	0			419
85					65	100			418
86									417
87					66	47			416
88			-200mm thick silty sand and gravel lense -75mm thick silty sand sand gravel lense		67	100			415
89			-150mm thick silty sand and gravel lense, brownish						414
90							SIEVE=G11%, S58%,		

BOREHOLE LOG KX04397-2001-BH-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/26/08

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Prince George, British Columbia
Canada V2N 2P9

LOGGED BY: HA | COMPLETION DEPTH: 95.3 m

ENTERED BY: SR | COMPLETION DATE: 11/15/01

CLIENT: City of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH3**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-53 MOBILE/HW CASING	NORTHING: 5869597 EASTING: 532264	ELEVATION: 503.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SPT "N" (BLOWS/300 mm) 20 40 60 80 / POCKET PEN (kPa) 100 200 300 400	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
90			-300mm thick silty sand and gravel lense				F31%	
91			TUFF, alternating coarse and fine-grained beds *(continued)*		68	88		
			-130mm thick silty sand and gravel lense		69	47		
92								
			-130mm thick silty sand and gravel lense					
93			-180mm thick seam of breccia		70	0		
94								
					71	10		
95								
			End of Borehole at 95.1m, vibrating wire piezometer installed at 37.5m below grade					
96								
97								
98								
99								
100								
101								
102								
103								
104								
105								
106								
107								
108								
109								
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117								
118								
119								
120								

413 412 411 410 409 408 407 406 405 404 403 402 401 400 399 398 397 396 395 394 393 392 391 390 389 388 387 386 385 384

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LOGGED BY: HA
ENTERED BY: SR
COMPLETION DEPTH: 95.3 m
COMPLETION DATE: 11/15/01

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **PW4**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: TH60/Air Rotary	NORTHING: 5870265.93 EASTING: 531614.55	ELEVATION: 557 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND, gravelly, some silt to silty, brown, dry				
3		gravel, sandy				
4		SAND and GRAVEL				
5		sand, some gravel, some silt, trace cobbles				
6					-casing to 6.1m -slotted screen from 6.1m to 30.5m	
12		gravel and cobbles, sandy, moist				
14		gravel and cobbles, clean, grey				
15		sandy, brown				
16		SAND, some gravel to gravelly, brown, moist				
17		GRAVEL, some sand, some fines, trace cobbles, brown, moist to wet				
21		saturated				
22		trace fines				
23		sandy some sand, trace to some fines				
24						
25		sandy, some fines some sand, trace fines				
26		CLAY, some silt, some sand to sandy, trace gravel, grey, saturated				
29		clay, trace silt, bluish				

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BOREHOLE LOG KX0439717 PUMP WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **PW4**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: TH60/Air Rotary	NORTHING: 5870265.93 EASTING: 531614.55	ELEVATION: 557 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL	
30							
31		End hole at 30.5m Installed slotted PVC well					526
32							525
33							524
34							523
35							522
36							521
37							520
38							519
39							518
40							517
41							516
42							515
43							514
44							513
45							512
46							511
47							510
48							509
49							508
50							507
51							506
52							505
53							504
54							503
55							502
56							501
57							500
58							499
59							498
60							

BOREHOLE LOG KX0439717 PUMP WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: NE/KB
ENTERED BY: BP
COMPLETION DEPTH: 30.5 m
COMPLETION DATE: 6/27/07

CLIENT: City Of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH12**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: HC 2000 Coring	NORTHING: 5870271.58 EASTING: 531620.09	ELEVATION: 556.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	◆POCKET PEN (kPa)◆ 100 200 300 400 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
0			SAND AND GRAVEL, silty, compact, well graded, subrounded particles, grades into SAND, silty, brown, moist to wet					556
1					1	11		555
2					2	23		554
3	◆		SILT AND SAND, fine grained, trace gravel, dense to very dense, moist, brown		3	58		553
4					4	0		
5					5	0		552
5			SAND, fine grained, some silt, some interbeds of medium SAND, trace silt and SILT AND SAND, compact to dense, brown, moist to wet		6	81		
7					7	56		551
6					8	76		
7					9	68		550
8			-field log indicates saturated soil (possible water table) at 7.8 m		10	97		549
8					11	59		
9					12	34		548
10					13	73		547

BOREHOLE LOG KX04397-2005.SIMP.BH05-7-8-9-11-12-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/26/08

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LOGGED BY: HR/CD
ENTERED BY: CD
COMPLETION DEPTH: 70.2 m
COMPLETION DATE: 6/22/06

CLIENT: City Of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH12**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: HC 2000 Coring	NORTHING: 5870271.58 EASTING: 531620.09	ELEVATION: 556.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	POCKET PEN (kPa) 100 200 300 400 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
10			SAND, fine grained, some silt, some interbeds of medium SAND, trace silt and SILT AND SAND, compact to dense, brown, moist to wet *(continued)*		14	0		546
					15	102		
11			-some gravel to gravelly from 11.1 m		16	47		545
			-no recovery from 11.7 to 12.0m		17	0		
12					18	62		544
			-no recovery from 12.5m to 14.0m		19	0		
13								543
					20	0		
14								
					21	64		542
15			GRAVEL, silt and sand matrix, subrounded to subangular, well graded up to 70 mm sized clasts, dense, damp		22	85		
					23	62		541
16					24	7		
			SAND, medium grained, some silt, some gravel, dense to compact, brown, moist to wet		25	68		540
			SAND AND GRAVEL, well graded, rounded to angular, trace to some silt, brown, wet		26	0		
17			-no recovery from 16.5m to 18.0m					
					27	0		539
					28	0		
18			**-Vibrating Wire Piezometer 12A at 18.0m**		1	203		
			-no recovery from 18.2m to 20.7m					538
					29	0		
19								
								537
20								

BOREHOLE LOG KX04397-2005.SIMP BH05-7-8-9-11-12-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/26/08

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Prince George, British Columbia
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LOGGED BY: HR/CD	COMPLETION DEPTH: 70.2 m
ENTERED BY: CD	COMPLETION DATE: 6/22/06

CLIENT: City Of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH12**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: HC 2000 Coring	NORTHING: 5870271.58 EASTING: 531620.09	ELEVATION: 556.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	POCKET PEN (kPa) 100 200 300 400 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
20			SAND AND GRAVEL, well graded, rounded to angular, trace to some silt, brown, wet *(continued)*		30	0		536
21			GRAVEL AND SAND, some silt, rounded to subangular, well graded up to 70 mm clasts, compact to dense, with some interbeds of GRAVEL, loose, washed and interbeds of SAND trace to some silt, dense, moist to wet, brown		31	79		535
22					32	48		534
23			-SAND, some gravel, some clay grading to SAND, clayey, stiff/dense, moist, greyish brown at 22.4 m **-Vibrating Wire Piezometer 12B at 22.9m**		33	27		533
24			-no recovery from 23.7m to 25.2m		34	0		532
25			GRAVEL AND CLAY, medium sized gravel, subangular clasts TUFF, alternating coarse and fine-grained beds					531
26			CLAY TUFF, trace sand-sized clasts, very stiff, high plastic, green/blue from 25.3 to 45.2m Note: fractured between 25.3m and 51.3m with average joints (51 recorded) spaced 0.35m to 0.40m apart **-Vibrating Wire Piezometer 12C at 26.5m**		35	108		530
27					36	103		529
28			-sandy, hard from 28.2m to 28.5m		37	106		528
29					38	107		527
30								

BOREHOLE LOG KX04397-2005.SIMP BH05-7-8-9-11-12-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/26/08

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Canada V2N 2P9

LOGGED BY: HR/CD
ENTERED BY: CD
COMPLETION DEPTH: 70.2 m
COMPLETION DATE: 6/22/06

CLIENT: City Of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH12**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: HC 2000 Coring	NORTHING: 5870271.58 EASTING: 531620.09	ELEVATION: 556.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	POCKET PEN (kPa) 100 200 300 400 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
30			TUFF, alternating coarse and fine-grained beds *(continued)*		39	102		526
31								525
32			-slightly oxidized, orange colour from 31.8m to 32.7m		40	107		524
33								523
			-sandy from 33.5m to 33.8 m		41	105		
34								522
			-sandy from 34.5m to 34.6 m					
35					42	114		521
			-sandy from 35.2m to 35.6 m					
36					43	95		520
37								519
			-sandy from 37.7m to 38.0m		44	99		
38			-sandy, some fine gravel-sized clasts from 38.0m to 38.0m		45	106		518
			-trace organics from 38.6m to 40.2m					
39					46	106		517
40			-sandy from 39.8m to 40.0m					

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LOGGED BY: HR/CD
ENTERED BY: CD
COMPLETION DEPTH: 70.2 m
COMPLETION DATE: 6/22/06

CLIENT: City Of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH12**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: HC 2000 Coring	NORTHING: 5870271.58 EASTING: 531620.09	ELEVATION: 556.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	POCKET PEN (kPa) 100 200 300 400 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
40			TUFF, alternating coarse and fine-grained beds *(continued)*					516
41					47	102		515
42			-some sand to sandy from 41.9m to 42.2m		48	93		514
43			-sandy from 43.4m to 43.8m -some fine whitish gravel-sized clasts from 43.7m to 43.8m		49	123		513
44			-slough from 44.7m to 44.8m		50	130		512
45	◆		CLAY TUFF, trace sand-sized clasts, very stiff, high plastic, green-blue from 44.8m to 45.7m -sandy from 45.2 m to 45.3 m		51	97		511
46	◆		SAND AND GRAVEL TUFF, fine gravel-sized clasts, subrounded, mix of weak weathered clay rich and more resistant clasts, clay matrix, hard, blue/green from 45.7m to 45.8m CLAY TUFF, trace sand-sized clasts, very stiff, high plastic, green-blue from 45.8m to 46.6m -soft, damp from 46.0 m to 46.1 m		52	102		510
47			SAND AND GRAVEL TUFF, fine gravel-sized clasts, subrounded, mix of weak weathered clay rich and more resistant clasts, clay matrix, hard, blue/green from 46.6m to 46.7m CLAY TUFF, trace sand-sized clasts, very stiff, high plastic, green/blue from 46.7m to 48.0m		53	130		509
48			CLAY AND SAND TUFF, very stiff, medium plastic, blue-green from 48.0m to 49.0m		54	102		508
49			GRAVEL AND SAND TUFF, clay matrix, clasts well graded up to medium-sized gravel, mix of weak weathered clay-rich and more resistant clasts, very stiff/dense, green/blue from 49.0m to 49.3m CLAY AND SAND TUFF, very stiff, medium plastic, green-blue, whitish sand-sized inclusions from 49.3m to 49.7m		55	108		507
50			CLAY TUFF, trace to no sand-sized clasts, very stiff to hard, high					

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LOGGED BY: HR/CD | COMPLETION DEPTH: 70.2 m
ENTERED BY: CD | COMPLETION DATE: 6/22/06

CLIENT: City Of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH12**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: HC 2000 Coring	NORTHING: 5870271.58 EASTING: 531620.09	ELEVATION: 556.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	POCKET PEN (kPa) 100 200 300 400 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
50			plastic, blue-green from 49.7m to 50.1m TUFF, alternating coarse and fine-grained beds *(continued)* SAND TUFF, coarse grained, some fine gravel-sized clasts, clay matrix, very stiff to dense, blue-green from 50.1m to 50.4m CLAY TUFF, trace to some sand-sized clasts, very stiff, medium plastic, damp from 50.4m to 53.5m					506
51					56	91		505
52								504
53					57	100		503
54			CLAY AND SAND TUFF, trace fine gravel-sized clasts, very stiff, high plastic, whitish sand-sized inclusions from 53.5m to 56.6m note: highly fractured between 54.0m and 54.5m with slickensided joints, 15-40° from core axis (10 recorded) spaced 0.1m apart (shear zone)		58	100		502
55			**-Vibrating Wire Piezometer 12D at 54.9m**					501
56					59	93		500
57			CLAY TUFF, trace sand-sized clasts, very stiff, medium plastic, blue-green from 56.6m to 57.9m note: highly fractured between 57.3m and 59.0m with joints, 45-50° from core axis (6 recorded) spaced 0.3m apart		60	102		499
58			SAND TUFF, medium to coarse-grained clasts, trace gravel-sized clasts, clay matrix, very stiff to hard, blue-green, damp from 57.9m to 58.1m CLAY TUFF, zones of some sand-sized clasts, hard, high plastic, blue-green, damp from 58.1m to 60.0m					498
59					61	117		497
60								

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LOGGED BY: HR/CD
ENTERED BY: CD
COMPLETION DEPTH: 70.2 m
COMPLETION DATE: 6/22/06

CLIENT: City Of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH12**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: HC 2000 Coring	NORTHING: 5870271.58 EASTING: 531620.09	ELEVATION: 556.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	POCKET PEN (kPa) 100 200 300 400 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
60			TUFF, alternating coarse and fine-grained beds *(continued)*					496
			GRAVEL AND SAND TUFF, well graded from fine sand to medium gravel-sized clasts, mix of weak weathered clay-rich and more resistant clasts, clay matrix and clast supported, hard from 60.0m to 60.2m		62	98		
61			CLAY TUFF, zones of fine sand-sized clasts, hard, high plastic, blue-green, damp, core breaks into slickensided fractures from 60.2m to 61.5m note: highly fractured between 60.4m and 62.3m with slickensided joints, 65-70° from core axis (10 recorded) spaced 0.2m apart (shear zone)					495
62			SAND AND CLAY TUFF, fine to medium-grained sand-sized clasts, clay matrix, hard, medium plastic, blue-green from 61.5m to 62.0m		63	108		494
			CLAY TUFF, trace to no sand-sized clasts, hard, high plastic, blue/green, damp, core breaks into slickensided fractures, from 62.0m to 62.4m					
63			GRAVEL AND SAND TUFF, clast and matrix (clay) supported, subrounded clasts of clays and lithic fragments, very hard, blue/green matrix from 62.4m to 63.7m note: no joints -SI-12 indicates displacement at 63.4m		64	103		493
64								492
65					65	93		491
66					66	15		490
67								489
68					67	110		488
69								487
					68	89		
70								

BOREHOLE LOG KX04397-2005.SIMP BH05-7-8-9-11-12-REV3.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/26/08

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LOGGED BY: HR/CD
ENTERED BY: CD
COMPLETION DEPTH: 70.2 m
COMPLETION DATE: 6/22/06

CLIENT: City Of Quesnel	PROJECT: West Quesnel Land Stability Study	BOREHOLE NO: **BH12**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: HC 2000 Coring	NORTHING: 5870271.58 EASTING: 531620.09	ELEVATION: 556.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	POCKET PEN (kPa) 100 200 300 400 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	ADDITIONAL INFORMATION	WELL
70			TUFF, alternating coarse and fine-grained beds *(continued)* SAND TUFF interbed, fine grained, some clay, trace to some gravel-sized clasts, supported by clay and sand matrix, blue-green from 63.7m to 70.2m note: no joints -coarse sand and fine gravel-sized clasts from 64.8 m to 65.5 m -coarse sand and fine gravel-sized clasts from 66.3 m to 66.4 m -coarse sand and fine gravel-sized clasts from 67.0 m to 67.2 m -coarse sand and fine gravel-sized clasts from 68.7 m to 68.9 m End of Borehole at 70.2m Drilling method did not allow observation of water level					
71								
72								
73								
74								
75								
76								
77								
78								
79								
80								

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CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-19**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX	NORTHING: 5870266.21 EASTING: 531609.22	ELEVATION: 557 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND, some gravel, trace fines, medium grained, brown, moist				
1						556
2						555
3						554
4						553
5						552
6		-fine grained, trace to some silt				551
7						550
8						549
9						548
10						547
11		GRAVEL, some sand, some silt, compact, brown, moist				546
12		-moist to wet				545
13						544
14						543
15						542
16		SAND and GRAVEL, silty, brown, moist				541
17		SAND, some gravel, trace silt, brown, moist **-Vibrating Wire Piezometer 19A (Geokon Model 4500-350kPa) installed at 16.5m**				540
18		-gravelly				539
19						538
20						537
21		-silt, some sand, trace gravel, brown, moist to wet				536
22		CLAY, some sand, trace to some gravel, trace silt, grey, saturated				535
23		**-Vibrating WIre Piezometer 19B (Geokon Model 4500-350kPa) installed at 22.3m**				534
24		End of Hole at 23.8m. Installed 2 vibrating wire piezometers.				533
25						532
26						531
27						530
28						529
29						528
30						

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LOGGED BY: BP
ENTERED BY: BP
COMPLETION DEPTH: 23.8 m
COMPLETION DATE: 7/10/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-20**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX	NORTHING: 5870268.36 EASTING: 531566.5	ELEVATION: 559.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND, trace gravel, trace fines, brown				
8		-silt, sandy, gravelly to 8.2m				
9		GRAVEL, some sand, trace fines, brown				
12		SAND and GRAVEL, trace fines, brown, moist				
13		SAND, silty, trace gravel, brown, moist				
20		-some greyish silt				
21		CLAY, trace sand, trace silt, trace gravel, hard, grey, wet **-Vibrating Wire Piezometer 20A (Geokon Model 4500-350kPa) installed at 21.4m**				
22		End of Hole at 22.9m. Installed 1 vibrating wire piezometer.				

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BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **PW5**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: TH60/Air Rotary	NORTHING: 5869414.08 EASTING: 532345.25	ELEVATION: 481.3 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND and GRAVEL, trace to some cobbles, some silt, dry to moist				
2		SAND, clayey, silty, some gravel, coarse grained, saturated				
7		silt, sandy, saturated, light brown				
11		gravelly, trace to some cobbles				
17		silt, sandy, trace gravel, grey				
21		gravelly				
24		clay, sandy, trace to some gravel, greenish				
25		SILT and CLAY, sandy, some fine gravel, (like clay TILL), greenish tinge				

Depth (m)	Elevation (m)
0	481
1	480
2	479
3	478
4	477
5	476
6	475
7	474
8	473
9	472
10	471
11	470
12	469
13	468
14	467
15	466
16	465
17	464
18	463
19	462
20	461
21	460
22	459
23	458
24	457
25	456
26	455
27	454
28	453
29	452
30	

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LOGGED BY: NE/KB
ENTERED BY: BP
COMPLETION DEPTH: 61.0 m
COMPLETION DATE: 6/26/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **PW5**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: TH60/Air Rotary	NORTHING: 5869414.08 EASTING: 532345.25	ELEVATION: 481.3 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
30–39		SAND, clayey, silty, some gravel, coarse grained				
39–60		CLAY, blue clay tuff			-casing to 42.7m -slotted screen from 42.7m to 61m	

451 450 449 448 447 446 445 444 443 442 441 440 439 438 437 436 435 434 433 432 431 430 429 428 427 426 425 424 423 422

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LOGGED BY: NE/KB
ENTERED BY: BP
COMPLETION DEPTH: 61.0 m
COMPLETION DATE: 6/26/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **PW5**
DRILLER: Cariboo Water Wells	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: TH60/Air Rotary	NORTHING: 5869414.08 EASTING: 532345.25	ELEVATION: 481.3 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL	
60		CLAY, blue clay tuff *(continued)*					421
61		End hole at 61m Installed slotted PVC well					420
62							419
63							418
64							417
65							416
66							415
67							414
68							413
69							412
70							411
71							410
72							409
73							408
74							407
75							406
76							405
77							404
78							403
79							402
80							401
81							400
82							399
83							398
84							397
85							396
86							395
87							394
88							393
89							392
90							

BOREHOLE LOG KX0439717 PUMP WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: NE/KB
ENTERED BY: BP
COMPLETION DEPTH: 61.0 m
COMPLETION DATE: 6/26/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-17**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869417.38 EASTING: 532349.64	ELEVATION: 481.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND and GRAVEL, some fines, brown, wet				481
3		SAND and SILT, some gravel, brown, compact, wet				478
5		SAND and GRAVEL, some fines, compact, brown, wet				476
7		SILT, some sand, some clay, trace gravel, firm to stiff, low plasticity, brown, wet -trace gravel seams				474
11		SAND, some silt to silty, trace gravel, compact, brown, wet				470
13		SILT and CLAY, trace to some sand, stiff to very stiff, low to high plastcity, greyish, wet Occasional sand silt layers throughout				468
30						452

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: SK
ENTERED BY: BP
COMPLETION DEPTH: 59.3 m
COMPLETION DATE: 7/7/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-17**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869417.38 EASTING: 532349.64	ELEVATION: 481.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
30		SILT and CLAY, trace to some sand, stiff to very stiff, low to high plastcity, greyish, wet				
31		Occasional sand silt layers throughout *(continued)*				
32						
33						
34						
35						
36						
37						
38		**- Vibrating Wire Piezometer 17A (Geokon Model 4500-350kPa) installed at 37.7m**				
39						
40						
41						
42		SAND and GRAVEL layer from 41.7m to 42.4m				
43		ODEX casing to 42.7m				
44						
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58		**- Vibrating Wire Piezometer 17B (Geokon Model 4500-700kPa) installed at 57.4m**				
59						
60		End of Hole at 59.3m. Installed 2 vibrating wire piezometers.				

451 450 449 448 447 446 445 444 443 442 441 440 439 438 437 436 435 434 433 432 431 430 429 428 427 426 425 424 423 422

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LOGGED BY: SK | COMPLETION DEPTH: 59.3 m

ENTERED BY: BP | COMPLETION DATE: 7/7/07

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-18**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869443.27 EASTING: 532352.97	ELEVATION: 481.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND and GRAVEL				481
4		SAND and GRAVEL, silty, interbedded				477
13		SILT, gravelly, stiff, brown, moist				468
18		-soft gravelly seam to 18.3m -grey				463
23		GRAVEL, some silt				458
25		SILT, trace gravel, trace clay				456
26		SAND and GRAVEL, some silt to silty, compact, brown, moist				455
28		SILT, some sand, some fine gravel, interlayered, brown to grey				453
30						452

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LOGGED BY: BP
ENTERED BY: BP
COMPLETION DEPTH: 60.7 m
COMPLETION DATE: 7/9/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-18**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869443.27 EASTING: 532352.97	ELEVATION: 481.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
30		SILT, some sand, some fine gravel, interlayered, brown to grey *(continued)*				451
31						450
32						449
33						448
34						447
35						446
36						445
37						444
38		**- Vibrating Wire Piezometer 18A (Geokon Model 4500-350kPa) installed at 38.2m**				443
39						442
40						441
41						440
42		CLAY and SILT, trace sand, stiff to very stiff, low plastic, grey				439
43						438
44						437
45						436
46						435
47						434
48						433
49						432
50						431
51						430
52						429
53						428
54						427
55						426
56						425
57						424
58						423
59						422
60						

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LOGGED BY: BP
ENTERED BY: BP
COMPLETION DEPTH: 60.7 m
COMPLETION DATE: 7/9/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-18**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869443.27 EASTING: 532352.97	ELEVATION: 481.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
60		CLAY and SILT, trace sand, stiff to very stiff, low plastic, grey *(continued)* **-Vibrating Wire Piezometer 18B (Geokon Model 4500-700kPa) installed at 60.1m**				
61		End of Hole at 60.7m. Installed 2 vibrating wire piezometers.				
62						
63						
64						
65						
66						
67						
68						
69						
70						
71						
72						
73						
74						
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90						

421 420 419 418 417 416 415 414 413 412 411 410 409 408 407 406 405 404 403 402 401 400 399 398 397 396 395 394 393 392

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: BP | COMPLETION DEPTH: 60.7 m

ENTERED BY: BP | COMPLETION DATE: 7/9/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-21**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: GT-300/Wet Rotary	NORTHING: 5869384.67 EASTING: 532177.32	ELEVATION: 505.9 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND and GRAVEL, trace fines, brown, moist			Note: hole logged by driller.	
4		SILT, sandy, gravelly, brown				
12		SAND, silty, trace gravel, brown **-Vibrating Wire Piezometer 21A (Geokon Model 4500-350kPa) installed at 12.6m**				
17		GRAVEL, some sand, some silt, trace clay, angular fragments, some quartz fragments, brown to grey				
21		CLAY, grey **-Vibrating Wire Piezometer 21B (Geokon Modell 4500-350kPa) installed at 21.3m**				
24		End of Hole at 24.4m. Installed 2 vibrating wire piezometers.				

Depth scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Elevation scale: 505 504 503 502 501 500 499 498 497 496 495 494 493 492 491 490 489 488 487 486 485 484 483 482 481 480 479 478 477

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: BP	COMPLETION DEPTH: 24.4 m
ENTERED BY: BP	COMPLETION DATE: 7/11/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-22**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-47/ODEX	NORTHING: 5869382.3 EASTING: 532131.6	ELEVATION: 508.7 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND, trace to some silt, fine to medium grained, brown to grey, dry to moist				
2		SILT, some sand to sandy, trace gravel, trace to some clay, brown, moist				
4		SAND, trace to some silt, trace gravel, trace clay, orange-brown to brown, moist to saturated -saturated				
7		GRAVEL, silty, some sand, trace clay, angular fragments, light brown to grey, saturated -grey				
9		SILT, some sand, trace to some gravel, some clay to clayey, grey, saturated				
11		GRAVEL, silty, some clay, some sand, rounded, grey, saturated -trace to some silt, trace clay, rounded to angular, grey-brown				
18		-trace silt, trace clay, grey **- Vibrating Wire Piezometer 22A (Geokon Model 4500-350kPa) installed at 18.3m**				
19		CLAY, some silt, trace gravel, grey, wet				
20		End of Hole at 19.8m. Installed 1 vibrating wire piezometer.				

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: BP	COMPLETION DEPTH: 19.8 m
ENTERED BY: BP	COMPLETION DATE: 7/24/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-23**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869945.47 EASTING: 532328.98	ELEVATION: 514.7 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0–1		SAND and GRAVEL, trace fines, compact, brown to grey, dry to moist			Note: hole partially logged by driller.	
1–6		SAND, trace gravel, trace silt, brown, moist				
6–9		SAND and GRAVEL, trace fines, brown				
9–24		GRAVEL, some sand, trace fines, brown **-Vibrating Wire Piezometer 23A (Geokon Model 4500-350kPa) installed at 22.4m**				
24–30		CLAY, trace sand, trace gravel, stiff, grey to blue				

514 513 512 511 510 509 508 507 506 505 504 503 502 501 500 499 498 497 496 495 494 493 492 491 490 489 488 487 486 485

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: BP
ENTERED BY: SK
COMPLETION DEPTH: 33.5 m
COMPLETION DATE: 7/11/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-23**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869945.47 EASTING: 532328.98	ELEVATION: 514.7 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
30		CLAY, trace sand, trace gravel, stiff, grey to blue *(continued)*				
31						
32						
33						
34		**-Vibrating WIre Piezometer 23B (Geokon Model 4500-350kPa) installed at 33.1m**				
35		End of Hole at 33.5m.				
36		Installed 2 vibrating wire piezometers.				
37						
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484	483	482	481	480	479	478	477	476	475	474	473	472	471	470	469	468	467	466	465	464	463	462	461	460	459	458	457	456	455

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LOGGED BY: BP	COMPLETION DEPTH: 33.5 m
ENTERED BY: SK	COMPLETION DATE: 7/11/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-24**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX	NORTHING: 5869943.54 EASTING: 532318.31	ELEVATION: 515.4 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SAND and GRAVEL, trace fines, brown			NOTE: hole partially logged by driller.	
6		GRAVEL, some sand to sandy, trace cobbles, brown to grey				
12		-cobbly				
21		-brown, moist				
23		**-Vibrating Wire Piezometer 24A (Geokon Model 4500-350kPa) installed at 22.9m**				
24		CLAY, trace sand, trace gravel, stiff, grey to blue				
		End of Hole at 24.4m. Installed 1 vibrating wire piezometer.				

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: BP	COMPLETION DEPTH: 24.4 m
ENTERED BY: BP	COMPLETION DATE: 7/12/07

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-25**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869935.58 EASTING: 532243.61	ELEVATION: 515.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
0		SILT, some sand, brown, dry to moist				515
1						514
2		SAND, silty, trace gravel, loose to compact, brown, moist				513
3						512
4		SAND and GRAVEL, trace fines, medium grained, brown, moist				511
5						510
6		-silt, some gravel, some sand, trace clay, brown, moist to 6.7m				509
7						508
8						507
9						506
10						505
11		-sand, gravelly				504
12						503
13		-gravel, sandy, coarse grained				502
14						501
15						500
16						499
17		-saturated **-Vibrating Wire Piezometer 25A (Geokon Model 4500-350kPa) installed at 16.8m**				498
18		-silt, trace gravel, trace clay, low plastic, light brown, moist				497
19		CLAY, trace to some silt, trace gravel, blue to grey, moist				496
20						495
21						494
22						493
23						492
24						491
25						490
26						489
27						488
28						487
29						486
30						

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LOGGED BY: BP
ENTERED BY: BP
COMPLETION DEPTH: 30.5 m
COMPLETION DATE: 7/12/07

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

CLIENT: City of Quesnel	PROJECT: West Quesnel Trial Dewatering	BOREHOLE NO: **BH07-25**
DRILLER: Geotech Drilling	Quesnel, BC	PROJECT NO: KX04397
DRILL TYPE/METHOD: B-80/ODEX/Wet Rotary	NORTHING: 5869935.58 EASTING: 532243.61	ELEVATION: 515.2 m

SAMPLE TYPE: TUBE | NO RECOVERY | SPLIT SPOON | GRAB | MUD RETURN | CORE RETURN

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	ADDITIONAL INFORMATION	WELL
30		**-Vibrating Wire Piezometer 25B (Geokon Model 4500-350kPa) installed at 30.2m**				
31		End of Hole at 30.5m.				
32		Installed 2 vibrating wire piezometers.				
33						
34						
35						
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485 484 483 482 481 480 479 478 477 476 475 474 473 472 471 470 469 468 467 466 465 464 463 462 461 460 459 458 457 456

BOREHOLE LOG KX0439717 MONITORING WELLS.GPJ AMEC-PG-MULTIWELL-DATATEMPLATE.GDT 5/27/08

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LOGGED BY: BP | COMPLETION DEPTH: 30.5 m

ENTERED BY: BP | COMPLETION DATE: 7/12/07

APPENDIX C

Data Collected from the Instrumentation Network

West Quesnel Land Stability Program

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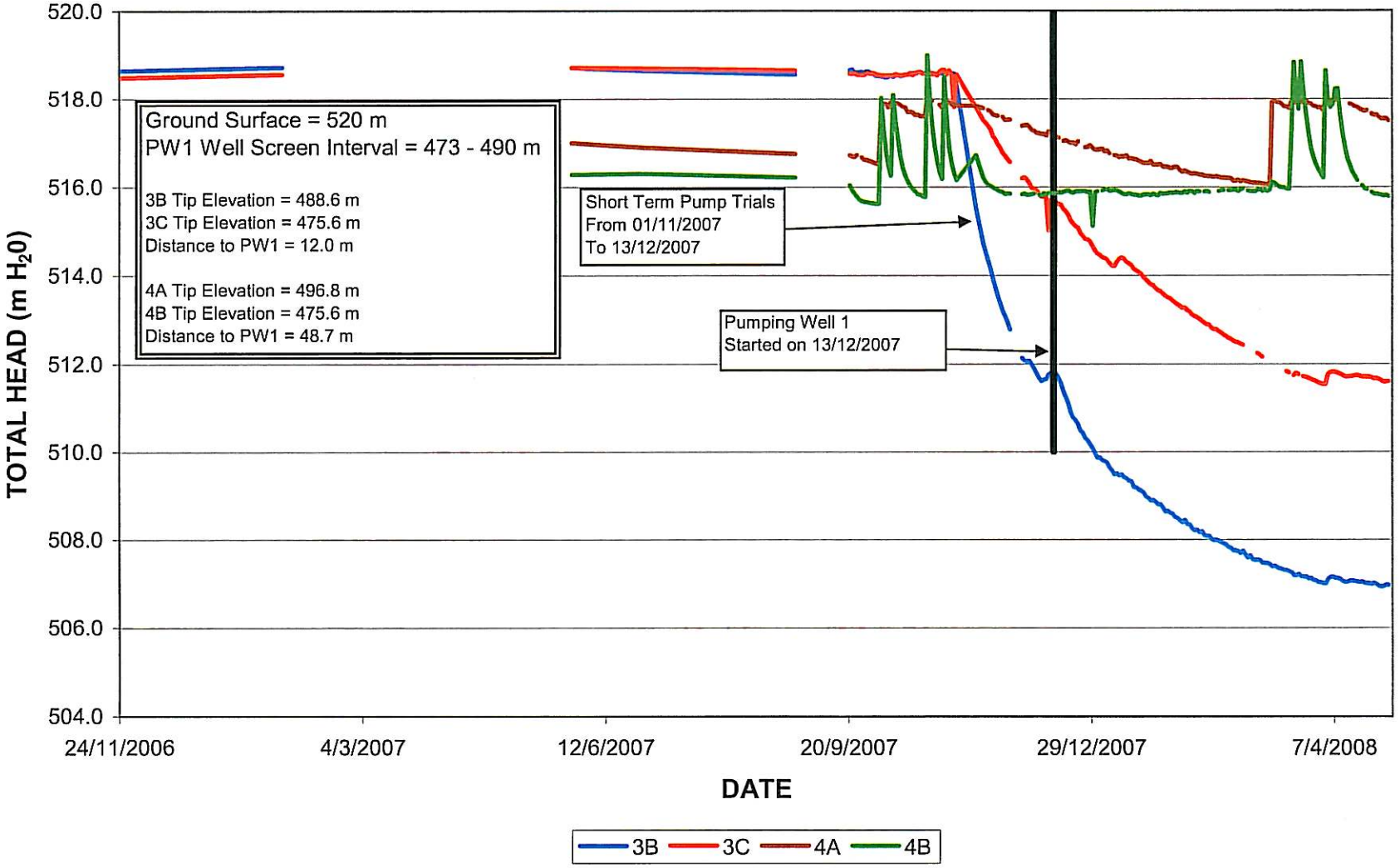
2007 - 2008 Trial Dewatering Program
TOTAL HEAD - PW1 MONITORING WELLS



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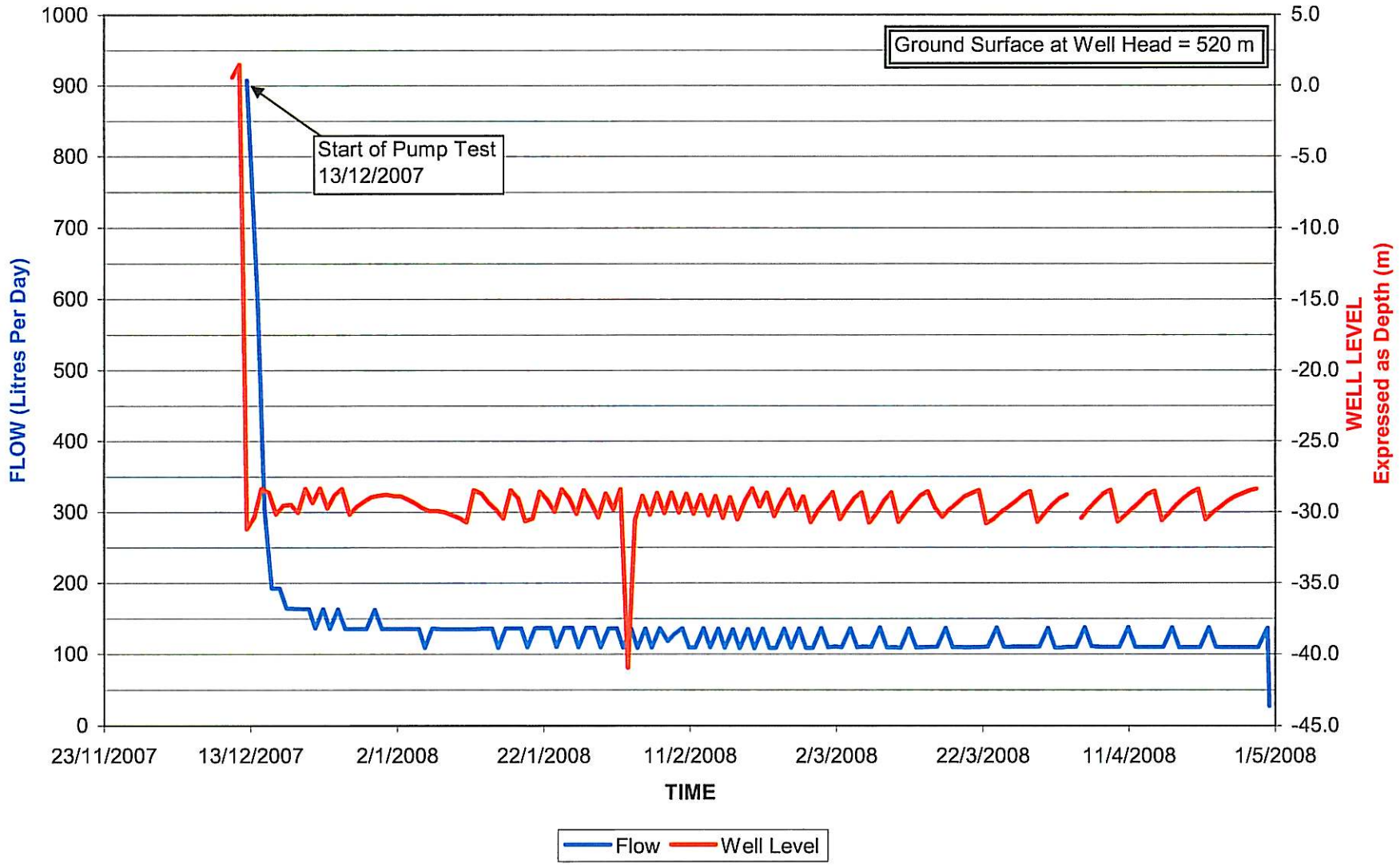
2007- 2008 Trial Dewatering Program
PW1 - TOTAL DAILY FLOW AND WELL LEVEL



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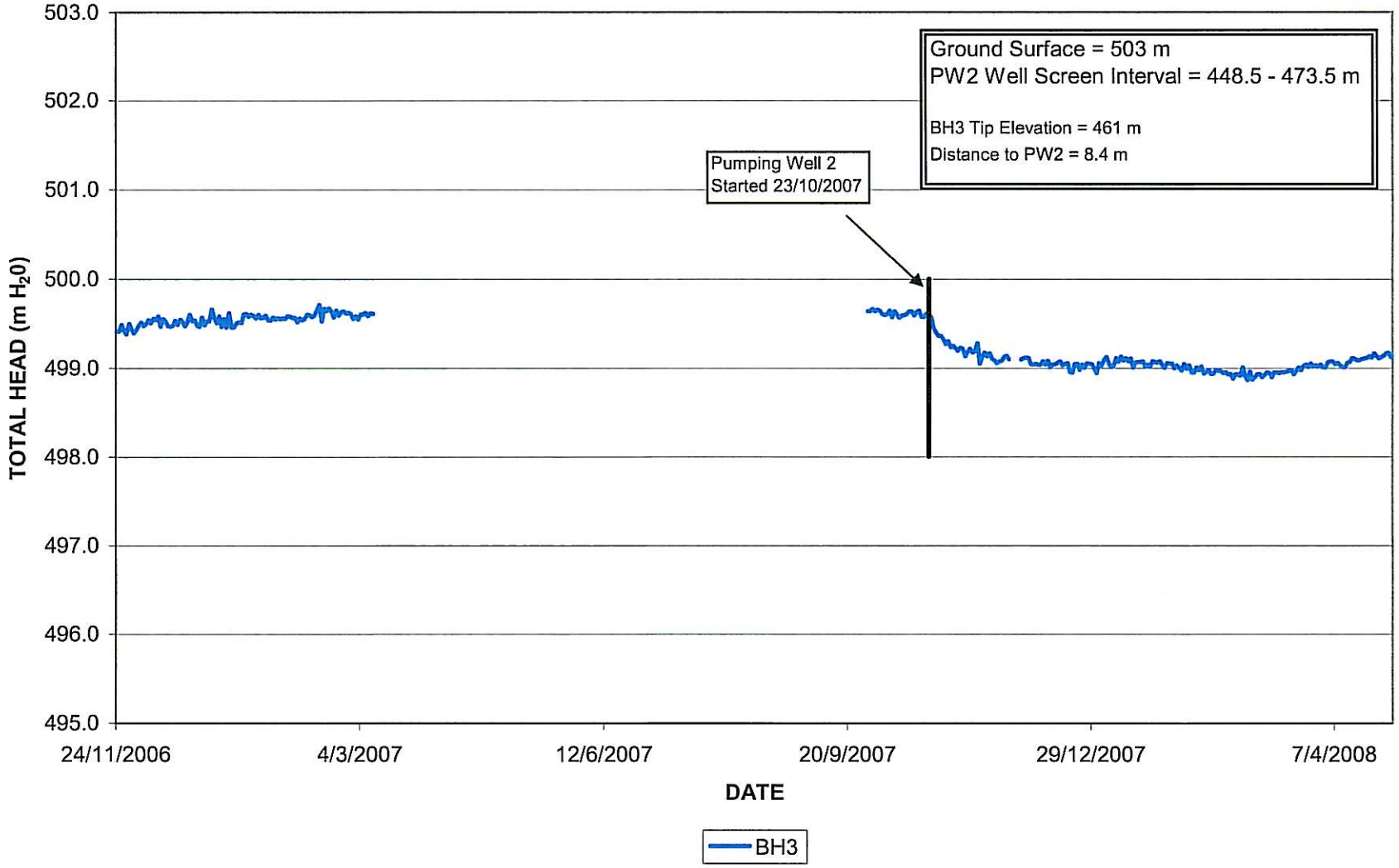
2007 - 2008 Trial Dewatering Program
TOTAL HEAD - PW2 MONITORING WELL



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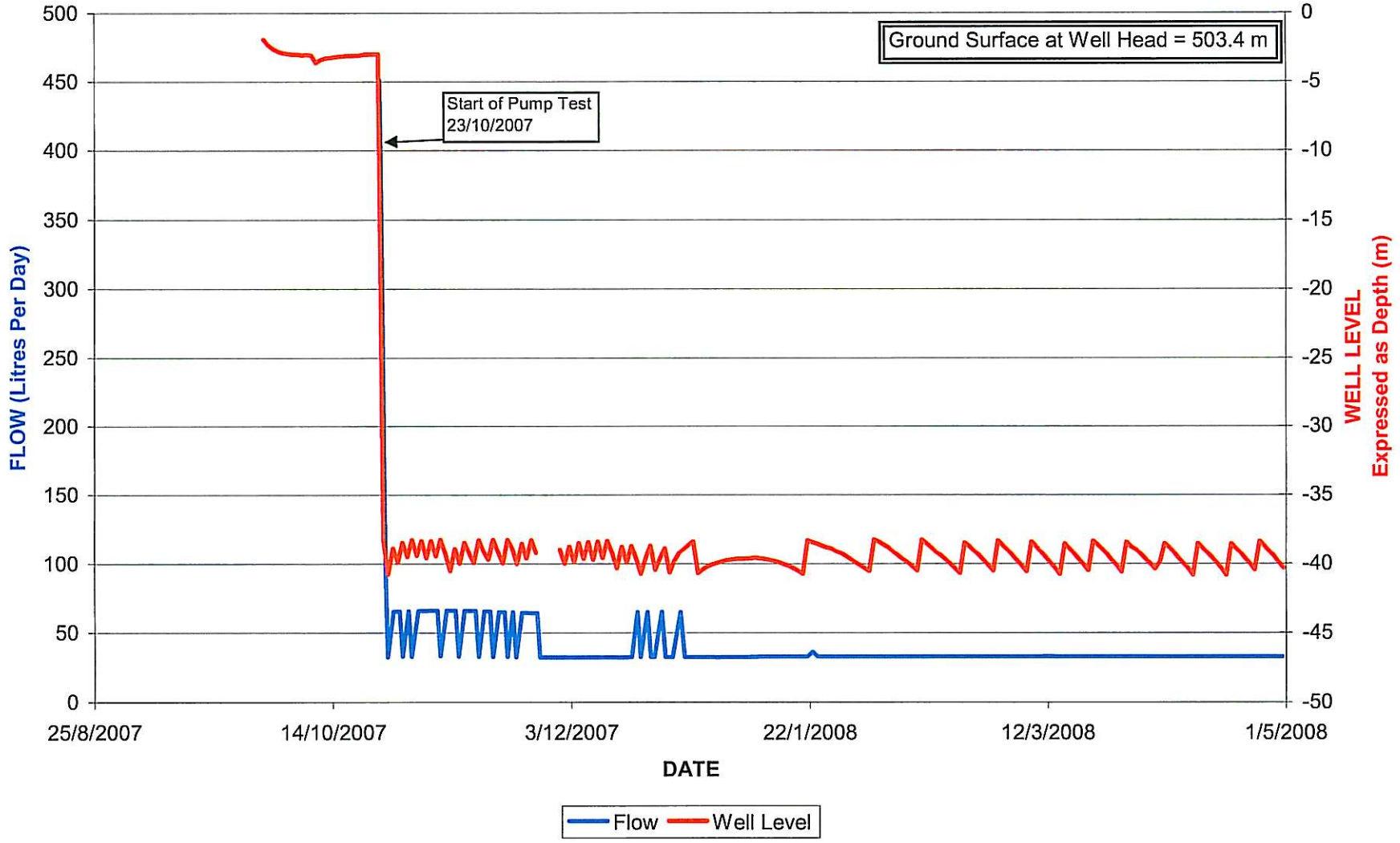
2007 - 2008 Trial Dewatering Program
PW2 - TOTAL DAILY FLOW AND WELL LEVEL



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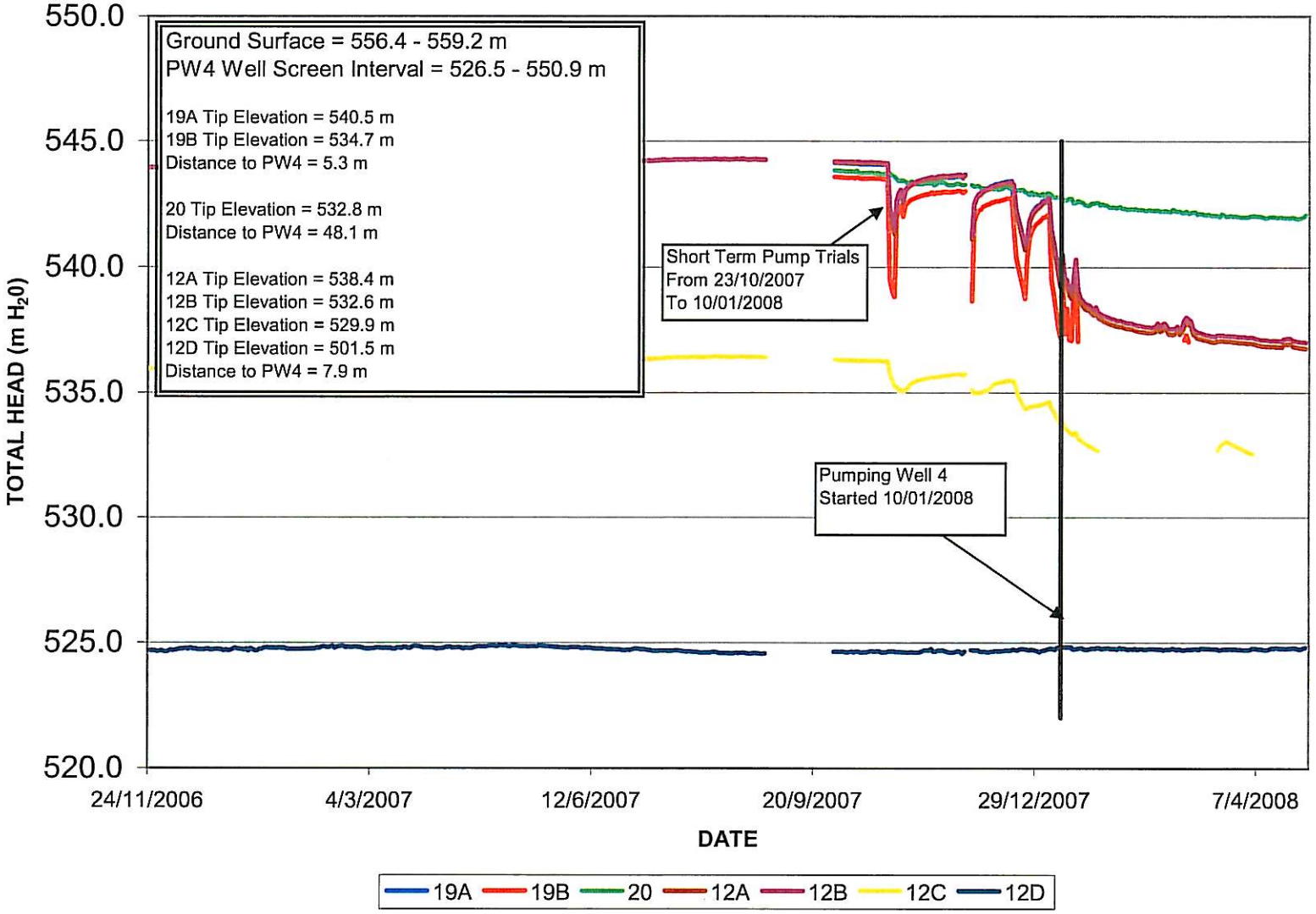
2007 - 2008 Trial Dewatering Program
TOTAL HEAD - PW4 MONITORING WELLS



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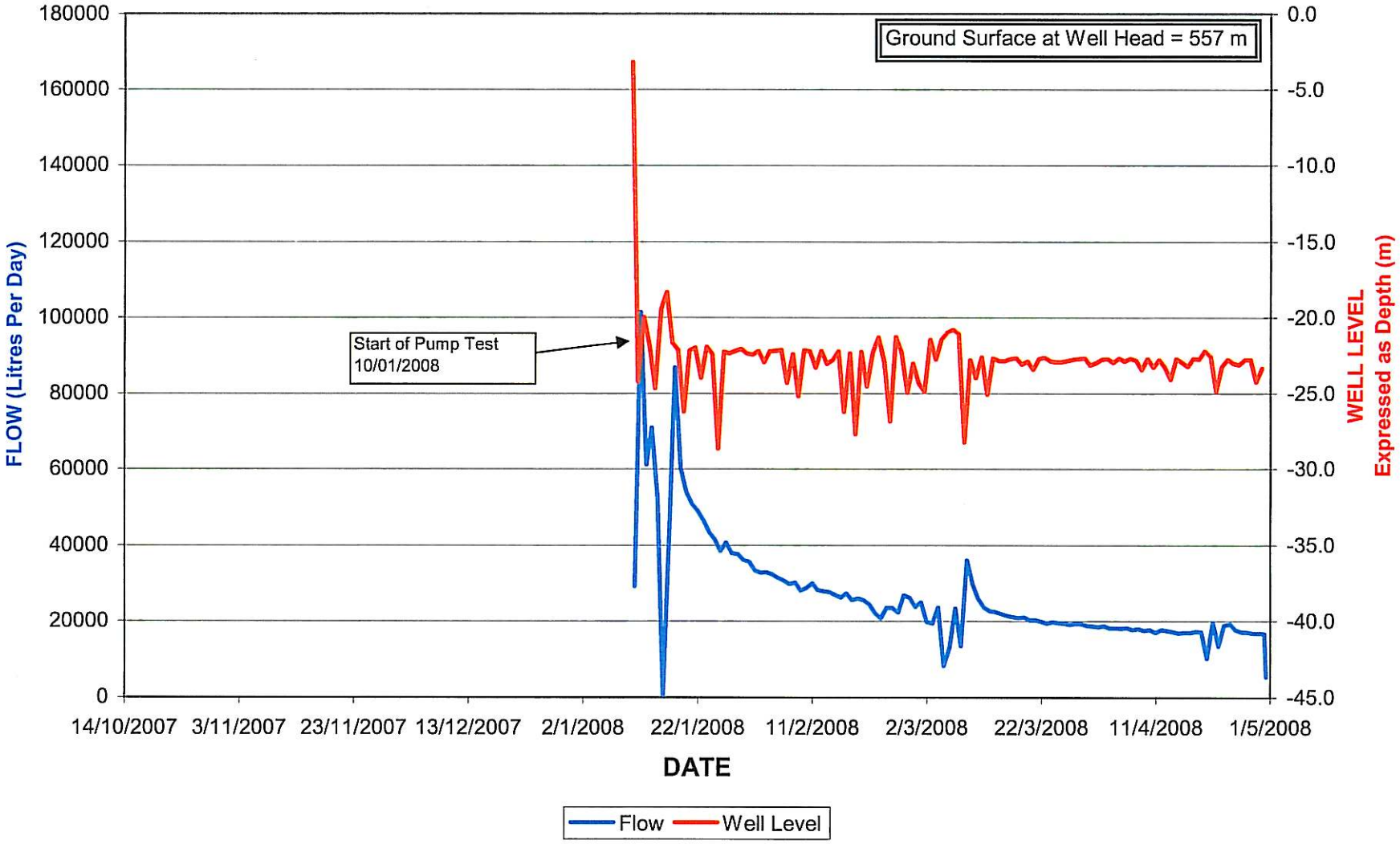
2007 - 2008 Trial Dewatering Program
PW4 - TOTAL DAILY FLOW AND WELL LEVEL



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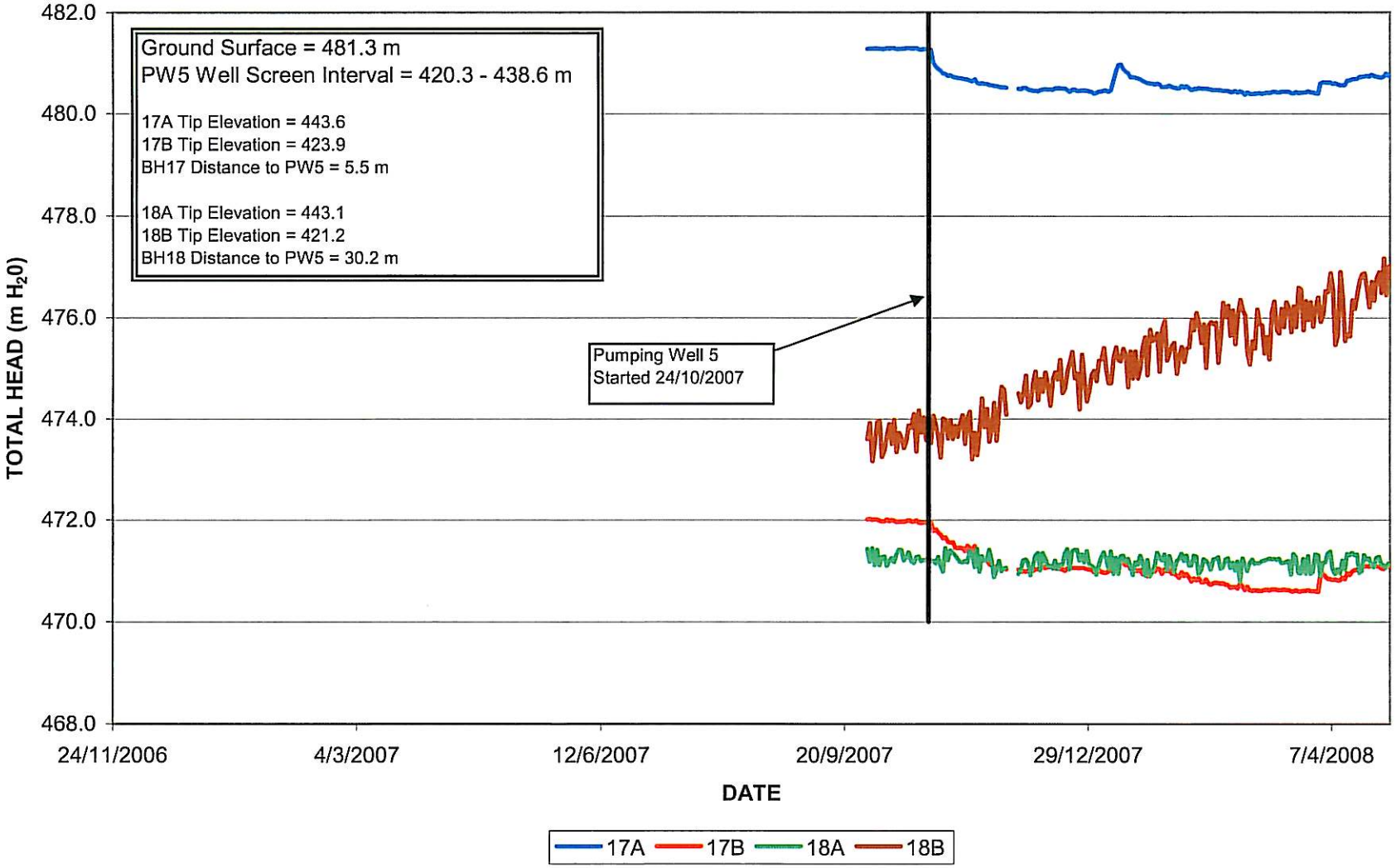
2007 - 2008 Trial Dewatering Program
TOTAL HEAD - PW5 MONITORING WELLS



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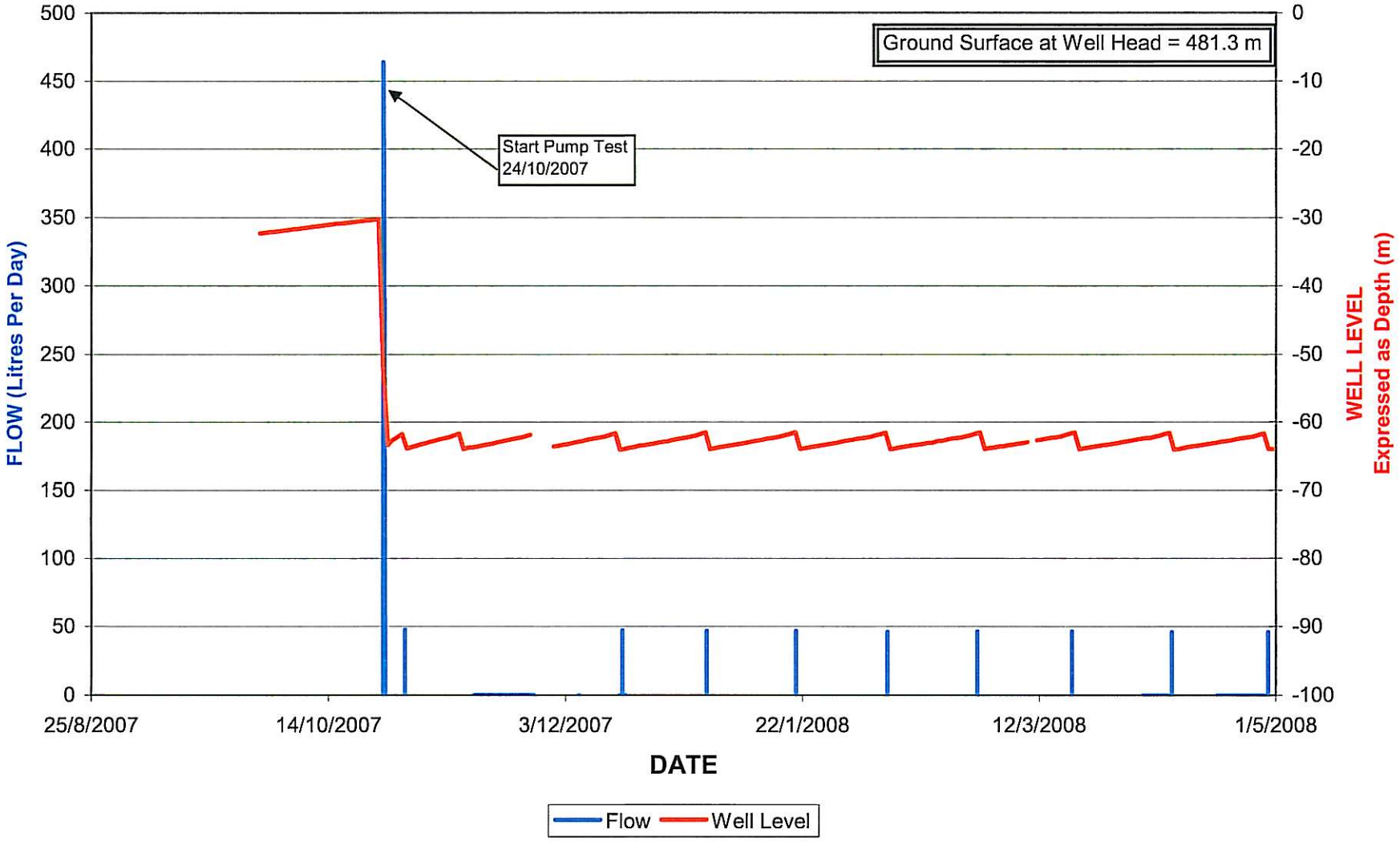
2007 - 2008 Trial Dewatering Program
PW5 - TOTAL DAILY FLOW AND WELL LEVEL



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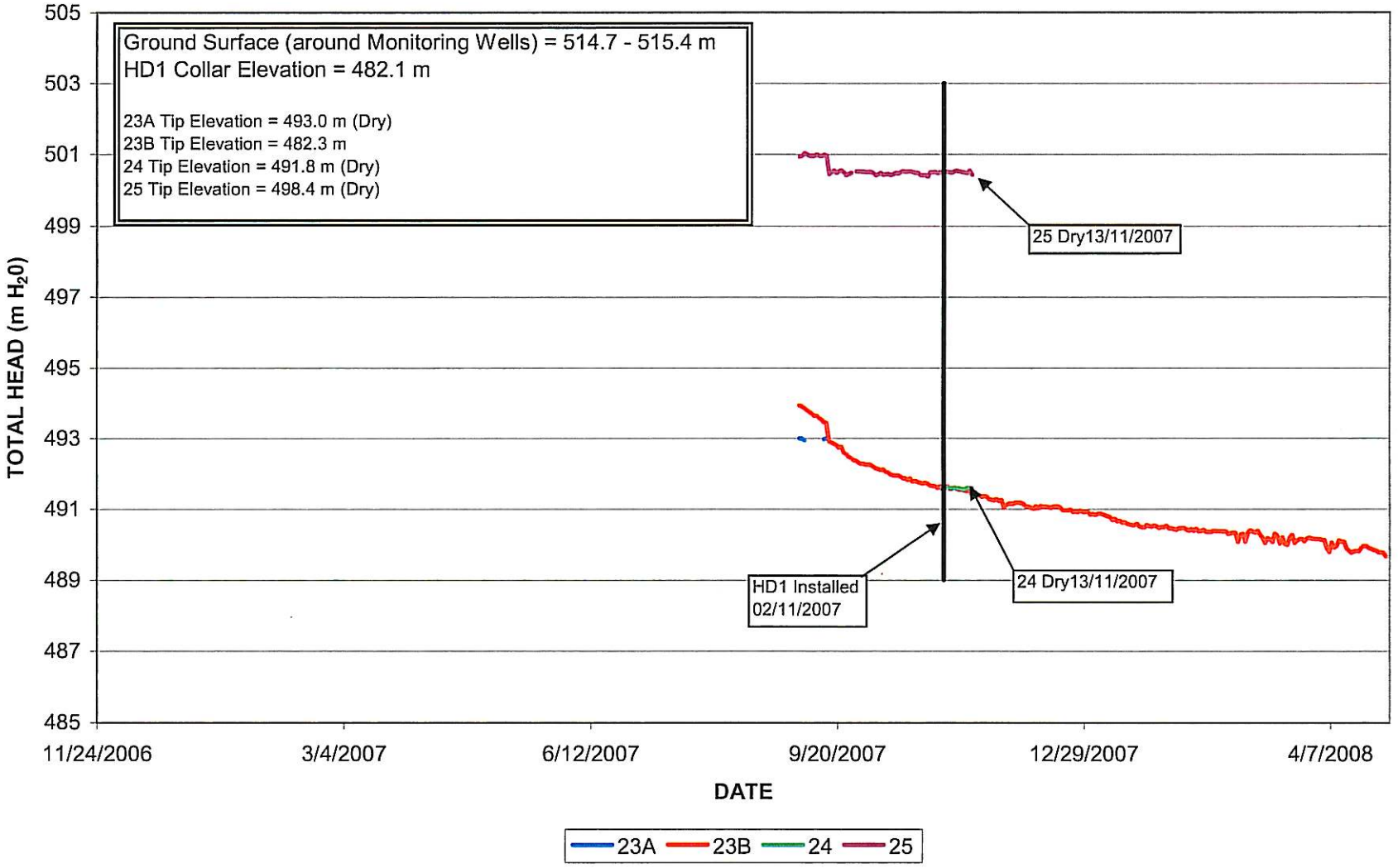
2007 - 2008 Trial Dewatering Program
TOTAL HEAD - HD1 MONITORING WELLS



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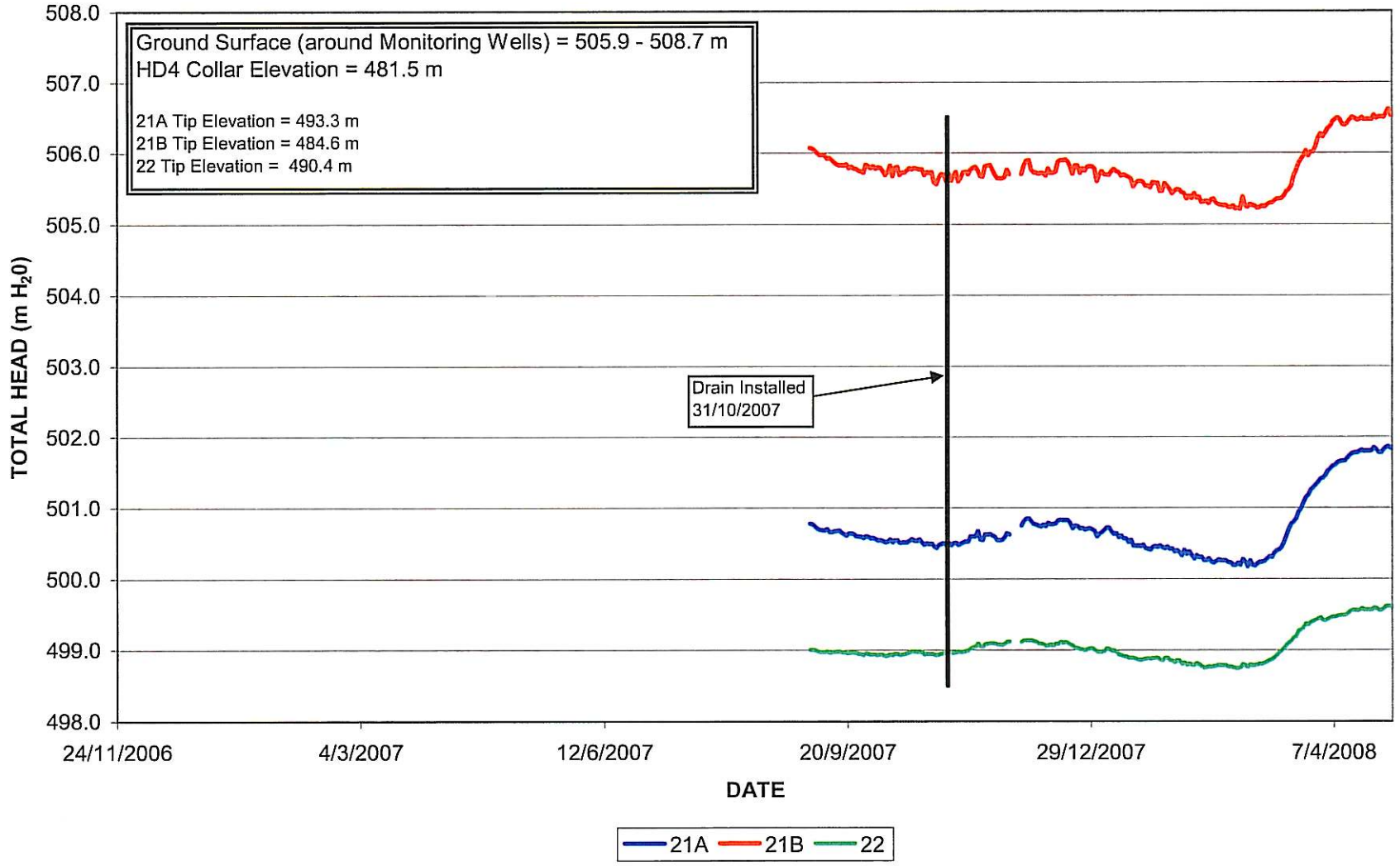
TOTAL HEAD - HD4 MONITORING WELLS



APPENDIX D

Pumping Test Curves for Each Pumping Well and Associated Monitoring Well

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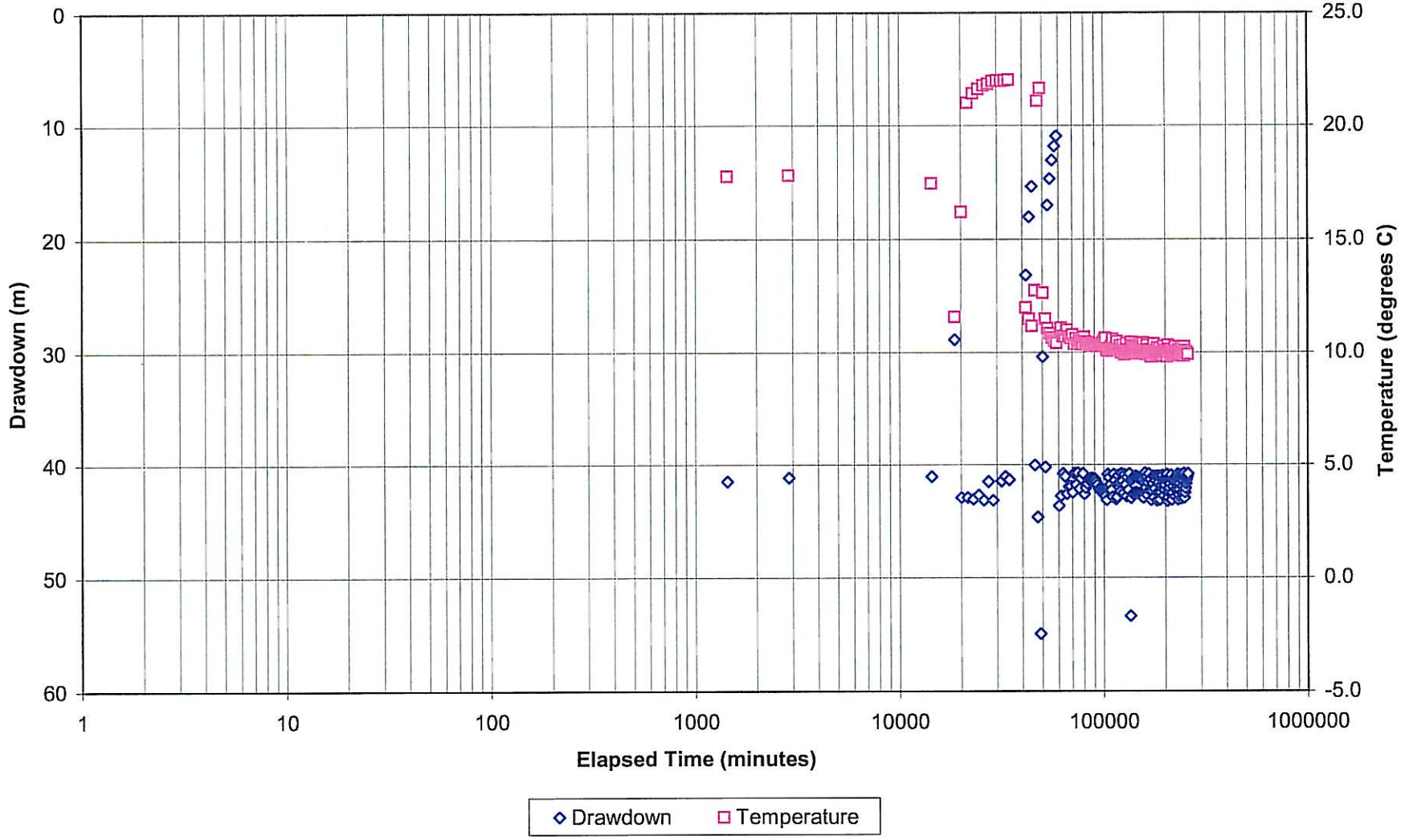
DRAWDOWN AND GROUNDWATER TEMPERATURE AT PW-1



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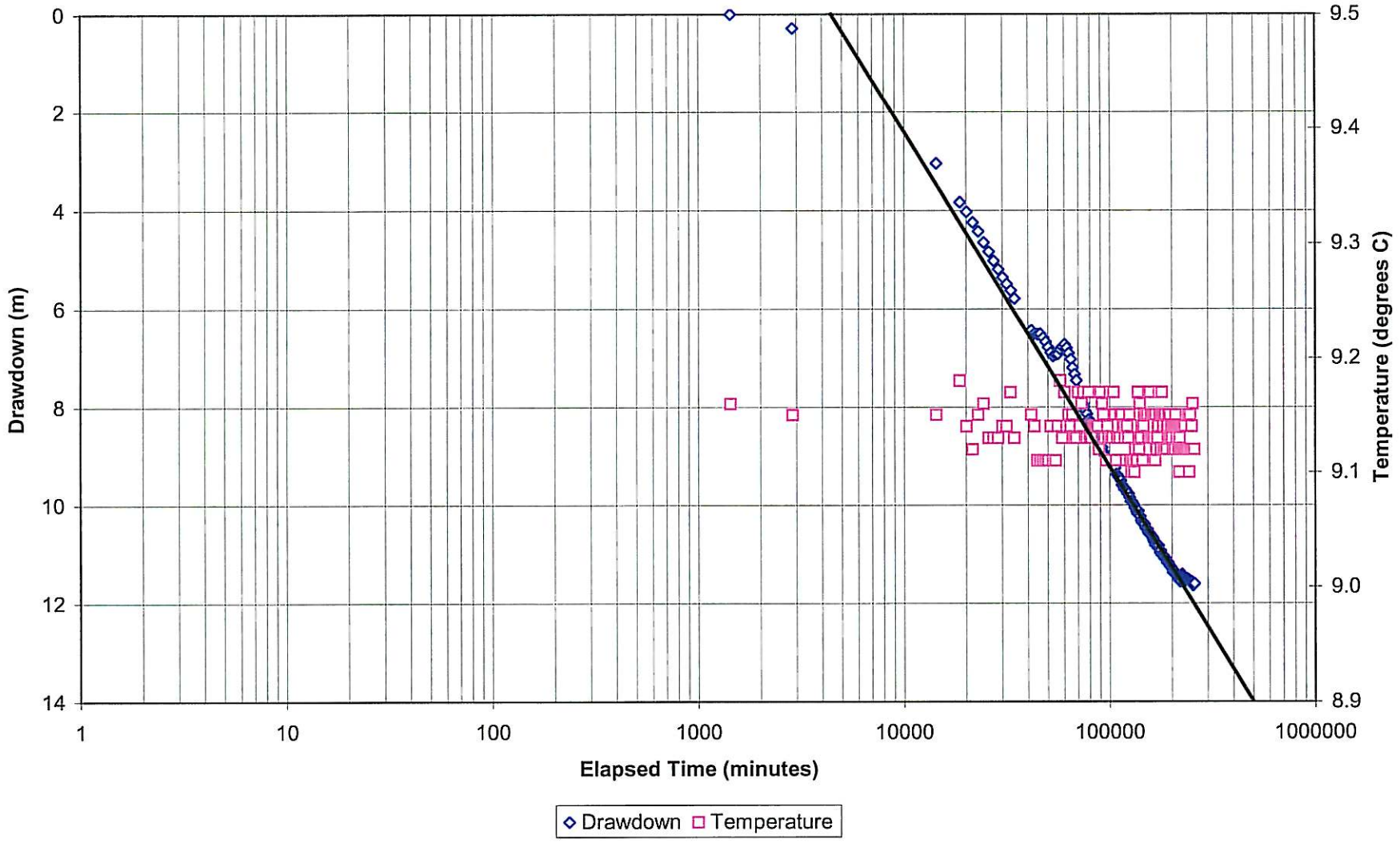
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-3B



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Land Stability Program

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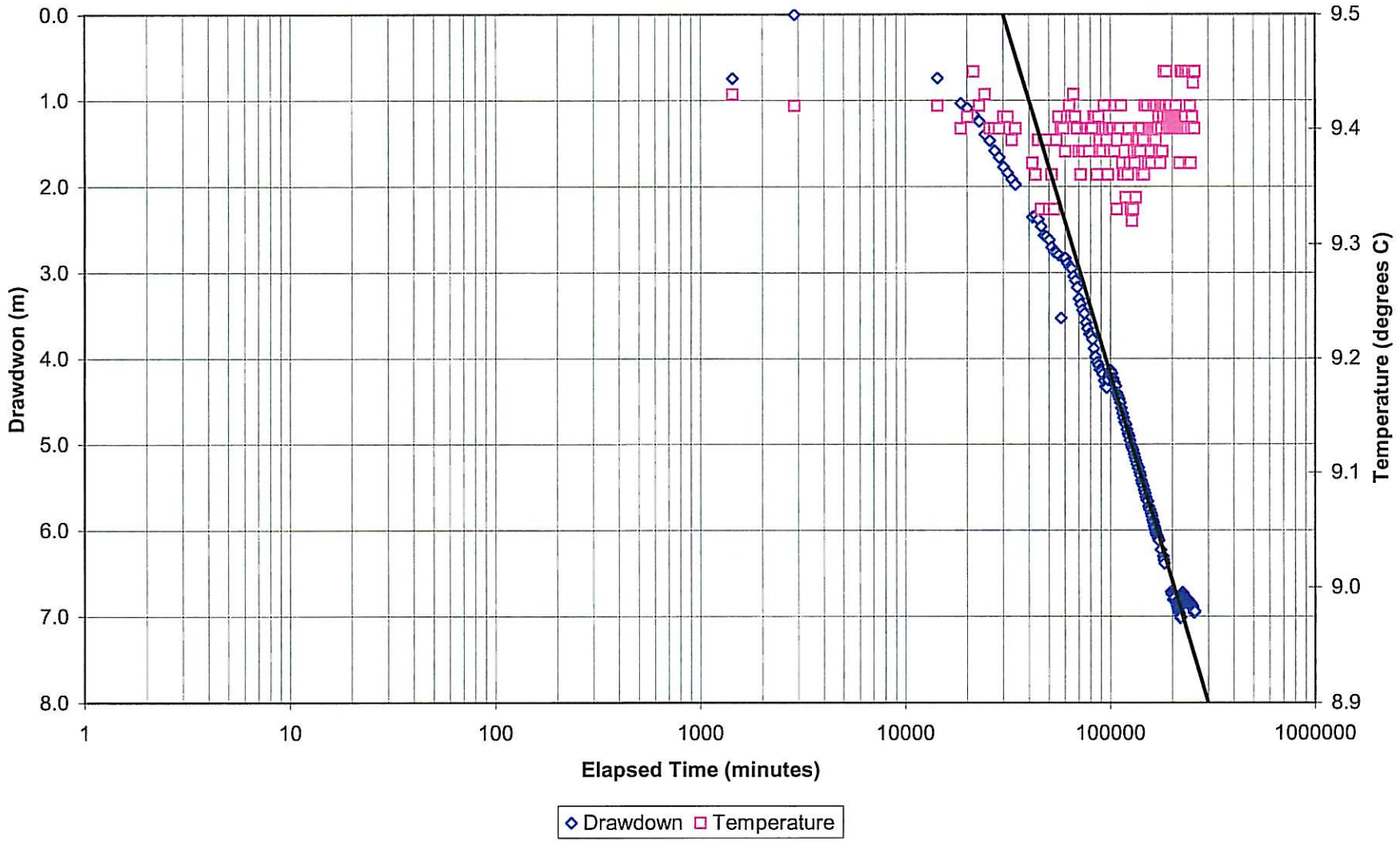
2007 - 2008 Trial Dewatering Program
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-3C



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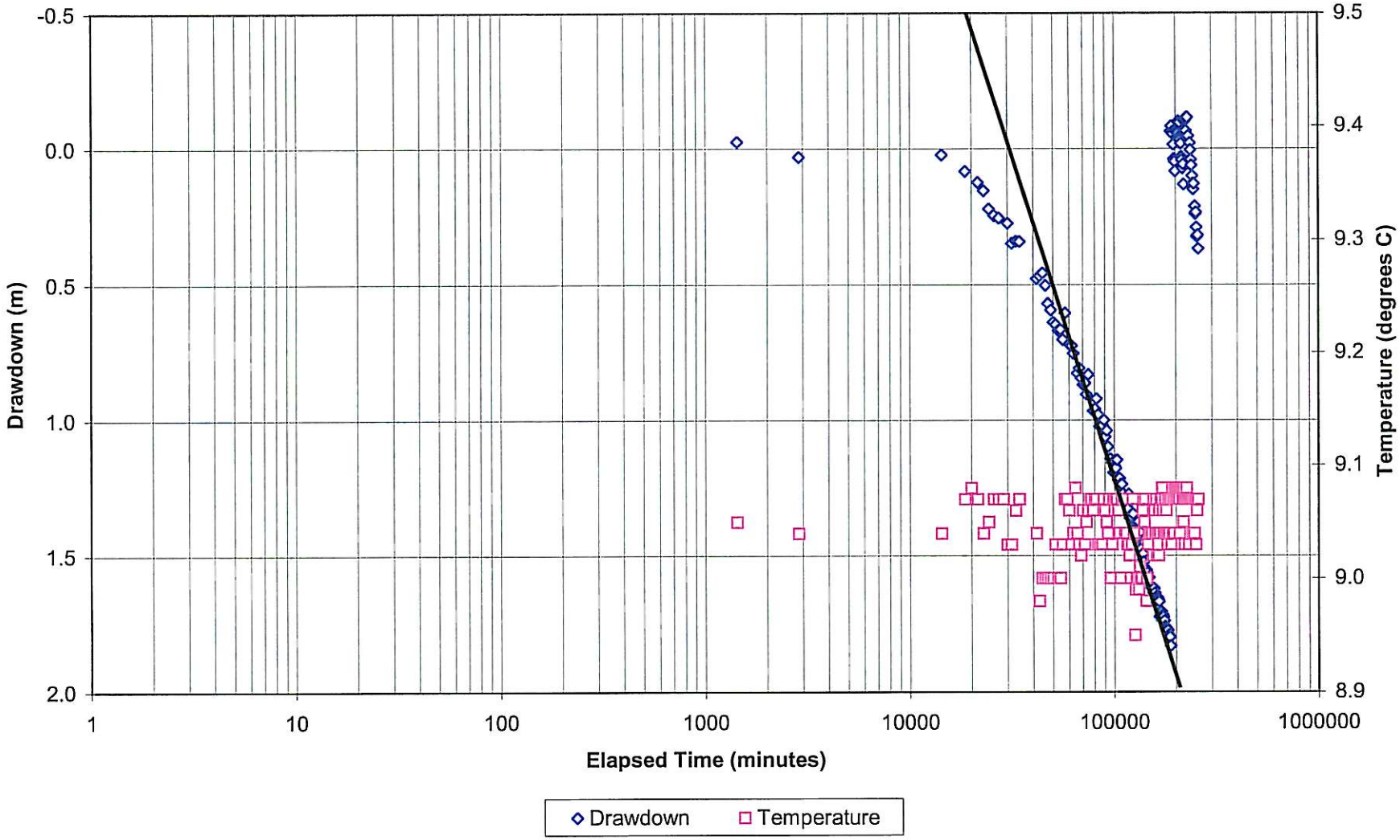
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-4A



West Quesnel
Land Stability Program

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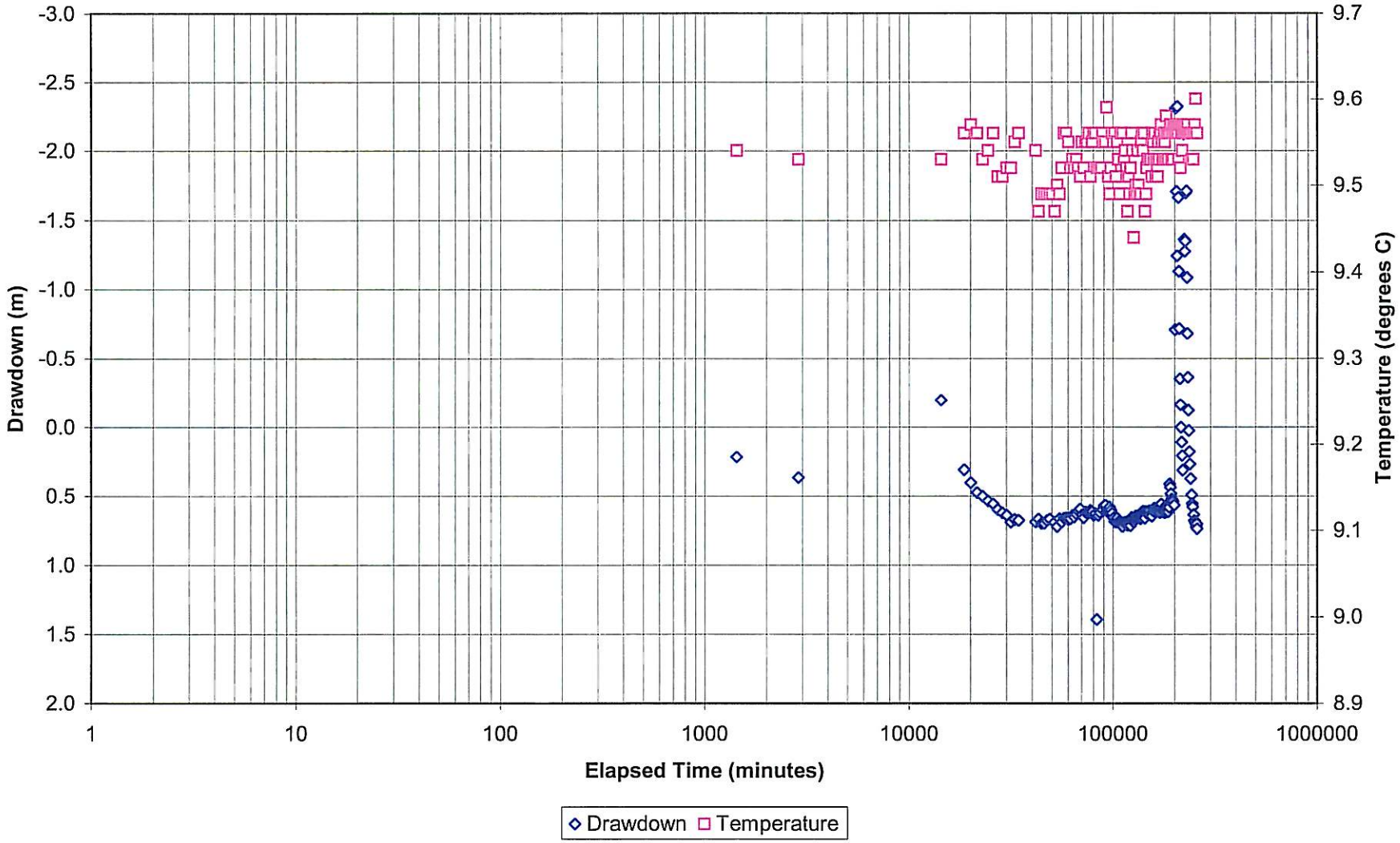
2007 - 2008 Trial Dewatering Program
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-4B



West Queensland Land Stability Program

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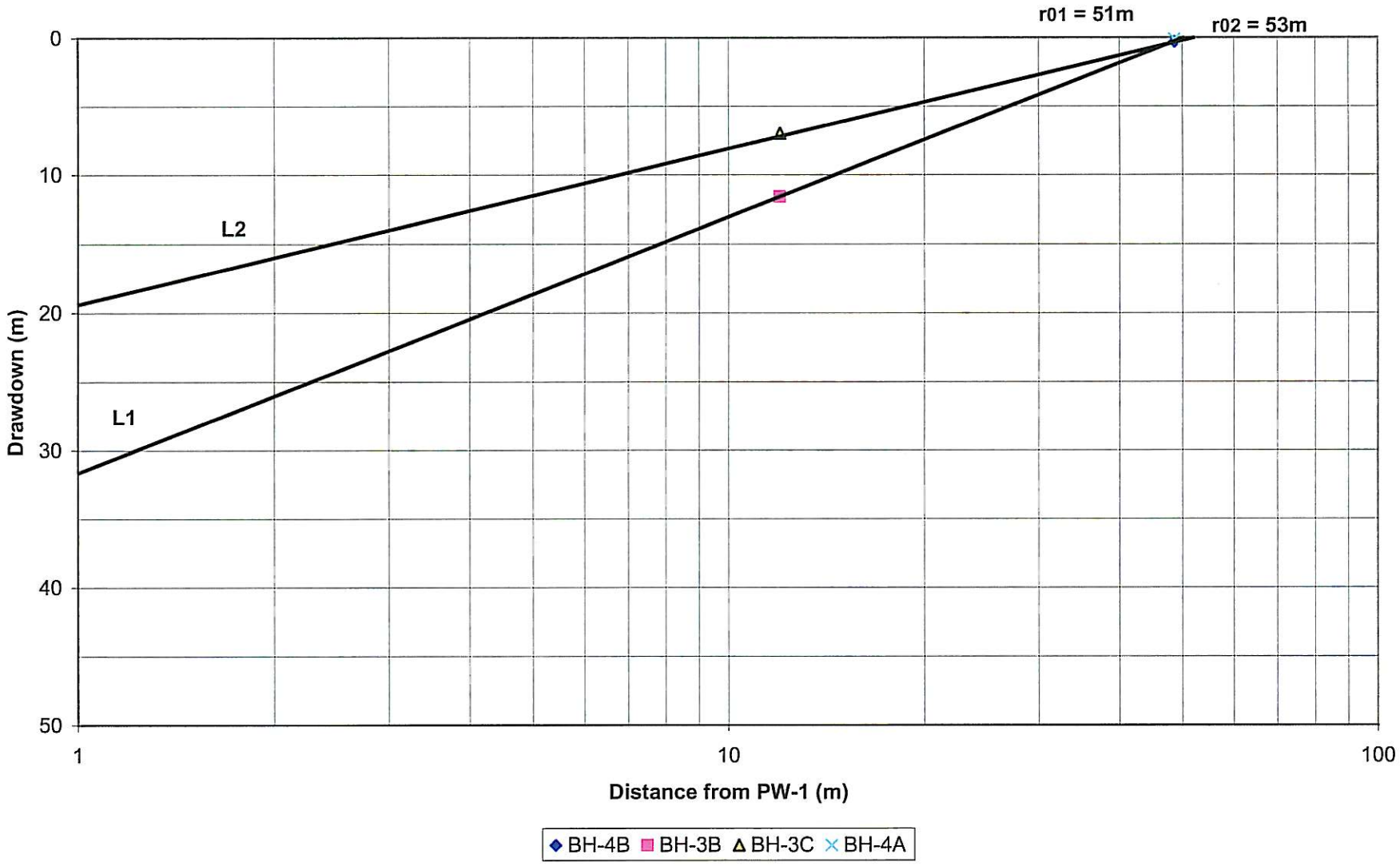
2007 - 2008 Trial Dewatering Program
PW-1 DISTANCE-DRAWDOWN CURVE AT T=153 DAYS



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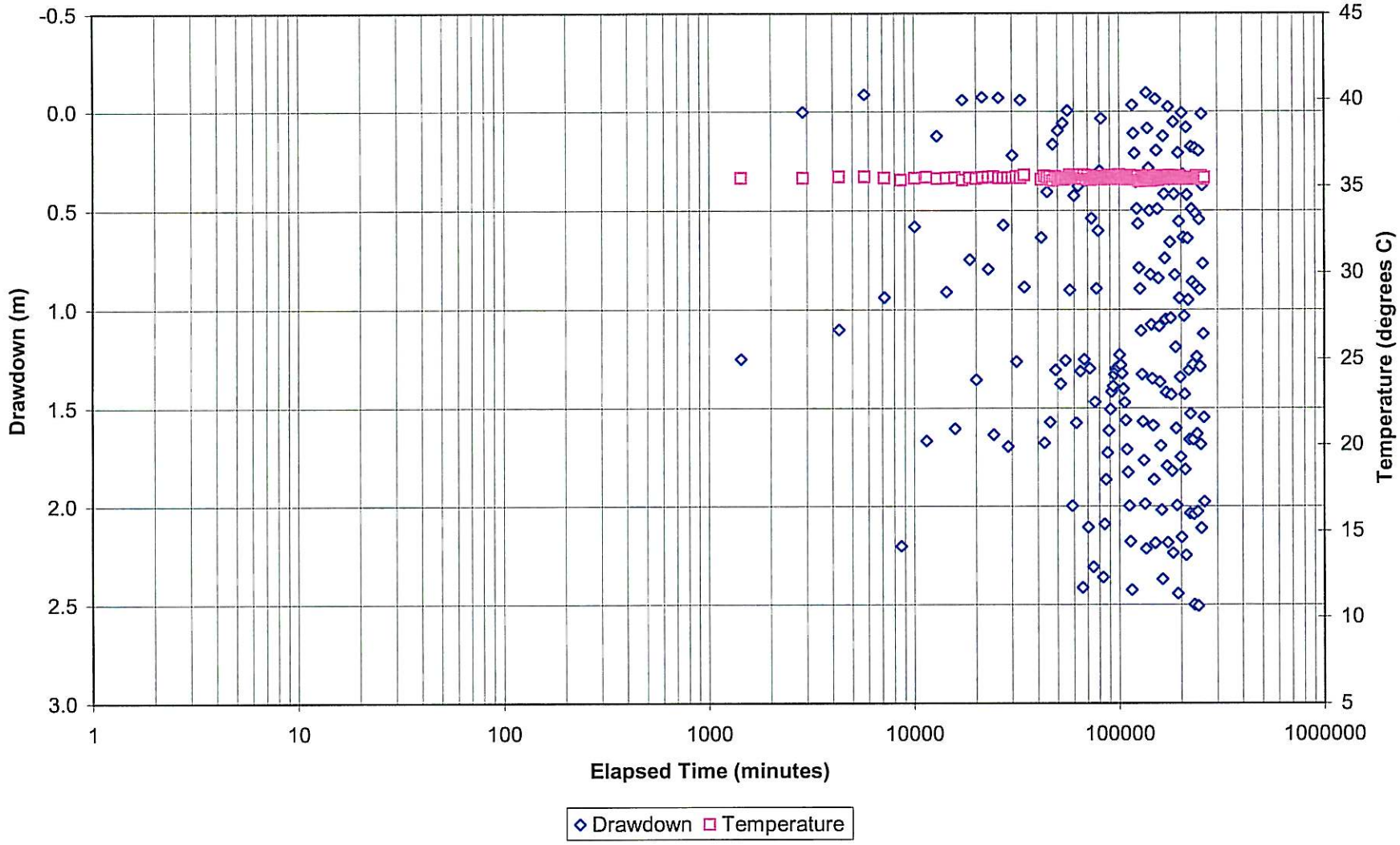
DRAWDOWN AND GROUNDWATER TEMPERATURE AT PW-2



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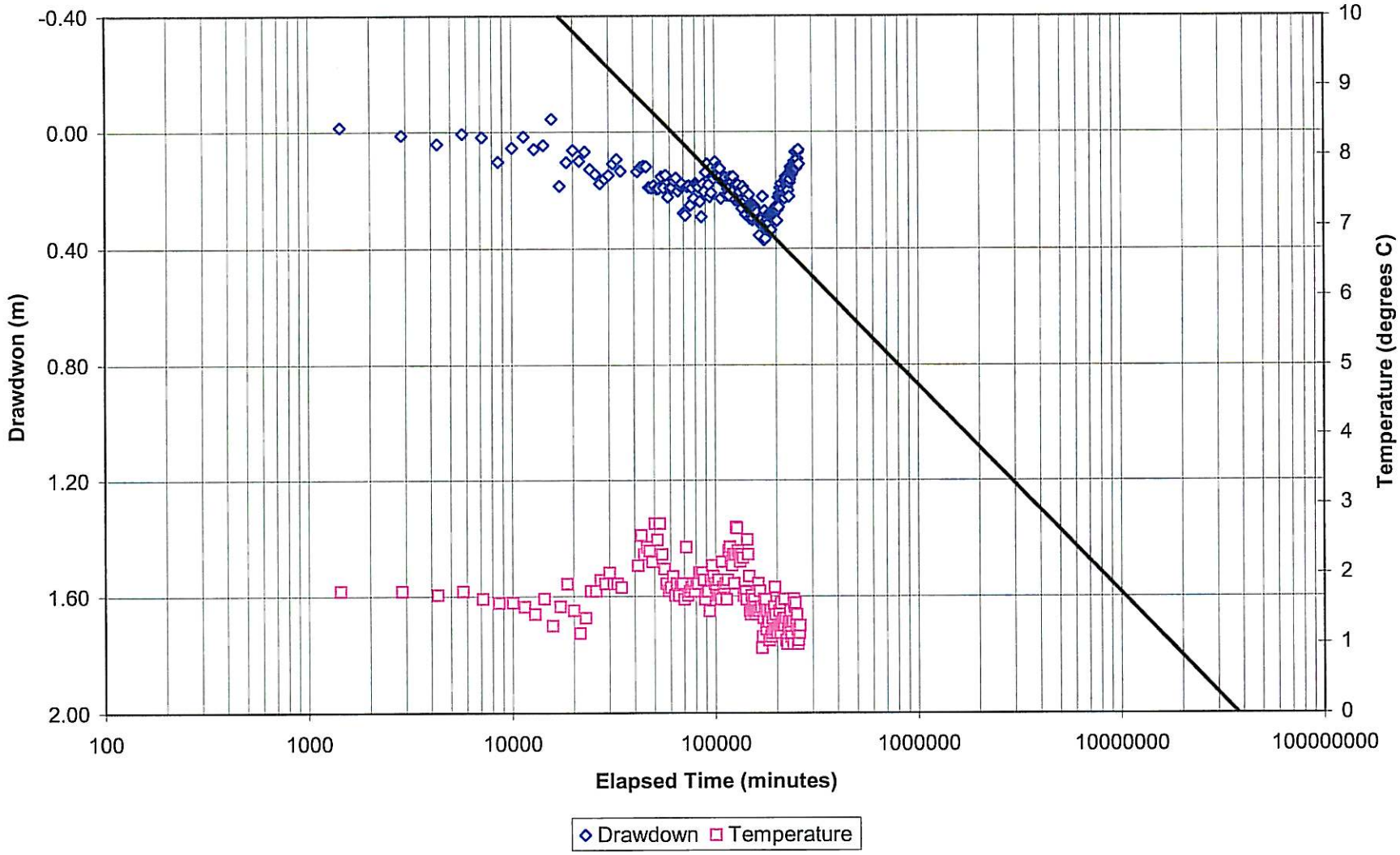
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-3



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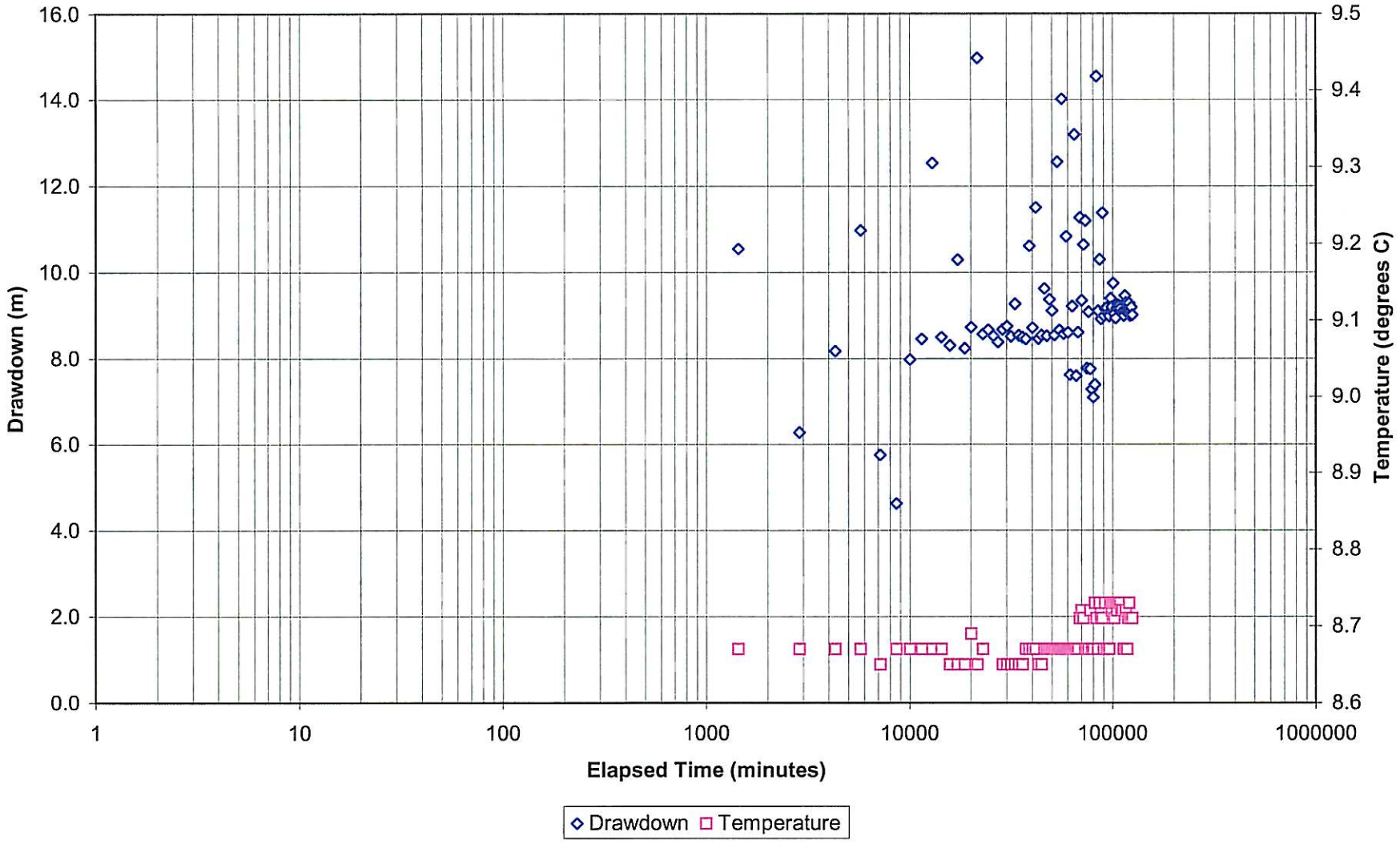
DRAWDOWN AND GROUNDWATER TEMPERATURE AT PW-4



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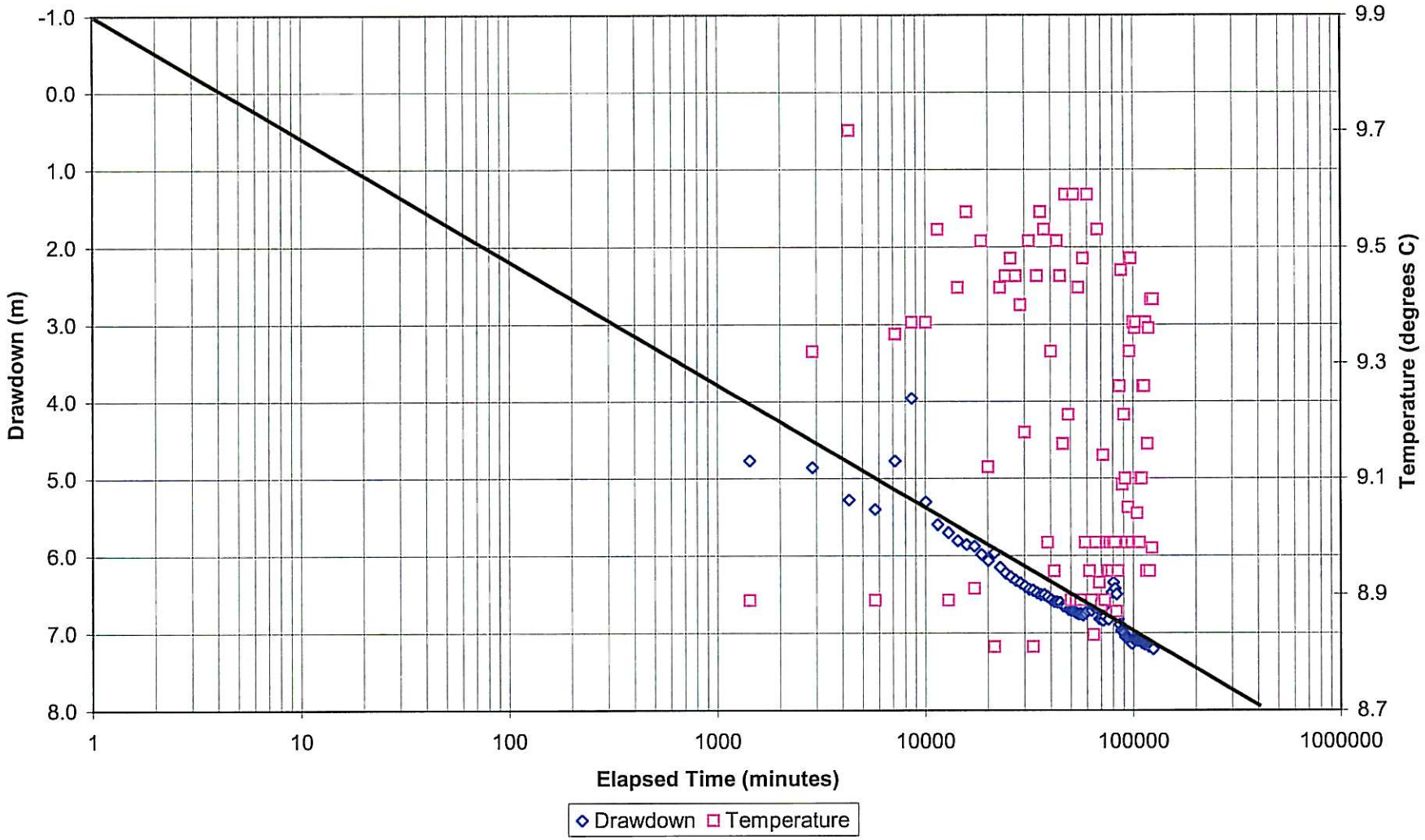
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-12A



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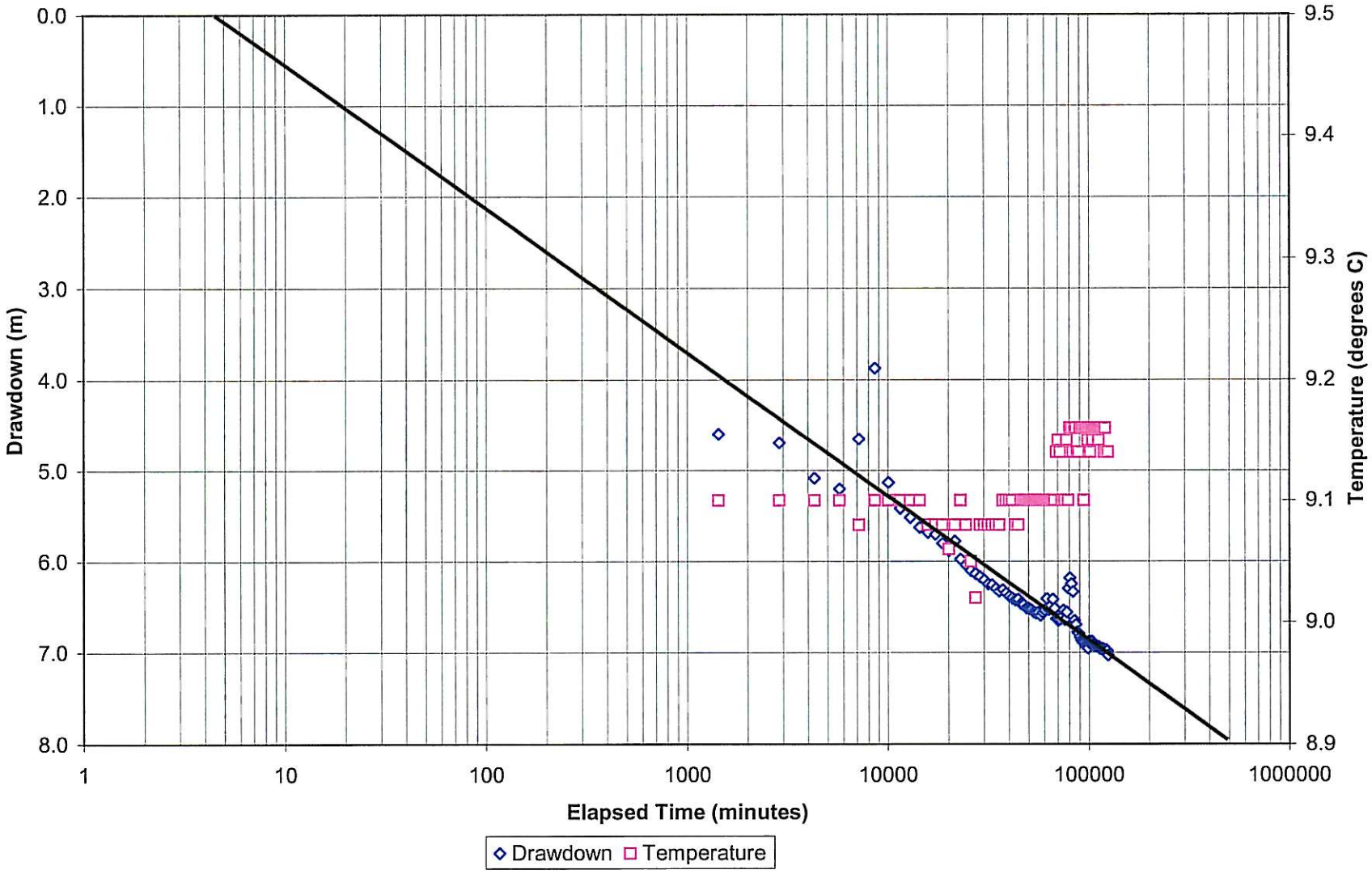
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-12B



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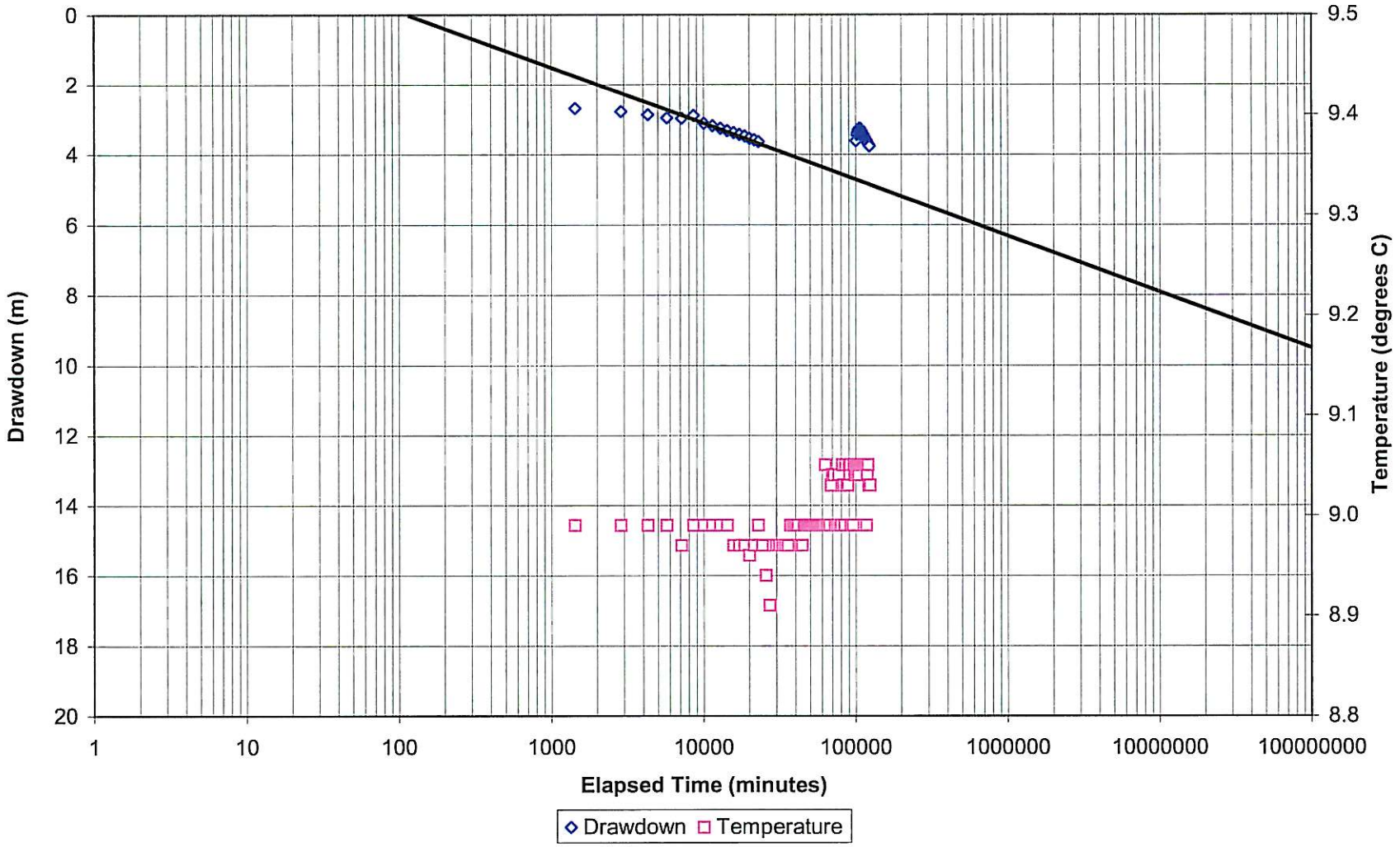
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-12C



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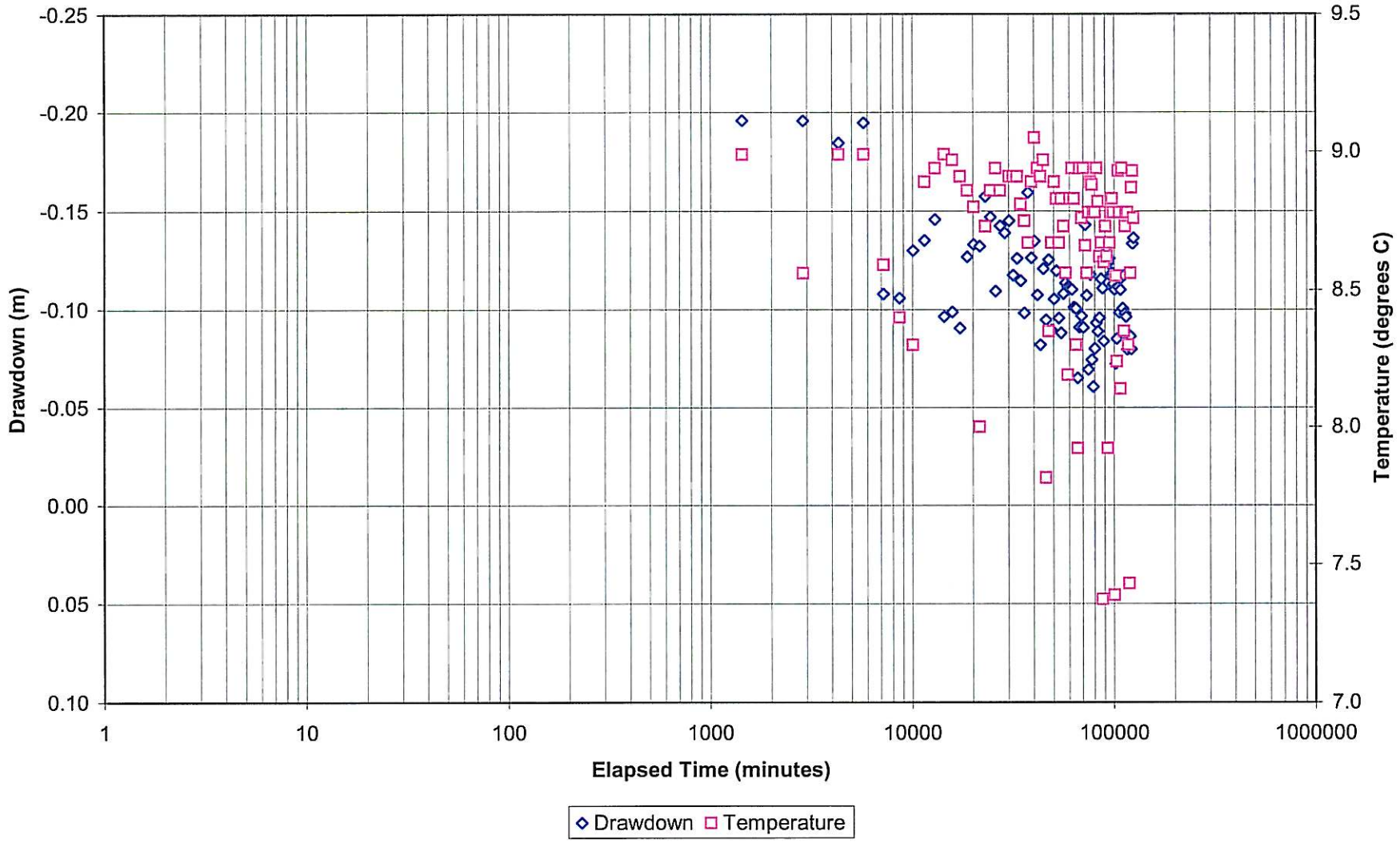
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-12D



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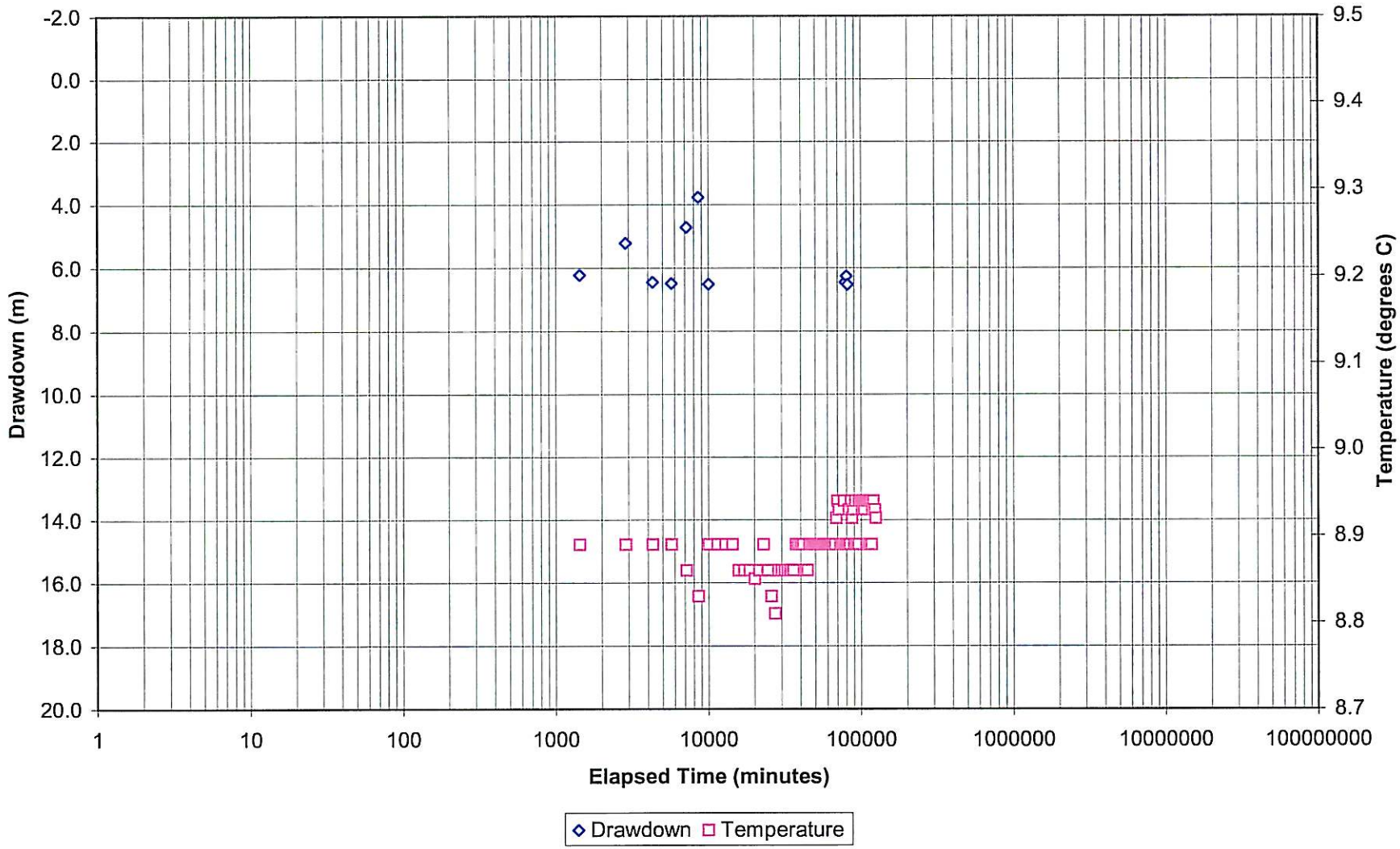
2007 - 2008 Trial Dewatering Program
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-19B



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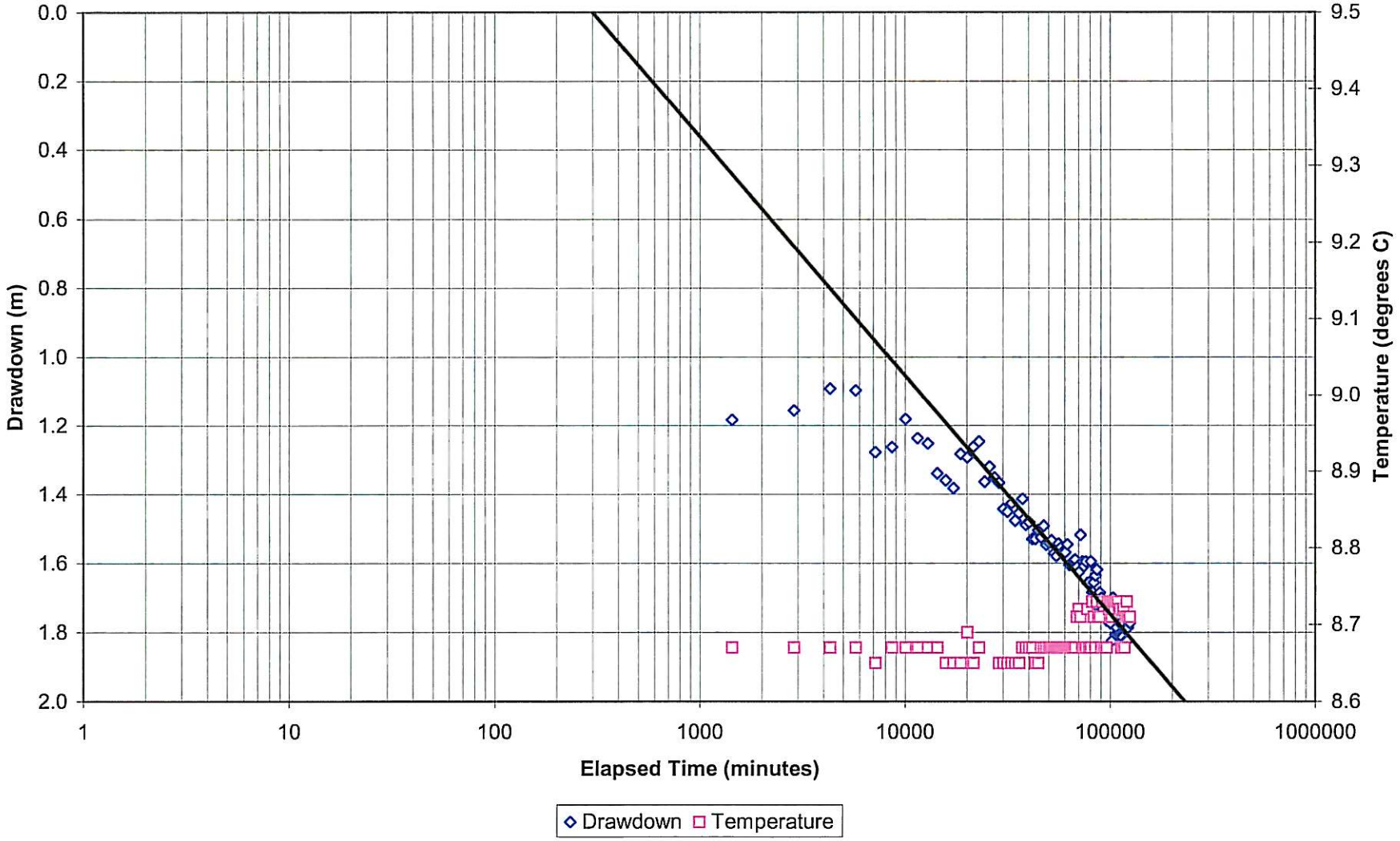
2007 - 2008 Trial Dewatering Program
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-20



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Land Stability Program

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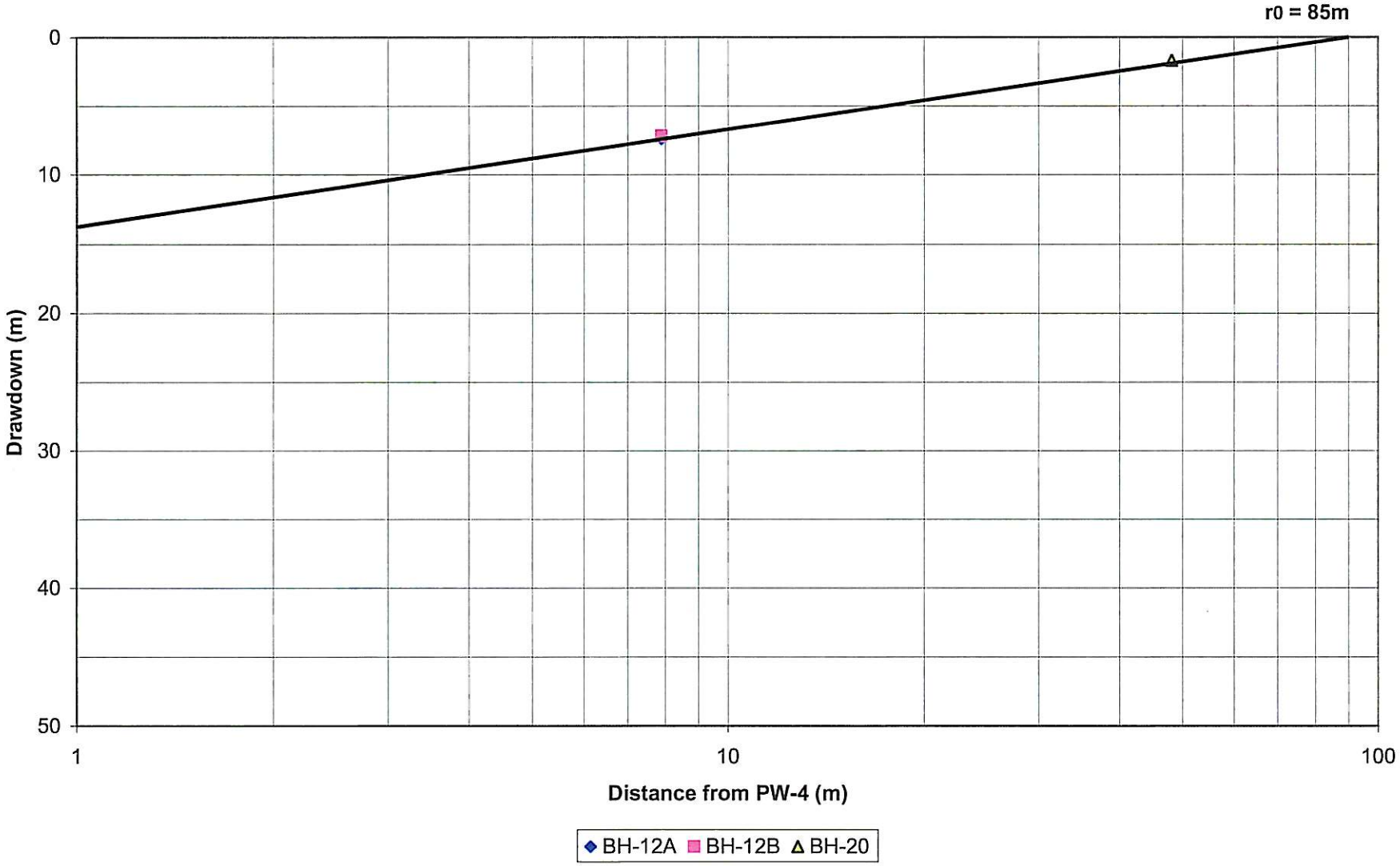
2007 - 2008 Trial Dewatering Program
PW-4 DISTANCE-DRAWDOWN AT T=211 DAYS



West Quesnel
Land Stability Program

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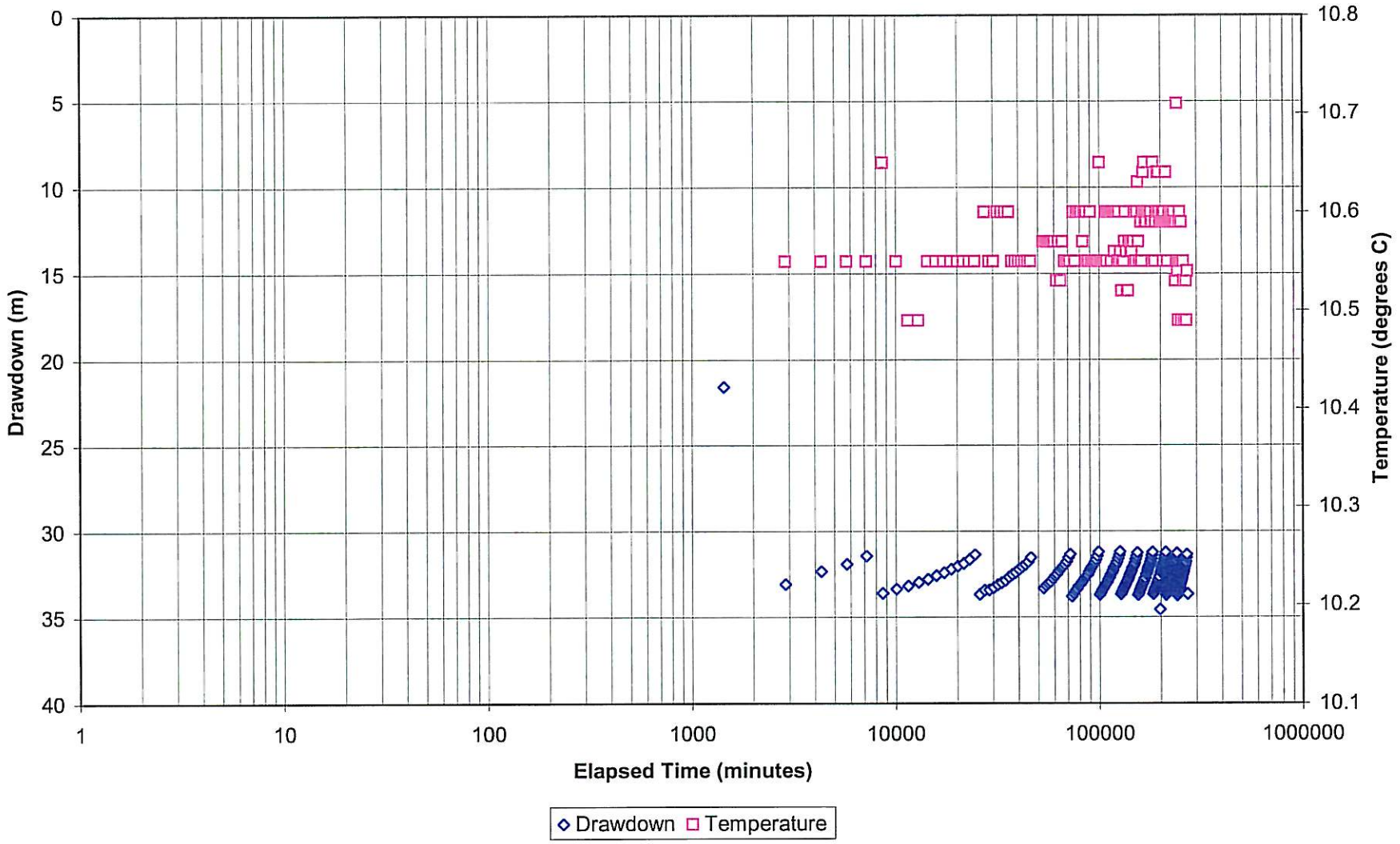
2007 - 2008 Trial Dewatering Program
DRAWDOWN AND GROUNDWATER TEMPERATURE AT PW-5



West Quesnel
Land Stability Program

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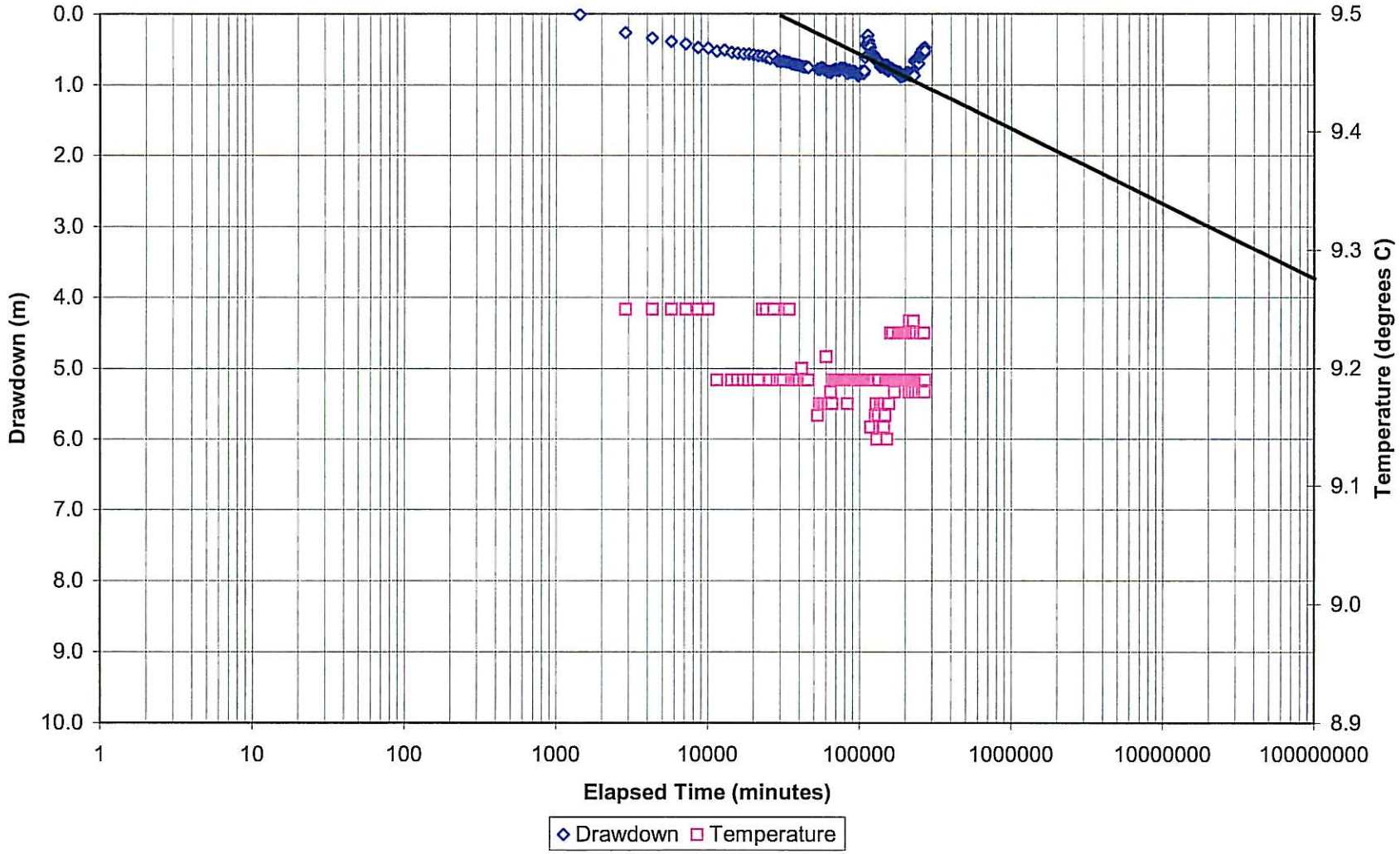
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-17A



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Land Stability Program

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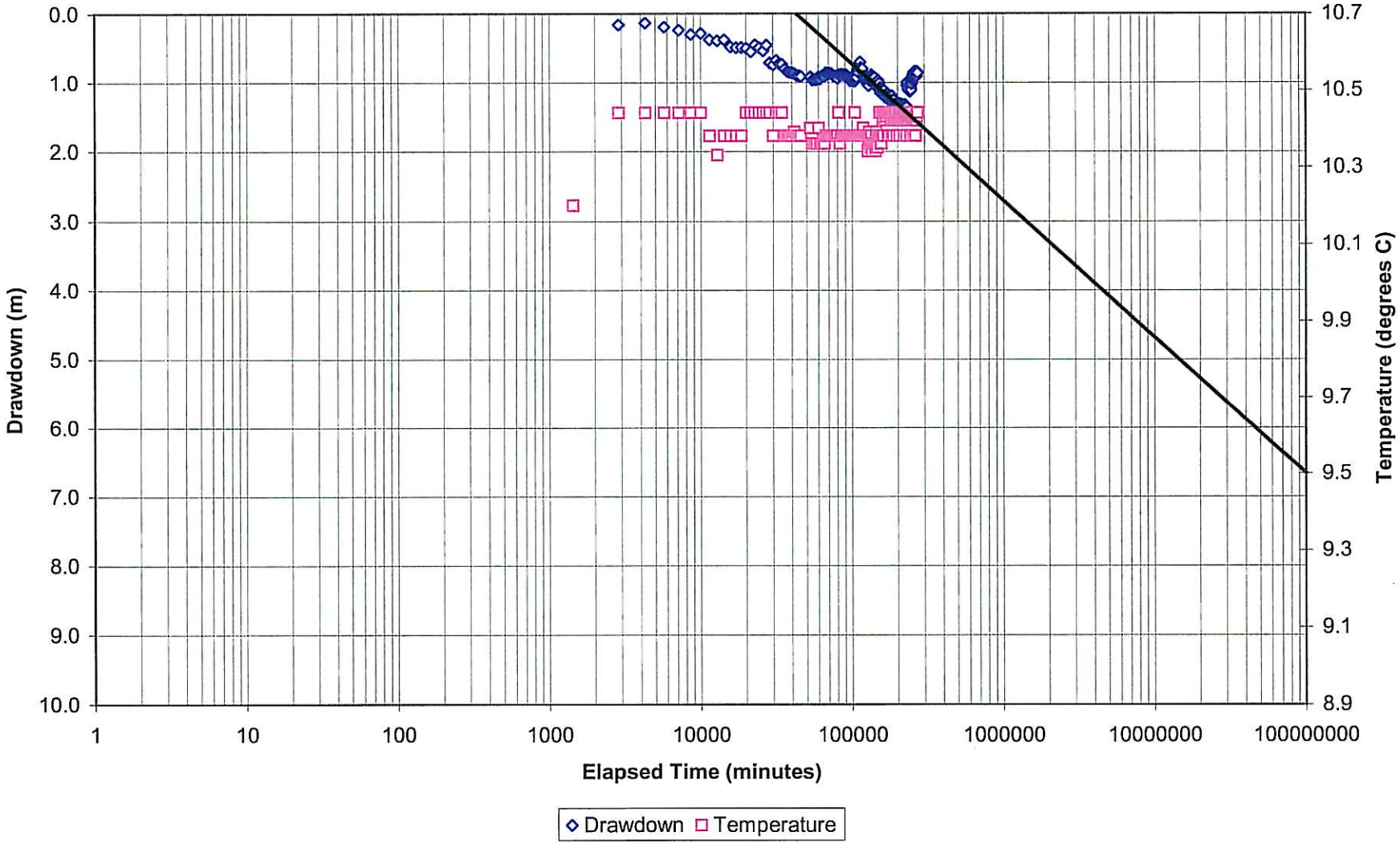
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-17B



West Quesnel
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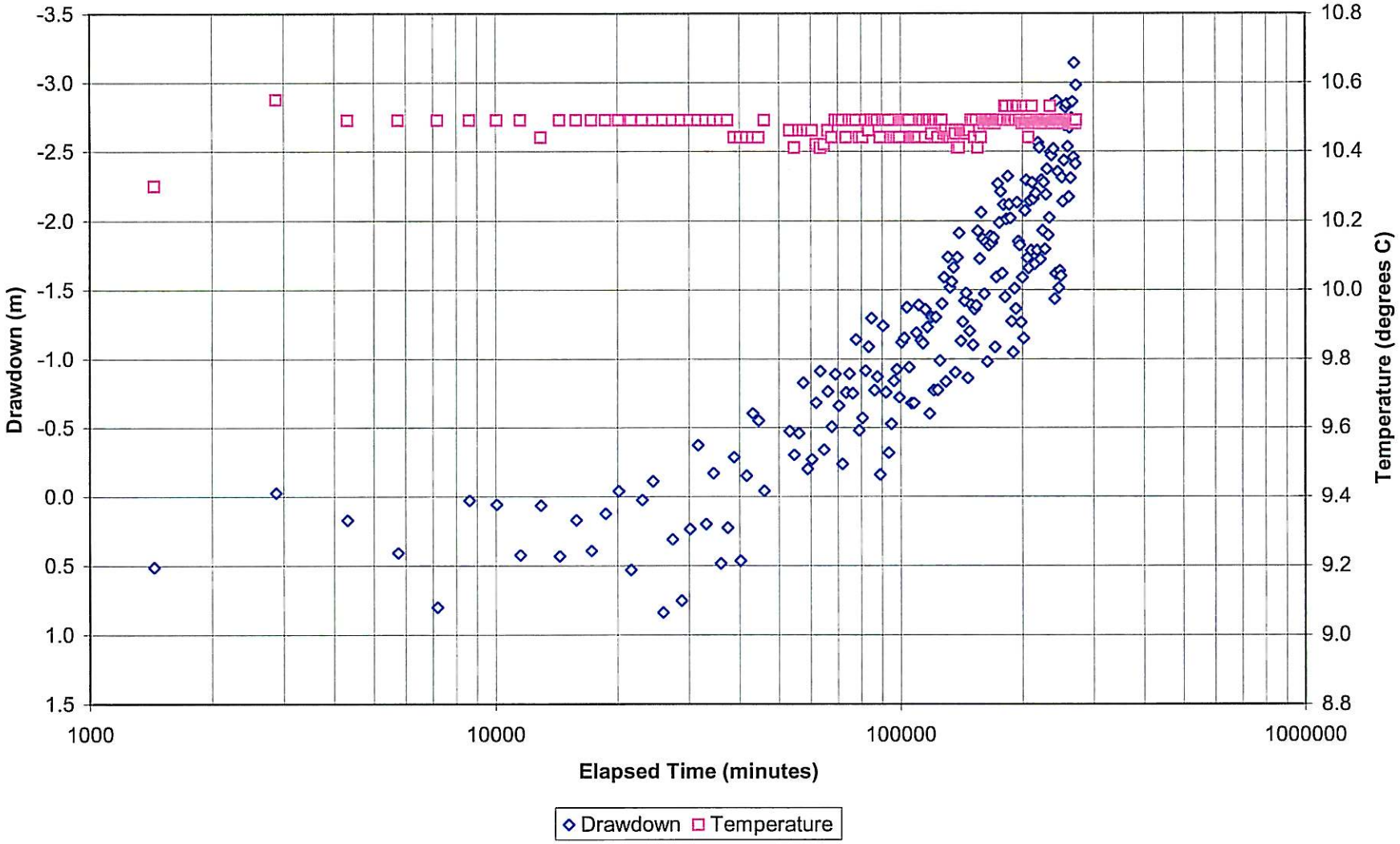
2007 - 2008 Trial Dewatering Program
DRAWDOWN AND GROUNDWATER TEMPERATURE AT BH-18B



West Quesnel
Land Stability Program

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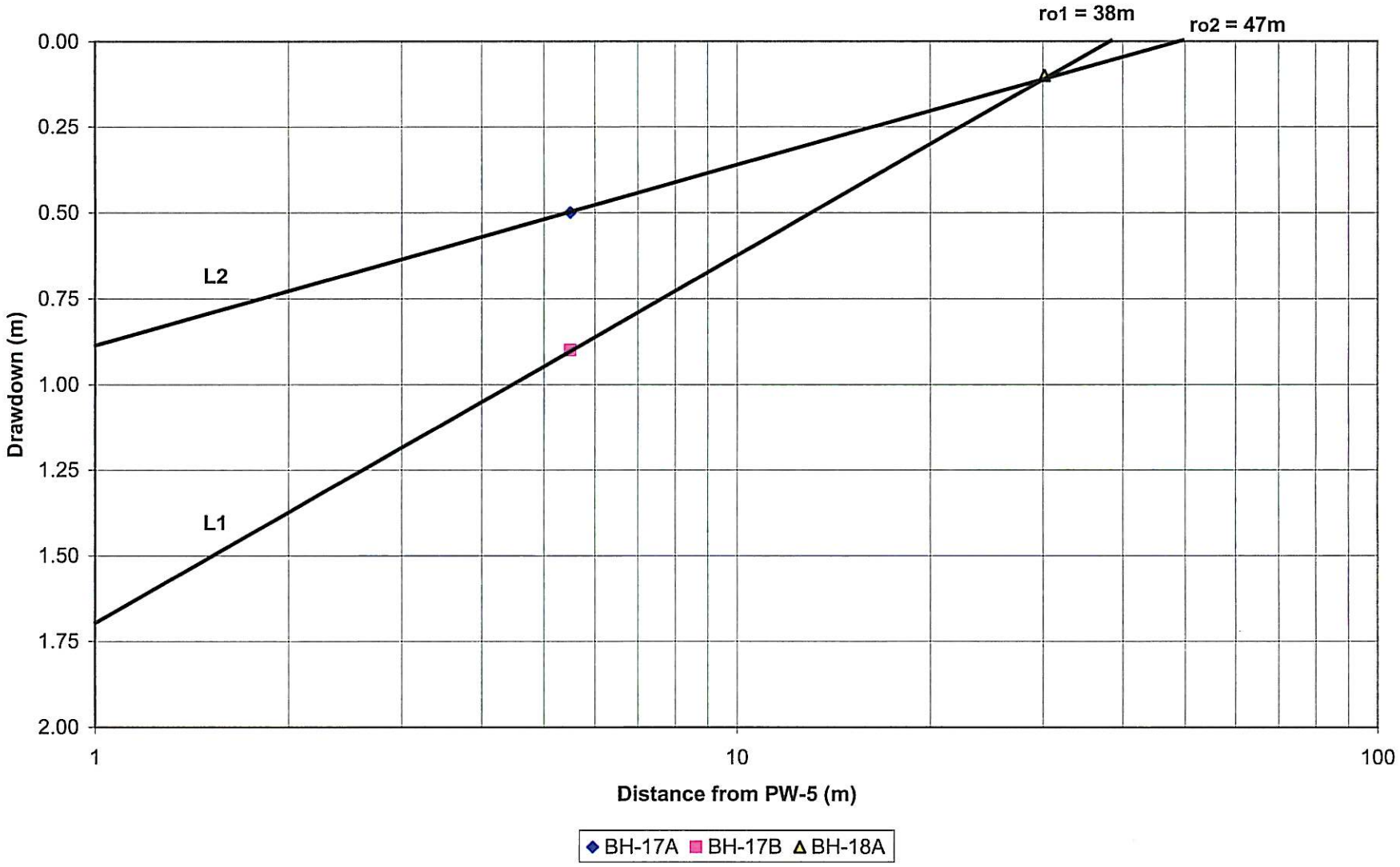
2007 - 2008 Trial Dewatering Program
PW-5 DISTANCE-DRAWDOWN AT T=189 DAYS



APPENDIX E

Results of the Testing

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

ANALYTICAL REPORT

AMEC Earth & Environmental
3456 Opie Crescent
Prince George, BC V2N 2P9

Date Received: 2008/05/02
Date Sampled:
Report Date: 2008/05/13

Water Analysis

Attention: Polysou, Nick

Project No. KX0439717

File No.: EC-53959

Analyst	Date of Analysis (yyyy/m/d)	Analytical Parameter	Units	Reference Method	MDL	08-3725 HD4	08-3726 PW4	08-3726-D PW4 Duplicate
MD	2008/05/02	Calcium	mg/L (ppm)	APHA 3120	0.5	65.5	98.7	95.5
MD	2008/05/02	Magnesium	mg/L (ppm)	APHA 3120	0.5	105	126	124
MD	2008/05/02	Potassium	mg/L (ppm)	APHA 3120	0.5	15.6	19.9	18.9
MD	2008/05/02	Sodium	mg/L (ppm)	APHA 3120 B	0.5	31.5	35.8	34.3
MD	2008/05/06	Iron (Total)	mg/L (ppm)	APHA 3030E/3120	0.10	< 0.10	< 0.10	—
MD	2008/05/06	Manganese (Total)	mg/L (ppm)	APHA 3030E/3120	0.01	< 0.01	< 0.01	—
AH	2008/05/02	Bicarbonate	mg/L (ppm)	APHA 2320	1	785	973	959
AH	2008/05/02	Carbonate	mg/L (ppm)	APHA 2320	1	< 1	< 1	< 1
MD	2008/05/02	Chloride	mg/L (ppm)	APHA 4110	0.1	31.5	7.5	7.4
AH	2008/05/02	Fluoride	mg/L (ppm)	APHA 4500F-c	0.02	0.20	0.22	0.22
AH	2008/05/02	Hydroxide (as CaCO3)	mg/L (ppm)	APHA 2320	1	< 1	< 1	< 1
MD	2008/05/02	Nitrate - Nitrogen	mg/L (ppm)	APHA 4110	0.05	3.67	1.46	1.46
MD	2008/05/02	Nitrite - Nitrogen	mg/L (ppm)	APHA 4110	0.05	< 0.05	< 0.05	< 0.05
MD	2008/05/02	Sulphate	mg/L (ppm)	APHA 4110	0.5	55.5	85.8	84.1
AH	2008/05/02	Conductivity @ 25°C	mS/cm	APHA 2510 B	0.001	1.25	1.41	1.40
AH	2008/05/02	pH @ 25°C	pH units	APHA 4500H	0.01	7.94	7.85	7.85
JF	2008/05/02	Turbidity	NTU	APHA 2130-b	1	< 1	< 1	< 1
AH	2008/05/02	T-Alkalinity as CaCO3	mg/L (ppm)	APHA 2320	1	644	798	786
JF	2008/05/05	T-Dissolved Solids180°C	mg/L (ppm)	APHA 2540 C	4	756	900	904
RdP	2008/05/02	T-Hardness as CaCO3	mg/L (ppm)	APHA 2340-b	6.0	594	765	749
RdP	2008/05/02	Balance (+ions/-ions)	Ratio	APHA 1030-e	0.01	0.90	0.96	0.95

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MDL - Method Detection Limit

Report reviewed by:

James LeBlanc, B.Sc., P.Chem.
Manager
Laboratory Services

Charlene Rollheiser
Director of QA/QC
Laboratory Services

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RdP	2008/05/02	Carbon (Total Organic)	mg/L (ppm)	APHA 5310-b	0.1	3.1	3.7	3.5

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Date Received: 2008/05/02
Date Sampled:
Report Date: 2008/05/13

Water Analysis - Total Metals - ICP/MS

Attention: Polysou, Nick

Project No. KX0439717

File No.: EC-53959

Analyst	Date of Analysis (yyyy/m/d)	Analytical Parameter	Units	Reference Method	MDL	08-3725 HD4	08-3726 PW4	08-3726-D PW4 Duplicate
MD	2008/05/05	Aluminum	µg/L (ppb)	APHA 3030E/3125B	2.5	< 2.5	3.6	—
MD	2008/05/05	Antimony	µg/L (ppb)	APHA 3030E/3125B	0.05	0.15	0.19	—
MD	2008/05/05	Arsenic	µg/L (ppb)	APHA 3030E/3125B	0.2	1.9	1.1	—
MD	2008/05/05	Barium	µg/L (ppb)	APHA 3030E/3125B	0.05	63.9	78.5	—
MD	2008/05/05	Beryllium	µg/L (ppb)	APHA 3030E/3125B	0.1	< 0.1	< 0.1	—
MD	2008/05/05	Boron	µg/L (ppb)	APHA 3030E/3125B	1	14	18	—
MD	2008/05/05	Cadmium	µg/L (ppb)	APHA 3030E/3125B	0.02	0.02	0.03	—
MD	2008/05/05	Chromium	µg/L (ppb)	APHA 3030E/3125B	0.5	1.6	0.6	—
MD	2008/05/05	Cobalt	µg/L (ppb)	APHA 3030E/3125B	0.05	0.31	< 0.05	—
MD	2008/05/05	Copper	µg/L (ppb)	APHA 3030E/3125B	0.1	2.2	21.9	—
MD	2008/05/05	Lead	µg/L (ppb)	APHA 3030E/3125B	0.05	0.06	0.57	—
MD	2008/05/07	Mercury (Total)	µg/L (ppb)	APHA 3112	0.02	< 0.02	< 0.02	—
MD	2008/05/05	Molybdenum	µg/L (ppb)	APHA 3030E/3125B	0.05	7.83	5.50	—
MD	2008/05/05	Nickel	µg/L (ppb)	APHA 3030E/3125B	0.1	1.1	1.4	—
MD	2008/05/05	Selenium	µg/L (ppb)	APHA 3030E/3125B	0.6	1.1	8.2	—
MD	2008/05/05	Silver	µg/L (ppb)	APHA 3030E/3125B	0.1	< 0.1	< 0.1	—
MD	2008/05/05	Thallium	µg/L (ppb)	APHA 3030E/3125B	0.05	< 0.05	< 0.05	—
MD	2008/05/05	Titanium	µg/L (ppb)	APHA 3030E/3120B	0.5	< 0.5	< 0.5	—
MD	2008/05/05	Uranium	µg/L (ppb)	APHA 3030E/3125B	0.05	14.5	17.5	—
MD	2008/05/05	Vanadium	µg/L (ppb)	APHA 3030E/3125B	0.5	5.6	3.8	—
MD	2008/05/05	Zinc	µg/L (ppb)	APHA 3030E/3125B	1	3	7	—
AH	2008/05/02	pH @ 25°C	pH units	APHA 4500H	0.01	7.94	7.85	7.85

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Prince George, BC V2N 2P9

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Date Sampled:
Report Date: 2008/05/13

Water Analysis - Total Metals - ICP

Attention: Polysou, Nick

Project No. KX0439717

File No.: EC-53959

Analyst	Date of Analysis (yyyy/m/d)	Analytical Parameter	Units	Reference Method	MDL	08-3725 HD4	08-3726 PW4	08-3726-D PW4 Duplicate
MD	2008/05/06	Calcium	mg/L (ppm)	APHA 3030E/3120	0.5	76.5	119	---
MD	2008/05/06	Iron	mg/L (ppm)	APHA 3030E/3120	0.10	< 0.10	< 0.10	---
MD	2008/05/06	Magnesium	mg/L (ppm)	APHA 3030E/3120	0.05	118	124	---
MD	2008/05/06	Manganese	mg/L (ppm)	APHA 3030E/3120	0.010	< 0.010	< 0.010	---
MD	2008/05/06	Sodium	mg/L (ppm)	APHA 3030E/3120	0.5	30.3	32.0	---
RdP	2008/05/02	T-Hardness as CaCO3	mg/L (ppm)	Calculation	6.0	677	807	---

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ANALYTICAL REPORT

AMEC Earth & Environmental
3456 Opie Crescent
Prince George, BC V2N 2P9

Report Date: 2008/05/13

Quality Control Standard

Attention: Polysou, Nick

Project No. KX0439717 **File No.:** EC-53959

Analyst	Date of Analysis (yyyy/m/d)	Analytical Parameter	Units	Reference Method	MDL	Analyzed Value	Advisory Range	Target Value	Reference No.
MD	2008/05/02	Calcium	mg/L (ppm)	APHA 3120	0.2	36.1	33.8-41.3	37.50	QCP-QCS (CCV-Cats)
MD	2008/05/02	Magnesium	mg/L (ppm)	APHA 3120	0.5	35.6	33.8-41.3	37.50	QCP-QCS (CCV-Cats)
MD	2008/05/02	Potassium	mg/L (ppm)	APHA 3120	0.5	45.0	38.3-46.8	42.50	QCP-QCS (CCV-Cats)
MD	2008/05/02	Sodium	mg/L (ppm)	APHA 3120	0.5	35.6	33.8-41.3	37.50	QCP-QCS (CCV-Cats)
MD	2008/05/06	Iron (Total)	mg/L (ppm)	APHA 3120	0.01	1.04	0.90-1.10	1.00	QCP-QCS (CCV-Cats)
MD	2008/05/06	Manganese (Total)	mg/L (ppm)	APHA 3120	0.01	1.00	0.90-1.10	1.00	QCP-QCS (CCV-Cats)
MD	2008/05/02	Chloride	mg/L (ppm)	APHA 4110	0.1	2.2	1.8-2.2	2.00	CC-Anion-90C
AH	2008/05/02	Fluoride	mg/L (ppm)	APHA 4500F-c	0.02	0.51	0.45-0.55	0.50	QC-Alk/F-14
MD	2008/05/02	Nitrate - Nitrogen	mg/L (ppm)	APHA 3120	0.05	0.87	0.72-0.88	0.80	CC-Anions-90C
MD	2008/05/02	Nitrite - Nitrogen	mg/L (ppm)	APHA 3120	0.05	0.32	0.27-0.33	0.30	CC-Anions-90C
MD	2008/05/02	Sulphate	mg/L (ppm)	APHA 4110	0.5	15.4	12.6-15.4	14.00	CC-Anion-90C
AH	2008/05/02	Conductivity @ 25°C	mS/cm	APHA 2510 B	0.001	2.82	2.661-2.941	2.80	CC-EC-0.02M-13
AH	2008/05/02	pH @ 25°C	'–	APHA4500-H	0.01	6.00	5.95-6.05	6.00	CC-pH-131
JF	2008/05/02	Turbidity	NTU	APHA 2130-b	1	25	20-28	24.40	Z-TURB01047
AH	2008/05/02	T-Alkalinity as CaCO3	mg/L (ppm)	APHA 2320	1	60	58.19-71.12	64.66	QC-Alk/F-14
JF	2008/05/05	T-Dissolved Solids180° C	mg/L (ppm)	APHA 2540-c	2	4000	3114-5098	4,106.00	QCP-SLD1147

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Analyst	Date of Analysis (yyyy/m/d)	Analytical Parameter	Units	Reference Method	MDL	Analyzed Value	Advisory Range	Target Value	Reference No.
RdP	2008/05/02	Carbon (Total Organic)	mg/L (ppm)	APHA 5310-B	0.1	3.6	3.225-4.145	3.69	DMD-44-TOC-LOW

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MD	2008/05/05	Aluminum	µg/L (ppb)	APHA 3125B	2.0	48.3	45-55	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Antimony	µg/L (ppb)	APHA 3125B	0.10	91.0	90.0-110	100.00	MS-CCV-HIGH-9
MD	2008/05/05	Arsenic	µg/L (ppb)	APHA 3125B	0.1	94.8	90.0-110	100.00	MS-CCV-HIGH-9
MD	2008/05/05	Barium	µg/L (ppb)	APHA 3125B	3.00	45.9	45-55	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Beryllium	µg/L (ppb)	APHA 3125B	0.1	45.7	45.0-55.0	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Boron	µg/L (ppb)	APHA 3125B	4	45	45-55	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Cadmium	µg/L (ppb)	APHA 3125B	0.05	46.5	45.0-55.0	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Chromium	µg/L (ppb)	APHA 3125B	0.4	46.7	45.0-55.0	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Cobalt	µg/L (ppb)	APHA 3125B	0.05	48.8	45.0-55.0	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Copper	µg/L (ppb)	APHA 3125B	2.0	48.6	45-55	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Lead	µg/L (ppb)	APHA 3125B	0.05	92.9	90.0-110	100.00	MS-CCV-HIGH-9
MD	2008/05/07	Mercury (Total)	µg/L (ppb)	APHA 3112	0.02	0.11	0.0814-0.1391	0.11	A2-QCP15070
MD	2008/05/05	Molybdenum	µg/L (ppb)	APHA 3125B	0.30	45.4	45.0-55.0	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Nickel	µg/L (ppb)	APHA 3125B	0.1	48.0	45.0-55.0	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Selenium	µg/L (ppb)	APHA 3125B	0.4	47.0	45-55	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Silver	µg/L (ppb)	APHA 3125B	0.1	12.4	11.25-13.75	12.50	MS-CCV-HIGH-9
MD	2008/05/05	Thallium	µg/L (ppb)	APHA 3125B	0.02	231	225-275	250.00	MS-CCV-HIGH-9
MD	2008/05/05	Titanium	µg/L (ppb)	APHA 3125B	0.3	48.4	45.0-55.0	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Uranium	µg/L (ppb)	APHA 3125B	0.05	97.1	90-110	100.00	MS-CCV-HIGH-9
MD	2008/05/05	Vanadium	µg/L (ppb)	APHA 3125B	0.5	46.9	45.0-55.0	50.00	MS-CCV-HIGH-9
MD	2008/05/05	Zinc	µg/L (ppb)	APHA 3125B	2	48	45.0-55.0	50.00	MS-CCV-HIGH-9
AH	2008/05/02	pH @ 25°C	-	APHA4500-H	0.01	6.00	5.95-6.05	6.00	CC-pH-131

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MD	2008/05/06	Calcium	mg/L (ppm)	APHA 3120	0.2	39.1	33.8-41.3	37.50	QCP-QCS (CCV-Cats)
MD	2008/05/06	Iron	mg/L (ppm)	APHA 3120	0.01	1.04	0.90-1.10	1.00	QCP-QCS (CCV-Cats)
MD	2008/05/06	Magnesium	mg/L (ppm)	APHA 3120	0.50	39.4	33.8-41.3	37.50	QCP-QCS (CCV-Cats)
MD	2008/05/06	Manganese	mg/L (ppm)	APHA 3120	0.010	1.00	0.90-1.10	1.00	QCP-QCS (CCV-Cats)
MD	2008/05/06	Sodium	mg/L (ppm)	APHA 3120	0.5	36.4	33.8-41.3	37.50	QCP-QCS (CCV-Cats)

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