Drilling, Installation and Development of Provincial Observation Wells 514 and 515

Falkland, British Columbia

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BRITISH COLUMBIA

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EXECUTIVE SUMMARY

The Provincial Groundwater Observation Well Network (PGOWN) monitors water levels and water quality in aquifers across B.C. to support effective and sustainable water management and to protect valuable groundwater resources.

Observation Well (OW) 514 is a shallow well completed in Provincial Aquifer 97 - Salmon River Upper, and OW 515 is a deep well completed in Aquifer 98 - Salmon River Lower. These wells are located near Water Survey of Canada (WSC) stream hydrograph station 08LE020 – Salmon River at Falkland. OW 514 and 515 will provide long-term groundwater level monitoring in a location of regular water scarcity concerns and improve understanding of the groundwater-surface water interactions in this area.

OW 514 was installed at a depth of 11.9 metres below ground surface (mbgs). The static water level in OW 514 at the time of installation was 3.05 mbgs. OW 515 was installed at a depth of 35.7 mbgs. The static water level in OW 515 at the time of installation was 2.28 mbgs. Hourly water level monitoring data has been collected since May 4, 2023, and is publicly available through the British Columbia Groundwater Level Data Interactive Map (Province of British Columbia, 2024).

The drilling and installation of these wells provides lithology and water level data that can be used to support; groundwater licensing and management decisions, protection and sustainability of the resource, and inform flood and drought emergency response in the area. These wells satisfy recommendations from Water Science Series Report (WSS2021-03) to include PGOWN locations paired with a hydrometric station to improve understanding of groundwater-surface water interactions and support Environmental Flow Needs (EFN) assessments. This report states that in order to facilitate aquifer - stream system characterization as well as future hydraulic connectivity research, new observation wells should be located near pre-existing hydrometric stations, and new hydrometric stations should be located near pre-existing observation wells. The Falkland observation wells also allow assessment of municipal pumping wells influence on river flow and groundwater levels.

Groundwater level and chemistry data from OW 514 and OW 515 will provide important baseline and ongoing level information that may inform future research on groundwater/surface water interactions in the area.

CONTENTS

1. INTRODUCTION

The purpose of this report is to summarize the hydrogeology, drilling, and testing activities related to the construction of two new groundwater observation wells in the Salmon River valley in Falkland, BC. The community of Falkland is located on Highway 97 approximately 75 km southeast of Kamloops, BC and 45 km northwest of Vernon, BC. Falkland is located in the Salmon River Valley on the north side of the Salmon River at its confluence with Bolean Creek.

One shallow well was completed in Aquifer 97, named the Salmon River Upper Aquifer, and one deep well was completed in Aquifer 98, named the Salmon River Lower Aquifer, located approximately 275 m to the northwest of a Water Survey of Canada (WSC) hydrometric station number 08LE020 Salmon River at Falkland. The observation wells have been incorporated into the Provincial Groundwater Observation Well Network (PGOWN) as Wells 514 – shallow (WTN 128015) and 515 – deep (WTN 128014). The site location is illustrated in Figure 1.

The purpose of these observation wells is to improve our understanding of the groundwater conditions within the Salmon River area and establish long-term groundwater monitoring locations. The Upper and Lower Salmon River aquifers run in a predominantly east-west trending valley from Westwold to Salmon Arm, BC (Figures 2 and 3).

The option to install 2 wells (one shallow and one deep) was selected because:

- shallow and deep monitoring points allow for better assessment groundwater/surface water interactions, influence of municipal pumping wells on river flow and groundwater levels, and hydraulic connection between the unconfined Salmon River Upper Aquifer 97 and the semi-confined Salmon River Lower Aquifer 98,
- it ensures there is a proper seal between the hydrostratigraphic units,
- there is potential for the option to fit more monitoring tools/sampling equipment downhole in the bigger 6”observation wells vs 2” PVC piezometers, and
- there is better long-term durability of steel wells vs PVC.

The shallow and deep monitoring points near a WSC hydrometric station will improve understanding of groundwater-surface water interactions, allow for better drought decision making, help inform EFN assessments, and allow for review of influence of municipal pumping wells on river flow and groundwater levels.

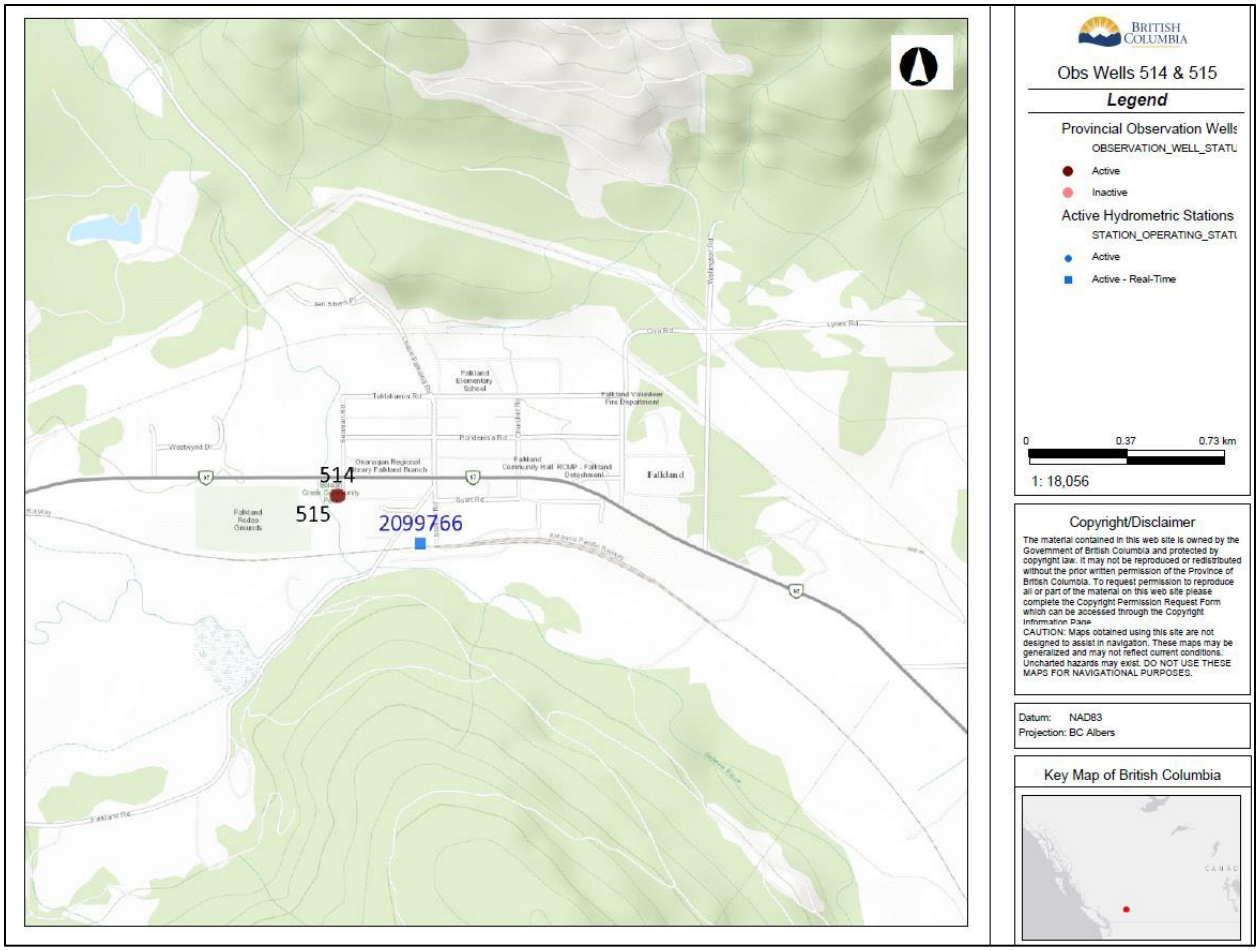

Figure 1 OW 514 (shallow) and OW 515 (deep) and WSC hydrometric station locations

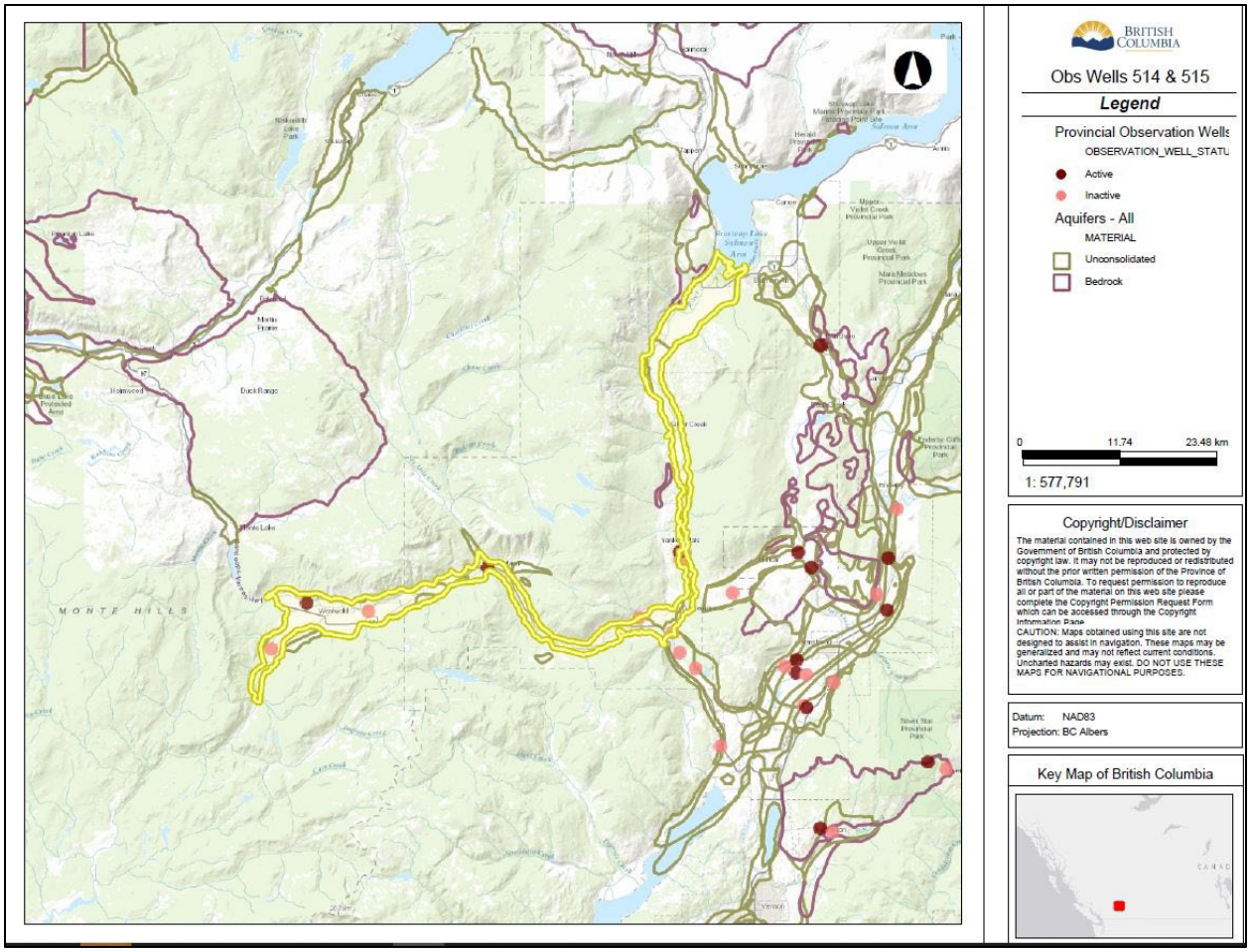

Figure 2 Aquifer 98 - Salmon River Lower (semi-confined)

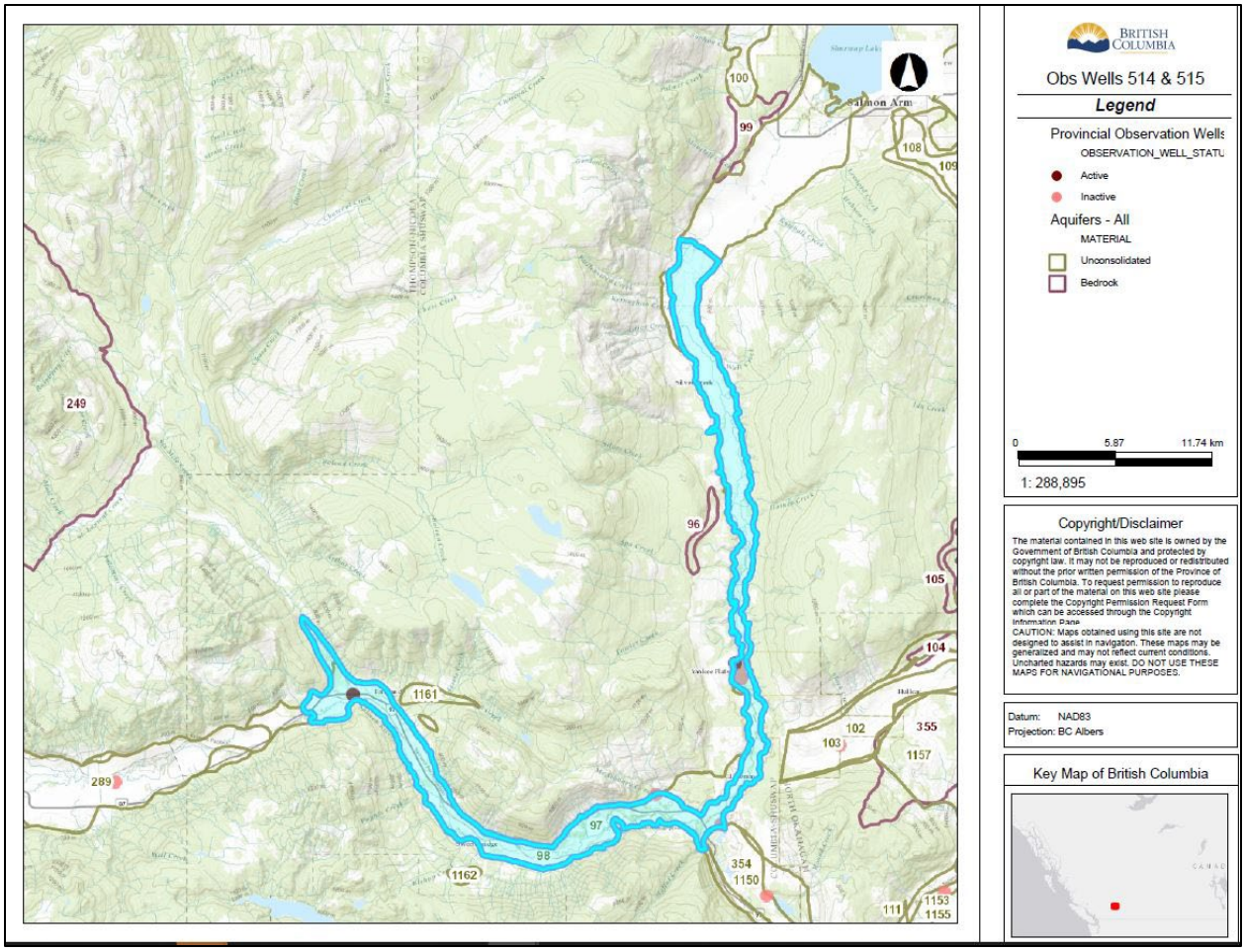

Figure 3 Aquifer 97 - Salmon River upper (unconfined)

2. BACKGROUND INFORMATION

2.1 Provincial Groundwater Observation Well Network

The Provincial Groundwater Observation Well Network (PGOWN) was established in 1961 and consisted initially of a number of unused dug and drilled wells in the Lower Fraser and the Okanagan Valleys. Currently, there are 204 drilled, active observation wells in the network covering major groundwater areas of the province, including the well that is the subject of this report.

The PGOWN serves several purposes including increasing the understanding of local and regional hydrogeological processes and characteristics and supporting effective use of the groundwater resource by collecting groundwater level data. Observation wells monitor water level fluctuations on an on-going basis. The benefits of this network include a better understanding of local and regional hydrogeological processes and characteristics including increasing the understanding of aquifer recharge characteristics, monitoring groundwater development and impacts on groundwater availability. The groundwater data collected through the Provincial Observation Well Network supports and promotes effective management, protection and sustainability of our groundwater resource and associated ecosystems.

BC Ministry of Environment and Climate Change Strategy (ENV) and Ministry of Water, Land And Resource Stewardship (WLRS) staff collect groundwater samples from many of the observation wells for submission for laboratory analyses of a suite of inorganic chemical parameters. Additional analyses for select parameters may be completed based on regional or local groundwater quality concerns. Criteria for the sampling frequency of observation wells are based on the degree of aquifer development, aquifer type and water quality trends and the amount of historical water quality data is available from the area.

There is an existing Observation Well 45 located to the west of OW 514 & OW 515 in Westwold Aquifer 289 installed in 1965. And Observation Well 185 is located to the east along the Salmon River Road and is completed in Aquifer 97 installed in 1974.

3. HYDROGEOLOGICAL SETTING

3.1 Climate, Surface Water and Topographic Setting

The Salmon River Basin climate is characterized by a warm and dry summer, a fairly long growing season, and a cool winter. The watershed lies in the rain shadow created on the leeward side of the Coast and Cascade Mountains. The Salmon River Valley normally experiences four winter months with a daily average temperature below 0^{o}C and five summer months with a daily average temperature above 10^{o}C. Mean annual precipitation in the valley is around 390 mm with approximately 25% of the precipitation coming as snow. Most stream flow in the Salmon River Basin originates from depletion of the winter snowpack at high elevations with high runoff in May and June, a rapid recession during July and baseflow for the remainder of the year.

The Salmon River watershed covers approximately 1,515 km^2. It is located within the Fraser River Basin and drains into Shuswap Lake at Salmon Arm. headwaters originate in the Bouleau Mountains south of Westwold and flow eastward to Shuswap Lake which drains into the South Thompson River.

The width of the main valley in the Westwold area is approximately 2 miles. The valley fill deposits are predominantly sand and gravel up to approximately 50 ft thick, commonly commencing at ground surface or beneath 10 to 30 ft of silt or clay deposits (Dept of Env., 1976).

A study conducted by the Department of Environment in 1976 completed an analytical assessment of flows in the Salmon River and indicated that it is possible to show a definite relation occurs between river flow and groundwater storage. These differences in stream flow for two stream gauging sites above and below Westwold show that 14 – 17 cubic ft/second (cfs) (34,252 – 41,591 m^3/day) of the river flow can be accounted for as coming from groundwater storage (Dept of Env, 1976).

The Salmon River watershed is home to 16 species of fish including 5 salmonid and 11 non-salmonid. It is part of the traditional territory of the Secwépemc nation and Okanagan Nation. Fishing for rainbow trout, coho salmon, chinook salmon, and mountain whitefish is an important part of the First Nation Culture (Associated, 2016). The Salmon River also provides important sources of raw water for domestic use, irrigation, and livestock watering. Recreation and aesthetics also represent important uses of the aquatic environment.

3.2 Geology

The unconsolidated overburden sediments in the western portion of Falkland are identified as Quaternary Post-Fraser Glaciation, non-glacial fan deposits, bog deposits and landslide deposits (Fulton

1975). The overburden sediments in the central and eastern portion of Falkland are identified as both Quaternary Fraser Glaciation, Kamloops Drift terrace deposits and Post-Fraser Glaciation non-glacial fan deposits (Fulton 1975). In the vicinity of OW 514 and OW 515 the unconsolidated sediments are stream terrace deposits of gravel, sandy gravel and sand deposited in a fluvial environment and fan deposits of poorly sorted gravel, sand, silt and clay.

The overburden deposits in all areas of Falkland, with the exception of the north-eastern portion, are underlain by Upper Triassic sedimentary rocks of the Nicola Group, consisting of shale, argillite, siltstone, sandstone, phyllite, tuff, local polymict conglomerate, limestone, greenstone and chloritic phyllite (Schiarizza and Church, 1996). In the north-eastern portion of Falkland the overburden deposits are underlain by Upper Triassic to Lower Jurassic volcanic rocks of the Nicola Group, consisting of intermediate and mafic plagioclase and augit-plagioclase-phyric flows, sills, tuffs and breccias; volcanic conglomerate, sandstone and mudstone (Schiarizza and Church, 1996).

3.3 Aquifer Information

The Salmon River valley currently has five mapped aquifers, including:

- Aquifer 97 – Upper Salmon River Unconfined
- Aquifer 98 – Lower Salmon River Confined
- Aquifer 289 – Westwold
- Aquifer 1161 – Falkland perched
- Aquifer 1162 -Cedar Hill perched

Observation Well 514 is completed in unconfined Aquifer 97. Observation Well 515 is completed in semi-confined Aquifer 98.

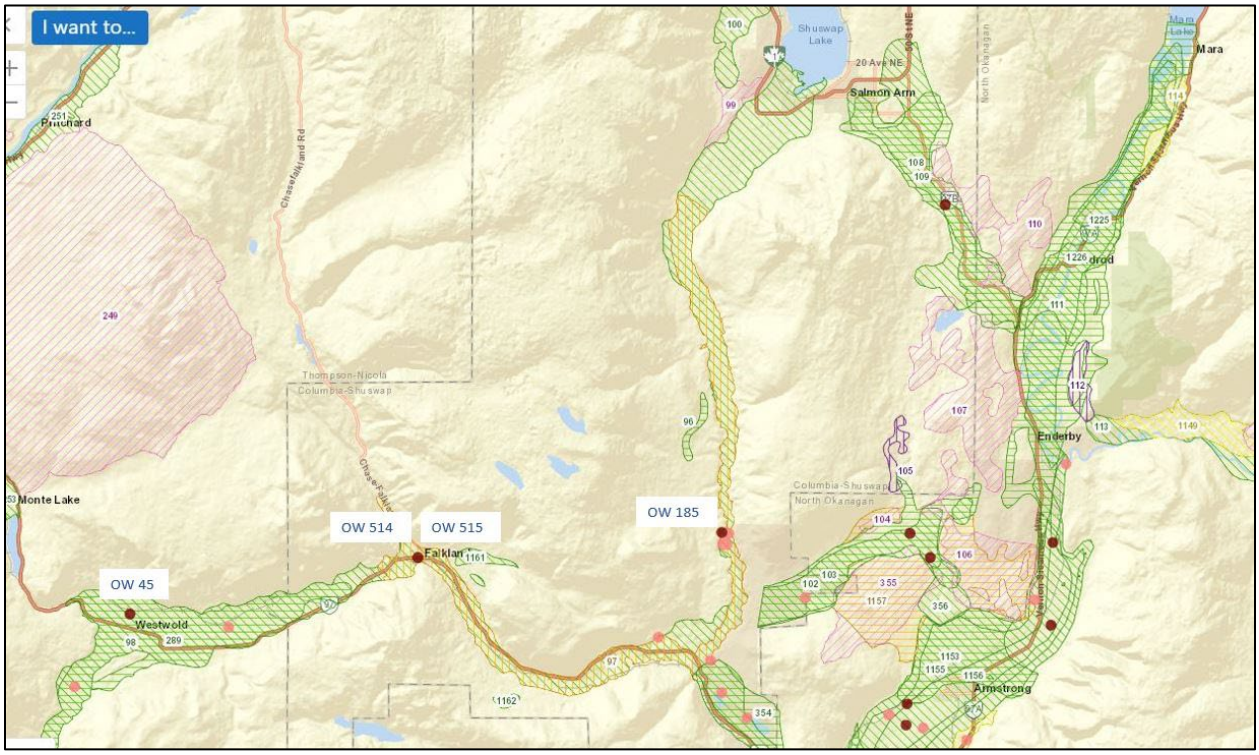

Figure 4 Aquifers and Observation Wells in the Salmon River Valley

Aquifer 97 – Upper Salmon River - Unconfined

The Salmon River upper aquifer is an unconfined sand and gravel aquifer. The aquifer material is a combination of fluvial sand and gravel lain down by the Salmon River in its valley, and alluvial fan material from Bolean Creek. It may also include glacially reworked upper portions of the Bessette sediments, ice contact deposits, glacial outwash or modern alluvium (Province of BC, 2017a).

Aquifer 97 is unconfined to partially confined along margins. It is bounded to the north by the southern arm of Shuswap lake and the western extent is just west of Falkland. The depth to water is generally shallow with reported depth to water in dug wells of 2 mbgs and average depth in drilled wells of 7.5 mbgs. The direction of groudnwater flow is assumed to be topographically driven and thus is predominantly across the valley towards the Lower Salmon River, and laterally along the axis of the valley in the direction of streamflow (northward).

Aquifer 98 – Lower Salmon River - Confined

The deep aquifer in the valley, Aquifer 98, is a semi-confined, glacio-fluvial sand and gravel aquifer. It is separated from overlying Aquifer 97 by discontinuous layer of green-grey to blue clay, and silty sand (Province of BC, 2017b).

The top of Aquifer 98 can be deeper than 100 mbgs in places but on average is about 50 m depth in wells. Overlying materials include confining clay and overlying aquifers (Aquifers 97 and 289). The low permeability confining unit is generally present in wells. However, model projections suggest this unit may thin east of Westwold providing the potential for hydraulic connection between the upper and lower aquifers (Piteau, 2018).

Recharge to Aquifer 98 is predominantly from leakage through the overlying confining unit from Aquifer 97 and mountain block recharge from catchments to the east and west of the valley. Groundwater flow is topographically driven and flows from south to north, following the flow direction of the Salmon River (Province of BC, 2017b).

Aquifer 289 – Westwold

Aquifer 289 in the Westwold area is a glacio-fluvial outwash or ice contact sand and gravel aquifer. It is confined along the southern and northern margins of the valley by a clay-rich till unit that is typically 10 to 15 m in thickness, but can exceed 30 m close to the valley walls. Extensive areas of the aquifer around Westwold and along the Salmon River remain unconfined; this exposure may be due to erosion, although there are no significant erosional features visible in current topography. The aquifer remains unconfined to approximately 4 km east of Westwold. Downstream of this point, the confining clay and till layers overlying Aquifer 289 and 97 can be greater than 50 m thick below the base of the valley, and appear continuous as far as Glenemma. The Salmon River flows over significant portions of the aquifer where it is unconfined. In these same areas, well production rates can be anomalously high (>200 USgpm). Thus, there is significant potential for surface water to interact with groundwater, and for shallow wells to draw water from the river and nearby wetlands (Piteau, 2018).

A water budget study conducted for Aquifer 289 in 2012 determined that river loss was the primary source of recharge to the aquifer comprising approximately 70% of the total annual recharge. Natural groundwater outflow into the Salmon River as baseflow was the largest outflow from the aquifer representing approximately 50% to 60% of the total groundwater outflow. The next largest outflow was groundwater pumping at approximately 35% of the total outflow (Bennett, 2012). This study also created a stratigraphic model which illustrated that the confining aquitard separating the shallow aquifer 289 from the deeper aquifer 98 likely pinches out in places connecting the shallow and deep

aquifers. The connection of the two aquifers (289 and 98) supports the application of both aquifers as a single unit in the water budget model (Bennett, 2012).

Aquifers 1161 and 1162

Aquifer 1161 underlies the highlands east of Falkland below Warren Creek and Aquifer 1162 underlies similar highland terrain south of Falkland near Bishop Creek (southwest of Sweetsbridge). These aquifers comprise thin accumulations of basal gravel deposited on the bedrock surface, which were subsequently buried under a significant thickness of till cover. These aquifers are limited in size and recharge but are sufficiently continuous and utilized to warrant definition as aquifers (Piteau, 2018).

4. APPROVALS AND PRELIMINARY SITE INVESTIGATION

4.1 Site Location

The location at Bolean Community Park was selected because it was the closest, publicly owned land with respect to the Salmon River at Falkland WSC hydrometric station (08LE020). The wells were completed in the southeast corner of the park to allow for ease of access for sampling and to avoid impacting recreational use and landscaping requirements in the park. The observation wells are located approximately 275 m to the northwest of the Salmon River at Falkland WSC station, 200 m to the north of the confluence of Bolean Creek with Salmon River, and 90 m to the east of the nearest community of Falkland water supply well located in the Falkland Rodeo Grounds.

The planned depth of completion for Observation Well 514 (shallow) was for a maximum depth of 28 mbgs based on the average reported depth of completion for all wells in Aquifer 97. The planned depth of completion for Observation Well 515 (deep) was for a maximum depth of 50 mbgs based on the average reported depth of completion for all wells in Aquifer 98. Appendix A contains supporting information for these planned depths; including a summary of GWELLs information for well records in the community of Falkland, as well as a couple of cross sections completed by hand with interpretation of hydrostratigraphic confining units.

Figure 5 - Site Map

4.2 Land Approvals

Ryan Nitchie, Team Leader Community Services for the Columbia Shuswap Regional District (CSRD), was contacted on December 6, 2022 to request approval from the CSRD to place the well in Bolean Municipal Park, located at 5793 Hwy 97 at the intersection with Seaman Road (UTM Northing 5597361 Easting 318331). The CSRD granted approval to drill in the park and signed an Agreement for License of Occupation on March 23, 2023.

The homeowners in the immediate vicinity of this proposed well were contacted to ensure they were aware of the project.

4.3 Utility Locates

A BC One Call was placed on March 6, 2023. Alan Clarke (Okanagan Utility Locators) was on site March 16, 2023 and cleared the drill area for all underground utilities including BC Hydro, Fortis, and Telus.

4.4 Land Surveying

On March 21, 2023, Nicole Bird from Browne Johnson Land Surveyors staked the property boundary adjacent to the proposed well location, to confirm the private property boundary and to ensure the well was located within the municipal park boundary. The ground elevation was also surveyed and two stakes placed in the proposed well location.

4.5 Site Safety

A tailgate safety meeting was conducted with all staff and contractors on site prior to initiating work. Appropriate Personal Protective Equipment (PPE) was worn by all people entering the worksite and included a hard hat, steel toe boots, safety glasses, and a high visibility vests. No traffic control measures were required as the project site is located in the parking area of a municipal park.

5. WELL CONSTRUCTION

5.1 Well Drilling

OW 514 and OW 515 were drilled by Dan-Gare Drilling Ltd. Of Armstrong, BC, between March 27-28, 2023, using a 1999 Strike TC800 air rotary drill rig. Logan Flett (WD 08042501) was the qualified well driller on-site. Well drilling, construction and development was monitored by Melissa Wade, P.Geo., Regional Hydrogeologist for BC Ministry of Water, Land and Resource Stewardship.

The deeper observation well was installed first to allow mapping of the sediments, identification of potential confining units, and selection of installation depth for the shallow well. During drilling, subsurface conditions were continuously monitored and documented. Drill cutting samples were collected every 0.5 to 3.0 m or when there was a change in lithology.

OW 515 was drilled to a depth of 35.66 m. An 8-inch borehole was drilled from 0 to 5.18 mbgs for the surface seal, followed by a 6-inch borehole from 5.18 to 35.66 mbgs. Water was first encountered at approximately 3.0 mbgs.

OW 514 was drilled to a depth of 11.88 mbgs. An 8-inch borehole was drilled from 0 to 4.88 mbgs for the surface seal, followed by a 6-inch borehole from 4.88 to 11.88 mbgs. Water was first encountered at approximately 3.96 mbgs.

Figure 6 shows borehole and well construction information. The well driller's construction report for both wells is provided in Appendix B, and a detailed summary of the borehole lithology encountered during drilling is provided in Tables 1 and 2 below.

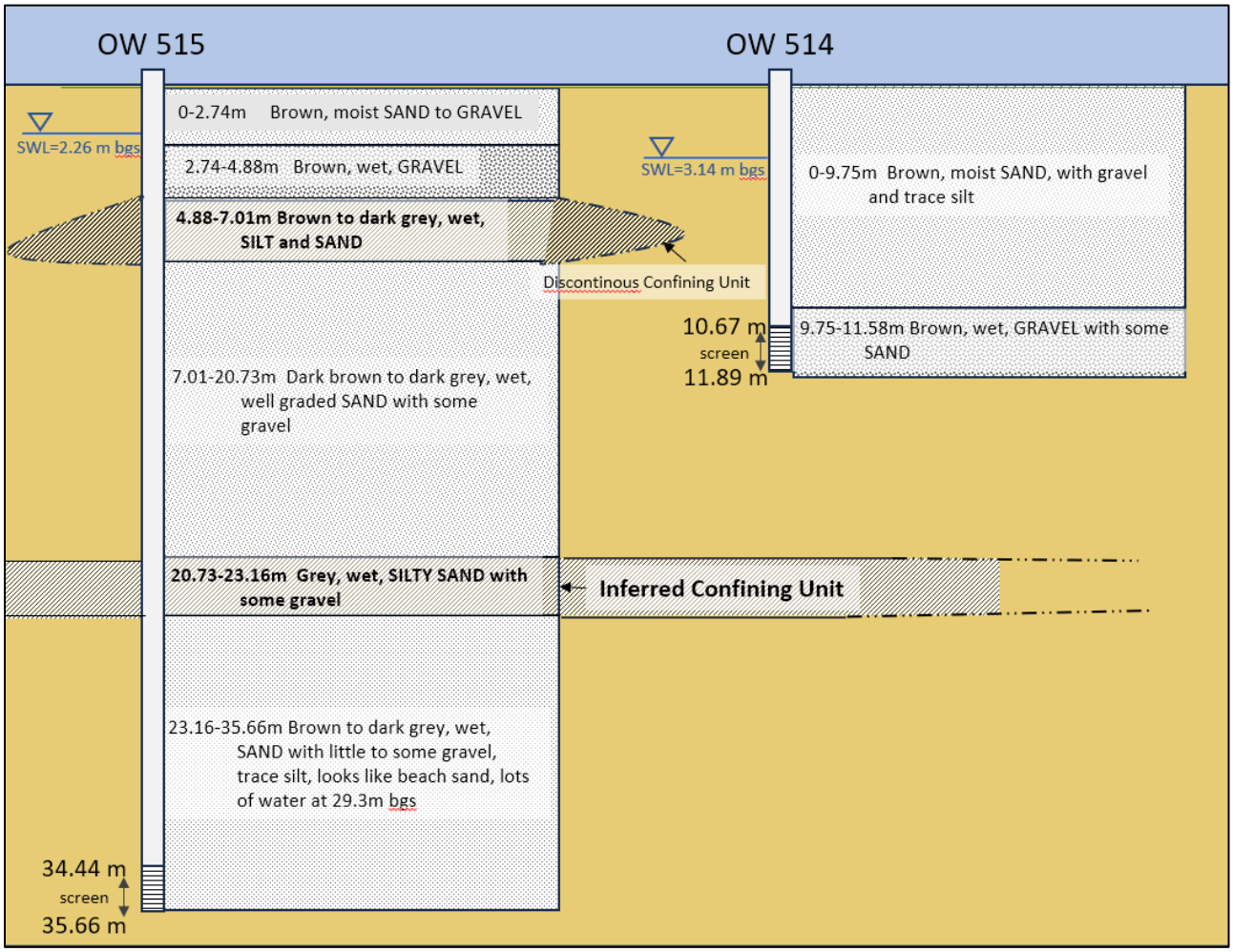

Figure 6 OW 515 and OW 514 Well Completion and Borehole Lithology Schematic

Table 1 – OW 515 Detailed Borehole Lithology

Depth/ Interval (bgs)		Description
meters	feet	
0 – 2.74	0 - 9	Dark brown, moist, well graded fine SAND to coarse GRAVEL (rounded). Red fragments of anthropogenic fill, little silt.
2.75 – 3.05	9 - 10	Dark brown, moist, rounded, coarse GRAVEL, little sand, trace silt
3.05 – 3.96	10 – 13	Dark brown, wet, subrounded-angular, coarse GRAVEL, little sand, race silt. Hit water around 10 ft bgs.
3.96 – 4.88	13 – 16	Dark brown, wet, subrounded-angular, fine GRAVEL, little coarse sand, little silt
4.88 – 5.79	16 - 19	Brown, wet SILT and SAND, few fine gravel (potential confining unit)
5.79 – 7.01	19 - 23	Dark grey, wet, well graded, fine-coarse SAND and SILT, trace gravel (potential confining unit)
7.01 – 10.67	23 - 35	Dark grey, wet, well graded fine-coarse SAND and fine-coarse GRAVEL, subrounded to subangular
10.67 – 13.72	35 - 45	Dark brown, wet, fine-coarse SAND, some fine gravel, little silt
13.72 – 15.24	45 - 50	Dark grey, wet, well graded, fine-coarse SAND and fine to coarse GRAVEL
15.24 – 20.73	50 – 68	Brown coarse SAND and fine GRAVEL, little to some silt, getting dirtier
20.73 – 23.16	68 - 76	Grey, wet, SILTY, med to coarse SAND, with <10% fine gravel, looks like beach sand (potential confining unit)
23.16 – 24.99	76 - 82	Brown, wet, fine to coarse SAND, 25% fine gravel, 5-10% silt
24.99 – 28.96	82 - 95	Grey, fine to med SAND, 5% fine gravel, trace silt, looks like beach sand
28.96 – 31.09	95 - 102	Dark grey-black, fine to coarse SAND and 40% fine GRAVEL, well graded, lots of water
31.09 – 35.66	102 – 117	Dark brown, fine to coarse SAND, 5% fine gravel, trace silt, looks like beach sand

Table 2 – OW 514 Detailed Borehole Lithology

Depth/ Interval (bgs)		Description
meters	feet	
0 – 9.75	0 - 32	Dark brown, moist, well graded med-coarse SAND with 40% fine-coarse, rounded GRAVEL, trace silt
9.75 – 11.58	32 - 38	Dark brown, wet, fine to coarse, rounded GRAVEL with some med-coarse SAND, ~5% silt

5.2 Well Construction

For OW 515, a 6-inch diameter steel casing was installed to 34.59 mbgs. A 1.22 m long, 6-inch diameter, 15-slot, stainless steel screen with rubber seal K-packer was installed from 34.44 to 35.66 ft bgs. Well ID Plate Number 68388 was affixed to the well casing with a steel clamp. A surface seal of 3/8-inch Holeplug (Wyoming Sodium Bentonite) was installed to 5.18 m in the annular space between the 8-inch borehole and the 6-inch casing. The final stick-up for the 6-inch casing was 0.91 m above ground surface. A Solinst Levelogger was installed to monitor water levels.

For OW 514, a 6-inch diameter steel casing was installed to 10.82 mbgs. A 1.22 m long, 6-inch diameter, 15-slot, stainless steel screen with rubber seal K-packer was installed from 10.67 to 11.89 mbgs. Well ID Plate Number 68387 was affixed to the well casing with a steel clamp. A surface seal of 3/8-inch Holeplug (Wyoming Sodium Bentonite) was installed to 4.89 m in the annular space between the 8-inch borehole and the 6-inch casing. The final stick-up for the 6-inch casing was 0.91 ft above ground surface.

5.3 Well Development

OW 515 was developed by airlifiting for 9 minutes at approximately 60 USgpm. Development continued until the water was running clear and discontinued before the discharging water could flood any nearby equipment. The static water level prior to airlifting was 2.13 mbgs. Recovery was measured for 15 minutes until the water level measured 1.98 mbgs.

OW 514 was also developed by airlifiting for 28 minutes at approximately 35 USgpm. Development continued until the water was running clear and discontinued before the discharging water could flood any nearby equipment. The static water level measured at 15 minutes of recovery was 3.69 mbgs. The static water level was not measured prior to airlifting, but at the time of drilling it was around 3.96 mbgs.

No pumping test or water quality samples were collected due to time and budget constraints.

6. WATER LEVEL MONITORING

6.1 OW 514 & 515 Monitoring

Groundwater level data has been collected from OW 514 and 515 since June 2023. The wells are currently set up with manual download Solinst leveloggers with plans to install satellite telemetry in the near future. There is not enough water level data to provide any summary of maximum, minimum or average groundwater level information.

7. SUMMARY AND CONCLUSIONS

OW 514 is completed in Aquifer 97 - Upper Salmon River unconfined, and OW 515 is completed in Aquifer 98 - Lower Salmon River confined. The purpose of these observation wells is to improve our understanding of the groundwater conditions within the Salmon River watershed and establish a long-term groundwater monitoring location in close proximity to a WSC hydrograph station.

The Salmon River watershed is a chronically drought-prone region with many different competing water uses. These wells will help develop a better understanding of surface water and groundwater interactions and provide decision makers with better tools to make water management decisions.

Recommendations for future work include the installation of satellite telemetry instrumentation to allow real-time monitoring of groundwater levels. It is also recommended that water quality samples be collected for analysis and pumping tests be conducted.

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APPENDIX A: FALKLAND GWELLS INFORMATION

GWELLs summary of wells in Falkland area Section:

- In Falkland (60 wells)
    - Wells completed in AQ 97 avg TD = 52.2 ft bgl and avg SWL = 32.5 ft btoc
    - Wells completed in AQ 98 avg TD = 89 ft bgl and avg SWL = 50.1 ft btoc

GWELLS

- Aquifer Mapping report for AQ97
    - Well depth; median = 23.2 m, avg = 28.5 m
    - SWL; median = 6.1 m, avg = 10.8 m
- Aquifer Mapping report for AQ98
    - Well depth; median = 51.8 m, avg = 58.5 m
    - SWL; median = 9.4 m, avg = 8.8 m

Artesian Conditions Notes:

- Aquifer 98 info sheet indicates it is confined glacio-fluvial sand and gravel underneath till, in between till layers, or underlying glacio-lacustrine deposits so potential for artesian conditions could exist.
- Aquifer classification worksheet identifies Aquifer 98:
    - As semi-confined, separated from overlying aquifer by discontinuous layer of green-grey to blue clay, silty sand.
    - Has limited windows through the confining layer, resulting in local hydraulic connection with the overlying unconfined aquifer, modelling suggests locally unconfined east of Westwold
    -
- Depth to water ranges from 1 to 56 mbgs and averages about 10 mbgs
- From North Okanagan Mapping Report:
    - The discontinuous nature of the confining unit renders it difficult to differentiate this aquifer from the overlying unconfined aquifer in some boreholes. This implies that the aquifer could act in an unconfined manner in places, and may be hydraulically connected to surface waters.
    - The average water level in the confined aquifer (7.6 mbgs) is higher than that in the unconfined aquifer (12.6 mbgs) implying the system on average has an upward hydraulic gradient.
- Cross sections made with WALLY analysis tool indicate semi-confined conditions and SWLs are all well below ground surface
- GWELLs online mapping indicates the nearest registered artesian wells are over 5 km upgradient of the site in the town of Westwold.

CSRD Website

- Falkland Waterworks. The Falkland Water System is located on Highway 97 N approximately halfway between Vernon and Kamloops in Electoral Area D. The water system consists of two groundwater wells. Water treatment methods include Iron and Manganese removal filtration,

ammonia removal by chlorination and distribution chlorination. The system has emergency backup power and SCADA (Supervisory Control and Data Acquisition) monitoring system that provides full remote monitoring capabilities. View the Falkland Waterworks Newsletters.

Water supply wells

- WTN 42777, AQ 98, NE corner of rodeo grounds.
  - TD = 103 ft bgl
  - SWL = 14 ft
- WTN 106352, AQ 97, SW corner of rodeo grounds
  - TD = 987 ft bgl
  - SWL = 29 ft
- WTN 104475, AQ 97, W side of rodeo grounds
  - TD = 96 ft bgl
  - SWL = 40 ft

Water Survey of Canada station
Salmon River at Falkland
08LE020

Q = 0.801 m^3/s to 18/27 m^3/s (211 to 4,755/7,132 USgpm)

Distance from proposed obs wells to hydrometric station = 280 m
Distance from proposed obs wells to Salmon River near confluence with Bolean creek = 200 m
Distance from proposed obs wells to community wells = 90 m and 330 m

Well Information pulled from GWELLs (https://apps.nrs.gov.bc.ca/gwells/) in February 2022

WTN	Construction date	diameter	Well Depth_ft	bedrock_depth	SWL_ft	well_yield	aquifer	aquifer_lithology
16897	1961-01-01	36.0	14		11	0.000	97	Unconsolidated
9132	1950-01-01	0.0	37		32	0.000	97	Unconsolidated
9067	1950-01-01	0.0	32		30	0.000	97	Unconsolidated
1822	1936-01-01	0.0	14		12	0.000	97	Unconsolidated
9090	1950-01-01	0.0	20			0.000	97	Unconsolidated
9209	1950-01-01	0.0	21		18	0.000	97	Unconsolidated
3272	1949-01-01	0.0	48			0.000	97	Unconsolidated
17907	1963-01-01	0.0	34		31	0.000	97	Unconsolidated
9121	1950-01-01	0.0	9			0.000	97	Unconsolidated
9140	1950-01-01	0.0	20				97	Unconsolidated
2496	1945-01-01	0.0	42		41	0.000	97	Unconsolidated
30149	1974-04-22	0.0	50		36	12.000	97	Unconsolidated
23648	1970-06-08	4.0	47		29	18.000	97	Unconsolidated
21456	1968-05-04	0.0	40		29	20.000	97	Unconsolidated
22711	1969-08-22	6.0	38		28	15.000	97	Unconsolidated
27064	1972-10-02	0.0	51		36	10.000	97	Unconsolidated
27100	1972-10-11	0.0	70		40	5.000	97	Unconsolidated
28780	1973-09-01	4.0	124			6.000	97	Unconsolidated
25322	1971-09-01	0.0	50		9	40.000	97	Unconsolidated
37660	1977-07-13	6.0	65		48	8	97	Unconsolidated
36843	1977-03-18	4.5	56			10	97	Unconsolidated
34770	1976-05-05	6.0	49		30	10	97	Unconsolidated
36851	1977-03-22	4.5	55		34	8	97	Unconsolidated
38183	1977-09-15	4.5	60		35	5	97	Unconsolidated
38104	1977-09-04	4.5	76		40	10	97	Unconsolidated
36873	1977-03-24	5.5	104		40	80	97	Unconsolidated
36874	1977-03-24	4.5	57		34	8	97	Unconsolidated
38103	1977-09-04	4.5	51		30	8	97	Unconsolidated
25463	1971-09-25	0.0	100		75	4.5	97	Unconsolidated
30158	1974-04-23	0.0	50		35	15	97	Unconsolidated
27183	1972-10-31	6.0	85		39	10	97	Unconsolidated
21458	1968-05-07	0.0	47		32	12	97	Unconsolidated
29490	1974-01-01	8.0	65		20	50	97	Unconsolidated
16486	1960-01-01	0.0	40		38	0	97	Unconsolidated
25245	1971-08-11	0.0	62		30	20	97	Unconsolidated
25254	1971-08-13	0.0	100		61	7	97	Unconsolidated
24945	1971-06-07	6.0	53		43	4	97	Unconsolidated
27082	1972-10-05	6.0	85		35	10	97	Unconsolidated
29489	1974-01-01	6.0	63		40	50	97	Unconsolidated
21328	1968-02-24	0.0	20		12	15	97	Unconsolidated
27188	1972-11-01	0.0	38		20	10	97	Unconsolidated
14572	1955-10-01	6.0	111		51	10	97	Unconsolidated
27104	1972-10-12	6.0	22		12	10	97	Unconsolidated
21392	1968-04-05	0.0	37		27	15	97	Unconsolidated
21326	1968-02-23	0.0	45		32	10	97	Unconsolidated
21071	1967-11-30	0.0	103		54	8	97	Unconsolidated
21433	1968-05-01	0.0	32		21	20	97	Unconsolidated
21451	1968-05-02	0.0	40		29	15	97	Unconsolidated
21459	1968-05-07	0.0	28		18	12	97	Unconsolidated
2755	1947-01-01	0.0	65				98	Unconsolidated
27484	1973-01-01	5.5	48		29	20.000	98	Unconsolidated
24067	1970-10-08	4.0	92		57	0.000	98	Unconsolidated
42308	1979-05-08	4.5	43		18	5.000	98	Unconsolidated
38166	1977-09-12	4.5	51		32	8	98	Unconsolidated
22277	1969-04-01	4.5	103		67	10	98	Unconsolidated
28777	1973-09-01	4.0	100		56	5	98	Unconsolidated
27872	1973-04-01	4.5	77		57	6	98	Unconsolidated
42777	1979-07-01	12.0	103		14	737	98	Unconsolidated
25852	1972-01-01	0.0	40		22	0.000		Unconsolidated
104105	2010-06-08		257	260.00	149	40		Unconsolidated

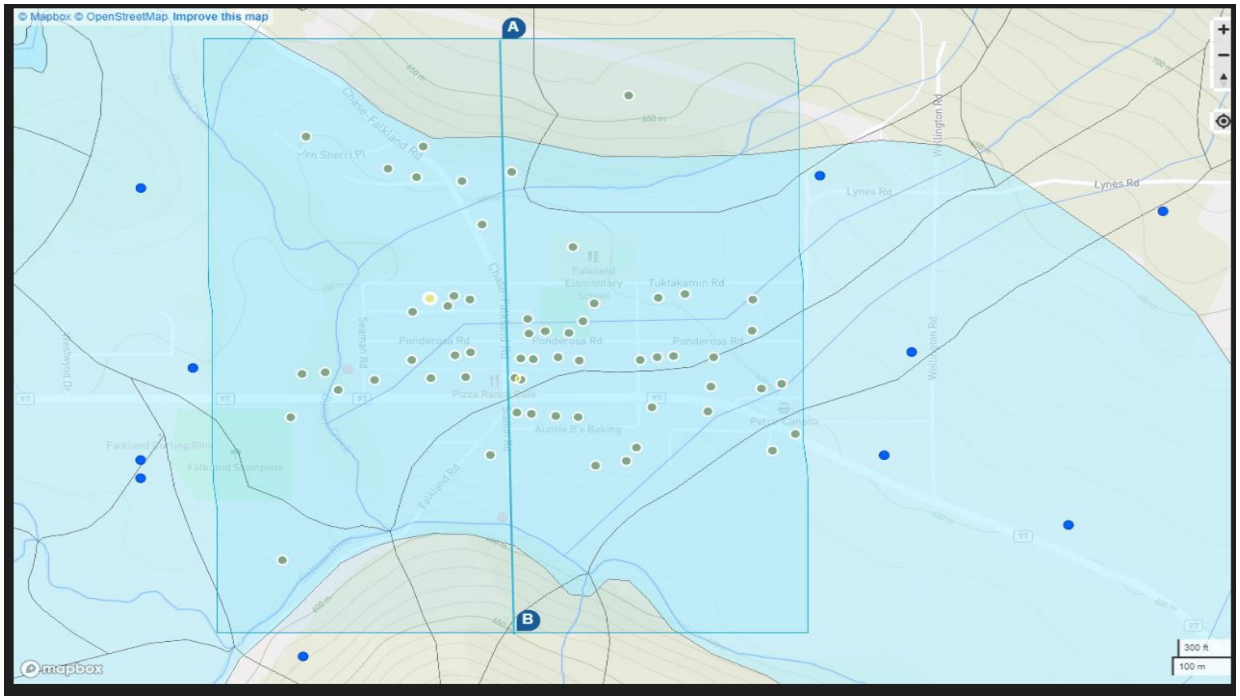
Aquifer 97
avg total depth (ft)
52.2

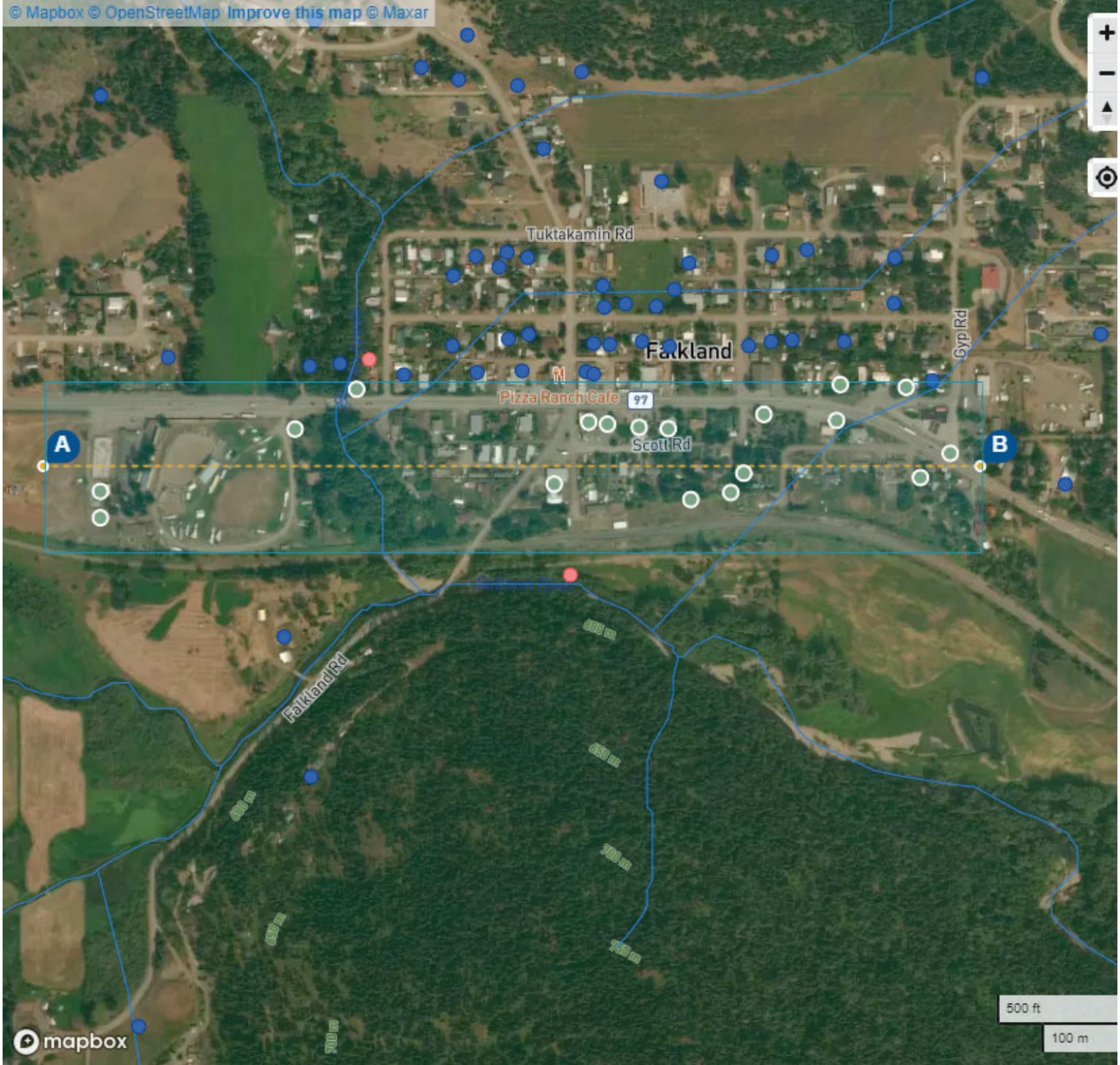
avg SWL (ft)
32.5

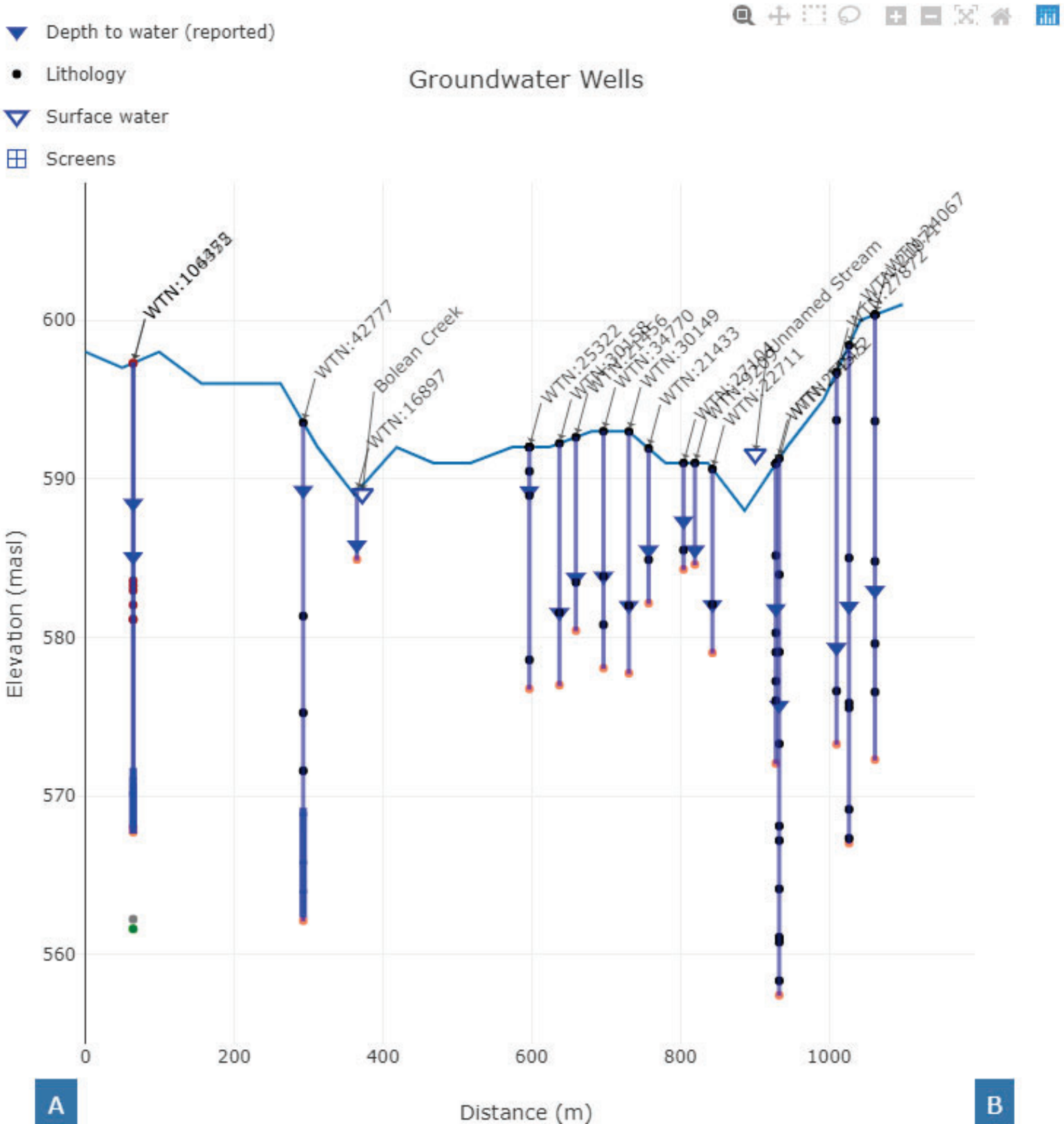
Aquifer 98
avg total depth (ft)
89.0

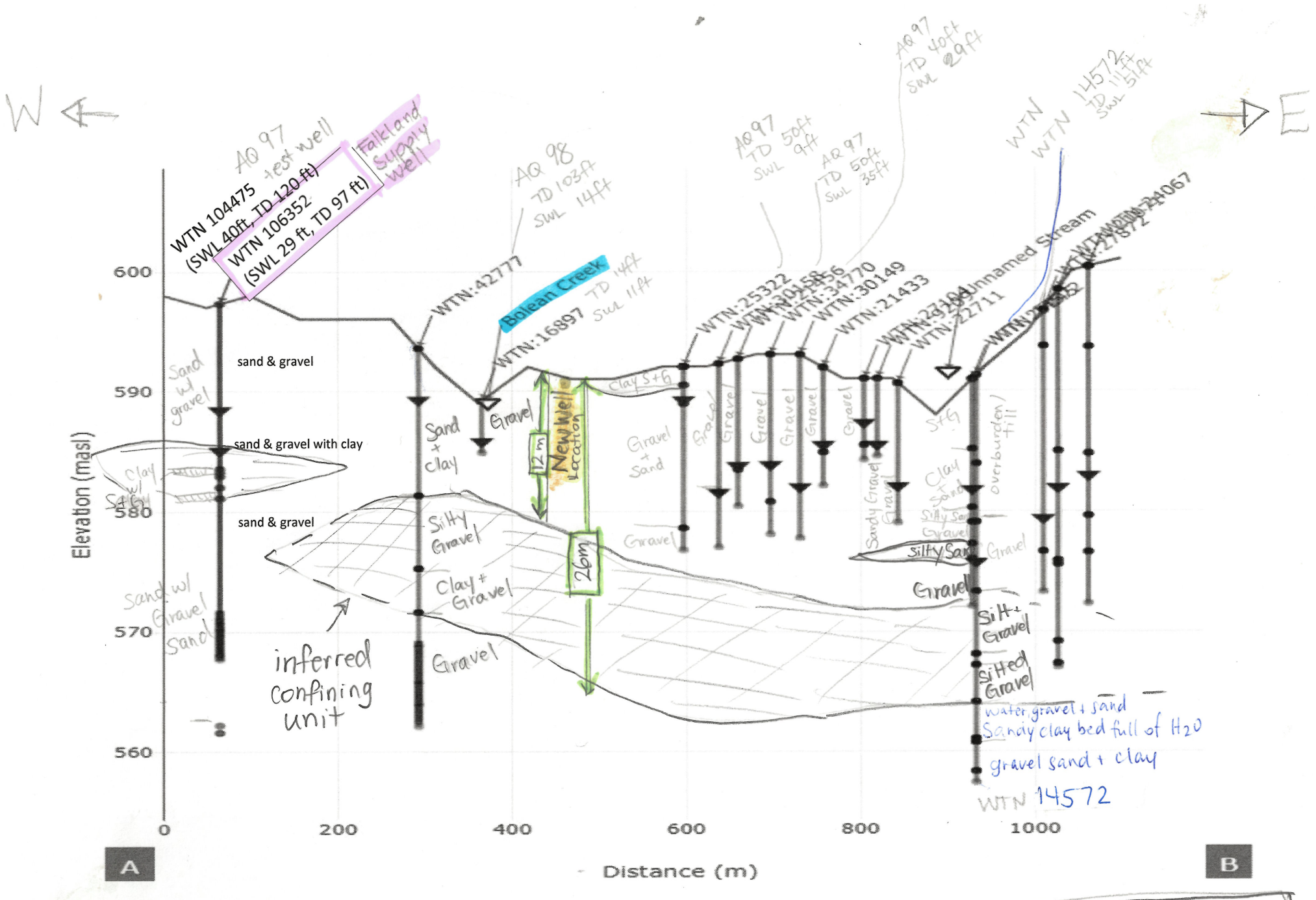
avg SWL (ft)
50.1

Snip of WALLY map showing wells (dots) in Falkland included in aquifer depth averages excel page



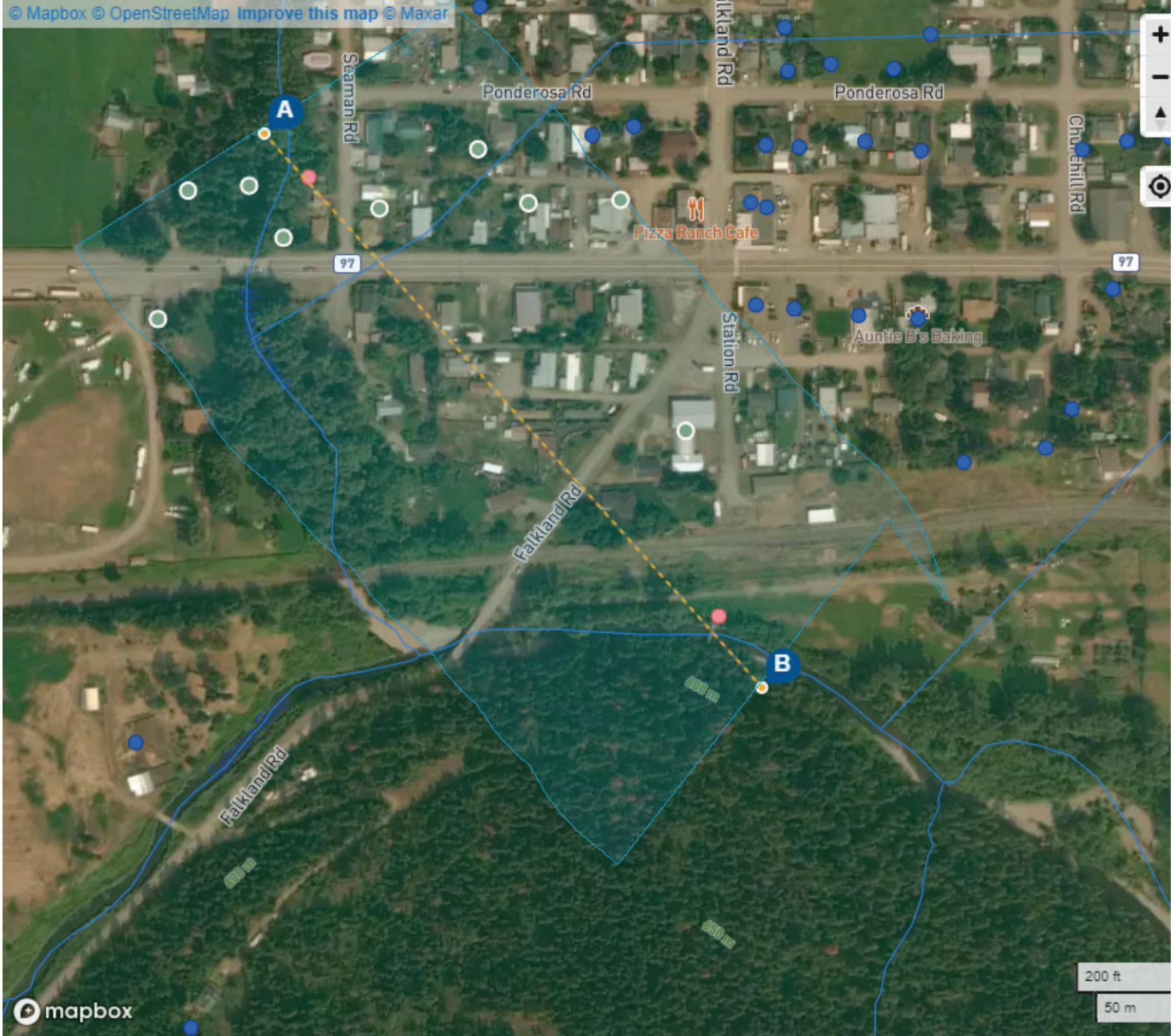

© Mapbox © OpenStreetMap Improve this map © Maxar
Tuktakamin Rd
Falkland
Gyp Rd
Pizza Ranch Cafe
97
Scott Rd
A
B
Salmon River
Falkland Rd
500 ft
100 m
mapbox

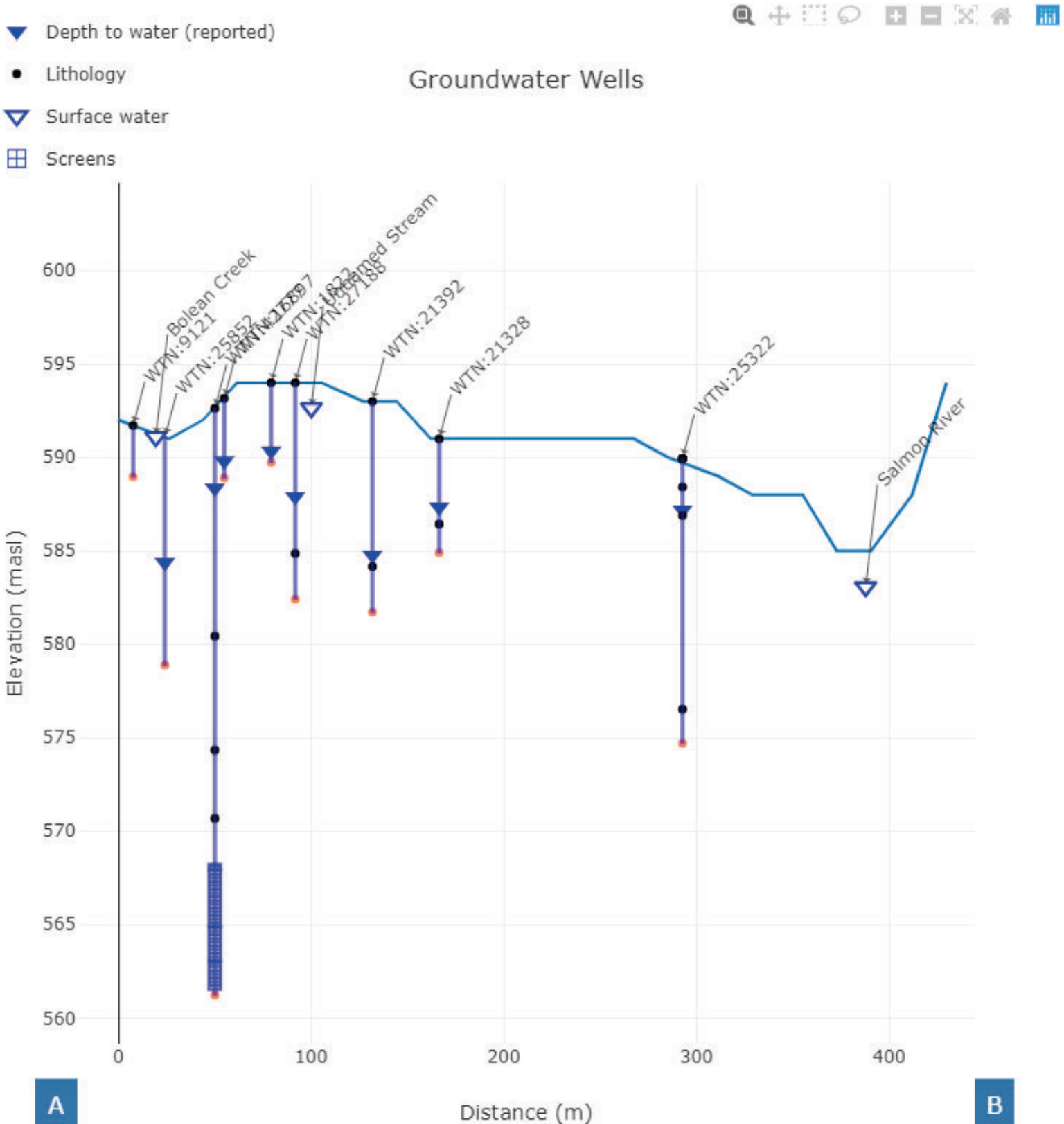

Depth to water (reported)
Lithology
Surface water
Screens
Groundwater Wells
WTN:42777
Bolean Creek
WTN:16897
WTN:25322
WTN:34770
WTN:30149
WTN:21433
WTN:22711
Unnamed Stream
600
590
580
570
560
Elevation (masl)
0
200
400
600
800
1000
Distance (m)
A
B

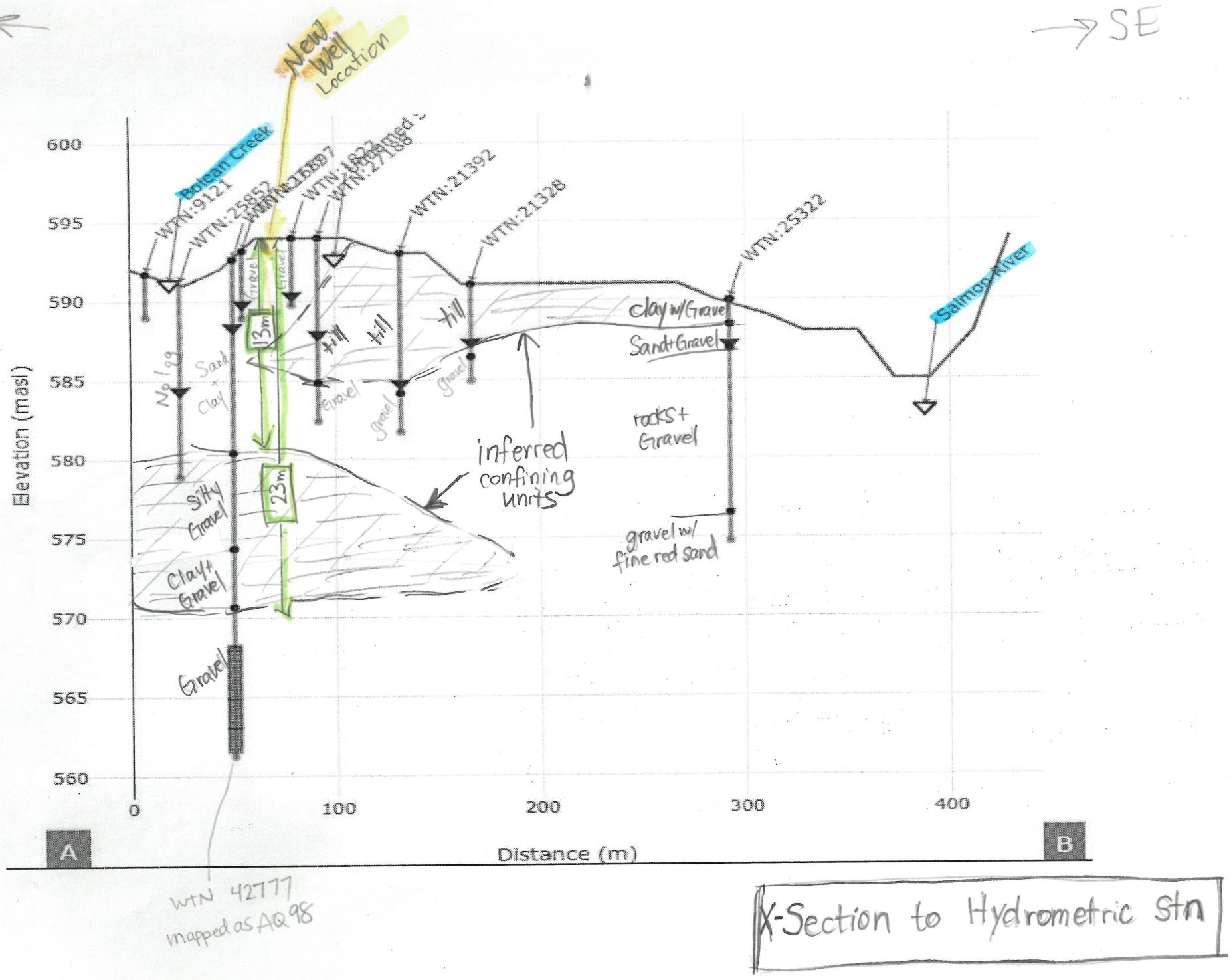


10 m = 2.5 cm
4m = 1 cm
13ft = 1 cm

X-Section Thru Production Wells


© Mapbox © OpenStreetMap Improve this map © Maxar
A
B
Seaman Rd
Ponderosa Rd
Ponderosa Rd
Falkland Rd
Churchill Rd
Pizza Ranch Cafe
97
97
Station Rd
Auntie B's Baking
Falkland Rd
Falkland Rd
200 ft
50 m
mapbox


Depth to water (reported)
Lithology
Surface water
Screens
Groundwater Wells
Bolean Creek
WTN:9121
WTN:25852
WTN:21392
WTN:21328
WTN:25322
Salmon River
Elevation (masl)
600
595
590
585
580
575
570
565
560
0
100
200
300
400
Distance (m)
A
B


NW
SE
New well Location
Bolean Creek
WTN:9121
WTN:25852
WTN:16897
WTN:1822
WTN:27188
WTN:21392
WTN:21328
WTN:25322
Salmon River
Elevation (masl)
600
595
590
585
580
575
570
565
560
0
100
200
300
400
Distance (m)
A
B
13m
23m
Gravel
Sand + Clay
No log
till
till
till
Gravel
Gravel
Gravel
clay w/ Gravel
Sand+Gravel
rocks + Gravel
inferred confining units
Silty Gravel
Clay+ Gravel
Gravel
gravel w/ fine red sand
WTN 42777
mapped as AQ98
X-Section to Hydrometric Stn

APPENDIX B: WELL COMPLETION RECORDS

BRITISH COLUMBIA

☑ Well Construction Report
☐ Well Alteration Report

Dan-Gare Drilling Ltd.
Box 722
Armstrong, B.C. V0E 1B0

Ministry Well ID Plate Number: 68388
Where ID Plate is attached: stick-up
Ministry Well Tag Number: _____

See reverse for notes & definitions of abbreviations.

Well Class: **Class of well** (see note 2): Monitoring **Sub-class of well:** _____

Water supply wells: indicate intended water use: ☐ private domestic ☐ water supply system ☐ irrigation ☐ commercial or industrial ☐ other (specify): _____

Start date of work (YYYY/MM/DD): 2023/03/27 **End date of work** (YYYY/MM/DD): 2023/03/28

Person Responsible for Work (print clearly): **Name (first, last)** (see note 3): Logan Flett

Person who completed the work: Logan **Registration no.** (see note 4): 0804 2501

Consultant (if applicable; name and company): Melissa Wade Ministry of Forests

DECLARATION: Well construction, well alteration or well decommission, as the case may be, has been done in accordance with the requirements in the Water Sustainability Act and the Ground Water Protection Regulation.

Signature of Person Responsible Logan Flett

Owner name: British Columbia - Ministry of Forests

Mailing address: 1259 Dalhousie Dr. Town Kamloops Prov. B.C. Postal Code V2C 5Z5

Well Location (see note 6): Address: Street no. _____ Street name Seaman Rd. Town Falkland

or **Legal description:** Lot _____ Plan _____ D.L. _____ Block _____ Sec. ___ Twp. ___ Rg. ___ Land District ___

or **PID:** _____ and **Description of well location (attach sketch, if nec.):** In the park beside Bolean Creek, Beside monitoring well ID # 68387

Well Location:

NAD 83: Zone: 11U (see note 7) and **UTM Easting:** 318331 m **UTM Northing:** 5597361 m (or) **Latitude** (see note 8): _____ **Longitude:** _____

Method of drilling: ☑ air rotary ☐ dual rotary ☐ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ other (specify): _____

Orientation of well: ☑ vertical ☐ horizontal Ground elevation: 1932 ft (asl) Method (see note 9): GPS

Lithologic description (see notes 10-15)

From ft (bgl)	To ft (bgl)	Material Description	Moisture: Dry	Damp	Moist	Wet	Colour: Black	Blue	Brown	Green	Grey	Vari-coloured	Red	Tan	White	Hardness: Dense	Hard	Loose	Medium	Soft	Stiff	Very Hard	Very Soft	Observations (e.g. other geological materials (e.g. boulders), est. water bearing flow (USgpm))
0	22	Silt, Sand & Dirty Gravel							✓															
22	41	Sand & Coarse Gravel							✓															Productive
41	76	Finer Sand & Gravel							✓															
76	84	Sand & Fine Gravel									✓													
84	96	Sand & Gravel, Silt							✓															
96	108	Sand & Gravel									✓													
108	112	Sand & Gravel									✓													Not as productive
112	117	Sand & Gravel							✓															High Production

Casing Details:

Type: ☐ Surface ☑ Production ☐ Open Hole ☐ Steel Removed

From ft (bgl)	To ft (bgl)	Dia in	Casing Material/Open Hole (see note 16)	Wall Thickness in	Drive Shoe
+3	113½	6	Steel	.219	Yes

Surface seal: Type: Bentonite Depth: 16 ft

Method of installation: ☐ Poured ☐ Pumped Thickness: 1 in

Backfill: Type: _____ Depth: _____ ft

Liner: ☐ PVC ☐ Other (specify): _____

Diameter: _____ in Thickness: _____ in

From: _____ ft (bgl) To: _____ ft (bgl)

Perforated: From: _____ ft (bgl) To: _____ ft (bgl)

Screen details:

From ft (bgl)	To ft (bgl)	Dia in	Type (see note 17)	Slot Size
113	117	6	K-Packer & Screen	15

Intake: ☑ Screen ☐ Open bottom ☐ Uncased hole

Screen type: ☑ Telescope ☐ Pipe size

Screen material: ☑ Stainless steel ☐ Plastic ☐ Other (specify): _____

Screen opening: ☑ Continuous slot ☐ Slotted ☐ Perforated pipe

Screen bottom: ☐ Bail ☑ Plug ☐ Plate ☐ Other (specify): _____

Filter pack: From: _____ ft To: _____ ft Thickness: ____ in

Type and size of material: _____

Developed by: ☐ Air lifting ☐ Bailing ☐ Jetting ☐ Pumping ☐ Surging ☐ Other (specify): _____ Total duration: _____ hrs

Notes: _____

Well yield estimated by: ☐ Pumping ☑ Air lifting ☐ Bailing ☐ Other (specify): _____

Rate: 60 USgpm Duration: _____ hrs SWL before test: _____ ft (btoc) Drawdown: _____ ft (btoc)

Hydro-fracturing: ☐ Yes ☐ No Increase in Well Yield due to Hydro-fracturing: _____ USgpm

Water Quality: Water sample collected: ☐ Yes ☑ No

Date (YYYY/MM/DD) _____ Water quality odour: _____

Characteristics: ☑ Clear ☐ Cloudy ☑ Fresh ☐ Gas ☐ Salty ☐ Sediment ☐ Other (specify): _____

Colour: ☐ Black ☐ Black flecks ☐ Brown ☐ Clear/none ☐ grey ☐ Slight colour/milky ☐ Orange ☐ Other (specify): _____

Comments: _____

Final well completion data:

Total depth drilled: 117 ft Finished well depth: 117 ft (bgl)

Final casing stick up: 36 in Depth to bedrock: _____ ft (bgl)

SWL: 10.4 ft (btoc) Estimated well yield: 60 USgpm

Artesian flow: _____ USgpm, or Artesian pressure: _____ ft

Type of well cap: Aluminum Well disinfected: ☐ Yes ☐ No

☐ **Confirmation/alternative specs. attached**

☐ **Original well construction report attached**

PLEASE NOTE: The information recorded in this well report describes the works and hydrogeologic conditions at the time of construction or alteration, as the case may be. Well yield, well performance and water quality are not guaranteed as they are influenced by a number of factors, including natural variability, human activities and condition of the works, which may change over time.

white: Customer copy
canary: Driller copy

BRITISH COLUMBIA

☑ Well Construction Report
☐ Well Alteration Report

Dan-Gare Drilling Ltd.
Box 722
Armstrong, B.C. V0E 1B0

Ministry Well ID Plate Number: 68387
Where ID Plate is attached: Stick-up
Ministry Well Tag Number: _____

See reverse for notes & definitions of abbreviations.

Well Class: Class of well (see note 2): Monitoring **Sub-class of well:** _____

Water supply wells: indicate intended water use: ☐ private domestic ☐ water supply system ☐ irrigation ☐ commercial or industrial ☐ other (specify): _____

Start date of work (YYYY/MM/DD): 2023/03/28 **End date of work** (YYYY/MM/DD): 2023/03/28

Person Responsible for Work (print clearly): **Name (first, last)** (see note 3): Logan Flett

Person who completed the work: Logan **Registration no.** (see note 4): 08042501

Consultant (if applicable; name and company): Melissa Wade Ministry of Forests

DECLARATION: Well construction, well alteration or well decommission, as the case may be, has been done in accordance with the requirements in the Water Sustainability Act and the Ground Water Protection Regulation.

Signature of Person Responsible Logan Flett

Owner name: British Columbia - Ministry of Forests

Mailing address: 1259 Dalhousie Dr Town Kamloops Prov. B.C. Postal Code V2C 5Z5

Well Location (see note 6): Address: Street no. _____ Street name Seaman Rd. Town Falkland

or **Legal description:** Lot _____ Plan _____ D.L. _____ Block _____ Sec. ___ Twp. ___ Rg. ___ Land District ____

or **PID:** _____ and **Description of well location (attach sketch, if nec.):** In the park beside Bolean Creek. Beside Monitoring Well # 68388

Well Location:

NAD 83: Zone: 11U (see note 7) and **UTM Easting:** 318331 m **UTM Northing:** 5597361 m (or) **Latitude** (see note 8): _____ **Longitude:** _____

Method of drilling: ☑ air rotary ☐ dual rotary ☐ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ other (specify): _____

Orientation of well: ☑ vertical ☐ horizontal Ground elevation: 1932 ft (asl) Method (see note 9): GPS

Lithologic description (see notes 10-15)

From ft (bgl)	To ft (bgl)	Material Description	Moisture: Dry	Damp	Moist	Wet	Colour: Black	Blue	Brown	Green	Grey	Vari-coloured	Red	Tan	White	Hardness: Dense	Hard	Loose	Medium	Soft	Stiff	Very Hard	Very Soft	Observations (e.g. other geological materials (e.g. boulders), est. water bearing flow (USgpm))
0	22	Silt, Sand & Dirty Gravel																						
22	39	Sand & Coarse Gravel																						

Casing Details:

Type: ☐ Surface ☑ Production ☐ Open Hole ☐ Steel Removed

From ft (bgl)	To ft (bgl)	Dia in	Casing Material/Open Hole (see note 16)	Wall Thickness in	Drive Shoe
+3	35	6	Steel	.219	Yes

Surface seal: Type: Bentonite Depth: 16 ft

Method of installation: ☑ Poured ☐ Pumped Thickness: 1 in

Backfill: Type: _____ Depth: _____ ft

Liner: ☐ PVC ☐ Other (specify): _____

Diameter: _____ in Thickness: _____ in

From: _____ ft (bgl) To: _____ ft (bgl)

Perforated: From: _____ ft (bgl) To: _____ ft (bgl)

Screen details:

From ft (bgl)	To ft (bgl)	Dia in	Type (see note 17)	Slot Size
35	39	6	K-Packer & Screen	15

Intake: ☑ Screen ☐ Open bottom ☐ Uncased hole

Screen type: ☑ Telescope ☐ Pipe size

Screen material: ☑ Stainless steel ☐ Plastic ☐ Other (specify): _____

Screen opening: ☑ Continuous slot ☐ Slotted ☐ Perforated pipe

Screen bottom: ☐ Bail ☑ Plug ☐ Plate ☐ Other (specify): _____

Filter pack: From: _____ ft To: _____ ft Thickness: ____ in

Type and size of material: _____

Developed by: ☐ Air lifting ☐ Bailing ☐ Jetting ☐ Pumping ☐ Surging ☐ Other (specify): _____ Total duration: _____ hrs

Notes: _____

Well yield estimated by: ☐ Pumping ☑ Air lifting ☐ Bailing ☐ Other (specify): _____

Rate: 35 USgpm Duration: _____ hrs SWL before test: _____ ft (btoc) Drawdown: _____ ft (btoc)

Hydro-fracturing: ☐ Yes ☐ No Increase in Well Yield due to Hydro-fracturing: _____ USgpm

Water Quality: Water sample collected: ☐ Yes ☐ No

Date (YYYY/MM/DD) _____ Water quality odour: _____

Characteristics: ☑ Clear ☐ Cloudy ☑ Fresh ☐ Gas ☐ Salty ☐ Sediment ☐ Other (specify): _____

Colour: ☐ Black ☐ Black flecks ☐ Brown ☐ Clear/none ☐ grey ☐ Slight colour/milky ☐ Orange ☐ Other (specify): _____

Comments: _____

Final well completion data:

Total depth drilled: 39 ft Finished well depth: 39 ft (bgl)

Final casing stick up: 36 in Depth to bedrock: _____ ft (bgl)

SWL: 13.3 ft (btoc) Estimated well yield: 35 USgpm

Artesian flow: _____ USgpm, or Artesian pressure: _____ ft

Type of well cap: Aluminum Well disinfected: ☐ Yes ☐ No

☐ **Confirmation/alternative specs. attached**

☐ **Original well construction report attached**

PLEASE NOTE: The information recorded in this well report describes the works and hydrogeologic conditions at the time of construction or alteration, as the case may be. Well yield, well performance and water quality are not guaranteed as they are influenced by a number of factors, including natural variability, human activities and condition of the works which may change over time.

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