FSCI Biological Consultants

April 10, 2021 File No.: FSCI-20-0015

Remko Rosenboom
General Manager, Infrastructure Services
Sunshine Coast Regional District
1975 Field Road, Sechelt, BC
V0N 3A1

Re: Chapman Creek Low Flow Assessment and Potential Impacts/Benefits to Rearing Salmonids

Dear Remko:

In 2020, ***FSCI*** Biological Consultants (*FSCI*) began a review of the environmental flow needs (EFN) for Chapman Creek. This process is required under the Provincial Water Sustainability Act and follows a process outlined in the provincial EFN Policy and applies to all applications and amendments to water use licenses using an environmental risk framework and where applicable quantitative assessments of existing aquatic habitats.

This document is the second, prepared for lower Chapman Creek and length of creek influenced by potable water withdrawal and periods of extreme water limitations. This paper summarizes the results of a review on the influence of reducing the existing instream flow on lower Chapman Creek. In particular the potential impacts on rearing juvenile salmonids.

1.0 Background

Chapman Creek is the principle potable water source for the lower sunshine coast, providing water to approximately 20,000 residents. In drier years, the source of this water, Chapman and Edwards Lakes has been drawn to critical levels resulting in Stage 4 water restrictions. In addition to the management of lake storage, the SCRD must ensure a minimum instream flow (IFR) below their water intake ensuring the lower river can safely support and maintain resident and anadromous rearing salmonid populations.

The current minimum instream flow (IFR) is established at 020 m^3/s throughout the year but is most critical during the summer period of Mid July to Late September. During this period, the IFR provides the baseflow. This volume established in 2016 was originally recommended to assist adult Pink Salmon migration in August and September. The original work did not specifically focus on the baseflow effects and benefits for rearing juvenile salmonids (*Bates*, 2016).

In recent years, the minimum flow threshold has presented challenges for the community. Following a review of the extreme low water and supply conditions in 2018 and 2019, it has been proposed that, if the IFR were dropped a to 0.18- m^3/s, beginning in Late June through to September, that the additional stored water would reduce the potential community water shortage emergency.

This change in IFR (200 to 160-180-lps), while seemingly low, is consistent with the 10-yr 7-day low flow estimates for Jun through September (*Ahmed*, 2017), and provides an estimated additional 20 days of water supply under and delay the need to activate the emergency siphon system.

The proposed reduction in IFR would include June through September, with compliance monitoring continuing at the SCRD gauge site below the intake and monitoring of juvenile salmonid response proposed for August and September, the most critical period.

2.0 Assessment Area

Chapman Creek is a 3rd order stream is located south of Sechelt BC approximately 40-km northwest of Vancouver, BC. It is approximately 18-km in length and flows from the Tetrahedron Plateau in Tetrahedron Provincial Park to the Strait of Georgia. The river is divided into anadromous and non-anadromous length and the area of interest for the effects of reduced baseflows is the anadromous length (**Figure 1**).

The river supports a variety of salmonids the entire length. A passage barrier (falls) located approximately 7-km upstream from the mouth defines the upper extent of anadromous salmonid distribution. The anadromous length of Chapman is divided into 5 reaches with Reaches 3-5 providing the majority of rearing habitat for; coho salmon (*Oncorhynchus kisutch*), salmon, steelhead (*O. mykiss*) and searun cutthroat (*O. clarkii clarkii*) trout. Further review has identified Reaches 3 and 4 as the areas of the greatest, available rearing (and spawning) and the reaches that are affected the most from summer baseflows and potential juvenile stranding.

3.0 Methodology

3.1 Habitat Assessment

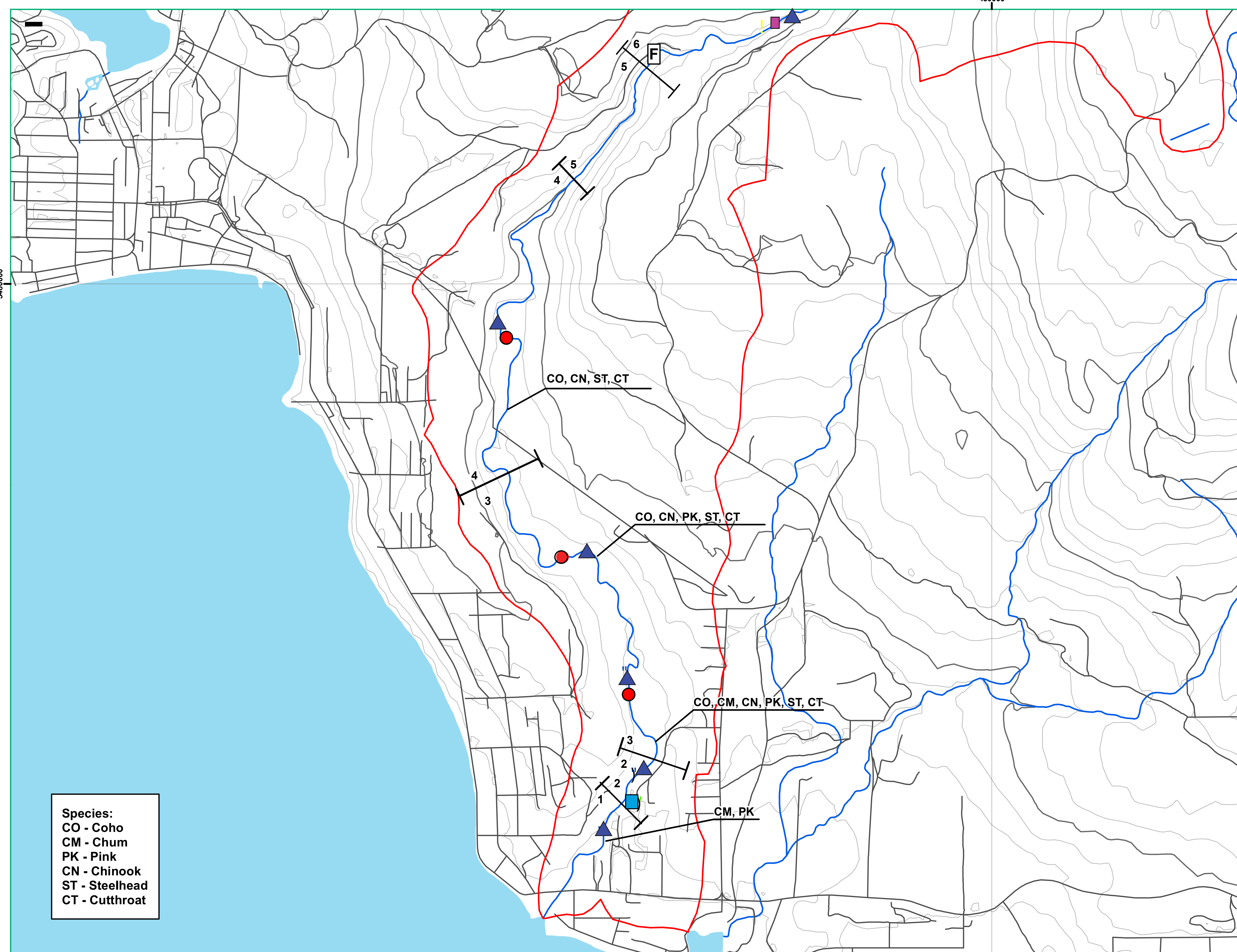
A habitat assessment was completed on the anadromous length of Chapman Creek between July 28 and 31, 2020. This assessment targeted the period of low summer

See attached

Figure 1: Chapman Creek, near Sechelt, BC. Map shows the reach breaks on the anadromous length of the creek and the upper distribution of salmonids controlled by an impassable fall. The locations of the sample sites and transects used in determining the proposed IFR are shown.

Chapman Creek Anadromous Reaches

June 15, 2020



Legend

- Chapman Creek WS
- Reach Break
- Assessment Sites
- Fish Sample
- Hatchery
- Falls
- SCRD Intake
- Temperature Logger
- Streams
- Roads
- CH Species Observed

Source: Province of British Columbia
Scale: 1 : 20,000
Map projection: UTM Zone 10N
Datum: NAD 1983

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FSCI Biological Consultants

Prepared For: Proprietary Purposes
Prepared On: May 18, 2017
Prepared By: FSCI Biological Consultants
NOT INTENDED FOR NAVIGATIONAL PURPOSES.

1:20,000

0 125 250 500

Meters

base flow (180-200-lps).

As a result, the assessment of reduced baseflow and its potential to affect juvenile coho salmon and steelhead and cutthroat trout rearing habitat and conditions was focused on Reaches 3 and 4.

In order to complete the assessment by reach, the current reach designation was revisited and approximate barrier confirmed. The completed filed assessment then followed the BC Fish Habitat Assessment Procedures (*Johnson and Slaney*, 1996) focused on defining and quantifying the macrohabitat features; pools, riffles and glides. Only primary features were recorded for ease of comparison. Habitats that contain primary or tertiary features within a larger macrohabitat unit were ignored and the dominant habitat within the stream length was recorded.

This classification and habitat delineation would allow for comparison to habitat assessments conducted in 2016 and 2017. In the case of the 2015 FHAP, the baseflows at the time were recorded at 120-lps and predated the current IFR.

Once completed, the habitat was summarized and the areas of each macrohabitat determined. Emphasis for the assessment of potential changes with a change in baseflow focused on Reach 3 and 4.

3.2 Weighted Useable Width Analysis

In order to determine any potential impacts and confirm areas that may, potentially result in an increased risk of stranding of rearing juveniles, Reaches 3 and 4 were targeted and a Weighted Useable Width (WUW) analysis was performed.

The WUW values will demonstrate the greatest useable width under various flow scenarios using preferred depth and velocity and select habitat suitability relationships. The targeted species and life stages were steelhead, both fry and parr or presmolts and coho. In Chapman Creek, the steelhead smolts are dominantly age 2+ years and coho are age 1+ (*Bates* unpublish). Other species utilizing the lower reaches; including; chinook, chum and pink salmon juveniles present less concern, as they have migrated from the river during spring flows prior to summer baseflow conditions. Searun cutthroat trout also require 2 years in freshwater but, conditions that provide coho and steelhead rearing is considered adequate to protect this population.

The weighted useable width analysis was conducted in 2020 and early 2021. The focus was on Reaches 3 and 4 and riffle macrohabitat features. In addition to recent data collected, past data was reviewed and where applicable the data incorporated. This was important for early instream flow information collected prior to the current IFR and re-calibration of the monitoring flow station.

In order to analyze the useable area for available rearing, transects were selected in Reaches 3 and 4 targeting riffles. A total of 6 transects were established in each reach targeting a range of flows. Flow targets were opportunistic and depended on current conditions. Transects analyzed included current transects and a combination of transects data from 2008 and 2015. The earlier data was used for comparison, providing a review of previous useable widths at flows lower than the current 200-lps IFR. Reaches 3 and 4 of Chapman Creek are showing little morphological changes over the last 12 years.

Each transect was established in the field using a 50-m tag line set horizontally and secured on the left and right bank using pins. Stations, numbering between 10 and 26 were selected along the tag line and then, at right angles to the tape, measurements of depth and velocity were recorded. Velocity was measured using a Swoffer 2100 and top setting rod and depth with a meter stick. Velocity was recorded at 0.80% of the vertical wetted depth. In addition, at each station, dominant substrate and cover, within 1.0-m of the stion centre was recorded.

Transect velocity and depth were measured in 2020 at 4 flows. Data was then transferred to an excel workbook were the weighted useable width was calculated by multiplying the width of each panel by the probability of use for a given fish species and life stage. The WUW of a transect and given flow was then calculated by the summation of all panel using:

$$\text{WUW (m)} = \sum_{i=1}^{n} p_i \text{ x panel width}_i$$

Where n=the number of panels

The probability of use (p) is provided by habitat suitability indices (HSI) specific to species and life stage and region. The HSI curves are provided by the BC Ministry of Environmental and Climate Change Strategy.

$$p_i = p_{depth} \text{ x } p_{velocity}$$

The WUW for each transect was then converted into a percentage of the transect width and the transects for each used to establish and average of the %WUW for Reaches 3 and 4. This was then used, along with the macro habitat measurements for each reach, to determine the amount of available, suitable habitat for the target species and life stages.

3.3 Water Temperature

Water temperatures have been recorded during the summer low (July through September in Chapman Creek for the years 2016 through 2020. This five-year period overlaps the current IFR and provides a baseline for continued monitoring.

Temperatures were logged using Onset Tidbits set to record every 15-minutes. The temperatures were then downloaded and the average daily temperatures and 7-day maximum determined. Year to year comparisons were then presented.

Temperature monitoring continues and is intended to remain in place over the next few years.

4.0 Results/Discussion

4.1 Habitat Assessment

The habitat assessment was completed in July of 2020 and the results tabulated using the macrohabitat features as metrics. These metrics are then expanded, providing an estimate of wetted surface area that will be further refined using adjusted weighted useable width estimates.

Table 1 summarizes the results of the fish habitat assessment. In order to determine the potential impact of reduced water discharge through the summer, the emphasis for comparison is placed on the riffle habitats within Reach 3 and 4. These reaches were selected because they provide the majority of rearing and spawning habitat for anadromous salmonids. These reaches have also had the least amount of alteration from development in the area.

In addition to focusing on Reaches 3 and 4, the riffle macrohabitat was selected for review of habitat change by reduced baseflow. Typically, the riffle areas show the most dramatic change during various river stage heights. It is also these areas that create the greatest risk for stranding and elevated water temperatures. This is attributed to their shallow, wider channel, characteristics.

Riffle habitat is the dominant habitat type in Chapman Creek. Reach 3 and 4 are comprised of 65% and 69% riffle when reviewing the total calculated area. Reach 5 is also dominated by riffle, but the morphology in this reach is less depositional with areas in all habitat types showing extensive areas of underlying bedrock and larger dominant substrates with pooling throughout.

Comparison to a similar assessment conducted in 2015 at 180-lps found similar proportions when comparing the results of Reach 3 (2015 assessment only included Reaches 1-3). As result it is expected that the results of the 2020 represent, closely, what the total spatial habitat would occur at a lower (160-180-lps) baseflow.

Figures 2 and 3 provide photographic representation of the targeted habitat types for this assessment. These photos are provided from the same approximate photopoint in 2020 and, for comparison, 2015.

Figure 2: *Example of the riffle habitat found in the section of Reach 3 on Chapman Creek. This is the area where stranding is considered a high possibility. The top photo represents the summer of 2020 and the lower the summer of 2016. These areas were selected because of the relatively little change between 2016 and 2020.*

Figure 3: *Example of the riffle habitat found in the section of Reach 4 on Chapman Creek. This is the area where stranding is c0nsidered a high possibility. The top photo represents the summer of 2020 and the lower the summer of 2016. These areas were selected because of the relatively little change between 2016 and 2020.*

Table I: Summary of the fish habitat assessment completed on Chapman Creek, near Sechelt, BC from July 28-231, 2020. The data is presented by macrohabitat feature and expressed as area and percentage of each reach.

Reach	Length (m)	Mean Ww	Macrohabitat								
			Pool			Riffle			Glide		
			Mean Ww	Area (m^2)	% of Total	Mean Ww	Area (m^2)	% of Total	Mean Ww	Area (m^2)	% of Total
1	635	17.7	11.2	450	4	23.0	7084	70	14.1	2641	26
2	310	16.7	0.0	0	0	16.7	5403	100	0.0	0	0
3	2314	11.1	12.0	1864	7	10.2	17159	65	11.6	7342	28
4	1902	11.1	10.8	3759	16	11.8	16769	69	10.4	3669	15
5	1017	12.4	15.6	2141	18	10.1	8544	72	12.5	1178	10
Total	**6178**			**8214**			**54959**			**14830**	

4.2 Weighted Useable Width and Environmental Flow

In 2020/21, the weighted useable width was determined for four flows at 6 transects in each of Reach 3 and 4. In order to determine the actual flow at the time cross sections were measured, a staff gauge was installed at the bottom of Reach 3. This gauge had a rating curve constructed over the summer and fall of 2020. The staff gauge was then “tied” back to pressure transducer located midway in Reaches 3 and 4, allowing a reasonably confident estimate of flows at the time the transect data was collected.

The staff gauge and its relationship will remain in Chapman Creek, to be used as a means to monitor baseflows during the critical summer period. This visual aid, coupled with transducers, will provide a record of base flows for proposed monitoring and a means to verify the SCRD gauge output.

The stage discharge curve is presented in **Figure 4**. The current relationship is:

$$\text{Stage} = 0.079{*}Q^{0.289}$$

This relationship will be maintained and additional points added to the curve in the future. It is also anticipated that these locations will have a continuous data logger added in 2021 as a compliance monitoring location.

The established transects were sampled at each selected flow. Depth (cm) and velocity (m/s) at the selected stations along the transect were recorded. Values were then entered into an Excel model (see Section 3.2) and using available habitat suitability indices (HSI), weighted useable widths (WUW) were established for target species and life stages. In addition to the depth and velocity data collected in 2020, an older data set, collected in the same reaches in 2015 was included for analysis.

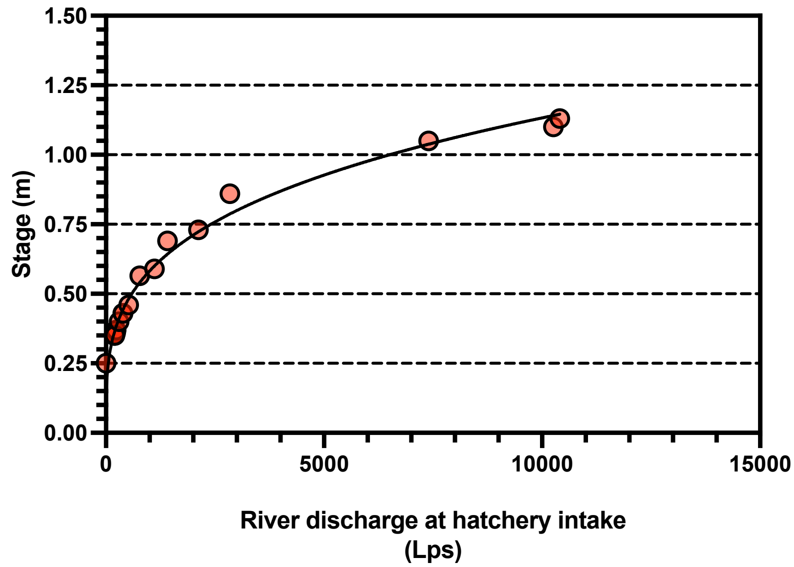

Figure 4: The stage discharge relationship established the flow monitoring location at the start of Reach 3. This site is currently a visual reading but is used to tie back flow estimates with stage data loggers (Solinst) located m within Reaches 3 and 4.

While this occurred 5 years prior, the assumption was made, that the channel morphology had changed very little. The importance of using these earlier measurements was the that they were collected at a flow below the current 200-lps IFR, providing WUW vs flow relationship at a lower baseflow. Closer to the proposed new target flow of 160-180-lps.

In order to facilitate analysis, the weighted useable width estimates, was combined and an average determined for each flow. The mean values were then plotted against the flow and a model relationship determined using Prism®. The "best" fitting relationship models, using the limited data, for Steelhead Trout was a power model represented as:

$$\%WUW_{(SH\ Parr)} = 6.18Q^{0.201}$$

$$\%WUW_{(SH\ Fry)} = 17.34Q^{0.096}$$

Where Q is in litres per second (LPS)

And for Coho Salmon fry it was a Lognormal relationship represented as:

$$\%WUW = (78749/Q)*\exp(-0.5(\mathrm{Ln}(Q/22002)/2.01)^2)$$

Where Q is in litres per second (Lps)

The relationship between the % WUW and the flows was then graphed. **Figure 4** shows the relationships and the curves for the target species and life stage over an expected range of low summer and summer base flows in Chapman Creek.

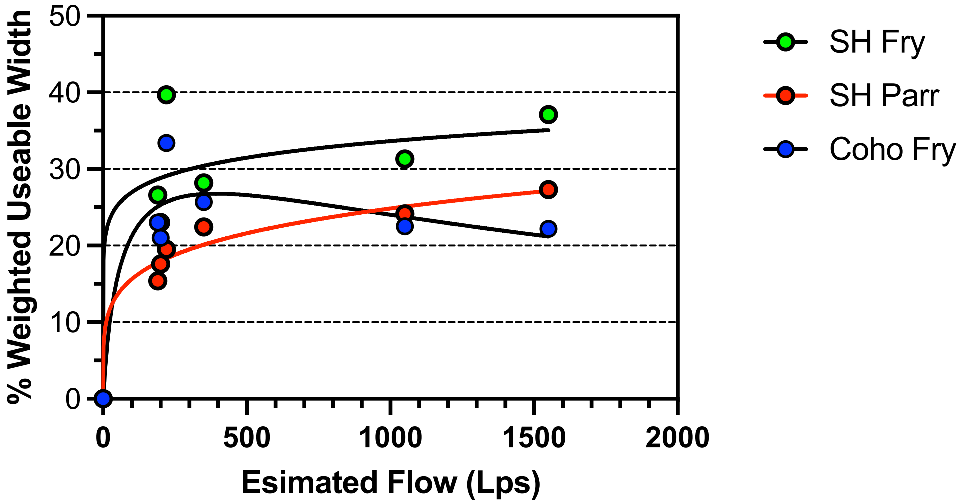

Figure 5: Relationship between the percent weighted useable width and the flow in Reach 3 and 4 of Chapman Creek. Data points represent the average of measurements collected at 12 cross sections initially established in 2016 and revisited in 2020 and 2021.

Using the relationships presented above, the weighted useable width, expressed as percent of the total width and averaged over all the samples, is: 18.0%, 28.8% and 25.3% for Steelhead trout fry, parr and coho fry, respectively at 200-lps. When flows are adjusted to 180-lps, using the relationships above, the %WUW is 17.6%, 28.5% and 24.8% for Steelhead fry, parr and coho fry, respectively. These values were then used to adjust the average riffle width in Reaches 3 and 4 and with the total length of the riffle habitat, the potential change in rearing habitat affected by the reduction in baseflow is estimated.

Table II summarizes the areas available and the difference between the 200-lps and 180-lps. Only the riffle macrohabitats was calculated because they present the greatest risk for stranding and the shallow depth, the greatest change in useable area. Assuming the change in base flow from 200-lps to180-lps results in a measurable change in useable stream width, the estimated decrease in riffle habitat could be an average of 1.7% in Reaches 3 and 4 combined. This equates to an approximate decrease in 385-m^2 of wetted riffle habitat during the low summer period. This reduction is expected to have minimal impact on the overall rearing capability of Chapman Creek,

Table II: Summary of the estimated change in available riffle habitat in Reach 3 and 4, using the weighted useable wetted width and total length of riffle habitat for Reaches 3 and 4.

Species	Reach	Lgth (m)	Ww(m)	200-lps		180-lps		Change (+/-)
				WUW	Area	WUW	Area	
SH-fry	3	1682	10.2	1.84	3095	1.80	3028	-2.2
	4	1421	11.8	2.12	3013	2.08	2956	-1.9
SH-Parr	3	1682	10.2	2.94	4945	2.91	4895	-1.0
	4	1421	11.8	3.40	4831	3.36	4775	-1.2
Coho-fry	3	1682	10.2	2.58	4340	2.53	4256	-1.9
	4	1421	11.8	2.98	4235	2.93	4164	-1.7
Total					**24459**		**24074**	

assuming that the change to more suitable and productive pool glide and deeper and cover complex riffle, habitats are not significantly altered.

While the change in higher risk habitats (riffles) appears to be small, there is a concern that decreased flows will adversely affect water quality. In this case the greatest risk is resulting elevated water temperatures.

4.3 Water Temperature

Water temperature data was collected in Chapman Creek between 2016 and 2020. This period coincides with the 200-lps instream flow release currently followed by the SCRD. The temperature data was collected in Reaches 1, 3, 4 and 6 (near the top of Reach 5) and provides a baseline for continuous monitoring.

Elevated water temperatures during the low base flow period are a concern for rearing juvenile salmonids. Although there are no documented impacts of summer base flow temperatures on juvenile salmonids, it I proposed to be the primary metric to monitor if reducing the base flow is approved.,

As previously stated, the target species and life stage are Steelhead trout , fry and parr and Coho salmon fry. Provincial water quality guidelines state that the optimal range for rearing Steelhead trout is between 16.0-18.0^{o}C and for Coho salmon, 9.0-16.0^{o}C.

In plotting the data from the 2016-2020 monitoring on Chapman Creek, the low summer base flows provide daily average temperatures within these ranges. There is a period, mid-summer, where the daily average spikes to temperatures exceeding 19^{o}C for short durations, While there are documented average daily temperatures above the optimal range, temperatures are below the 26°C, considered lethal

The recorded average daily eater temperatures for 4 stations in Chapman Creek, extending from the Reach 1 through 6 (See **Figure 1**) are presented in **Figures 6 through 9**.

While daily average temperature and the spikes noted do provide insight to the approximate timing and extent of summer water temperatures, a more meaningful metric and comparison is the 7-day average of the daily maximum temperature (7-DAM). This value, defined as the rolling average, provides a means to "smoothing" the data for comparison.

When the same time period (2016-2020 summer period) was analyzed, the 7-DAM ranges from a low of 17. 7°C in 2020 immediately downstream of the SCRD intake to a high of 20.8°C below the hatchery. The range of the 7-DAM within the target Reaches (3 and 4) was 17.8°C to 20.4°C and occurred from the end of July to mid-August. **Table II** summarizes the 7-DAM and the associated dates.

While the 7-DAM does report values outside the optimal temperature range, these values, calculated on the daily maximum, assumes fish under temperature "stress" have access to thermal refuge. This scenario is consistent with other ungulated flow systems and assumes, "brief" elevated temperature periods, do not adversely affect rearing juveniles.

Table III: Summary of 7-day mean maximum (7-DAM) temperatures reported in 2016 to 2020 in Reaches 1, 3, 4 and 5 of Chapman Creek.

Reach		2016	2017	2018	2019	2020
1**	Temp	18.91	19.27	20.79	19.20	19.37
	Date	08-17	08-10	07-29	08-06	07-30
3	Temp	18.43	18.92	20.23	18.83	18.96
	Date	08-17	08-10	07-30	08-06	07-30
4	Temp	17.75	18.39	20.45	17.86	18.07
	Date	08-17	08-10	07-29	08-06	07-30
5	Temp	17.71	18.48	19.61	17.81	17.67
	Date	08-17	08-10	07-30	08-07	07-31

** The temperature logger in Reach 1 is located below the hatchery outflow.

Given the results of the data monitoring to date, it is proposed that 20°C be adopted as the trigger for mitigation measures during low summer base flow periods. This may require an increased release of water in an attempt to provide additional thermal refuge but providing additional water volume and potential depth in key, monitored reaches and stream section.

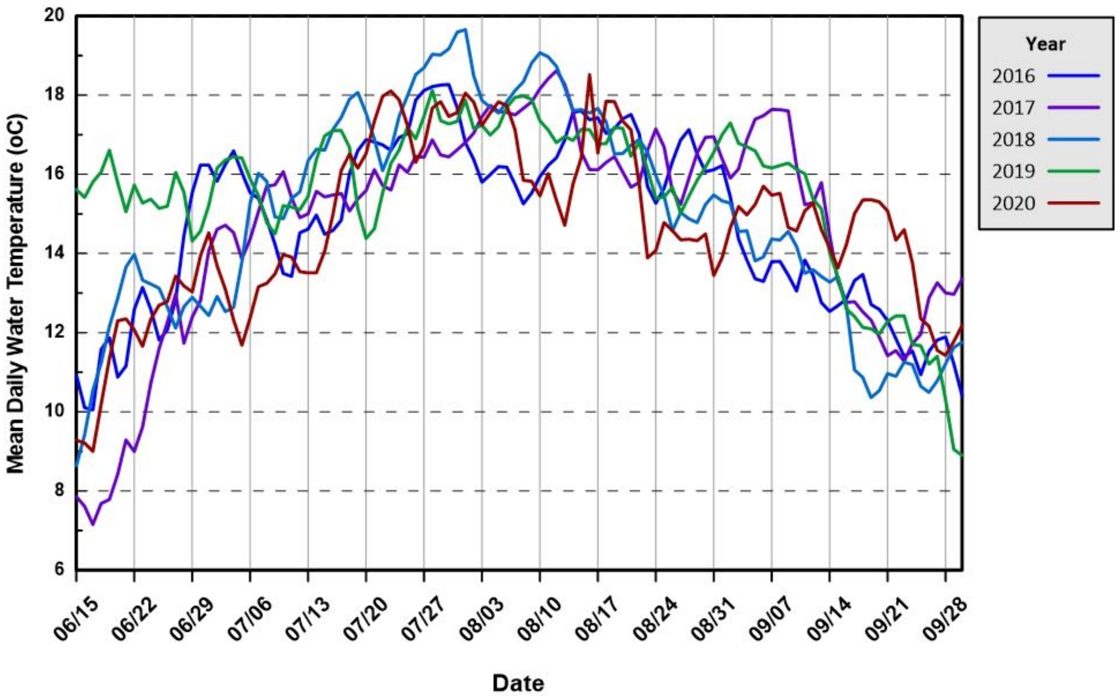

Figure 6: Daily mean water temperatures in 2016 to 2020 for Chapman Creek, Reach 1 (below hatchery). Period of record is June 15 and September 30.

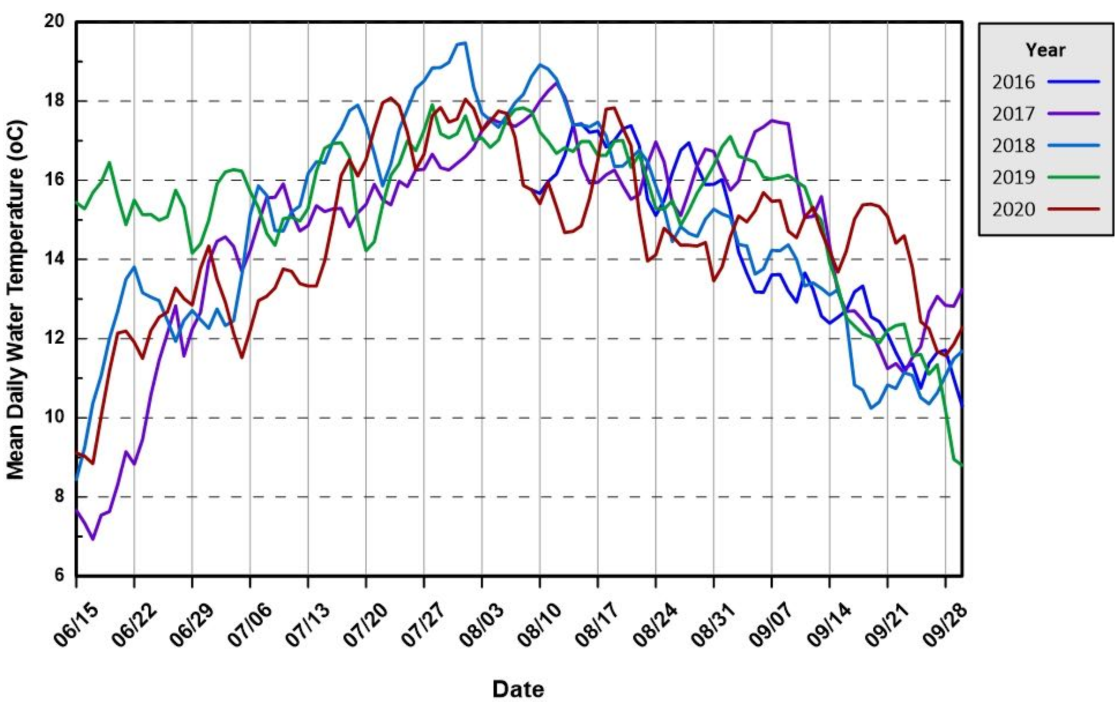

Figure 7: Daily mean water temperatures in 2016 to 2020 for Chapman Creek, Reach 3. Period of record is June 15 and September 30.

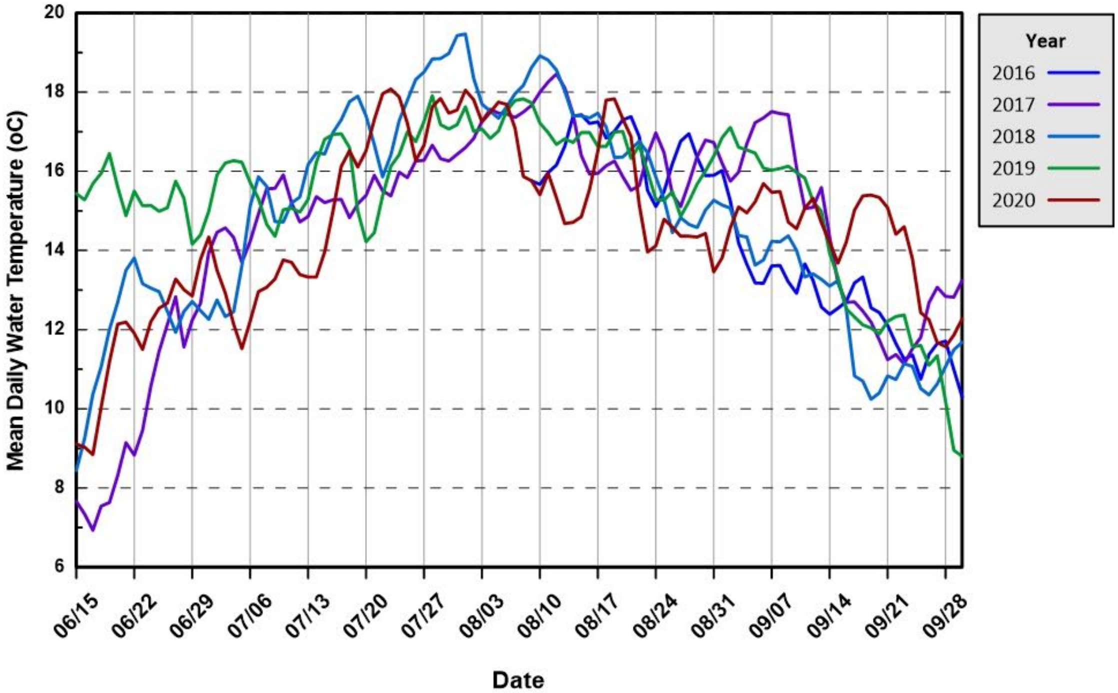

Figure 8: Daily mean water temperatures in 2016 to 2020 for Chapman Creek, Reach 4. Period of record is June 15 and September 30.

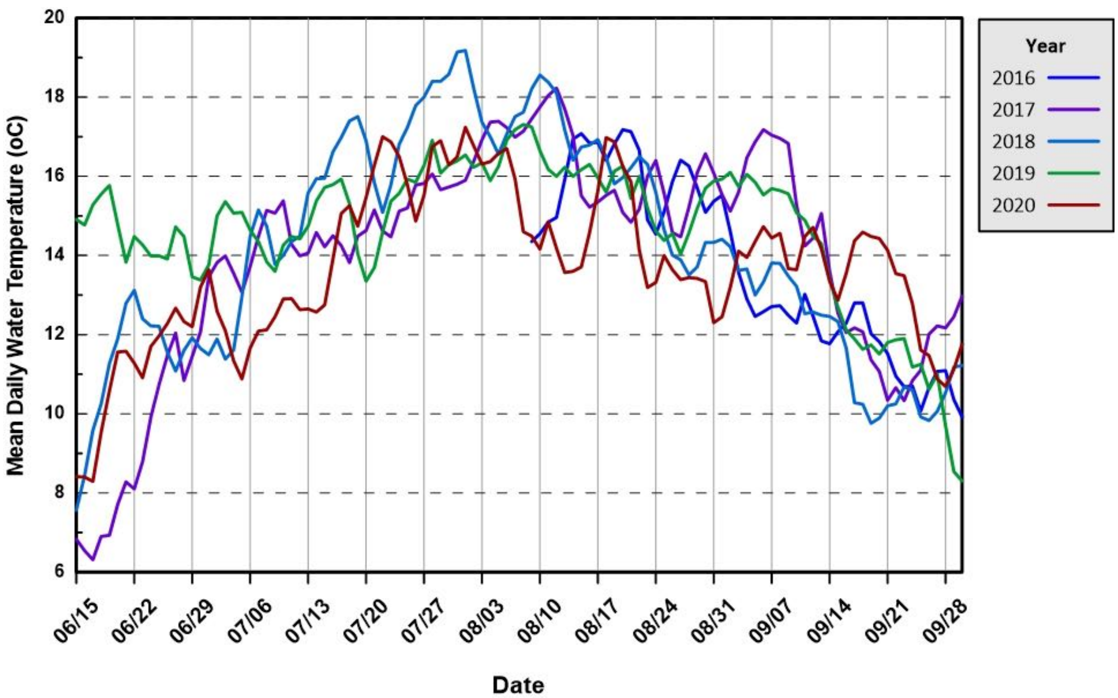

Figure 9: Daily mean water temperatures in 2016 to 2020 for Chapman Creek, Reach 6. Period of record is June 15 and September 30.

While it is proposed that temperature me used as the trigger for mitigation during summer baseflow conditions (180-lps), it is also important to note that the temperature at the intake, does approach 20°C immediately at diversion.

5.0 Conclusion/Comments

The purpose of this analysis was to review and predict what changes to the quality and quantity of fish habitat may occur, decreasing the base flow (IFR) from 200-lps to 160-180-lps during the critical period. The analysis focused on the two most susceptible reaches on lower Chapman Creek and the riffle habitat within Reaches 3 and 4. While only Reaches 3 and 4 were specifically targeted, it is expected all reaches would undergo some level of change, but, these two reaches, contribute the greatest habitat for rearing within the anadromous length of Chapman Creek.

The results of the analysis, predicts a slight decrease in spatial, wetted area. This decrease is small and likely would have, limited overall impact to rearing salmonids. While changes are considered small and may be low risk, monitoring of the reaches and specifically areas of these reaches with high stranding potential should be included in any monitoring plans.

The second metric reviewed was water temperature. It's recognized that the data presented is for a base flow of 200-lps. As with spatial change, it's not anticipated that the in-river temperatures will change with a slight reduction in IFR.

As with suggested monitoring for stranding, water temperature should continue in 2021 and in particular through any periods where the IFR is reduced below 200-lps. In this case it is suggested that daily average temperature or 20°C and 7-DAM of 21°C be used to trigger the increase in IFR. This presumably would help provide an increase in thermal refuge.

6.0 Recommendations

The following recommendations are provided for consideration in for the reduction in summer baseflow from 200-180-lps (lower in June and the start of July when natural flow contribution is higher exceeding base flow conditions).:

- Managing reduction if IFR for water conservation should follow an acceptable down ramping procedure. This would be accompanied by a stranding search in the susceptible areas of Reaches 3 and 4.

- The reduction in baseflow from 200 to 160-180-lps, must include a field observation component and photopoint documentation of habitat change. Field crews should be monitoring for indications of increased stranding in addition to distressed fish.

- Temperature should continue and daily averages and 7-DAM calculated for the summer months (June to September). A trigger is recommended that would alert the SCRD to release, through flow diversion, additional water into the lower river. This would be monitored on the ground by a qualified professional. At this time additional water quality may be collected, in particular dissolved oxygen. While measurements of DO in 2020 did not show any concerns regarding oxygen saturation at higher temperatures and lower flows, it is recommended that this be recorded through the summer months whenever possible.

- This document focuses on rearing Steelhead trout and Coho salmon fry. An earlier document suggested mitigation for adult Pink Salmon. This species is the only one of concern during the low summer period and only during odd years. This original document should be updated and become a part of the proposed monitoring plan adopted by the SCRD.

7.0 References

Ahmed, A. 2017. Inventory of streamflow in the South Coast and West Coast Regions. BC. Min. Environment and Climate Change Strategy, Victoria, BC.

BC Government. 2001. Water quality guideline for temperature. BC Ministry of Environment. Victoria, BC.

Bates, D. 2016. Re: Review of low summer flow on salmonid habitat/passage in Chapman Creek. Letter to D. Crosby, SCRD, November 4, 2016.

Richter, A. and Kolmes, S.A. 2005. Maximum temperature limits for Chinook, Coho and Chum salmon, and Steelhead trout in the Pacific Northwest. Reviews on Fisheries Science. 13:23-49.

Sullivan, K., Martin, D.J., Cardwell, R.D., Toll, J.E., and Duke, S. 2000. An analysis of the effects of temperature von salmonids of the Pacific Northwest with implication for selecting temperature criteria. Sustainable Ecosystem Institute. Portland, Oregon.

8.0 Closure

Services performed by ***FSCI*** Biological Consultants for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the fisheries profession practicing under similar conditions in the area in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this letter. No warranty or guarantee, express or implied is made concerning the results, comments, recommendation, or any other part of this report.

Prepared by

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