PITEAU ASSOCIATES
GEOTECHNICAL AND
HYDROGEOLOGICAL CONSULTANTS

SUITE 300 - 788 COPPING STREET
NORTH VANCOUVER, B.C.
CANADA - V7M 3G6
TEL: (604) 986-8551 / FAX: (604) 985-7286
www.piteau.com

Our file: 3232

January 22, 2014

Urban Systems Ltd.
550-1090 Homer Street
Vancouver, BC
V6M 2W9

Attention: Mr. Jacob Scissons, P.Eng.

Dear Sirs:

Re: Groundwater Supply Assessment – Hatzic Prairie Water System, Mission, B.C.

Piteau Associates Engineering Ltd. (Piteau) has been retained by Urban Systems Ltd. (USL), on behalf of the Fraser Valley Regional District (FVRD) to conduct an assessment of groundwater resources to supply future development in Hatzic Prairie, located west of Mission, B.C. One or more additional wells may be required to meet additional future demands of 20 to 30 L/s.

The existing potable water supply is sourced from two wells (Wells 1 and 2) located at the Durieu Elementary school near the intersection of Seux Road and Sylvester Road. This system services approximately 130 connections along Farms Road and Sward Road, including the Mountainview and Riverside subdivisions.

The following letter report has been prepared to summarize groundwater resources the Hatzic Prairie region and identify well locations having the potential to meet future water demand requirements, both in terms of water quantity and quality.

SCOPE OF WORK

As part of Piteau's assessment of local groundwater resources, the following information sources were reviewed:

- Stereo-paired air photos – for information on land use and morphology;
- Ministry of Environment Water Resources Atlas – for information on well locations, lithologies, water levels, and water chemistry;
- Ministry of Environment Site Registry – for identification of contaminated sites which may constitute groundwater pollution hazards;
- Previous consultant reports – for information on local hydrogeological conditions and the construction and testing of the existing supply wells;

A brief field reconnaissance was conducted by Mr. Dave Tiplady (P.Eng., Principal) on October 2, 2013. At this time he met with FVRD staff to obtain information on the current water supply system and to confirm areas of interest for a new groundwater source.

Topography, Drainage and Landuse

Hatzic Prairie is located on the east side of Mission, B.C (Fig. 1). It occupies part of a low-lying glacial trough which extends from Stave Lake southward to the Fraser River. Hatzic Prairie is bounded by Dewdney Peak and Durieu Ridge on the east side (maximum elevation 1300 metres above sea level, or m-asl) and more subdued upland areas on the west side (maximum elevation 600 m-asl).

The lower portion of Hatzic Prairie is a floodplain at about 20m elevation. It includes Hatzic Lake, an oxbow lake which was formerly a meander of the Fraser River. North of Durieu Road, the ground surface rises abruptly to 100 m-asl, forming a topographic bench that defines the northern terminus of Hatzic Prairie, and the southern terminus of the Miracle Valley.

Ground elevations moving northward in the Miracle valley rise gradually to 140 m-asl, then fall to 80 m-asl at the shoreline of Stave Lake. Hartley Road roughly defines a surface water flow divide. Watercourses on the north side (e.g., Cascade and Marino creeks), report to Stave Lake, and those on the south side (e.g., Belcharton, McNab, and Pattison creeks) report to Hatzic Slough and Hatzic Lake. No active surface water monitoring stations were found on the Water Survey of Canada database for Hatzic Prairie or the Miracle Valley.

The steep slopes of Durieu Ridge are subject to frequent landslides which send large quantities of debris to alluvial fans and streambeds on the valley floor. Watercourses draining these areas, including McNab Creek and Pattison Creek, require regular removal of sediment and debris to maintain their channel capacities and prevent flooding along the receiving channels of Lagace Creek and Hatzic Slough (Millard, 2013).

Private lands in Hatzic Prairie and the Miracle Valley are occupied by rural-residences and low-intensity agricultural operations, with some forested areas and small clusters of residential developments. Crown Lands mainly on the western sides of the valleys are actively logged.

Hydrogeology

The Hatzic Prairie is bounded by Mesozoic and Paleozoic plutonic bedrock (quartz diorite) belonging to the Coast Plutonic Complex (Armstrong, 1990). Relatively few wells are completed in bedrock in this region, and are expected to be low-yielding (< 1 L/s).

Hatzic Valley Aquifer

The Hatzic Prairie Aquifer (HPA) extends across Hatzic Prairie between Durieu and Hatzic Lake, covering an area of approximately 9.8 km^2 (Fig. 1). It has been tagged by the Province as Aquifer 0014, and is described as moderately productive and subject to low demand. It is a relatively shallow, unconfined aquifer comprised of sands and silts deposited by the Fraser River and other lowland streams (Fraser River and Salish sediments). In some places, these are overlain by thin patches of loamy bog sediments.

Surficial sediments in the northern and portion of the HPA consist of gravel and rubble deposited by landslides and debris flows. These deposits are up to 10m thick and are interpreted to be heterogeneous, based on significant differences in lithologies and yields across relatively short distances. The water table is shallow in this area (about 3 metres below ground level, or m-bgl) and many residents rely on dug wells.

The two production wells which currently supply water to Hatzic Prairie are completed in the HPA. Henceforth referred to as the School wells, they are located at Durieu Elementary School at 11620 Seux Road (Fig. 2). Well 2 was drilled in 1981 to a depth of 19.8m and encountered clay at 17.4m. It is nominally 8" in diameter and is screened across a gravel horizon between 14.3 and 17.4m. In October 2007, the well was tested for a 24-hour period, and determined to have a safe yield of 15.1 L/s (Pacific Hydrology Consultants Ltd., PHCL, 2007). The static water level at the time of testing was 3.4 m-bgl.

The newer well, Well 1, was approximately 10m south of Well 2 in 2008. It is screened across saturated sand and gravels between 15.2 and 18.9 m-bgl. Clay was encountered at 19.2 m-bgl and the water table was at 3.5 m-bgl in February. The safe yield of this well was assessed to be 29.1 L/s shortly after its construction (PHCL, 2008).

In March 2008, a 24-hour pumping test was conducted with both wells pumping simultaneously at a combined rate of 27.6 L/s (PHCL, 2008). Drawdown was recorded at several nearby domestic wells, two of which were dug wells. The maximum drawdown interference observed at the end of the pumping period was 0.25m at a 3.9m deep well located approximately 25m from the tested wells (the Simmonds well). Drawdown interference at Well 2 due to pumping of Well 1 at a rate of 24.9 L/s was about 0.41m.

Sources of recharge to the HPA are incident rainfall and snowmelt, and possibly exfiltration of surface runoff from creeks draining the side walls of the valley. Groundwater is interpreted to flow southward toward Hatzic Lake. Several tributaries to Hatzic Slough originate on the floor of the valley and are likely sustained by the high water table.

Miracle Valley Aquifer

The Miracle Valley Aquifer (MVA) extends north of the HPA to Stave Lake, covering an area of approximately 13.1 km^2. Identified in the Province`s aquifer database as Aquifer Nu. 0025, it is a moderately productive, confined aquifer that is subject to low demand. It comprises glaciofluvial and ice contact sands and gravels (Vashon Drift) which pre-date the alluvial and stream deposits underlying Hatzic Prairie. The MVA is confined by layer of glaciomarine clay and till (Fort Langley Formation) that is up to 50m thick in some areas.

Residents in the MVA obtain their drinking water from wells drilled a short distance into the MVA, or from perched permeable zones within the confining aquitard. Most wells are over 40m deep, and driller estimated yields are 1.5 L/s or greater.

In 2011 and 2012, Piteau oversaw the drilling of two test wells in the southern and northern portion of the MVA. The southernmost well, TW11-1, located at the south terminus of Burns Road (Fig. 2). The lithology of the borehole comprised sandy overburden to 4.6m, clay to 27.4m, and sand and gravel to 77m. An 8" telescopic screen was set between 54.4 and 59.2m, and the static water level was at 25.3m. Pumping tests conducted with TW11-1 in December 2011 confirmed that the aquifer is highly permeable (transmissivity value of about 1.6×10^{-3} m/s) and that the well was capable of sustaining a flow of 124 L/s. Drawdown interference measured at a domestic well located 109m from TW11-1, after 24 hours of pumping at 34.7 L/s, was less than 0.2m.

The MVA discharges to numerous springs along the topographic bench at its south end. Durieu Creek, Oru Creek, and Seux Brook are expressions of this groundwater discharge, with total flows estimated to be on the order of 450 L/s. The creeks are low-gradient and likely serve as spawning habitat for coho and chum salmon and cutthroat trout. There are two fish hatcheries located in the vicinity – one northwest of the intersection between Stave Lake Road and Durieu Road, and another near the intersection of Durieu and Seux Road.

As shown in Section A-A' presented on Fig. 3, the MVA aquifer likely extends below the HPA south of Durieu Road. A search of the Ministry of Environment Water Resources Atlas indicated two flowing artesian wells in the vicinity: one at 11964 Seux Road, and another at the Cedar Acres Trailer Park at 35584 Durieu Road. They are identified by Well Tag Nos. 92411 and 60484, respectively, on Fig. 2, and Well 92411 is shown in cross-section on Fig. 3. Both wells intercepted an upper gravel unit (HPA), followed by a thick (30-40m) clay layer, and an underlying sand and gravel unit (MVA?). Well No. 29299 at 35631 Durieu Road also intercepts this lower sand and gravel unit, although no static water elevation is given. The thickness or southern extent of the MVA is uncertain, owing to the general absence of deep wells in the vicinity.

The MVA is interpreted to be recharged by seepage from creeks draining the east and west walls of the valley, and by slow infiltration of incident precipitation through the confining clay and till layer. Lagace Creek has downcut through the confining layer on the west side of the valley, which facilitates exfiltration of surface water into the aquifer. This is illustrated in Section B-B' on Fig. 4. The westward sloping water table suggests that there is a component of groundwater flow from east to west, although the predominant direction of groundwater flow through the MVA is interpreted to be southward.

Groundwater Quality

Hatzic Prairie Aquifer

There are numerous anecdotal accounts of elevated iron concentrations in wells situated in the HPA. Water quality reports for a domestic well(s) located at Dale Road and Farms Road indicated elevated manganese concentrations in an upper aquifer at 14 m-bgl, and brackish water in a lower aquifer at 73.5 m-bgl (PHCL, 2006). Other wells producing water with abnormally high total dissolved solids (TDS), or iron and manganese concentrations exceeding Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ) were reported in regional groundwater quality study conducted in 2004 (Magwood, 2004).

The School wells and neighbouring shallow domestic wells produce water that is calcium-bicarbonate type, soft, and low in dissolved minerals (<40 mg/L), based on sampling conducted during testing of the School wells in 2008, and subsequent routine sampling conducted by the FVRD. Iron and manganese concentrations are consistently within GCDWQ.

Elevated concentrations of arsenic have been reported in groundwater obtained from a well at the Firehall on Sylvester Road just above Pattison Road[1]. The exact depth of this well is uncertain, however, a few wells in the vicinity encountered fractured granite at depths of about 20m, one of which is reported to be artesian (Fig. 2). These rocks may contain arsenic-bearing minerals such as arsenopyrite which dissolve in contact with bedrock groundwater. Elevated arsenic levels have also been observed in wells completed in granite bedrock on Bowen Island and the Sunshine Coast (Mattu and Schreier, 2000).

Miracle Valley Aquifer

About 10% of the groundwater samples collected from domestic wells throughout the HPA and MVA by Magwood in 2004 were found to have isolated occurrences of elevated iron and manganese. These are naturally occurring, and are a function of the contact times and types of minerals along the groundwater flow path.

Water samples collected from TW11-1 at the end of the December 2011 pumping test were of the calcium bicarbonate type, with moderate TDS (76 mg/L). They were in compliance with all GCDWQ, and had dissolved iron and manganese concentrations below method detection limits. Water samples collected at a nearby domestic well, screened at a higher elevation within the

[1] Interview with Scott Salsbury and James Storey of FVRD, October 2, 2013

aquifer, had a lower TDS (44 mg/L) and elevated iron (0.197 mg/L). Therefore, iron and manganese concentrations are expected to vary with depth and location in the MVA.

Similarities in inorganic water chemistry were noted between the Miracle Valley and Hatzic Prairie aquifers (Magwood, 2004), suggesting that a large component of groundwater flow from the MVA may discharge into the HPA.

Groundwater Pollution Hazards

As the HPA is largely unconfined, with a water table close to ground surface, it is considered to be highly vulnerable to surface-sourced contamination. These include nitrates sourced from forest harvesting and agricultural activities (e.g., poultry and livestock rearing, tree farming), and sewage effluent disposal to ground. Elevated concentrations of nitrate (> 3 mg/L) have been observed in several shallow wells throughout the HPA, particularly in more developed areas in the vicinity of Hatzic Lake. In these areas, nitrate is most likely sourced from nearby septic systems (Magwood, 2004).

The MVA is less vulnerable to contamination, owing to the protective confining layer. Although the confining layer appears to be continuous across its aerial footprint, it may be thinner in some areas, or exposed in some heavily incised ravines (Fig. 4).

A search of the BC Ministry of Environment Site Registry conducted to locate potential groundwater pollution hazards within a 1km x 1km square centred on Seux Road between Durieu Road and Lagace Creek. No records were found in this search.

Pathogens

According to the Province’s most recent guidance document (Ministry of Health, 2012), a groundwater source is considered to be potentially at risk of containing pathogens (GARP) if it meets any of the following criteria related to water quality, well placement, well construction, or aquifer setting:

- Repeat occurrences of total coliform, fecal coliform, or E. Coli bacteria, or high turbidity in water samples;
- The well is located within minimum setback distances from contaminant sources (e.g., septic fields, cesspools, cemeteries) defined by the *Human Health Regulation*;
- The well intake is less than 15 m-bgl and the well is situated within the natural boundary of a nearby surface water body (e.g., floodplain);
- The is located within 150m of the natural boundary of a nearby surface water body, and the well intake is between the high-water mark and 15m below the normal water level;

- The well is located within 300m of a source of enteric viral contamination, and there is no confining layer between the source and the aquifer;
- The well construction does not meet standards set out in the Province's *Groundwater Protection Regulation* (GWPR);
- The well intake is less than 15 m-bgl and completed in a unconfined, unconsolidated, or fractured bedrock aquifer; or
- The well is completed in a karst bedrock aquifer.

With reference to these criteria, many wells in the HPA aquifer, including the School wells, may be considered potentially GARP owing to their shallow completions in a relatively permeable unconfined aquifer, and their proximity to sources of enteric viral contamination (e.g., septic fields) and surface watercourses (e.g., Lagace Creek). Wells in the MVA aquifer have a low probability of being GARP owing to their protection by the confining clay layer.

Current Groundwater Withdrawals

Records of cumulative flow volumes and pump hours for Wells 1 and 2 were obtained for the period May 2010 to September 2013. The average daily well withdrawal rate (assuming continuous well operation) over the past year was 1.1 L/s, and doubled during the summer months (Fig. 5). The average combined instantaneous pumping rate from both wells was 13 L/s, and increased occasionally to 24 L/s in July and August. Pump hour readings indicate that the wells operate about 8% of the time. Based on this usage information and the wells' estimated combined sustainable yield of 44.5 L/s, there remains some unutilized capacity.

For a future scenario of 230 connections, daily average demand is estimated to be 10.5 L/s, with a peak day demand of 17.9 L/s (PHCL, 2006). Predicted drawdown interferences at neighboring wells under a combined withdrawal rate of 17.9 L/s is estimated to be small (<0.2m, or less than 1% of total available drawdown), with the exception of the Simmonds well.

Water levels at Wells 1 and 2 were generally lowest in mid-October, at the end of the summer drought period (Fig. 5). They rose rapidly in response to rainfall in November and December (by about 3m), and again in response to snowmelt and rainfall in March. The almost 10m variation in water levels recorded in Well 2 is suspected to be an instrument measurement error.

DISCUSSION

Two areas for the drilling of a new production well(s) are recommended, and an additional two may be considered, as described further in the following section.

Area A

Area A is located near the top of Seux Road, and is our preferred location for a new production well (Figs. 2 and 3). A well drilled in this area would target the MVA, the top of which is expected to be encountered at 25 m-bgl. The probability of drilling an artesian well at this location is low, since the piezometric surface is not expected to be above ground elevation (Fig. 3).

This location is protected from flooding, as it is situated about 50m above the Hatzic Prairie floodplain. The risk of GARP is also expected to be low, due to the protection afforded by the confining clay horizon. Since neighbouring surface water courses (Seux Brook) are interpreted to be expressions of groundwater discharge, they would not constitute a potential source of waterborne pathogens to the aquifer (GWUDI).

Conversely, groundwater extraction in this area could reduce baseflows in Seux Brook, which may potentially affect fish habitat. Although effects are expected to be very small at the rates in question (up to 30 L/s), this may need to be confirmed by a biological assessment and/or numerical groundwater flow modeling. The Province's new *Water Sustainability Act*, which is scheduled to pass before the legislature in 2014, will require that new groundwater extraction wells be licensed, and may require an evaluation of Environmental Flow Needs (EFN) where there is a potential for streamflows to be impacted. At this juncture, it has not been disclosed what rate of groundwater extraction would be considered “small volume” and not subject to an EFN evaluation.

Area B

Area B is located on the east side of Sylvester Road near its intersection with Cascade Ridge Drive (Fig. 2). There are a cluster of about 10 wells at this location servicing a small residential development. These withdraw water from the eastern portion of the MVA, as indicated by Well Nos. 95926 and 92386 on Fig. 4. They are completed at depths of about 40m, and static water levels are at about 30 m-bgl. Several well logs note a silty sand layer at the bottom of the borehole, but no instances of bedrock. A production well drilled in this area may have limited available drawdown, owing to the low static elevation. A well located closer to Sylvester wall (away from the valley wall) may encounter permeable sediments at greater depth.

A 45m deep well in Area B would be at low risk of contamination by anthropogenic pollutants or pathogens, owing to the protection afforded by a 10m thick clay horizon. If the well intake is located a minimum of 15m below the invert of Lagace Creek, it would also be considered to be at low risk of containing pathogens sourced from surface water.

Other options: Area C

Area C is located between Durieu Road and Lagace Creek on the Hatzic Prairie floodplain. A well drilled at this location could target the HPA, or the deeper MVA. However, potential drawdown interference with neighbouring shallow wells are a concern. Furthermore, the aquifer's shallow, unconfined nature and the proximity to pathogen sources (e.g., septic fields) render this location less attractive.

A 70m deep well in this area has the potential to be high yielding without negatively impacting neighbouring wells, and produce high quality water that is at low risk of GARP. However, it is not certain how thick and extensive the MVA is at this location. Also, extra precautions would be required during well construction given the high likelihood that it would be artesian (e.g., drilling with mud, installing an adequate surface seal), which, in addition to its depth, would increase cost.

Other Options: TW11-1

Another option to consider is the utilization of test well TW11-1, as it has been demonstrated to be very productive, and produce high quality groundwater. It is also at low risk of GARP, owing to its completion in the MVA.

This well may present a challenge from a distribution perspective, however, there is an east-west oriented road right-of-way that would facilitate connection to Stave Lake and Sylvester roads. Potential impacts to flows in Oru Creek and Seux Brook, and associated effects on fisheries resources, are considered to be negligible, but may require further evaluation in compliance with the *Water Sustainability Act*; which is expected to come into force in the near future.

Preliminary Cost Estimate for Drilling a New Well

An estimate of contractor costs to construct and test a new production well at the above locations are broken out in Table I. A test well diameter of 8" is recommended, as this will accommodate a submersible pump capable of pumping at up to 40 L/s. Following well construction, a 24-hour constant-rate aquifer pumping test is recommended to assess the sustainable yield of the well and potential drawdown interferences at neighboring wells.

Estimated costs to drill and test a new well range from $25,000 to $35,000, as set out in the table below:

	Site A	**Site B**	**Site C**
Target well depth	35 m	45 m	70 m
Estimated Drilling Costs	$15,000	$17,500	$25,000
Estimated Testing Costs	$10,000	$10,000	$10,000
Total	**$25,000**	**$27,500**	**$35,000**

The above costs are based on typical unit rates charged by local contractors. They reflect anticipated well depths at each site, and include some contingency for handling artesian conditions at Site C. They do not include site preparation costs, or consulting services to oversee well construction and testing. Actual costs may vary.

CONCLUSIONS

1. There are two aquifers having the potential to provide additional groundwater to the Hatzic Prairie water supply system: The Hatzic Prairie Aquifer (HPA), and the Miracle Valley Aquifer (MVA) to the north.

   The north portion of the HPA is relatively productive and yields water in compliance with GCDWQ. However, it is more vulnerable to surface sourced contamination, owing to its shallow depth and unconfined nature. Under the new GARP guidelines, it is recommended that wells be located 300m from a source of human enteric viruses, which may be challenging in this rural agricultural setting that relies on sewage effluent disposal to ground.

   The MVA also constitutes a promising groundwater source in terms of quantity and quality, and is less vulnerable to contamination from surface-sourced pollutants and from pathogens, owing to a laterally continuous, confining clay and till unit.

2. Flow and water level monitoring data at the existing School wells indicate that they are underutilized, with an average instantaneous withdrawal rate of 13 L/s over the year. Seasonal variations in water levels are about 3m. Increasing their withdrawal rates, or adding other wells at this property, is not recommended owing to potential to impact neighboring wells which already experience compromised yields at certain times of year.

3. The two preferred areas for drilling of a new production well are at the top of Seux Road (Site A), and near the intersection of Cascade Ridge Drive and Sylvester Road (Site B). Both locations would target the MVA. Both are located high above the floodplain, are considered to be at low risk of contamination by pathogens (GARP) and other surface-sourced pollutants. There is a remote possibility that Site A, which is situated close to Seux Brook, may require an evaluation impacts to fish habitat as part the upcoming *Water Sustainability Act*.

4. Site C on the south side of Durieu Road also offers good potential for yielding sufficient quantities of high quality groundwater from the MVA, but carries the risk of encountering artesian conditions which can be technically challenging and costly. It is also situated on the alluvial fan of Lagace Creek, which is subject to occasional flooding. Commissioning of a test well on Burns Road (TW11-1) should also be considered, but may present challenges with respect to access and possible impacts to downgradient fisheries resources.

5. Final selection of a production well site should consider the locations of proposed new developments, as well as land ownership and access, which were not a part of this assessment. Continuous monitoring of water levels and sampling of water quality near the selected well should also be considered as a preparatory step to well drilling.

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 B.C. No warranty is expressed or implied.

This report is prepared for the sole use of Urban Systems Ltd. and 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 accepts no liability for such unauthorized use.

We trust that this letter provides sufficient information for your present purposes. Please contact the undersigned if you have any questions or comments.

Yours truly,

PITEAU ASSOCIATES ENGINEERING LTD.

Jan 22 2014

Kathy Tixier, P.Eng.
Senior Hydrogeologist

Reviewed by:

David J. Tiplady, P.Eng.
Principal Hydrogeologist

KCT/DJT/slc

Att.

REFERENCES

Armstrong, J.E., 1990. Surficial Geology: Mission, British Columbia. NTS Map Sheet 92G/1; 1:50 000 scale. Geological Survey of Canada, Map 1485-A.

BC Ministry of Environment (2013). A Water Sustainability Act for BC. Legislative Proposal, October. http://engage.gov.bc.ca/watersustainabilityact/files/2013/10/WSA_legislative-proposal_web-doc.pdf (December 4, 2013)

BC Ministry of Environment – Water Stewardship Division (2007). BC Water Resources Atlas, http://www.env.gov.bc.ca/wsd/data_searches/wrbc/index.html (December 4, 2013).

BC Ministry of Health – Health Protection Branch, Population and Public Health Division (2013). Guidance Document for Determining Groundwater at Risk of Containing Pathogens (GARP) including Groundwater Under Direct Influence of Surface Water (GWUDI), Version 2 Draft for Technical Consultation, July, 35pp.

Health Canada, 2012. Guidelines for Canadian Drinking Water Quality. Prepared by the Federal-Provincial-Territorial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment. <http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/2012-sum_guide-res_recom/index-eng.php.> [Accessed December, 2012]

Magwood, S., 2004. Groundwater and surface water management and drinking water issues in the Hatzic Valley. Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Faculty of Graduate Studies, Institute of Resources, Environment and Sustainability Resource Management and Environmental Studies Program, University of British Columbia, April, 98pp.

Mattu, E., and Schreier, G., 2000. An Investigation of High Arsenic Levels in Wells in the Sunshine Coast and Powell River Regions of BC. Report prepared for Coast Garibaldi Community Health Services Society by the Institute for Resources and Environment, University of British Columbia, March, 49pp.

Millard, T., 2013. Hatzic Region Hydrology and Watershed Stability Assessment. Research Geomorphologist with Ministry of Forests, Lands, and Natural Resource Operations, February, 24pp.

Pacific Hydrology Consultants Ltd., 2006. Groundwater Potential Study for Sheltered Cove Improvement District. Prepared for the Fraser Valley Regional District, December 8, 10pp.

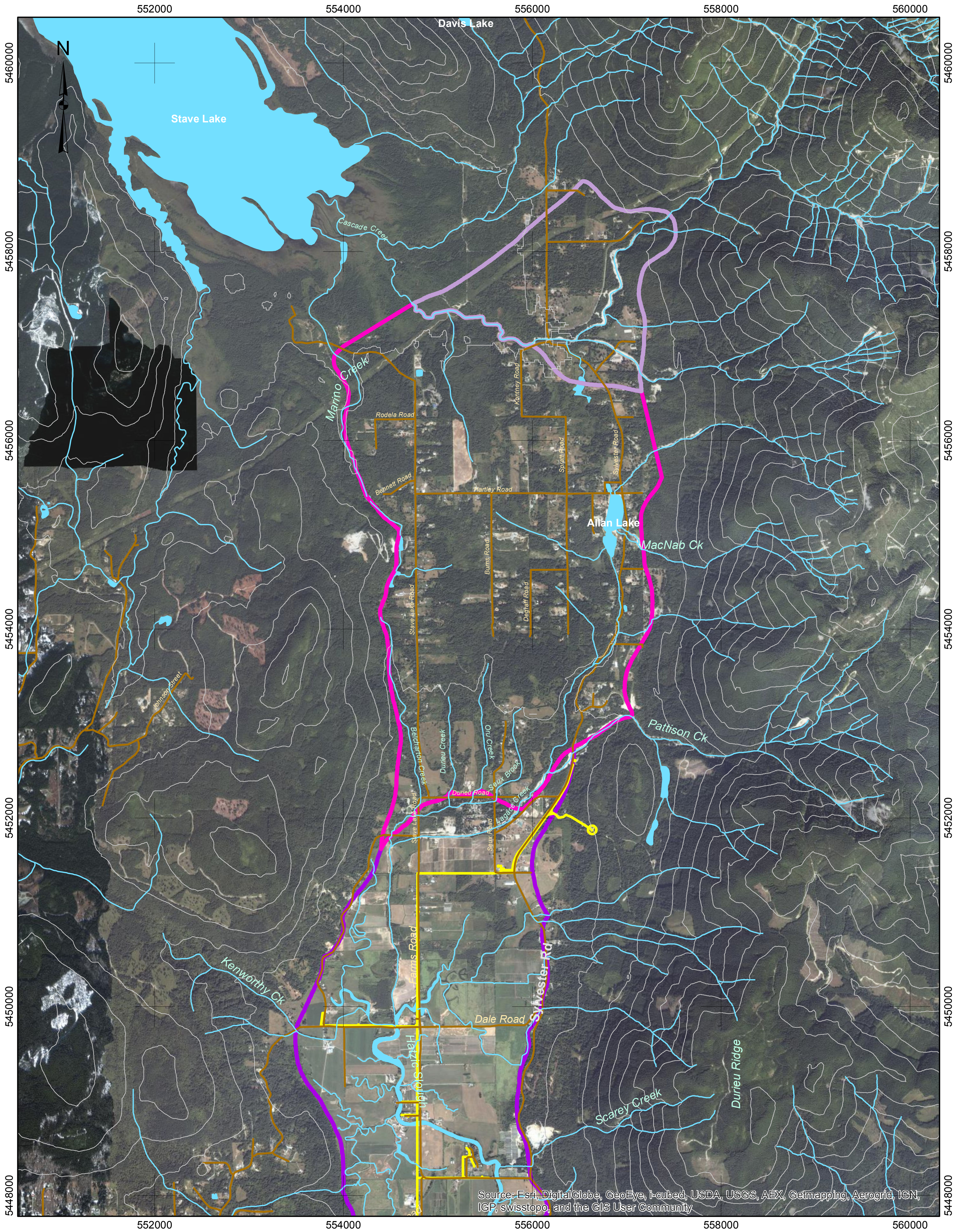
Pacific Hydrology Consultants Ltd., 2007. Evaluation of the Durieu Elementary School Well, at 11565 Seux Road, in Mission. Prepared for the Fraser Valley Regional District, October 30, 15pp.

Pacific Hydrology Consultants Ltd., 2008. Construction and Testing of a new 200mm (8”) Diameter Well at Durieu Elementary School, at 11620 Seux Road, Hatzic. Prepared for the Fraser Valley Regional District, June 5, 24pp.

Roddick, J.A., 1965. Pit Lake Bedrock Geology Map. Geological Survey of Canada 1: 253,440 map no. 1151A.

FIGURES

H:\Project\3232\ArcGIS\Arcmaps\Reports\Fig 1.mxd



Legend

- STREAM
- WATER BODY
- CONTOUR (100m)
- HATZIC PRAIRIE WATER DISTRIBUTION SYSTEM
- ROAD
- NORTH HATZIC PRAIRIE AQUIFER
- MIRACLE VALLEY AQUIFER
- HATZIC PRAIRIE AQUIFER

0 400 800 1200 1600 m

SCALE: 1:40,000

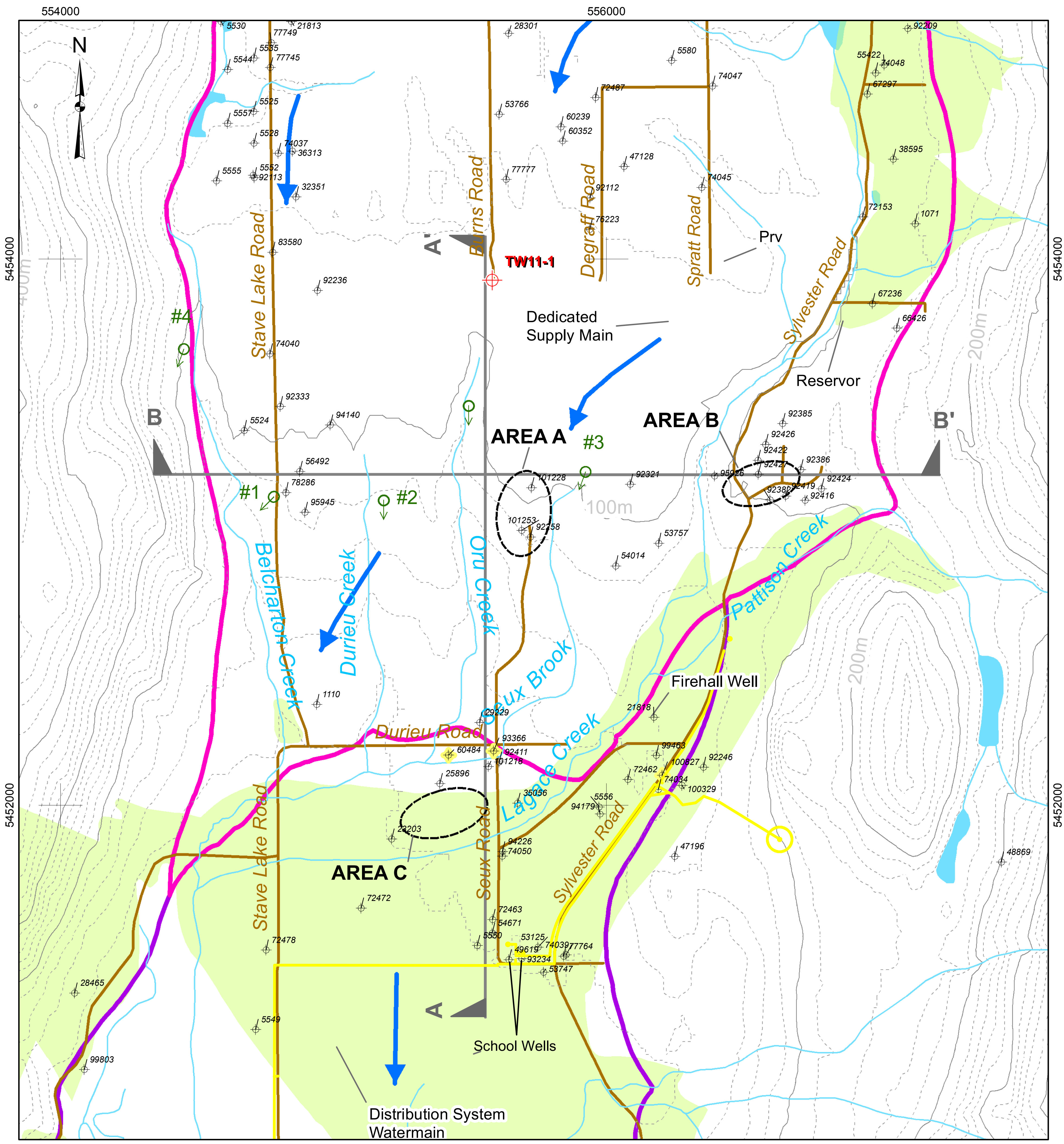
URBAN SYSTEMS LTD.
GROUNDWATER SUPPLY ASSESSMENT,
HATZIC PRAIRE WATER SYSTEM, MISSION, B.C.

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

AREA PLAN

BY:	DATE:
MLS/lf	DEC 13
APPROVED:	FIG:
KT	1

H:\Project\3232\ArcGIS\Arcmaps\Reports\Fig 2.mxd



Legend

- SPRING (APPROXIMATE LOCATION)
- TEST WELL (PITEAU 2012)
- REGISTERED WELL
- REGISTERED WELL (ARTESIAN)
- INFERRED DIRECTION OF GROUNDWATER FLOW
- PROPOSED LOCATION FOR NEW PRODUCTION WELL
- STREAM
- HATZIC PRAIRIE WATER DISTRIBUTION SYSTEM
- CROSS SECTION
- CONTOUR (100m)
- CONTOUR (20m)
- ROAD
- MIRACLE VALLEY AQUIFER
- HATZIC PRAIRIE AQUIFER
- ALLUVIAL FAN
- WATER BODY

0 250 500 750 1000 m

SCALE: 1:15,000

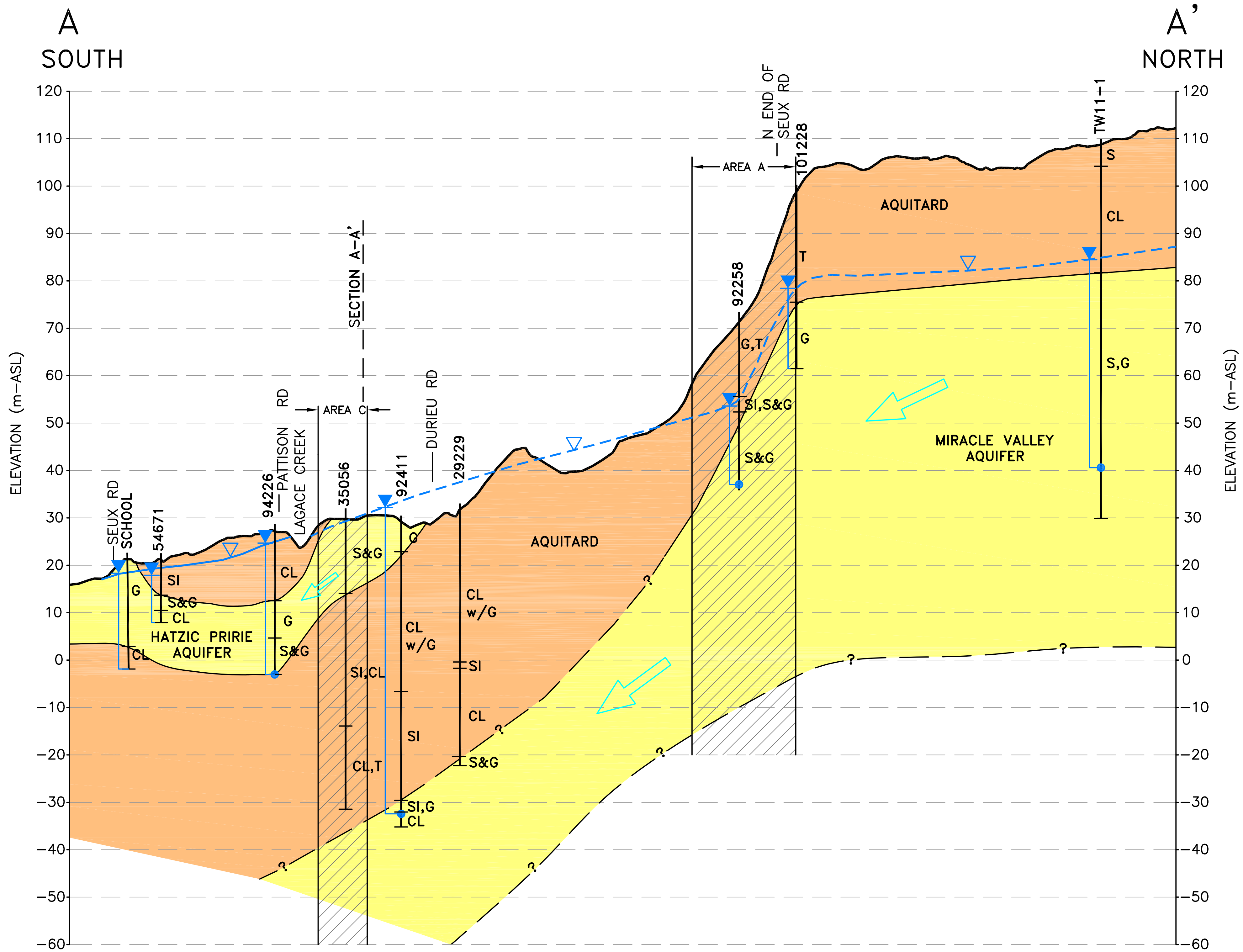
URBAN SYSTEMS LTD.
GROUNDWATER SUPPLY ASSESSMENT,
HATZIC PRAIRE WATER SYSTEM, MISSION, B.C.

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

STUDY AREA HYDROGEOLOGY AND PROPOSED WELL LOCATIONS

BY:	DATE:
MLS/lf	DEC 13
APPROVED: KT	FIG: 2

DWG. NUMBER: K:\3232\Cadd\3232-001.dwg (Fig 3)



SECTION A–A'

LEGEND

DRILLED WELL SHOWING WATER ELEVATION AND BCMOE WELL TAG NO. SCREENED INTERVAL

WATER TABLE ELEVATION

PIEZOMETRIC ELEVATION

GEOLOGICAL BOUNDARY

INFERRED DIRECTION OF GROUNDWATER FLOW PARALLEL TO SECTION

INFERRED DIRECTION OF GROUNDWATER FLOW OUT OF SECTION TO SOUTH

SPRINGS

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

AQUIFER

AQUITARD

0 100 200 300 400 500m

HORIZONTAL SCALE 1:12500

VERTICAL EXAGGERATION 12.5x

NOTE:

SEE LOCATION OF SECTION ON FIG.2

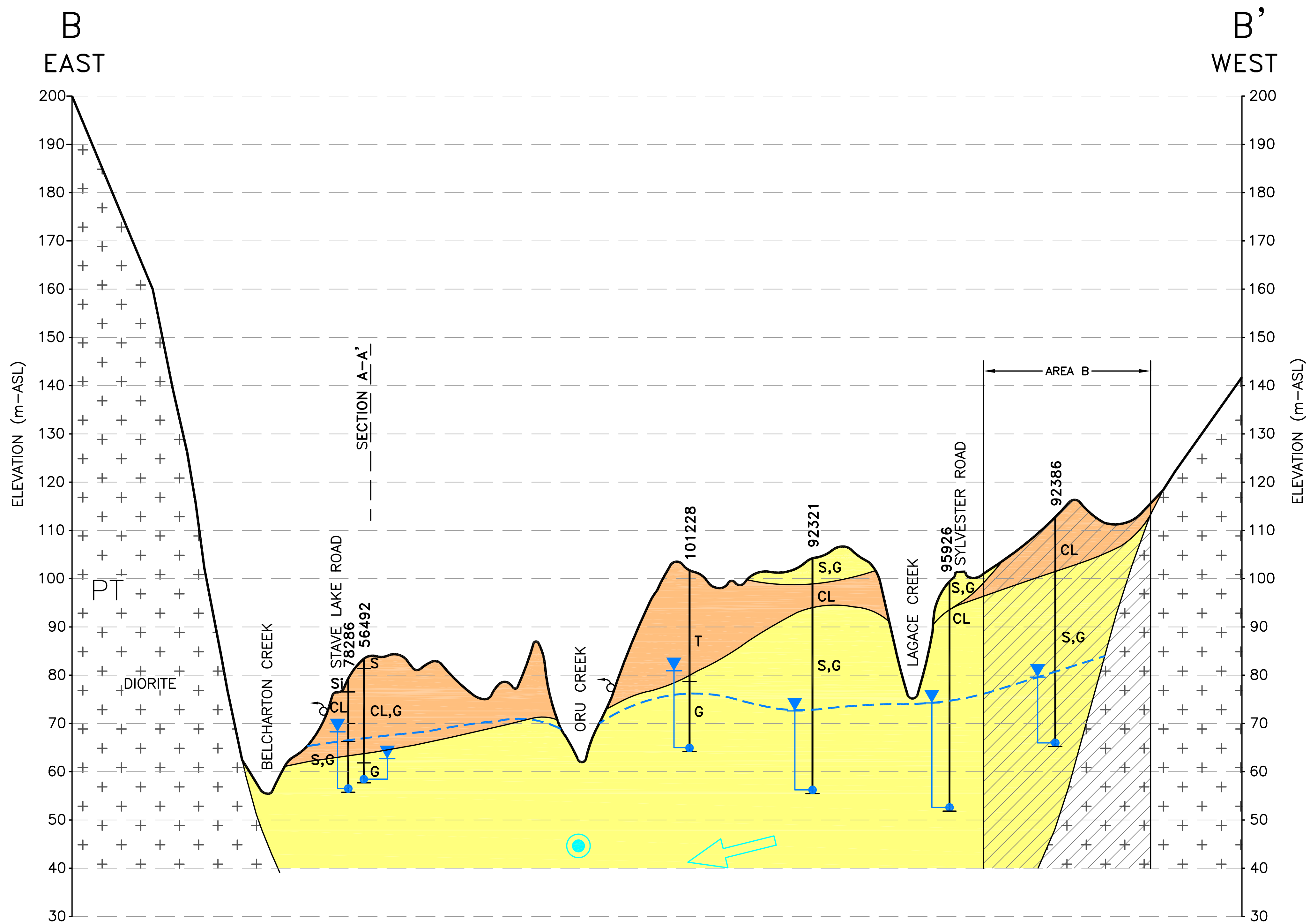
URBAN SYSTEM LTD.
GROUNDWATER SUPPLY ASSESSMENT
HATZIC PRAIRIE WATER SYSTEM
MISSION, B.C.

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

HYDROGEOLOGICAL SECTION A-A'

BY:	DATE:
KT/sl	DEC 13
APPROVED: KT	FIG: 3

DWG. NUMBER: K:\3232\Cadd\3232-001.dwg (Fig 4)



SECTION B–B'

LEGEND

DRILLED WELL SHOWING WATER ELEVATION AND BCMOE WELL TAG NO.

PIEZOMETRIC ELEVATION

GEOLOGICAL BOUNDARY

INFERRED DIRECTION OF GROUNDWATER FLOW PARALLEL TO SECTION

INFERRED DIRECTION OF GROUNDWATER FLOW OUT OF SECTION TO SOUTH

SPRINGS

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

AQUIFER

AQUITARD

0 100 200 300 400 500m

HORIZONTAL SCALE 1:12500

VERTICAL EXAGGERATION 12.5x

NOTE:

SEE LOCATION OF SECTION ON FIG.2

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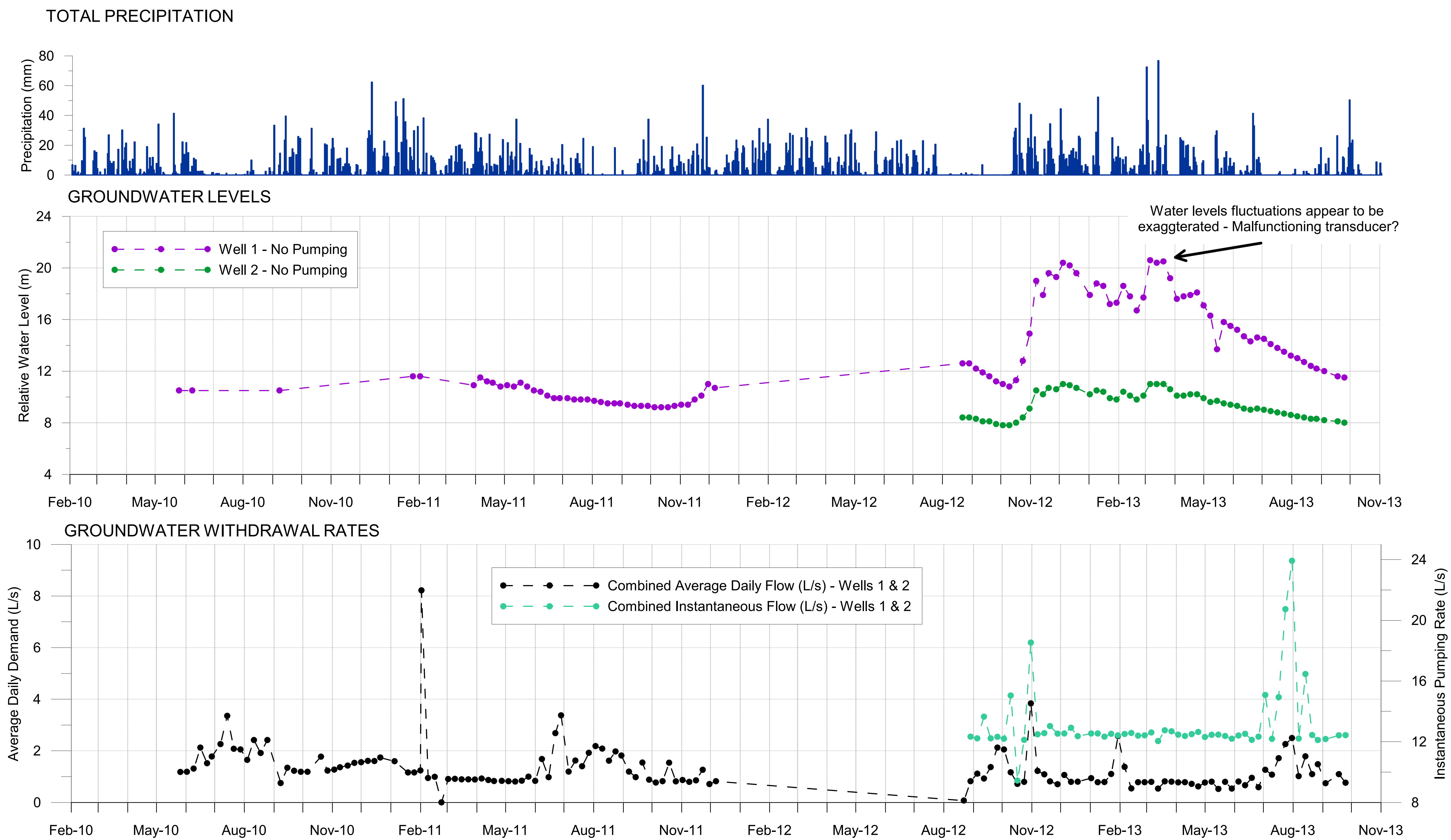
HYDROGEOLOGICAL SECTION B-B'

BY:	DATE:
KT/sl	DEC 13
APPROVED: KT	FIG: 4



URBAN SYSTEMS LTD.
GROUNDWATER SUPPLY ASSESSMENT
HATZIC PRAIRIE WATER SYSTEM, MISSION, B.C.

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GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

PRECIPITATION, GROUNDWATER WITHDRAWL AND GROUNDWATER LEVEL TRENDS

BY:	DATE:
BD/KT	DEC 13
APPROVED:	FIG:
KT	5