Fish Habitat Offsetting Plan for Bulk Water Supply Intake in Englishman River

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July 2015

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 Introduction

Englishman River Water Service (ERWS) is a joint venture of the City of Parksville and the Regional District of Nanaimo (RDN) formed to secure, treat and distribute water originating from the Englishman River for municipal drinking water supply. The bulk water supply from the river is intended to supplement existing supply sources owned and operated by the individual jurisdictions. An existing City of Parksville river intake downstream of Highway 19A currently extracts river water from the mainstem to supplement its well water supply during the peak demand period between June and October.

The current project being proposed by ERWS is the construction of a new river intake and pump station, with construction of a water treatment plant (WTP) and associated water distribution system to follow in the future. The current population in the service area is ~17,500 full time residents with an additional ~10,400 part-time residents in the summer. It is estimated that by 2035 the population will have increased to ~24,290 full-time residents. The river intake and WTP form the final phase of a regional water supply strategy that was initiated in the 1970s. The first phase of the strategy was implemented through construction of the Arrowsmith Lake dam in the late 1990s which is used to supplement summer baseflows in Englishman River for water supply withdrawals and fisheries.

Department of Fisheries and Oceans (DFO) considers the proposed municipal water supply intake to be a new project in accordance with the Fisheries Act and have determined that the project will cause serious harm to fish that support a commercial, recreational or Aboriginal fishery. In a letter to ERWS dated 2 February 2015, DFO stated that the proposed works will result in "permanent alteration of fish habitat that supports various salmon and trout life history stages due to the reduction of flow in the Englishman River from instantaneous water withdrawal". An Authorization under Section 35(2) of the Fisheries Act is therefore required in order for the proposed works to be in compliance with this federal legislation.

This report presents an offsetting plan for the purpose of obtaining a Section 35(2) Fisheries Act Authorization for the proposed water intake construction project on the Englishman River. The Authorization application for the proposed intake is based on a maximum instantaneous daily water withdrawal rate of 28.8 ML/d. Potential effects of the project on fish and fish habitat were described previously in LGL Limited (2014). The following fish habitat offsetting plan will:

- Document the existing distribution and status of the fish populations;
- Document the distribution of the various channel types (i.e., riffle, pool and glide) downstream of the proposed intake site;
- Identify the types and relative quality of the existing fish habitats;

- Describe and quantify the potential effects of water withdrawal on Englishman River flows and fish rearing and spawning habitats downstream of the bulk water supply intake based on habitat-flow modeling results in riffle, pool and glide habitats;
- Describe and quantify the measures that will offset residual impacts relating to fish rearing and spawning habitats downstream of the bulk water supply intake;
- Describe mitigation measures; and
- Describe a five year monitoring plan to evaluate the effectiveness of mitigation and offset measures.

2.0 Physical Description of New Water Intake

The new ERWS intake will replace the existing intake, located downstream of the old Island Highway Bridge (Highway 19A), which uses a buried well screen infiltration gallery. The new water intake site will be located on the right (north) bank immediately upstream of the Highway 19 bridge crossing of the Englishman River (Figure 1), about 2.62 km upstream of the existing intake. The north bank consists of glacial till and bedrock that extends to just downstream of the railway crossing. It appears that the channel position and banks at this site have remained relatively stable since at least 1949 (Gaboury 2005).

The proposed design is a side bank intake structure with inclined wedge wire screen panels having 2.54 mm slots. The screen is designed to meet DFO fish protection criteria and to prevent debris from entering the pumps. The width of the intake structure is approximately 10.5 m with a 15 m^2 flat maintenance deck above the screens. The intake will be fitted with an air-backwash system to back flush debris and sediment from screens to maintain adequate screen area and ensure approach velocities are ≤0.11 m/s. Further details on the design of the new water intake are included in Technical Memorandum 2C – Intake, Raw Water Pump Station, and Transmission Mains prepared by CH2M HILL and KWL, dated October 21, 2014 (CH2M HILL and KWL 2014).

Figure 1. Map of lower Englishman River showing the proposed water intake site and boundaries of Reaches 1 and 2.

3.0 Operation of Water Distribution System

The flows in a water distribution system are governed almost entirely by water use by residential, commercial, institutional, industrial and agricultural customers; these flows are termed "demands". In the ERWS water distribution system, residential demands make up about 70% of the water use and agricultural demands are insignificant. Water demands vary by season and time of day. Water demands are lowest in winter, when outdoor water use (e.g. irrigation) is low. Water demands are highest in the summer irrigation season. Water demand in the summer is often governed by the weather; people tend to irrigate more during hot dry periods (droughts) and therefore irrigation demand changes from year to year. Daily water demands tend to reach a peak in the morning before people go to work, and the evening when they get home; there is also a lower peak mid-day. Irrigation demands tend to reach a peak just before dawn and dusk because this is considered to be the most efficient time to water. Apart from "regular" water demands, there is also water used for firefighting and watermain flushing; these demands are intermittent.

The water demands described above generally come from storage tanks in the water distribution system. It is the job of the water treatment plant (and intake) to pump water to these tanks when required. Water tanks generally have enough storage in them to satisfy demands on the highest demand day of the year as long as the water treatment plant is pumping to them at a constant rate all day. At lower demand times of the year, the tanks will empty and get periodically refilled by the water treatment plant. In winter, when demands are low, this may only happen once a day. Given that there are several tanks in the ERWS system, the water treatment plant may be called upon to fill tanks several times a day, often simultaneously. The water treatment plant is designed to fill them all at the same time, if needed. Firefighting demands also come from the storage tanks in the system. The ERWS system is designed such that there is adequate water for firefighting even if the water treatment plant does not supply any water. However, after the fire is extinguished (or during the fire), the tanks will eventually need to get refilled by the water treatment plant and this could occur at any time.

As actual water demands and thus withdrawals are a function of random events throughout the water system network, it is very difficult to develop a temporal distribution of future withdrawals. Therefore, the assessment of downstream impacts in this assessment is based on future withdrawals assuming distribution based on historical withdrawal records scaled up to match the maximum design withdrawal rate.

In addition to variation as a result of changes in water demand in the system, water withdrawals will also vary as a result of the need for additional water for the treatment process. The filters for the treatment plant need periodic flushing flow which would be supplied from the river intake. During flushing the instantaneous flow could vary by +/- 20% of the maximum average daily withdrawal rate of 24

ML/d. However, the increased withdrawal would only be required for approximately 1 minute three times an hour on average. Given the relatively short duration of the increased withdrawal, any impact on water levels and flows in the river will be localized to the vicinity of the intake pool. The short duration increase in withdrawals at the maximum instantaneous daily water withdrawal rate of 28.8 ML/d would likely not have a significant effect on aquatic habitat downstream of the intake. Therefore, the analytical assessment of impacts on fish habitat in Section 5.3.3.1 is based on the maximum average daily withdrawal rate of 24 ML/d with a recognition that the maximum instantaneous withdrawal rate of 28.8 ML/d will occur for 1 minute three times an hour.

4.0 Assessment Methods

The assessment of effects of water withdrawals at the proposed intake on fish populations and habitats downstream in the lower Englishman River involved the following field and office activities:

1. Review and summarize relevant fish population and habitat information for the Englishman River;
2. Complete a meso-habitat survey to identify, map and quantify the length of the habitat types downstream of the intake (pools, riffles and glides);
3. Establish up to ten channel cross sections at representative locations for riffles and glides;
4. Complete topographic surveys using a level and rod at each of the channel cross sections;
5. Classify channel substrate at each of the channel cross sections; and
6. Use Habitat Suitability Indices for Steelhead (ST) (*Oncorhynchus mykiss)*, Chinook (CH) (*O. tshawytscha)*, Coho (CO) (*O. kisutch*) and Chum (CM) (*O. keta*) to establish weighted useable area versus discharge relationships along the section of the Englishman River downstream of the proposed intake location to the river mouth across the range of expected summer flow levels (less than 5 m^3/s) using RHYHABSIM (River Hydraulics and Habitat Simulation) software.

4.1 Assessment of Existing Fish Values

Existing information on fish populations and habitat within the lower Englishman River mainstem was obtained from published reports and unpublished assessment data. Existing data and reports on the Englishman River environment that were pertinent to potential environmental concerns / impacts associated with the siting and construction of the water intake were reviewed.

4.2 Meso-habitat Survey

The classification and distribution of meso-habitats in the lower Englishman River was completed during a field survey conducted on 22 August 2013 at ~1.6 m^3/s (Water Survey of Canada, Station 08HB002). Two fisheries biologists waded the river from the proposed intake site to downstream of tidally-influenced waters. Habitats were classified as pool, riffle or glide and the upstream and downstream limits of the channel section for each habitat type were located using a handheld GPS. Using the GPS waypoint data, meso-habitats were mapped and their length measured using ArcView.

4.3 Habitat-Flow Modeling

Bed profile, water surface elevation, velocity, depth, substrate and discharge measurements were collected at a total of 10 cross sections representing riffle (five cross sections) and glide (five cross sections) habitats within Reach 2 of the lower Englishman River mainstem. Cross section surveys occurred on 24 July and 5 September 2013 in accordance with data requirements for completing hydraulic modelling with the RHYHABSIM model using a single velocity calibration data set (Jowett 2006; Jowett et al. 2008). This calibration method entailed measuring water surface elevations (WSELs) at a series of calibration flows, mean-column-velocity calibration data at one flow, and stream discharge at each WSEL calibration flow. Transects were located in representative riffle and glide habitats that encompassed typical spawning and rearing habitats for salmon and trout. Water surface elevations at these riffle and glide transects were surveyed over a range of at least three calibration flows.

A permanent benchmark for each survey transect was defined by a head pin established on the top of the right bank (looking downstream). Each pin was flagged and semi-permanently fixed with rebar. The location of each transect was marked with a Garmin model 76CSx GPS unit.

Hydraulic-habitat modeling provided a mechanism to examine the suitability of the existing habitat for ST and salmon as well as the potential suitability of the habitat for species-specific life stages at river discharges under the proposed water withdrawal scenario. Habitat suitability indices (HSI) for native salmon and ST fry, parr and spawners were used with the modeling program RHYHABSIM, Vers. 5.1 (River Hydraulics and Habitat Simulation; Jowett 1999) to predict weighted usable area (WUA) for species-specific life stages of salmon and trout inhabiting riffle and glide habitats. The HSIs had been prepared previously for BC Hydro Water Use Plans and were provided by BC Forests, Lands and Natural Resource Operations for this project (Appendix A to Appendix I). These published HSIs are based on preferences of embryo, fry, parr and adult life stages to velocity, depth, and substrate in characteristic spawning and rearing habitats of salmon and trout. A suitability of 1.0 represents the optimum amount of usable habitat, 0 represents unsuitable habitat conditions, and values in-between represent varying degrees of suitability (Thorn and Conallin 2006).

RHYHABSIM is a habitat-hydraulic model and is designed to measure the amount of microhabitat available in a stream or river for fish or macroinvertebrates at different life stages and at different flows (Jowett 1989). Habitat-hydraulic models combine biological data of the indicator species (i.e., habitat suitability indices) with the hydrologic and morphological characteristics of the stream to produce a quantitative relationship between flow and usable habitat areas (Thorn and Conallin 2006). In the model, hydraulic variables are combined with the species and life stage specific biological habitat suitability values to produce life stage specific curves representing the usable habitat area (i.e., weighted useable area) versus stream discharge (Thorn and Conallin 2006). In our application of the RHYHABSIM model, riffle and glide habitats were included in the assessment for trout and salmon fry, parr and adults.

A benefit to using RHYHABSIM is its ability to analyze multiple species and life stages and derive information on how they will respond to changes in flow rates. It should be noted that RHYHABSIM only provides information regarding potential habitat available for the indicator species and how habitat area changes for different flows. If the model indicates optimal habitat for a particular species at a given flow, it does not mean that species will be able to survive in the stream because other abiotic factors such as water quality and biotic factors such as competition also play a role (Thorn and Conallin 2006).

4.4 Potential Effects on Fish

The potential harmful effects of withdrawing water at the proposed intake site on fish species or their habitats at and downstream of the intake site were assessed based on the expected construction and operational schemes for the water intake (CH2M HILL and KWL 2014). The context for the evaluation of these effects on fish and fish habitat is relative to the type, quality and quantity of fish habitat within the lower Englishman River under existing conditions. Where it was determined that there may be negative short or long term potential impacts, recommendations were made to mitigate or offset these impacts.

5.0 Results and Discussion

5.1 Fish Populations and Habitats

The Englishman River supports significant populations of salmon. CM is the dominant anadromous species followed by Coho (CO). ST, Cutthroat Trout (CCT) (*Oncorhynchus clarkii*), CH, Pink (PK) (*O. gorbuscha*) and Sockeye (SK) (*O. nerka*) are also present (Bocking and Gaboury 2001). The anadromous section extends up to the upstream end of Reach 6, a distance of about 16.6 km from the mouth (Higman et al. 2003). Englishman River falls is located at the upstream end of the canyon section in Reach 7 (Figure 2). Table 1 shows when the various life stages for each anadromous salmonid species are present within the Englishman River and estuary. Resident game species include Dolly Varden (DV) (*Salvelinus malma*) and Rainbow Trout (RB) (*O. mykiss*).

Figure 2. Map of Englishman River watershed showing river reaches and location of Arrowsmith Lake. Reaches for mainstem from nhc (2002). Note: The anadromous section extends up to Reach 6, with Englishman River falls at the head of Reach 7.

5.1.1 Adult Abundance

DFO snorkel survey observations found that all five pacific salmon species as well as RB and CCT were distributed throughout Reaches 1-5 in the Englishman River (S. Baillie, DFO, unpubl. data; Table 2; Figure 1). PK and CM were the most abundant salmon species observed during the 2001 spawning period, followed by CO and CH with only incidental occurrences of SK.

Chum
Between 1990 and 2014, CM escapements to the Englishman River were as high as 42,058 in 2011 and as low as 130 in 2006 (Figure 3). Over the past 5 years (2010-2014), the average escapement has been 17,962 CM.

Coho
Maximum escapement of CO in the 1990-2013 period was recorded at 17,238 in 2013 (Figure 3). Over this period, escapement has averaged 3,126 with a minimum of 200 CO observed in 1997.

Table 1. Life history timing for anadromous salmonids within the Englishman River and estuary.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coho	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry							
	Parr	Parr	Parr			Parr	Parr	Parr	Parr	Parr	Parr	Parr
				Smolts	Smolts	Smolts						
	Adults								Adults	Adults	Adults	Adults
Chinook	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry							
						Parr	Parr	Parr	Parr	Parr		
				Smolts	Smolts	Smolts	Smolts	Smolts				
								Adults	Adults	Adults		
Pink	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry								
									Adults	Adults		
Chum	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry	Fry						
									Adults	Adults	Adults	Adults
Sockeye	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry	Fry						
					Smolts	Smolts						
							Adults	Adults	Adults	Adults		
Steelhead		Eggs	Eggs	Eggs	Eggs	Eggs						
						Fry	Fry	Fry				
	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr
				Smolts	Smolts	Smolts						
	Adults	Adults	Adults	Adults	Adults	Adults	Adults				Adults	Adults

Eggs Fry Parr Smolts Adults

Table 2. Summary of snorkel survey observations conducted between September 17 and November 2, 2001 from the Englishman River mouth to 13 km above the mouth (S. Baillie DFO, unpubl. data). The data are actual observations (not expanded for observer efficiency) of live, adult (non-jack) salmon and trout. Number of fish in each Reach was calculated to nearest 500 m section break from DFO survey.

Species	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Chinook	417	2600	1366	12	224
Chum	1107	2907	3969	485	673
Coho	614	5125	1527	9	189
Pink	109	4828	4396	224	2390
Sockeye	0	9	12	0	5
Rainbow Trout	0	24	49	11	58
Cutthroat Trout	41	326	190	14	125

Other Salmon

Prior to 2001, abundances of PK, CH and SK were lower than CM and CO. Englishman River PK salmon declined precipitously from 1958-1962 to near extinction levels (Bocking and Gaboury 2001). In 1992, attempts were made to re-establish the PK salmon run in the Englishman River by transferring eyed eggs from the Quinsam River hatchery. PK and CH escapements have been variable from 2001 to 2014 with a range in values of 50 to 19,692, and 20 to 2,900, respectively (Figure 3; Figure 4). CH salmon in the Englishman are now predominantly of Big Qualicum River stock due to enhancement efforts since 1989. There is just a small population of stream-type SK in the Englishman River with an average escapement of ~12 fish, but little is known about this population.

Steelhead

Winter-run ST salmon abundances have declined considerably since the high numbers observed in the mid-1980s (Figure 5). Historical abundances of wild ST ranged from 500 to 2,000 adult returns to the river (Bocking and Gaboury 2001). During this period, Englishman River ST were enhanced and it is difficult to discern the population size of the wild stock. Current abundances of adult ST in the Englishman River are <200 fish and considered to be at critically low levels (C. Wightman BCCF, pers. comm.). Snorkel surveys by staff of BC Conservation Foundation (BCCF) have documented the distribution of adult ST from the anadromous barrier (Reach 7) to Big Tent Run (located at most downstream bridge crossing; Reach 2), with the highest concentrations typically occurring in Reaches 3 and 4 (J. Craig, BCCF, pers. comm.).

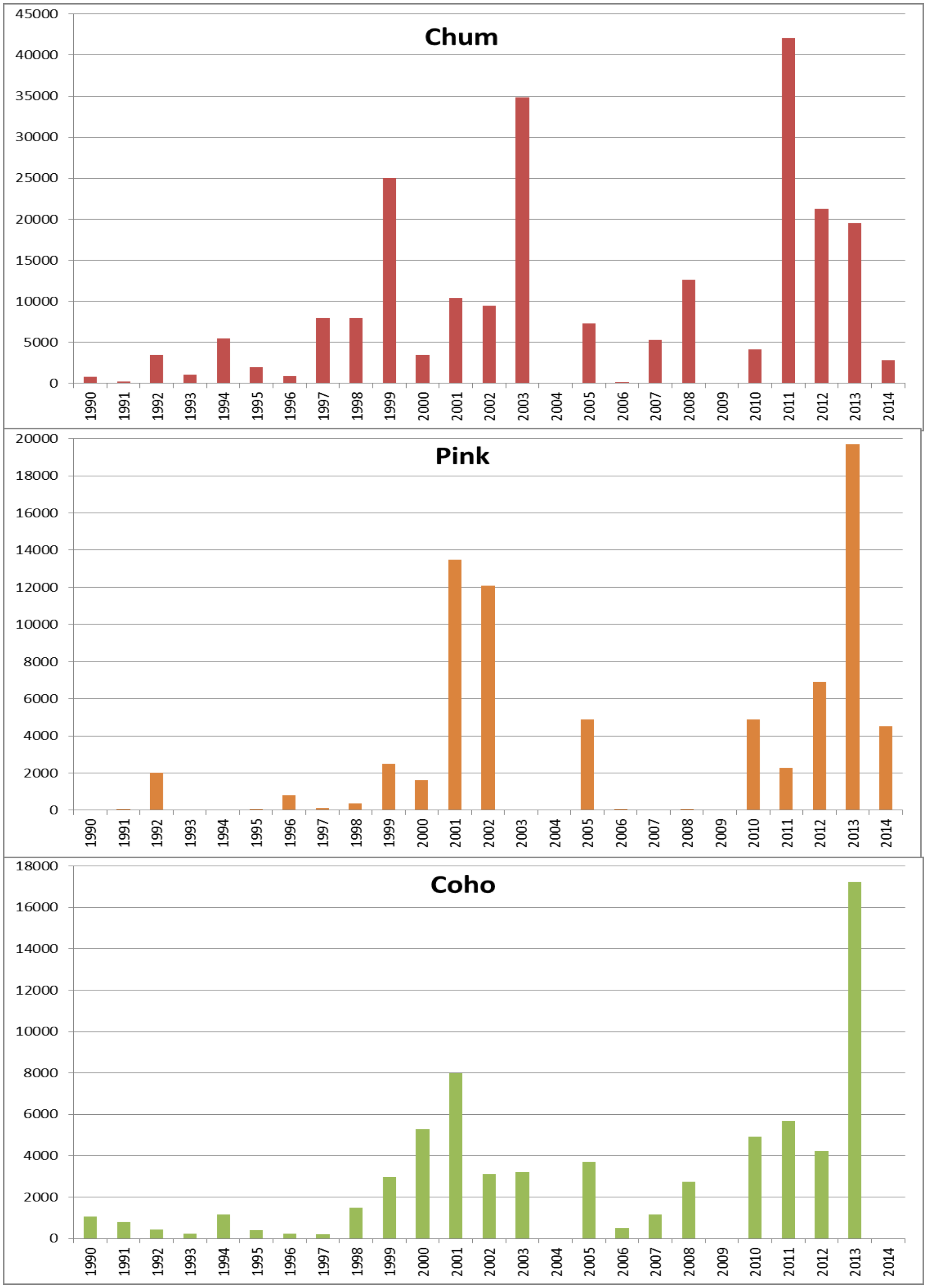

Figure 3. Chum, Pink and Coho salmon escapements to Englishman River, 1990-2014.

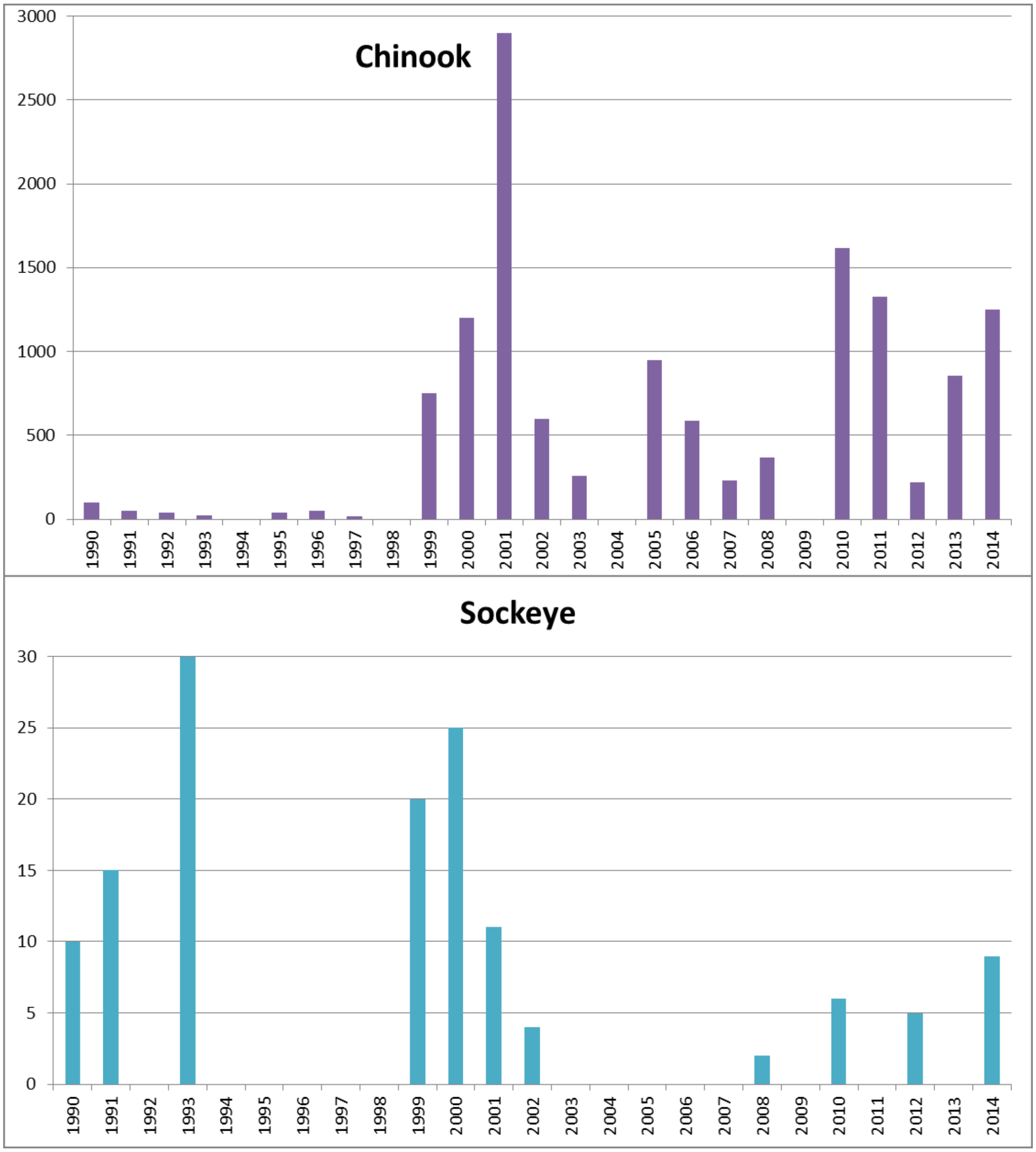

Figure 4. Chinook and Sockeye salmon escapements to Englishman River, 1990-2014.

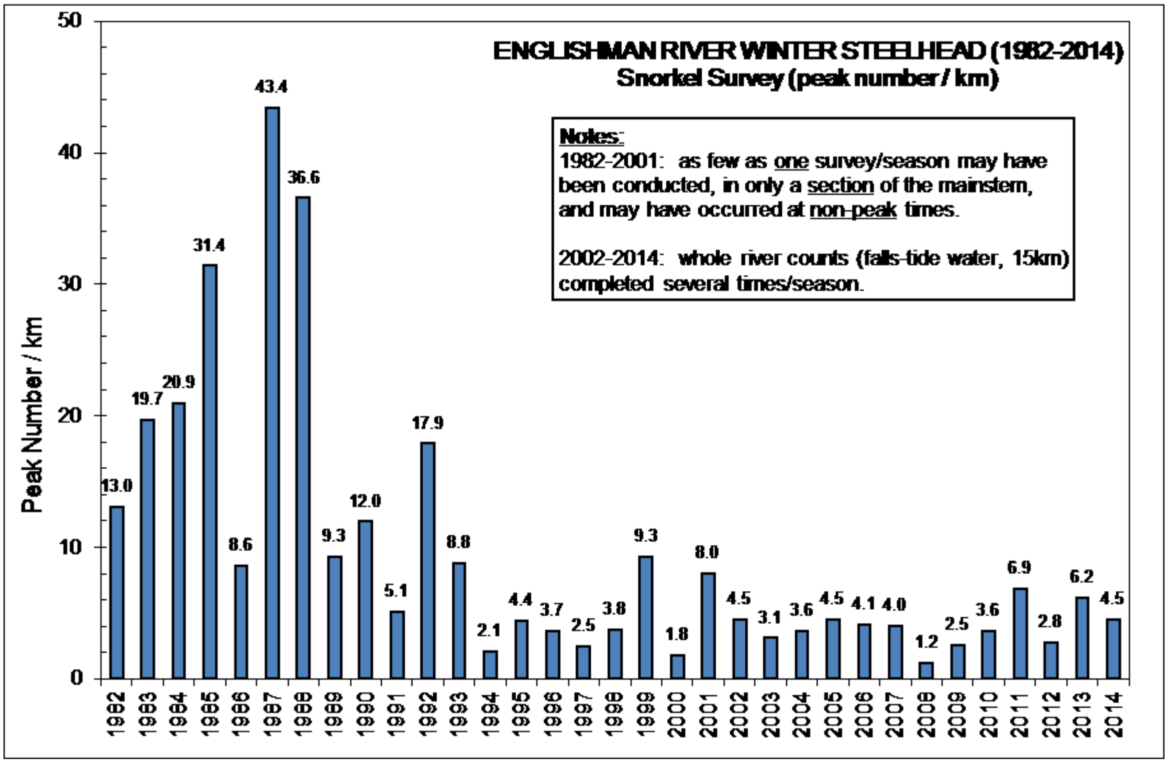

Figure 5. Winter Steelhead snorkel survey counts, 1982-2014 (M. McCulloch, FLNRO unpubl. data).

5.1.2 Juvenile Abundance

CO and RB rearing in Reaches 2-6 has been confirmed through electrofishing surveys by Lough and Morley (2002) (Table 3). From the brief surveys, Reach 3 tended to have higher abundances of CO fry while RB fry were fairly evenly distributed throughout the five reaches.

Monitoring of CO smolt production from the watershed in 1998 and 1999 generated estimates of 27,000 and 46,000 CO smolts, respectively (Decker et al. 2000). For these two years, between 17% and 20% of the smolt production came from the two constructed side-channels (Clay W. Young and MB side channels; Figure 6) within Reach 3 and the remainder came from natural watercourses. In 2007, the Clay W. Young side channel was extended by 2.9 km, which increased total rearing habitat area to 7.44 ha (Taylor and Wright 2010b). Total smolt emigration from the Englishman River was estimated at ~42,038 CO in 2010 (Taylor and Wright 2010b). Estimated contribution of the Clay W. Young side channel to the river's CO smolt output was estimated at >40% in both 2009 (Taylor and Wright 2010a) and 2010.

Over the period 1998 to 2014, electrofishing surveys targeting ST fry were conducted in 14 yrs by BCCF on behalf of FLNRO. The electrofishing surveys were conducted in riffle habitat at ~9 sites (Appendix J) and found average annual densities between 10.2 and 32.6 ST fry per 100 m^2 with an overall mean of 17.1 fry per 100 m^2 (Table 4). ST fry densities in Englishman River are relatively low but appear to be appropriately scaled to the known limit of the parr habitat base (R. Ptolemy pers. comm.). Parr habitat in the Englishman River is relatively poor and limited by the amount of riffle habitat with large, emergent boulders (R. Ptolemy pers. comm.).

Table 3. Catch data from open site electrofishing (100 m) sections in anadromous Reaches E2-E6 of the Englishman River (raw data from Lough and Morley 2002).

Location		Date (2001)	Coho	Rainbow Trout	
Reach #	Site			Fry	Parr
2	R13	Oct. 17	0	22	0
2	R31	Oct. 17	23	11	0
3	R40	Oct. 15	36	21	2
3	G25	Oct. 16	84	14	3
3	G25	Oct. 17	24	14	0
4	G4	Oct. 15	8	14	0
4	R1	Oct. 15	31	17	0
5	R16	Oct. 28	2	19	0
5	R66	Oct. 14	21	33	1
5	G46	Oct. 14	57	20	0
6	R27	Oct. 13	5	20	2
6	G7	Oct. 13	21	24	1
		Total	312	229	9

Table 4. Summary of electrofishing survey results for Steelhead fry at nine sites in Englishman River, 1998-2014 (M. McCulloch, unpubl. data). Site catches have been adjusted to a unit area of 100 m^2.

Year	Site Catches (Steelhead per 100 m^2)									Mean
	1	2	3	4	5	6	7	8	9	
1998	2.4	17.5	7.2	11.6	27.2	12.4	8.5	25.4	57.9	18.9
1999	6.1	12.1	46.0	32.8	30.5	28.7	17.2	59.3	60.8	32.6
2000	12.0	9.8	1.3	8.7	5.7	9.6	2.6	10.2	44.1	11.6
2001	8.4	7.2	7.9	18.0	22.0	6.9	7.7	10.7	36.7	13.9
2002	13.5	16.3	2.6	5.7	28.6	28.0	14.8	5.0	36.2	16.7
2003	10.6	12.5	7.2	2.2	6.9	18.0	10.2	8.4	19.7	10.6
2004	25.3	9.0	5.7	17.2	3.9	7.2	3.8	1.1	20.4	10.4
2005	13.0	4.2	5.9	6.5	8.5	16.5	16.7	9.3	28.9	12.2
2006	25.4	7.9	6.0	17.4	17.7	45.9	11.6	15.0	57.6	22.7
2008	7.9			1.1	19.9		9.5	3.1	19.5	10.2
2011	12.1	17.1	2.7	23.8	32.4		6.1	13.9	62.4	21.3
2012	18.3	24.0	12.3	24.3	1.4		16.0	25.0	18.4	17.5
2013	20.3	18.4		22.6	29.0		17.6	29.9	38.2	25.1
2014	1.3	10.6		10.5	4.8		3.1	17.4	62.4	15.7

5.1.1 Anadromous Fish Habitat

The mainstem reach that extends from Morison Creek to downstream of Highway 19A is an important spawning area for all species of anadromous fish within the Englishman River, including CM, CO, CH and PK salmon, ST and RB (Figure 6). Some salmon and ST spawning has also been observed as far upstream as the anadromous barrier (Lough and Morley 2002; J. Craig, BCCF pers. comm.). J. Craig (BCCF) indicated that the most critical fish habitat in the mainstem is located in Reach 3 (from the confluence of the South Englishman River downstream to Top Ridge Park (Allsbrook Canyon)) and Reach 4 (from below the confluence of Morison Creek downstream to the South Englishman River confluence). As identified above, the habitats in these reaches are most important for salmon, ST and RB spawning, and CO, CH, ST and RB rearing.

In Reach 3 above Allsbrook Canyon, the Clay W. Young side channel on the left bank of the river, downstream of Morison Creek, is used for spawning by the same species as found in the mainstem as well as CCT. CO and CM salmon and CCT spawn in the MacMillan Bloedel (MB) side channel, on the right bank of the river just downstream of the BC Hydro transmission corridor. Both channels extract water from the Englishman River mainstem at two separate locations and then discharge flow back to the mainstem at two separate locations. Both side channel outlets are upstream of Allsbrook Canyon and the proposed water intake location.

Under existing conditions, summer rearing habitat in the Englishman River is considered one of the primary limiting factors of CO, ST, CH and RB production within the watershed (Bocking and Gaboury 2001; Lough and Morley 2002). Rearing habitat is limited by low summer flows that typically occur between July and October. In Reaches 1 and 2 (i.e., the river section downstream of the proposed water intake), production of rearing salmonids is limited by the lack of winter refuge and lack of pools with adequate cover in summer and winter (Lough and Morley 2002).

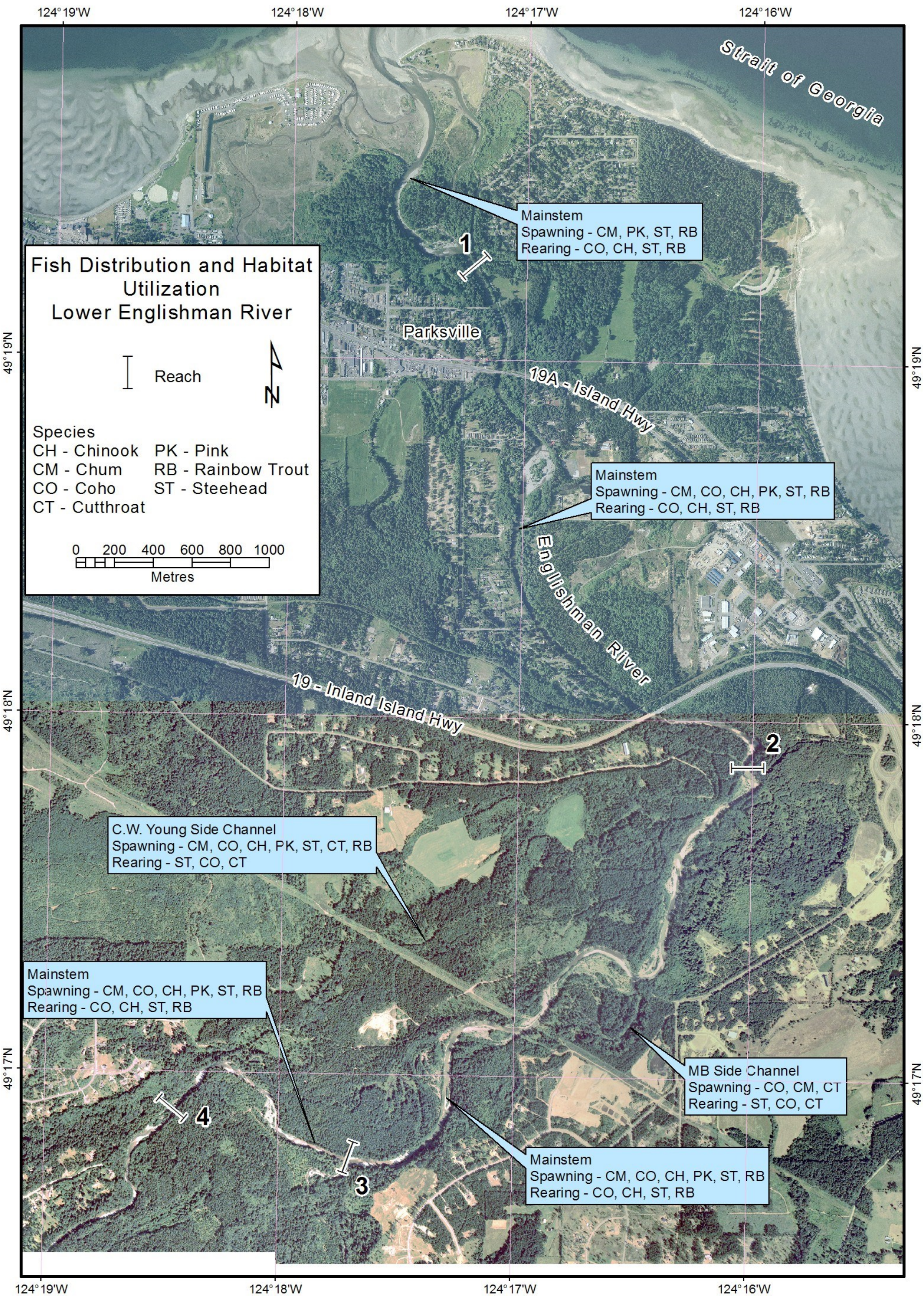

Figure 6. Map of lower Englishman River showing distribution of salmon and trout species that use mainstem and side channel habitats for spawning and rearing.

5.1.2 Fish Habitat at Intake Site

The proposed water intake would be located on the right bank (facing downstream) at a shallow curve meander bend of the river near the upstream end of Reach 2 (Figure 1). Boulders and cobbles are the predominant channel substrates present near the water intake site. Water depth during the summer is ~0.5 m in the thalweg of the right bank channel. The habitat immediately adjacent to the site is characterized as shallow glide. At low discharges the site is adjacent to a large mid-channel outcropping of bedrock, with short riffle and glide sections immediately downstream.

The glide habitat at the intake site would be suitable as rearing habitat for salmonids, particularly ST, RB, CCT, CH and CO fry, at low and moderate flows. The glide habitat would also be suitable as rearing habitat for ST and RB parr and adults at moderate and high flows. The large cobble and boulder substrate in the glide and riffle immediately downstream of the intake site would limit its utilization by salmonids for spawning.

Although the bank vegetation near the Highway 19 and railway crossings has been disturbed, large mature Douglas fir and red cedar are the dominant tree species found on the right bank at the proposed intake site.

5.1.3 Fish Habitat Downstream of Intake Site

The proposed intake site is located ~2.62 km upstream of the existing water intake and ~2.92 km upstream of tidally-influenced waters at the Reach 1-2 break. Fish habitat downstream of the proposed intake site is situated within Reach 2 of the Englishman River (Figure 1). Fish habitat between the proposed intake and tidal waters is currently utilized by salmon and ST for spawning, and by CO, CH, ST and Rainbow and CCT for rearing (Figure 6). Timing of use of this habitat by these species would be as described in Table 1.

The lower river is characterized as a riffle-pool-glide morphology with an overall gradient of ~0.4%. Composition of habitat types in the lower Englishman River from the proposed intake to tidally-influenced waters at the Reach 1-2 break was predominantly glides, followed by riffles and pools (Table 5; Figure 7). The preponderance of glide habitat with an average composition of ~20% sand, ~61% gravel and ~6% cobble and 2%boulder provides a large quantity of moderate quality spawning habitat and moderate to high quality fry rearing habitat (Table 6). Riffles were comprised predominantly of gravel and cobbles with only a few riffles in primarily the upper river section having emergent boulders. The relatively low composition of boulders on the riffles suggests moderate quality rearing habitat for ST parr. Pools had primarily gravel and sand substrates. Exposed lateral gravel / cobble bars adjacent to the right and/or left banks were observed in some riffle, pool and glide habitats at a survey flow of 1.6 m^3/s.

Table 5. Channel length and proportion by length of glide, riffle and pool habitats downstream of the proposed water intake on the Englishman River. Refer to Figure 7 for meso-habitat distribution on river.

	Tidal Waters to Existing Intake		Existing to Proposed Intake	
Habitat Type	Habitat Length (m)	Proportion	Habitat Length (m)	Proportion
Glide	238	78.3%	1255	47.9%
Riffle	36	11.8%	737	28.1%
Pool	30	9.9%	628	24.0%
Total	304	100.0%	2620	100.0%

Table 6. Substrate composition (%) of glide and riffle habitats surveyed at river cross sections.

Habitat Type	Sand	Fine Gravel	Coarse Gravel	Cobble	Boulder
Glide	20	20	41	6	2
Riffle	8	7	53	16	5

Figure 7. Distribution of meso-habitats between the zone of tidal influence and the proposed water intake site on Englishman River.

5.2 Habitat-Flow Relationships

5.2.1 Fry

Area of CO, CH (spring period) and ST fry habitat in glides increases rapidly to peak WUA values as flows increase, and then suitability decreases gradually with increasing discharge (Figure 8). Area of ST parr and CH (summer period) fry habitat in glides increases gradually as flows increase to peak WUA values, then taper off very gradually with increasing discharge. Discharges at peak WUA values for fry inhabiting glides ranged from 0.10 m^3/s for CH spring fry to 5.80 m^3/s for CH summer fry (Table 7). Peak WUA values for ST and CO fry were 0.60 and 1.40 m^3/s, respectively.

Area of salmon and ST fry habitat in riffles increases quite rapidly to peak WUA values as flows increase, and then suitability decreases gradually with increasing discharge (Figure 9). Discharges at peak WUA values for fry inhabiting riffles ranged from 1.30 m^3/s for CH spring fry to 3.90 m^3/s for CH summer fry (Table 7). Peak WUA values for ST and CO fry were 1.90 and 2.40 m^3/s, respectively.

The decline at a constant rate in habitat suitability at higher flows is indicative of increasing velocities and depths in riffle and glide areas. For all sites, there is generally more available habitat area at a given discharge for CO, CH summer and ST fry than for CH spring fry.

5.2.2 Parr

Area of ST parr habitat in glides and riffles increases gradually to peak WUA values as flows increase, and then suitability tapers off very gradually with increasing discharge (Figure 8 and Figure 9). Discharges at peak WUA values for ST parr were 8.30 m^3/s for glides and 5.50 m^3/s for riffles (Table 7).

5.2.3 Spawning

Spawning area for salmon and ST increases quite gradually in glides with maximum WUA values for all species at >10 m^3/s (Table 7; Figure 10). Spawning area of salmon and ST increases rapidly in riffles with maximum WUA values at >6 m^3/s (Figure 11). Flows at maximum WUA for CH spawning were the highest with estimates of ~32 m^3/s in glides and ~35 m^3/s in riffles.

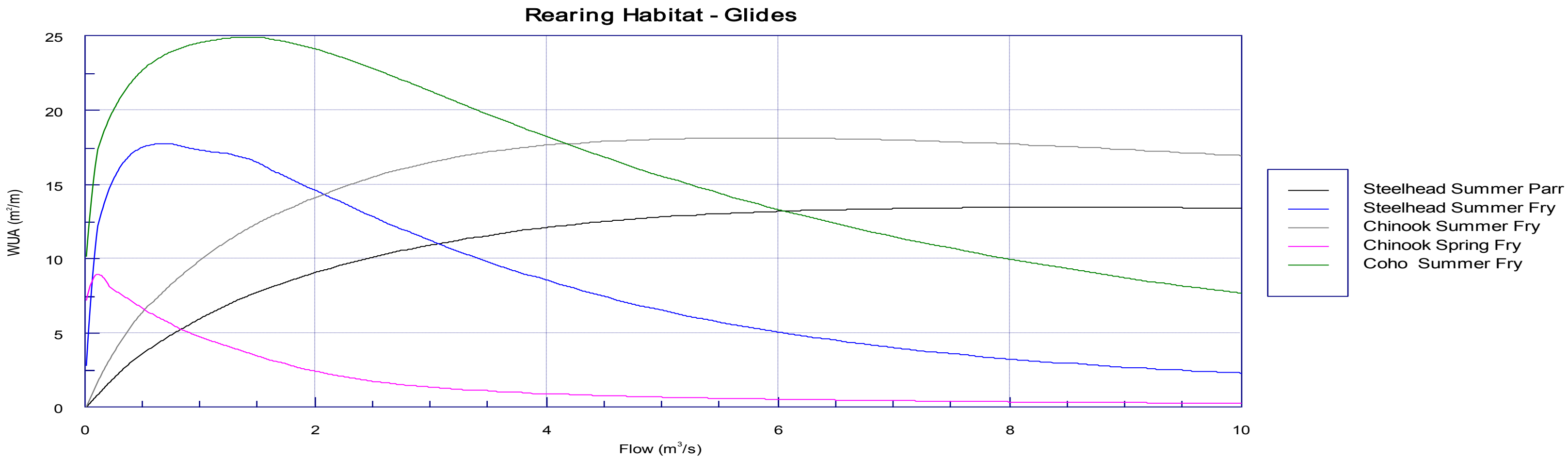

Figure 8. Weighted usable area plots for lower Englishman River glides based on rearing habitat suitability indices for Steelhead, Chinook and Coho.

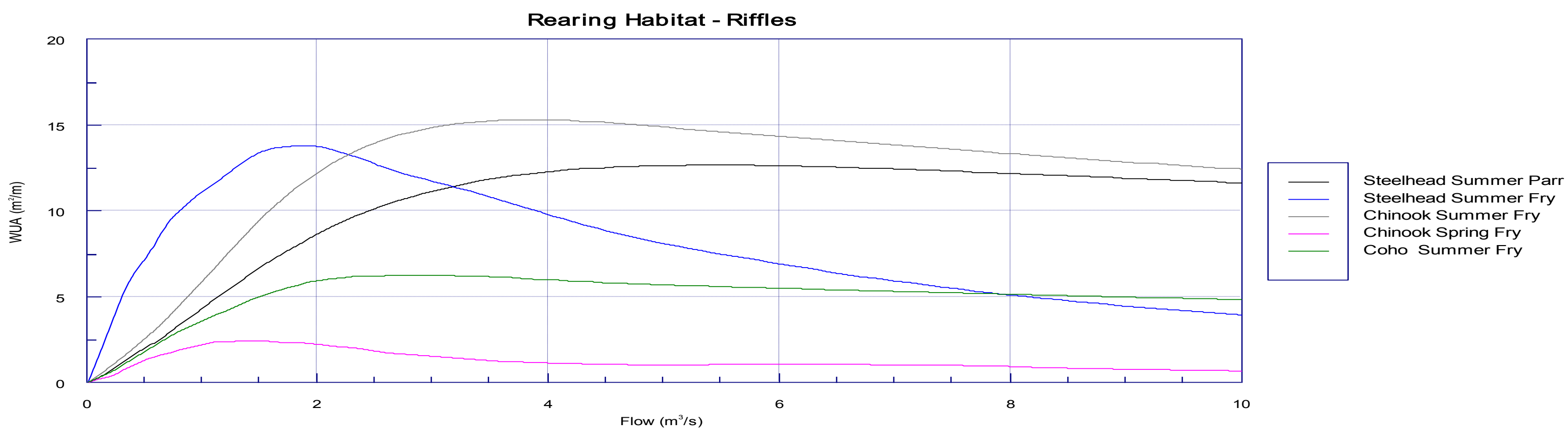

Figure 9. Weighted usable area plots for lower Englishman River riffles based on rearing habitat suitability indices for Steelhead, Chinook and Coho.

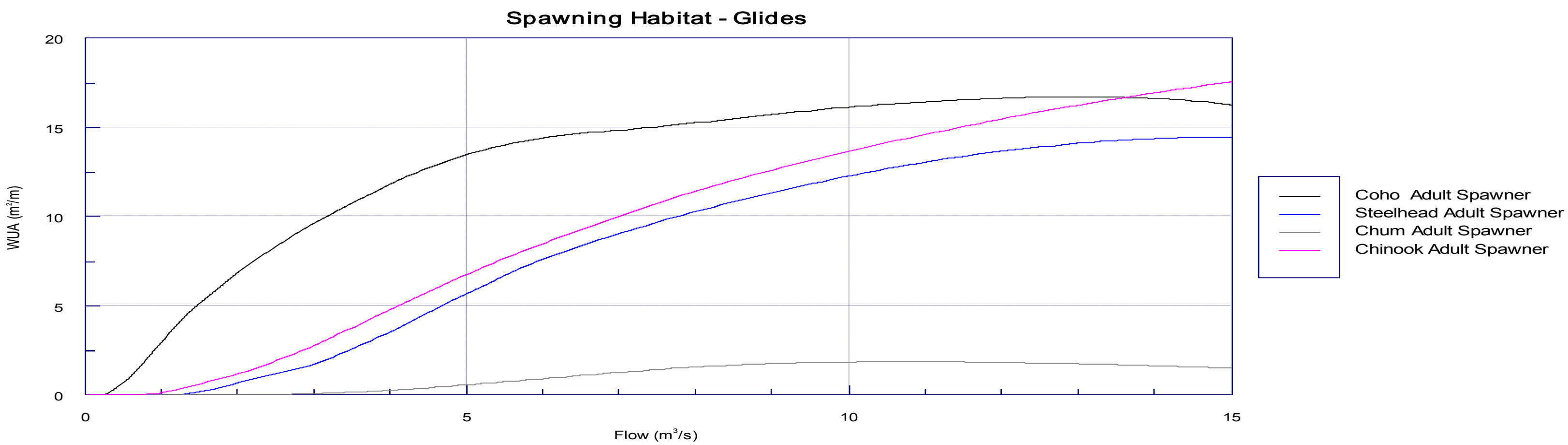

Figure 10. Weighted usable area plots for lower Englishman River glides based on spawning habitat suitability indices for Steelhead, Chinook, Coho and Chum.

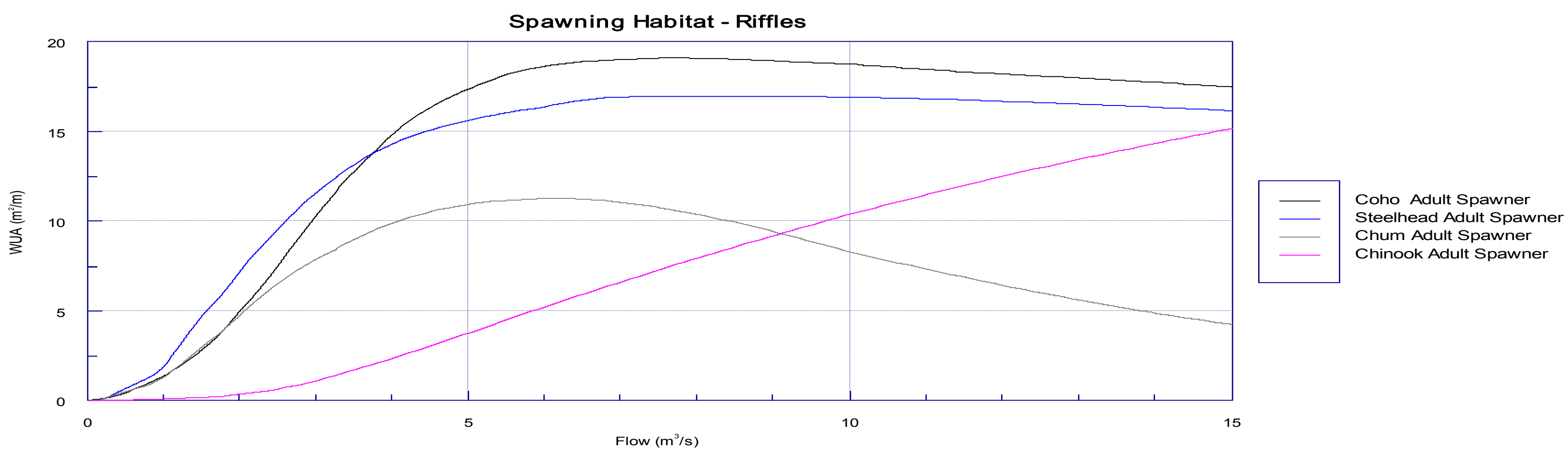

Figure 11. Weighted usable area plots for lower Englishman River riffles based on spawning habitat suitability indices for Steelhead, Chinook, Coho and Chum.

Table 7. Channel and flow characteristics at maximum weighted usable area for salmon and Steelhead in lower Englishman River.

				At Maximum WUA				
Species	Lifestage	Habitat	Maximum WUA	Discharge (cms)	Mean Depth (m)	Mean Velocity (m/s)	Wetted Width (m)	Wetted Perimeter (m)
Steelhead	Summer Fry	R	14.35	1.90	0.18	0.35	29.36	29.49
	Summer Fry	G	17.70	0.60	0.30	0.07	29.42	29.50
	Summer Fry	R+G	15.51	1.30	0.29	0.18	30.32	30.43
	Summer Parr	R	13.18	5.50	0.35	0.48	32.45	32.70
	Summer Parr	G	13.44	8.30	0.73	0.33	33.27	33.69
	Summer Parr	R+G	13.05	7.10	0.59	0.38	33.17	33.52
	Spawner	R	16.94	7.70	0.43	0.54	33.41	33.70
	Spawner	G	14.44	14.90	0.91	0.48	33.82	34.40
Coho	Summer Fry	R	6.15	2.40	0.21	0.37	29.75	29.90
	Summer Fry	G	24.90	1.40	0.38	0.11	31.92	32.05
	Summer Fry	R+G	18.37	1.50	0.31	0.19	30.76	30.89
	Spawner	R	19.08	7.60	0.43	0.54	33.39	33.67
	Spawner	G	16.70	12.90	0.86	0.44	33.67	34.21
Chinook	Spring Fry	R	2.16	1.30	0.13	0.33	27.14	27.25
	Spring Fry	G	8.92	0.10	0.20	0.02	24.33	24.38
	Spring Fry	R+G	6.06	0.10	0.16	0.12	18.29	18.34
	Summer Fry	R	15.96	3.90	0.29	0.43	31.19	31.39
	Summer Fry	G	18.12	5.80	0.63	0.27	32.99	33.33
	Summer Fry	R+G	16.99	4.80	0.50	0.31	32.56	32.84
	Spawner*	R	15.16	15.00	0.61	0.72	34.89	35.30
	Spawner*	G	17.56	15.00	0.91	0.48	33.82	34.41
Chum	Spawner	R	11.26	6.10	0.38	0.50	32.82	33.13
	Spawner	G	1.85	10.70	0.80	0.39	33.49	33.98

Note: * Chinook spawner WUA is greater than 15 cms, estimated at ~32 cms in glides and ~ 35 cms in riffles

5.3 Potential Effects on Fish and Fish Habitats

5.3.1 Footprint of Intake Infrastructure

Installation of the intake structure will permanently replace the natural right bank of the channel with concrete (CH2M Hill and KWL 2014). The area of natural channel affected will include ~49 m^2 for the footprint of the water intake. Installation of the intake and access stairway will also result in a permanent loss of ~40 m^2 of riparian habitat. In total, ~49 m^2 of channel and ~40 m^2 of riparian habitat will be lost as a result of the installation of the intake and stairway.

5.3.2 Construction Phase

Potential harmful effects on fish and fish habitats during construction in the specified fisheries work window would primarily result from short term disturbance to juvenile CO, CH, ST and resident trout that rear in glides and riffles proximal to the proposed water intake. Impacts could result from activities such as bedrock blasting or hydraulic hammering, construction of cofferdams, fish salvaging, bank or bed disturbance by equipment or labourers, and sediment inputs to the Englishman River.

5.3.3 Operation and Maintenance Phase

During intake operation, entrainment or impingement of particularly juvenile fish may occur with inappropriate or inadequate screening of the water intake or if the screen is not regularly maintained. Approach velocities (i.e., the water velocity into or perpendicular to the face of an intake screen) that exceed 0.11 m/s may be too great for salmon or trout juveniles to avoid, causing impingement and potential fish losses.

Upstream migration by juvenile and adult salmon and trout may be impeded at low river discharges. Although the incidence of upstream migration by juvenile salmon and trout at low flow conditions in summer is expected to be relatively low, water extraction will lower discharges downstream of the water intake and may reduce upstream fish passage success by juvenile salmon and trout from July to October. Also, fish passage success may also be reduced for several adult salmon species found in the Englishman River that commence their spawning migrations in August and September (Table 1).

Maintenance activities that could occur within the wetted perimeter of the channel could include: 1) cleaning of intake screens using the air-backwash system screen, 2) removing gravel, cobble and boulders from the intake pool to improve water withdrawal efficiency, 3) removal, cleaning or replacement of the intake screens, and 4) repair of other components of the water intake structure. Depending on the maintenance activities involved and the timing of these activities at the water intake site, there could be some short term disturbance to either spawning or rearing fishes that are proximal to the intake.

5.3.3.1 Flow Changes

Water withdrawals from the proposed water intake will have a maximum average daily demand (MDD) in July of 24 ML/d (0.27 m^3/s). Under actual water intake operation average monthly withdrawal rates will vary by projected water demand. The actual withdrawal rates as well as the withdrawal rates as percentages of the maximum average daily withdrawal rate of 24 ML/d or 0.27 m^3/s are shown in Table 8.

Based on predicted increases in the population within the service area, a MDD of 24 ML/d is forecasted for 2035, with higher water demand (and potentially higher withdrawal rates) after 2035. However, it is quite conceivable that future water withdrawals after 2035 may be less than 24 ML/d because of more widespread acceptance of water conservation programs, successful implementation of Aquifer Storage and Recovery, and a less than anticipated population growth rate for the service area.

Table 8. Maximum daily average design pumping rates by month as a percentage of the maximum average daily withdrawal rate of 24 ML/d or 0.27 m^3/s.

Month	% of Max Instantaneous Withdrawal	Water Withdrawal Rate (m^3/s)
November	44%	0.12
December	44%	0.12
January	41%	0.11
February	41%	0.11
March	44%	0.12
April	44%	0.12
May	59%	0.16
June	81%	0.22
July	100%	0.27
August	93%	0.25
September	74%	0.20
October	56%	0.15

The key concern of water withdrawals at the proposed intake site relates primarily to the decrease in flows downstream of the new intake during the low flow summer period that could affect the amount and quality of functional fish habitat in the 2.92 km length of mainstem between the proposed intake and tidal waters. As is common with most east Vancouver Island streams, low summer flows in the lower Englishman River generally limit the potential quantity of rearing habitat available to native salmon and trout populations. Under existing conditions, the lowest flows occur from July to October. Water withdrawals are not expected to significantly affect flows for overwintering, or salmon spawning, egg incubation, emergence and smolt migration between the months of November and June (LGL Limited 2014). However, a reduction in flow with water withdrawals at the intake could potentially reduce rearing habitat area for CH, CO and ST during July-October, and spawning area for ST during July in the section of Reach 2 downstream of the proposed intake (Table 1).

Potential impacts on flows and fish habitat in this fish habitat offsetting plan were assessed based on the predicted MDD water withdrawals in 2035 of 24 ML/d. In the analysis, post-project flows were based on existing recorded flows (2000-2011) minus the predicted water withdrawal in each month. Pre-dam, post-dam and post-project flows were based on hydrological analyses carried out by Kerr Wood Leidal Associates Ltd. For our analysis we considered the fish habitat effects during Critical Period Stream Flows (CPSF) which occurs between July and October and based water withdrawals in each of the four months on the average water withdrawal rates specified for each month in Table 8. WUA losses were calculated by subtracting species and life stage specific WUA values under existing (post-dam) conditions from post-project conditions. It was also assumed in the analysis of post-project flows that Stage 3 or 4 conservation measures would be implemented when river discharges declined during 10 or 20 yr return period droughts. In the analysis, species and life stage specific WUA values for riffles and glides were determined for 2, 10 and 20 yr return period drought discharges. These return period discharges are essentially equivalent to the 50, 90 and 95%, respectively, exceedance values for CPSF quoted in the Aquatic Effects Assessment (LGL Limited 2014).

The effect of water withdrawals on rearing habitat for ST, CH, and CO in July to October and ST spawning habitat in July only is presented for the two affected sections of the river:

1. Between the proposed and existing water intakes (Appendix K and Appendix L); and
2. Downstream of the existing water intake to tidal waters (Appendix M and Appendix N).

Weighted Usable Area losses for the section of channel from the proposed intake to tidal waters are summarized in Table 10 based on the aforementioned detailed appendix tables. Overall, proposed water withdrawals in August caused the greatest decrease in the quantity of suitable rearing habitat for these species and life stages, followed by July, September and October. Based on Table 10, between the proposed water intake and tidal waters, maximum losses in the quantity of suitable habitat (i.e., WUA-based wetted channel area) for each species and life stage with predicted water withdrawals during the CPSF are listed in Table 9.

Table 9. Maximum WUA losses in riffle and glide habitats between the proposed water intake and tidal waters.

	Maximum WUA Loss	
Species / Life Stage	Riffle	Glide
Steelhead Summer Parr	-913	-1337
Steelhead Summer Fry	-900	136
Chinook Summer Fry	-1359	-1948
Coho Summer Fry	-	-481
Steelhead Spawner	-	-420

The fish species and life stages most affected by flow changes in rearing habitat and, therefore the best indicators of habitat impact, are ST parr and CH summer fry. Rearing habitat for CO fry and ST fry would be affected to a lesser degree by flow reductions because of behavioural preferences for these life stages for lower velocity habitats (i.e., margins of riffles and glides). Furthermore, flow-habitat models such as RHYHABSIM do not accurately reflect the impacts of lower flows on fish habitat for these species as lower flows will result in lower velocities which typically results in increases in WUA for CO and ST fry. Conversely, higher flows for some life stages will result in lower WUA values. For example, an increase in 2 yr return period drought flows from pre-dam (1.7 m^3/s) to post-project (4.1 m^3/s) conditions in October results in a 9,148 m^2 loss of WUA for ST fry inhabiting glides (Appendix R). Therefore, even though some habitat losses have been shown for CO fry and ST fry in Table 10 and Appendix K to Appendix N, habitat losses will only be measured against habitat gains for ST parr, ST spawner and CH summer fry in riffles and glides when calculating habitat offsets.

Table 10. Weighted Usable Area losses at riffles and glides in Englishman River between the proposed water intake and tidal waters, based on existing post-dam conditions and predicted monthly average withdrawals (post-project).

Habitat	Return Period Drought (yr)	Month	Loss (-ve) or Gain (+ve) in WUA (m^2)				
			Steelhead Summer Parr	Steelhead Summer Fry	Chinook Summer Fry	Coho Summer Fry	Steelhead Spawner
Riffle	2	July	-761	67	-998	-	-
		August	-821	-396	-1215	-	-
		September	-671	-267	-988	-	-
		October	-70	251	34	-	-
	10	July	-875	-877	-1310	-	-
		August	-913	-900	-1359	-	-
		September	-771	-754	-1148	-	-
		October	-337	-384	-487	-	-
	20	July	-739	-683	-1081	-	-
		August	-808	-767	-1190	-	-
		September	-592	-531	-862	-	-
		October	-334	-469	-477	-	-
Glide	2	July	-957	1389	-1257	755	-420
		August	-1029	1318	-1363	374	-
		September	-839	1173	-1108	392	-
		October	-204	540	-135	684	-
	10	July	-1277	350	-1858	-447	-32
		August	-1337	353	-1948	-481	-
		September	-1137	296	-1657	-412	-
		October	-532	213	-771	-254	-
	20	July	-1107	265	-1620	-431	-1
		August	-1186	306	-1733	-448	-
		September	-901	225	-1322	-363	-
		October	-593	136	-863	-413	-

5.4 Measures and Standards to Avoid or Mitigate Impacts

5.4.1 Construction Phase

Short term disturbance to fish populations and potential impacts on river water quality (i.e., riparian clearing, bank erosion, sediment mobilization, etc.) as a result of intake construction can be effectively mitigated through established environmental protection procedures that have been endorsed by the regulatory agencies and by site-specific environmental management and erosion and sediment control plans to be developed by ERWS for construction operations. Construction of the intake will occur during the DFO instream work window in the summer months when the river levels are at their lowest and when spawning, egg incubation and fry emergence are not occurring. The work site will be isolated by upstream and downstream cofferdams, and fish will be salvaged from within the isolated work area. The upstream cofferdam will divert the flow around the south side of the large mid-channel bedrock outcropping. The downstream cofferdam will prevent river water from entering the intake construction area. A sump will be dug on the dry side of the cofferdam to allow pumping of subsurface flow and any sediment-laden water to an appropriate settling area, pond or apparatus outside of the wetted perimeter of the river. These plans and procedures will prevent sediment laden waters from the worksite from entering Englishman River.

Disturbance to riparian vegetation will be kept to the absolute minimum required to conduct the works. Riparian vegetation which is damaged or lost as a result of this construction project will be replaced, where appropriate.

5.4.2 Operation and Maintenance Phase

5.4.2.1 Water Storage Development to Improve Flows

The ERWS water supply project has been planned and implemented in several distinct phases. The time period from the start of planning and assessment to completion of the constructed water supply works was forecasted to occur over approximately 50+ years. The ongoing planning by AWS and ERWS has been guided by two main objectives: 1) to provide an adequate domestic water supply to service the ERWS area, now and in the future, and 2) to maintain sufficient streamflows after water withdrawal to protect the integrity and function of the natural aquatic environment in the Englishman River.

Work began in 1972 with the first regional water study which considered all of the RDN's water supply needs ranging from Bowser to Cedar. Later in 1988, a comprehensive water supply study was completed that focused on the Englishman River and Nanaimo River, South Fork - Jump Creek. The conclusions from this water supply study led to the construction of the Arrowsmith

Dam water storage impoundment in 1999. The Dam is located approximately 35 km southwest of Parksville on Arrowsmith Creek, a tributary to the Englishman River. It was commissioned in 2000 and built under the auspices of the Arrowsmith Water Service, a joint venture between the City of Parksville, the RDN and the Town of Qualicum Beach.

The Arrowsmith Dam, with a live storage volume of 9 Mm^3, is used to regulate flows in the Englishman River for release during the summer and fall to meet the domestic water demands of the City of Parksville and the Nanoose Water Supply Area operated by the RDN. About half of the live storage volume behind Arrowsmith Dam is provided to supplement low natural river flows for conservation purposes, which has greatly improved summer flows in the reaches of the Englishman River downstream of the confluence of Arrowsmith Creek with the mainstem river. Currently, flows are released based on a Provisional Operating Rule developed in collaboration with BC Ministry of Environment and Fisheries and Oceans Canada and issued by Order under s. 18, *Water Act*. The Provisional Operating Rule provides a relationship between remaining storage in Arrowsmith Lake and flow releases to the Englishman River.

As required by the Conditional Water Licence, the Operating Rule has been reviewed and updated to allow discharges to be maintained between 0.90-1.60 m^3/s at the Water Survey of Canada (WSC) gauge located at the Highway 19A bridge crossing (Figure 12). The revised operating rule accounts for water withdrawals at the proposed intake upstream of the WSC gauge.

The proposed operating rules apply to a series of five reservoir operating zones which will guide the magnitude of the minimum conservation flows downstream of the Water Survey of Canada gauge given the level of storage remaining the reservoir. The proposed minimum conservation flows range from 1.6 m^3/s for average inflow conditions to 0.9 m^3/s under a 20-year drought condition. These operating rules will become an order under the water licence for the dam and as such AWS will be legally required to follow the operating rules, unless otherwise directed by the Provincial Comptroller of Water Rights. Further details of the proposed operating rules are outlined in the following section.

5.4.2.1 Management of Arrowsmith Dam Releases

During the operational phase, potential impacts on spawning, incubation and rearing habitat downstream of the intake as a result of a decrease in river discharge after raw river water is extracted can be mitigated by ensuring that releases from Arrowsmith Dam meet, where conditions permit, a minimum maintenance flow in the mainstem immediately downstream of the proposed water intake.

To determine achievable minimum maintenance flow targets downstream of the proposed water intake, Kerr Wood Leidal Associates Ltd. (KWL) modeled Englishman River flows based on available water storage at the Arrowsmith Lake reservoir and a maximum average daily demand (MDD) in July of 24 ML/d (0.27 m^3/s). The hydrologic modelling completed by KWL indicated that, provided storage management operations at Arrowsmith Lake were optimized, the lake has sufficient storage capacity to maintain minimum maintenance flows of 0.9-1.6 m^3/s downstream of the intake plus provide sufficient flow to meet the required withdrawal rates (Table 11). Based on hydraulic-habitat modelling, it was found that these minimum maintenance flow provisions will mitigate potential impacts as a result of water withdrawals and ensure that all important spawning and rearing sections of the river downstream of the intake remain productive and viable for salmon and trout.

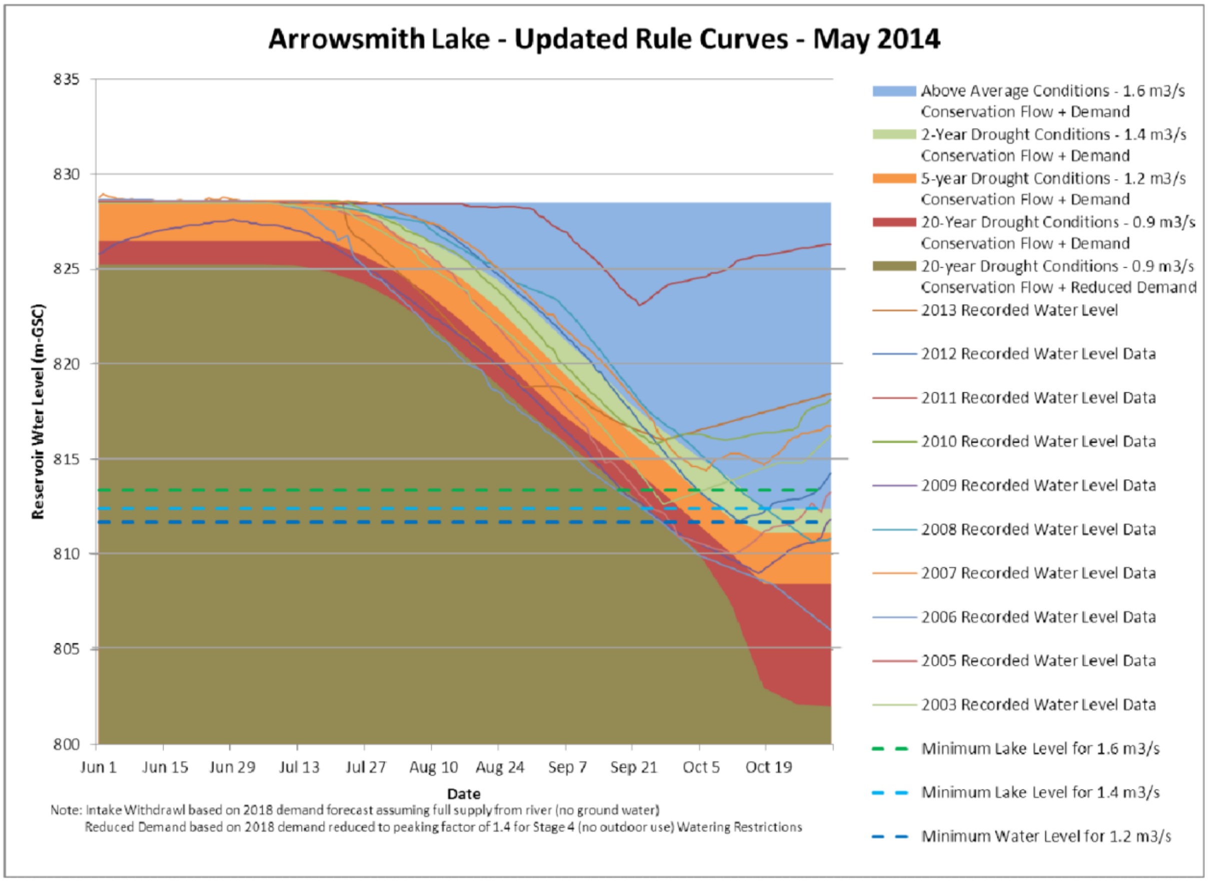

Figure 12. Provisional operating rule for Arrowsmith Lake. Prepared by Kerr Wood Leidal Associates Ltd. for ERWS, June 2014.

Table 11. Minimum maintenance flows downstream of the proposed water intake under various flow conditions in the Englishman River.

Flow Conditions	Target Flow at Hwy 19 (m^3/s)
Above Average Year	1.6
Below Average Year 2 yr to 5 yr Return Period Drought	1.4
Dry Year 5 yr to 20 yr Return Period Drought	1.2
Very Dry Year >20 yr Return Period Drought	0.9

Under these minimum flow scenarios, CO summer fry, CH spring fry and ST fry residing in glides and riffles downstream of the water intake would be at or near maximum WUA at flows between 0.9 and 1.6 m^3/s (Figure 8; Figure 9). ST parr and CH summer fry are the most affected by low summer flows but 39% and 47% of maximum WUA for ST parr and CH summer fry, resp. will be present at discharges of 0.9 m^3/s, and 60% and 70%, resp. will be present at 1.6 m^3/s.

Prudent management of Arrowsmith Dam releases is fundamental to ensuring the highest possible maintenance flows occur during July-October so that critical period streamflows and the area of suitable salmonid rearing habitats are maximized during this critical fish production period. Within the CPSF July-October period, the lowest flows occur between August 15 to October 15 (80% occurrence of annual minimum flow in period of record). Further refinements in the management of flow releases from Arrrowsmith Dam could potentially increase the minimum maintenance flows during this narrower time period and mitigate potential impacts to rearing habitats in drought years in particular.

5.4.2.2 Water Supply and Conservation Measures

Refinements in the implementation of existing municipal water demand conservation measures will be used to reduce water withdrawals during critical streamflow periods. Water conservation measures will also be implemented in anticipation of future increased uncertainty in natural inflow to Arrowsmith Lake and Englishman River as a result of climate change and other hydrologic impacts such as land use changes.

The City of Parksville has four water conservation levels in which irrigation (lawn watering) and outdoor water use is limited as required to reduce demands and preserve supply. Conservation Stages 1 and 2 are applied every year and limit irrigation to certain days of the week, certain times of the day and durations. Conservation Stages 3 and 4 are implemented by the Operations Department when required. Stage 3 water conservation limits irrigation to 6-10 AM and 6-10

PM once per week; Stage 4 water conservation is a comprehensive outdoor water use ban. The Capital Regional District implemented a complete outdoor water use ban in 2001 (similar to Parksville's Stage 4 restrictions) and was successful in reducing Maximum Day Demand by about one-third compared to years with normal water conservation measures. The equivalent reduction in the ERWS system would be about 7.5 ML/d or 0.09 m^3/s for existing demands.

Aquifer Storage and Recovery (ASR) system is currently being assessed to determine its feasibility. ASR is defined as the storage of water in a suitable aquifer when water is available and then recovery of the same water later on when it is needed. Incorporating ASR into ERWS's system would involve contributing treated water to the storage aquifer in the winter, when excess supply is available, and withdrawing this water in the summer when supply is most challenged to meet demands. ASR would create additional reservoir storage for the ERWS, which would provide more contingency should a supply source be taken offline, and allow the ERWS greater flexibility in managing the water resources.

5.4.2.3 Intake Screen Design

Intake screens will be designed so that when the pumps are operating there is a low approach velocity through the screen. This will minimize potential fish entrainment or impingement on the screen, particularly for juvenile life stages. DFO (1995) states in their 'Freshwater Intake End-of-Pipe Fish Screen Guideline' that the surface area of the screen of the water intake be large enough to ensure the maximum approach velocity during water withdrawal for sub-carangiform fish (trout or salmon) is ≤0.11 m/s. This guideline covers small water intakes with a withdrawal rate up to 125 L/s but should be acceptable at the higher withdrawal rates for the proposed intake. Although the maximum instantaneous withdrawal rate will be 28.8 ML/d, the intake screen was designed based on maintaining a maximum approach velocity of ≤0.11 m/s for 48 ML/d flow (ultimate capacity under water license). The screen sized with an additional 10% screen area at the ultimate flow of 48 ML/d. Consequently, the screen will be oversized for a withdrawal rate of 28.8 ML/d. The increased screen area allows for approach velocities to be maintained at ≤0.11 m/s with some debris accumulation on the screen. The intake screen will be cleaned as frequently as necessary by an automated air backwash system to reduce the likelihood of higher approach velocities and potential fish impingement.

5.4.2.4 Ramping Rate

A maximum ramping rate of 2.5 cm/hr will be established to prevent impacts during fry emergence and summer and winter rearing. This maximum ramping rate is within guidelines recommended by Cathcart (2005) for the protection of aquatic resources. Five representative riffles were surveyed downstream of the proposed intake structure location and used to examine the habitat-flow relationship in the RHYHABSIM modeling. Based on this RHYHABSIM modeling information, a maximum river water level change of 2.5 cm/hr for representative riffles would equate to withdrawal rate changes at the intake that would vary with river flows and range between maxima of 0.25 and 0.37 m^3/s/hr (Table 12). The control system for the water intake pump would be designed to meet the ramping rates during normal system operation. However, these ramping rates may be exceeded during emergency conditions such as delivering water for firefighting or refilling storage after a watermain break.

Table 12. Maximum ramping rates for a maximum river water level change of 2.5 cm/hr (vertical difference) at riffle habitats.

Base River Flow (m^3/s)	Max ramping rate		Time from pump stop to full run (28.8 ML/d)
	m^3/s/hr	ML/d/hr	
0.9	0.25	21.6	80 min
1.2	0.31	26.5	65 min
1.4	0.37	31.7	54 min

5.4.2.5 Fish Passage

The intake structure layout has been designed to not impede upstream or downstream fish passage by juvenile and adult fish. Channel features such as riffles and glides downstream of the intake structure will not be modified to a significant degree. The existing glide adjacent to where the intake structure will be constructed will be deepened to improve the function of the intake screen to meet the required water withdrawals. No permanent structures will be constructed in the channel that would constitute obstructions or impediments to fish passage.

5.4.2.6 Maintenance

Maintenance activities that could occur within the wetted perimeter of the channel can be mitigated by working in the least risk work window, and by following established environmental protection procedures, and site-specific environmental management and erosion and sediment control plans developed by ERWS. Where considerable maintenance work is planned, environmental protection procedures will be similar to those described under Section 5.4.1 Construction Phase. In some cases, site isolation and fish salvage may be required.

5.5 Residual Harm to Fish

As described in Section 5.3.3.1 above, the residual harm to fish is represented by the maximum potential monthly loss in WUA resulting from the reduction in flows in the section of Englishman River between the proposed intake and tidal waters. In particular, the fish species and life stages most affected by flow changes are ST parr and CH summer fry. Spawning habitat for ST would also be affected to a limited extent in July when the fry are emerging from the gravels. Based on Table 10, maximum WUA losses in riffles and glides during the CPSF for ST parr, CH summer fry and ST spawners are summarized in Table 13.

Table 13. Maximum WUA losses for ST parr, CH summer fry and ST spawners in riffle and glide habitats between the proposed water intake and tidal waters.

Species / Life Stage	Return Period Drought (yr)	Month	Maximum WUA Loss		
			Riffle	Glide	Total
Steelhead Summer Parr	10-yr	August	-913	-1337	-2250
Chinook Summer Fry	10-yr	August	-1359	-1948	-3307
Steelhead Spawner	2-yr	July	-	-420	-420

5.6 Offsetting Plan

5.6.1 Flow Supplementation Offsets

5.6.1.1 Downstream of Proposed Intake

A key criterion in the design of the water storage facility at Arrowsmith Lake was to provide sufficient flow releases to mitigate for potential streamflow impacts on aquatic habitat downstream of the proposed water supply intake. Controlled releases from Arrowsmith Dam have resulted in greater discharges in the lower river than occurred under the pre-dam condition. With water extraction under post-project conditions, 10 yr return period drought discharges downstream of the intake will be ~134% greater than pre-dam conditions, and the median critical period streamflow (CPSF) from July to October will be ~84% greater (Table 14). It is important to note that the pre-dam baseline statistics suggest a wetter hydrological period in 1980-1998 than for the post-project estimates which were based on the 2000-2011 period. This would further suggest that Arrowsmith Dam releases will provide a potentially greater relative contribution to baseflows than the statistics in Table 14 show.

Water supply storage in Arrowsmith Lake will provide significant offsets to the potential impacts caused by reduced flows downstream of the proposed water intake. Supplementation from Arrowsmith Lake will continue to ensure that Post-

Project median CPSF values remain an acceptable 13% of Post-Project MAD values and well above the median CPSF value of 6% of the Pre-Dam MAD (Table 14).

Table 14. Comparison of pre-dam versus estimated post-project flows.

Statistic	Pre-Dam Baseline (cms)	Pre-Dam Baseline / Pre-Dam MAD (%)	Post-Project (cms)	% Change - Pre-Dam minus Post-Project	Post-Project / Post-Project MAD (%)
Mean Annual Discharge	13.78	100%	12.63	-8.4%	100%
Median Flow	6.86	50%	6.91	0.7%	55%
Min Daily	0.14	1%	0.56	287.8%	4%
Max Daily	393	2852%	303	-22.9%	2398%
10 yr return period drought	0.556	4%	1.30	134.1%	10%
20 yr return period drought	0.38	3%	1.00	164.6%	8%
CPSF Median (July-Oct)	0.87	6%	1.61	84.4%	13%

Notes:

1) Pre-dam baseline for the period 1980-1998, and post-project defined by the period post construction of the Arrowsmith Lake Dam from 2000 to 2011

2) Post-project flows based on water extraction rates as a percentage of the maximum average daily withdrawal rate of 24 ML/d or 0.27 m^3/s, as described in Table 8

3) Post-project flows are the flows in the river downstream of the water intake and after the proposed water withdrawals have occurred

A summary of the potential gains in WUA in the Englishman River between the proposed water intake and tidal waters based on post-project versus pre-dam flow regimes showed that flow supplementation from Arrowsmith Lake has resulted in gains in WUA for those fish species that are the best indicators of flow effects (i.e., ST parr and CH summer fry) (Table 15; Appendix O; Appendix P; Appendix Q; Appendix R). WUA gains resulting from flow increases from pre-dam to post-project conditions have offset most of the rearing habitat losses in riffles and glides, as described in Table 10. The analysis for ST parr showed:

- the range in WUA gains was 121 to 6057 m^2 with a mean of 3191 m^2;
- WUA habitat gains occurred for each month with the lowest gain occurring in July and the greatest gain generally occurring in September;
- habitat gains were greater in glides than in riffles; and
- overall, there were WUA gains in riffles and glides under 2, 10, and 20 yr drought flow conditions.

The analysis for CH summer fry showed:

- the range in WUA gains was 128 to 9454 m^2 with a mean of 4580 m^2;

- WUA habitat gains occurred for each month with the lowest gain occurring primarily in July and the greatest gain occurring in September;
- habitat gains were greater in glides than in riffles; and
- overall, there was positive WUA gains in riffles and glides under 2, 10, and 20 yr drought flow conditions.

Table 15. Potential gain in Weighted Usable Habitat (WUA) in the Englishman River between the proposed water intake and tidal waters based on post-project versus pre-dam flow regimes.

Habitat	Return Period Drought (yr)	Month	Potential Gain in WUA (m^2)		
			Steelhead Summer Parr	Chinook Summer Fry	Steelhead Spawner
Riffle	2	July	196	278	-
		August	3082	4556	-
		September	3564	5261	-
		October	3681	3469	-
	10	July	121	128	-
		August	2389	3345	-
		September	2532	3521	-
		October	1896	2660	-
	20	July	1293	1853	-
		August	2491	3438	-
		September	2556	3487	-
		October	1460	1977	-
Glide	2	July	288	377	108
		August	5090	7340	-
		September	5893	8483	-
		October	4805	5663	-
	10	July	1734	2530	0
		August	5398	8264	-
		September	5697	8743	-
		October	4366	6675	-
	20	July	2455	3589	0
		August	5752	8886	-
		September	6057	9454	-
		October	3786	5943	-

Net area effects are relatively small for ST spawning habitat with gains only occurring at the 2 yr return period drought flow (Table 15). WUA gains resulting from flow increases from pre-dam to post-project conditions have partially offset ST spawning habitat losses in glides (see Section 5.6.3 for a more detailed discussion of net habitat gains).

5.6.1.2 Upstream of Proposed Intake

With the location of the proposed intake structure immediately upstream of the Inland Island Highway crossing, the entire volume of Arrowsmith Dam releases will continue to augment aquatic habitat function in the non-anadromous and anadromous sections of the river down to the new intake site. These streamflow improvements will continue to enhance summer rearing habitat for salmonids over a river distance of ~12 km between the proposed intake and the anadromous barrier and another ~14 km from the anadromous barrier upstream to the confluence with Arrowsmith Creek. In particular, flow supplementation from Arrowsmith Lake during the CPSF has increased median, and 10 and 20 yr return period drought discharges substantially from pre-dam discharges (Table 16).

The wetted habitat area gains associated with the increased CPSF discharges from pre-dam to post-project are summarized in Table 17 and are shown in detail in Appendix S to Appendix U. For the calculations of wetted habitat area gains, channel width values for Reaches 3-6 were based on wetted width measurements taken by Lough and Morley (2002), and adjusted to specific discharge values using a width to discharge relationship from surveyed data from Reach 2. Channel length measurements for riffle, pool and glide habitats were based on survey data from Lough and Morley (2002) (Appendix V).

As a consequence of controlled Arrowsmith Dam releases, mean wetted area gains in riffle, glide and pool habitats have varied with streamflow but gains have been most significant during low discharges under a 20 yr return period drought. The increase in flows from pre-dam to post-project for 10 and 20 yr return period droughts in particular, increases the quality and quantity of rearing habitat for salmon and Steelhead during critical summer baseflow periods, and by addressing this critical limiting factor helps to improve production for all freshwater rearing salmonids. These habitat benefits have occurred since Arrowsmith Dam releases began in 1999-2000 and will continue to occur under the post-project flow regime.

Table 16. Comparison of pre-dam and post-project flows in the anadromous Reaches 3-6 upstream of the proposed water intake.

			Reach Flows (m^3/s)			
	Month	Flow Period	3	4	5	6
Median	July	Pre-Dam	1.7	1.4	1.1	1.1
		Post-Project	2.0	1.7	1.5	1.5
	August	Pre-Dam	0.6	0.5	0.4	0.4
		Post-Project	1.7	1.6	1.5	1.5
	September	Pre-Dam	0.6	0.5	0.4	0.4
		Post-Project	1.7	1.6	1.6	1.6
	October	Pre-Dam	1.7	1.4	1.1	1.1
		Post-Project	4.2	3.9	3.7	3.7
10 yr return period	July	Pre-Dam	0.7	0.6	0.5	0.5
		Post-Project	1.2	1.1	1.0	1.0
	August	Pre-Dam	0.3	0.2	0.2	0.2
		Post-Project	1.2	1.2	1.1	1.1
	September	Pre-Dam	0.3	0.2	0.2	0.2
		Post-Project	1.2	1.2	1.1	1.1
	October	Pre-Dam	0.3	0.3	0.2	0.2
		Post-Project	1.0	0.9	0.9	0.9
20 yr return period	July	Pre-Dam	0.6	0.5	0.4	0.4
		Post-Project	1.2	1.0	1.0	1.0
	August	Pre-Dam	0.3	0.2	0.2	0.2
		Post-Project	1.2	1.1	1.1	1.1
	September	Pre-Dam	0.2	0.2	0.2	0.2
		Post-Project	1.1	1.1	1.0	1.0
	October	Pre-Dam	0.3	0.2	0.2	0.2
		Post-Project	0.8	0.8	0.7	0.7

Flow in the Clay W. Young Side Channel is nearly fully supported by releases from the Arrowsmith Dam during the critical summer period. Licenced flow for the Clay W. Young Side Channel is 0.028 m^3/s over the entire year. Diversion of 0.028 m^3/s to the side channel would be ~10% of pre-dam August-October flows in Reach 3 under a 10 yr return period drought, but <3% under post-project flows (Table 16). Without supplementation from Arrowsmith Lake during the summer period the feasibility of constructing the 7.44 ha Clay W. Young Side Channel would have been jeopardized and CO smolt contributions to the Englishman River of >40% (Taylor and Wright 2010a; 2010b) would not have been realized.

Table 17. Mean gain in wetted habitat area of riffles, glides and pools in Reaches 3-6 based on post-project vs pre-dam flow regimes.

Return Period Drought (yr)	Month	Mean Gain in Wetted Habitat Area (m^2)		
		Riffle	Glide	Pool
2	July	2066	514	97
	August	13181	2383	682
	September	14385	2544	735
	October	6205	961	638
10	July	7865	1328	425
	August	15010	11268	723
	September	15247	3415	731
	October	10658	2292	586
20	July	8499	1511	460
	August	15089	11312	727
	September	15890	3636	746
	October	9445	2415	514

5.6.2 Additional Instream Habitat Offsets

During intake construction, ~15 oversized boulders will be added to existing riffles proximal to the proposed water intake site to enhance ST parr and CH summer fry habitat. Up to three riffle areas proximal to the construction work area will be enhanced by placing approximately five oversized, round boulders on the downstream face of each riffle. The boulders will increase hydraulic diversity by roughening the streambed and providing localized zones of high velocity immediately adjacent to back eddy zones of lower velocity. ST parr and CH summer fry prefer moderate to high velocity habitats with high bed roughness. The heights of boulders will be adjusted relative to the streambed and bankfull discharge to achieve preferred hydraulic conditions similar to the boulder structures constructed in the Big Qualicum River (McCulloch 2000). The design criteria will include:

- back eddy pockets on the downstream side of the boulders with ~0.5 m in depth;
- shear zones of high/low velocities along on the outside edges of the emergent boulders;
- overtopping of the boulder at discharges greater than bankfull discharge; and
- broken water cover from aeration and surface turbulence.

It is assumed that each boulder will create approximately 3 m^2 of habitat area for a total area for 15 boulders of ~45 m^2. The boulders will be installed during the reduced risk instream work window, and follow standard environmental protection procedures as outlined in Chilibeck et al. (1993), Standards and Practices for Instream Works (BC Ministry of Water, Land and Air Protection 2004), and Best Management Practices (BMP's) for Instream Works (http://www.env.gov.bc.ca/wld/instreamworks/index.htm#). The cost for the boulder placements is estimated at $10K.

5.6.3 Net Habitat Gains

Flow supplementation from Arrowsmith Lake has generally resulted in net gains in WUA within Reach 2, downstream of the proposed intake location. As a consequence of higher post-project versus pre-dam flows for the CPSF, there will be positive net WUA gains for ST parr and CH summer fry downstream of the proposed water intake (Table 18). In Table 18 WUA values for each species and life stage are based on monthly potential maximum WUA losses (Table 10) or gains (Table 15) in riffles and glides between July and October.

The extended areas of moderate to high quality spawning gravels in the anadromous reaches of the Englishman River and the wide distribution of ST spawning throughout the reaches suggest that ST spawning habitat availability is not limiting ST production. Offsets for the maximum WUA loss of -420 m^2 for ST spawners, which is predicted to occur in a 2-yr return period drought, will be provided by a gain of 108 m^2 in WUA for ST spawners as a consequence of Arrowsmith Dam releases (Table 18; Appendix P and Appendix R), and by additional gains based on post-dam flow improvements affecting mean wetted habitat area of glides in Reaches 3-6 upstream of the proposed water intake at 2, 10 and 20 yr return period drought flows during the CPSF (Table 19; Appendix T). It's also important to note that ST WUA spawning losses at lower flows in 10-yr and 20-yr return period droughts, which would be of greater concern for ST, were considerably lower at -32.1 and -1.3 m^2, resp. (Appendix L and Appendix N).

In summary, flow supplementation from Arrowsmith Lake has resulted in net gains in wetted habitat area upstream of the proposed intake location. Higher post-project versus pre-dam flows for the CPSF will continue to provide significant wetted habitat area gains for riffle, glide and pool habitats in Reaches 3-6 (Table 19). These flow improvements will continue to provide increased wetted areas for ST and CH rearing and ST spawning during the CPSF. The WUA and wetted habitat area gains as presented in Table 18 and Table 19, respectively, and the additional instream habitat offsets described in Section

5.6.2, will offset WUA habitat impacts in Reach 2 as a result of the proposed water extractions at the new intake.

Table 18. WUA losses and gains (m^2) for target fish habitats downstream of the proposed water intake during the CPSF. WUA Gain values are specific to month of Maximum WUA Loss and are based on species-specific WUAs in riffles and glides under post-project vs pre-dam flow regimes (Table 15).

Species / Life Stage	Maximum WUA Loss				WUA Gain		Net Change in WUA	
	Return Period Drought	Month	Riffle	Glide	Riffle	Glide	Riffle	Glide
Steelhead Summer Parr	10-yr	August	-913	-1337	2389	5398	1475	4060
Chinook Summer Fry	10-yr	August	-1359	-1948	3345	8264	1986	6316
Steelhead Spawner	2-yr	July	-	-420	-	108	-	-311

Table 19. Additional gains based on post-dam flow improvements affecting mean wetted habitat area in Reaches 3-6 upstream of the proposed water intake at 2, 10 and 20 yr return period drought flows during the CPSF. Habitat area gains based on wetted habitat areas under post-project vs pre-dam flow regimes (Table 17).

Habitat	Mean Gain in Wetted Habitat Area (m^2)
Riffle	11128
Glide	3632
Pool	589

5.7 Contingency Plan

Habitat enhancement measures will be implemented in the Englishman River mainstem if, over the course of the 5 yr monitoring period, it is determined that either mitigation measures or offset works and measures are found to not be functioning as intended. The contingency measures will involve ERWS contributing funds to finance the implementation of remedial measures by either BCCF or FLNRO on existing large wood debris (LWD) structures in Reach 3. BCCF constructed ~35 LWD structures in Reach 3 between 2003 and 2006 (McCulloch 2004; 2005; Silvestri 2007). After ~12 yrs creating high quality rearing and holding habitat in the Englishman River and reducing channel bank erosion, the LWD structures require replacement of some LWD pieces and anchor cables to maintain their stability and habitat function. ERWS would work with BCCF or FLNRO to develop a funding agreement for the implementation of these remediation works.

Monitoring of the contingency works would involve regular snorkel surveys to assess habitat utilization of the LWD structures by juvenile and adult salmonids. These snorkel surveys would start in the year after the completion of remedial works and occur annually over 5 yrs. The surveys would be performed in conjunction with the ongoing BCCF/FLNRO surveys being undertaken four times per year between February and June.

5.8 Monitoring Plan

A monitoring program will be implemented to confirm effectiveness of mitigation measures and operational strategies (e.g., maintenance flows, flow ramping, Arrowsmith Dam flow release management, screening of water withdrawals) in avoiding serious harm to fish. The five year monitoring plan will examine:

a. the effectiveness of any identified mitigation works and management actions at reducing impacts of the project on fish and fish habitat;
b. the effectiveness of measures that have been identified to offset residual fish habitat impacts; and
c. the effectiveness of any contingency measures, if required and implemented.

Monitoring will include field measurements and reporting on the following parameters in Year 1 to Year 4 after intake commissioning (Table 20):

1. Weighted Usable Area estimates on CH, CO and ST rearing at previously surveyed riffle, pool and glide cross sections downstream of the intake based on mean monthly flows in July, August, September and October,
2. distribution and relative abundance of fish species and life stages through electrofishing and snorkel surveys,
3. temperature, turbidity and discharge,
4. effects of ramping rates on fish stranding, and
5. incidence of fish being impinged on the intake screen.

The above monitoring parameters will also be measured in one additional year (Year 5) when CPSF are expected to exceed a 10 yr drought return period discharge. The estimated budget for the 5 yr monitoring program is shown in Table 21.

The work plans pertaining to each of these components are described below. Where determined through monitoring activities, revisions to structural or operational measures under the jurisdiction of ERWS, for example, water withdrawal operations, intake screen back-flushing, or Arrowsmith Dam management, will be recommended to prevent or further mitigate environmental impacts.

1. Weighted Usable Area

Based on mean monthly flows in July, August, September and October, a desktop assessment will be made of the effect of discharge on Weighted Usable Area for CH summer fry and ST parr rearing, and ST spawning at previously surveyed riffle and glide cross sections downstream of the intake. The assessment will estimate WUA for the target species and life stages in each of the four months, and compare these values to the predicted post-project WUA values. An evaluation will be made of habitat suitability for native salmon and trout and whether or not the discharge regime downstream of the water intake is maintaining the function of salmon and trout habitats as predicted under post-project conditions. The assessments will be undertaken using the RHYHABSIM model in the first summer after commissioning of the intake structure and subsequently annually over the 5 yr monitoring programme.

2. Distribution and Relative Abundance of Fish Species and Life Stages

Electrofishing surveys will be repeated annually at the same riffle sites as previously surveyed between 1998 and 2014 by FLNRO and BCCF. Following previously established survey protocols by FLNRO, juvenile fish densities (fish/100 m^2) will be determined at two sites downstream of the intake and up to five sites upstream of the intake (Appendix J). An evaluation of the relative abundance estimates for the salmon and trout, with an emphasis on ST parr and CH summer fry, will be made for the riffle habitats under baseflow conditions. Comparisons of current abundance estimates will be made with previous fish population surveys by FLNRO (M. McCulloch unpubl. data) in the Englishman River. The evaluation will discuss the relationship of current flows and habitat suitability for the native fish species, and compare the effects of current versus historic minimum flows on fish distribution, growth and survival.

Snorkel surveys as currently conducted by FLNRO and BCCF will be repeated annually in Reaches 2-6 of the anadromous section of the river. The snorkel surveys would start in the year after the completion of intake construction and occur annually over the 5 yr monitoring programme. The surveys would be performed in conjunction with the ongoing BCCF/FLNRO surveys being undertaken four times per year between February and June. Comparisons to historic distributions and abundances of ST adults would be made to infer changes in population statistics, and to assess if water intake extractions are affecting the ST population.

3. Temperature, Turbidity and Discharge

Continuous temperature and discharge measurements are collected by Water Survey of Canada, and temperatures are monitored by the BC Ministry of Environment at the Highway 19A bridge. Turbidity and discharge measurements of raw water withdrawn from the river will be taken at the Intake Site by ERWS.

This data will be reviewed in conjunction with ERWS records of water withdrawals and back-flushing operations to document water quality and quantity conditions, and to evaluate the severity of environmental effects, where applicable. To assist in the evaluation of effects on the environment that can be attributed to the operation of the intake structure, ERWS will install continuous recording devices to monitor temperature and turbidity upstream and downstream of the intake site during back-flushing effects assessments. The field assessments and evaluations will begin in the first year after commissioning of the intake structure and will occur from July 1 to October 31 in each monitoring year. The work will involve:

- documenting discharge releases from the Arrowsmith Dam, water withdrawal rates at the water intake, and flows downstream of water intake;
- analyzing summer temperature and discharge records collected by the agencies and ERWS upstream and downstream of the intake structure:
    - to compare current temperature and discharge regimes with historic data;
    - to determine the suitability of the current temperature and discharge regimes relative to maintaining growth and survival of native fish species;
    - to examine ERWS compliance at meeting or exceeding the minimum maintenance flows predicted in the fish habitat offsetting plan; and
    - to determine effectiveness of Arrowsmith Lake Rule Curve at meeting predicted flows between July and October during 2, 10 and 20 yr return period droughts.
- analyzing turbidity measurements upstream and downstream of the intake structure during back-flushing operations at the intake screen:
    - to determine the effect of back-flushing on turbidity levels in the river by comparing turbidity values collected by ERWS upstream and downstream of the water intake during the summer baseflow period; and
    - to evaluate the potential or observed impact of these turbidity changes on aquatic organisms.

Streamflow downstream of the intake will be monitored using data collected at the Water Survey of Canada streamflow gauge (Englishman River near Parksville – 08HB002) located approximately 2.5 km downstream of the intake. As there are no major tributaries between the proposed intake site and the gauge location, it is considered to be representative of discharge throughout the lower reaches of the river between the proposed intake location and the mouth. The gauge forms part of Water Survey of Canada real-time hydrometric network. Data collected at five minute intervals can be viewed and retrieved via Environment Canada's website. Although not currently active, other parameters including water temperature, conductivity and turbidity data have also been collected at this site.

Manual discharge measurements are carried out regularly (once or twice a month during low flow period) at this gauge to confirm the water level vs discharge relationship. The data is used by Environment Canada to re-calibrate the rating curve as required. The accuracy of the gauge is considered to be +/- 5%. If manual measurements fall outside of this range, then consideration is given to adjusting the rating curve.

4. Fish Stranding

Effects of ramping rates on fish stranding will be examined during commissioning of the new water intake and opportunistically on two more events during intake start-up under low summer discharges over the 5 yr monitoring programme. Riffle and glide transects established for the RHYHABSIM modelling work in Reach 2 will be revisited and measurements of wetted width will be taken at regular intervals during intake start-up. Changes in wetted width over time will provide an estimate of the rate of change in wetted width. Biologists will also investigate the riffle and glide sites to identify and document any stranded fish.

5. Fish Impingement on Intake Screen

Regular monitoring of the intake screen will be undertaken to determine if fish impingement occurs and, if it does, the species and life stage(s) impinged, and the incidence of their impingement. This assessment work will occur throughout the year with greater survey intensity between July 1 and October 31 when flows are lower and fish may be more concentrated in the glide adjacent to the intake. Additional field surveys by fisheries biologists will be undertaken once per year between July 1 and October 31 over the 5 yr monitoring programme. ERWS operational staff that work at the site regularly will be instructed to observe and record instances of fish impingement. Whenever impingement is observed, fish species and life stage will be identified and their numbers enumerated. River discharges at the intake and water extraction rates will also be recorded during all monitoring events, even if no fish are found impinged on the screen.

<u>Reporting</u>

An annual monitoring report will be prepared by ERWS that documents the results of the field programs and the evaluation of environmental effects, and provides recommendations on potential mitigation measures to reduce any identified environmental effects. These reports will be distributed to DFO and FLNRO for their review and comment. The monitoring work plan will be revised as necessary after the agencies and ERWS meet to discuss agency comments.

Table 20. Scheduling of activities for the effectiveness monitoring program.

Year	Monitoring Component	Activities	Schedule (estimated dates)
1-4	1. Weighted Usable Area estimates	● Obtain July-October mean monthly discharges	November - 2017, 2018, 2019, 2020
		● Estimate WUA for ST parr and CH summer fry in each month of CPSF for riffle and glide habitats	December - 2017, 2018, 2019, 2020
		● Evaluate habitat suitability and compliance with post-project predictions	December - 2017, 2018, 2019, 2020
	2. Distribution and Relative Abundance of Fish	● Electrofish at two riffle sites downstream of the intake and up to five riffle sites upstream of the intake	September - 2017, 2018, 2019, 2020
		● Evaluate relative abundances for captured salmon and trout, with an emphasis on ST parr and CH summer fry	October-December - 2017, 2018, 2019, 2020
		● Compare current abundance estimates to previous fish surveys by FLNRO	October-December - 2017, 2018, 2019, 2020
		● Evaluate relationship between current flow regime and habitat suitability for fish	October-December - 2017, 2018, 2019, 2020
		● Conduct four snorkel surveys in Reaches 2-6	February-June - 2017, 2018, 2019, 2020
		● Compare current results to historic distributions and abundances of ST adults and assess effects of water intake extractions	October-December - 2017, 2018, 2019, 2020
	3. Temperature, Turbidity and Discharge	● Continuously monitor discharges at Arrowsmith Dam, water intake withdrawals, and flows downstream of intake	July-October - 2017, 2018, 2019, 2020
		● Analyze summer water temperature records	November-December - 2017, 2018, 2019, 2020
		● Evaluate effects of current year temperatures on fish populations	November-December - 2017, 2018, 2019, 2020
		● Evaluate effectiveness of Arrowsmith Lake Rule Curve at meeting predicted CPSF discharges	November-December - 2017, 2018, 2019, 2020
		● Evaluate effects of current year discharges on fish populations relative to post-project predictions	November-December - 2017, 2018, 2019, 2020
		● Record turbidity upstream vs downstream of intake during screen back-flushing	July-October - 2017, 2018, 2019, 2020
		● Evaluate turbidity effects from back-flushing on fish populations	November-December - 2017, 2018, 2019, 2020

Table cont'd

Year	Monitoring Component	Activities	Schedule (estimated dates)
1-4	4. Ramping Rate Effects on Fish	● Monitor riffle and glide habitats downstream of intake to determine rate of wetted width changes and to document incidence of fish stranding	September - 2016; at baseflows, once/yr in 2017 & 2019
	5. Incidence of Fish Impingement on Intake Screen	● Monitor intake screen throughout year (ERWS operational staff), and once per year (field biologists) to determine incidence of fish impingement	July-October - 2017, 2018, 2019, 2020
		● Document incidence of fish impingement, river discharge, and intake extraction rate for all monitoring events	July-October - 2017, 2018, 2019, 2020
5	The above monitoring parameters will also be measured in one additional year (Year 5) when CPSF are expected to exceed a 10 yr drought return period discharge		

Table 21. Estimated budget for the effectiveness monitoring program.

Component	Year ($,000)					
	1	2	3	4	5	Total
1 Weighted Usable Area						
Validate Wetted Width vs Discharge	$2.0					$2.0
Analysis & Reporting of WUA vs CPSF discharges in current year	$2.0	$2.0	$2.0	$2.0	$2.0	$10.0
2 Distribution & Abundance of Fish						
Electrofishing	$10.0	$10.0	$10.0	$10.0	$10.0	$50.0
Snorkel Survey	$10.0	$10.0	$10.0	$10.0	$10.0	$50.0
Reporting	$2.0	$2.0	$2.0	$2.0	$2.0	$10.0
3 Temperature, Turbidity & Discharge						
City of Parksville WSC gauge operation[1]	$12.0	$12.0	$12.0	$12.0	$12.0	$60.0
Download, Analyze & Report Temperature & Discharge (Intake & WSC) data	$4.0	$4.0	$4.0	$4.0	$4.0	$20.0
4 Fish Stranding						
At commissioning	$2.0					$2.0
During CPSF		$2.0		$2.0		$4.0
Reporting	$0.5	$0.5		$0.5		$1.5
5 Fish Impingement						
ERWS operational staff monitoring[1]	$4.0	$4.0	$4.0	$4.0	$4.0	$20.0
Onsite Investigation & Reporting	$1.5	$1.5	$1.5	$1.5	$1.5	$7.5
Total	$50.0	$48.0	$45.5	$48.0	$45.5	$237.0
Amount captured in existing operational budget for ERWS	$16.0	$16.0	$16.0	$16.0	$16.0	$80.0
Total applicable to Letter of Credit	$34.0	$32.0	$29.5	$32.0	$29.5	$157.0

Notes: 1 - Captured within existing annual operational budget for ERWS

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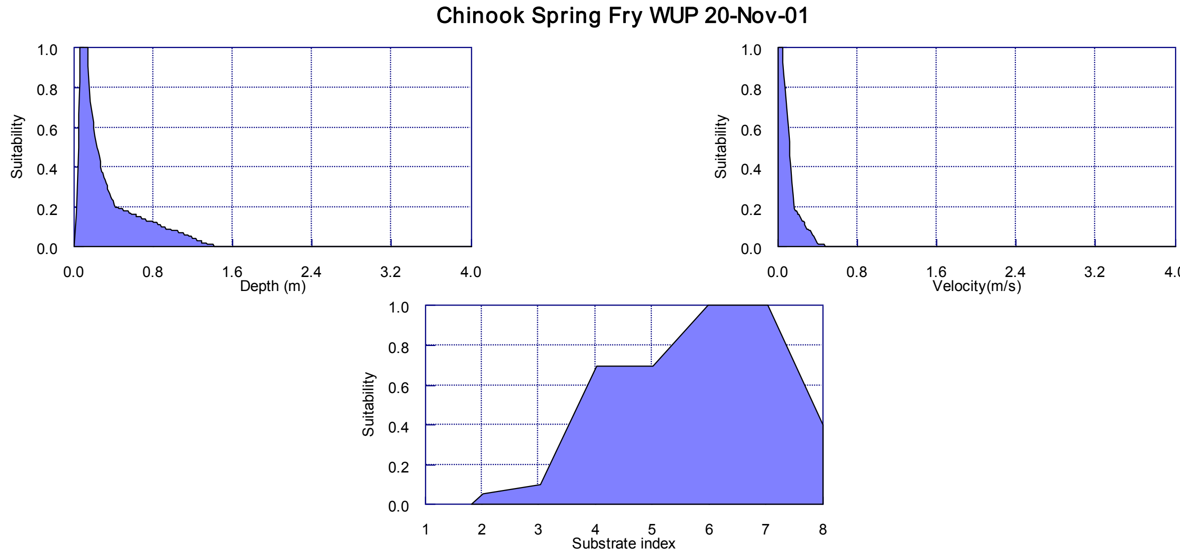
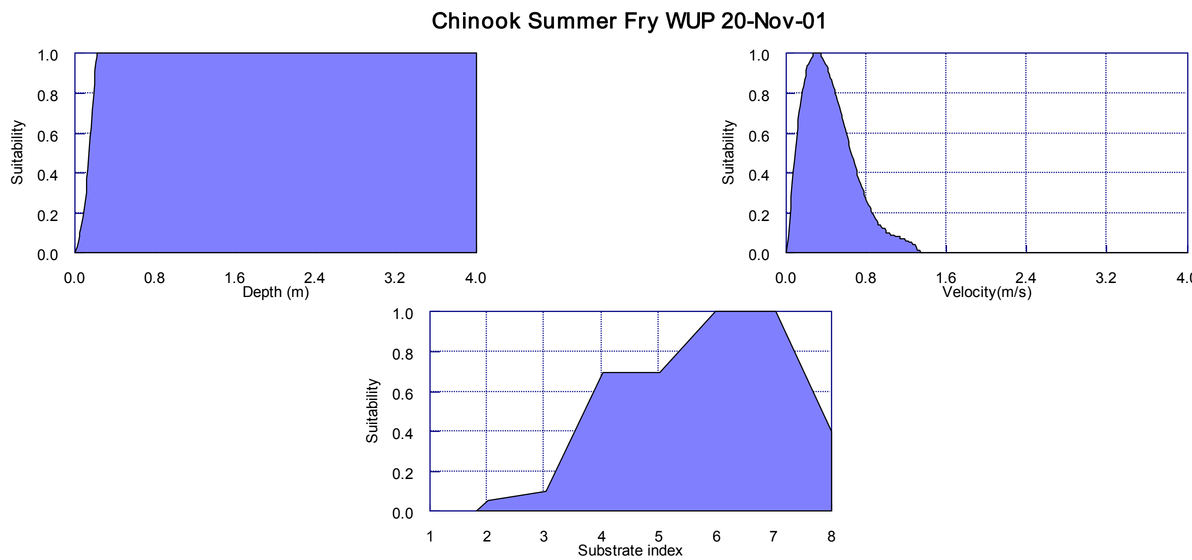
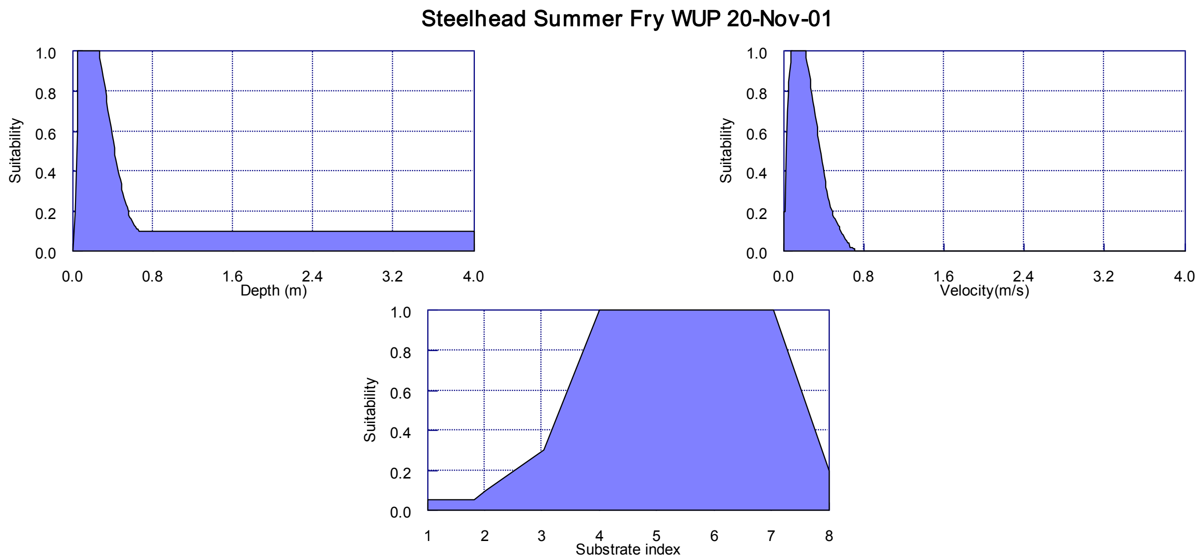
APPENDICES



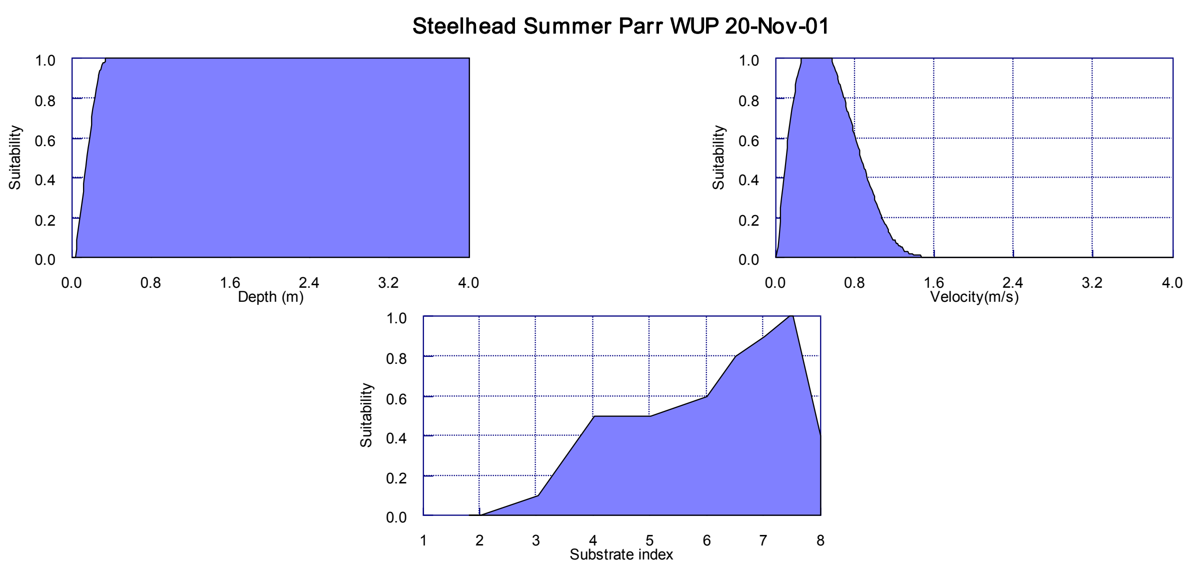
Appendix A. Habitat suitability indices for Chinook – spring fry rearing.



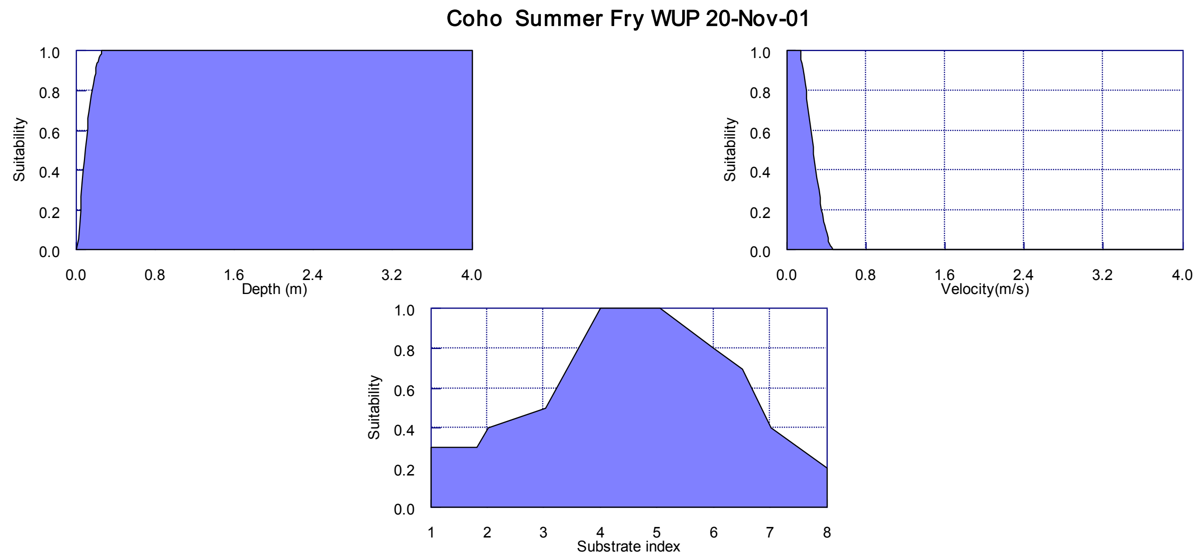
Appendix B. Habitat suitability indices for Chinook – summer fry rearing.



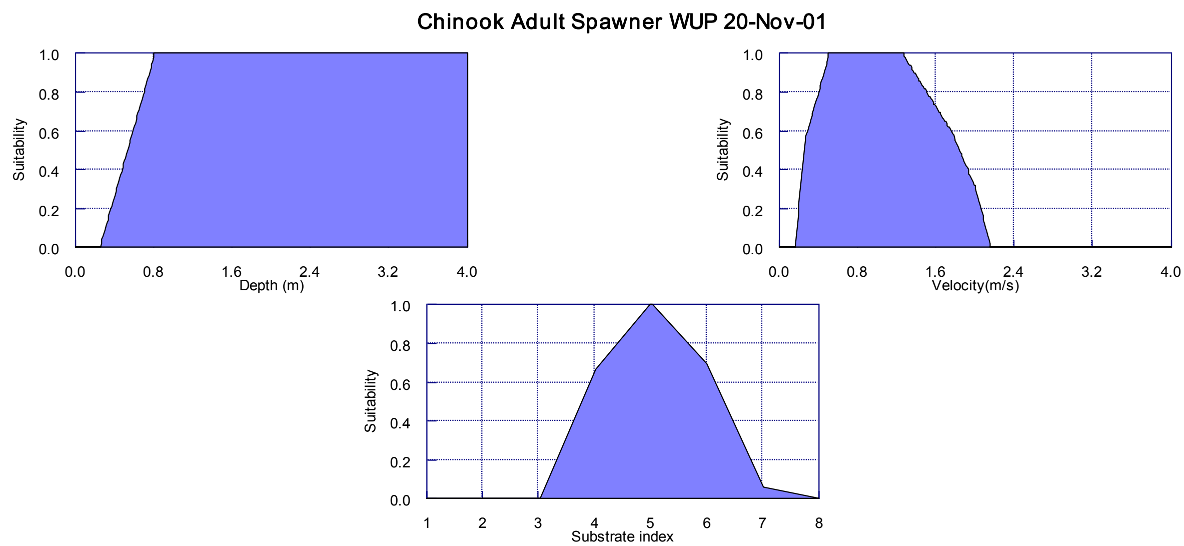
Appendix C. Habitat suitability indices for Steelhead – summer fry rearing.



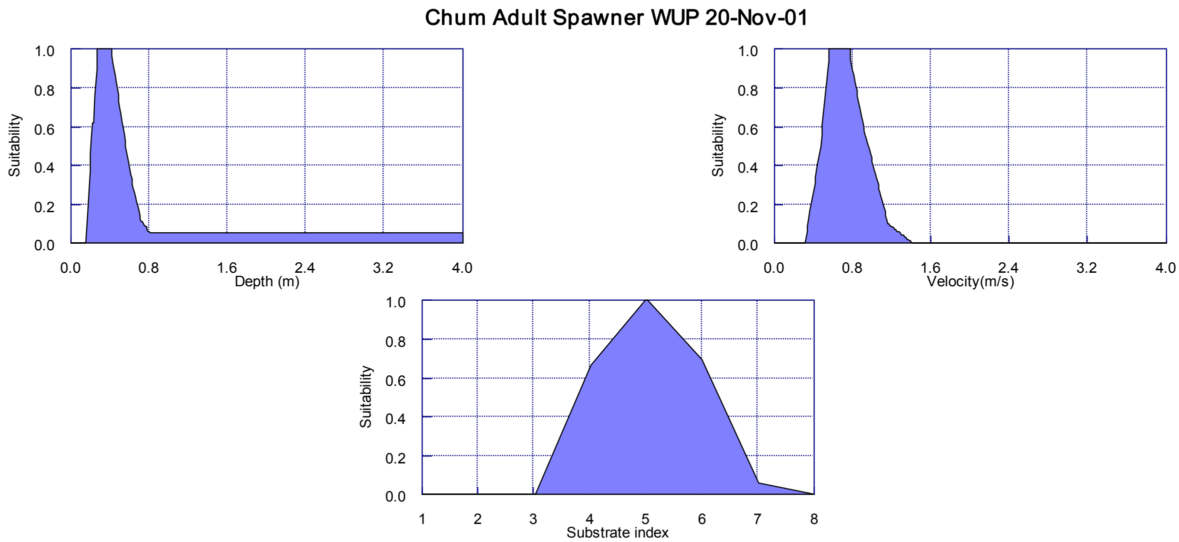
Appendix D. Habitat suitability indices for Steelhead – summer parr rearing.



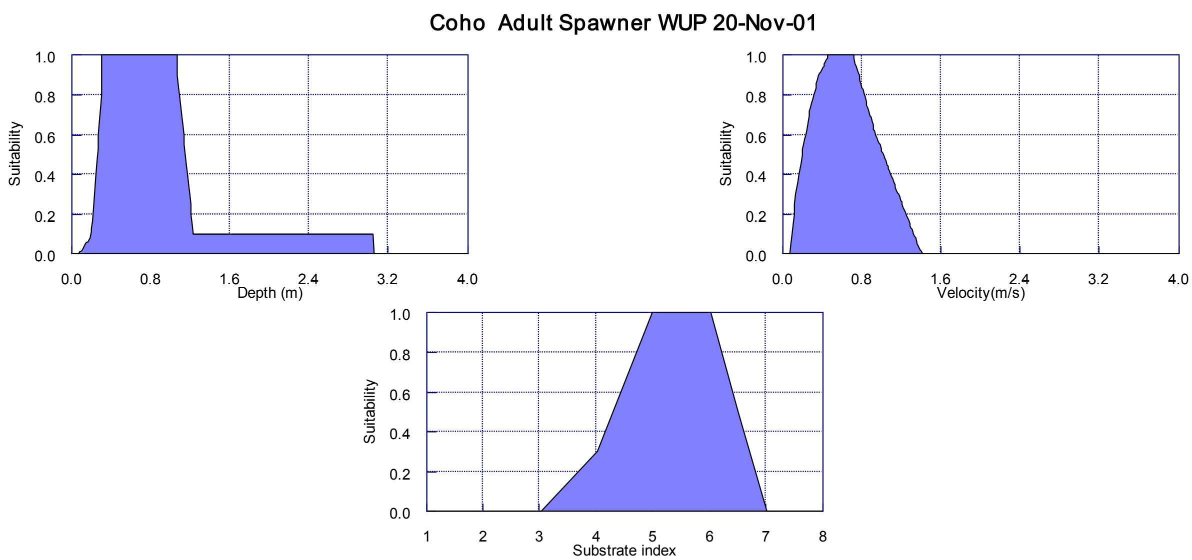
Appendix E. Habitat suitability indices for Coho – summer fry rearing.



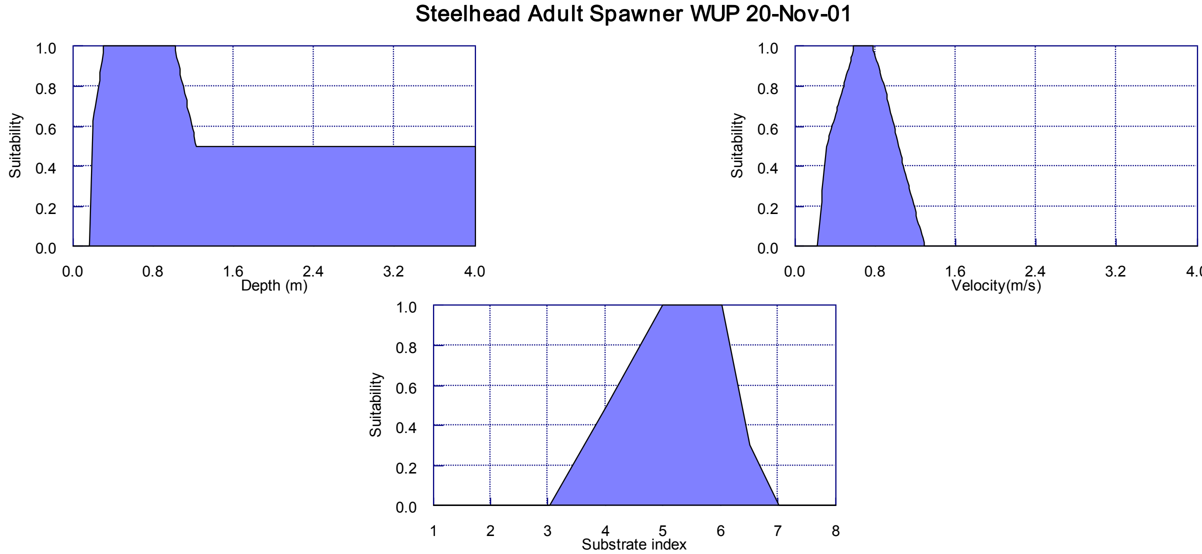
Appendix F. Habitat suitability indices for Chinook – adult spawner.



Appendix G. Habitat suitability indices for Chum – adult spawner.



Appendix H. Habitat suitability indices for Coho – adult spawner.



Appendix I. Habitat suitability indices for Steelhead – adult spawner.

Appendix J. BCCF and FLNRO electrofishing site locations in Englishman River.

Site	Location	UTM Code
1	50 m d/s of Hwy 19A bridge	406669, 5463666
2	Martindale Road	407176, 5461951
3	Allsbrook Canyon	407855, 5461575
4	Grassy Bank	406923, 5460354
5	Powerlines	406608, 5460077
6	South Fork	405716, 5459144
7	Side Channel Intake	404713, 5459345
8	End of Englishman River Road	404214, 5458815
9	Falls Site	401996, 5456485

Appendix K. Weighted Usable Area losses at riffles in Englishman River between the proposed and existing water intakes under existing post-dam conditions and after predicted monthly average withdrawals (post-project).

Return Period Drought (yr)	Discharge & Species Life Stage	Weighted Usable Area											
		July			August			September			October		
		Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)
2	Discharge (m^3/s)	2.0	1.8		1.7	1.4		1.7	1.5		4.2	4.1	
	Steelhead Summer Parr	8.8	7.8	-734.1	7.5	6.5	-794.5	7.7	6.8	-647.8	12.4	12.3	-67.8
	Steelhead Summer Fry	13.7	13.8	66.3	13.7	13.2	-381.0	13.8	13.4	-256.5	9.3	9.6	241.7
	Chinook Summer Fry	12.4	11.1	-961.8	10.7	9.1	-1175.5	11.0	9.7	-954.4	15.2	15.3	33.2
10	Discharge (m^3/s)	1.2	1.0		1.2	1.0		1.2	1.0		1.0	0.9	
	Steelhead Summer Parr	5.5	4.3	-845.3	5.4	4.2	-883.7	5.3	4.3	-743.6	4.2	3.7	-328.0
	Steelhead Summer Fry	12.3	11.1	-849.8	12.2	11.0	-873.3	12.1	11.1	-728.2	11.0	10.5	-372.9
	Chinook Summer Fry	7.6	5.9	-1266.2	7.6	5.8	-1315.5	7.4	5.9	-1107.0	5.7	5.1	-474.6
20	Discharge (m^3/s)	1.2	1.0		1.2	1.0		1.1	0.9		0.8	0.7	
	Steelhead Summer Parr	5.1	4.1	-714.2	5.2	4.2	-783.4	4.9	4.1	-572.6	3.4	3.0	-325.0
	Steelhead Summer Fry	11.8	10.9	-660.4	12.0	11.0	-745.1	11.6	10.9	-513.7	10.0	9.4	-456.9
	Chinook Summer Fry	7.1	5.6	-1045.1	7.3	5.7	-1154.1	6.7	5.6	-833.5	4.6	3.9	-465.0

Notes: Reach lengths are 737 m for riffle, 1255 m for glide, and 628 m for pool habitats

Under Post-Dam and Post-Project Regime, WUA shown for fish species and life stage as m^2/m

Appendix L. Weighted Usable Area losses at glides in Englishman River between the proposed and existing water intakes under existing post-dam conditions and after predicted monthly average withdrawals (post-project).

Return Period Drought (yr)	Discharge & Species Life Stage	Weighted Usable Area											
		July			August			September			October		
		Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)
2	Discharge (m^3/s)	2.0	1.8		1.7	1.4		1.7	1.5		4.2	4.1	
	Steelhead Summer Parr	9.1	8.5	-837.1	8.3	7.6	-908.6	8.4	7.8	-737.9	12.3	12.2	-178.2
	Steelhead Summer Fry	14.4	15.4	1218.6	15.6	16.6	1170.9	15.5	16.3	1032.9	7.9	8.3	471.9
	Chinook Summer Fry	14.2	13.3	-1099.4	13.1	12.2	-1203.5	13.3	12.5	-973.9	17.8	17.7	-118.0
	Coho Summer Fry	24.0	24.5	665.2	24.6	24.9	337.6	24.6	24.8	348.9	17.5	17.9	597.4
	Steelhead Spawner	0.7	0.4	-367.7									
10	Discharge (m^3/s)	1.2	1.0		1.2	1.0		1.2	1.0		1.0	0.9	
	Steelhead Summer Parr	6.9	6.0	-1123.2	6.9	5.9	-1181.0	6.8	6.0	-991.5	5.9	5.5	-480.7
	Steelhead Summer Fry	17.0	17.3	312.5	17.0	17.3	316.3	17.1	17.3	261.0	17.3	17.5	190.8
	Chinook Summer Fry	11.2	9.9	-1632.8	11.2	9.8	-1719.4	11.1	9.9	-1444.5	9.7	9.2	-696.5
	Coho Summer Fry	24.8	24.5	-389.1	24.8	24.5	-420.4	24.8	24.5	-356.4	24.5	24.3	-228.4
	Steelhead Spawner	0.0	0.0	-31.4									
20	Discharge (m^3/s)	1.2	1.0		1.2	1.0		1.1	0.9		0.8	0.7	
	Steelhead Summer Parr	6.6	5.8	-975.1	6.7	5.9	-1055.5	6.4	5.8	-795.7	5.2	4.8	-535.9
	Steelhead Summer Fry	17.1	17.3	234.7	17.1	17.3	273.6	17.2	17.3	197.0	17.6	17.7	121.7
	Chinook Summer Fry	10.8	9.7	-1425.7	11.0	9.7	-1541.1	10.5	9.6	-1167.2	8.7	8.1	-780.6
	Coho Summer Fry	24.8	24.5	-377.8	24.8	24.5	-395.3	24.7	24.4	-320.0	24.1	23.8	-371.5
	Steelhead Spawner	0.0	0.0	-1.3									

Notes: Reach lengths are 737 m for riffle, 1255 m for glide, and 628 m for pool habitats

Under Post-Dam and Post-Project Regime, WUA shown for fish species and life stage as m^2/m

Appendix M. Weighted Usable Area losses at riffles in Englishman River between the existing water intake and tidal waters under existing post-dam conditions and after predicted monthly average withdrawals (post-project).

Return Period Drought (yr)	Discharge & Species Life Stage	Weighted Usable Area											
		July			August			September			October		
		Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)
2	Discharge (m^3/s)	2.0	1.8		1.6	1.4		1.7	1.5		4.2	4.1	
	Steelhead Summer Parr	8.5	7.8	-27.0	7.2	6.5	-26.9	7.4	6.8	-22.9	12.4	12.3	-2.6
	Steelhead Summer Fry	13.7	13.8	0.9	13.6	13.2	-14.8	13.7	13.4	-10.6	9.3	9.6	9.1
	Chinook Summer Fry	12.1	11.1	-35.9	10.2	9.1	-39.9	10.6	9.7	-34.1	15.2	15.3	1.2
10	Discharge (m^3/s)	1.2	1.0		1.1	1.0		1.2	1.0		0.9	0.9	
	Steelhead Summer Parr	5.2	4.3	-29.6	5.1	4.2	-29.7	5.1	4.3	-27.8	4.0	3.7	-8.9
	Steelhead Summer Fry	11.9	11.1	-27.5	11.8	11.0	-26.7	11.8	11.1	-25.4	10.8	10.5	-11.5
	Chinook Summer Fry	7.1	5.9	-43.6	7.0	5.8	-43.3	7.1	5.9	-40.9	5.4	5.1	-12.8
20	Discharge (m^3/s)	1.1	1.0		1.1	1.0		1.1	0.9		0.8	0.7	
	Steelhead Summer Parr	4.8	4.1	-24.5	4.9	4.2	-24.4	4.6	4.1	-19.4	3.2	3.0	-8.7
	Steelhead Summer Fry	11.6	10.9	-22.8	11.6	11.0	-22.4	11.4	10.9	-17.4	9.8	9.4	-12.5
	Chinook Summer Fry	6.6	5.6	-35.5	6.7	5.7	-35.5	6.3	5.6	-28.0	4.3	3.9	-12.4

Notes: Reach lengths are 36 m for riffle, 238 m for glide, and 30 m for pool habitats

Under Post-Dam and Post-Project Regime, WUA shown for fish species and life stage as m^2/m

Appendix N. Weighted Usable Area losses at glides in Englishman River between the existing water intake and tidal waters under existing post-dam conditions and after predicted monthly average withdrawals (post-project).

Return Period Drought (yr)	Discharge & Species Life Stage	Weighted Usable Area											
		July			August			September			October		
		Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)	Post-Dam Regime	Post-Project Regime	Habitat Area Loss (-ve) (m^2)
2	Discharge (m^3/s)	2.0	1.8		1.6	1.4		1.7	1.5		4.2	4.1	
	Steelhead Summer Parr	9.0	8.5	-120.0	8.1	7.6	-120.0	8.3	7.8	-101.4	12.3	12.2	-26.2
	Steelhead Summer Fry	14.7	15.4	170.9	15.9	16.6	147.3	15.7	16.3	139.7	8.0	8.3	68.3
	Chinook Summer Fry	14.0	13.3	-158.0	12.8	12.2	-159.0	13.1	12.5	-134.0	17.7	17.7	-17.4
	Coho Summer Fry	24.1	24.5	89.5	24.7	24.9	36.9	24.6	24.8	43.6	17.6	17.9	86.9
	Steelhead Spawner	0.6	0.4	-51.9									
10	Discharge (m^3/s)	1.2	1.0		1.1	1.0		1.2	1.0		0.9	0.9	
	Steelhead Summer Parr	6.6	6.0	-154.2	6.6	5.9	-156.1	6.6	6.0	-145.7	5.7	5.5	-50.9
	Steelhead Summer Fry	17.1	17.3	37.8	17.1	17.3	36.9	17.1	17.3	35.2	17.4	17.5	22.1
	Chinook Summer Fry	10.9	9.9	-225.1	10.8	9.8	-228.7	10.8	9.9	-212.8	9.5	9.2	-74.0
	Coho Summer Fry	24.8	24.5	-58.3	24.8	24.5	-60.7	24.8	24.5	-55.7	24.4	24.3	-25.9
	Steelhead Spawner	0.0	0.0	-0.7									
20	Discharge (m^3/s)	1.1	1.0		1.1	1.0		1.1	0.9		0.8	0.7	
	Steelhead Summer Parr	6.4	5.8	-132.1	6.4	5.9	-130.7	6.2	5.8	-105.7	5.0	4.8	-57.4
	Steelhead Summer Fry	17.2	17.3	30.7	17.2	17.3	32.1	17.2	17.3	27.8	17.6	17.7	14.5
	Chinook Summer Fry	10.5	9.7	-194.4	10.5	9.7	-192.1	10.3	9.6	-155.2	8.5	8.1	-82.6
	Coho Summer Fry	24.7	24.5	-53.3	24.7	24.5	-52.4	24.6	24.4	-43.3	24.0	23.8	-41.2
	Steelhead Spawner	0.0	0.0	0.0									

Notes: Reach lengths are 36 m for riffle, 238 m for glide, and 30 m for pool habitats

Under Post-Dam and Post-Project Regime, WUA shown for fish species and life stage as m^2/m

Appendix O. Weighted Usable Area gains at riffles in Englishman River between the proposed and existing water intakes under pre-dam conditions and after predicted monthly average withdrawals (post-project).

Return Period Drought (yr)	Discharge & Species Life Stage	Weighted Usable Area											
		July			August			September			October		
		Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)
2	Discharge (m^3/s)	1.7	1.8		0.6	1.4		0.6	1.5		1.7	4.1	
	Steelhead Summer Parr	7.5	7.8	176.9	2.5	6.5	2926.6	2.2	6.8	3390.9	7.6	12.3	3504.4
	Steelhead Summer Fry	13.7	13.8	27.3	8.5	13.2	3466.1	7.8	13.4	4111.0	13.7	9.6	-3063.7
	Chinook Summer Fry	10.7	11.1	250.6	3.3	9.1	4326.2	2.9	9.7	5005.0	10.8	15.3	3299.5
10	Discharge (m^3/s)	0.7	1.0		0.3	1.0		0.3	1.0		0.3	0.9	
	Steelhead Summer Parr	3.0	4.3	909.5	1.2	4.2	2264.8	1.1	4.3	2404.8	1.3	3.7	1803.4
	Steelhead Summer Fry	9.6	11.1	1092.2	5.1	11.0	4394.7	4.8	11.1	4619.5	5.4	10.5	3702.7
	Chinook Summer Fry	4.1	5.8	1313.3	1.5	5.8	3175.7	1.4	5.9	3346.0	1.6	5.1	2530.9
20	Discharge (m^3/s)	0.6	1.0		0.3	1.0		0.2	0.9		0.3	0.7	
	Steelhead Summer Parr	2.5	4.1	1221.9	1.0	4.2	2363.6	0.8	4.1	2428.4	1.1	3.0	1387.8
	Steelhead Summer Fry	8.5	10.9	1776.9	4.5	11.0	4771.3	3.7	10.9	5271.8	4.8	9.4	3370.3
	Chinook Summer Fry	3.3	5.6	1751.1	1.3	5.7	3265.6	1.1	5.6	3313.6	1.4	3.9	1879.4

Notes: Reach lengths are 737 m for riffle, 1255 m for glide, and 628 m for pool habitats

Under Post-Dam and Post-Project Regime, WUA shown for fish species and life stage as m^2/m

Appendix P. Weighted Usable Area gains at glides in Englishman River between the proposed and existing water intakes under pre-dam conditions and after predicted monthly average withdrawals (post-project).

Return Period Drought (yr)	Discharge & Species Life Stage	Weighted Usable Area											
		July			August			September			October		
		Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)
2	Discharge (m^3/s)	1.7	1.8		0.6	1.4		0.6	1.5		1.7	4.1	
	Steelhead Summer Parr	8.3	8.5	203.3	4.2	7.6	4193.0	3.9	7.8	4898.3	8.3	12.2	4792.8
	Steelhead Summer Fry	15.6	15.4	-292.4	17.7	16.6	-1430.7	17.7	16.3	-1698.0	15.6	8.3	-9147.7
	Chinook Summer Fry	13.1	13.3	266.1	7.4	12.2	6041.6	6.9	12.5	7045.6	13.2	17.7	5645.0
	Coho Summer Fry	24.6	24.5	-123.0	23.4	24.9	1877.5	23.1	24.8	2223.9	24.6	17.9	-8352.0
	Steelhead Spawner	0.4	0.4	77.8									
10	Discharge (m^3/s)	0.7	1.0		0.3	1.0		0.3	1.0		0.3	0.9	
	Steelhead Summer Parr	4.9	6.0	1388.0	2.4	5.9	4420.1	2.3	6.0	4700.0	2.6	5.5	3628.2
	Steelhead Summer Fry	17.7	17.3	-465.6	16.2	17.3	1388.0	15.9	17.3	1672.9	16.5	17.5	1186.0
	Chinook Summer Fry	8.2	9.9	2025.6	4.4	9.8	6745.6	4.2	9.9	7196.2	4.8	9.2	5542.1
	Coho Summer Fry	23.9	24.5	790.6	20.8	24.5	4597.1	20.6	24.5	4957.3	21.2	24.3	3904.3
	Steelhead Spawner	0.0	0.0	0.0									
20	Discharge (m^3/s)	0.6	1.0		0.3	1.0		0.2	0.9		0.3	0.7	
	Steelhead Summer Parr	4.2	5.8	1989.2	2.1	5.9	4728.8	1.8	5.8	4996.2	2.3	4.8	3138.8
	Steelhead Summer Fry	17.7	17.3	-493.2	15.7	17.3	2060.7	15.0	17.3	2877.7	15.9	17.7	2186.2
	Chinook Summer Fry	7.4	9.7	2905.3	3.9	9.7	7284.0	3.4	9.6	7777.2	4.2	8.1	4920.9
	Coho Summer Fry	23.4	24.5	1354.1	20.3	24.5	5238.4	19.7	24.4	5951.2	20.6	23.8	4056.2
	Steelhead Spawner	0.0	0.0	0.0									

Notes: Reach lengths are 737 m for riffle, 1255 m for glide, and 628 m for pool habitats

Under Post-Dam and Post-Project Regime, WUA shown for fish species and life stage as m^2/m

Appendix Q. Weighted Usable Area gains at riffles in Englishman River between the existing water intake and tidal waters under pre-dam conditions and after predicted monthly average withdrawals (post-project).

Return Period Drought (yr)	Discharge & Species Life Stage	Weighted Usable Area											
		July			August			September			October		
		Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)
2	Discharge (m^3/s)	1.6	1.8		0.5	1.4		0.5	1.5		1.7	4.1	
	Steelhead Summer Parr	7.2	7.8	19.0	2.1	6.5	155.7	2.0	6.8	173.2	7.4	12.3	177.0
	Steelhead Summer Fry	13.6	13.8	4.6	7.6	13.2	202.9	7.2	13.4	223.2	13.7	9.6	-147.9
	Chinook Summer Fry	10.3	11.1	27.5	2.7	9.1	230.0	2.6	9.7	255.6	10.5	15.3	169.7
10	Discharge (m^3/s)	0.7	1.0		0.2	1.0		0.2	1.0		0.3	0.9	
	Steelhead Summer Parr	2.7	4.3	56.5	0.8	4.2	123.9	0.8	4.3	127.5	1.2	3.7	92.8
	Steelhead Summer Fry	9.0	11.1	73.4	3.7	11.0	262.0	3.7	11.1	265.2	5.1	10.5	194.6
	Chinook Summer Fry	3.6	5.8	81.3	1.1	5.8	169.6	1.1	5.9	174.6	1.5	5.1	129.3
20	Discharge (m^3/s)	0.5	1.0		0.2	1.0		0.2	0.9		0.3	0.7	
	Steelhead Summer Parr	2.2	4.1	70.9	0.7	4.2	127.0	0.5	4.1	127.9	0.9	3.0	72.7
	Steelhead Summer Fry	7.7	10.9	115.8	3.1	11.0	282.2	2.5	10.9	302.8	4.3	9.4	183.7
	Chinook Summer Fry	2.8	5.6	102.0	0.9	5.7	172.8	0.7	5.6	173.8	1.2	3.9	97.4

Notes: Reach lengths are 36 m for riffle, 238 m for glide, and 30 m for pool habitats

Under Post-Dam and Post-Project Regime, WUA shown for fish species and life stage as m^2/m

Appendix R. Weighted Usable Area gains at glides in Englishman River between the existing water intake and tidal waters under pre-dam conditions and after predicted monthly average withdrawals (post-project).

Return Period Drought (yr)	Discharge & Species Life Stage	Weighted Usable Area											
		July			August			September			October		
		Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (+ve) (m^2)
2	Discharge (m^3/s)	1.6	1.8		0.5	1.4		0.5	1.5		1.7	4.1	
	Steelhead Summer Parr	8.1	8.5	84.3	3.8	7.6	896.8	3.7	7.8	994.8	8.2	12.2	934.9
	Steelhead Summer Fry	15.9	15.4	-120.9	17.6	16.6	-251.1	17.5	16.3	-297.5	15.8	8.3	-1772.4
	Chinook Summer Fry	12.9	13.3	110.9	6.7	12.2	1298.5	6.5	12.5	1437.3	13.0	17.7	1104.8
	Coho Summer Fry	24.7	24.5	-47.4	22.9	24.9	464.8	22.7	24.8	501.0	24.7	17.9	-1598.4
	Steelhead Spawner	0.3	0.4	30.5									
10	Discharge (m^3/s)	0.7	1.0		0.2	1.0		0.2	1.0		0.3	0.9	
	Steelhead Summer Parr	4.5	6.0	345.8	1.8	5.9	977.5	1.8	6.0	996.7	2.4	5.5	737.3
	Steelhead Summer Fry	17.7	17.3	-102.8	15.0	17.3	536.2	15.0	17.3	531.9	16.2	17.5	303.7
	Chinook Summer Fry	7.7	9.9	504.1	3.4	9.8	1518.2	3.4	9.9	1546.5	4.4	9.2	1133.1
	Coho Summer Fry	23.6	24.5	214.0	19.7	24.5	1141.0	19.7	24.5	1148.8	20.8	24.3	824.4
	Steelhead Spawner	0.0	0.0	0.0									
20	Discharge (m^3/s)	0.5	1.0		0.2	1.0		0.2	0.9		0.3	0.7	
	Steelhead Summer Parr	3.9	5.8	465.8	1.6	5.9	1023.2	1.3	5.8	1060.5	2.0	4.8	647.4
	Steelhead Summer Fry	17.6	17.3	-77.1	14.5	17.3	672.4	13.9	17.3	820.9	15.5	17.7	515.7
	Chinook Summer Fry	6.8	9.7	683.8	3.0	9.7	1602.2	2.6	9.6	1676.5	3.8	8.1	1022.4
	Coho Summer Fry	23.0	24.5	350.3	19.2	24.5	1255.0	18.7	24.4	1374.9	20.2	23.8	868.7
	Steelhead Spawner	0.0	0.0	0.0									

Notes: Reach lengths are 36 m for riffle, 238 m for glide, and 30 m for pool habitats
Under Post-Dam and Post-Project Regime, WUA shown for fish species and life stage as m^2/m

Appendix S. Wetted habitat area gains at riffles in Englishman River in anadromous Reaches 3-6 upstream of the proposed water intake under pre-dam and post-project conditions.

Return Period Drought (yr)	Reach	Wetted Width & Habitat Area											
		July			August			September			October		
		Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)
2	Reach 3	20.3	20.7	657.2	12.4	20.3	13029.0	11.9	20.3	13834.1	20.3	22.0	2826.0
	Reach 4	16.3	18.0	1093.4	8.9	17.0	5266.6	8.4	17.4	5816.5	16.4	20.7	2833.9
	Reach 5	17.3	19.4	4271.8	9.5	19.4	19968.7	9.0	19.8	21882.9	17.3	22.6	10639.2
	Reach 6	19.0	20.6	2243.5	10.0	20.6	14459.8	9.5	21.2	16005.6	19.0	25.2	8522.6
10	Reach 3	14.0	18.2	6884.2	8.1	18.1	16397.1	7.8	18.0	16692.9	8.8	16.5	12651.1
	Reach 4	9.7	14.7	3254.4	6.4	15.4	5803.6	6.2	15.4	5913.6	6.7	12.9	4024.3
	Reach 5	10.2	16.5	12593.8	6.6	17.2	21298.6	6.4	17.2	21842.6	7.1	14.8	15354.3
	Reach 6	11.0	17.4	8727.8	6.6	18.7	16539.1	6.6	18.7	16539.1	7.8	15.5	10602.0
20	Reach 3	12.4	17.4	8297.2	7.7	17.6	16249.3	7.1	17.1	16413.6	8.0	14.9	11386.0
	Reach 4	8.9	14.1	3396.8	6.0	15.0	5855.4	4.7	14.4	6301.8	6.2	11.5	3409.7
	Reach 5	9.5	16.0	13178.1	6.4	17.1	21520.2	5.0	16.8	23716.6	6.4	13.0	13379.6
	Reach 6	10.0	16.7	9124.6	6.2	18.5	16730.6	5.2	17.7	17127.4	6.6	13.6	9603.4

Appendix T. Wetted habitat area gains at glides in Englishman River in anadromous Reaches 3-6 upstream of the proposed water intake under pre-dam conditions and post-project conditions.

Return Period Drought (yr)	Reach	Wetted Width & Habitat Area											
		July			August			September			October		
		Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)
2	Reach 3	19.2	19.3	152.3	17.6	19.2	2497.7	17.5	19.2	2650.0	19.2	19.7	639.7
	Reach 4	17.3	17.8	254.0	15.7	17.8	1082.0	15.5	17.8	1153.2	17.4	18.2	431.8
	Reach 5	20.3	20.9	1076.5	18.4	20.9	4175.4	18.2	20.9	4468.9	20.3	21.4	1859.3
	Reach 6	19.9	20.8	574.5	18.1	20.8	1776.9	17.9	20.8	1903.8	19.9	21.3	915.2
10	Reach 3	17.9	19.1	1827.6	8.1	18.1	15199.5	16.4	19.0	4066.4	16.7	18.4	2695.7
	Reach 4	15.9	16.9	477.5	6.4	15.4	4556.8	14.2	17.0	1391.9	14.7	16.6	929.6
	Reach 5	18.6	19.9	2152.9	6.6	17.2	17239.7	16.6	20.2	5936.8	17.3	19.6	3783.9
	Reach 6	18.3	19.6	855.0	6.6	18.7	8076.1	16.4	19.8	2264.5	16.7	19.3	1756.8
20	Reach 3	17.6	19.0	2162.7	7.7	17.6	15062.5	16.0	19.0	4569.0	16.4	18.0	2421.6
	Reach 4	15.7	16.8	569.0	6.0	15.0	4597.4	13.9	16.8	1488.4	14.2	16.3	1066.8
	Reach 5	18.4	19.8	2365.0	6.4	17.1	17419.1	16.3	20.0	6099.9	16.6	19.3	4420.0
	Reach 6	18.1	19.5	948.6	6.2	18.5	8169.6	16.1	19.7	2384.8	16.4	19.1	1750.2

Appendix U. Wetted habitat area gains at pools in Englishman River in anadromous Reaches 3-6 upstream of the proposed water intake under pre-dam conditions and post-project conditions.

Return Period Drought (yr)	Reach	Wetted Width & Habitat Area											
		July			August			September			October		
		Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)	Pre-Dam Regime	Post-Project Regime	Habitat Area Gain (m^2)
2	Reach 3	19.2	19.3	32.0	17.0	19.2	460.1	16.8	19.2	513.3	19.2	19.8	129.9
	Reach 4	17.8	18.0	52.8	16.1	17.9	365.4	16.1	18.0	389.8	17.8	19.7	389.8
	Reach 5	19.2	19.5	180.2	17.4	19.5	1107.7	17.4	19.6	1181.9	19.2	21.4	1155.4
	Reach 6	21.0	21.3	124.6	19.1	21.3	793.9	19.0	21.4	854.4	21.0	23.4	875.8
10	Reach 3	17.3	17.9	125.7	15.8	17.8	426.0	15.8	17.8	432.4	15.9	17.6	345.1
	Reach 4	16.3	17.5	241.6	15.7	17.6	391.8	15.6	17.6	397.9	15.7	17.3	324.8
	Reach 5	17.6	19.0	768.5	16.9	19.2	1208.4	16.9	19.2	1229.6	17.0	18.9	975.2
	Reach 6	19.2	20.8	562.5	18.5	20.9	865.1	18.5	20.9	865.1	18.6	20.6	697.8
20	Reach 3	17.0	17.8	166.1	15.8	17.8	434.5	15.7	17.7	438.8	15.8	17.4	325.9
	Reach 4	16.1	17.5	272.0	15.6	17.5	397.9	15.5	17.5	410.1	15.6	16.9	259.8
	Reach 5	17.4	19.0	816.2	16.9	19.1	1208.4	16.7	19.1	1250.8	16.9	18.6	916.9
	Reach 6	19.1	20.7	583.8	18.4	20.9	868.6	18.3	20.8	882.9	18.5	20.0	551.8

Appendix V. Channel lengths for riffle, glide and pool habitats in anadromous Reaches 3-6 of the Englishman River.

Reach	Channel Lengths (m)		
	Riffle	Glide	Pool
3	1643	1523	213
4	647	508	203
5	2015	1631	530
6	1368	668	356