FINAL
Bevan Avenue Groundwater Supply Development Project

Year 12 Environmental Monitoring Report

Prepared for:

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Executive Summary

The City of Abbotsford was granted approval under a BC Environmental Certificate (EAC) #W11-01 to increase the withdrawal of water from the Abbotsford – Sumas Aquifer (the Aquifer) to meet seasonal peak drinking water demands. The Bevan Wells Groundwater Supply Development Project (The Project) was initially intended to extract water at an increased rate from a maximum 74.9 liters per second (L/s) to 290 L/s during times of seasonal peak usage (May to September) until such time as an additional surface water supply was constructed. The original EAC expired December 31, 2015 but was extended to the end of 2016 to allow sufficient time to prepare a comprehensive amendment application to operate the wells indefinitely. The amendment allowing indefinite operation of the wells was granted on June 12, 2017.

Schedule B of the EAC outlines the City of Abbotsford's commitments with respect to the project. Condition #4 stipulates that the City must implement a monitoring program for the duration of operation of the project. The program includes monitoring surface water flows, surface water levels, and surface water quality. Conditions added in the 2017 Amendment include implementation of a monitoring and mitigation plan (Condition #22), which includes vegetation monitoring (Condition # 23), and inviting Matsqui First Nation to continue participation in existing fish habitat monitoring programs and participate in the new and expanded vegetation and fish habitat monitoring programs (Condition #27). If any unanticipated adverse effects are identified in the monitoring reports, then the City of Abbotsford must develop and implement appropriate mitigation measures to the satisfaction of the EAO.

As per Conditions #4 and #27, annual reporting is to be completed and submitted to the Environmental Assessment Office, Ministry of Water, Land and Resource Stewardship, and Matsqui First Nation. This report summarizes the Year 12 (May 2022 to April 2023) monitoring data. The expanded monitoring programs were implemented in 2018 and continued in 2019-2023. Matsqui First Nation were invited to participate in the summer 2022 fish habitat and vegetation monitoring events. They participated in the fish habitat monitoring in July and October. They did not respond to the invitations to participate in September and chose the fish habitat monitoring over the vegetation monitoring in October.

Flows measured in the creeks during Year 12 were within range of previous measurements and did not exhibit any long-term declining trends. Although calculated flows for Downes Creek went below the 27.9 L/s threshold during Year 12, all manual measurements during this interval were greater than this trigger value. The occurrence of calculated flow at

Downes Creek below the 27.9 L/s threshold likely reflects the high sensitivity of calculated flows to changes in the measured water level in the creek.

Flow measurements at the Fishtrap Creek SCADA station have been challenging. Due to variability in low flow measurements, it has not been possible to develop a rating curve for the site. As a result, the monitoring station will operate as a water level station, and further flow measurements will not be completed. To mitigate potential low-flow periods, it is recommended that the Fishtrap Creek mitigation well continues to be turned on during the summer months.

An apparent shift in the flow pattern Downes Creek hydrometric station occurred on December 24, 2022, triggered by a rainfall event. Although an adjustment was made to the rating curve, all reported discharge data after December 24, 2022 should be considered estimates. An additional five flow measurements encompassing a range of low, medium, and high flows are recommended to allow redevelopment of the rating curve.

Manual flow monitoring at several sites experienced challenges related to high or low water levels. Water levels in Fishtrap Creek at F-02 were too high to allow complete flow measurements in in June 2022 and October 2022 through April 2023. Likewise, the water at F-04 was too deep for flow measurements in January 2022. Conversely, the channel was dry at both F-02 and F-04 in September 2022. Waechter Creek at the staff gauge was also dry in September 2022, and in August 2022 the flow at this point was too low to measure accurately. A similar issue occurred in Boa Brook at B-01. The staff gauge was above the water line from July through September/early October 2022.

A programming error in the shuttle for the Hobo loggers resulted in a lack of flow data for April and May 2022. Additionally, the WT-01 and D-04 Hobo loggers failed, and no valid data were recorded at these sites during the summer of 2022.

The expanded flow monitoring stations have continued to be problematic. In addition to the high and low water level issues, the manual stream flow data recorded at B-02, D-02, D-03 and D-04 have been too variable to establish a stage-discharge rating curve.

Year 12 water quality data were generally consistent with Year 2 baseline data. The only observed change was a statistically significant decreasing trend in dissolved oxygen concentrations at B-01, H-02 and the Willband Creek reference site (W-01). However, water temperature at H-02 did not show a corresponding increase, which suggests that the trend was unrelated to the operation of the Bevan Wells. Other data for Years 2 to 12 show that the use of the Bevan Wells has not affected water quality.

Prior to Year 8, water quality in Downes Creek (D-01) and Fishtrap Creek (F-01 and F-02) was monitored in April, September, October, and January. Therefore, the available data were insufficient to analyze seasonal or annual trends. However, trends during each of the four months were analyzed. The only statistically significant trend in these watercourses was a decrease in dissolved oxygen in May at F-02.

Groundwater quality monitoring was conducted to compare the quality of augmentation flows relative to surface water quality guidelines. Water quality in the Garibaldi Park mitigation well (which discharges to Horn Creek) was good. The Allen Park mitigation well had consistently elevated arsenic concentrations, over three times the water quality guideline. However, a risk assessment completed in 2018 found that risks related to arsenic exposure would not be expected even if receptors in Boa Brook were exposed to undiluted groundwater. In addition, annual average phosphorus concentrations in the Allen Park well were above the water quality objective for the Sumas River. The new Fishtrap Creek mitigation well also had an average phosphorus concentration above the objective for the Sumas River, but all other parameters were below guidelines to protect aquatic life.

The water quality of several drinking water wells was also assessed to show background water quality in the Abbotsford Sumas Aquifer. All wells had generally good water quality. The average concentrations of arsenic, fluoride and iron were below the maximum guidelines for protection of aquatic life. However, concentrations of nitrate and copper were higher in some or all drinking water wells than in the mitigation wells.

The fish habitat monitoring program for Horn Creek and Boa Brook did not identify any changes over time that appeared to be associated with operation of the Bevan Wells. Over the 12 years of monitoring there were no statistically significant decreasing trends in bankfull width or bankfull depth. The only significant decreasing trend in wetted width occurred at Site 3C in Horn Creek.

Habitat suitability for coho, cutthroat trout fry and parr, and rainbow trout fry and parr was evaluated as changes in the amount of usable habitat based on depth and velocity across the channel. There were statistically significant changes in habitat suitability for some species and/or life stages at some sites but no overall decrease in availability of suitable habitat in Horn Creek or Boa Brook. The changes over time do not reflect effects of water withdrawal by the Bevan Wells.

Groundwater levels were measured at seven monitoring well locations. During the first half of Year 12 (May 1 to November 30, 2022), aquifer water level elevations and the magnitude of seasonal variation were generally consistent with trends for the same interval during prior years. Water levels were lower from December 2022 to April 2023 than previously observed. However, there was no evidence of a progressive year-over-year decline in water levels in any of the observation wells.

The fifth full year of stream flow, water quality, and mesohabitat monitoring was completed at the expanded monitoring sites in Fishtrap Creek and Downes Creek from May 2022 to April 2023. The fifth year of shallow groundwater monitoring and sixth year of vegetation monitoring were also completed during this time period. The results of these monitoring programs are presented in the current report.

No unanticipated adverse effects were identified in Year 12 monitoring. The five or six years of monitoring is not sufficient to draw robust conclusions, but there were no changes that would suggest an immediate need for a mitigation well for Downes Creek (Condition #25).

Some issues with the water level loggers occurred in Year 12. A fault in the shuttle caused its internal clock to reset, making all loggers record dates erroneous dates from April to October 2022. Although it was possible to correct the date, the loggers did not collect data in April and May 2022, and large shifts in baseline water levels in several wells suggested possible data errors. Additionally, the logger at F02 failed to record data from October 2022 to April 2023, and the downloaded data from all three wells in Control Wetland B could not be corrected for barometric pressure, resulting in no valid data for the wetland during this period.

There was an overall decrease in water level in the Downes Creek wetland from 2018 to 2023. The decrease did not correspond to withdrawals by the Bevan Wells.

After five years of data collection, the vegetation monitoring showed neither a major shift in species composition nor changes to ecosystem boundaries that would suggest a response to drier conditions. Trend analyses of indicator plant (skunk cabbage) parameters showed decreases in average petiole length in four plots, one each in the Horn Creek and Boa Brook watershed and two in the Downes Creek watershed. Decreasing trends in plant density and total petiole length per metre were noted at the Horn Creek plot with no downward trends at the other sites. The changes in Downes Creek do not signify a downward trend at the watershed level. There are too few plots in the Horn-Boa study area to provide conclusions about watershed level changes. In all, the indicator plant measurements showed did not show adverse effects attributable to operation of the Bevan Wells.

Five years of conducting the expanded monitoring program required by the 2017 Amendment have resulted in some challenges that may require adjustments to the program. Specific issues are related the expanded flow and mesohabitat monitoring stations and the indicator plant monitoring sites in Horn Creek-Boa Brook watershed.

Several expanded flow monitoring stations have continued to be problematic. In addition to high and low water level issues, the manual stream flow data recorded at B-02, D-02, D-03 and D-04 have been too variable to establish a stage-discharge rating curve. ENKON recommends that a qualified professional hydrologist in consultation with a qualified professional fisheries biologist re-evaluate the expanded flow monitoring sites to determine whether:

- monitoring at these sites can provide sufficiently accurate flows to determine temporal trends in summer low flows;

- sufficiently accurate flow monitoring can be achieved without significant channel configuration (e.g., weir installation) and if not, whether the flow data is valuable enough to warrant the disturbance to fish habitat; and
- whether the program objectives (identification of negative effects on fish habitat) can be achieved through seasonal flow monitoring (manual measurements) in conjunction with the current mesohabitat monitoring program.

For several years beavers have been active at F-02 and F-03, changing the site characteristics. It will be difficult to identify effects, if any, of the Bevan Wells on fish habitat at these sites due to the confounding influence of beaver activity. A qualified fisheries biologist should assess the possibility of finding additional or alternate mesohabitat monitoring sites that are unaffected by beavers, although these sites will not likely be available in some reaches.

The indicator plant surveys focus on Downes Creek, where potential changes in the shallow groundwater regime are a greater concern than in the Horn-Boa watershed. Originally three indicator plant plots were established in this watershed, but one Horn Creek plot was lost. Given the apparent trends in the remaining Horn Creek and Boa Brook plots, ENKON recommends the establishment of replacement/additional plots in this watershed.

Monitoring is continuing for Year 12 (May 2022 to April 2023), and results will be presented in a separate annual monitoring report.

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1.0 INTRODUCTION

1.1 Background

The Bevan Avenue Wells Groundwater Supply Development Project (the Project) was proposed in response to increasing summer water use demand in the City of Abbotsford (the City) and the District of Mission (Mission). The Bevan Avenue Wells are operated by the City on behalf of the Abbotsford Mission Water & Sewer Commission (AMWSC). In October 2010, the City submitted an *Application for an Environmental Assessment Certificate* (the *Application,* (Hemmera, 2010) for the Project in accordance with the requirements and guidance of the British Columbia Environmental Assessment Office (EAO), and as required under the British Columbia *Environmental Assessment Act S.B.C. 2002* (BC EAA) and the *Canadian Environmental Assessment Act* (CEAA). An Environmental Assessment Certificate (EAC) was awarded on May 10, 2011 (EAC number: W11-01) and allowed for the operation of the Bevan Wells for five years under prescribed conditions. The EAC was amended on June 12, 2017 to allow for the wells to operate indefinitely, with additional conditions.

Potential environmental effects of the Project are related to drawdown of water levels in the Abbotsford – Sumas Aquifer (the Aquifer), which may affect surface water flows and in turn fish and fish habitat. The original *Application* predicted that changes in surface flows would be below acceptable thresholds in the reaches of all evaluated watercourses except Horn Creek and its tributary, Boa Brook (Hemmera, 2010). A decrease in flow could change the quantity and potentially affect the quality of available habitat for fish. In particular, a decrease in flow could result in elevated water temperatures and a decrease in dissolved oxygen, which could directly affect fish. The most critical period for fish is mid-July to end of October, when base flow is at or near seasonal lows.

The subsequent *Amendment Application* (ENKON 2016) addressed long-term operation of the Project, including operation during extended (5 year) unusually dry periods. This assessment identified a potential for the Project to affect surface flows in Fishtrap Creek and Downes Creek and shallow groundwater that sustains wetlands, particularly in the Downes Creek watershed.

In order to mitigate potential effects to fish and fish habitat and in accordance with the terms and conditions of the EAC, the City installed and operates mitigation wells. Two wells, located in the headwaters of Horn Creek and Boa Brook, are intended to supplement predicted low flows to pre-Project levels. Both wells pump water to their respective creeks when measured flows at the Horn Creek station are below 25.2 L/s (equivalent to 90% of the minimum base flow of 28 L/s) and the Bevan Wells have pumped more than 175 ML during the preceding 30 days. A third mitigation well was installed in Fishtrap Creek in 2019.

In 2011, an Operational Environmental Management Plan (OEMP) was prepared for the Project by Hemmera. The intent of the mitigation measures described in the OEMP was to meet a standard of no negative change in water quality and stream flow as a result of the Project. The OEMP included a monitoring program, the purpose of which was to compare conditions in Horn Creek and Boa Brook during operation of the Bevan Avenue Wells and mitigation wells to baseline conditions.

The OEMP was updated in July 2018 (ENKON *et al*., 2018) to address the new conditions in the amended EAC. This update expanded the aquatic monitoring program in Fishtrap Creek and Downes Creek and added vegetation and shallow groundwater monitoring programs. New monitoring sites and/or monitoring programs were established in the fall of 2017, and routine monitoring began in May 2018.

The goals of the monitoring program in the current OEMP are to:

- Assess the efficiency of the mitigation measures in protecting fish and fish habitat;
- Compare baseline conditions to conditions during operation of the Bevan Wells and, if applicable, the mitigation wells;
- Assess the ability of the mitigation measures to sufficiently supplement groundwater inputs to affected watercourses;
- Determine the need (if any) for further mitigation measures to protect instream fish habitat and riparian/wetland vegetation, especially in Downes Creek; and
- Verify the assessments presented in the original Application and the Amendment Application regarding potential residual effects of the Project on water quality, stream flows, riparian vegetation, and shallow groundwater.

This report presents the results of the Year 12 monitoring program, which began in May 2022 and concluded in April 2023. It includes comparisons of all years of the Project for which multi-year data are available. A summary and schedule of the Year 12 monitoring activities for groundwater, surface water, and fish habitat is presented in Table 1-1. Shallow groundwater monitoring sites are monitored continuously. Vegetation monitoring occurs annually in late summer.

Table 1-1 Monitoring Activities and Schedule (2022-2023) for the Bevan Wells Project

Component & Site	**2022** May	**2022** June	**2022** July	**2022** August	**2022** September	**2022** October	**2022** November	**2022** December	**2023** January	**2023** February	**2023** March	**2023** April
Water Quality Samples & *In-Situ* Water Quality												
Boa Brook (B-01)	x	x	x	x	x	x	x	x	x	x	x	x
Boa Brook (B-02)	x	x	x	x	x	x	x	x	x	x	x	x
Horn Creek (H-01)	x	x	x	x	x	x	x	x	x	x	x	x
Horn Creek (H-02)	x	x	x	x	x	x	x	x	x	x	x	x
Horn Creek (H-03)	x	x	x	x	x	x	x	x	x	x	x	x
Willband Creek (W-01)	x	x	x	x	x	x	x	x	x	x	x	x
Downes Creek (D-01)	x	x	x	x	x	x	x	x	x	x	x	x
Downes Creek (D-02)	x	x	x	x	x	x	x	x	x	x	x	x
Fishtrap Creek (F-01)	x	x	x	x	x	x	x	x	x	x	x	x
Fishtrap Creek (F-02)	x	x	x	x	x	x	x	x	x	x	x	x
Fishtrat Creek (FOF)	x	x	x	x	x	x	x	x	x	x	x	x
Fishtrap Creek (F-03)	-	-	x	x	x	x	-	-	-	-	-	-
Fishtrap Creek (F-04)	-	-	x	x	x	x	-	-	-	-	-	-
Duplicate	F-01	F-02	W-01	H-01	D-01	H-02	H-03	B-01	B-02	H-01	H-02	H-03
Number of sites	10	10	12	12	12	12	10	10	10	10	10	10
Manual Streamflow and Water Level												
Boa Brook (B-01)	x	x	x	x	x	x	-	-	x	-	-	x
Boa Brook (B-02)	x	-	x	-	x	-	-	-	x	-	-	-
Horn Creek (H-01)	x	x	x	x	x	x	-	-	x	-	-	x
Horn Creek (H-02)	x	x	x	x	x	x	-	-	x	-	-	x
Horn Creek (H-03)	x	x	x	x	x	x	-	-	x	-	-	x
Willband Creek (W-01)	x	x	x	x	x	x	-	-	x	-	-	x
Downes Creek (D-01)	x	x	x	x	x	x	-	-	x	-	-	x
Downes Creek (D-02)	x	-	x	-	x	-	-	-	x	-	-	-
Downes Creek (D-03)	x	-	x	-	x	-	-	-	x	-	-	-
Downes Creek (D-04)	x	-	x	-	x	-	-	-	x	-	-	-
Fishtrap Creek (F-01)	x	-	x	-	x	-	-	-	x	-	-	-
Fishtrap Creek (F-02)	x	-	x	-	x	-	-	-	x	-	-	-
Waechter (WT-01) +	x	-	x	-	x	-	-	-	x	-	-	-
Fishtrap Creek (F-04)	x	-	x	-	x	-	-	-	x	-	-	-
Judson Lake	x	x	x	x	x	x	x	x	x	x	x	x
Laxton Lake	x	x	x	x	x	x	x	x	x	x	x	x
Number of stream flow sites	14	6	14	6	14	6	0	0	14	0	0	6

Component & Site	2022 May	2022 June	2022 July	2022 August	2022 September	2022 October	2022 November	2022 December	2023 January	2023 February	2023 March	2023 April
Fish & Fish Habitat Monitoring												
Site 1 (Mesohabitat A, B, C)	-	-	x	x	x	x	-	-	-	-	-	-
Site 2 (Mesohabitat A, B)	-	-	x	x	x	x	-	-	-	-	-	-
Site 3 (Mesohabitat A, B, C)	-	-	x	x	x	x	-	-	-	-	-	-
Site 4 (Mesohabitat A, B)	-	-	x	x	x	x	-	-	-	-	-	-
Site 5 (Mesohabitat A, B, C, D)	-	-	x	x	x	x	-	-	-	-	-	-
Site 6 (Mesohabitat A, B)	-	-	x	x	x	x	-	-	-	-	-	-
Downes Creek (D-01) (pool & riffle)	-	-	-	-	-	-	-	-	-	-	-	-
Downes Creek (D-02) (pool & riffle)	-	-	x	x	x	x	-	-	-	-	-	-
Downes Creek (D-03) (pool & riffle)	-	-	x	x	x	x	-	-	-	-	-	-
Downes Creek (D-04) (pool & riffle)	-	-	x	x	x	x	-	-	-	-	-	-
Fishtrap Creek (F-01) (pool & riffle)	-	-	x	x	x	x	-	-	-	-	-	-
Fishtrap Creek (F-02) (pool & riffle)	-	-	x	x	x	x	-	-	-	-	-	-
Fishtrap Creek (F-03) (pool)	-	-	x	x	x	x	-	-	-	-	-	
Fishtrap Creek (F-04) (pool & riffle)	-	-	x	x	x	x	-	-	-	-	-	-
Number of sites	0	0	13	13	13	13	0	0	0	0	0	0
TEM, Indicator Plants, Snail Habitat												
Downes Creek TEM Sites (11 plots)	-	-	-	-	x *		-	-	-	-	-	-
Downes Creek Indicator Plants (8 Plots)	-	-	-	-	x **	-	-	-	-	-	-	-
Downes Creek Oregon Forestsnail Habitat	-	-	-	-	x	-	-	-	-	-	-	-
Fishtrap Creek TEM Sites (6 plots)	-	-	-	-	x *		-	-	-	-	-	-
Horn/Boa TEM Sites (4 plots)	-	-	-	-	x *		-	-	-	-	-	-
Horn/Boa Indicator Plants (2 Plots)	-	-	-	-	x **	-	-	-	-	-	-	-
Number of sites	0	0	0	0	22	10	0	0	0	0	0	0
Shallow Groundwater Well Monitoring												
Downes Creek (8 wells)	-	-	-	-	-	x	-	-	-	-	-	x
Control Wetland A (3 wells)	-	-	-	-	-	x	-	-	-	-	-	x
Control Wetland B (3 wells)	-	-	-	-	-	x	-	-	-	-	-	x
Control Wetland C (3 wells)	-	-	-	-	-	x	-	-	-	-	-	x
Fishtrap Creek (3 wells)	-	-	-	-	-	x	-	-	-	-	-	x
Horn Creek/Boa Brook (2 wells)	-	-	-	-	-	x	-	-	-	-	-	x
Number of sites	0	0	0	0	0	22	0	0	0	0	0	22
Groundwater Quality Monitoring												
Allen Park Mitigation Well	x	x	x	x	x	x	x	x	x	x	x	x
Garibaldi Park Mitigation Well	x	x	x	x	x	x	x	x	x	x	x	x
AMWSC Drinking Water Wells	x	x	x	x	x	x	x	x	x	x	x	x
Number of sites	3	3	3	3	3	3	3	3	3	3	3	3

Component & Site	2022 May	2022 June	2022 July	2022 August	2022 September	2022 October	2022 November	2022 December	2023 January	2023 February	2023 March	2023 April
Groundwater Level Monitoring												
Exhibition Park	x	x	x	x	x	x	x	x	x	x	x	x
Columbia Bible College	x	x	x	x	x	x	x	x	x	x	x	x
DND South Townline	x	x	x	x	x	x	x	x	x	x	x	x
Heritage RV	x	x	x	x	x	x	x	x	x	x	x	x
TW06-2 Bevan	x	x	x	x	x	x	x	x	x	x	x	x
TW06-3 Courthouse	x	x	x	x	x	x	x	x	x	x	x	x
Number of sites	6	6	6	6	6	6	6	6	6	6	6	6

+ Substituted for station F-03

*TEM Plots to be assessed between September 15 and October 15

**Indicator plant plots to be completed after 1065 degree-days above 10 degrees Celsius (approximately September 20th). Surveys should take place no later than October 1st.

1.2 Year 12 Operation

In Year 12 of the Project (May 1, 2022 to April 30, 2023) the Bevan Wells pumped 1,971 million litres (ML). This total is equivalent to 79% of the total groundwater diversion (2,505 ML/year) permitted in accordance with EA Certificate W11-01. The maximum daily pumping rate was 19.394 ML/day on August 1, 2022, which represents 83% of the 25-ML/day allowable maximum pumping rate.

The Allen Park and Garibaldi Park mitigation wells were not triggered in Year 12. Flows in Horn Creek did not drop below 25 L/s at any time during Year 12.

The Fishtrap Creek mitigation well came online on May 10, 2019. The associated flow monitoring station was completed in January 2021, but it has not been possible to develop a rating curve for the station. As a result, the mitigation well 3was turned on as a precaution and pumped from to 29 and from October 14 to November 11 (Appendix I). The intent was to keep the well running during the summer period, but it was shut off by mistake from July 30 to October 13.

Apart from maintenance and sampling, during Year 12 the Bevan Wells were used outside of the operating window from April 7 to 28, 2022 and from December 20, 2022 to April 30, 2023. The Norrish Water Treatment Plant was offline throughout Year 12 due to needed repairs. Therefore, the Bevan Wells and other sources were used for supply. The repairs at Norrish have continued into Year 13.

2.0 SURFACE WATER MONITORING PROGRAM

Hydrological investigations undertaken during preparation of the *Application* determined that is potential for the Project to affect surface flows in Horn Creek and Boa Brook. Subsequent analysis undertaken for the *Amendment Application* identified the potential for effects on flows in Fishtrap Creek and Downes Creek during multi-year dry periods. Such decreases in flow have the potential to affect fish habitat and water quality through decreases in water volume, possibly resulting in increased concentrations of nutrients, elevated water temperature, and corresponding decreases in dissolved oxygen. The most critical period is late summer to early autumn, when base flows are at or near seasonal lows.

Mitigation for reduction in surface flows in Horn Creek and Boa Brook as a result of the Project operations consists of augmentation of surface flows with groundwater. This occurs when measured flows at the Horn Creek station are below 25.2 L/s (equivalent to 90% of the minimum base flow of 28 L/s) (Hemmera, 2011b). Flow augmentation for Fishtrap Creek came online in the summer of 2019 (Year 9) and was operated as a precaution in the summers of Years 9 through 12, as the associated flow monitoring station initially was not operational and subsequently it was not possible to develop a rating curve for the station.

The Year 12 surface water monitoring program included the following:

- Streamflow measurements (watercourses);
- Water level measurements (water bodies);
- Collection of *in-situ* water quality measurements; and
- Collection of water quality samples for laboratory analysis.

2.1 Site Description

Water quality and/or stream flow measurements were taken at 15 sites (watercourses), and water levels were recorded at two sites (water bodies). These are described in Table 2-1 and shown in Figures 2-1 to Figure 2-3.

The monitoring sites on Horn Creek, Boa Brook, Fishtrap Creek, and Downes Creek are locations potentially impacted by the Project and/or the groundwater mitigation measures. Willband Creek was chosen as a control, as it is not expected to be affected by the Project, but is surrounded by land use (i.e., city park, urban mix of residential and commercial) similar to that around Horn Creek and Boa Brook (Hemmera, 2011).

Table 2-1 Surface Water Monitoring Sites

Water Feature	Site ID	Description	UTM Northing	UTM Easting
Watercourses				
Boa Brook	B-01	Boa Brook mitigation well outfall	5433683	550844
	B-02	Hydrometric station - Boa Brook, downstream of mitigation well outfall (monitoring station was moved in 2018 to a suitable location for level logger installation)	5434336	550671
		Water quality - Boa Brook, downstream of mitigation well outfall	5434298	550651
Downes Creek	D-01	Downes Creek (monitoring station was moved in September 2014 due to a hazardous tree)	5435965	549189
	D-02	Located 30m upstream of Downes Road	5435905	549143
	D-03	Approximately 20m downstream of headwall	5435425	549298
	D-04	Approximately 60m upstream from pedestrian bridge.	5435296	549169
Fishtrap Creek	F-01	Confluence of Enns Brook and Fishtrap Creek	5433158	546746
	F-02	Fishtrap Creek downstream from Marshall Road Extension[a]	5431962	545250
	F-03	Near previously established staff gauge (water quality only)	5430294	544294
	F-04	Flow logger installed at right bank piles under Echo Rd Bridge	5430337	544026
Horn Creek	H-01	Horn Creek headwaters, upstream of mitigation well outfall	5433951	550190
	H-02	Horn Creek, downstream of confluence with Boa Brook	5434380	550784
	H-03	Horn Creek, downstream of mitigation well outfall	5434025	550234
Waechter Creek	WT-01	Waechter Creek at 1266 Hope Road (hydrometric only; site selected because F-03 was unsuitable for installing a level logger) [b]	5430425	544487
Willband Creek	W-01	Willband Creek (control site)	5432998	551363
Water Bodies				
Judson Lake	-	Judson Lake (discussed with groundwater program)	5427980	548328
Laxton Lake	-	Laxton Lake (discussed with groundwater program)	5428820	547457

Note: UTM Coordinates are NAD83, Zone 10U

[a] Station was moved to 10U 545221 E 5431928 N in September 2018 to avoid conflict with Marshall Road widening and culvert replacement works.

[b] The flow at F-03 can be calculated by subtracting flow at WT-01 from F-04.

2.2 Schedule

2.2.1 Water Quality

In-situ water quality measurements and samples for laboratory analyses collected at 11 locations (B-01, B-02, H-01, H-02, H-03, F-01, F-02, FOF, D-01, D-02, and W-01) on a monthly basis. The remaining locations (F-03 and F-04) had water quality samples collected only in September and/or October (Table 1-1). Due to a misunderstanding F-03 and F-04 were sampled for field measurements only in July and August 2022. F-03 was also sampled for field measurements only in November.

2.2.2 Stream Flow

The hydrometric network for the Bevan Wells monitoring program included automated hydrometric stations installed on Horn Creek (H-02), Fishtrap Creek (F-01 and F-02), Downes Creek (D-01), and Willband Creek (W 01). The automated hydrometric stations were installed by Piteau in 2008. The site on Horn Creek (H-02) was vandalized and taken out of the monitoring program early in Year 3. It was replaced with a SCADA monitoring station.

In 2019, new flow monitoring stations were installed on Fishtrap Creek near F-02 and Downes Creek near D-01. The Fishtrap Creek station transmits data to SCADA, while the Downes Creek station uploads data to FlowWorks via cellular telemetry. Kerr Wood Leidal (KWL) has assumed responsibility for maintenance and manual flow measurements at these two stations plus the Horn Creek SCADA station.

The expanded monitoring program (ENKON, 2018a) included installation of level loggers at the following locations:

- H-02 on Horn Creek as a back-up to the SCADA system (Figure 2-1);
- B-02 to better characterize flows in Boa Brook on a continuous basis (Figure 2-1);
- D-02, D-03, and D-04 to characterize flows within the Downes Bowl tributaries to Downes Creek on a continuous basis (Figure 2-2); and
- WT-01 (on Waechter Creek in lieu of F-03) and F-04 to better characterize flows within Fishtrap Creek on a continuous basis (Figure 2-3).

Manual stream flow measurements were made or attempted monthly from May through October 2022 plus January and April 2023. These months capture the high flows in January, the early dry season in April, May, and June, and summer low flows which typically extend from July to October.

Legend

- Surface water monitoring location
- Abbotsford-Sumas aquifer
- Streams
- Waterbody

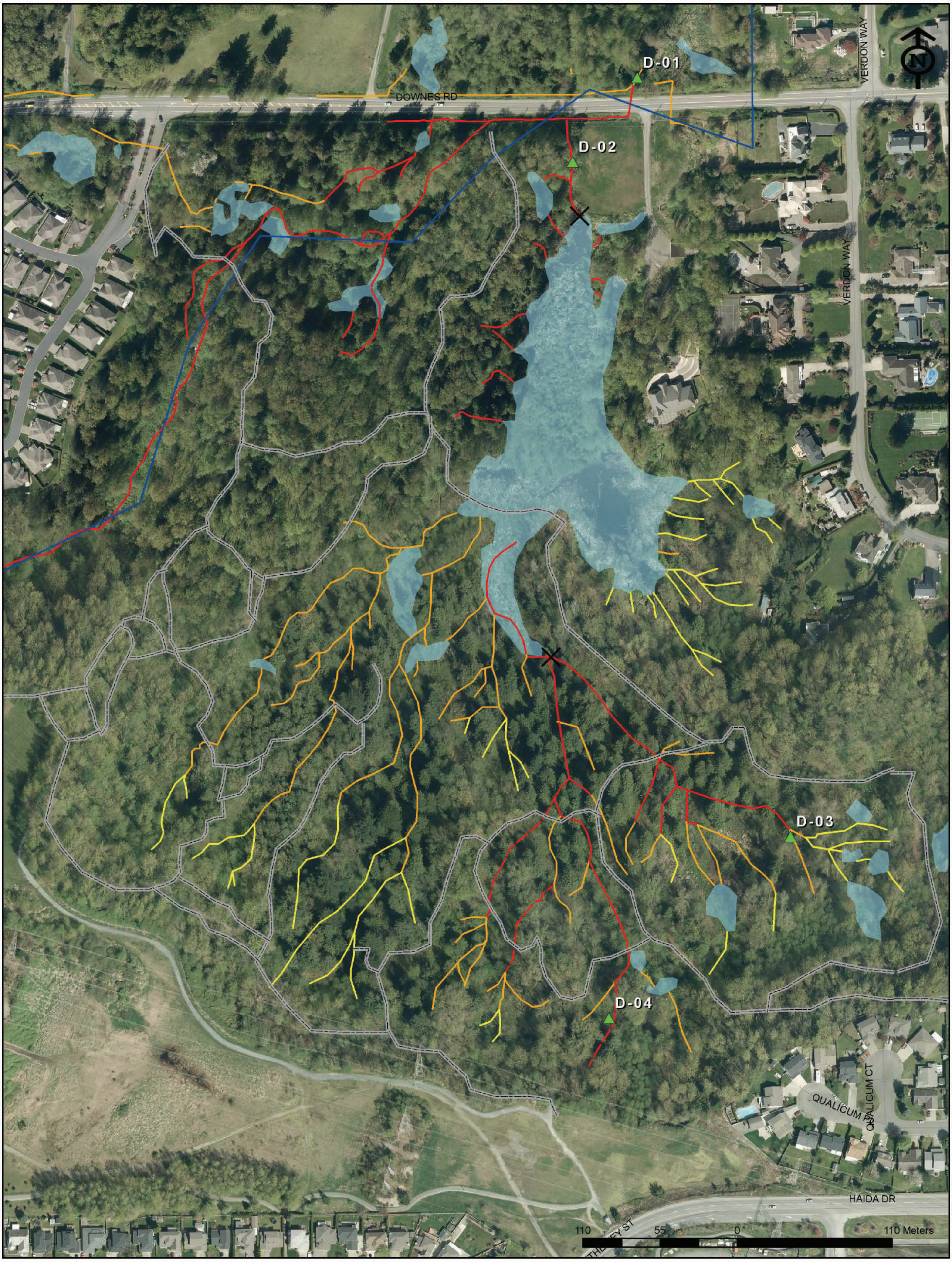
Prepared by:
ENKON
Environmental Ltd.

Created: December 2019
Projection:
NAD 83 UTM Zone 10N
1:6,000

Horn Creek, Boa Brook & Willband Creek Surface Water Monitoring Sites

City of Abbotsford

Figure 2-1



Legend

- Surface water monitoring location
- DownesTrails
- Abbotsford-Sumas aquifer
- Waterbody

Watercourses (CoA Modified)

- Class A (fish-bearing)
- Class Ao (overwintering)
- Class B (food and nutrient)
- Permanent (Unclassified)

Prepared by: ENKON Environmental Ltd.

Created: December 2019
Projection:
NAD 83 UTM Zone 10N
1:2,500

Downes Creek
Surface Water Monitoring Sites

City of Abbotsford

Figure 2-2

Legend

- Surface water monitoring location
- Abbotsford-Sumas aquifer
- Streams
- Waterbody

Prepared by: ENKON Environmental Ltd.

Created: December 2019
Projection:
NAD 83 UTM Zone 10N
1:10,000

Fishtrap Creek
Surface Water Monitoring Sites

City of Abbotsford

Figure 2-3

2.3 Study Methods

2.3.1 Stream Flow

Stream flow monitoring at Horn Creek and Fishtrap Creek SCADA stations and the Downes Creek FlowWorks station was conducted by KWL. The methods and results of this monitoring program are attached in Appendix A with supporting information from the Horn Creek events log in Appendix B.

The original and expanded stream flow and water level monitoring program included:

- Download of data from the monitoring sites where water level loggers are installed; and
- Stream flow transects at each of the 14 monitoring sites listed in Table 2-1 and Table 2-2.

Table 2-2 Hydrology Stations on Streams

Site ID	Stream Flow Transect	Automated Data Logger
H-01	X	
H-02	X	X
H-03	X	
B-01	X	
B-02	X	X
D-01	X	X
D-02	X	X
D-03	X	X
D-04	X	X
F-01	X	X
F-02	X	X
WT-01	X	X
F-04	X	X
W-01	X	X

Stream transects were conducted in accordance with the methods described in *The Manual of British Columbia Hydrometric Standards* (RISC, 2009). Stream flow was measured with a SonTek FlowTracker or FlowTracker2® handheld Acoustic Doppler Velocimeter (ADV®).

Concurrent stage and flow measurements were used to establish a stage-discharge relationship for each instrumented station. These relationships were used to estimate flowrates from the hourly water level records. Equivalent water level elevations were determined by correcting the measured levels against a surveyed datum.

2.3.2 Water Quality

2.3.2.1 Parameters Monitored

The water quality monitoring program included:

- *In-situ* water quality monitoring of dissolved oxygen, pH, specific conductance, and temperature;
- Field monitoring of turbidity;
- Monitoring of nutrients (nitrate/nitrite, ammonia, and phosphorus);
- Monitoring of total metals;
- Monitoring of water hardness;
- Monitoring of total fluoride; and
- Coordination of scheduling and sampling locations with surface water flow monitoring.

Potential surface water quality effects of the Project are predicted to be from reduced flows rather than inputs of new contaminants. Watercourses and water quality in the Abbotsford area are currently affected by agricultural and urban activities. Physical and chemical analyses of water samples collected during the field program were reflective of these concerns. In addition to the monitoring of nutrients, total metals analysis was added to the analysis requirements for all surface water samples beginning in October 2012 due to the elevated background levels of arsenic and fluoride in the Abbotsford-Sumas aquifer groundwater (Hemmera, August 2011).

The selected water quality attributes are described below:

- **Turbidity** – A measure of the optical properties of a water sample induced mostly by suspended particulate matter which results in a scattering of light as it passes through water. High levels are commonly the result of suspended solids and can reduce biological productivity of the water or prey capture success by visual predators such as trout and salmon. Turbidity guidelines primarily deal with induced increases above background level. The City of Abbotsford's Erosion and Sediment Control Bylaw specifies 25 NTUs as the maximum limit. This is meant to be measured at point of release rather than above background. Turbidity below 8 NTU is used to define "clear" flow (Singleton, 2001).
- **Dissolved Oxygen** – A measure of the amount of oxygen dissolved in water, essential to the survival and health of most aquatic organisms. Turbulent water

contains more dissolved oxygen than stagnant water. Water also contains more oxygen at saturation at colder temperatures. Anthropogenic inputs such as agricultural runoff and other organic materials use oxygen as they decompose, reducing dissolved oxygen levels.

- **Temperature** – Aquatic organisms have an optimal temperature range outside of which they become stressed, more susceptible to disease, and grow more slowly. Increased temperature contributes to algal growth and is a contributing factor toward eutrophication of a watercourse. Temperature also affects the toxicities of a range of other substances, including ammonia.
- **pH** – Aquatic organisms have an optimal pH range outside of which they become stressed, more susceptible to disease, and grow more slowly. pH is a factor in the toxicities of numerous pollutants, including ammonia. Eutrophication may cause a slight rise in pH in watercourses during the daytime due to photosynthesis.
- **Nitrate and Nitrite** – Nitrate and nitrite occur naturally but also can be introduced by anthropogenic sources such as agricultural and urban run-off. Both nitrate and nitrite are useable by plants. Nitrite is an intermediate step in the nitrification of ammonia. It is unstable in surface waters and rapidly degrades to nitrate, the most oxidized and stable form of nitrogen in a water body. Nitrate can contribute to the eutrophication of water bodies, and nitrite can be toxic to aquatic organisms.
- **Ammonia** – The most reduced inorganic form of nitrogen in water, and an essential plant nutrient. Excess ammonia contributes to eutrophication of water bodies and is toxic to aquatic life at high concentrations. Ammonia occurs naturally at low concentrations but similarly to nitrate can be introduced by anthropogenic sources such as agricultural and urban run-off.
- **Total Phosphorus** – Both inorganic and organic forms of phosphorus can be present as dissolved or particulate matter. Phosphorus is generally the limiting nutrient to plant growth in fresh water and is found in very low concentrations in natural waters. Anthropogenic inputs of phosphorus include agricultural and urban run-off and industrial effluents. Such inputs are often responsible for eutrophication of freshwater systems.
- **Total Metals** – As noted in the *Surface Water and Mitigation Well Groundwater Quality Report* (Hemmera, August 2011), no metals concentrations of potential concern were detected in the single sampling event; however, the report recommended further sampling due to high detection limits for arsenic, cadmium, chromium, and zinc in historical surface water samples.
- **Total Fluoride** – The *Surface Water and Mitigation Well Groundwater Quality Report* (Hemmera, August 2011) recommended that additional groundwater

samples from the drinking water and mitigation wells should be taken to determine the range of fluoride (and arsenic) concentrations in the aquifer.

2.3.2.2 Sampling Methods

Water quality sampling was done in accordance with the *BC Field Sampling Manual* (Ministry of Environment, 2013) and Resources Information Standards Committee (RISC) guidelines (Cavanagh, 1994; RISC, 1998). Sampling containers and preservatives were obtained from Bureau Veritas (BV). *In-situ* parameters (pH, temperature, dissolved oxygen, and conductivity) were measured with a YSI ProPlus multi-parameter meter with the probe placed directly into the stream flows. Field turbidity was measured using a LaMotte 2020e turbidity meter. Sample containers were filled directly from the stream. Water samples were sent to BV for chemical analyses.

2.3.2.3 Quality Assurance and Quality Control

Quality assurance (QA) procedures during field sampling included:

- Proper maintenance and calibration of field equipment;
- Labelling sample containers prior to collection with company information, project identification, station identification, sample date and time;
- Keeping samples cool and dark, and preserving as specified for the type of sample;
- Delivering samples to the laboratory within specific holding times; and
- Keeping accurate records for sample chain-of-custody.

The following quality control samples were collected during each sampling event:

- **Duplicate samples** – two samples collected at the same location and time;
- **Travel blanks** - a bottle of deionized water filled and preserved at the analytical laboratory, then taken into the field in the sample cooler and returned unopened to the laboratory; and
- **Field blanks** – prepared by filling the sample bottles with deionized water in the field and then preserving the samples, if appropriate.

Analyses were completed by an analytical laboratory accredited by the Canadian Association for Environmental Analytical Laboratories (CAEAL). Internal laboratory QA/QC procedures are consistent with the *BC Environmental Laboratory Manual* (Ministry of Environment and Climate Change Strategy, 2020) and include the use of quality control samples such as blanks, duplicates, and reference materials (standards, spikes, etc.). Values exceeding set standards or control limits undergo an internal review process.

2.3.2.4 Data Analysis

Results of laboratory analyses were entered into the CCME Water Quality Index (WQI) Calculator 2.0 (CCME, 2017). The CCME water quality index summarizes the results of a number of water quality variables in comparison to established criteria in order to describe water bodies as "poor", "marginal", "fair", "good" or "excellent"[1]. This approach was used both here and during the environmental assessment, as the streams under study are not in pristine condition and on some occasions, do not meet federal and provincial water quality guidelines for selected parameters. The water quality index allows for a comparison of overall changes in stream quality over time, which is a more meaningful analysis in the context of potential impacts of the Project than comparison to set criteria.

Annual reports for Year 1 to Year 7 used the CCME Water Quality Index Calculator 1.2 (CCME, 2011a). The Year 8 annual report (ENKON 2020) used Version 2 of the WQI Calculator and the 19 parameters and associated guidelines listed in Table 2-3. The WQI values for Years 2 through 7 were updated using the same calculations in order to make the data for these years comparable. [2] Subsequent years' WQI values also have been determined using WQI Calculator Version 2 and the 19 parameters listed in Table 2-3.

2.4 Results

2.4.1 Stream Flow

2.4.1.1 Original Hydrometric Monitoring Program Sites

The original hydrometric monitoring sites include Horn Creek 2 (H-02), Fishtrap Creek 1 (F-01) Fishtrap Creek 2 (F-02B, which replaces station F-02), Downes Creek D-01), and Willband Creek (W-01). Water levels are graphed in Figure 2-4, and flows are shown in Figure 2-5. Total daily precipitation at the Abbotsford Airport (recorded by Environment Canada) is included on Figure 2-4.

[1] **Excellent (E):** (CCME WQI Value 95-100) – water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within objectives virtually all of the time.

Good (G): (CCME WQI Value 80-94) – water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.

Fair (F): (CCME WQI Value 65-79) – water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.

Marginal (M): (CCME WQI Value 45-64) – water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

Poor (P): (CCME WQI Value 0-44) – water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

[2] The Year 1 WQI was not recalculated because the raw water quality data were unavailable.

Table 2-3 Water Quality Criteria Used in the Water Quality Index Calculation

Parameter	Source	Criteria
Nitrate as N (mg/L as N)	CCME	2.9 mg/L as N
Nitrite as N (mg/L as N)	CCME	0.06 mg/L as N
Ammonia (mg/L as N)	CCME	Temperature and pH dependent.
Phosphorus (mg/L)	SSWQG	0.03 mg/L
Dissolved Oxygen (mg/L)	BCWQG	Species and life stage dependent. In study area streams, July 1 to October 31: ≥8 mg/L November 1 to June 30: ≥11 mg/L
Temperature (°C)	BCWQG	Species and life stage dependent. In study area streams, July 1 to October 31: ≤15°C November 1 to June 30: ≤13°C
pH	BCWQG	Between 6.5 and 9
Fluoride	CCME	0.12 mg/L (interim guideline)
Total Metals	CCME	
Arsenic		5 µg/L
Cadmium		$10^{(0.083(\log[hardness])-2.46)}$
Chromium VI		1 µg/L
Copper		$0.2 * e^{0.8545[\ln(hardness)]-1.465}$
Iron		300 µg/L
Lead		$e^{1.273[\ln(hardness)]-4.705}$
Mercury (inorganic)		0.026
Nickel		$e^{0.76[\ln(hardness)]+1.06}$
Selenium		1 µg/L
Silver		0.1 µg/L
Zinc		30 µg/L

CCME – Canadian Council of Ministers of the Environment; BCWQG – British Columbia Water Quality Guideline; SSWQG - Site-Specific Water Quality Guidelines (for the Sumas River)

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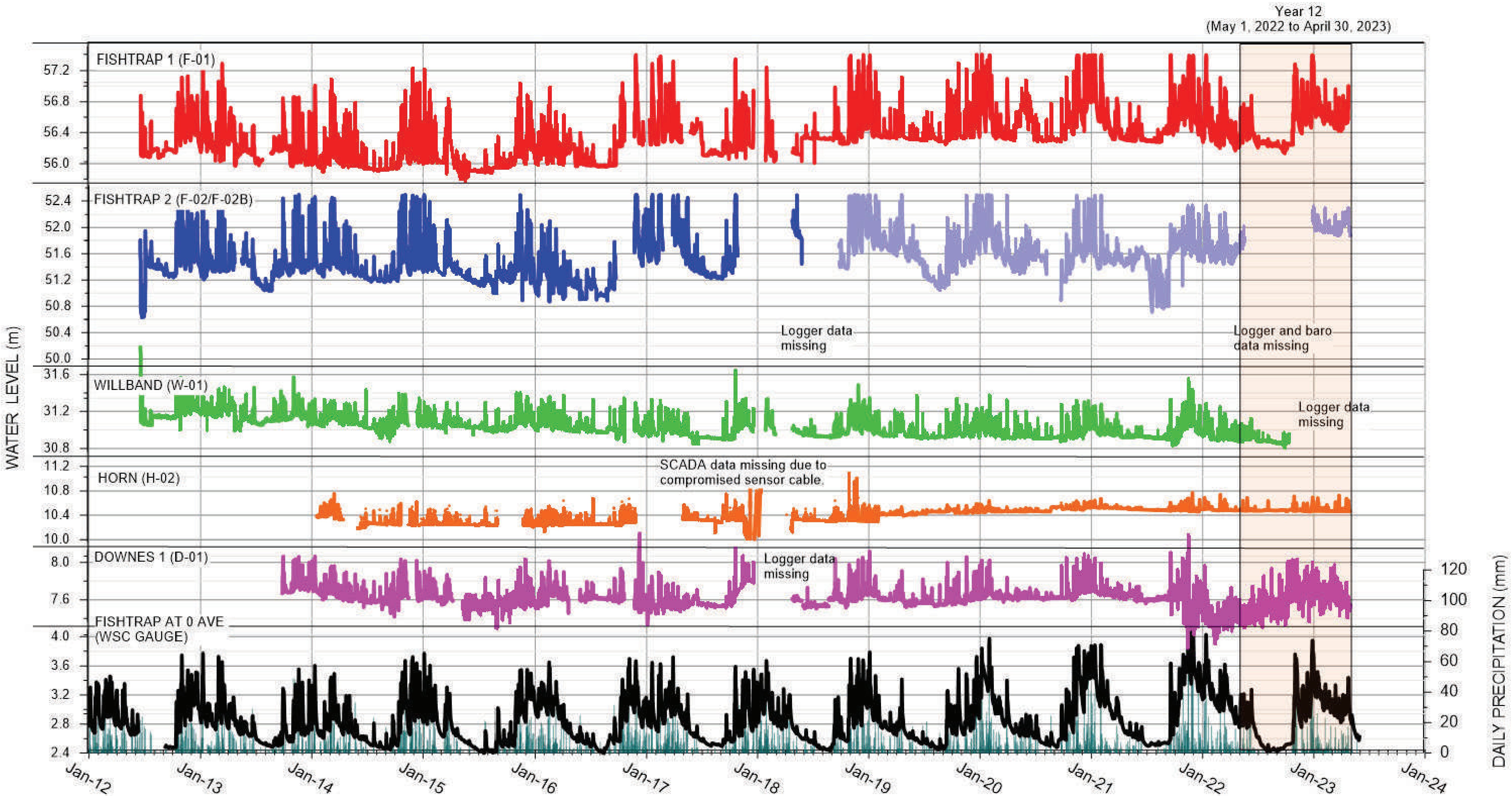

Fishtrap 1 (F-01)
Fishtrap 2 (F-02)
Fishtrap 2 (F-02B)
Willband (W-01)
Horn (H-02)
Downes (D-01)
Fishtrap at 0 Ave (WSC gauge)
Precipitation

Water levels shown as elevations for all except Fishtrap at 0 Ave

All precipitation data from Environment Canada station at Abbotsford Airport.

CITY OF ABBOTSFORD
UPDATED HYDROGEOLOGICAL ASSESSMENT
BEVAN WELLS PROJECT

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS
A TETRA TECH COMPANY

HYDROGRAPHS OF 2011 TO 2023
SURFACE WATER LEVEL TRENDS

BY:	DATE:
YR	DEC 23
APPROVED:	FIG:
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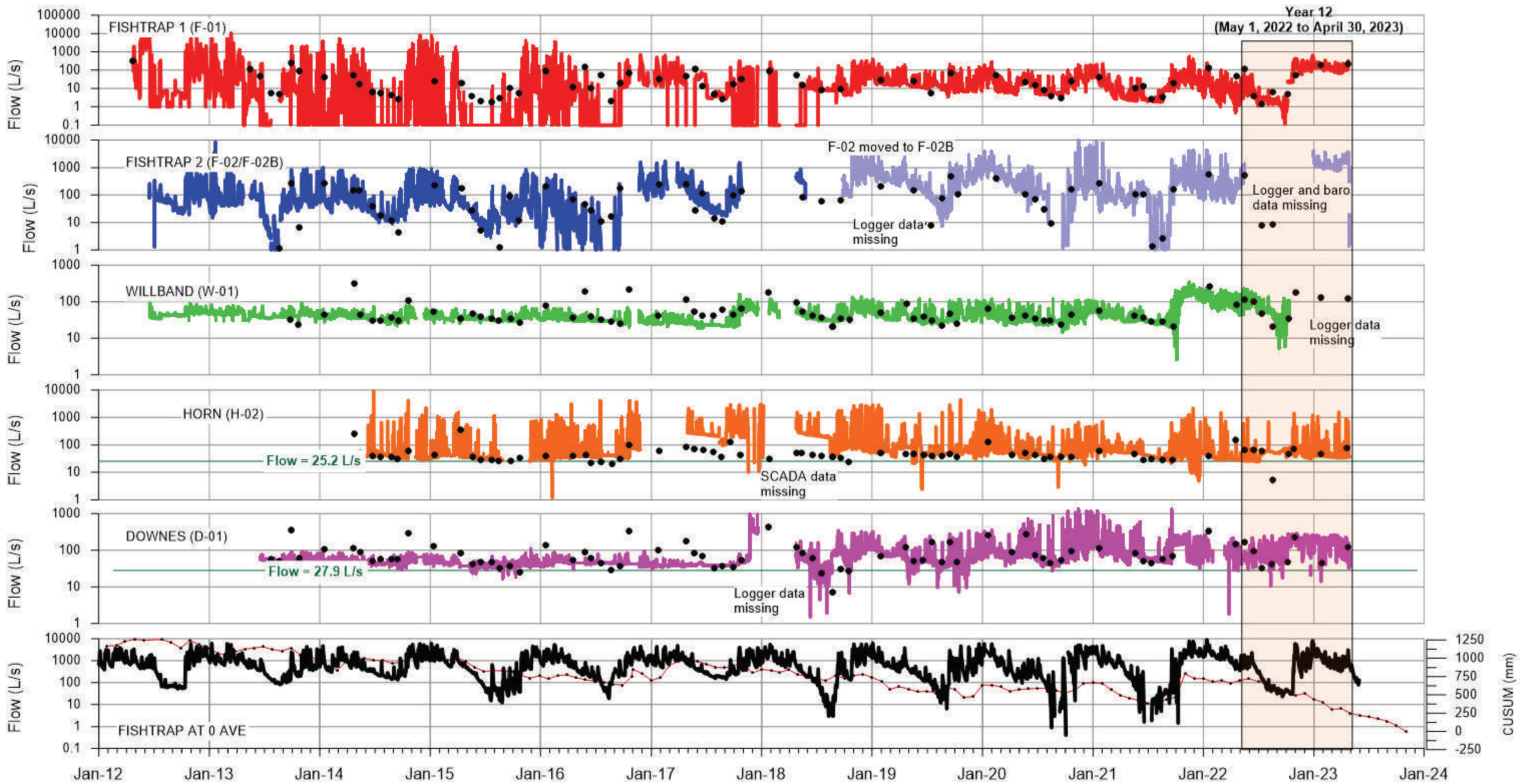

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CITY OF ABBOTSFORD
UPDATED HYDROGEOLOGICAL ASSESSMENT
BEVAN WELLS PROJECT

PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS
A TETRA TECH COMPANY

HYDROGRAPHS OF 2011 to 2023
CREEK FLOW TRENDS

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APPROVED:	FIG:
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2.4.1.2 Original Hydrometric Monitoring Stations

Fishtrap 1 (F-01)

Although calculated flow at Fishtrap Creek station F-01 prior to July 2018 are unreliable, subsequent calculated flows at this location correlate well with measured flows. Estimated and measured flows for Year 12 are with the range noted during prior years, and the pattern for this interval is similar to flow trends in Willband Creek (the reference station) and Fishtrap Creek at 0 Avenue.

Fishtrap (F-02B)

Changes in the creek characteristics resulting from culvert replacement upstream of station F-02B on Fishtrap Creek, and possibly beaver activity in the area, have caused this location to become unsuitable as a site for flow monitoring. Water level data is only available for this location between January and April 2023. If feasible, an alternative location for Station F-02B will be established in 2024.

Willband Creek (W-01)

Observed and calculated flows in Willband Creek (W-01) shows a slight decreasing trend up to October 2021, followed by noticeable increase in water level and flow from October 2021 and onward into 2022. The levels in and flows during Year 12 are within the range of previous observations and estimations. The declining flow trend noted between about June and October 2022 corresponds to a prolonged interval with lower-than-average precipitation.

Horn Creek (H-02)

Observed and calculated Year 12 flows in Horn Creek (H-02) fluctuate within previously observed levels. The single manual flow reading in August 2022 (5.2 L/s) does not correspond to a lowered water level in the creek and may be in error.

Downes Creek (D-01)

Although calculated flows for Downes Creek went below the 27.9 L/s threshold during Year 12, all discrete manual measurements during this interval were greater than this amount. The occurrence of calculated flow at Downes Creek below the 27.9 L/s threshold likely reflects the high sensitivity of calculated flows to changes in the measured water level in the creek.

Fishtrap at 0 Ave

Even though the interval was drier, flows in Fishtrap Creek at 0 Ave for Year 12 are generally consistent with prior years.

2.4.1.3 Expanded Hydrometric Monitoring Program Sites

Year 12 represents the fifth year of monitoring at new hydrometric stations established at Boa Brook (B-02), Downes Creek (D-02, D-03 and D-04), Fishtrap Creek (F-04) and Waechter Creek (WT-01); thus, no year-over-year trend analysis was completed. Water levels at these sites are shown in Figure 2-6.

Some issues with the water level loggers occurred in Year 12. One issue arose when the Hobo loggers were downloaded and redeployed in March 2022. A fault in the shuttle caused its internal clock to reset, making all loggers record dates starting in 2010. Hobo technicians were able to correct the dates based on redeployment times, but the loggers had not begun collecting data until early June. Thus, no flows were calculable in April and May 2022. Additionally, the D-04 Hobo logger failed, and no data were recorded until the logger was replaced on October 31, 2022.

Stream flows at Fishtrap Creek F-03 and F-04 and Waechter Creek WT-01 are presented in Figure 2-7. The flows at F-03 on Fishtrap Creek were derived by subtracting flows at WT-01 from F-04. The flow records contain data gaps due to the Year 12 shuttle issue and earlier problems. For example, the F-04 logger failed sometime during the fall or winter of 2020-21. It could not be downloaded in April 2021, and data after September 28, 2020 could not be recovered. A new logger was installed on August 4, 2021. As a result, it was not possible to calculate F-03 flows for the period from the end of September 2020 through July 2021.

Flow measurements at WT-01 also experienced additional problems. In May 2021, the creek was too shallow to obtain a reliable flow measurement. In July, August, and September 2021 the creek bed was dry, and there was no water at the staff gauge. An additional issue was identified in January 2022, when the field crew noted that the staff gauge was missing. In March 2022, the field crew reported that the PVC pipe and Hobo logger were also missing. These losses likely occurred due to the Fraser Valley flooding in November 2021. The logger, PVC pipe, and staff gauge were recovered in May and reinstalled 70 m downstream of the previous location on May 26, 2022. However, the recovered logger failed to function properly, and no valid data were collected in the summer of 2022. The logger was replaced on October 31, 2022. Thus, logger data are unavailable from November 15, 2021 to October 31, 2022. Likewise, F-03 flow could not be calculated for this period.

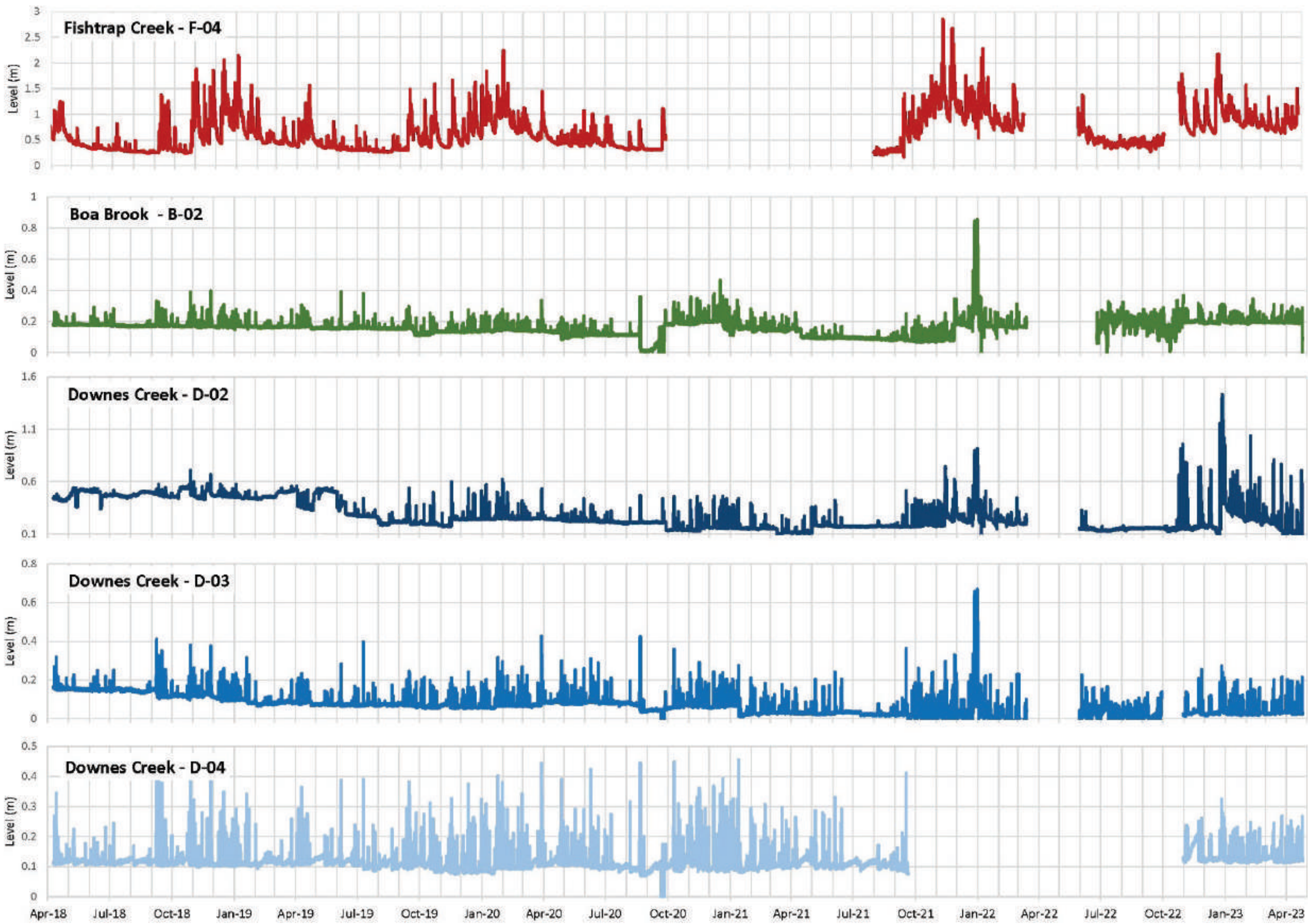

Figure 2-6 Surface Water Levels at Expanded Hydrometric Monitoring Sites

The significance of the ratings curves for both F-04 and WT-01 deteriorated in Years 11 and 12. Manually measured low flows at Fishtrap Creek in September 2020, August 2021 and October 2022 were significantly lower than the calculated flows (Figure 2-7). However, the higher flows measured in Years 11 and 12 matched the calculated flows relatively well. Similarly, the lowest flows measured in Waechter Creek were lower than the calculated flows.

Flows could not be calculated from the water level data recorded at the three Downes Creek hydrometric stations and the B-02 station on Boa Brook as stage-discharged rating curves could not be established. Based on the manual streamflow measurements recorded in Year 12 (Appendix C), flows at B-02 ranged from 1.0 L/s (January 24, 2023) to 18.9 L/s (May 18, 2022). The January 24, 2023 and April 21, 2023 (4.3 L/s) were lower than the minimum flow measured between October 2017 and September 2022. In Year 12, measured stream flows at D-03 and D-04, respectively, ranged from 2.4 L/s (July 13, 2022) to 4.4 L/s (April 24, 2023) and 1.5 L/s on May 17, 2022 to 47.1 L/s on October 6, 2022. The maximum flow at D-04 was an outlier; the second highest flow recorded at this site was 24.4 L/s on May 25, 2020. The maximum flow at D-03 was 9.1 L/s on May 25, 2020. Minimum flows over the monitoring period were 0.7 L/s at D-03 and 1.0 L/s at D-04 on July 21, 2020.

Flows and staff gauge readings (stages) measured at D-02 from May 2020 to January 2021 produced a weak stage-discharge relationship ($R^2 = 0.61$). However, the relationship broke down completely with addition of the Year 11 and Year 12 data. Flows measured at D-02 in Year 12 ranged from 17.1 L/s on January 26, 2023 to 33.0 L/s on May 17, 2022. Over the monitoring period, flows ranged from 0.6 L/s on August 23, 2018 to 80.7 L/s on May 25, 2020. The minimum flow in 2018 was due to the effects of a beaver dam. The minimum flow when the stream was unaffected by beaver dams was the 17.1 L/s in January 2023.

2.4.2 Water Quality

2.4.2.1 Background

A major purpose of the water quality monitoring program is to compare conditions during operation of the Bevan Avenue Wells, and, potentially, during operation of the mitigation wells, to baseline conditions. The intent of project mitigation measures is to meet a standard of no negative change in water quality as a result of the Project. The CCME Water Quality Index (WQI) summarized overall water quality based the extent to which multiple parameters meet federal and provincial guidelines. Thus, the data analysis includes comparing CCME WQI ratings from year to year over the life of the Project. In addition, as the number of years of monitoring increases it becomes possible to conduct statistical analysis of temporal trends in both the WQI and in parameters of particular concern.

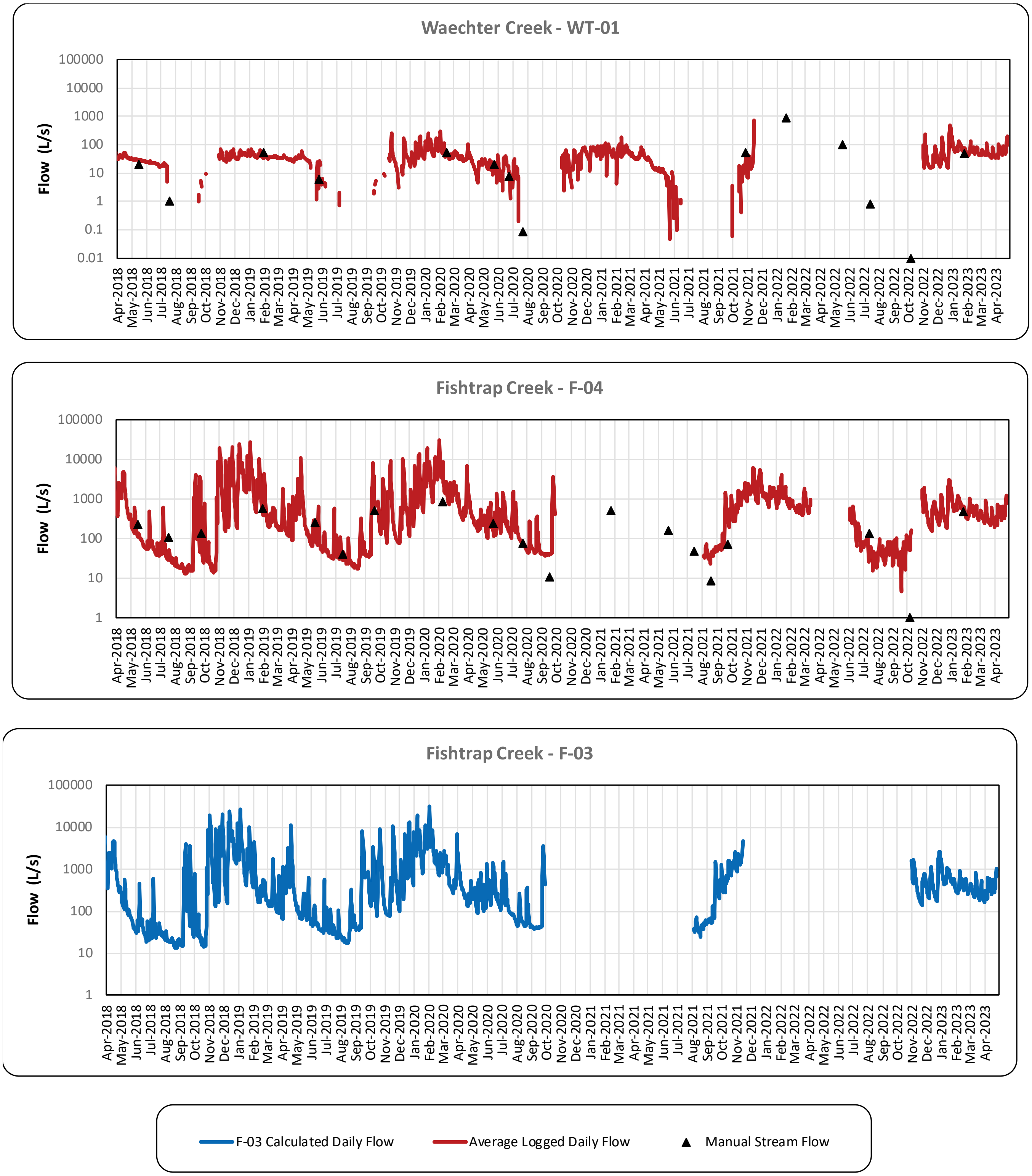

Figure 2-7 Flows at Expanded Hydrometric Monitoring Sites in Fishtrap Creek

Comparison of water quality data to provincial and federal guidelines for freshwater aquatic life should be performed with care when assessing project effects or mitigation effectiveness, as the streams in the monitoring program area are impacted by urban influences and in some cases already exceed various guidelines. However, a discussion of the results in relation to these guidelines is provided to add detail to the CCME WQI ratings and to establish baseline conditions and subsequent changes in these streams. Table 2-3 describes the guidelines used in calculating the CCME WQI ratings and referred to in the discussion of results below. Raw surface water quality results are located in Appendix D (tables) and Appendix E (laboratory reports). Temporal graphs of Years 1 through 12 surface water quality data are located in Appendix F.

2.4.2.2 CCME Water Quality Index Results

Table 2-4 contains the results of the CCME WQI calculations for Year 12. According to the WQI, water quality at most sites was fair, with B-01 and H-03 rated "marginal." At the extremes, water quality of D-01 was "good," and that of H-01 was "poor" (Table 2-4). The Year 12 results are consistent with or slightly better than the baseline results from Year 1 and reflect the fact that water quality in the Abbotsford area is affected by agricultural and urban activities. Potential surface water quality effects of the Project would result from reduced flows producing higher temperatures, lower dissolved oxygen, and lower dilutions rather than inputs of new contaminants.

WQI results for Years 2 through 12 showed some variability but no apparent downward trends (Figure 2-8), suggesting that the use of the Bevan Wells has not significantly affected the water quality in Boa Brook, Horn Creek, Downes Creek, or Fishtrap Creek. Year-to-year variability included upward or downward changes of one category, but differences in the absolute value of the WQI generally were small (Table 2-5). H-01 was an exception in Year 12, when the WQI was rated as "poor" compared with a "fair" rating in Year 11. However, the WQI at H-01 in Year 12 (43.8) was similar to that in Year 1 (45.0) (Table 2-5).

The mean frequencies of water quality parameters not meeting applicable guidelines from Year 2 to Year 12 are summarized in Figure 2-9. Dissolved oxygen, temperature, phosphorus, fluoride, and a variety of metals did not consistently meet their respective guidelines at any monitoring site. Dissolved oxygen was particularly problematic in the headwaters of Boa Brook and Horn Creek with on average 92.4% and 89.9% of the samples at B-01 and H-01, respectively, having concentrations below the minimum guideline. FOF, which has been monitored only since 2019, had 93.8% of the monthly dissolved oxygen concentrations below the minimum guideline, while F-03 and F-04, which have been monitored in the summers since 2018, had 95% and 100% of dissolved oxygen concentrations below the guideline. In addition, over 50% of the samples from H-03, F-01, F-02, and W-01 (the reference site) did not meet the guideline for dissolved oxygen.

Historically, between 28.2% and 30.3% of the samples from Fishtrap Creek (F-01 and F-02, respectively) have not met the seasonal guidelines for temperature. These incidences occurred most frequently in May. However, from 2018 to 2022 the temperatures in Fishtrap Creek were elevated from April or May through August or September.