Associated Environmental Consultants Inc.
Suite 200, 2800 29 Street
Vernon, BC V1T 9P9 Canada
www.ae.ca | ISO 9001 & 14001 Certified

TEL: 250.545.3672
FAX: 250.545.3654

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Scott Babakaiff
Assistant Water Manager
Ministry of Water, Lands and Resource Stewardship

Re: RELIABLE ENVIRONMENTAL FLOW NEEDS FOR SOAMES CREEK

1 INTRODUCTION

Associated Environmental Consultants Inc. (Associated) was retained by the Sunshine Coast Regional District (SCRD) in 2019 to prepare a Reliable Environmental Flow Needs (EFN) for Soames Creek in support of the long-term operation of the Church Road Wellfield (wellfield). Currently, the wellfield, which is hydraulically connected to Soames Creek, operates under a preliminary EFN, which was developed from a synthetic hydrological streamflow record using two methodologies, the BC modified Tenant method and the instream flow thresholds method[1]. The preliminary EFN was developed to maintain fish and fish habitat for a resident Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) population in Soames Creek. The wellfield was permitted by the Ministry of Water, Lands and Resource Stewardship (WLRS) to operate temporarily under the preliminary EFN while additional field surveys were completed to evaluate the fish and fish habitat response to the preliminary EFN flows and develop a Reliable EFN. An adaptive management plan (AMP)[2] was prepared that outlined the "Steps to Set a Reliable EFN" and the field survey requirements needed to develop the Reliable EFN. This report summarizes the field surveys and data collection on Soames Creek completed between January 2023 and July 2024, which included fish sampling, habitat transects, weighted usable width measurements, and riffle-pool crest assessments.

2 PROJECT BACKGROUND

Since 2017, the Sunshine Coast Regional District (SCRD) has initiated several groundwater investigation projects, which consisted of desktop studies to identify suitable aquifers for groundwater development. Eleven sites were identified during the initial investigation and were evaluated and ranked, with the Church Road aquifer (aquifer 560) ranking at the top. In 2019, Associated completed a groundwater investigation to support the application for a water license to extract groundwater from

[1] Hatfield, T., A. Lewis, D. Ohlson, & M. Bradford. 2003. Development of Instream Flow Thresholds as Guidelines for Review Proposed Water Uses. Ministry of Environment and Climate Change Strategy. Victoria, BC.

[2] Associated Environmental Consultants Inc. 2023. Church Road Wellfield Project and Granthams Landing Water Treatment Plant – Adaptive Management Plan R04. Prepared for Sunshine Coast Regional District.

the proposed wellfield. A technical assessment report[3], submitted to the Ministry of Forests (MoF) characterized the groundwater and related conditions at the proposed wellfield site as well as the hydrological connectivity of groundwater with Soames Creek. The technical assessment also indicated that operation of the wellfield would negatively impact streamflow in Soames Creek during the proposed annual operation period (i.e., May-October).

With minimal surface runoff contributing to streamflow in Soames Creek in the summer, most of the flow is derived from these two-point sources, the naturally occurring seepage (Granthams Spring) and overflow from an artesian well (Granthams Landing Well) (Figure 2-1). The wellfield proposed to divert water from the same aquifer (i.e., aquifer 560) that provides the groundwater flows to the creek. This hydraulic connection was confirmed during pumping tests conducted by Associated in 2019 and 2020, when groundwater diverted from the aquifer led to reduced streamflow from Granthams Springs and Granthams Landing Well, thereby reducing the Soames Creek streamflow.

Based on the hydraulic connection to Soames Creek, it was determined that groundwater diversion from the proposed wellfield could negatively impact the ecology of Soames Creek, including fish and fish habitat. To account for this, Associated conducted an EFN assessment following British Columbia's accepted provincial guidelines to identify seasonally varying minimum flow requirements, or thresholds, for the creek[4]. The results of the EFN were used to support the creek augmentation portion downstream of the wellfield; however, due to differences in streamflow noted between the 2020 recorded streamflow in Soames Creek and the synthetic dataset used to determine the EFN, the EFN was considered preliminary at the time and required further assessment to be considered a Reliable EFN.

Additionally, it was determined that developing a Reliable EFN would require collecting data from field surveys over various stream flows and important life stage periodicities for CCT (Table 2-2). Consequently, the BC Ministry of Water, Lands and Resource Stewardship (WRLS) (formerly the Ministry of Forests [MoF]) approved the temporary use of the preliminary EFN (Table 2-1) to minimize risks to the public drinking water supply and the wellfield infrastructure was constructed in 2022 and fully commissioned into service in December 2023.

[3] Associated Environmental Consultants Inc. 2019. Technical Assessment. Groundwater Use License Application Tracking No. 100292061. Prepared for Sunshine Coast Regional District. November 2019.

[4] Associated Environmental Consultants Inc. (Associated). 2021. Environmental Flow Needs Assessment for Soames Creek – Revision 2. Prepared for Sunshine Coast Regional District.

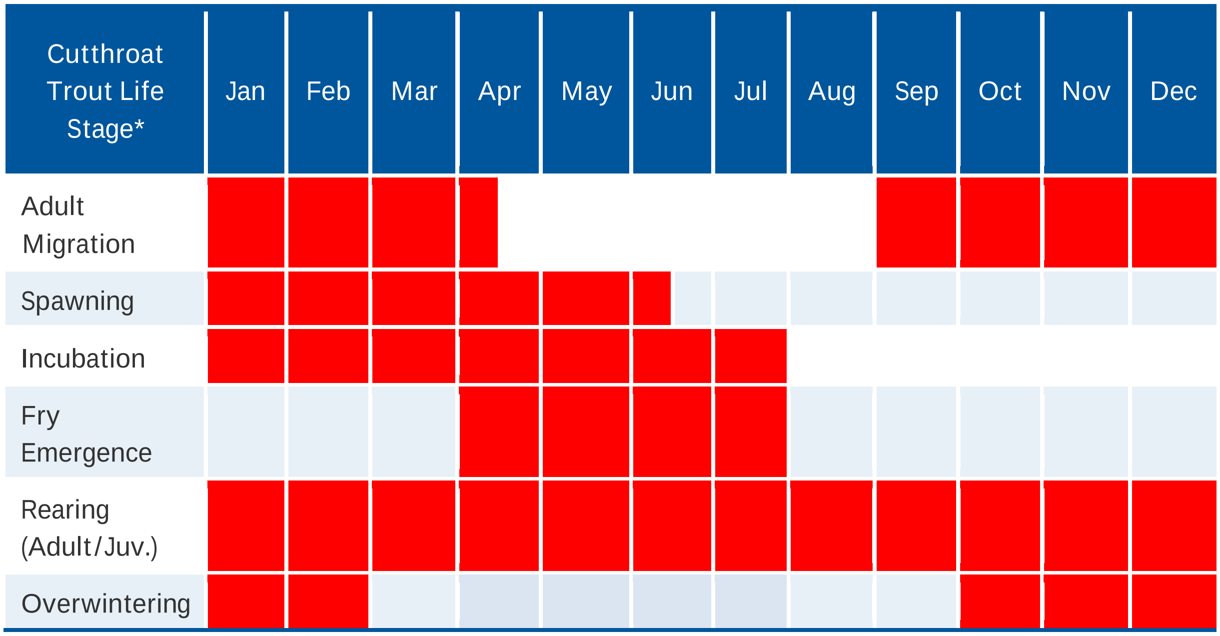
Figure 2-1 Project Location

Table 2-1 Preliminary EFNs for Soames Creek

Month	Preliminary EFN (L/s)/(m^3/s)*
January	20.3 / 0.0203
February	22.1 / 0.0221
March	22.5 / 0.0225
April	23.0 / 0.023
May	20.8 / 0.0208
June	17.2 / 0.0172
July	13.5 / 0.0135
August	13.5 / 0.0135
September	13.7 / 0.0137
October	24.0 / 0.024
November	18.3 / 0.0183
December	20.7 / 0.0207

*Preliminary EFN values were determined using the BC Instream Flow Methodology for a fish bearing stream (Hatfield et. al., 2004).

Table 2-2 Cutthroat Trout Life Stage Periodicity



* Cutthroat trout periodicity was developed in communication with Scott Babakaiff, Assistant Water Manager, Ministry of Forests on March 31, 2023.

In this report streamflow and discharge are used interchangeably.

3 OBJECTIVES

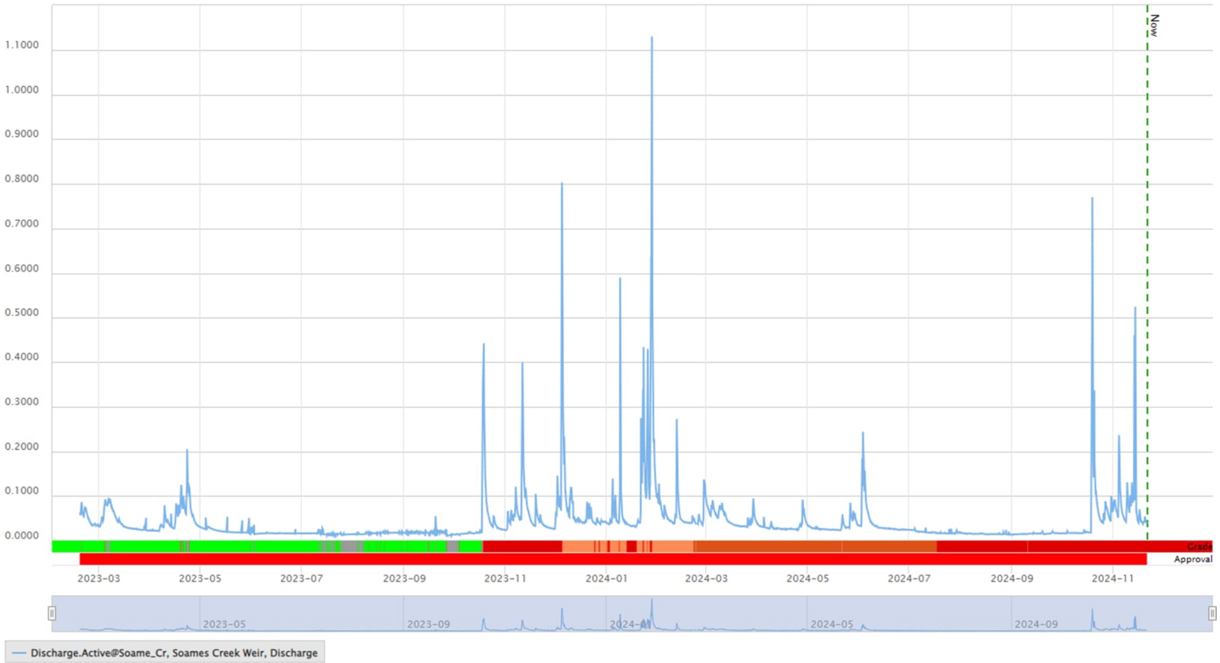
The objective of the field surveys and data collection along Soames Creek was to refine the preliminary EFN and develop a Reliable EFN that maintains fish and fish habitat and supports the long-term operation of the wellfield.

4 WATERSHED AND HYDROLOGICAL CHARACTERISTICS

Soames Creek is a short watercourse with headwaters, originating at an elevation of approximately 140 masl, 600 m to the northwest of Granthams Landing with flows collecting in three main tributaries, within an approximate watershed area of 1.76 km^2. The creek flows in a southeasterly direction towards the coast, discharging into the ocean at Granthams Landing. The creek flows through woodland forest and has cut a steeply incised ravine through the underlying geology. Soames Creek is a rain dominant system, with peak flows in the late fall/winter and low flows occurring in the summer (Figure 4-1). The primary contributor of streamflow changes seasonally, with rainfall in the fall/winter and groundwater upwelling in the summer (May-October).

Groundwater seeps, known as Granthams Springs, are located approximately 30 m to the northeast of the wellfield and discharge into the creek (Figure 2-1). The seeps emerge at several points across the valley floor resulting in a coalescing braided channels which drain into the main creek channel. Hydrometric measurements on Soames Creek indicate that the springs contribute approximately 7 L/s to Soames Creek[3].

Figure 4-1 Hydrometric Data Soames Creek



In addition, a constant, uncontrolled, artificial discharge from the confined aquifer is being added to Soames Creek approximately 50 m downstream from Granthams Springs by the Granthams Landing Well (which is no longer used as a drinking water source). The well was constructed in 1990 and was found to be artesian. Groundwater from this well is piped under natural artesian pressure to Granthams Pumphouse (no longer in operation) where it was previously used in municipal water supply or overflowed into the creek. Now all flow that is piped across to Granthams Pumphouse overflows and discharges back into the creek. Additional groundwater, not captured by the well, flows uncontrollably up the outside of the well casing and where it emerges at the wellhead surface it is captured and discharged via a short pipeline into Soames Creek (Figure 2-1) (also not used as a drinking water source). The combined artesian flow from Granthams Landing Well is approximately 6 L/s, continuously through the year.

5 FIELD SURVEYS METHODS

Field surveys (sampling and assessment) of Soames Creek were completed between January 2023 and July 2024. The field surveys focused on a 300 m section of Soames Creek from the mouth of the creek to upstream passed the Granthams Landing Well seepage point into Soames Creek (the study area) (Figure 2-1). The primary objectives of the field surveys included assessing fish presence and distribution, and fish habitat connectivity and quality at various stream flow stages.

Fish and fish habitat information was collected both before and after construction and operation of the wellfield. This information was used to evaluate whether the preliminary EFN provided suitable instream conditions to sustain the resident CCT populations in Soames Creek and determine whether revisions needed to be made before recommending a Reliable EFN.

5.1.1 Fish Presence and Distribution Sampling

Fish presence and distribution sampling was completed both before and after operation of the newly constructed wellfield to determine whether the preliminary EFN flows during operation (May-October) impacted the resident population (life-stage composition, relative population size, and distribution) of CCT in Soames Creek.

Two conventional types of fish sampling methods were used to capture fish in Soames Creek. Electrofishing and minnow trapping were conducted, employing the methodologies in Fish Collection Methods and Standards[5]. Fish sampling events and methods were completed at targeted flows and times of the year in an attempt to determine and document CCT age class and activity during critical

[5] Ministry of Environment, Fish Inventory Unit (MOE). 1997. Fish Collection Methods and Standards. Prepared for the Aquatic Ecosystems Task Force, Resource Inventory Committee. Available at: https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/fishml04.pdf

periods, as opposed to a fixed timeline (e.g., monthly sampling). We also wanted to determine any effects of wellfield operation on the fish in the impacted reach after the first year of operation and compare the results, assuming similar methods, effort, timing and conditions (including flows, water clarity and temperature) of the previous sampling efforts were duplicated. This confirmed the species, life stages and relative abundance for comparison.

Sampling techniques were deployed throughout the study area during four of the six field surveys (Table 5-1). Fish sampling efforts were focused on the study area along Soames Creek (at total length of approximately 300 m) (Figure 2-1). The sampling locations and methodologies to determine fish presence and distribution were based on *The Fish-Stream Identification Guidebook*[6]. The data and effort expended during the field surveys was collected and recorded in accordance with the Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures V. 2.0[7]. Sampling methods, equipment (timing, settings, and duration) are presented below, and in the field summary memos that were prepared after each site visit (dates listed in Table 5-1).

Table 5-1 Fish Sampling

Method / Date	Flow (m3/s)/(L/s)	Water Temperature (degrees Celsius)	Electrofishing	Minnow Trapping
17-January-2023	0.310/310	5	-	-
01-March-2023	0.031/31	4.8-5	X[1]	X[4]
15-May-2023	0.021/21	11.1	-	-
13-September-2023	0.013/13	8.7	-	X[5]
29-February-2024	0.081/81	5.5	X[2]	X[6]
08-July-2024	0.025/25	10.1	X[3]	X[7]

Notes: [1]Electrofishing for 300 m, for a total of 300 seconds; [2]Electrofishing 300 m, for a total of 200 seconds; [3]Electrofishing 300 m, for a total of 90 seconds. [4] Minnow trapping at 8 sites (14 traps), average soak time was 16 hours; [5] Minnow trapping at 7 sites

[6] Ministry of Forests (MoF). 1998. Fish-stream Identification Guidebook. V 2.1. Forest Practices Code of British Columbia. Prov. B.C., Victoria. B.C. Available at: fishstream.pdf (gov.bc.ca)

[7] Ministry of Environment, Fish Inventory Unit (MOE). 2001. Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: Standards and Procedures. Version 2.0. Resource Inventory Standards Committee. Available at: Reconnaissance (1:20 000) (gov.bc.ca)

(12 traps), average soak time of 12 hours. [6] Minnow trapping at 7 sites (12 traps), average soak time of 22 hours. [7] Minnow trapping at 10 sites (10 traps), average soak time of 24 hours.

Electrofishing was completed by a two-person crew including an AE qualified environmental professional (QEP), targeting preferred habitat features for CCT (i.e., pools and riffles with cover). A thorough single pass of the sampling areas in the study area was completed using a Smith Root Model LR-24 Electrofisher. The electrofisher settings were based on water conductivity and expected size of fish encountered in Soames Creek. Electrofishing was completed over a total channel of the study area, selectively picking high-quality habitats.

Minnow trapping was also completed by an AE QEP and support crew. Minnow trapping was focused on deeper, slower habitats associated with cover (habitat preferred by juvenile CCT). At each sampling site, traps were labelled with ribbon. Traps deployed were baited with either cured salmon-roe or dry cat food. During all fish sampling events, traps were placed during the day and left to fish overnight.

All fish captured were identified to species and measured for length and weight before being carefully released unharmed at the site of capture. All fish handling was completed in situ, via a fish view or while in a fine mesh net.

Basic water quality parameters (temperature, pH, and conductivity) were also measured during each fish sampling event, immediately before sampling occurred.

5.1.2 Fish Habitat Assessment

The fish habitat assessment included surveying the biophysical components that characterized the aquatic environment in Soames Creek. The fish habitat assessment was completed during the initial field survey on January 17, 2023. The fish habitat assessment followed the assessment methods in Resource Inventory Committee (RIC) (2001)[8] and associated fish habitat site cards were completed along four representative locations of Soames Creek between Marine Drive and upstream above Granthams Spring discharge location (Figure 4-1). During the fish habitat assessment, habitat conditions were noted, and multiple potential fish passage obstructions were documented. Obstructions to anadromous fish passage including the 1.7 m hanging culvert downstream of Marine Drive were previously documented in a fish habitat assessment completed by Associated in 2019 that was submitted to MoF[3].

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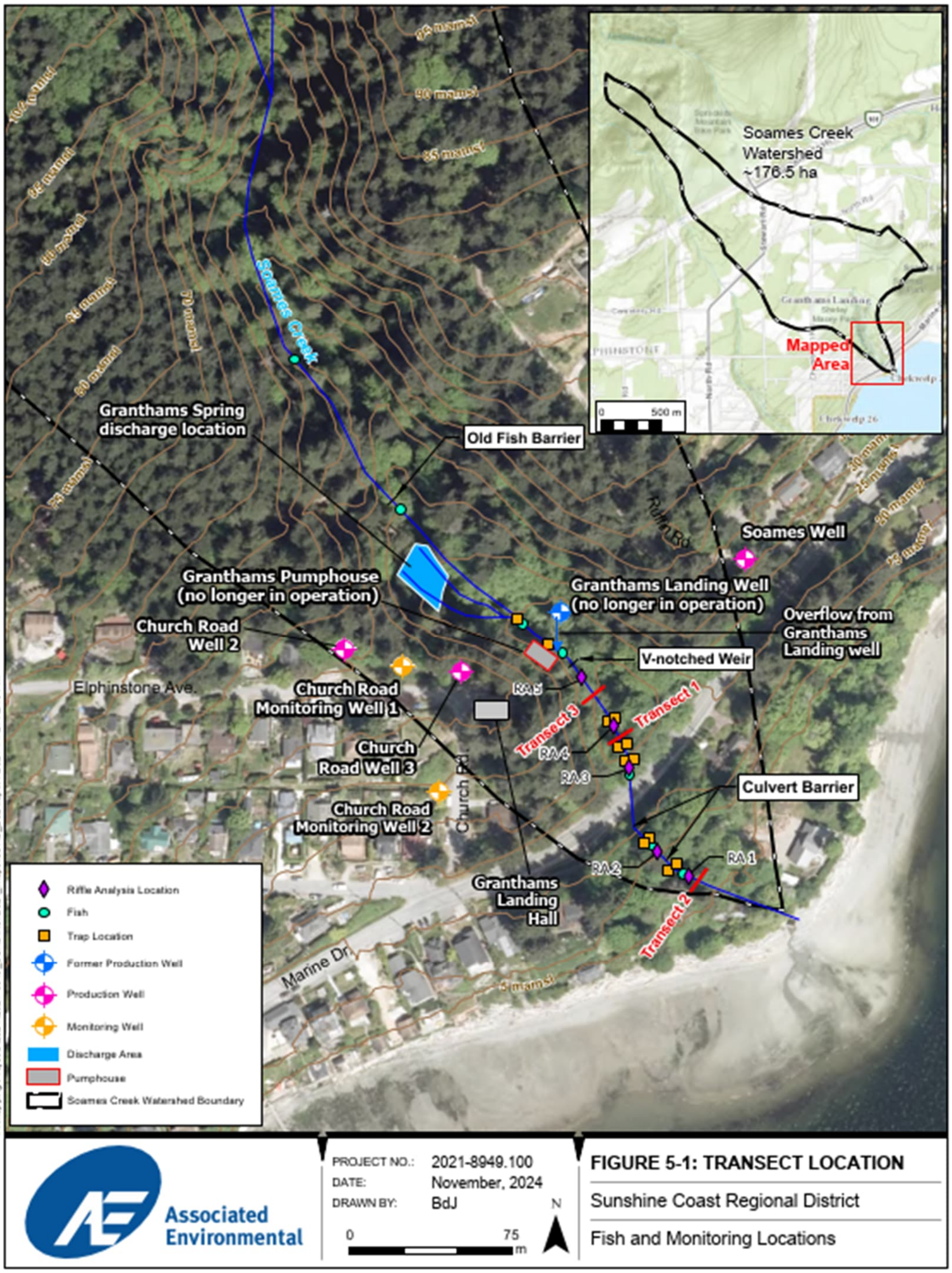
[8] Resources Inventory Committee (RIC). 2001. Prepared by the BC Fisheries Information Services Branch for the Resources Inventory Committee. 2001. Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures. Available at: https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/recce2c.pdf

Figure 5-1 Field Sampling Program



5.1.2.1 Habitat Transects and Weighted Usable Width Measurements

To evaluate the preliminary EFN and develop a Reliable EFN, three cross-channel transects (transects) were established downstream of the Granthams Spring and Granthams Landing Well locations along Soames Creek prior to the operation of the wellfield (Transect 1 and 2 were established on January 17, 2023, and Transect 3 was established March 1, 2023) (Figure 5-1) (Table 5-2). The transects were installed following the standards and procedures provided in Hatfield (2003)[9]. All three transects were installed and surveyed in riffle mesohabitats based on providing suitable rearing (T1 and T2) and spawning (T3) habitat for CCT (Table 5-2). Transects through pools were not chosen as we were focussing mainly on spawning and rearing habitat for CCT. Documented higher winter flows maintain sufficient depth to allow successful overwintering in Soames Creek.

Table 5-2 Cross-Channel Transect Locations

Cross-Channel Transect	Habitat Type	UTM Easting	UTM Northing
Transect 1 (T1)	Pool tail-out/riffle	464239	5473588
Transect 2 (T2)	Pool tail-out/riffle	464282	5473518
Transect 3 (T3)	Pool tail-out/riffle	464219	5473618

Depth, velocity and substrate type at each transect site were measured using standard industry accepted survey techniques based on the BC Instream Flow Methodology[10]. Transect panels were generally spaced 0.15 m apart to capture the stream topography and channel characteristics around objects including boulders and exposed mid-channel gravel bars. Substrate type was assessed for dominant size class, observed within a radius of 0.5 m around the base of the SonTek FlowTracker2 at the respective vertical panel. Repeated measurements at each transect were collected during subsequent field surveys (Table 5-3). Field surveys and transect measurements targeted a range of streamflow conditions (high, moderate and low flows) to capture seasonal flow conditions experienced

[9] Hatfield, T., A. Lewis, D. Ohlson and M. Bradford, 2003. Development of Instream Flow Threshold as Guidelines for Reviewing Proposed Water Uses. Prepared for the BC Ministry of Sustainable Resource Management and the BC Ministry of Water, Land, and Air Protection. Victoria, BC. Available at: https://www.env.gov.bc.ca/wld/documents/bmp/phase2_instreamflow_thresholds_guidelines.pdf

[10] Lewis, A., T. Hatfield, B. Chilibeck and C. Robert. 2004. Assessment methods for fish, fish habitat, and in-stream flow characteristics in support of applications to dam, divert, or extract water from streams in British Columbia. Prepared for Ministry of Water, Land, and Air Protection and Ministry of Sustainable Resource Development. Victoria, BC. Available at: https://www.env.gov.bc.ca/wld/documents/bmp/assessment_methods_instreamflow_in_bc.pdf

in Soames Creek. Transect measurements at Transect 3 were not collected beyond the field survey on September 13, 2023, since subsequent visits determined that the channel morphology had changed.

Table 5-3 Transect Measurements at Various Streamflow Conditions in Soames Creek.

Streamflow (m^3/s)/(L/s)	Date	Transect 1	Transect 2	Transect 3
0.310/310	January 17, 2023	Measured	Measured	Transect not established
0.031/31	March 1, 2023	Measured	Measured	Measured
0.021/21	May 15, 2023	Measured	Measured	Measured
0.013/13	September 13, 2023	Measured	Measured	Measured
0.081/81	February 29, 2024	Measured	Measured	Not measured (channel morphology has changed)
0.025/25	July 8, 2024	Measured	Measured	Not measured (channel morphology has changed)

The data collected during the transect measurements was used to determine weighted usable widths (WUW) for both rearing and spawning habitat for CCT at each transect over a range of flows. The WUW's for rearing and spawning were calculated based on the procedure outlined in the BC Instream Flow Methodology[10]. Habitat suitability indexes (HSI) for cutthroat trout rearing and spawning were used to assess a value to the depth, velocity and substrate measurements at each vertical panel along the transects and were used to calculate the WUW's. The WUW's calculated at each transect were plotted graphically for the range of flow conditions measured and were used to evaluate the habitat quality during preliminary EFN flows, specifically the low streamflow conditions between May and October (Table 2-1).

5.1.2.2 Riffle-Pool Crest Assessment

Riffle-pool crest measurements were collected along the study area (300 m section of Soames Creek from below the private driveway upstream, past the Grathams Landing Well) and were focused on areas between high-quality deep pool habitats. Riffle-pool crest (RPC) measurements were collected by a QEP using a foldable field ruler. The RPC measurements were used to determine whether suitable depths occurred to permit fish habitat use (i.e., connectivity) under the lowest flow conditions (July-September) outlined in the preliminary EFN (Table 2-1). Based on discussions with MoF, the minimum RPC depth suitable for fish passage of small-bodied resident CCT in Soames Creek was set at 6 cm. RPC measurements were recorded during all five field surveys along the study area in Soames Creek to assess for fish habitat connectivity.

6 FIELD SURVEY RESULTS

6.1 FISH PRESENCE AND DISTRIBUTION SAMPLING

Fish sampling was completed a total of four times along Soames Creek between March 1, 2023, and July 8, 2024. All fish sampling events focused on the study area. A summary of fish captures for each fish sampling event is provided in Table 6-1.

Table 6-1 Fish Captures for Each Fish Sampling Event

Field Sampling Date	Streamflow (m^3/s)/(L/s)	Coastal Cutthroat Trout (*Oncorhynchus clarki clarki*) Age Class			Total Capture
		Young of Year	Juveniles	Subadult	
01-March-2023	0.031/31	6	30	1	37
13-September-2023	0.013/13	2	17	-	19
29-February-2024	0.081/81	4	12	-	16
08-July-2024	0.025/25	10	35	-	45

Notes: Fish capture data for electrofishing and minnow trapping were combined. Fish sampling was completed by AE staff on March 1, 2023, and September 13, 2023, and by ISL staff on February 29, 2024, and July 8, 2024. Electrofishing was not conducted during the September 13, 2023, fish sampling event. Young of year fork length <80 mm; Juvenile fork length 81-174 mm; Subadult fork length 175-250 mm.

To conduct a preliminary comparison of fish capture results between sampling events in the study area, the catch per unit effort (CPUE), for electrofishing and minnow trapping were analyzed. This required converting effort (time) for both sampling techniques into a common unit (minutes). Results of the CPUE comparison between fish sampling events by sampling techniques is provided in Table 6-2.

Table 6-2 CPUE Results Between Sampling Events along Soames Creek

Field Sampling Date	Fish Captured in Minnow Traps	Effort for Minnow Trapping (min)	CPUE for Minnow Trapping	Fish Capture by Electrofishing	Effort for Electrofishing (min)	CPUE for Electrofishing
01-March-2023	14	960 (16 hrs)	0.015	23*	5 (300 s)	4.6
13-September-2023	19	720 (12 hrs)	0.026	-	-	-
29-February-2024	4	1,320 (22 hrs)	0.003	12	3.3 (200 s)	3.6
08-July-2024	36	1,440 (24 hrs)	0.025	9	1.5 (90 s)	6

Notes: CPUE=Catch per Unit Effort (Fish/Effort), "-" Electrofishing was not conducted during the sampling event.
*During the March 1, 2023, field sampling, Associated captured a spawning coastal cutthroat trout while electrofishing. Subsequently, Associated staff stopped electrofishing after the spawning fish was captured and release immediately.

The CCT captured during the field sampling indicates that several age classes are present in Soames Creek based on the various fork lengths observed. Also, the consistency in age classes between fish captures from March 1, 2023, to July 8, 2024, suggests that impacts to the resident CCT population from the first year of operation under the preliminary EFN has not occurred (or is not detected based on the sampling results).

6.2 FISH HABITAT ASSESSMENT

A fish habitat assessment of the study area (approximately 300 m) was completed on January 17, 2023. During the survey, two reaches of Soames Creek were assessed for biophysical conditions and four site cards were completed (Reach 1 – Site Card 1, Reach 2 – Site Card 2,3,4) (Table 6-3). Reach 1 was from the mouth of Soames Creek to Marine Drive. Reach 2 was upstream of Marine Drive and ended above the Granthams Springs discharge location. During this assessment the stream discharge was considered high stage (~310 L/s).

Table 6-3 Key Fish Habitat Characteristics at each Site Card Location

Site Card	Gradient (%)	Channel Width (m)	Wetted Width (m)	Res Pool Depth (cm)	Substrate		Morphology
					Dominant	Sub Dom	
1	5	5.5	2.7	0.15	Cobble	Gravel	SP_b
2	12	4.8	3.9	0.22	Cobble	Gravel/Boulder	CP_w
3	11	4.8	3.4	0.22	Cobble	Gravel/Boulder	SP_b
4	12	6.2	3.2	0.22	Cobble	Gravel/Boulder	SP_b

SP_b – Step-pool morphology with dominant boulder bed material; CP_w- Cascade-pool morphology with large woody debris (LWD) present, minor function.

At the Reach 1 site card location, all cover types were observed (except small woody debris and instream vegetation), overhanging vegetation and deep pools were dominant and subdominant cover types, respectively. The channel was occasionally confined with stream banks comprised of gravels and cobbles, and riparian vegetation was predominantly shrubs. Spawning habitat was observed in small patches but was observed to likely be dry outside of flood or high-flow stages. Rearing habitat was fair given the abundant overhanging cover but limited large woody debris preferred by CCT. Overwintering habitat was poor based on the absence of deep pool habitat. Evidence of channel dredging was observed in Reach 1 and Reach 2, below and above Marine Drive, respectively.

At the Reach 2 site card 2 location, all cover types were observed (except instream vegetation) with overhanging vegetation as the dominant type. Cover types observed the site card 3 location was boulder and deep pool, and the site card 4 location was boulder and undercut bank. The channel was fairly confined for site card 2 and 4, and occasionally confined for site card 3. Riparian vegetation at site card location 2 and 4 was a mature mixed forest. Riparian vegetation at the site card 3 was absent, due to riprap placed along the channel. Spawning habitat was fair for all three site card locations, with small patches of suitable gravels along the stream margins. Rearing habitat was fair at all three site card locations, based on the presence of small side channels and habitat complexity associated with instream boulder cover. Overwintering was fair at all three site card locations, since limited deep pool habitat (>0.5 m depth) was observed.

6.2.1 Habitat Transects and Weighted Usable Widths

The WUW rearing and spawning values for each transect is provided in Table 6-4 and illustrated in graphically in Figures 6-1 to 6-6. Note that Transect 3 only has three measurements due to significant changes in the channel cross-sectional profile from sediment aggregation after the September 13, 2023, field survey.

Table 6-4 WUW Values for Spawning and Rearing Life-Stages for Coastal Cutthroat Trout in Soames Creek

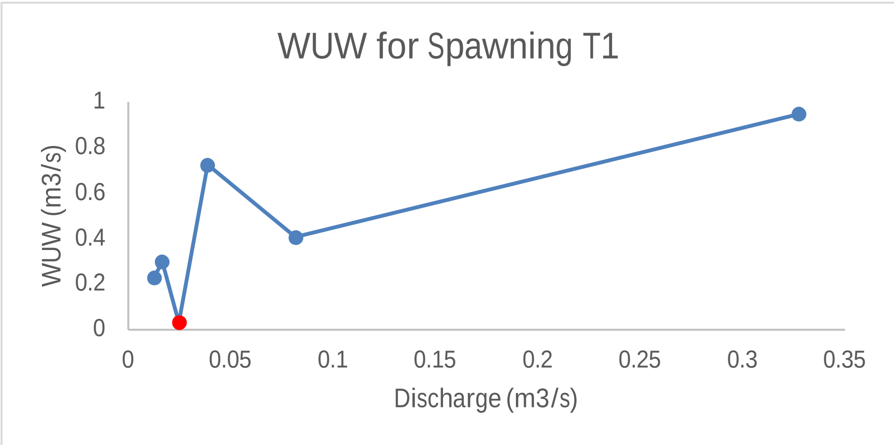
Transect	Date	Discharge (m^3/s)/(L/s)	WUW for Spawning (m^3/s)	WUW for Rearing (m^3/s)
T1 (50m US of Marine Drive)	January 16, 2023	0.310/310	0.945	0.744
	March 1, 2023	0.031/31	0.721	1.729
	May 15, 2023	0.021/21	0.298	1.460
	September 13, 2023	0.013/13	0.227	1.068
	February 29, 2024	0.081/81	0.405	0.983
	July 8, 2024	0.025/25	0.0288*	0.358*
T2 (25m US of Ocean)	January 16, 2023	0.310/310	0.939	1.654
	March 1, 2023	0.031/31	0.710	1.212
	May 15, 2023	0.021/21	0.515	1.316
	September 13, 2023	0.013/13	0.228	0.963
	February 29, 2024	0.081/81	1.325	1.119
	July 8, 2024	0.025/25	0.221*	0.497*
T3 (9.6m DS of V-notch weir)	March 1, 2023	0.031/31	0.609	1.818
	May 15, 2023	0.021/21	0.373	1.783
	September 13, 2023	0.013/13	0.261	1.122

* The spawning and rearing WUW values from the July 8, 2024, field measurements by ISL were lower than anticipated based on the WUW values produced from flows both lower and higher then the 25 L/s during the field visit. This would suggest either a sampling bias (AE vs. ISL field staff) or a change in channel morphology occurred at both T1 and T2.

Transect 1 (T1)

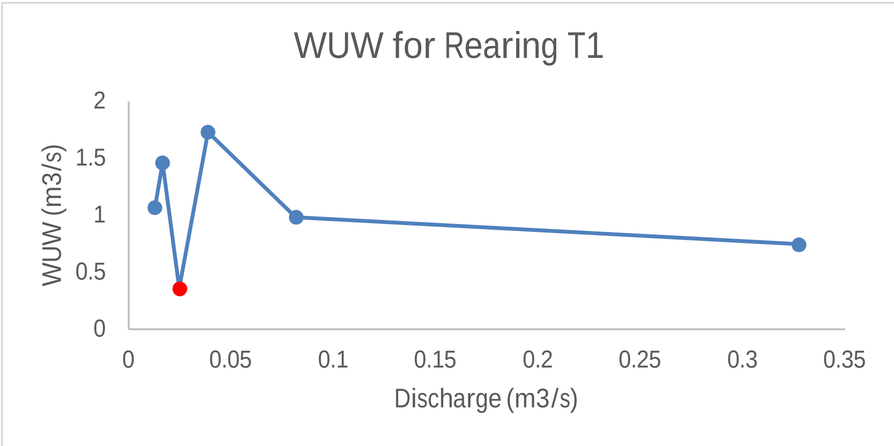
The spawning WUWs at T1 indicates that a streamflow of 0.031 m^3/s in Soames Creek provides the highest spawning habitat value for CCT, with exception of the WUW value at 0.310 m^3/s (Figure 6-1). The spawning WUW at 0.310 m^3/s is expected to provide higher spawning habitat simply based on the larger wetted width and sampled vertical panels across the transect, however, such flows are typical of a high-flow stage (i.e., spring freshet or flood event) and cannot be realistically expected to occur across the periodicity of spawning for CCT (Table 2-2). In addition, WUWs for CCT rearing habitat at T1 was also the highest at 0.031 m^3/s (Figure 6-2). This is likely attributed to the lower velocities and depth measurements that corresponded to higher HSI values at this discharge. The WUW for spawning and rearing habitat at T1 at a stream discharge of 0.025 m^3/s was less than half that of the WUW's at a discharge of 0.021 m^3/s, and less then the WUW's at a discharge of 0.013 m^3/s (Table 6-4). These results suggest that an abnormality occurred in either the data collection by ISL or the transect bathymetry, resulting in WUW's below expectations given the WUW values at similar or lower discharges at the T1 for spawning and rearing habitat, respectively.

Figure 6-1 WUWs for Coastal Cutthroat Trout Spawning Habitat at Transect 1



*The red dot corresponds to the WUW value from the data collected by ISL on July 8, 2024.

Figure 6-2 WUWs for Coastal Cutthroat Trout Rearing Habitat at Transect 1

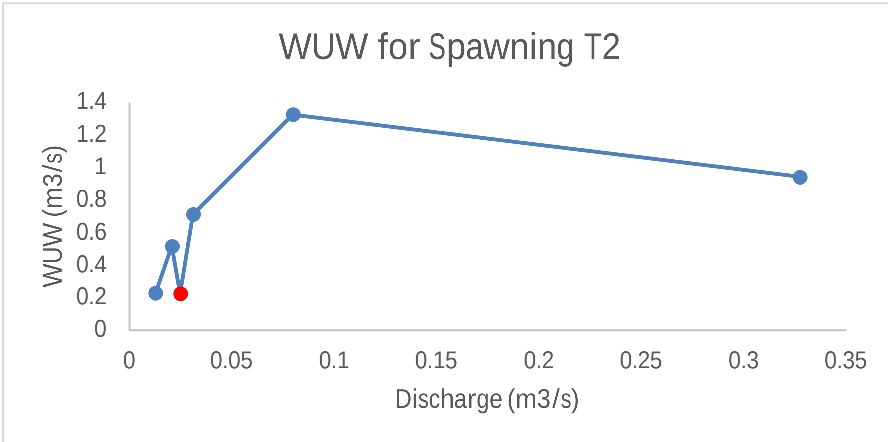


*The red dot corresponds to the WUW value from the data collected by ISL on July 8, 2024.

Transect 2 (T2)

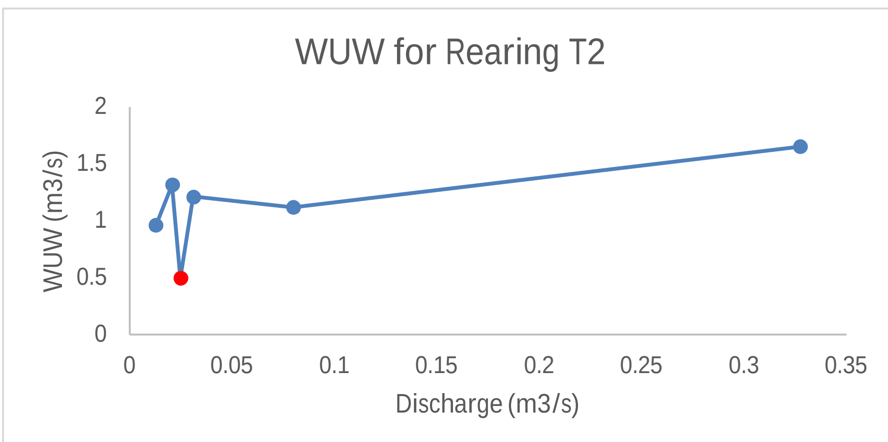
The highest WUWs for spawning at T2 occurred at flows of 0.081 m^3/s (February 29, 2024). WUWs at discharges lower than 0.081 m^3/s decline drastically, while at higher flows, the WUW's appear to decline more gradually (Figure 6-3). The WUW values for CCT rearing habitat at T2 was the highest at 0.021 m^3/s with exception to flows at 0.310 m^3/s; however, flows from 0.013 m^3/s to 0.81 m^3/s also relatively comparable to 0.021 m^3/s (Figure 6-4). The WUW for spawning and rearing habitat at T2 at a stream discharge of 0.025 m^3/s was less than that of the WUW's at a discharge of 0.021 m^3/s, and less then the WUW's at a discharge of 0.013 m^3/s (Table 6-4). These results suggest that an abnormality occurred in either the data collection by ISL or the transect bathymetry, resulting in WUW's below expectations given the WUW values at similar or lower discharges at T2 for spawning and rearing habitat, respectively.

Figure 6-3 WUWs for Coastal Cutthroat Trout Spawning Habitat at Transect 2



*The red dot corresponds to the WUW value from the data collected by ISL on July 8, 2024.

Figure 6-4 WUWs for Coastal Cutthroat Trout Rearing Habitat at Transect 2



*The red dot corresponds to the WUW value from the data collected by ISL on July 8, 2024.

Transect 3 (T3)

The WUWs for CCT spawning habitat increased linearly at T3 between flows of 0.013 m^3/s and 0.310 m^3/s (Figure 6-5). The WUWs for CCT rearing habitat at T3 were highest at 0.031 m^3/s, however, the WUW at 0.21 m^3/s was similar, only deviating by 0.035 m^3/s in WUW value (Table 6-4). Below 0.021 m^3/s, the WUW for rearing decreases rapidly based on the flow measurements at 0.013 m^3/s (Figure 6-6). The wetted channel width surveyed at T3 were mostly consistent between 0.021 m^3/s and 0.031

m^3/s which corresponded to similar rearing habitat availability based on the values from the rearing HSI.

Figure 6-5 WUWs for Coastal Cutthroat Trout Spawning Habitat at Transect 3

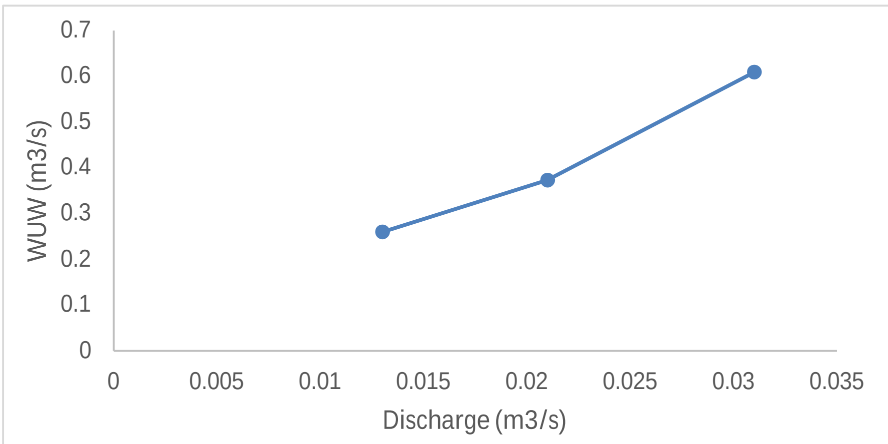
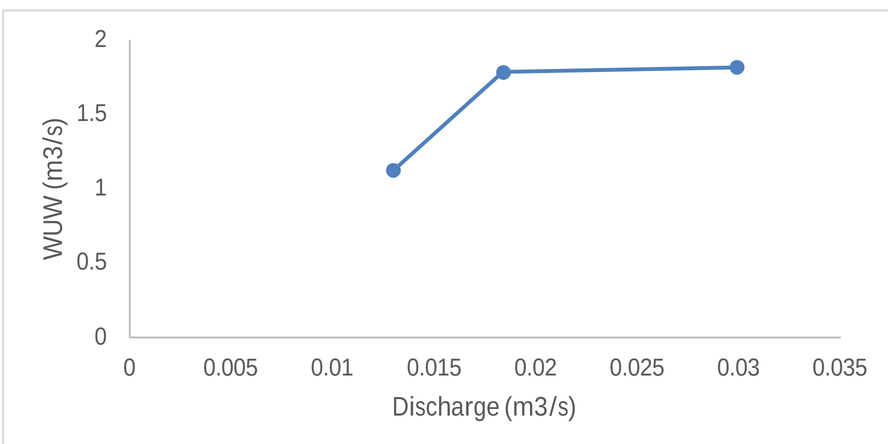


Figure 6-6 WUWs for Coastal Cutthroat Trout Rearing Habitat at Transect 3



The highest WUWs for CCT spawning and rearing habitat at T1 and T3 corresponds to a discharge of 0.031 m^3/s (Table 3-1). The highest WUW for CCT spawning and rearing habitat for T2 coincided with a discharge of 0.081 m^3/s and 0.021 m^3/s, respectively (Table 6-4). In comparison, the preliminary EFN values during CCT spawning life-stage (January – mid June) proposes a discharge ranging from 0.0203 m^3/s in January to 0.017 m^3/s in June, and discharge of 0.0135 m^3/s from July to September (Table 2-1).

At T1, preliminary EFN values of 0.017 m^3/s to 0.023 m^3/s, correspond to WUWs for spawning habitat below the optimum streamflow of 0.031 m^3/s (Table 6-4; Figure 6-1). The WUW for the transect measurement on May 15, 2023 (0.021 m^3/s), which closely resembles to the preliminary EFN value for CCT spawning periodicity (January – June) (Table 2-1), was 0.298 m^3/s, which is much lower than the WUW of 0.945 m^3/s at flows of 0.031 m^3/s. A similar difference in WUWs can be seen at T3, however, the relatively few sampling data points (three) limit the ability to interpret the WUWs at this transect (Figure 6-5). At T2, the highest WUWs for spawning habitat occurred at a discharge of 0.081 m^3/s (WUW of 1.325 m^3/s) (Table 6-4; Figure 6-3), while the preliminary EFN values during the CCT spawning periodicity would produce WUWs near 0.515 m^3/s, based on the WUW value measures at a discharge of 0.021 m^3/s during the May 15, 2023, field visit (which most closely resembles the current preliminary EFN flows). The large difference between WUWs at each transect between the preliminary EFN values and the optimum flows, suggests that additional flows of 0.01 m^3/s could provide a notable increase in spawning habitat; however, the preliminary EFN values are already likely exceeded due to the rain dominated natural hydrological nature of Soames Creek during the winter-spring (November to April), and an increase to preliminary EFN values would not likely require the need for additional supplemental flows from the wellfield, especially when the well field is not in operation.

6.2.2 Riffle-Pool Crest Assessment

The riffle-pool crest analysis at low flows during the September 13, 2023 (flows of 0.013 m^3/s) and subsequently at flows of 0.025 m^3/s on July 8, 2024, were determined to provide sufficient depths for fish passage between pool habitats (at least 6 cm) (Table 6-3).

Three anthropogenic barriers to fish movement were identified during the assessments include the hanging culverts under the private driveway (downstream of Marine Drive), and under Marine Drive, and a concrete weir immediately downstream of Transect 3, which block upstream fish passage. Resident CCT are limited to downstream passage, or they are confined to the reaches that they reside in.

In addition, during the September assessment, the channel upstream of the spring was completely dry in Soames Creek, suggesting that the remaining water in the study reach is 100% dependent on flows from the spring, well seepage and additional flows SCRD releases from the supplemental flow pipe. A buffer of 2 L/s has been added to the preliminary EFN values as a contingency to mitigate potential errors in the automated operation during operations to ensure flow for fish movement, when the well field is in operation.

Table 6-5 Riffle-Pool Crest Measurements along Soames Creek

Field Survey Date	Streamflow (m^3/s)/(L/s)	Range of Riffle-Pool Crest Depths Measured(cm)
March 1, 2023	0.031/31	8-12
May 15, 2023	0.021/21	8-10
September 13, 2023	0.013/13	6-10
February 29, 2024	0.081/81	12-17
July 8, 2024	0.025/25	6-9.5

Outside of the low flow period (November to April), the hydrometric data suggests that the natural stream flow in Soames Creek is sufficient to support overwintering, rearing and spawning activities.

7 DISCUSSION

7.1 FISH PRESENCE AND DISTRIBUTION

The fish sampling results indicate the Preliminary EFN flows used during the operating period of the wellfield in 2023 did not negatively impact the fish presence, distribution, age class composition for the resident CCT population in Soames Creek; especially during the lowest flow months (June-September; Table 2-1) where available habitat in Soames Creek was most limiting. Based on the field sampling results between March 1, 2023, and July 8, 2024, CPUE results demonstrate that similar or greater populations of CCT were present in Soames Creek; however, there are many variables that could contribute to this result including, sampling bias and skill between QEP's, warm winter conditions providing a shorter cessation period from feeding (invertebrate production in Soames Creek was good, and winter conditions were short-lived). Subsequently, the fish sampling results suggests that the preliminary EFN flows are suitable for maintaining the CCT populations in Soames Creek.

7.2 WEIGHTED USABLE WIDTHS

The highest WUWs for rearing habitat at each transect coincided with flows that are higher than the preliminary EFN flows during the lower flow period (June-September) (Table 2-1; Table 6-4). At T1 and T3, the highest WUWs coincided with flows of 0.031 m^3/s and flows of 0.021m^3/s at T2 (Table 6-4). Unlike the differences observed in WUWs between the optimum flows and the preliminary EFN values during the CCT spawning periodicity (Figure 6-1; Figure 6-3; Figure 6-5), the difference in WUWs for CCT rearing periodicity are less pronounced (Figure 6-2; Figure 6-4; Figure 6-6). For example, the WUWs for T2 at flows between 0.013 m3/s and 0.081 m3/s are closely grouped and reflect a subtle increase in WUW at a discharge of 0.021 m^3/s (Figure 6-4). While the WUW at T1 is lower at a discharge of 0.013 m^3/s than at a discharge of 0.031 m^3/s, the WUW at 0.013 m^3/s is still higher for rearing habitat than at measured flows of 0.081 m^3/s (Figure 6-1).

From a preliminary review of the highest WUWs from the stream transect measurements, it is evident that the optimum instream flows for all three transects (T1, T2, and T3) are higher than the suggested discharge in the preliminary EFN for the spawning and rearing life-stage periodicity of CCT (Table 2-2). This suggests that the preliminary EFN values may provide insufficient habitat for CCT. However, based on the hydrometric data collected to date for Soames Creek (Figure 4-1), it appears unlikely that these optimum flow conditions (0.021 – 0.031 m^3/s) will occur over the duration of the spawning and rearing life-stage for CCT in Soames Creek, even when no water withdrawal from the wellfield is occurring (i.e., before wellfield operation in May). This is consistent with historic hydrological records of streamflow in Soames Creek which has been as low as 10L/s (0.010 m^3/s), and resident populations of CCT have sustained viable populations. It is important that the Reliable EFN does not have flows lower than the lowest flows in the preliminary EFN (Table 2-1), as these low flows have yet to be studied.

7.3 RIFFLE-POOL CREST ASSESSMENT

Based on the consistent RPC measures above the threshold depth of 6 cm, especially during the September 13, 2023, field survey visit suggests that the preliminary EFN flows are conducive to maintaining the connectivity between quality fish habitat in the study area for Soames Creek.

8 RECOMMENDED RELIABLE EFN FOR SOAMES CREEK

Results from both the fish presence and distribution assessment (fish sampling) and the RPC assessment are supportive of the preliminary EFN flows established from the synthetic flow dataset. While the rearing and spawning WUW's for CCT suggests that increased flow augmentation in June-September would increase the habitat quality , however the spawning periodicity does not overlap (June-September) (Table 2-2). In addition, the WUW results would not likely be achieved if proposed (i.e., 31 L/s for optimum rearing conditions based on the three transects measures) as realistic flows from the hydrometric data prior to operation of the wellfield showed that the streamflow often dropped near 10 L/s during the summer (most of the surface flow coming from both Granthams Landing Well and Granthams Springs).

Our recommendations for the Reliable EFN are to maintain similar flows as the preliminary EFN (plus 2L/s) but create a stable step-up and step-down stage in monthly flows (Table 8-1). For example, rather than incremental changes in EFN flows in Soames Creek between months (Table 2-1), the recommended Reliable EFN proposes a consistent flow of 22.7 L/s between December and May, with an intermediary step-up in November and step-down in June after CCT incubation and emergence periodicity (Table 2-2) and prevent desiccation or stranding (the channel is occasionally to frequently confined which would limit stranding more typical of a lower gradient unconfined stream). Followed by a step-up in November when municipal water demand from the wellfield will likely cease.

Table 8-1 Recommended Reliable EFN Flows for Soames Creek to Support the Wellfield Operation

Month	Preliminary EFN (m^3/s)/(L/s)	Preliminary EFN + 2 L/s Buffer (m^3/s)/(L/s)*	Recommended Reliable EFN (m^3/s)/(L/s)
January	0.0203/20.3	0.0223/22.3	0.0227/22.7
February	0.0221/22.1	0.0241/24.1	0.0227/22.7
March	0.0225/22.5	0.0245/24.5	0.0227/22.7
April	0.023/23.0	0.025/25.0	0.0227/22.7
May	0.0208/20.8	0.0228/22.8	0.0227/22.7
June	0.0172/17.2	0.0192/19.2	0.019/19.0
July	0.0135/13.5	0.0155/15.5	0.0155/15.5
August	0.0135/13.5	0.0155/15.5	0.0155/15.5
September	0.0135/13.5	0.0155/15.5	0.0155/15.5
October	0.024/24.0	0.026/26.0	0.0155/15.5
November	0.0183/18.3	0.0203/20.3	0.0207/20.7
December	0.0207/20.7	0.0227/22.7	0.0227/22.7

*A buffer of 2L/s was added to the preliminary EFN flows and to the recommended reliable EFN flows, as employed during the preliminary EFN.

9 CONCLUSION

After two years (2023-2024) of observing the management of flows in Soames Creek under the use of the preliminary EFN, we believe that the information collected during the field surveys were adequate to develop a Reliable EFN for the long-term operation of the wellfield. We determined that over the last two years, the CCT population has not been negatively impacted by the wellfield operation and the preliminary EFN based on the life stage assemblages (i.e., fry and juveniles captured) observed during fish sampling events (Table 6-1). The proposed Reliable EFN has been developed following the "Steps to Set a Reliable EFN" outlined in the AMP; however, we have proposed to keep flow levels consistent during important fish periodicity timelines such as overwintering, spawning, and incubation periods (Table 8-1).

Annual monitoring of flows and fish sampling that replicate the previous data collection methods (transects and fish sampling) is recommended. Changes to the hydrological conditions, habitat value, connectivity, and CCT (age class and numbers captured) can be determined by comparing new fish and flow data to previous years. If signification changes are identified, flow adjustments and changes to the reliable EFN can be revisited, with support of Provincial agencies.

Soames Creek is a highly manipulated stream in a highly variable seasonal and rain dominated system. It is also a stream that is directly connected to an unconfined aquifer, hence proper management of the flows is critical to support the aquatic species that reside in the lower reaches. It is important that the proposed Reliable EFN is followed to order maintain that population, following the ramping and aquifer recharge conclusions that have been incorporated into the AMP.

To date, the flows in Soames Creek have been managed to support community drinking water needs from the wells, operating between May and October, in a typical year. Once the needs to take water subside in the fall, the pumps ramped down and shut off for the winter. Following ramp down, the creek returns to natural baseflow conditions, and SCRD no longer needs to supplement the flows in Soames Creek.

10 CLOSURE

This report was prepared for the Sunshine Coast Regional District to provide a proposed Reliable EFN for Soames Creek in support of the long-term operation of the Church Road Wellfield.

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If you have any questions, please contact the undersigned.

Prepared by,

FOR

Samuel Grenier, BIT, CESCL
Environmental Scientist

SG

Reviewed by,

Dave Hayward, R.P.Bio., CPESC
Manager, Environmental Assessment and Planning.