PITEAU ASSOCIATES
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FILE: 3793-TM1

TECHNICAL MEMORANDUM

DATE: October 14, 2021

TO: Michael Neill
Fraser Valley Regional District

FROM: Arnd Burgert
Email: aburgert@piteau.com

RE: **Hydrogeology Assessment for Aquifer Protection**
Stave Lake Quarry, Miracle Valley, B.C.

Piteau Associates Engineering Ltd. (Piteau) was retained by the Fraser Valley Regional District (FVRD) to assess hydrogeology in the vicinity of the Stave Lake Quarry (the Quarry) in the Miracle Valley. The purpose of this study was to evaluate the potential for operations at the Quarry to affect water quality in the Miracle Valley Aquifer (the Aquifer) and to comment on the suitability of proposed monitoring well locations for detecting nitrate pollution. The investigation included a desktop review of information pertaining to hydrogeology in the vicinity of the Quarry, a site reconnaissance by A. Burgert on August 30, 2021, interviews with the Quarry operators, and collection surface water samples from two locations for nitrate analysis. Results are summarized in the following technical memorandum.

BACKGROUND

Regulatory Considerations

FVRD Bylaw 1181 Section 26 provides measures for the protection of community drinking water sources. The FVRD owns production well 113520 (Figure 1), situated about 2 km southwest of the Quarry. Aggregate manufacturing with the potential to impact water quality in the source aquifer for Well 113520 is subject to the provisions of the bylaw. This includes requirements for a quarry operator to prepare a drinking water assurance plan identifying potential risks to the water source and providing recommendations for protection and monitoring of water quality.

Location, Geomorphology, Geology, and Land Use

The Miracle Valley (the Valley), sometimes referred to as the Upper Hatzic Valley, is located on a terrace north of the Hatzic Valley (Figure 1). It extends from Lagace Creek at its south end to the Stave Lake reservoir at its north end.

Ground elevations rise abruptly north of Durieu Road from 20 to 100 m above sea level (m-asl), then continue to rise gradually to 140 m-asl at Hartley Road. Continuing northward, ground elevations decline gradually to about 80 m-asl at Stave Lake. The Valley is bounded by steep mountainous terrain on the east and west sides (Photo 1).

The Valley floor is covered with unconsolidated sediments including a thick (>50 m) accumulation of sand and gravel overlain by about 30 m of marine silt and clay belonging to the Fort Langley Formation. The steep Valley walls are largely bedrock mapped as quartz diorite, covered by a discontinuous veneer of Fort Langley silt/clay that extends up the Valley walls to approximately 180 m-asl elevation (Photo 2). The bedrock is fractured and planar jointing is evident at several orientations (Photo 3).

The Valley is partially forested with second-growth stands of various ages. Land uses include rural residential and low-intensity agriculture. There are two fish hatcheries at the south end of the Valley. A BC Hydro transmission line runs southwest to northeast across the north end of the Valley.

The Quarry is situated on a bedrock bench in the west Valley wall at an elevation of approximately 240 m-asl (Figure 1; Photo 4). The hillside between the Quarry and the Valley floor has an average grade of 57%.

The FVRD is planning to initiate a program to monitor water quality in the Aquifer using a network of existing wells. Locations of candidate wells are shown on Figure 1.

Climate

The nearest weather station is at the Mission West Abbey, located about 8 km southwest of the Valley at an elevation of 221 m-asl. Data released by Environment Canada for the interval 2007 to 2016 indicate that this station receives 1,845 mm of precipitation annually. Average monthly precipitation amounts range from 37 mm in August to 244 mm in January. Approximately 65% of the total annual precipitation falls between the months of October and March.

Surface Water

Harriet Lake is situated on the lower (terrace) portion of the Quarry site and is intersected with several causeways. Culverts through the causeways allow uniform lake levels to be maintained.

Morrison Swamp is situated adjacent to the northwest end of the Quarry, and a sump excavated at the edge of the swamp is utilized as a water source for Quarry operations.

A pond is situated in a pit in the lowest portion of the Quarry (Photo 3).

Watercourses draining the west Valley wall include Belcharton Creek, which drains southward along the west end of the terrace, and Marino Creek (Figure 1), which drains Harriet Lake (Photo 5) and spring-fed marshy areas adjacent to the Quarry northward to Stave Lake.

A surface water divide exists at the high point near the centre of the Valley near Hartley Road (Figure 2). Runoff on the north side of Hartley Road flows towards Stave Lake and runoff on the south side reports to Lagace Creek. A subtle east-west surface water flow divide follows Burns Road. In this part of the Valley the ground is soggy and poorly drained, owing to fine-textured, clayey soils. Boggy conditions also exist in the low-lying areas at the north end of the Valley.

Regional Hydrogeology and Groundwater Usage

The glaciofluvial sands and gravels underlying the Fort Langley Formation host a deep confined aquifer known as the Miracle Valley Aquifer (the Aquifer). Its mapped extents[1] cover about 10 km^2 (Figure 1). Locations of the aquifer and the overlying clay are depicted in cross section on Figures 2 and 3.

[1] Kreye et al., 1998. An Aquifer Classification System for Groundwater Management in British Columbia, BC Ministry of Environment, Water Management Division, Victoria.

An east-west trending groundwater divide is situated between Hartley Road and about 1,000 m to the south of Hartley Road. To the north of this divide groundwater flows northward, and to the south groundwater flows to the south. The Aquifer is recharged by infiltrating surface runoff from Cascade Creek and ephemeral creeks draining the east wall of the Valley, by slow infiltration of direct precipitation through the overlying aquitard, and by flow through bedrock fractures (mountain block recharge). Shallow perched aquifers have been encountered in small pockets of sandy material within the clay.

Numerous domestic water supply wells have been drilled into the Aquifer. These include a Provincial observation well at the south end of Burns Road (Well Tag No. 105719) that was tested at 35 L/s and a test-production well in the northern portion of the aquifer (33953) that was tested at 33 L/s. A municipal production well (113520) in the southern portion of the aquifer has a yield of 9 L/s. An unregistered artesian well about 200 m east of the intersection of Durieu Road and Stave Lake Road flowed at 16 L/s. Analyses of pumping tests completed with wells constructed in 2011, 2012[2], and 2017[3] confirm an extensive and productive aquifer. Private wells commonly have reported yields generally greater than 1.5 L/s.

The portion of the Aquifer south of the east-west divide discharges to several springs at the south end of the Valley, where the terrace slope intercepts the piezometric surface. Water from the springs is utilized for uses including fish hatcheries, domestic supply, pond maintenance, and irrigation. The springs noted above are distinct from springs discharging from fractured bedrock at the west margin of the Valley, which include the Conroy Spring (Spring No. 4) at 12699 Stave Lake Road at an elevation of 92 m-asl (above Belcharton Creek near the Miracle Valley Trout Hatchery), and Spring No. 5[4] on the Marino Creek bed on the north side of the Quarry above 200 m-asl.

Oru, Seux, Belcharton, and possibly Lagace Creek are mostly groundwater-fed, especially along their lower reaches.

The portion of the Aquifer to the north of the aforementioned divide flows into Stave Lake.

QUARRY OPERATIONS

Operations at the Quarry commenced in the mid-1990s. According to the Quarry operators, bedrock is mined by blasting with ammonium nitrate-fuel oil (ANFO) explosive, typically once or twice per month. Explosive is not stored on site. The blast rock is then crushed and sorted on site to produce various sizes of crushed product that is stockpiled on site (Photo 6). Water for dust control is obtained from an excavated sump at the edge of Morrison Swamp, adjacent to the northwest end of the Quarry.

The operators indicated there is no runoff from the Quarry. Rainfall accumulates in a pond that has formed in the lowest portion of the Quarry (Photo 3) where it infiltrates.

Diesel fuel is stored on-site in two double-walled tanks, and from there is transported to on-site equipment via portable steel tanks (tidy-tanks) mounted in pickup trucks or a van.

In accordance with the Quarry's Mines Act permit, samples of surface water from Harriet Lake (Figure 4) at the base of the bedrock slope are collected annually for laboratory analysis. Water from the pond in the Quarry has never been sampled.

[2] Piteau, 2012. Hydrogeological Investigation for Groundwater Supply Miracle Valley, B.C. Report to District of Mission. April.
[3] Piteau, 2017. Construction and Testing of Production Well PW17-1 Durieu, BC. report to Fraser Valley Regional District. November.
[4] Piteau, 1994. Review Comments Relating to Groundwater Supplies and Hydrogeological Impacts. Report to John Conroy and Residents of Upper Hatzic Prairie/McConnel Creek Area Mission, British Columbia. September.

WATER QUALITY

Nitrate concentrations in groundwater samples from wells 105719 and 33953 in 2011 and 2012 were 0.204 and 0.0729 mg/L-N, respectively. The concentration in a sample collected from the production well in the southern part of the aquifer (113520) in 2017 was 0.239 mg/L-N. These values are all well below the 10 mg/L-N maximum allowable concentration included in the Guideline for Canadian Drinking Water Quality.

During Piteau's August 30, 2021 site visit water samples were collected from the Quarry's water source sump and Harriet Lake at the Quarry exit road (inverted purple triangles on Figure 4). Water from the Quarry pond was not sampled during Piteau's site visit at the request of the operator. Nitrate concentrations at the source sump and at the exit road were 2.27 and <0.0050 mg/L-N, respectively. The laboratory certificate of analysis is included in Appendix A.

EVALUATION OF POTENTIAL HAZARDS TO GROUNDWATER QUALITY

Potential groundwater pollution hazards at the Quarry with the potential to adversely affect groundwater quality in the Aquifer include fuel spills and nitrate residue.

Since diesel fuel is handled on site in mobile equipment and double-walled storage tanks, leaks are unlikely to go undetected. The hazard posed by fuel handling can be mitigated by crews being diligent with respect to refuelling equipment and promptly cleaning up any spills. Fuel management practices and a spill response plan should be in place and reviewed periodically. Accordingly, fuel spills at the Quarry represent a low risk to water quality in the Aquifer and FVRD Well 113520.

Nitrogen compounds (ammonia, nitrate and nitrite) are often released on mine sites during the detonation of ANFO[5]. Nitrate (NO_3) is the most soluble and stable form of nitrogen and is essentially unreactive upon reaching the water table. Nitrate in groundwater is attenuated only by dilution. Since crushed rock products are stockpiled uncovered in the Quarry, it can be expected that any nitrate residue present would be rinsed onto the quarry floor by rainfall, and from there it will percolate into the fractured bedrock.

The presence of springs with a bedrock source and observations of surface water infiltrating into the ground at the Quarry indicate that the fractured quartz diorite in the vicinity of the Quarry is hydraulically conductive. The direction of groundwater flow in fractured bedrock at the Quarry would be controlled by the orientations of interconnected joints and fractures. Water percolating into the rock at the Quarry would seep generally vertically through the unsaturated zone to the water table. From there, the overall flow direction would be from generally higher to lower head. As indicated by blue arrows on Figure 3, the interpreted overall flow direction is downward and to the east.

The nitrate concentration at the source sump (2.27 mg/L) is higher than would typically be expected in a mountain environment with no anthropogenic inputs, and is most likely related to explosives residue from the pit. The low nitrate concentration in the water sample collected at Harriet Lake is consistent with the interpretation that surface water from the pit does not report eastward to Harriet Lake, but either drains northward to Marino Creek or infiltrates into the ground. The presence of the silt/clay unit covering bedrock on the Valley walls would tend to act as a hydraulic barrier (Figure 3), reducing the potential for groundwater seeping through the

[5] Ministry of Environment and Climate Change Strategy, 2018. Guidance on Preparing Nitrogen Management Plans for Mines Using Ammonium Nitrate Fuel Oil Products for Blasting Version 1. February.

bedrock to report to ground surface and Harriet Lake. As a result, surface water quality in Harriet Lake is likely not strongly influenced by seepage from the fractured bedrock beneath the Quarry.

At depth beneath the silt/clay unit, the sand and gravel aquifer is interpreted to lie in contact with the fractured bedrock (Figure 3), thereby providing a direct flow path from the bedrock into the Aquifer.

Based on the foregoing analysis we conclude that the potential exists for nitrate blasting residue at the Quarry to leach into the Aquifer along a flow path that bypasses Harriet Lake. As such, it would not be detected by the Quarry's annual surface water sampling program. However, given that the amount of nitrate-enriched groundwater flowing through the bedrock into the Aquifer can be expected to form only a small proportion of the total flow in the Aquifer (less than 5%), it is judged unlikely that this will result in nitrate concentrations in the Aquifer rising above levels of concern on a widespread basis. The corresponding risk is judged qualitatively as low. Any nitrate effects would most likely be detected along the west edge of the Aquifer where groundwater from bedrock may enter.

FURTHER STUDY

The FVRD has identified prospective locations throughout the Aquifer where existing wells could be monitored to assess potential effects to the aquifer associated with the Quarry (Figure 1). At least one monitoring location in the Aquifer downgradient of the Quarry would be valuable to assess concentrations of dissolved nitrate to the east. A construction log for Well 77745 (Figure 1) indicates it is screened in a confined aquifer between depths of 47.5 and 48.8 m-below ground level and appears favourably situated to serve as a monitoring well. However, since it is situated near the interpreted groundwater divide (Figure 2), the groundwater flow direction is indeterminate. Accordingly, it would be prudent to monitor an additional well further north along Stave Lake Road. We also recommend an additional monitoring well be considered approximately 600 m south of Harriet Lake. These recommended additional monitoring locations are within the green ovals on figures 1 and 4.

SUMMARY OF FINDINGS

This memorandum summarizes a review of hydrogeology in the vicinity of Stave Lake Quarry and an assessment of the risk of aquifer pollution posed by Quarry operations. Key findings are as follows:

- The Miracle Valley Aquifer is relied on by local residents and the FVRD as a water source. The Aquifer also feeds springs that sustain several streams. As the Aquifer is the source for the FVRD's production well 113520, aggregate operations are subject to FVRD Bylaw 1181 Section 26 which provides measures for the protection of community drinking water sources.
- Available nitrate analysis results for water samples collected from the Aquifer indicate nitrate concentrations far below the maximum allowable concentration included in the Guideline for Canadian Drinking Water Quality.
- Nitrate is often released on mine sites during the detonation of explosives, and was detected in a sump at the Quarry at a concentration of 2.27 mg/L. Nitrate is persistent in the environment, attenuated in aquifers only by dilution.
- A pathway may exist for nitrate residue washed off crushed rock at the Quarry to infiltrate into fractured bedrock and then seep into the Miracle Valley Aquifer. The Quarry's annual surface water monitoring program at Harriet Lake would not be expected to detect nitrate seeping along this pathway.

- While it is judged unlikely that residue seeping from the Quarry will result in nitrate concentrations in the Aquifer rising above levels of concern on a widespread basis (low risk), initiation of a program to monitoring aquifer nitrate concentrations would be prudent.
- One of the wells selected for monitoring by the FVRD (Well 77745) appears favourably situated to observe water quality downgradient of the Quarry. Since the groundwater flow direction at this location is indeterminate, two additional monitoring locations (to the north and south) are recommended.

LIMITATIONS

This investigation has been conducted using a standard of care consistent with that expected of scientific and engineering professionals undertaking similar work under similar conditions in BC. No warranty is expressed or implied.

This memorandum is prepared for the sole use of the Fraser Valley Regional District. Any use, interpretation, or reliance on this information by any third party, is at the sole risk of that party, and Piteau Associates accepts no liability for such unauthorized use.

CLOSING

We trust the above is adequate for your current needs. If you have any questions regarding the above, or we can be of further service, please contact the undersigned.

Respectfully submitted,

PITEAU ASSOCIATES ENGINEERING LTD.

PROFESSIONAL GEOSCIENTIST
PROVINCE OF BRITISH COLUMBIA
A. BURGERT
#30284
Oct. 14, 2021
AB

Arnd Burgert, P.Geo.
Sr. Hydrogeologist

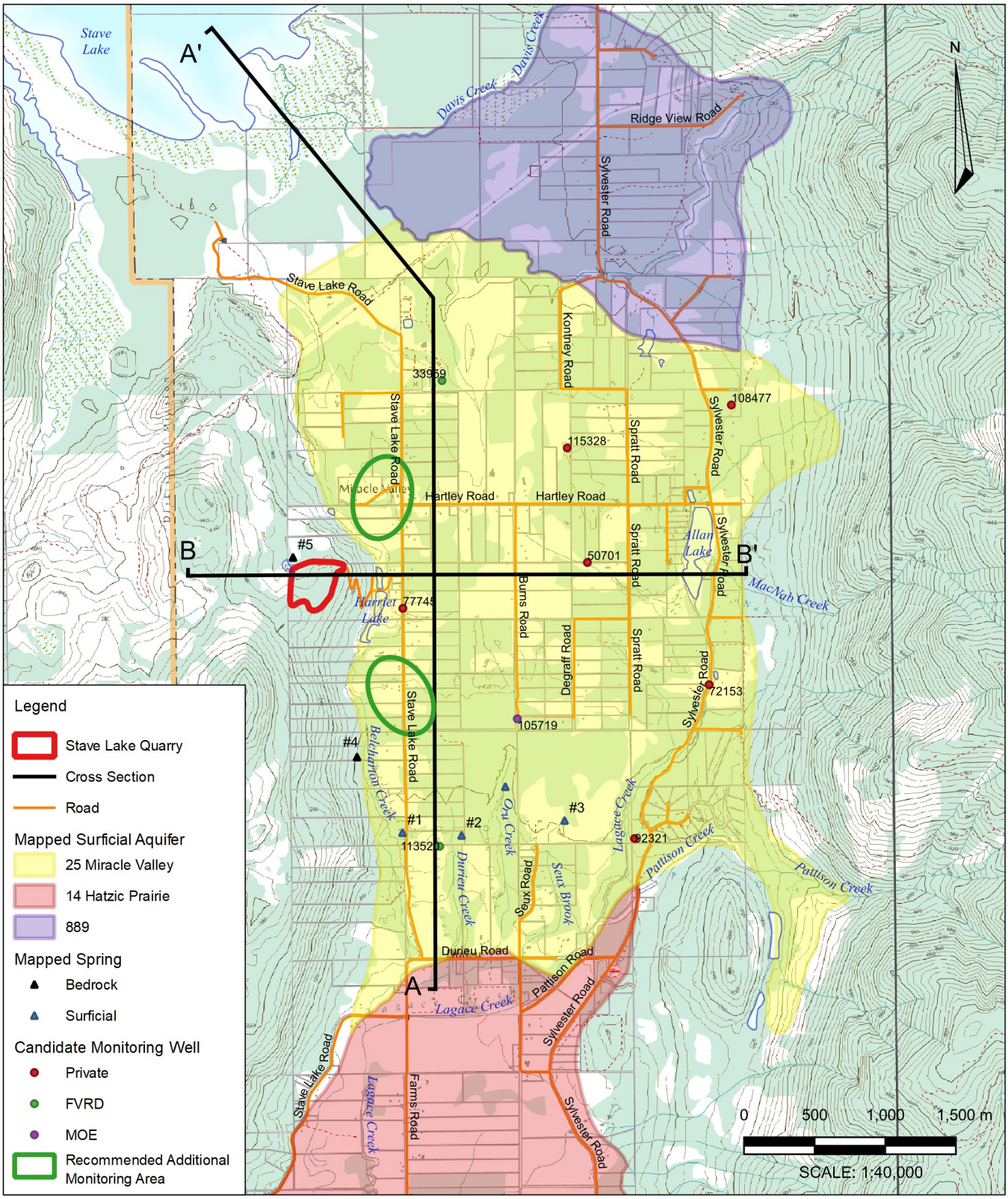
Reviewed by:

David J. Tiplady, P.Eng
Principal Hydrogeologist
Vice President, Groundwater

AB/DJT/ld

FIGURES

C:\Users\laburgert\Documents\ArcGIS\3793\Location Big.qgz



Aquifer mapping by Krye et al, 1998.

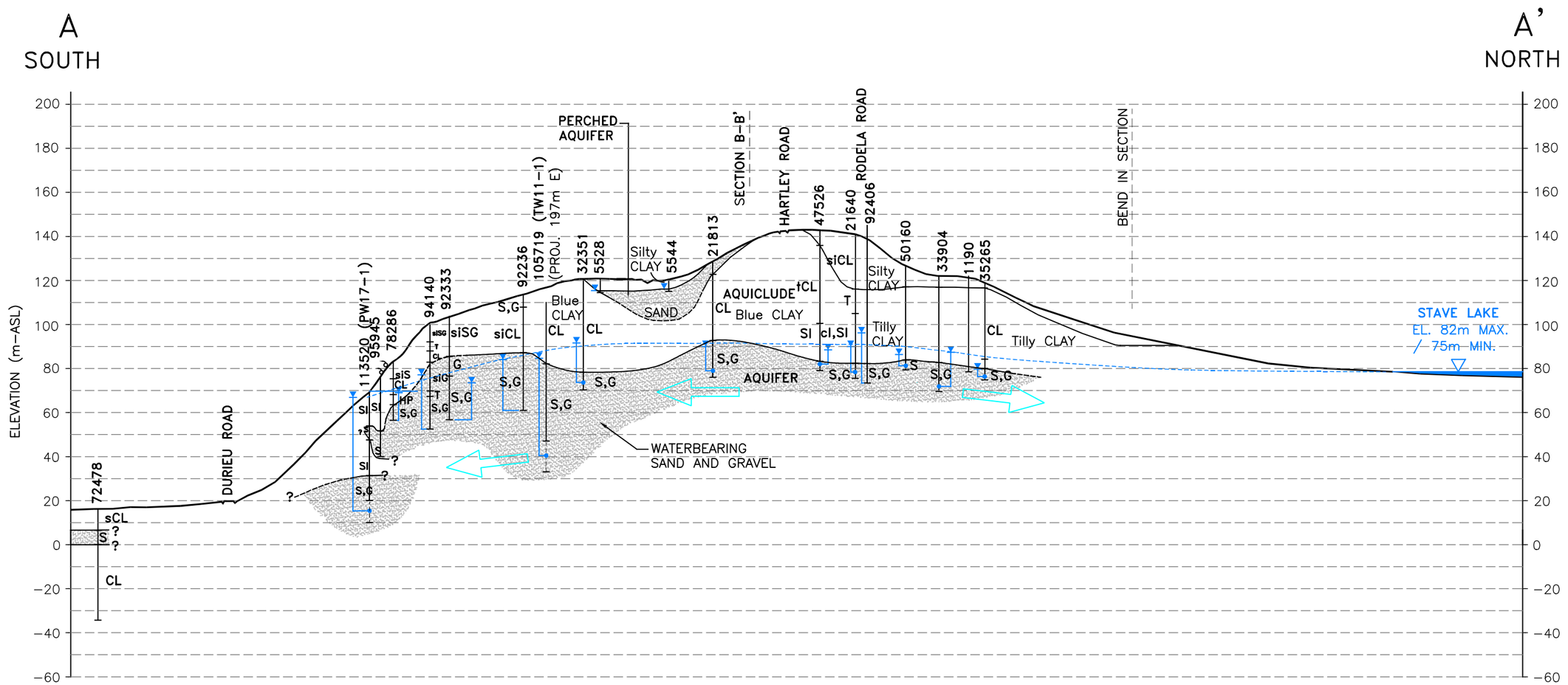
FRASER VALLEY REGIONAL DISTRICT
HYDROGEOLOGY ASSESSMENT
FOR AQUIFER PROTECTION
STAVE LAKE QUARRY, MIRACLE VALLEY

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS

LOCATION PLAN

BY:	DATE:
AB	SEP 21
APPROVED:	FIG:
	1

DWG. NUMBER: K:\3793a\Cadd\3793-001.dwg (Fig 10)



SECTION A–A'

LEGEND

DRILLED WELL SHOWING WATER ELEVATION AND BCMOE WELL TAG NO.

PIEZOMETRIC ELEVATION

GEOLOGICAL BOUNDARY

INFERRED DIRECTION OF GROUNDWATER FLOW

SPRING

G	GRAVEL
S	SAND
SI	SILT
CL	CLAY
T	TILL
HP	HARDPAN

(LOWER CASE INDICATES MINOR COMPONENT)

0 200 400 600 800 1000m

SCALE 1:25,000

VERTICAL EXAGGERATION 12.5x

NOTE:

SEE LOCATION OF SECTION ON FIG. 1.

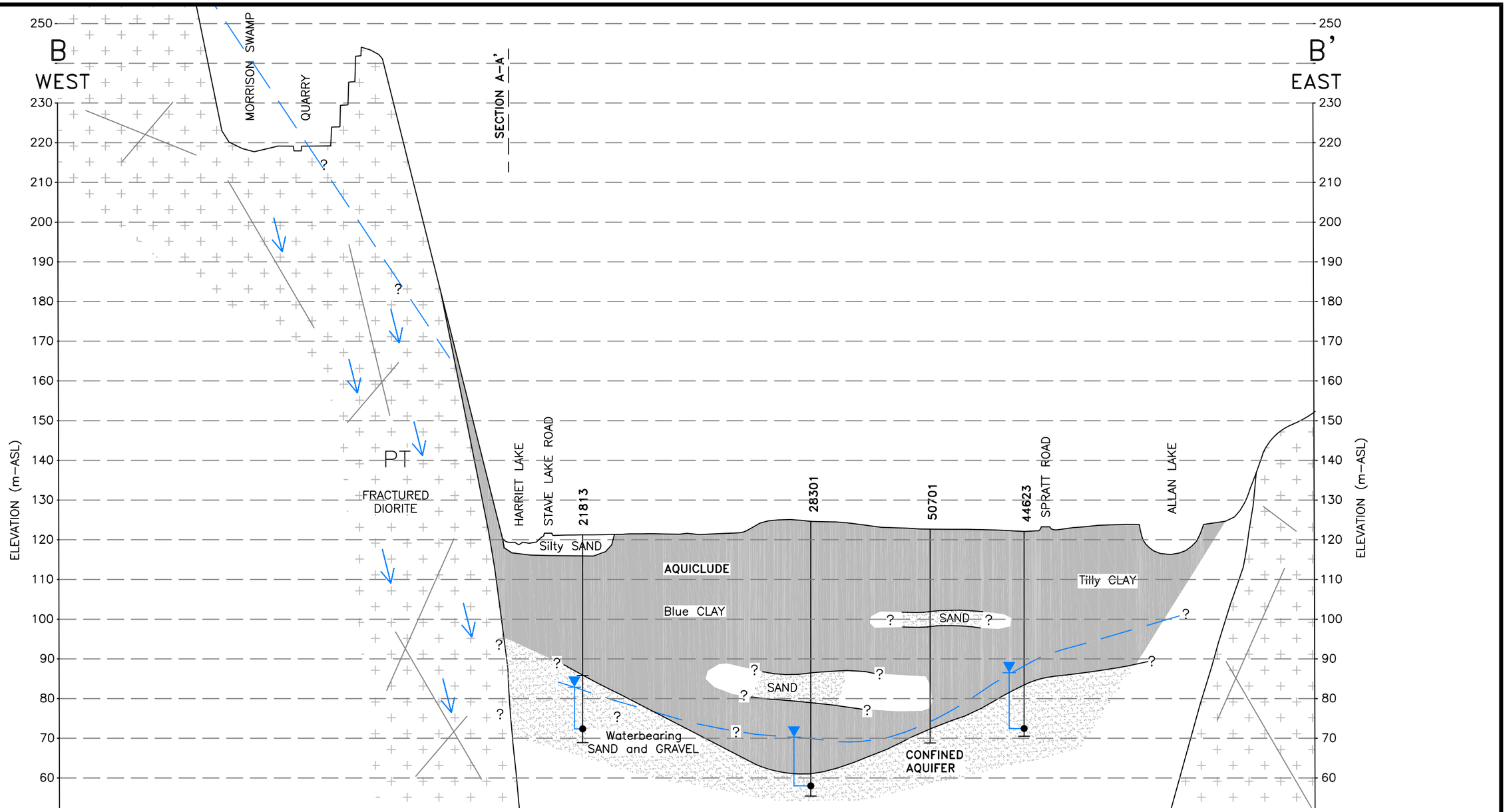
FRASER VALLEY REGIONAL DISTRICT
AQUIFER PROTECTION ASSESSMENT
FOR QUARRY OPERATION
DURIEU, B.C.

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

HYDROGEOLOGICAL SECTION A-A'

BY:	DATE:
AB/sl	SEP 21
APPROVED:	FIG:
DJT	2

DWG. NUMBER: K:\3793a\Cadd\3793-002XSC.dwg (Fig 12)



NOTE:

SEE LOCATION OF SECTION ON FIG.1.

LEGEND

DRILLED WELL SHOWING WATER ELEVATION AND BCMOE WELL TAG NO.

PIEZOMETRIC ELEVATION

GEOLOGICAL BOUNDARY

0 100 200 300 400 500m

HORIZONTAL SCALE 1:12500

VERTICAL EXAGGERATION 12.5x

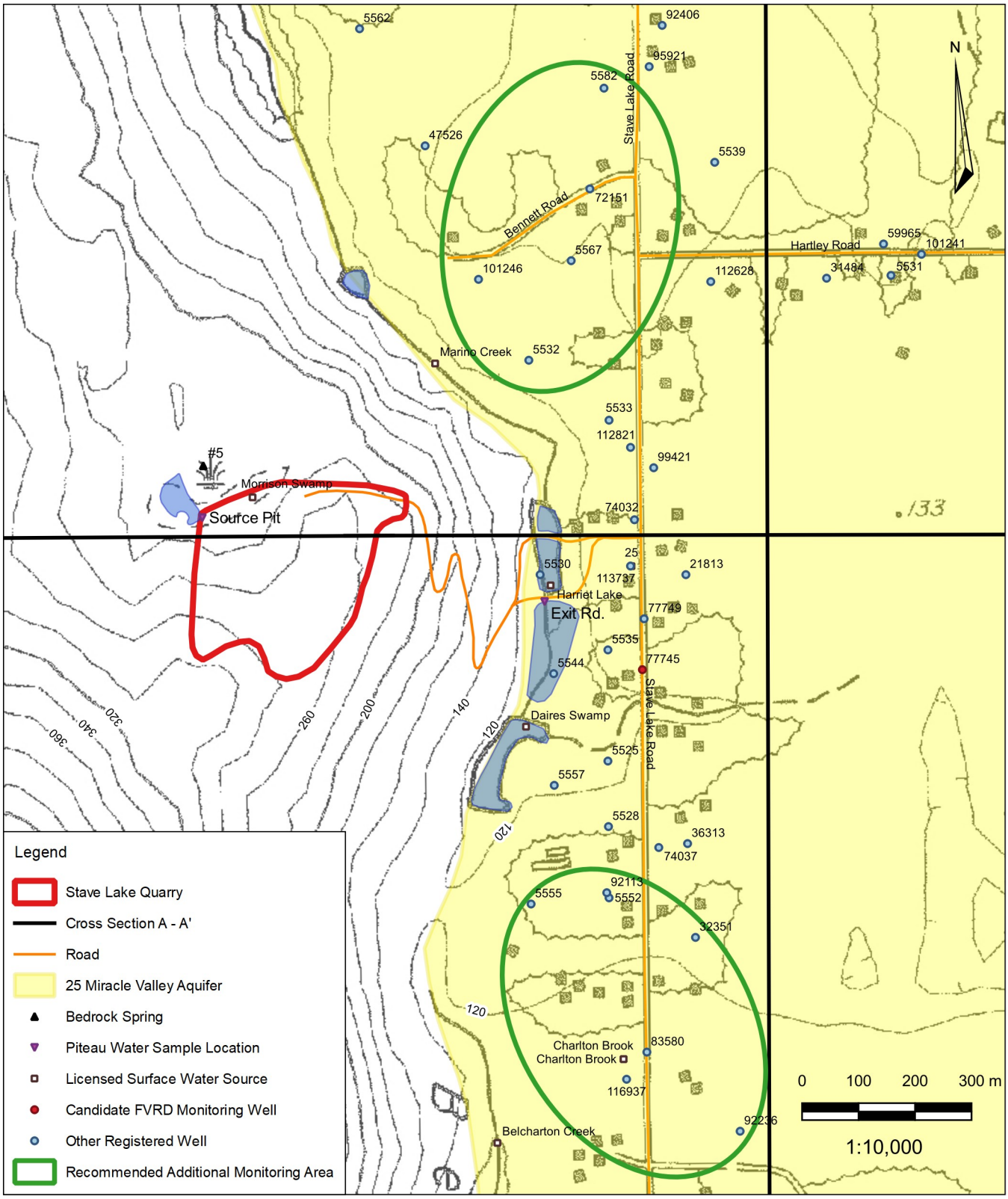
FRASER VALLEY REGIONAL DISTRICT
AQUIFER PROTECTION ASSESSMENT
FOR QUARRY OPERATION
DURIEU, B.C.

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS

HYDROGEOLOGICAL SECTION B-B'

BY:	DATE:
AB	SEP 21
APPROVED:	FIG:
DJT	3

C:\Users\laburaert\Documents\ArcGIS\3793\Location Detail.qgz



FRASER VALLEY REGIONAL DISTRICT
HYDROGEOLOGY ASSESSMENT
FOR AQUIFER PROTECTION
STAVE LAKE QUARRY, MIRACLE VALLEY

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS

DETAIL PLAN

BY:	DATE:
AB	SEP 21
APPROVED:	FIG:
	4

PHOTOS

Photo 1: View northwest across the south end of the Terrace toward the steep west valley wall. The Quarry is situated on a bedrock bench near the right side of the photo. June 15, 2017.

Photo 2: Laminated silt and clay in a road cut at approximately 160 m elevation along the Quarry access road. August 30, 2021.

Photo 3: Fractured and jointed quartz diorite at the Quarry. The Quarry pond can be seen. August 30, 2021.

Photo 4 The Quarry, situated on a bedrock bench at approximately 240 m-asl elevation. August 30, 2021.

Photo 5: Harriet Lake, situated on the Terrace below the Quarry. August 30, 2021.

Photo 6: Various sizes of crushed rock manufactured and stockpiled at the Quarry. August 30, 2021.

APPENDIX A
LABORATORY CERTIFICATE OF ANALYSIS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B8572**	Page	: 1 of 2
Client	: **Piteau Associates Engineering Ltd.**	Laboratory	: Vancouver - Environmental
Contact	: Arnd Burgert	Account Manager	: Brent Mack
Address	: 300 - 788 Copping Street North Vancouver BC Canada V7M 3G6	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: 778-370-3279
Project	: 3793	Date Samples Received	: 30-Aug-2021 12:52
PO	: ----	Date Analysis Commenced	: 01-Sep-2021
C-O-C number	: 20-937345	Issue Date	: 07-Sep-2021 13:27
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
mg/L	milligrams per litre

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)				*Client sample ID*	**Supply Sump**	**Pond at Exit Road**	**----**	**----**	**----**
				Client sampling date / time	30-Aug-2021 10:15	30-Aug-2021 10:45	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21B8572-001**	**VA21B8572-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	2.27	<0.0050	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B8572**	Page	: 1 of 4
Client	: **Piteau Associates Engineering Ltd.**	Laboratory	: Vancouver - Environmental
Contact	: Arnd Burgert	Account Manager	: Brent Mack
Address	: 300 - 788 Copping Street North Vancouver BC Canada V7M 3G6	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: 778-370-3279
Project	: 3793	Date Samples Received	: 30-Aug-2021 12:52
PO	: ----	Issue Date	: 07-Sep-2021 13:27
C-O-C number	: 20-937345		
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Pond at Exit Road	E235.NO3-L	30-Aug-2021	----	----	----		01-Sep-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Supply Sump	E235.NO3-L	30-Aug-2021	----	----	----		01-Sep-2021	3 days	2 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Nitrate in Water by IC (Low Level)	E235.NO3-L	281558	1	11	9.0	5.0	✓
Laboratory Control Samples (LCS)							
Nitrate in Water by IC (Low Level)	E235.NO3-L	281558	1	11	9.0	5.0	✓
Method Blanks (MB)							
Nitrate in Water by IC (Low Level)	E235.NO3-L	281558	1	11	9.0	5.0	✓
Matrix Spikes (MS)							
Nitrate in Water by IC (Low Level)	E235.NO3-L	281558	1	11	9.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

QUALITY CONTROL REPORT

Work Order	: **VA21B8572**	Page	: 1 of 3
Client	: Piteau Associates Engineering Ltd.	Laboratory	: Vancouver - Environmental
Contact	: Arnd Burgert	Account Manager	: Brent Mack
Address	: 300 - 788 Copping Street North Vancouver BC Canada V7M 3G6	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: 778-370-3279
Project	: 3793	Date Samples Received	: 30-Aug-2021 12:52
PO	: ----	Date Analysis Commenced	: 01-Sep-2021
C-O-C number	: 20-937345	Issue Date	: 07-Sep-2021 13:27
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia