Fisheries Component of Aquatic Effects Assessment of Proposed Bulk Water Supply Intake in Englishman River

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1.0 Introduction

Englishman River Water Service (ERWS) is a joint venture of the City of Parksville and the Regional District of Nanaimo 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. To determine whether the project will cause serious harm to fish that support a commercial, recreational or Aboriginal fishery, a project proposal will be submitted by ERWS to DFO for their review and decision pertaining to the necessity for a formal Authorization for the project under Section 35 of the Fisheries Act. Part of the ERWS proposal submission will include this Aquatic Effects Assessment which provides a summary of the fish habitat at the site, the potential fish habitat impacts caused by the project, and the measures proposed to mitigate the potential impacts. The assessment includes both the impacts of construction of the intake as well as downstream impacts relative to changes in flow as a result of water withdrawal during the operational stage. The assessment on the effects of flow changes on fish habitat is based on the projected water demand for the service area in 2035 (Kerr Wood Leidal Associates Ltd. 2014b). Therefore, the application for regulatory approvals for the proposed intake is based on a maximum water withdrawal rate of 28.8 MLD.

The purpose of this report is to:

- 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;
- Assess the potential effects of water withdrawal on Englishman River flows and fish habitats downstream of the bulk water supply intake by modeling riffle and glide habitats for native salmon and trout rearing and spawning;
- Estimate the change in weighted useable area as a result of water withdrawals at the intake relative to timing of habitat use and frequency of flows;
- Identify and quantify permanent or temporary aquatic resource impacts, and
- Recommend mitigation 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 2.5 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.

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 (*Oncorhynchus mykiss)*, Chinook (*O. tshawytscha)*, Coho (*O. kisutch*) and Chum (*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 tidal 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 Steelhead 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 Steelhead 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 lifestages 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 these impacts.

5.0 Results and Discussion

5.1 Fish Populations and Habitats

The Englishman River supports significant populations of salmon. Chum is the dominant anadromous species followed by Coho. Steelhead, Cutthroat Trout (*Oncorhynchus clarkii*), Chinook, Pink (*O. gorbuscha*) and Sockeye (*O. nerka*) are also present (Bocking and Gaboury 2001). The anadromous section extends up to Englishman River falls, a distance of about 16.6 km from the mouth (Higman et al. 2003). Resident game species include Dolly Varden (*Salvelinus malma*) and Rainbow Trout (*O. mykiss*).

Table 1 shows when the various life stages for each anadromous salmonid species are present within the Englishman River and estuary. The mainstem reach that extends from downstream of Highway 19A to Morison Creek is an important spawning area for all species of anadromous fish within the Englishman River, including Chum, Coho, Chinook and Pink salmon, Steelhead and Rainbow Trout (Figure 2). Some salmon and Steelhead 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) (Figure 2). As identified above, the habitats in these reaches are most important for salmon, Steelhead and Rainbow Trout spawning, and Coho, Chinook, Steelhead and Rainbow Trout rearing and overwintering.

In Reach 3 above Allsbrook Canyon, the C.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 Cutthroat Trout. Coho and Chum salmon and Cutthroat Trout spawn in the MacMillan Bloedel 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.

Under existing conditions, summer rearing habitat in the Englishman River is considered one of the primary limiting factors of Coho, Steelhead, Chinook and Rainbow Trout 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).

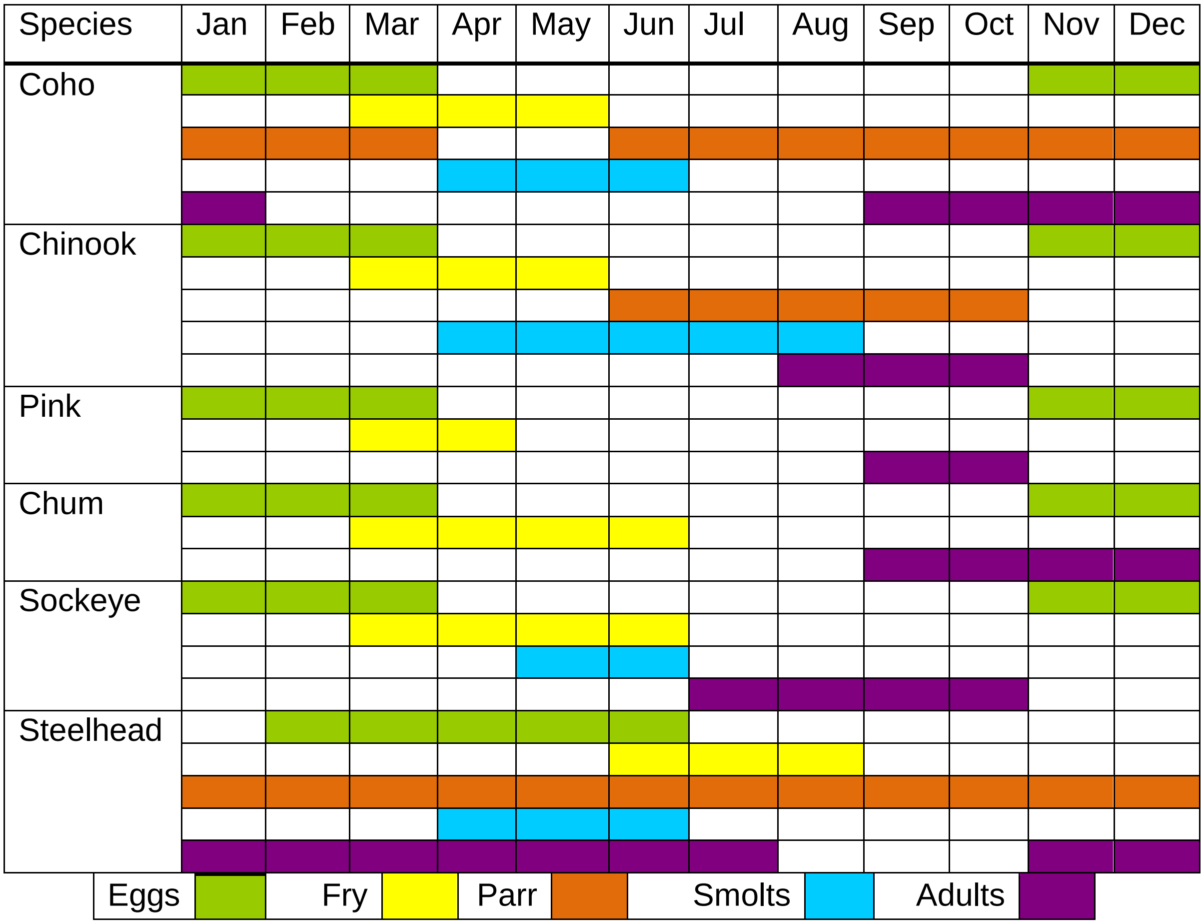
5.1.1 Fish Habitat at Intake Site

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 Steelhead, Rainbow Trout, Cutthroat Trout, Chinook and Coho fry at low and moderate flows. The glide habitat would also be suitable as rearing habitat for Steelhead and Rainbow trout 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.

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



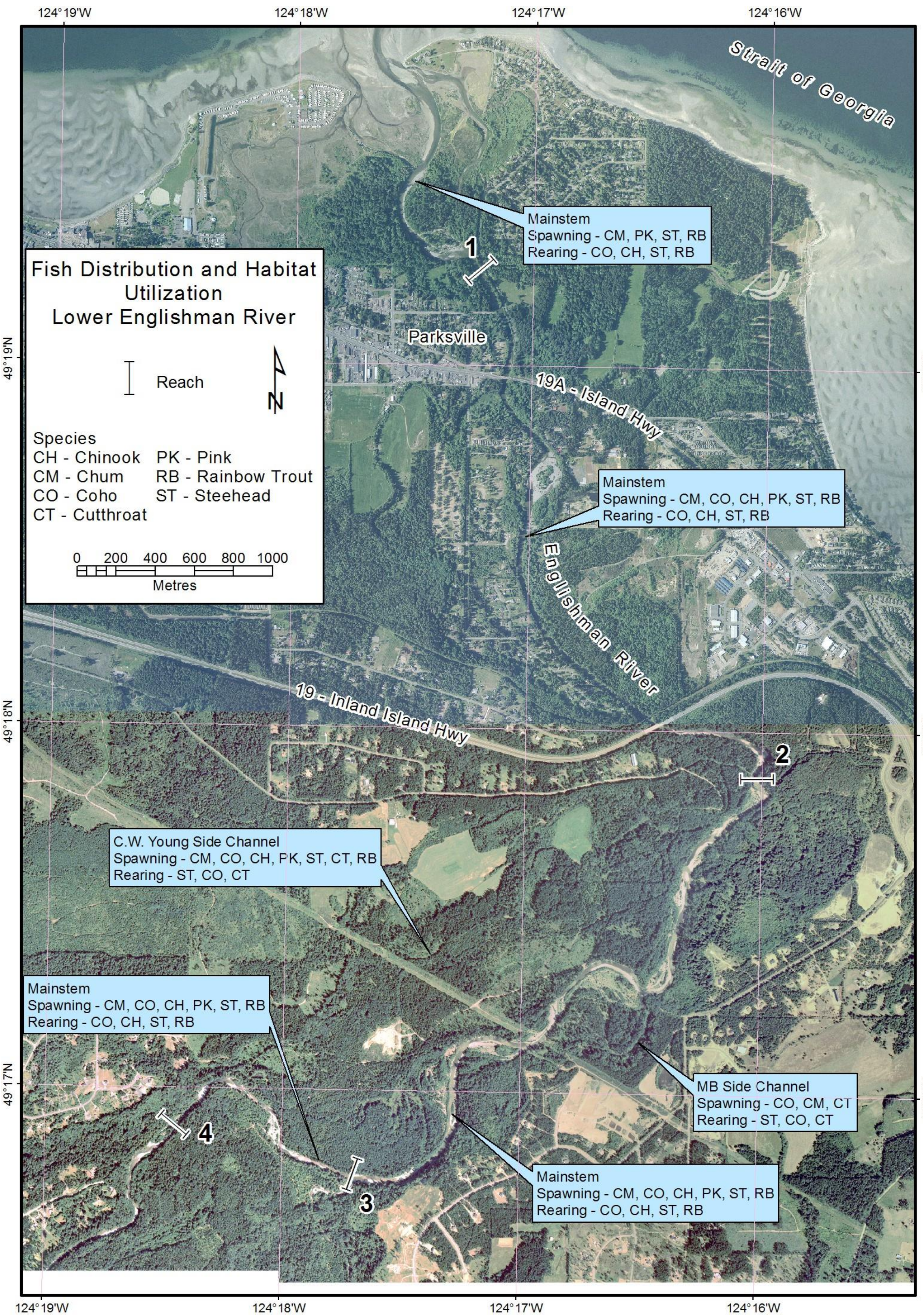


Figure 2. Map of lower Englishman River showing distribution of salmon and trout species that use mainstem and side channel habitats for spawning and rearing.

5.1.2 Fish Habitat Downstream of Intake Site

The proposed intake site is located ~2.7 km upstream of the existing water intake and ~4.5 km upstream of the river mouth. Fish habitat downstream of the proposed intake site is situated within Reaches 1 and 2 of the Englishman River (Figure 1). Fish habitat within this ~4.5 km section of channel is characterized as predominantly glide with current utilization by salmon and Steelhead for spawning, and by Coho, Chinook, Steelhead and Rainbow and Cutthroat Trout for rearing (Figure 2). 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%. Overall composition of habitat types in the lower Englishman River downstream of the proposed water intake was ~53% glides, ~26% riffles and ~20% pools (Table 2; Figure 3; Photo 1 to Photo 12). The preponderance of glide habitat with an average composition of ~20% sand, ~61% gravel and ~8% cobble and boulder provides a large quantity of moderate quality spawning habitat and moderate to high quality fry rearing habitat (Table 3). 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 Steelhead 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 2. 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 3 for meso-habitat distribution on river.

Habitat Type	Channel Length (m)	Proportion
Glide	1762	53.4%
Riffle	860	26.1%
Pool	676	20.5%
Total	3298	100.0%

Table 3. 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

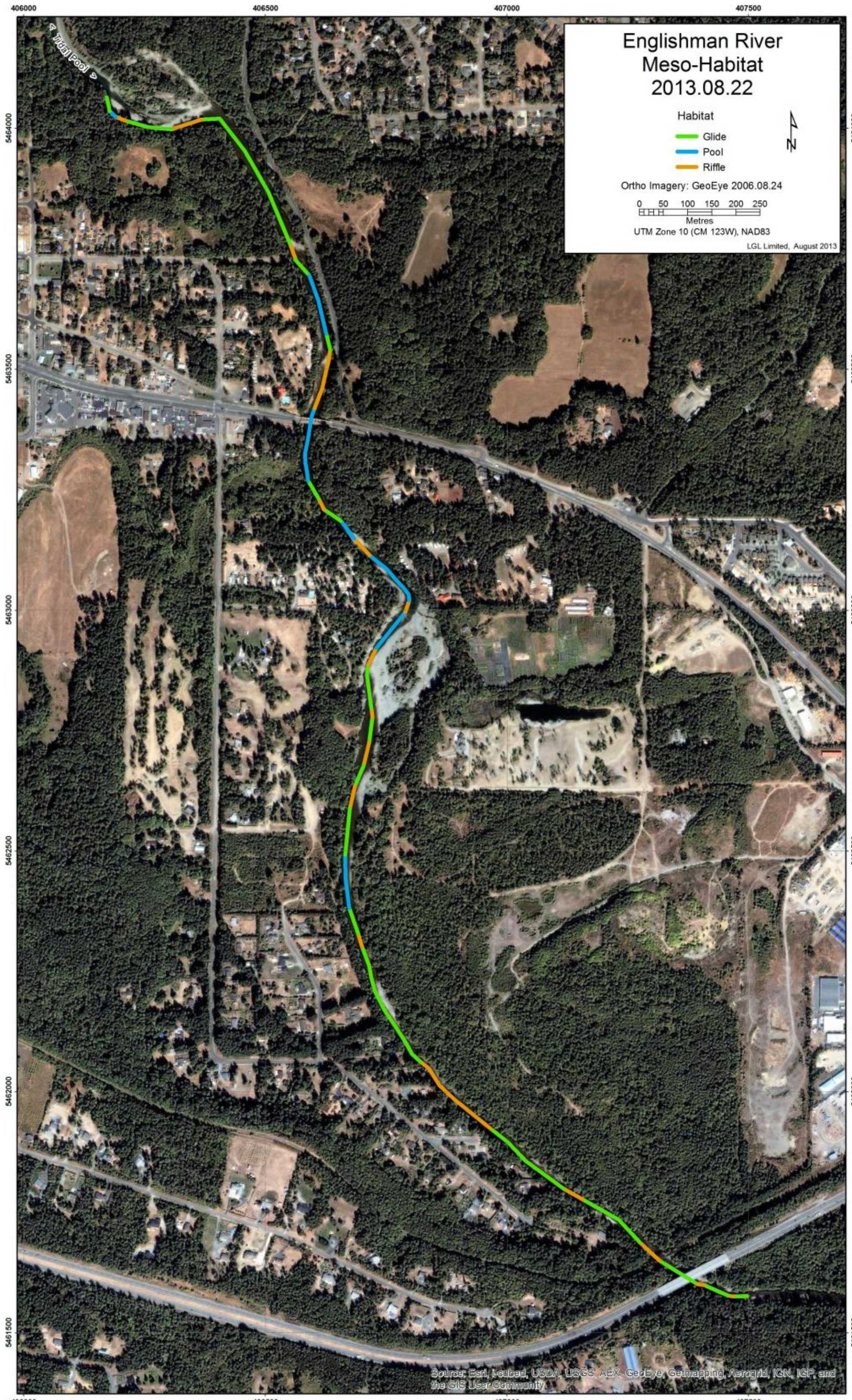


Figure 3. Distribution of meso-habitats between the zone of tidal influence and the proposed water intake site on Englishman River.

5.2 Habitat-Flow Relationships

5.2.1 Fry

Area of Coho and Chinook (spring period) and Steelhead fry habitat in glides increases rapidly to peak WUA values as flows increase, and then suitability decreases gradually with increasing discharge (Figure 4). Area of Steelhead parr and Chinook (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 Chinook spring fry to 5.80 m^3/s for Chinook summer fry (Table 4). Peak WUA values for Steelhead and Coho fry were 0.60 and 1.40 m^3/s, respectively.

Area of salmon and Steelhead fry habitat in riffles increases quite rapidly to peak WUA values as flows increase, and then suitability decreases gradually with increasing discharge (Figure 5). Discharges at peak WUA values for fry inhabiting riffles ranged from 1.30 m^3/s for Chinook spring fry to 3.90 m^3/s for Chinook summer fry (Table 4). Peak WUA values for Steelhead and Coho 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 Coho, Chinook summer and Steelhead fry than for Chinook spring fry.

5.2.2 Parr

Area of Steelhead 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 4 and Figure 5). Discharges at peak WUA values for Steelhead parr were 8.30 m^3/s for glides and 5.50 m^3/s for riffles (Table 4).

5.2.3 Spawning

Spawning area for salmon and Steelhead increases quite gradually in glides with maximum WUA values for all species at >10 m^3/s (Table 4; Figure 6). Spawning area of salmon and Steelhead increases rapidly in riffles with maximum WUA values at >6 m^3/s (Figure 7). Flows at maximum WUA for Chinook spawning were the highest with estimates of ~32 m^3/s in glides and ~35 m^3/s in riffles.

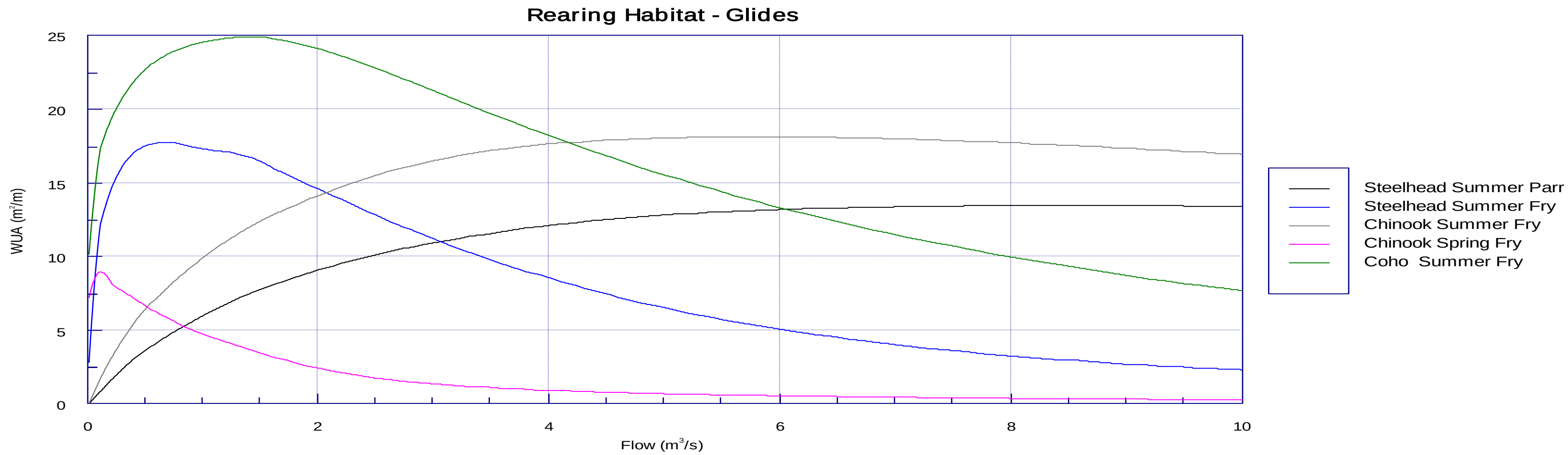


Figure 4. Weighted usable area plots for lower Englishman River glides based on rearing habitat suitability indices for Steelhead, Chinook and Coho.

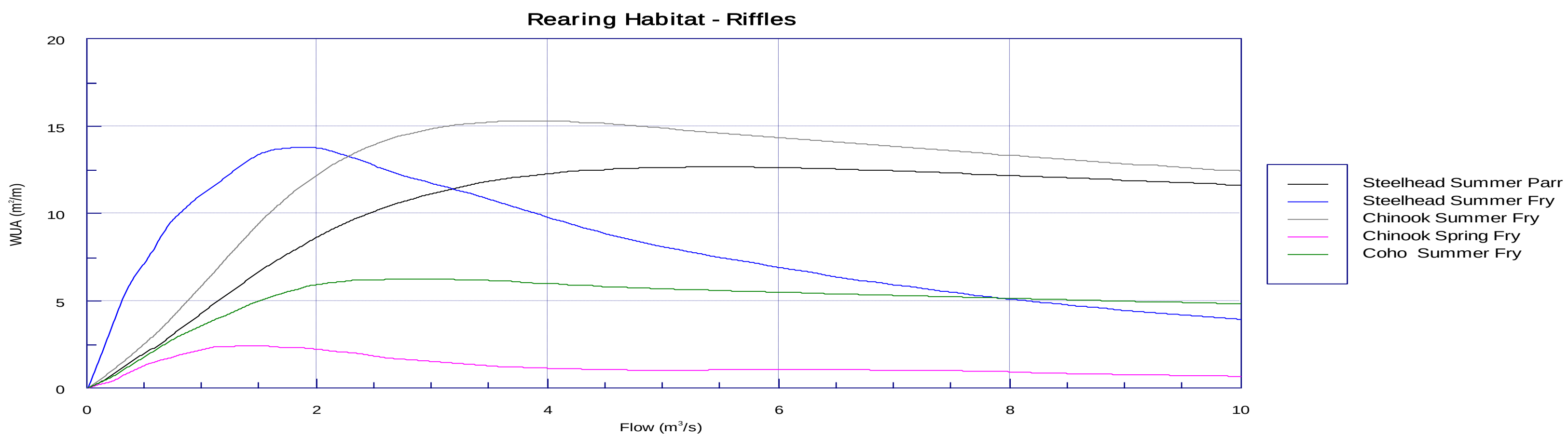


Figure 5. Weighted usable area plots for lower Englishman River riffles based on rearing habitat suitability indices for Steelhead, Chinook and Coho.

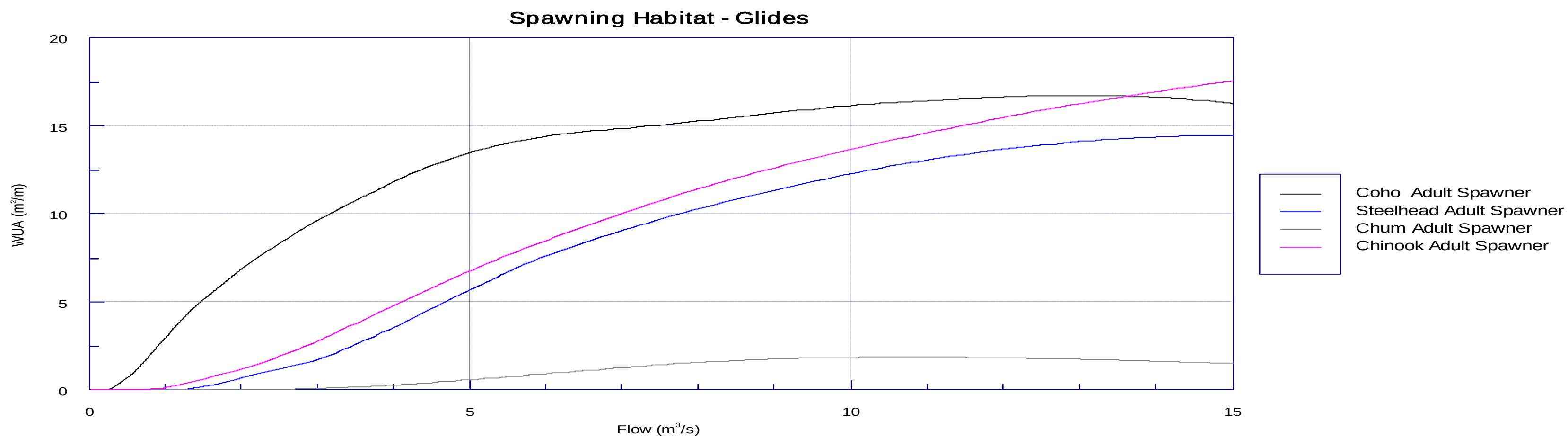


Figure 6. Weighted usable area plots for lower Englishman River glides based on spawning habitat suitability indices for Steelhead, Chinook, Coho and Chum.

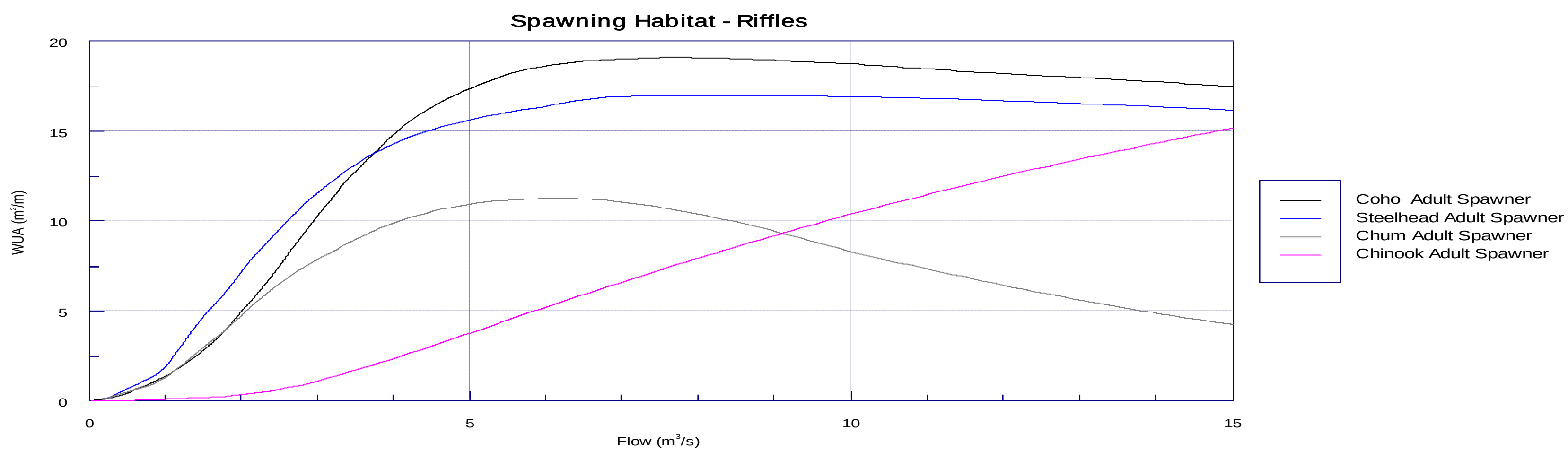


Figure 7. Weighted usable area plots for lower Englishman River riffles based on spawning habitat suitability indices for Steelhead, Chinook, Coho and Chum.

Table 4. 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. 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 Coho, Chinook, Steelhead 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) when very low discharges have been recorded (Table 8).

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/day (0.27 m^3/s) with a maximum instantaneous withdrawal of 28.8 ML/day (0.33 m^3/s) for treatment plant operation. 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 instantaneous withdrawal rate of 28.8 ML/d or 0.33 m^3/s are shown in Table 5.

Table 5. Maximum daily average design pumping rates by month as a percentage of the maximum instantaneous withdrawal rate of 28.8 ML/d or 0.33 m^3/s.

Month	% of Max Instantaneous Withdrawal	Water Withdrawal Rate (m^3/s)
November	36%	0.12
December	36%	0.12
January	33%	0.11
February	33%	0.11
March	36%	0.12
April	36%	0.12
May	48%	0.16
June	67%	0.22
July	82%	0.27
August	76%	0.25
September	61%	0.20
October	45%	0.15

Based on predicted increases in the population within the service area, a MDD of 24 ML/day 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/day 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.

Potential impacts on flows and fish habitat in this aquatic effects assessment targeted the period 2016-2035. For our analysis we assumed a worst-case scenario and applied the maximum instantaneous withdrawal rate of 28.8 ML/day (0.33 m^3/s) in the calculations of 'after withdrawal' flow exceedances to examine flow effects on flows and fish habitats (Appendix J to Appendix M; Table 6). In this analysis, flow exceedances 'after max withdrawal' were based on existing recorded flows (2000-2011) minus the maximum instantaneous withdrawal of 28.8 ML/day or 0.33 m^3/s in each month. Flow exceedances are based on hydrological analyses carried out by Kerr Wood Leidal Associates Ltd. (2014a).

The key concern of water withdrawals at the proposed intake site relates primarily to the potential loss of flow downstream of the new intake during the low flow summer period that could affect the amount and quality of functional fish habitat in this 4 km length of mainstem. 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 (Table 6). From the flow comparison in Table 6, water withdrawals are not expected to significantly affect flows for overwintering, or salmon and Steelhead spawning, egg incubation, emergence and smolt migration between the months of November and June. However, potentially lower flows in August-October will reduce rearing habitat area, delay the start of spawning, or reduce the wetted area suitable for spawning by Chinook, Pink, Chum and Coho or (Table 1). At an 80% flow exceedance, low flow conditions of <1.44 m^3/s that currently occur in August-October will be further reduced with a maximum water withdrawal of 0.33 m^3/s to <1.11 m^3/s (Table 6).

A reduction in flow with proposed water withdrawals could potentially reduce the quantity of suitable rearing habitat for Steelhead fry and parr, Chinook summer and spring fry, and Coho summer fry. An analysis was completed to assess the effect of water withdrawals on rearing habitat area. In the analysis, species and life stage specific WUA area for riffles and glides combined (Table 4) was determined for flow exceedance discharges of 50% to 90% under existing and after maximum water withdrawal conditions (Table 7). Each species and life stage specific WUA was then calculated as a percent of maximum WUA at each flow condition. The change in the 'percent of maximum WUA' was used as a measure of the expected change in the quantity of suitable rearing habitat for that species and life stage with water withdrawal. Steelhead parr and Chinook summer fry are the species and life stages most affected by low summer flows (i.e., 80% and 90% exceedance flows) and therefore they are the best indicator of potential rearing habitat impacts caused by water withdrawals. Overall, proposed water withdrawals in July caused the greatest decrease in the quantity of suitable rearing habitat for these species and life stages, followed by August, September and October. The greatest change in the quantity of suitable rearing habitat (i.e., WUA) for these indicator species and life stages with water withdrawals of 28.8 ML/day were as follows:

- a reduction of 9% for Steelhead parr and Chinook summer fry at 50% exceedance flows (July);
- a reduction of 14% for Chinook summer fry and 13% for Steelhead parr at 80% exceedance flows (August); and
- a reduction of 15% for Chinook summer fry and 13% for Steelhead parr at 90% exceedance flows (August and September).

Reduced water flows in the summer downstream of the water intake could also contribute to higher water temperatures that exceed optimal conditions for salmonid growth and survival. However, water is typically being extracted from the siphon deep in Arrowsmith Lake during the summer low flow period. The water being withdrawn is therefore colder than the river which helps to decrease the maximum temperatures in the lower reach during low flow conditions.

Table 6. Mean daily flow exceedances in Englishman River at WSC gauging station under existing post-dam conditions and after maximum withdrawal assuming a maximum instantaneous withdrawal rate of 28.8 ML/day (0.33 m^3/s) in each month.

Month	Flow Exceedance (%)					
	50		80		90	
	Post-Dam Baseline (cms)	After Max Withdrawal (cms)	Post-Dam Baseline (cms)	After Max Withdrawal (cms)	Post-Dam Baseline (cms)	After Max Withdrawal (cms)
January	13.95	13.62	8.17	7.84	5.94	5.61
February	9.80	9.47	5.17	4.84	3.83	3.50
March	10.90	10.57	6.58	6.25	5.09	4.76
April	11.30	10.97	7.89	7.56	6.47	6.14
May	9.71	9.38	6.64	6.31	5.74	5.41
June	5.28	4.95	3.11	2.78	2.39	2.06
July	2.02	1.69	1.34	1.01	1.26	0.90
August	1.69	1.36	1.30	0.97	1.22	0.89
September	1.73	1.40	1.44	1.11	1.21	0.88
October	4.24	3.91	1.13	0.80	0.97	0.64
November	11.70	11.37	5.53	5.20	3.78	3.45
December	11.65	11.32	5.21	4.88	3.76	3.43

Notes:

1) Post-Dam Baseline and After Max Withdrawal flows based on 2000-2011 flow records at Englishman WSC station, 08HB002

2) After Max Withdrawal flows calculated from average daily Post-Dam Baseline discharges minus Maximum Instantaneous Withdrawal Rate (0.33 m^3/s)

Table 7. Change in the quantity of suitable rearing habitat (riffles and glides combined) for salmon and Steelhead relative to the change in river flows downstream of the proposed intake between July and October. Post-project conditions assume a maximum instantaneous withdrawal rate of 28.8 ML/day (0.33 m^3/s) in each month.

			July			August			September			October		
Flow Exceedance (%)	Species & Life Stage	Max WUA	Post-Dam Baseline	Post-Project	Change with Water Withdrawal	Post-Dam Baseline	Post-Project	Change with Water Withdrawal	Post-Dam Baseline	Post-Project	Change with Water Withdrawal	Post-Dam Baseline	Post-Project	Change with Water Withdrawal
50	Steelhead Summer Parr	13.05	68.7%	59.5%	-9.2%	59.5%	51.3%	-8.2%	62.0%	54.2%	-7.8%	94.3%	92.5%	-1.8%
	Steelhead Summer Fry	15.512	91.8%	98.0%	6.2%	98.0%	100.0%	2.0%	96.6%	99.9%	3.3%	54.5%	58.7%	4.2%
	Chinook Summer Fry	16.992	79.7%	70.3%	-9.4%	70.3%	61.4%	-8.9%	72.9%	64.6%	-8.3%	99.6%	99.0%	-0.6%
	Chinook Spring Fry	6.062	38.1%	47.7%	9.6%	47.7%	56.5%	8.7%	45.0%	53.6%	8.6%	15.0%	16.2%	1.2%
	Coho Summer Fry	18.37	98.6%	100.0%	1.4%	100.0%	99.2%	-0.8%	99.8%	99.7%	-0.1%	74.9%	78.2%	3.3%
80	Steelhead Summer Parr		51.3%	42.1%	-9.2%	51.3%	38.7%	-12.6%	54.2%	45.3%	-8.9%	45.3%	35.2%	-10.1%
	Steelhead Summer Fry		100.0%	98.4%	-1.6%	100.0%	98.0%	-2.0%	99.9%	99.0%	-1.0%	99.0%	97.5%	-1.5%
	Chinook Summer Fry		61.4%	51.0%	-10.4%	61.4%	47.3%	-14.2%	64.6%	54.7%	-9.9%	54.7%	43.3%	-11.3%
	Chinook Spring Fry		56.5%	63.4%	6.9%	56.5%	66.0%	9.6%	53.6%	61.5%	7.9%	61.5%	69.1%	7.5%
	Coho Summer Fry		99.2%	96.4%	-2.8%	99.2%	95.2%	-4.0%	99.7%	97.4%	-2.3%	97.4%	93.7%	-3.8%
90	Steelhead Summer Parr		48.4%	38.7%	-9.7%	48.4%	35.2%	-13.2%	48.4%	35.2%	-13.2%	38.7%	27.7%	-11.0%
	Steelhead Summer Fry		99.5%	98.0%	-1.5%	99.5%	97.5%	-2.1%	99.5%	97.5%	-2.1%	98.0%	94.5%	-3.5%
	Chinook Summer Fry		58.1%	47.3%	-10.8%	58.1%	43.3%	-14.8%	58.1%	43.3%	-14.8%	47.3%	35.0%	-12.3%
	Chinook Spring Fry		59.0%	66.0%	7.0%	59.0%	69.1%	10.1%	59.0%	69.1%	10.1%	66.0%	76.4%	10.4%
	Coho Summer Fry		98.4%	95.2%	-3.2%	98.4%	93.7%	-4.7%	98.4%	93.7%	-4.7%	95.2%	89.5%	-5.7%

5.4 Mitigation of Potential Habitat Impacts

5.4.1 Footprint of Intake Infrastructure

Mitigation for the permanent alteration or loss of ~49 m^2 of natural channel habitat and ~40 m^2 of riparian habitat as a result of the installation of the intake and stairway could be mitigated by enhancing or creating rearing and overwintering habitats in the lower Englishman River. Rearing and overwintering habitats are often considered critical limiting factors for freshwater life stages of Pacific salmonids. Creation or enhancement of rearing and overwintering habitats in the Englishman River is considered biologically relevant and an appropriate approach to mitigate some of the potential impacts associated with construction of the new water intake structure (M. McCulloch FLNRO pers. comm.). Habitat enhancement / creation options could include strategic placement of large woody debris (LWD) structures in Reach 3, and boulder placements in Reaches 2 and 3. Each option above would have benefits that target different fish species groups and life stages but all options would provide benefits to native salmonid rearing and overwintering habitats in the Englishman River.

5.4.2 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.

5.4.3 Operation and Maintenance Phase

5.4.3.1 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 Regional District of Nanaimo'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 south of Parksville on 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 Regional District of Nanaimo and the Town of Qualicum Beach.

The Arrowsmith Dam, with a live storage volume of 9 million cubic meters, 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 Regional District of Nanaimo. 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 8). The revised operating rule accounts for water withdrawals at the proposed intake upstream of the WSC gauge.

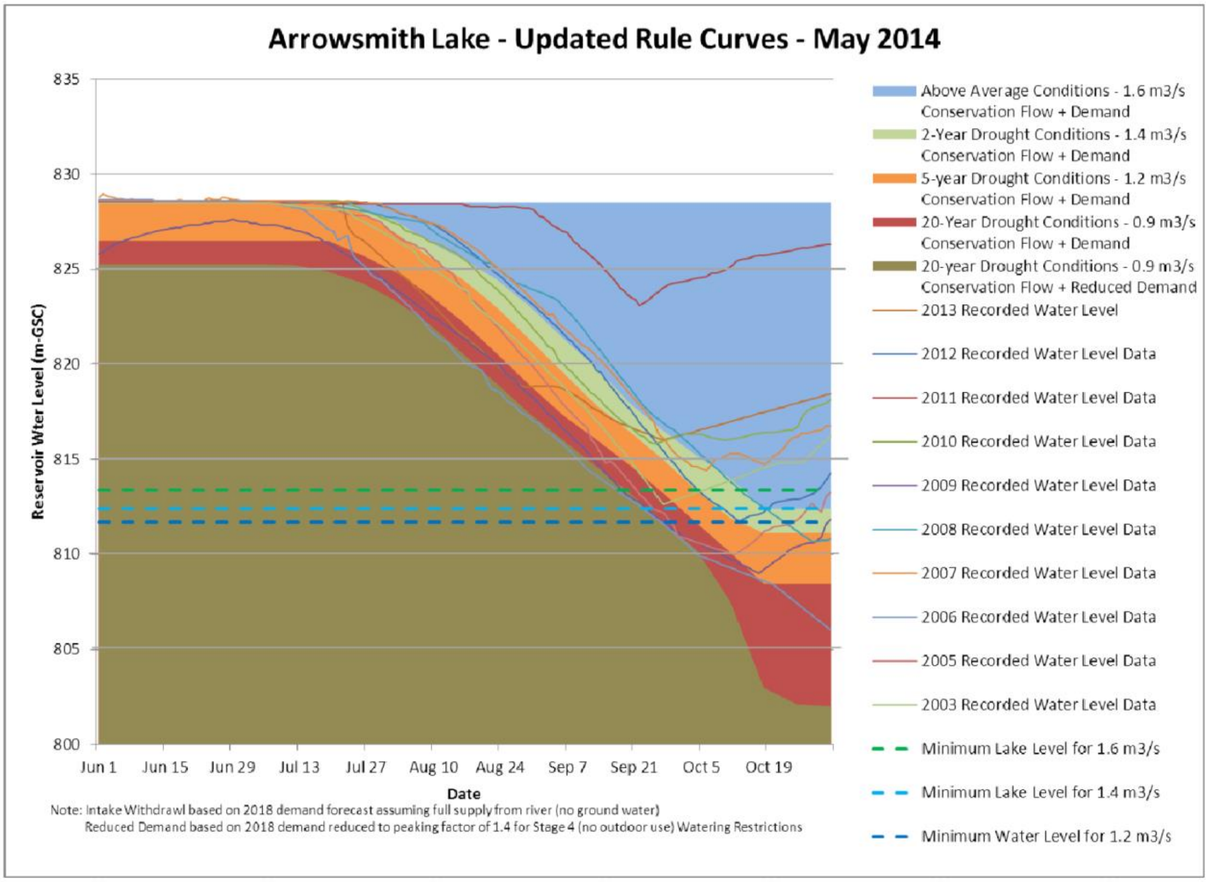


Figure 8. Provisional operating rule for Arrowsmith Lake. Prepared by Kerr Wood Leidal Associates Ltd. for ERWS, June 2014.

With construction of Arrowsmith Dam low summer baseflows have improved in the non-anadromous and anadromous sections of the Englishman River, a total river distance of ~30 km to the river mouth (Figure 9). The streamflow improvements have helped to alleviate the impacts of historically low summer flows on fish rearing habitats. However, due to the relatively small storage volume of Arrowsmith Lake coupled with years of low precipitation and the naturally low summer discharges in the Englishman River, annual minimum discharges have been below 1.20 m^3/s eight times between 2000 and 2012, albeit for short durations (Table 8). Nevertheless, the release of water from Arrowsmith Dam has greatly improved summer discharges when compared to the pre-dam period. For example, the median annual minimum flow in Englishman River prior to Arrowsmith Dam was recorded at 0.29 m^3/s but with the dam releases since 2000 has improved to 1.12 m^3/s.

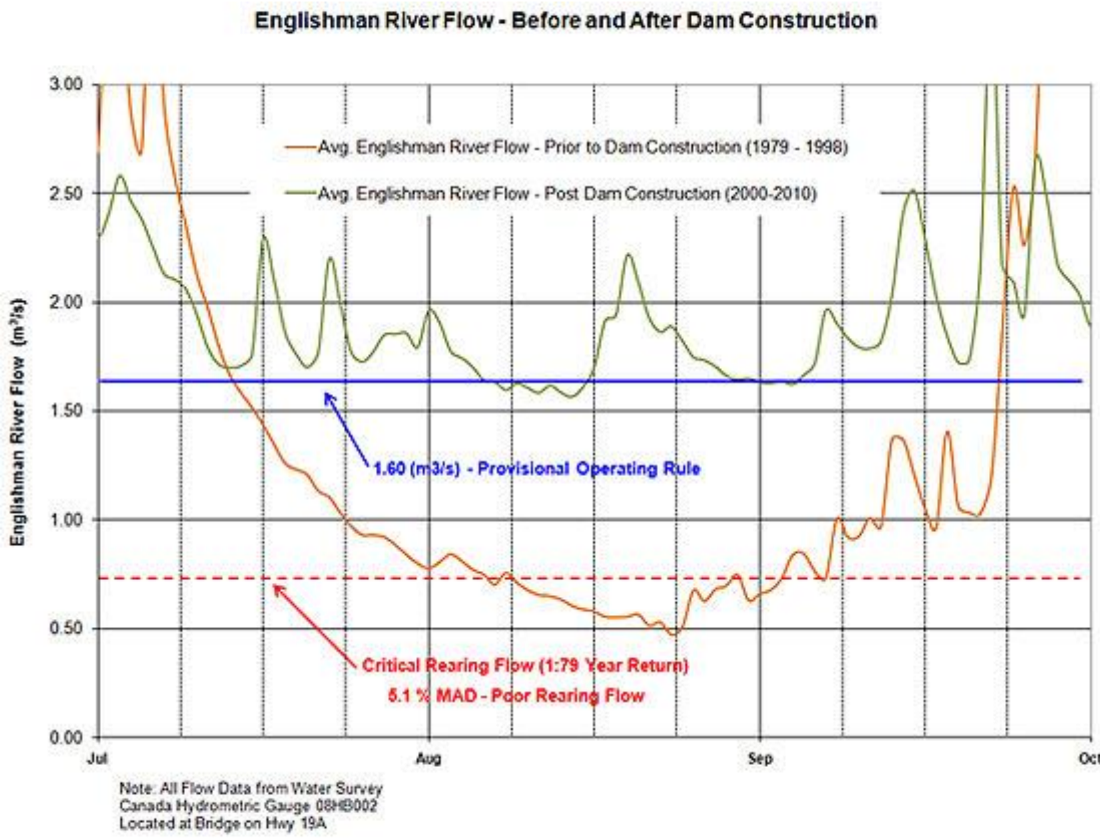


Figure 9. Comparison of Englishman River discharges pre- and post-dam construction. Reproduced from ERWS website (http://www.englishmanriverwaterservice.ca/fisheries_benefits.asp).

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 will result in greater discharges in the lower 4 km of the river than occurred under the pre-dam condition. With water extraction under post-project conditions, 90% exceedance flows 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 9). 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 provide a potentially greater relative contribution to baseflows than the statistics in Table 9 show.

Table 8. Annual minimum discharges in Englishman River, WSC gauge 08HB002, over period of record, 1913-2012.

Year	Minumum Daily Discharge (cms)	Date (Month--Day)	Period Summaries	
1913	0.28	9--1		
1914	0.09	9--4		
1915	0.65	9--20		
1916	0.43	10--17		
1917	1.10	8--11		
1970	0.17	9--1		
1971	1.16	8--29		
1980	0.63	9--19		
1981	0.46	8--23		
1982	0.49	9--3		
1983	0.48	10--12		
1984	0.42	8--31		
1985	0.27	8--28		
1986	0.29	9--19		
1987	0.27	10--19		
1988	0.27	9--14		
1989	0.31	10--3		
1990	0.22	8--29		
1991	0.29	8--5		
1992	0.25	8--16		
1993	0.14	9--30		
1994	0.34	9--2		
1995	0.25	9--25		
1996	0.21	8--28		
1997	0.83	8--19		Minimum
1998	0.17	9--7	1913~1998	Discharge
1999	0.89	10--12	Minimum	0.09
2000	0.67	9--28	Median	0.29
2001	1.12	7--24		
2002	0.97	11--5		
2003	1.02	7--21		
2004	1.15	9--7		
2005	1.22	9--28		
2006	0.74	10--13		
2007	1.56	9--14		
2008	0.94	8--17		
2009	0.76	10--12		Minimum
2010	1.29	8--11	2000-2012	Discharge
2011	1.21	8--18	Minimum	0.67
2012	1.52	9--3	Median	1.12

Table 9. 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%
90% Exceedance	0.556	4%	1.30	134.1%	10%
80% Exceedance	1.11	8%	1.75	57.4%	14%
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 instantaneous withdrawal rate of 28.8 ML/d or 0.33 m^3/s, as described in Table 5.

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

Under the proposed project, river discharges will be similar to the Post-Dam Baseline values upstream of the water intake and similar to the Post-Project flows downstream of the intake (Table 10). Water supply storage in Arrowsmith Lake will mitigate for water withdrawals at the proposed intake by ensuring that Post-Project median CPSF values remain an acceptable 13% of both Post-Dam Baseline MAD (Table 10) and Post-Project MAD values (Table 9), and well above the median CPSF value of 6% of the Pre-Dam MAD.

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 over a river distance of ~26 km and a wetted habitat area of ~650,000 m^2 (assuming a nominal wetted width of 20 m in the non-anadromous section and 30 m in the anadromous section). The probable future flows within this section of river upstream of the intake site are represented by the Post-Dam Baseline flows shown in Table 10.

Table 10. Comparison of post-dam baseline and estimated post-project flows.

Statistic	Post-Dam Baseline (cms)	Post-Dam / Post-Dam Baseline MAD (%)	Post-Project (cms)	% Change - Post-Dam Baseline minus Post-Project	Post-Project / Post-Dam Baseline MAD (%)
Mean Annual Discharge	12.79	100%	12.63	-1.3%	99%
Median Flow	7.08	55%	6.91	-2.4%	54%
Min Daily	0.67	5%	0.56	-16.0%	4%
Max Daily	303	2368%	303	0.0%	2367%
90% Exceedance	1.53	12%	1.30	-14.9%	10%
80% Exceedance	1.99	16%	1.75	-12.2%	14%
CPSF Median (July-Oct)	1.85	14%	1.61	-12.7%	13%

Notes:

1) Post-dam baseline 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 instantaneous withdrawal rate of 28.8 ML/d or 0.33 m^3/s, as described in Table 5

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

5.4.3.2 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 intake. This minimum maintenance flow target will be high enough to ensure that serious harm to fish that are part of or support a commercial, recreational or Aboriginal fishery, as specified under Section 35 of the Fisheries Act (2012), does not occur.

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/day (0.27 m^3/s) with a maximum instantaneous withdrawal of 28.8 ML/day (0.33 m^3/s) for treatment plant operation (Table 5). The hydrologic modelling completed by KWL indicated that, provided storage management operations at Arrowsmith Lake are optimized, the dam 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.

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, Coho summer fry, Chinook spring fry and Steelhead fry residing downstream of the water intake would be at or near maximum WUA at flows between 0.9 and 1.6 m^3/s (Figure 10). Steelhead parr and Chinook summer fry are the most affected by low summer flows but 39% and 47% of maximum WUA for Steelhead parr and Chinook 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. Under post-project conditions, WUA for the target species and lifestages at the estimated minimum maintenance flow of 0.9 m^3/s for a >20 yr drought will be similar to the WUA values at the pre-dam median CPSF value of 0.87 m^3/s (Table 9). Also, the estimated post-project median CPSF (Table 9) of 1.61 m^3/s will be similar to the estimated flows of 1.6 m^3/s in ≤2 yr drought or above average conditions.

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; Table 8). 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.

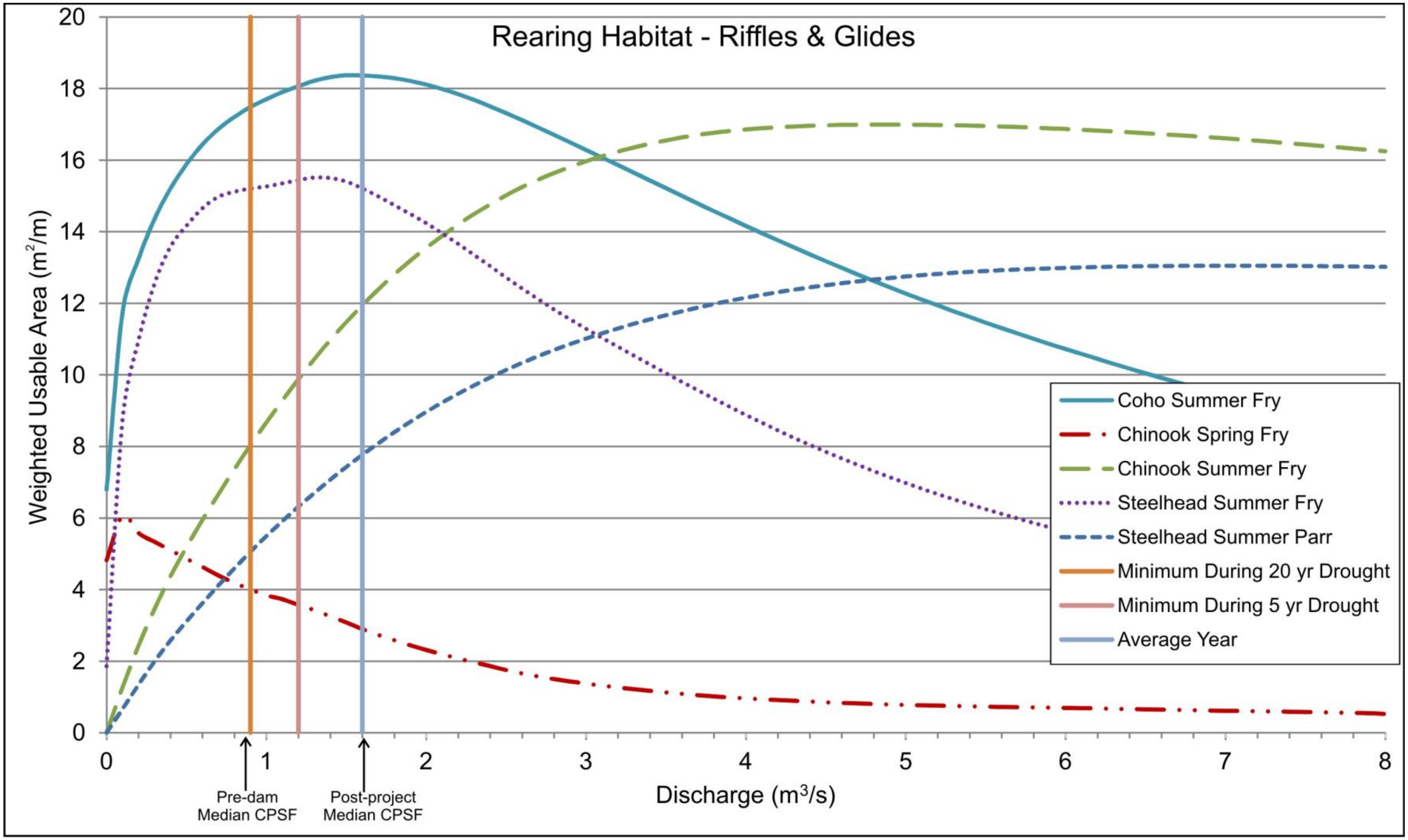


Figure 10. Weighted usable area plots for riffles and glides combined in lower Englishman River based on rearing habitat suitability indices for Steelhead, Chinook and Coho. Minimum maintenance flow targets (0.9-1.6 m^3/s; Table 11) for drought and average flow years, and pre-dam (0.87 m^3/s) and post-project (1.61 m^3/s) median critical period streamflows (CPSF) are shown.

5.4.3.3 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 MLD or 0.09 m^3/s for existing demands.

The development of water supply from an 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 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 an additional supply for the ERWS, which would provide more contingency should one supply source be taken offline, and allow the ERWS greater flexibility in managing the water resources. ASR can reduce the maximum amount of water that needs to be supplied by the treatment plant. This means that less water will need to be drawn from the Englishman River during the summer, when river discharges are at their lowest.

5.4.3.4 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.

5.4.3.5 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 MLD)
	m^3/s/hr	MLD/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

5.4.3.6 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.

5.4.3.7 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 4.4.2 Construction Phase. In some cases, site isolation and fish salvage may be required.

5.5 Effectiveness 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. Monitoring will include field measurements and reporting on the following parameters:

- temperature, turbidity and discharge,
- wetted widths and depths at riffle and glide habitats,
- distribution and relative abundance of fish species and life stages, and
- incidence of fish being impinged on the intake screen.

The work plans pertaining to each of these three components are described below. Where appropriate, 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 that could reduce environmental impacts determined through these assessments and evaluations.

Temperature, Turbidity and Discharge

Continuous temperature, turbidity and discharge measurements collected by Water Survey of Canada and the BC Ministry of Forests, Lands and Natural Resource Operations at the Highway 19A bridge 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, turbidity and discharge upstream of the intake site. The field assessments and evaluations will be undertaken in the first year after commissioning of the intake structure and will occur from July 1 to October 31. The work will involve:

- 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, and
    - to examine ERWS compliance at meeting or exceeding the minimum maintenance flows predicted in the aquatic effects assessment,
- 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,
    - to compare current turbidities to historic values collected by FLNRO during the summer baseflow period, and
    - to evaluate the potential or observed impact of these turbidity changes on aquatic organisms.

Discharge Monitoring - Long Term

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 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.

Wetted Widths and Depths

Riffle and glide transects were established for the RhyHabsim modeling in the Aquatic Effects Assessment. The monitoring objective will be to re-visit these 10 transects downstream of the water intake at summer baseflows of 0.9, 1.2 and 1.6 m^3/s to measure water stage, wetted widths and depths and compare them to model predictions of these parameters. The field assessments and evaluations will be undertaken in the first year after commissioning of the intake structure and will occur between July 1 and October 31. An evaluation of habitat suitability for the salmon and trout, with an emphasis on Steelhead parr and Chinook summer fry, will be made for the riffle and glide habitats at each baseflow based on weighted usable area and professional opinion.

Distribution and Relative Abundance of Fish Species and Life Stages

Electrofishing surveys will be conducted at the five riffle habitats selected for transect surveys in the RhyHabsim modeling for Reach 2 of the Englishman River. The objective will be to collect and identify fish species and life stages, and determine their relative abundances. The field assessments and evaluations will be undertaken in the first year after commissioning of the intake structure. The riffle surveys will be conducted on three occasions between July and September at summer baseflows of ~0.9, ~1.2 and ~1.6 m^3/s. An evaluation of the relative abundance estimates for the salmon and trout, with an emphasis on Steelhead parr and Chinook summer fry, will be made for the riffle habitats at each baseflow. Comparisons of current abundance estimates will be made with previous fish population surveys in the Englishman River and in similar east Vancouver Island streams. 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 distributions, growth and survival.

Fish Screen Impingement

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 are more concentrated in the glide adjacent to the intake. ERWS operational staff that work at the site regularly will be instructed to observe and record instances of fish impingement. Additional field surveys will be undertaken by fisheries biologists on weekly intervals during the baseflow period. Whenever impingement is observed, fish species and life stage will be identified and their numbers enumerated.

Reporting

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.

6.0 Summary and Conclusions

Based on the results of this assessment it is concluded that:

1. The Englishman River supports significant populations of salmon including Chum, Coho, Steelhead, Rainbow Trout, Cutthroat Trout, Chinook, Pink and Sockeye;
2. Summer rearing habitat is considered to be one of the primary limiting factors of Coho, Steelhead, Chinook, Rainbow Trout and Cutthroat Trout production within the watershed due to naturally occurring low summer baseflows;
3. River habitat at the intake site is glide habitat that is suitable as rearing habitat for salmonids, but 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;
4. Construction of the intake will result in the permanent loss or alteration of about 49 m^2 of river channel habitat and 40 m^2 of riparian habitat;
5. Water demand for the new intake and treatment plant is 24 ML/day with a maximum instantaneous withdrawal of 28.8 ML/day (0.33 m^3/s) for treatment plant operation. This withdrawal rate is expected to support municipal demand up to 2035;
6. The key concern of water withdrawals at the proposed intake site is the reduction of instream flow in the 2.5 km reach between the proposed intake and existing intake just downstream of Highway 19A;
7. Compared to current conditions (post-dam baseline), maximum instantaneous water withdrawals of ~28.8 ML/day at the proposed intake site would result in a reduction in weighted useable area of up to 9% for Steelhead parr and Chinook summer fry during median summer flow conditions (50% exceeded flow for July);

8. Compared to current conditions, maximum instantaneous water withdrawals of ~28.8 ML/day at the proposed intake site would result in a reduction of 14% for Chinook summer fry and 13% for Steelhead parr at 80% exceedance flows in August;
9. Compared to current conditions, maximum instantaneous water withdrawals of ~28.8 ML/day at the proposed intake site would result in a reduction of up 15% for Chinook summer fry and 13% for Steelhead parr, at 90% exceedance flow in August and September;
10. As part of phased water supply development by ERWS, construction of water storage at Arrowsmith Lake has increased summer baseflows significantly throughout the anadromous section of the river when compared to pre-dam conditions;
11. Management of Arrowsmith Lake releases using the current provisional rule curve will mitigate potential fish habitat impacts in Reaches 1 and 2 caused by water extraction at the proposed intake structure by ensuring that Post-Project median CPSF values remain an acceptable 13% of both Post-Dam Baseline MAD and Post-Project MAD values, and well above the median CPSF value of 6% of the Pre-Dam MAD;
12. At anticipated withdrawal rates based on average monthly water demand, the current dam is capable of supporting flows of 1.6 m^3/s, 1.2 m^3/s and 0.9 m^3/s downstream of the intake for median flows, low summer flows (5-year to 20-year drought) and extreme low summer flows (>20-year drought), respectively, provided the operating rules for Arrowsmith Lake maximize conservation of storage in the early part of the summer season; and
13. Upstream migration by juvenile and adult salmon and trout will not be impeded at low, moderate or high river discharges as a result of water intake operation.

Given the potential impacts to fish and fish habitat outlined above, the following mitigation measures will be implemented as part of the construction of the proposed ERWS water intake structure:

1. Adhere to current provisional operating rule curves for the Arrowsmith Dam to ensure discharges of 1.6 m^3/s in median summer baseflow conditions, 1.2 m^3/s during 5-year to 20-year drought conditions and 0.9 m^3/s during >20-year drought conditions;
2. A drought management plan will be developed by ERWS that requires watering restrictions or other water demand reduction measures during periods of drought (5 to 20-year return periods) which will reduce water withdrawals from the river such that a minimum flow of 0.9 m^3/s can be maintained downstream of the intake;

3. Water conservation measures and development of the Aquifer Storage and Recovery system, if proved to be feasible, will be implemented to reduce summer withdrawals from the river;
4. Intake screens will be designed so that when the pumps are operating the approach velocity at the screen will be maintained within DFO guidelines of ≤0.11 m/s. The design screen area will be at least 10% larger than required to maintain a maximum approach velocity of ≤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 potentially fish impingement;
5. A maximum ramping rate of 2.5 cm/hr will be established to prevent impacts during fry emergence and summer and winter rearing. 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;
6. Footprint losses of aquatic and riparian habitat as a result of the construction of the intake will be offset through habitat enhancement or creation options such as, strategic placement of large woody debris (LWD) structures in Reach 3, boulder placements in Reaches 2 and 3, and replanting of riparian vegetation adjacent to the intake structure; and
7. Best Management Practices for sediment management, water control, spill control and response, and site isolation and fish salvage will be implemented to limit potential impacts of construction and maintenance activities on water quality and habitat.

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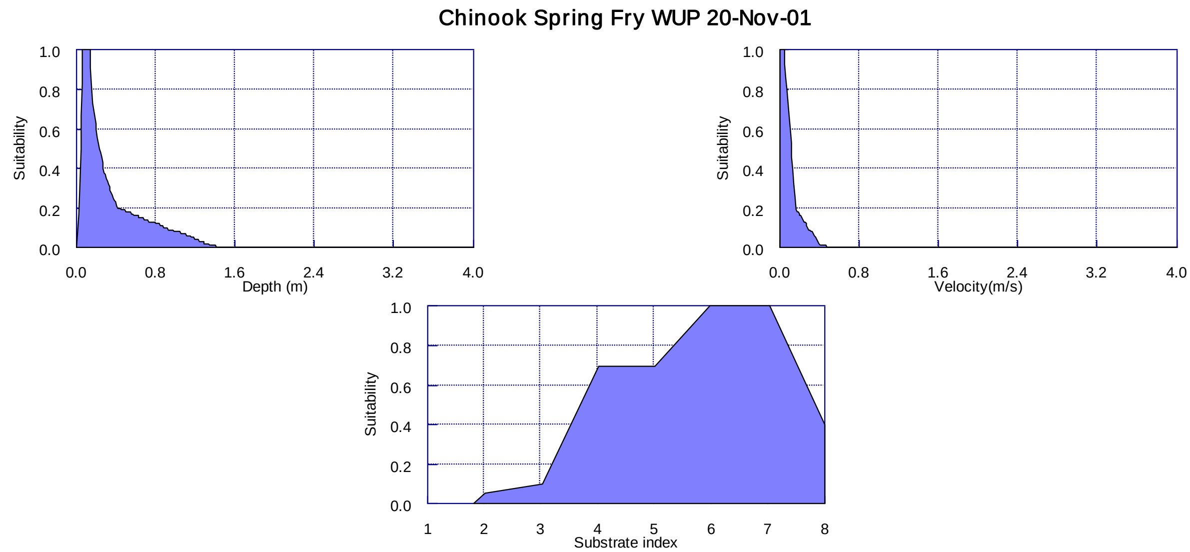
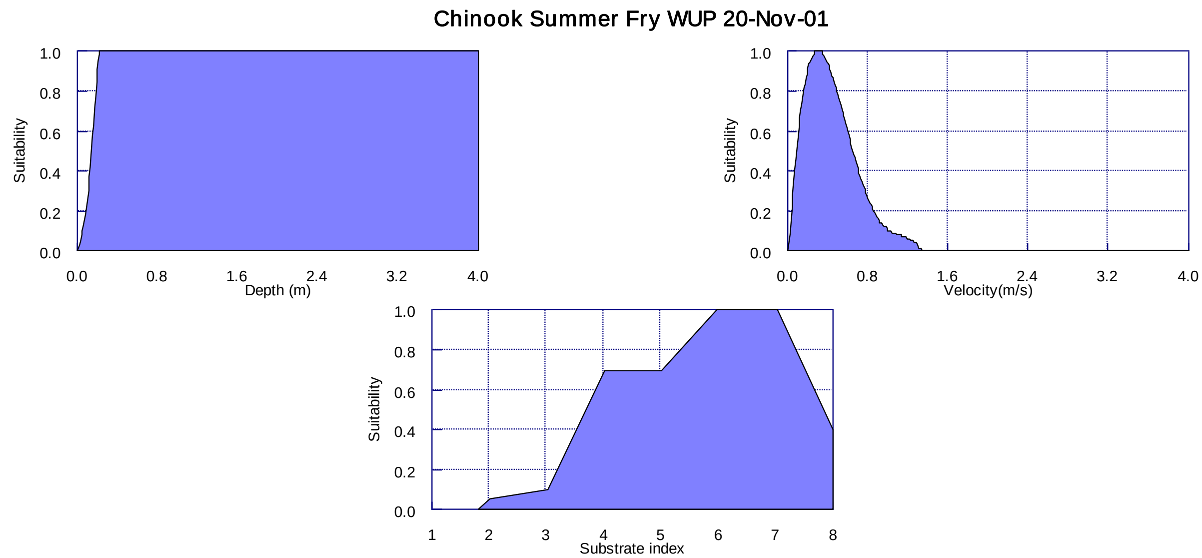
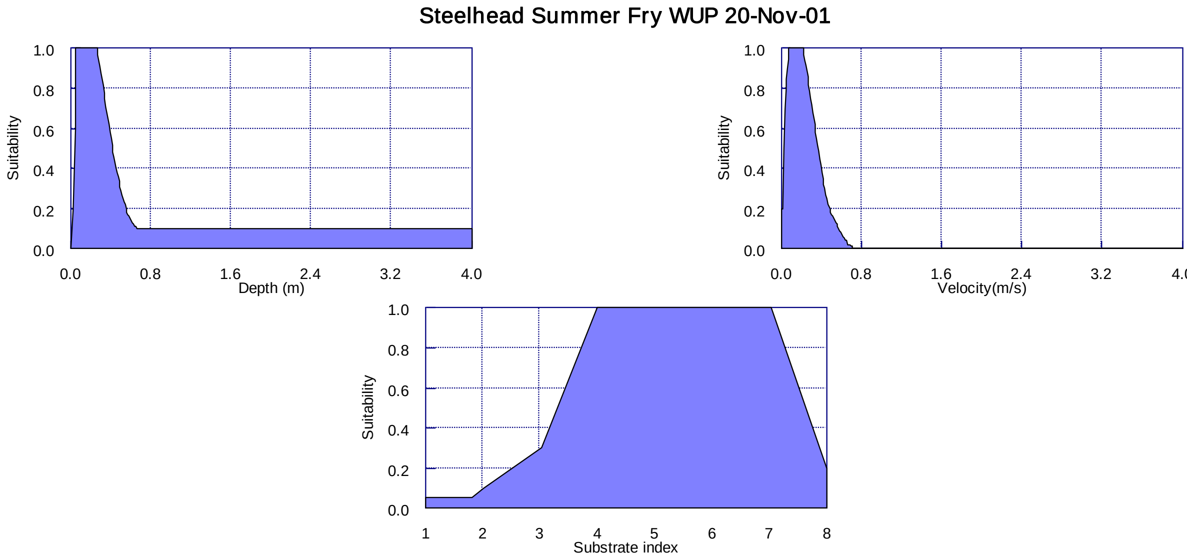
APPENDICES



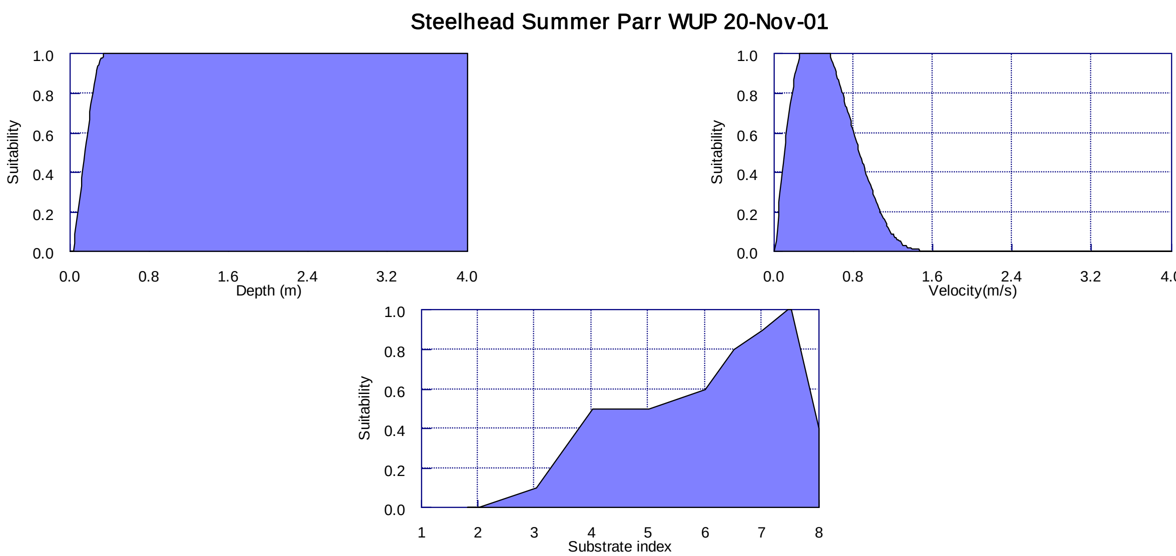
Appendix A. Habitat suitability indices for Chinook – spring fry rearing.



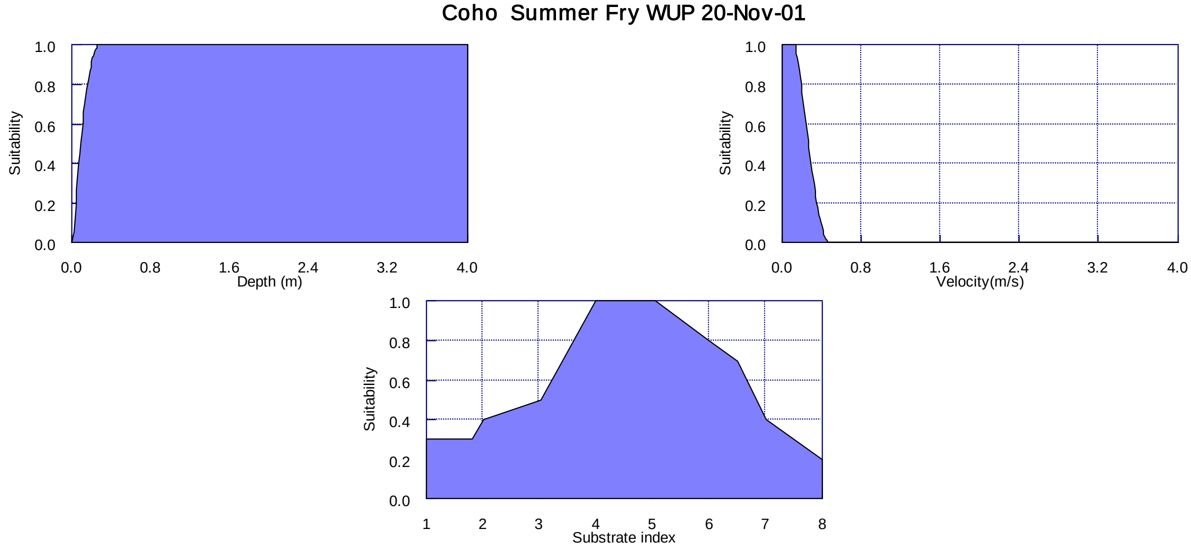
Appendix B. Habitat suitability indices for Chinook – summer fry rearing.



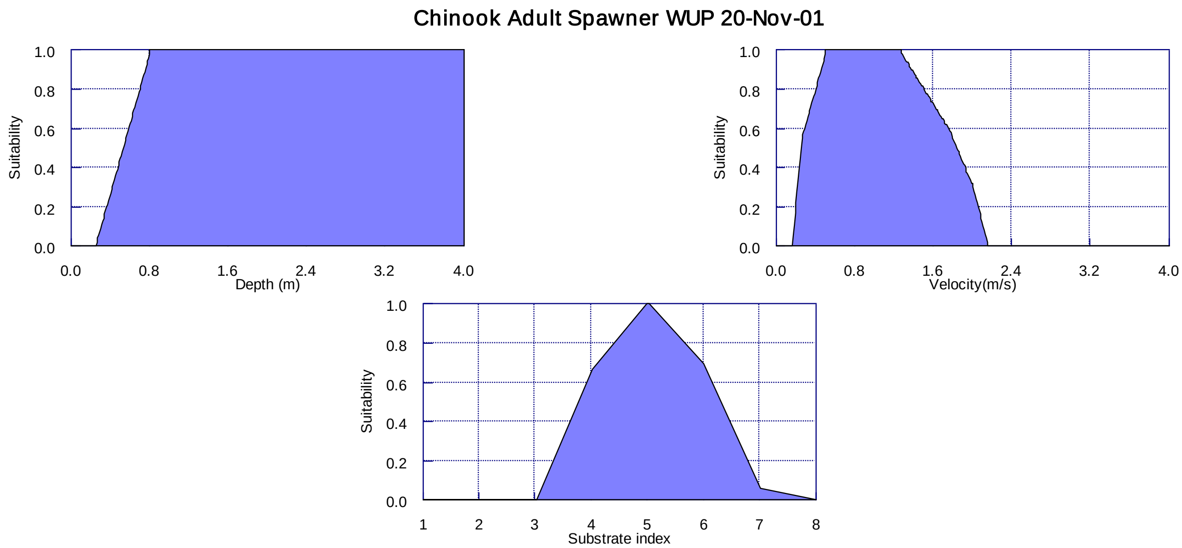
Appendix C. Habitat suitability indices for Steelhead – summer fry rearing.



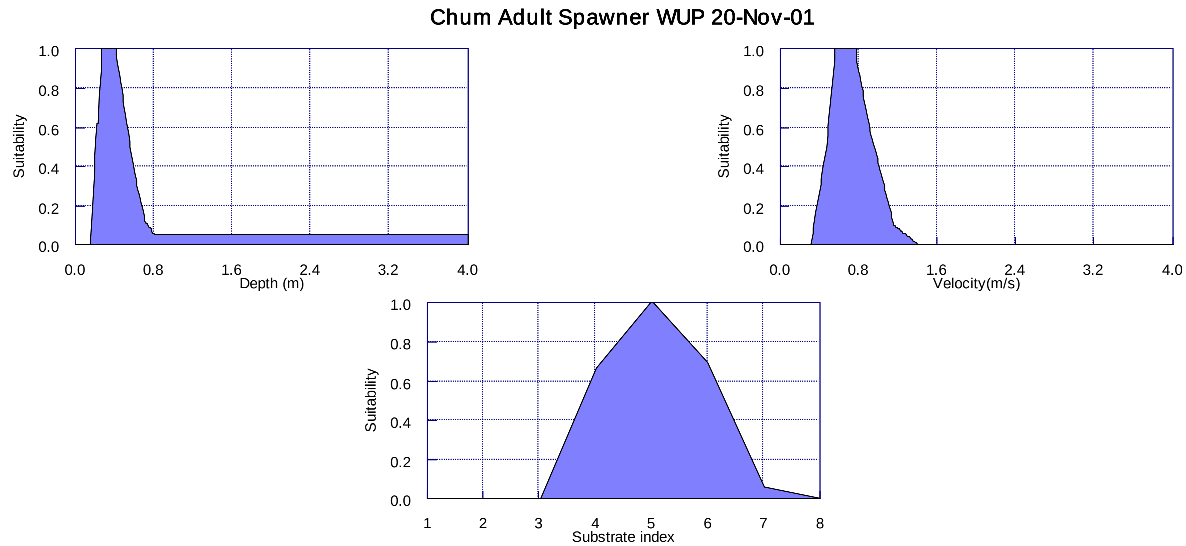
Appendix D. Habitat suitability indices for Steelhead – summer parr rearing.



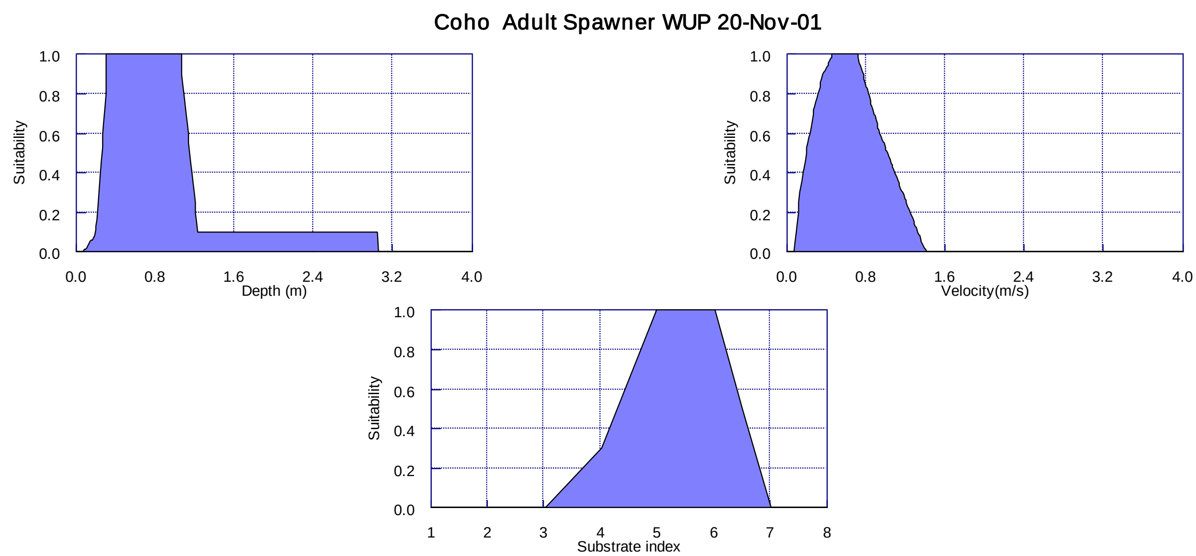
Appendix E. Habitat suitability indices for Coho – summer fry rearing.



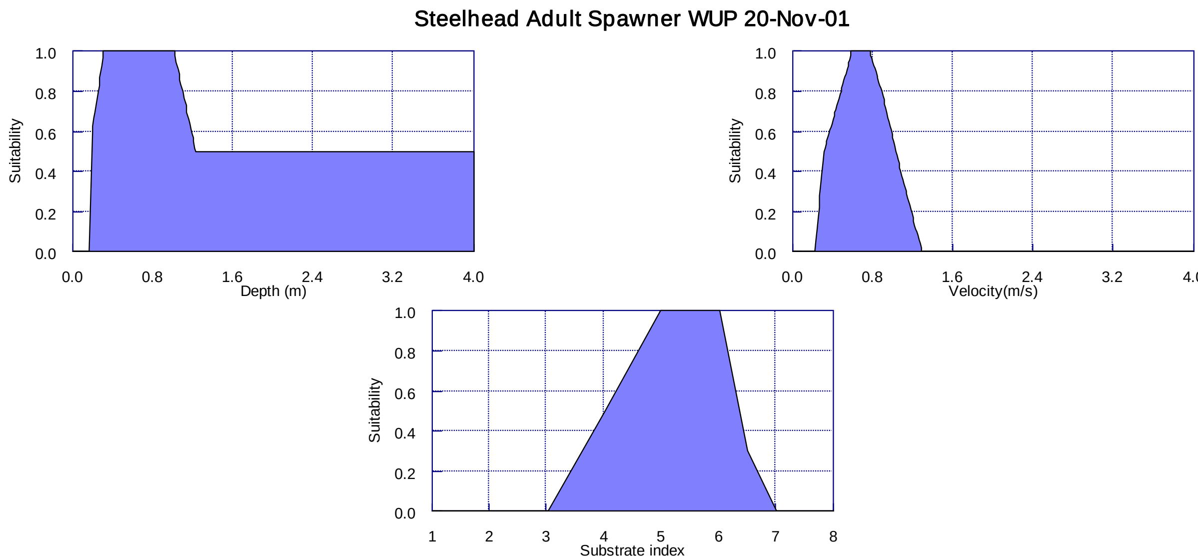
Appendix F. Habitat suitability indices for Chinook – adult spawner.



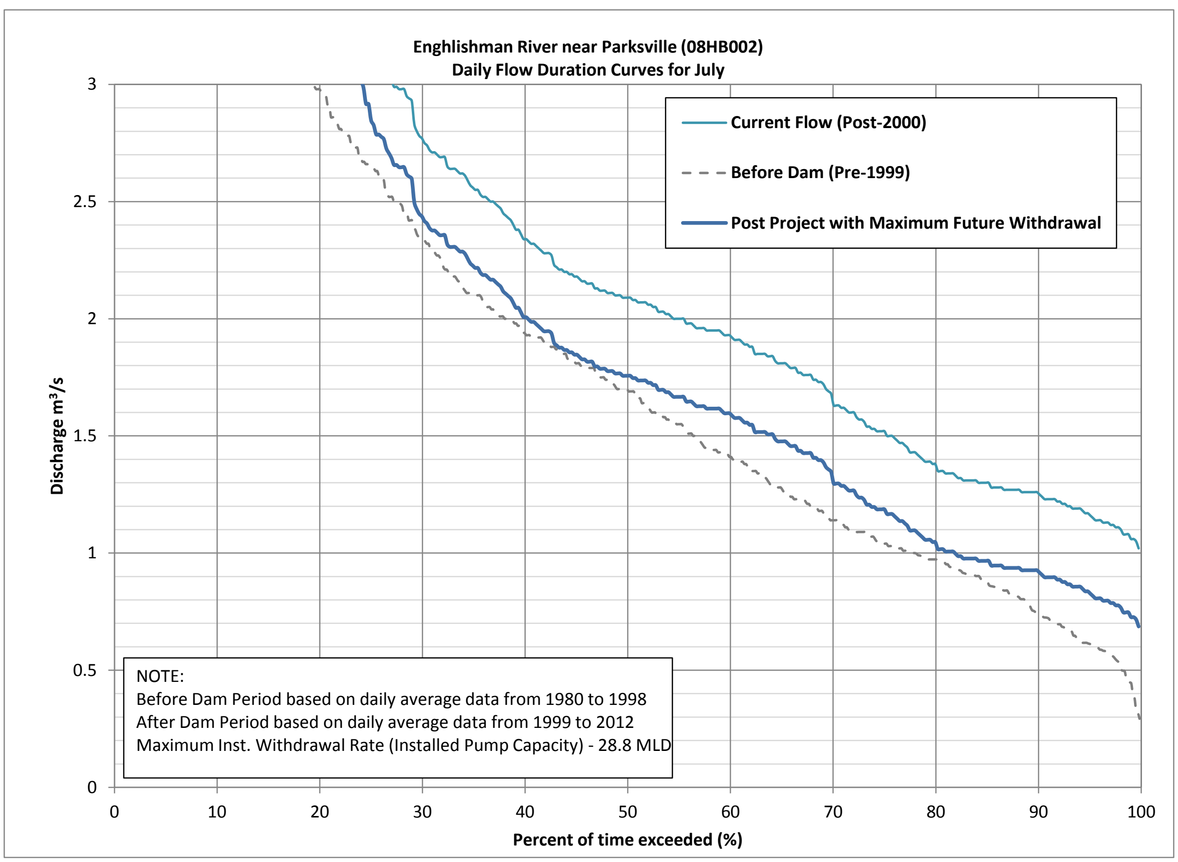
Appendix G. Habitat suitability indices for Chum – adult spawner.



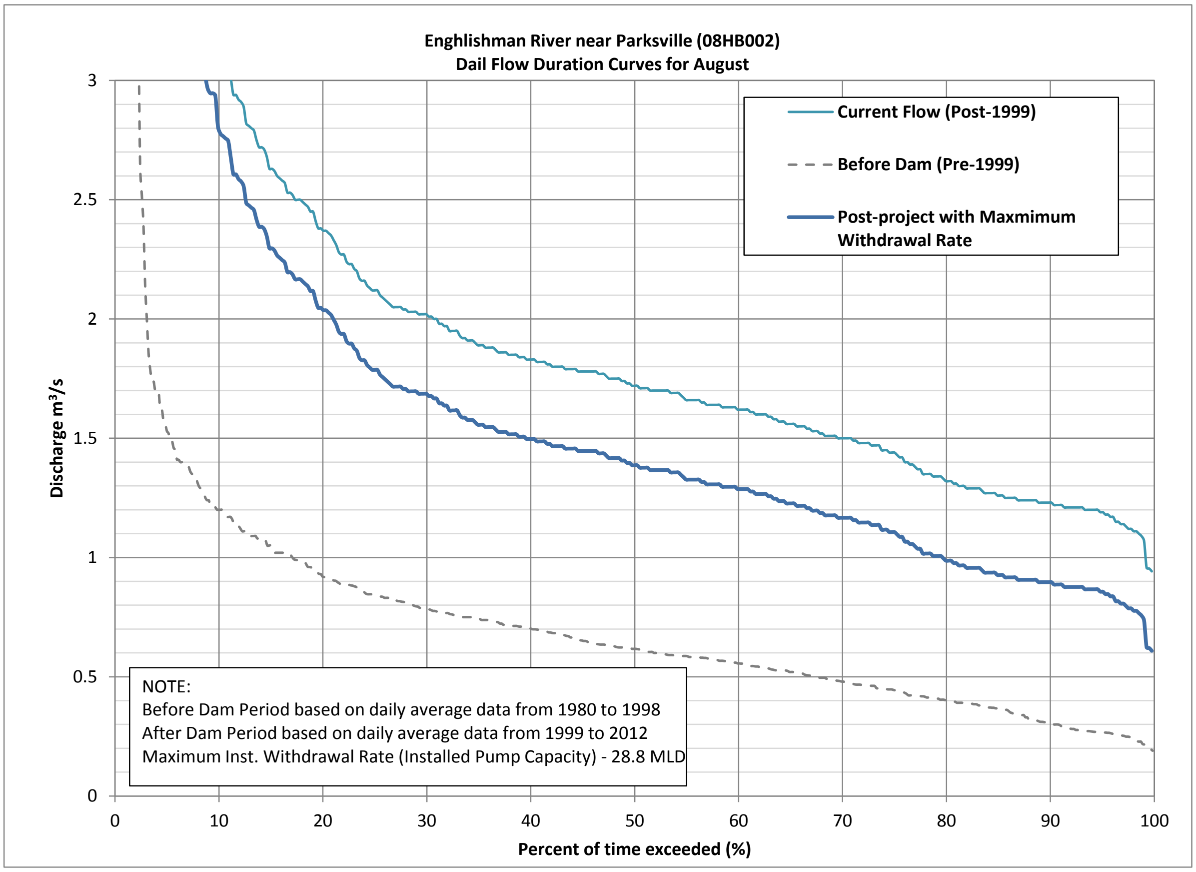
Appendix H. Habitat suitability indices for Coho – adult spawner.



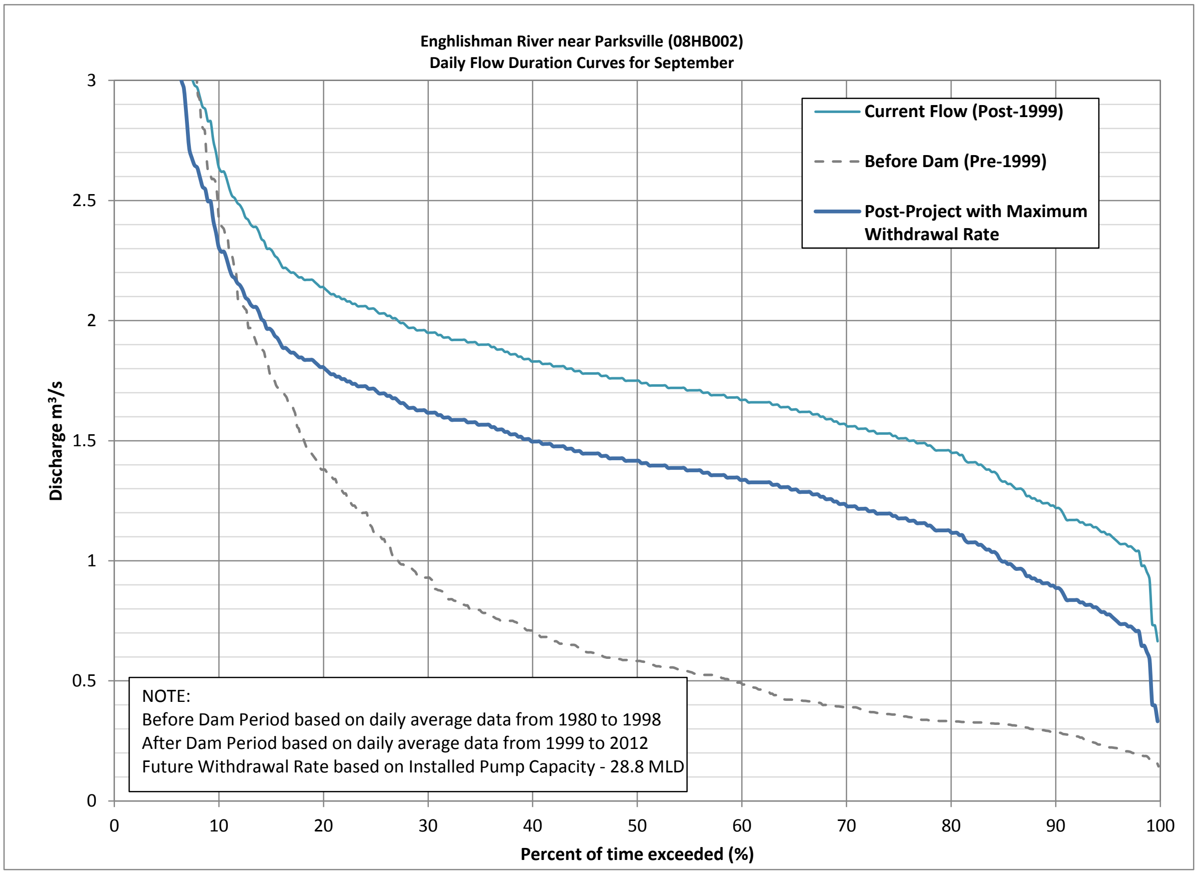
Appendix I. Habitat suitability indices for Steelhead – adult spawner.



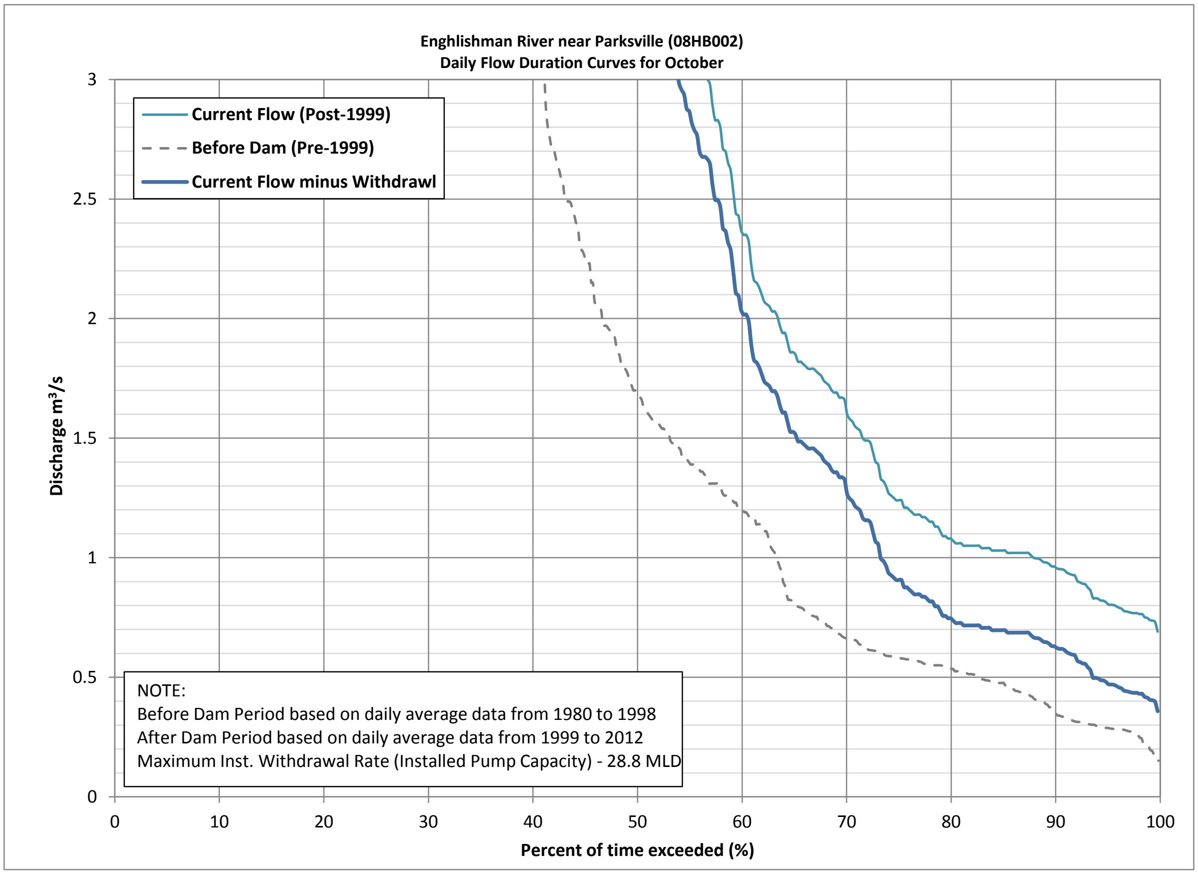
Appendix J. Exceedance curves for July showing flows under pre-dam, current and post-project conditions at the WSC gauging station.



Appendix K. Exceedance curves for August showing flows under pre-dam, current and post-project conditions at the WSC gauging station.



Appendix L. Exceedance curves for September showing flows under pre-dam, current and post-project conditions at the WSC gauging station.



Appendix M. Exceedance curves for October showing flows under pre-dam, current and post-project conditions at the WSC gauging station.

PHOTOS

Photo 1. Looking upstream at proposed water intake site on right bank of river.

Photo 2. Looking downstream from proposed water intake site.

Photo 3. Looking downstream at riffle habitat near Inland Island Highway crossing.

Photo 4. Looking downstream at riffle habitat downstream of Island Corridor Railway crossing.

Photo 5. Looking downstream at glide habitat downstream of Island Corridor Railway crossing.

Photo 6. Looking downstream at glide habitat near middle of survey section.

Photo 7. Looking downstream at pool habitat near middle of survey section.

Photo 8. Looking downstream at riffle habitat near middle of survey section.

Photo 9. Looking downstream at pool habitat immediately upstream of Island Highway 19A crossing.

Photo 10. Looking downstream at riffle habitat downstream of Island Highway 19A crossing.

Photo 11. Looking downstream at glide habitat in section below Island Highway 19A.

Photo 12. Looking upstream at riffle habitat near downstream end of survey section.