3.7 akɬxʷmina? - Shingle Creek

Shingle Creek flows from the west side of the basin into the Okanagan River, just south of Okanagan Lake at Penticton, B.C. The Shingle Creek watershed is approximately 299 km^2 and has one main tributary, Shatford Creek (Associated 2016). This project focused on two reaches of Shingle Creek, named Lower Shingle Creek and Upper Shingle Creek for the purpose of this study (Figure 3-13). Information regarding stream conditions and recommended EFNs in the two reaches is provided in sections 3.7.1 and 3.7.2 and general information about the stream is provided below. A summary of creek characteristics is found in Table 3-19 and stream-specific data is provided in Appendices B7.1 and B7.2.

Until 2015, the lowest barrier to fish migration was an irrigation dam 2 km from the mouth. Removal of the irrigation dam opened up over 30 km of stream habitat to migrating fish including anadromous salmon (Rivard-Sirois 2013). The Upper Shingle Creek tributary was also made available to anadromous salmon (Enns 2015), which has led to additional scrutiny of flow management practices in those reaches due to the high quality of habitat and wetlands upstream of the dam site (Lukey & Louie 2015). The stream currently supports populations of fluvial and adfluvial Rainbow, spawning Kokanee, and spawning Sockeye (Lukey & Louie 2015; Ernst & Vedan 2000). It is also possible that anadromous Steelhead utilize the stream. Shingle Creek once provided spawning habitat for Okanagan Spring Chinook (Rae 2005) but the species was previously extirpated from the system; however, returns from hatchery programs downstream have been observed to enter the creek in recent years (Mahony et al. 2019). The only nearby existing Okanagan Chinook population, Okanagan summer Chinook, which spawn in the mainstem, are designated as "Endangered" by COSEWIC (2017). There is a greater effort underway by ONA to re-build Okanagan Chinook populations.

At present there are 222 points of diversion within the watershed; however, the actual volume extracted is unknown (Associated 2019). The Penticton Indian Band is the main water supplier in the watershed (Associated 2016). Water storage for licences is held in Brent and Farleigh Lakes (Associated 2016). In 1969, Shingle Creek was designated as having a possible water shortage for water licensing purposes (FLNRORD 2016).

Table 3-19: Shingle Creek description (Upper and Lower)

Drainage Area	299 km^2 (Lower) & 118.4 km^2 (Upper)
Median Elevation	1273 m
WSC station	08NM037 (Active) – Shatford Creek near Penticton (1919-present) 08NM038 (Historic) – Shingle Cr above Kaledon Div. (1920-1977) 08NM070 (Historic) – Riddle Creek near W. Summerland (1930-1931) 08NM150 (Historic) – Single Creek at the Mouth (1969-1981)
ONA station	08NM706 – Lower Shingle Creek PIT Array (2015-2018) 08NM170 – Upper Shingle Gabriel Field (2016-2018)
LTMAD	Lower 0.641 m^3/s (Associated 2019) Upper 0.272 m^3/s (Associated 2019)
Fish species expected	Rainbow, Kokanee, Eastern Brook Trout, Mountain Whitefish, Largescale Sucker, Longnose Dace, Prickly Sculpin, Peamouth Chub (ESSA & Solander, 2009). Steelhead, Spring Chinook, Summer Chinook, Sockeye (Ernst & Vedan 2000)
Land use	Forestry, agriculture (Associated 2016). Most of Shingle Creek is on the Penticton India Band reserve except for the upper most reaches and the Shatford tributary

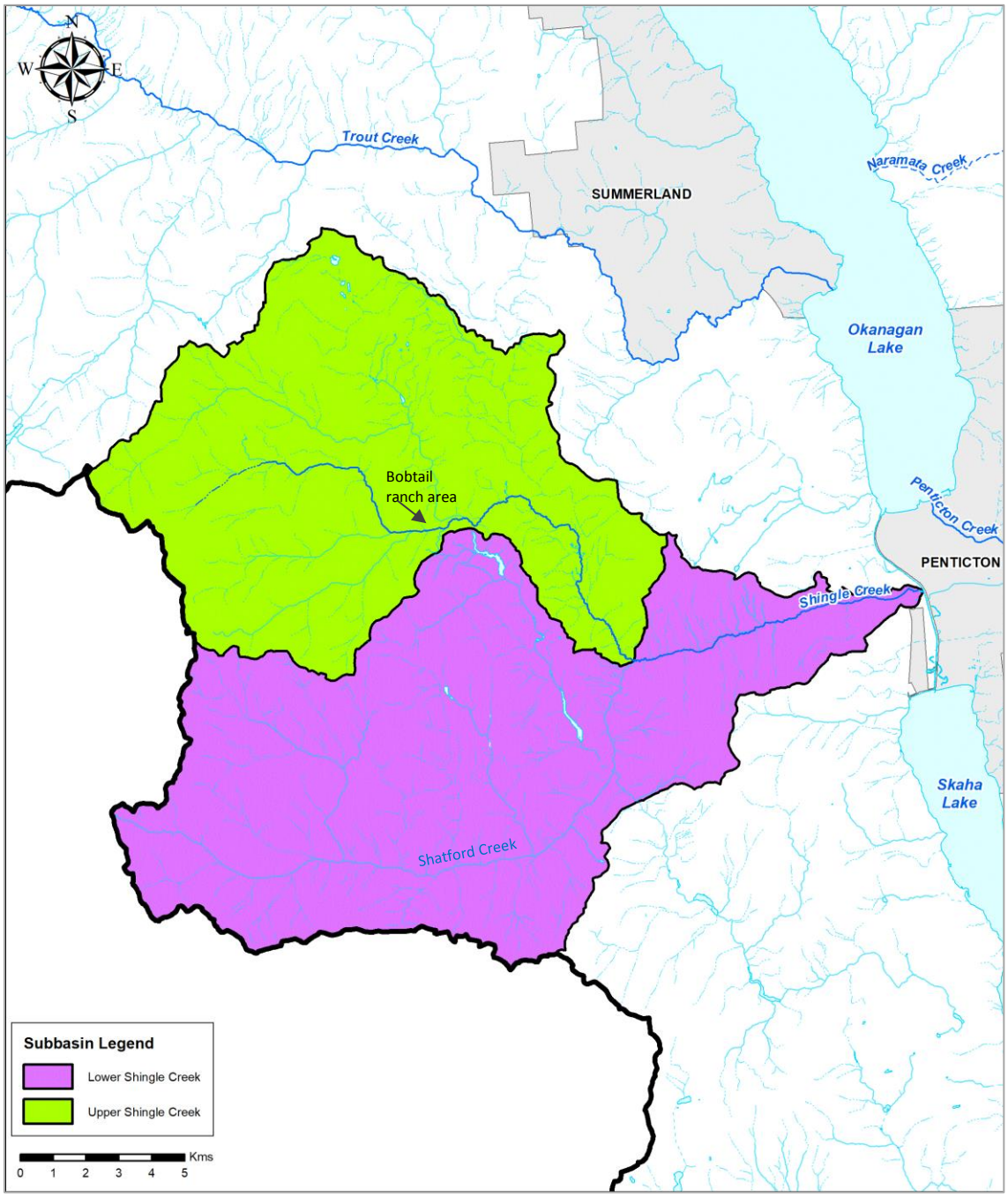


Figure 3-13: Upper and lower reaches of Shingle Creek

3.7.1 Lower Shingle Creek

The Lower Shingle Creek reach is 10.8 km long, extending from its confluence with Shatford Creek to the mouth at the Okanagan River. Most of the water volume in Lower Shingle Creek originates from Shatford Creek. The lowest reach of Shingle Creek has been subjected to rural and industrial encroachment and considerable hydro-modification and riparian function impairment. Downstream of an old irrigation dam, Shingle Creek has been straightened with corresponding intermittent makeshift diking and bank armouring especially adjacent to bridges. Modifications to the streambanks reduce the creek's ability to interact with riparian areas, and riparian vegetation has been reduced to tree cover with some light shrub cover in some areas. There is a subsequent deficiency of large woody debris. The width of the riparian areas is typically limited to a narrow strip of trees with yards and roads directly adjacent. The lowest sections of Shingle Creek are highly entrenched in areas subject to bank erosion. Industrial encroachment includes a storage yard, gravel storage yard, gas station, and the ONA Fish Hatchery. Shingle Creek flows over an alluvial fan in this reach before its confluence with the Okanagan River. Paired streamflow measurements indicate streamflow gains from groundwater on the fan.

Two riffle and two glide transects were installed in the lowest 1 km of the stream downstream of the removed irrigation dam in August 2016. One hydrometric station was installed in this reach. The station was subsequently washed out during the 2017 freshet and data provided in this report is from the ONA hydrometric station at the removed irrigation dam 2 km from the mouth (station is operated by the Okanagan Basin Monitoring and Evaluation Program [OBMEP]). Lower Shingle Creek is 'flow sensitive' during summer and winter as naturalized flows are below 20% LTMAD (Table 3-20). Naturalized flow data were provided by Associated (2019) with an estimated data quality rating of B (data error between 10% and 25%); residual and maximum licensed flow data were not available at the time of reporting.

Okanagan Tennant EFNs for Lower Shingle Creek were developed in accordance with the methods outlined in Section 2.2. Fish periodicity and flow standards described in Table 2-2 to Table 2-6 were used. Weekly Okanagan Tennant EFNs were set to the lower of the naturalized flow or flow standard. WUW information from the study transects was then reviewed to determine whether final EFN recommendations needed adjustment from the Okanagan Tennant EFN. A summary of EFNs for Lower Shingle Creek is provided in Table 3-21 including the median EFN and the range of weekly EFNs, with weekly details in Figure 3-14, Figure 3-15 and Appendix B7.1 and flow sensitives in Table 3-20. Critical flows were calculated as described in Section 2.4. Further information regarding EFN and critical flow setting in Lower Shingle Creek is provided at the end of this section.

Table 3-20: Flow sensitivities in Lower Shingle Creek

Species & life stage	1-in-2 yr 30-day summer low flow		1-in-2 yr 30-day winter low flow	
	Flow (m^3/s)	% LTMAD	Flow (m^3/s)	% LTMAD
O. mykiss & Chinook rearing	0.110	17%		
Insect production				
Kokanee & Chinook spawning				
O. mykiss & Chinook overwintering			0.063	10%
Kokanee, Sockeye & Chinook egg incubation				

Source: Associated (2019)

Table 3-21: EFN summary table for Lower Shingle Creek

Species & life stage	Time period	Okanagan Tennant EFN		WUW EFN (m^3/s)	Recommended EFN (m^3/s)				Critical flow	
		Median (m^3/s)	% of LTMAD		Median	% of LTMAD	Min	Max	Flow (m^3/s)	% of LTMAD
O. mykiss parr, Chinook fry & insect production[a]	April 1- Oct 31	0.128	20%	0.128	0.128	20%	0.098	0.629	0.053	8%
Steelhead spawning	April 1 – June 25	0.702	110%	1.12	1.12	174%	0.094	3.87	0.493	77%
Rainbow spawning	May 20 – July 10	1.12	174%	1.12	1.12	174%	0.893	3.87	0.493	77%
Chinook migration	July 1 – Sep 17	0.321	50%	x	0.321	50%	0.144	1.12	0.321[b]	50%
Chinook spawning	Aug 27 – Sep 30	0.125	19%	0.125	0.125	19%	0.098	0.184	0.125[c]	19%
Kokanee spawning	Sep 25 – Nov 1	0.127	20%	0.128	0.127	20%	0.098	0.128	0.064	10%
Sockeye spawning	Sep 16 – Oct 31	0.126	20%	0.128	0.126	20%	0.098	0.128	0.064	10%
Overwintering salmonids	Nov 1 - March 31	0.073	11%	x	0.073	11%	0.064	0.115	0.053	8%

a while EFNs apply to the entire period, median values are presented for the summer low flow period from Jul 15-Sept 30.
b median for the migration period
c median for the spawning period

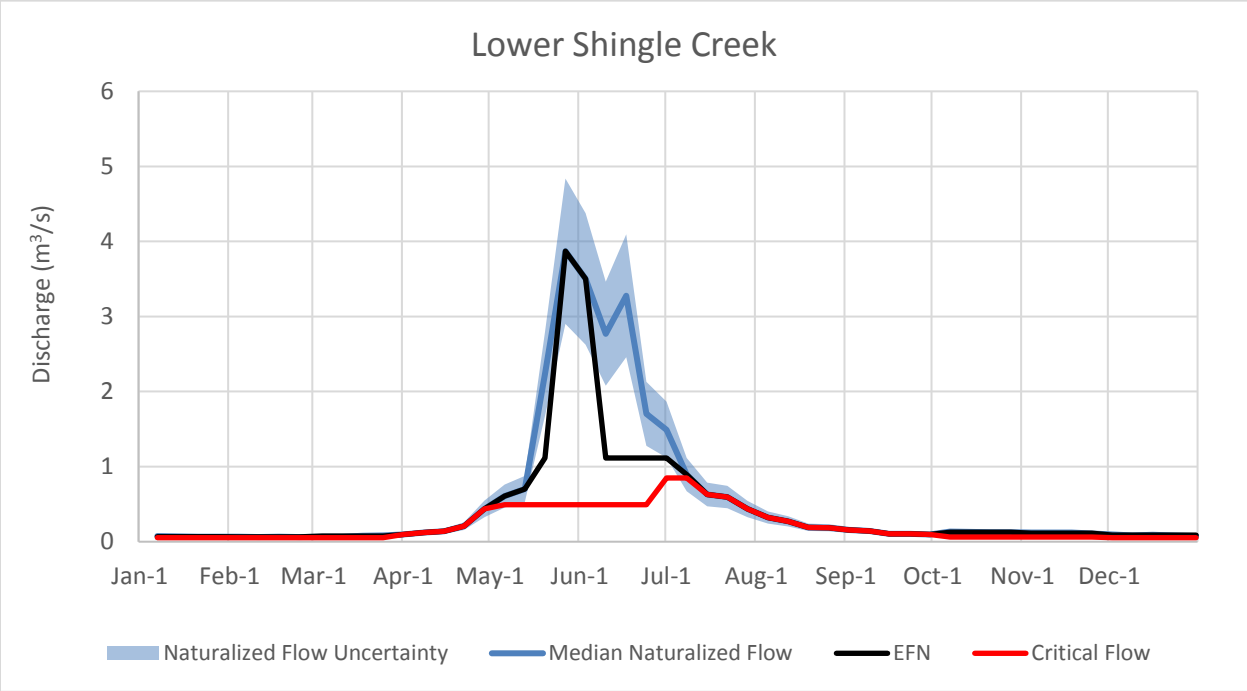


Figure 3-14: Weekly EFNs, critical flow and streamflows in Lower Shingle Creek

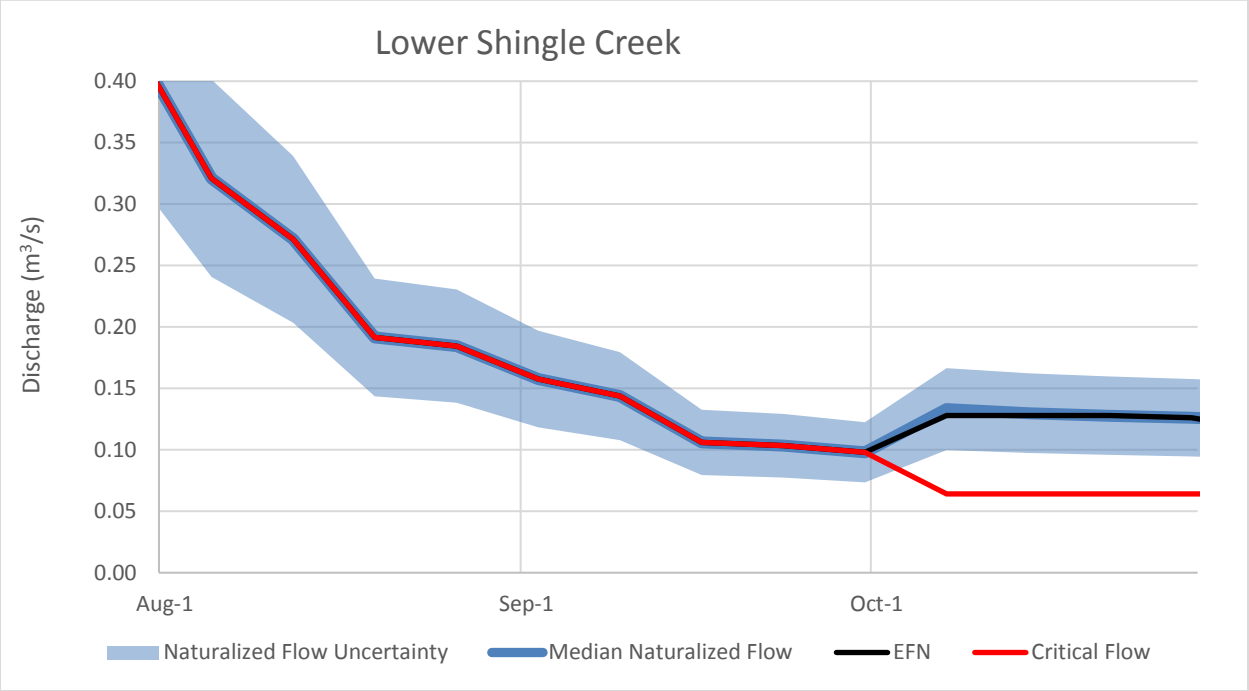


Figure 3-15: Weekly EFNs, critical flow and streamflows during the summer and fall period in Lower Shingle Creek

O. Mykiss parr and Chinook fry rearing

The recommended EFN for Steelhead and Rainbow (*O. mykiss*) parr and Chinook fry rearing is 0.128 m^3/s, which is equivalent to the flow standard of 20% (Table 3-21). The recommended EFN maintains approximately 50% of maximum WUW for *O. mykiss* parr rearing (Figure B7-6, Appendix B7.1) and 60% for Chinook fry rearing (Figure B7-7, Appendix B7.1), as well as 28% of maximum insect production WUW (Figure B7-8, Appendix B7.1). Previously recommended EFNs for Lower Shingle Creek range from 0.11 m^3/s (Koshinsky 1972b) to 0.25-0.6 m^3/s (ESSA & Solander 2009). Photos of habitat conditions in Lower Shingle Creek at the recommended EFN flows are provided in Plate 3-13.

Median naturalized flows for the summer and fall period (mid-July to late September, 0.188 m^3/s) are above the recommended EFN, with weekly flows greater than the EFN except from mid- to late September when they are approximately 0.1 m^3/s. Residual flows recorded at the ONA hydrometric station were frequently at or above the recommended EFN in late summer of 2018 and below it for a brief period in early September 2016 (Figure B7-3, Appendix B7.1). Limited historical residual streamflow data from 1969-1972 and 1978-1981 (WSC 08NM150, Shingle Creek near the Mouth; Figure B7-4, Appendix B7.1) demonstrate that the reaches near the mouth frequently went dry from early August to late October. Abrupt fluctuations in the record suggest that this was related to water storage and diversion activities rather than natural causes.

Water temperatures in Lower Shingle Creek recorded at the hydrometric station were generally favourable to *O. mykiss* and Chinook rearing, except in late July when they were at the upper range of suitable rearing temperatures (20°C) (Figure B7-5, Appendix B7.1). Given the presence of a species of concern (spring Chinook), maintaining sufficient flows is vital to maintain favourable thermal conditions

in this creek though flow thresholds for temperature maintenance were not formally studied under this project.

The recommended critical flow for *O. mykiss* parr and Chinook fry rearing is 0.053 m^3/s (8% LTMAD, Table B7-2, Appendix B7.1) based on the riffle width criterion (Table 2-7) applied to the lowermost riffle. It is approximately equal to the Summer 1 in 10-year return period 30-Day naturalized low flow (Table B7-3, Appendix B7.1).

Steelhead and Rainbow spawning

The recommended EFN for Steelhead and Rainbow spawning is 1.12 m^3/s (174% LTMAD, Table 3-21, Figure B7-9 and B7-10, Appendix B7.1), which is equivalent to the Okanagan Tennant EFN. This EFN maintains near maximum spawning WUW (>90% for both) while also maximizing *O. mykiss* parr and Chinook fry rearing WUW during the freshet period, and maintains high insect production from riffles. ESSA & Solander (2009) previously recommended an EFN of 0.4-1.9 m^3/s during the Steelhead spawning period and an EFN of 1.5-1.9 m^3/s during the Rainbow spawning period. Photos of habitat conditions in Lower Shingle Creek at the recommended EFN flows are provided in Plate 3-14.

Flows greater than the recommended EFN are observed under naturalized flows for a substantial portion of the freshet season (mid-May to early July), and have been recorded at the ONA hydrometric station from mid-April to late June (Figure B7-3, Appendix B7.1), and thus EFNs are considered achievable.

The recommended critical flow for Steelhead and Rainbow spawning is 0.493 m^3/s (77% LTMAD) from May to early July based on the passage depth criterion (Table 2-7). Prior to this period, critical flows are defaulted to the lower naturalized median weekly flows (Table B7-2, Appendix B7.1).

Spring Chinook spawning

Low numbers of spring Chinook have been observed to enter and spawn in the creek in recent years (Mahony et al. 2019). Flows needed to ensure good conditions for Chinook spawning, and particularly migration, likely exceed naturally available flows at times and as a result it is recommended that EFNs during the Chinook migration and spawning period are set to the weekly naturalized flow estimates. The median naturalized flow during the Chinook spawning period is 0.125 m^3/s (19% LTMAD), which provides approximately 23% of maximum spawning WUW (Table 3-21, Figure B7-11, Appendix B7.1). ESSA & Solander (2009) previously recommended an EFN of 0.3 m^3/s during the Chinook spawning period. Photos of habitat conditions in Lower Shingle Creek at the recommended EFN flows are provided in Plate 3-13.

While appropriate spawning WUW is maintained under relatively low flows (e.g. ~45% at 0.25 m^3/s), riffle passage conditions for Chinook are of concern. Riffle analysis indicates that 0.849 m^3/s (138% LTMAD) would be required to sustain safe riffle passage for Chinook (Table B7-1, Appendix B7.1). These conditions are met under naturalized flow conditions at the end of freshet in early July, which is the typical timing of spring Chinook migration into other streams in Washington State (CCT 2004; Snow et al. 2018; PTAGIS 2018). The 10% LTMAD (0.06 m^3/s) typically used by FLNRORD as a critical flow for Chinook spawning would result in <10% spawning WUW and likely total inability for Chinook to pass riffles because average depths would be approximately 5 cm. It is thus recommended to set critical flows in Shingle Creek at naturalized flows to protect the spring Chinook population. Further, protecting natural flows during rainfall driven flow pulses in the migration period is likely vital to enable spawner access.

Recently recorded flow data from the mouth indicates that EFNs and critical flows are frequently not met and that low flows likely limit Chinook migration and spawning during some years (Figure B7-3, Appendix B7.1), which matches field observations of Chinook spawners during low flows. Residual flow data estimates from Associated (2019) were not available but would be useful to illustrate the impact of water use on fish populations in Shingle Creek. Historical discharge data shows dry periods near the mouth during Chinook spawning and migration (Figure B7-4, Appendix B7.1).

Water temperatures in Lower Shingle Creek during the Chinook migration and spawning season reached thermal tolerance limits (20–22°C, Keefer et al. 2018) in July and August (Figure B7-5, Appendix B7.1). Any water use during mid-July to late September will have serious consequences for Chinook migration and spawning conditions in the creek. Maintaining EFNs and critical flows at naturalized flows until spawning has ended will protect Chinook that have entered Lower Shingle Creek and provide the best chance for successful spawning. Flows higher than the recommended EFN should be strongly encouraged to improve migration and spawning conditions.

Sockeye and Kokanee spawning

Sockeye and Kokanee spawn in Lower Shingle Creek from mid-September to late October. The median naturalized weekly flow during the spawning period is 0.127 m^3/s; however, the recommended EFN is 0.128 m^3/s, equal to the flow standard for Kokanee (20% LTMAD) as well as the summer juvenile rearing EFN (Table 3-21, Figure B7-12 and B7-13, Appendix B7.1). The recommended EFN maintains 50% of maximum Kokanee spawning WUW. The flow standard for Sockeye (40% LTMAD) is greater than naturalized flows and the recommended EFN, but adequate (~45%) spawning WUW for Sockeye is maintained at the recommended EFN. However, riffle passage conditions are of concern. Riffle analysis indicates that 0.173 m^3/s (27% LTMAD) would be required to sustain safe riffle passage for Kokanee and for Sockeye would be 0.493 m^3/s (77% LTMMAD) (Table B7-1, Appendix B7.1). These flows are greater than estimated naturalized flows during the spawning season and rain events are likely of very high importance to allow for movement between successive glides during the spawning period. Thus, the recommended critical flow for Sockeye and Kokanee spawning is 0.064 m^3/s (10% LTMAD, Table B7-2, Appendix B7.1) based on the %LTMAD criterion (Table 2-7). Previously recommended EFNs for the Sockeye and Kokanee spawning period were 0.20-0.23 m^3/s (Koshinsky 1972b) and 0.3 m^3/s (ESSA & Solander 2009). Photos of habitat conditions in Lower Shingle Creek at the recommended EFN flows are provided in Plate 3-13.

Residual flows recorded during the spawning season at the ONA hydrometric station between 2016 and 2018 were generally above the recommended EFN (up to 0.481 m^3/s, Figure B7-3, Appendix B7.1), indicating that the EFN can be met under current water use conditions. However, decreases in flow below the EFN did occur and flow conditions should be closely monitored during the spawning season. Flows greater than the EFN lead to relatively rapid gains in Kokanee and Sockeye spawning WUW and improved riffle passage conditions, and should be encouraged where possible.

Plate 3-13: Lower Shingle Creek habitat conditions at flows near the recommended *O. Mykiss* parr and Chinook fry rearing EFNs and Kokanee and Sockeye spawning EFNs (0.128 m^3/s), and median Chinook spawning EFNs (0.125 m^3/s)

SHG20GL at 0.145 m^3/s (23% LTMAD)

SHG40GL at 0.154 m^3/s (24% LTMAD)

SHG10SCR at 0.120 m^3/s (19% LTMAD)

SHG30SCR at 0.145 m^3/s (23% LTMAD)

Plate 3-14: Lower Shingle Creek habitat conditions at flows near the recommended Rainbow and Steelhead spawning EFNs (1.12 m^3/s)

SHG40GL at 1.02 m^3/s (160% LTMAD)

SHG20GL at 1.07 m^3/s (168% LTMAD)

3.7.2 Upper Shingle Creek

The Upper Shingle Creek reach is 12.74 km long, extending from Bobtail Ranch down to the confluence of Upper Shingle Creek and Shatford Creek. This section of the creek has not been straightened or armoured but has some agricultural encroachment with minimal hydromodification and riparian function impairment. The stream is able to flood its banks regularly and interact with the riparian areas, and riparian vegetation is a complex of large trees, shrubs, and herb layers with subsequent large woody debris. The riparian area is wide in most sections except for some localized sections of canyon and agricultural encroachment. An extensive area of wetlands providing prime fish rearing habitat is located at the downstream end of this reach near the confluence with Shatford creek. The dewatering of Upper Shingle Creek above the wetland and below a known irrigation intake has been observed during several years and is an issue considering the high quality of habitat in this reach.

Very large *O. mykiss* have been observed to spawn in Upper Shingle Creek (OBMEP 2016-2019). There is no recent record of Chinook spawning in Upper Shingle Creek though spawning has been noted by Okanagan Knowledge Keepers historically near the confluence with Shatford Creek. Therefore, spring Chinook fry use in Upper Shingle is highly likely due to nearby spawning and suitable habitat. Upper Shingle Creek occurs at an elevation that is higher than the other creeks. As a result, winter breakup starts later and therefore the periodicity of migration and spawning for Steelhead have been altered to coincide with a natural increase in flows at the beginning of freshet (Table 2-2).

Two riffle, 2 glide and 1 pool tailout transects were installed in a 1 km section starting 7.19 km upstream from the Upper Shingle and Shatford confluence. During previous habitat surveys (OBMEP 2016-2019), this section of Upper Shingle Creek was observed to go dry frequently in summer months and there are a number of large water extraction points upstream. One hydrometric station was previously installed by ONA in this reach through the OBMEP program. Naturally, Upper Shingle Creek is 'flow sensitive' during summer and winter as naturalized flows are below 20% LTMAD (Table 3-22).

Naturalized flow data were provided by Associated (2019) with an estimated data quality rating of B (data error between 10% and 25%); residual and maximum licensed flow data were not available at the time of reporting. Okanagan Tennant EFNs for Upper Shingle Creek were developed in accordance with the methods outlined in Section 2.2. Fish periodicity and flow standards described in Table 2-2 to Table 2-6 were used. Weekly Okanagan Tennant EFNs were set to the lower of the naturalized flow or flow standard. Available WUW at the flow standards was often relatively low; thus, WUW information from the study transects was used to adjust the recommended EFN upward to match median naturalized flows. A summary of EFNs for Upper Shingle Creek is provided in Table 3-23 including the median EFN and the range of weekly EFNs, with weekly details in Figure 3-16, Figure 3-17 and Appendix B7.2, and flow sensitivities in Table 3-22. Critical flows were calculated as described in Section 2.4. Further information regarding EFN and critical flow setting in Upper Shingle Creek is provided at the end of this section.

Table 3-22: Flow sensitivities in Upper Shingle Creek

Species & life stage	1-in-2 yr 30-day summer low flow		1-in-2 yr 30-day winter low flow	
	Flow (m^3/s)	% LTMAD	Flow (m^3/s)	% LTMAD
O. mykiss & Chinook rearing	0.036	13%		
Insect production				
Chinook spawning				
O. mykiss & Chinook overwintering			0.020	7%
Chinook egg incubation				

Source: Associated (2019)

Table 3-23: EFN summary table for Upper Shingle Creek

Species & life stage	Time period	Okanagan Tennant EFN		WUW EFN (m^3/s)	Recommended EFN (m^3/s)				Critical flow	
		Median (m^3/s)	% LTMAD		Median	% LTMAD	Min	Max	Flow (m^3/s)	% LTMAD
O. Mykiss parr & Chinook Fry rearing, insect production [a]	April 1 – Oct 31	0.054	20%	0.064	0.064	24%	0.032	0.240	0.020	7%
Steelhead spawning	April 16 – Jun 25	0.641	236%	0.900	0.900	331%	0.074	1.74	0.306	113%
Rainbow spawning	May 20 – Jul 10	0.641	236%	0.900	0.900	331%	0.352	1.74	0.306	113%
Chinook migration	July 1 – Aug 26	0.115	42%	n/a	0.115	42%	0.048	0.613	0.054	20%
Chinook spawning	Aug 27 – Sep 30	0.041	15%	0.063	0.041	15%	0.032	0.063	0.027	10%
Overwintering salmonids	Nov 1 - March 31	0.023	9%	n/a	0.023	9%	0.021	0.038	0.020	7%

a while EFNs apply to the entire period, median values are presented for the summer low flow period from Jul 15-Sept 30.

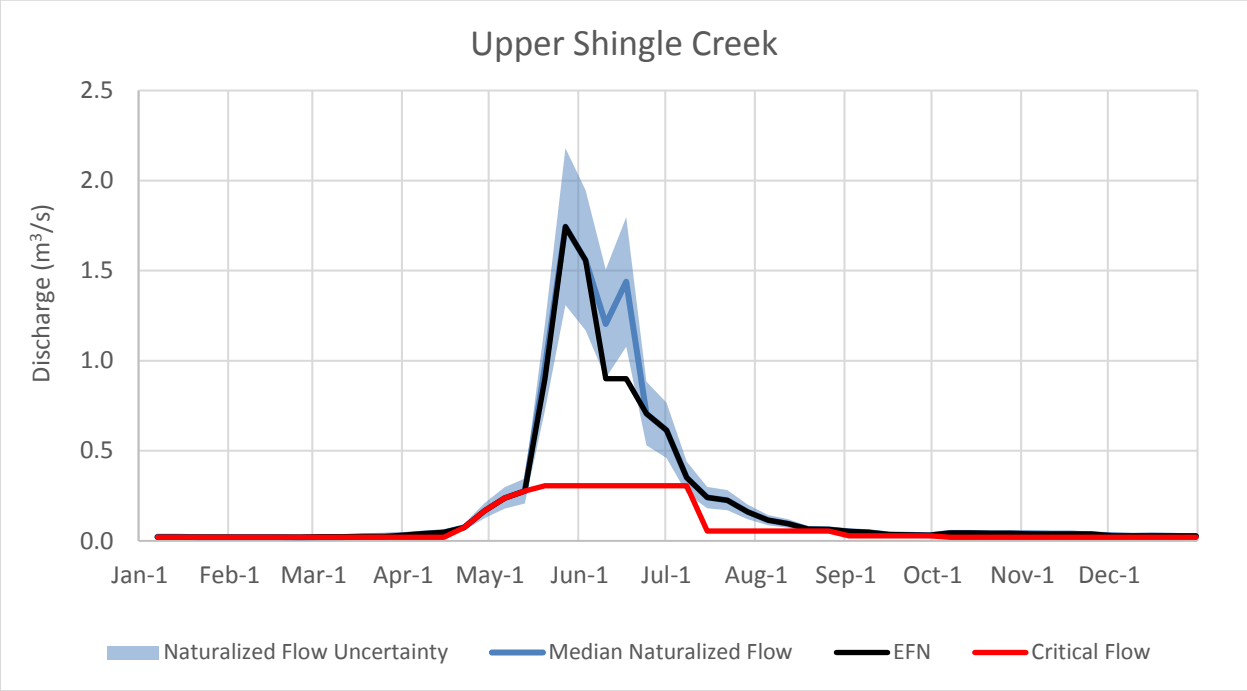


Figure 3-16: Weekly EFNs, critical flow and streamflows in Upper Shingle Creek

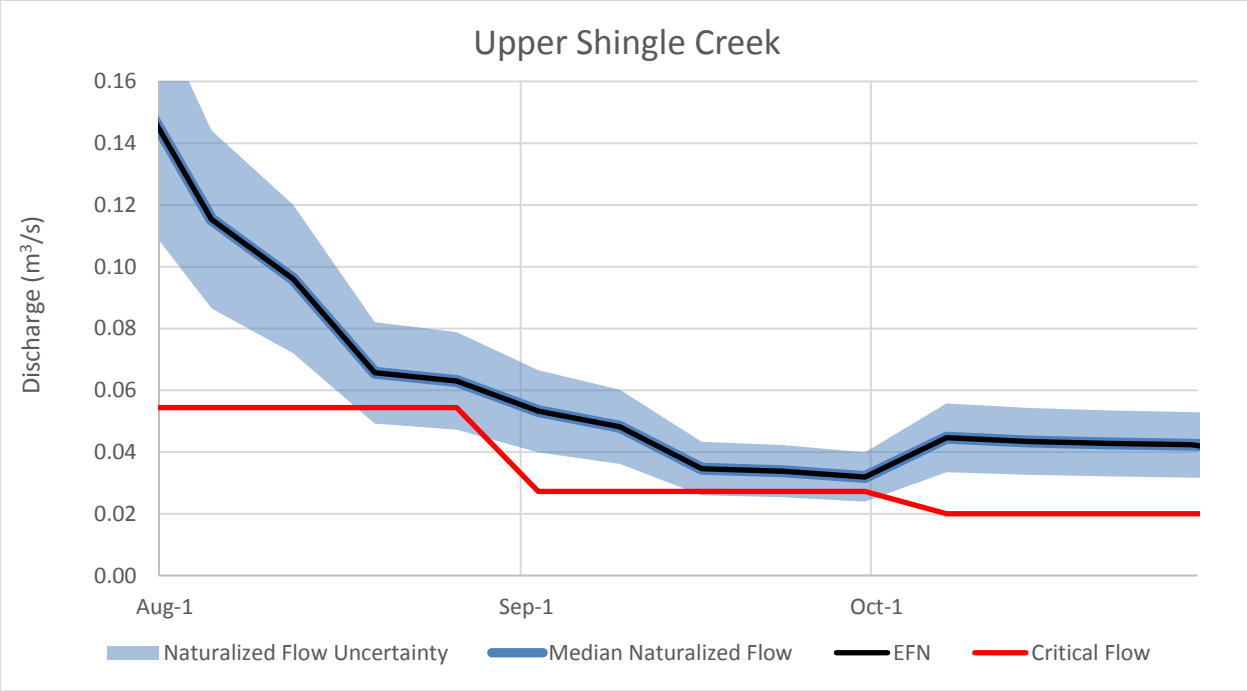


Figure 3-17: Weekly EFNs, critical flow and streamflows during the summer and fall period in Upper Shingle Creek.

O. Mykiss parr and Chinook fry rearing

The recommended EFN for Steelhead and Rainbow (*O. mykiss*) parr and Chinook fry rearing is 0.064 m^3/s (24% LTMAD), which is equal to the median naturalized flow during the summer low flow period (mid-July to late September) and slightly greater than the flow standard of 20% LTMAD. The recommended EFN maintains approximately 25% of maximum WUW for *O. mykiss* parr rearing and 35% for Chinook fry rearing (Figure B7-18 and B7-19, Appendix B7.2). Insect production under these flows is somewhat marginal at 8% of maximum WUW (Figure B7-20, Appendix B7.2). The steeply increasing WUW curves indicate that rearing conditions improve rapidly at flows above the recommended EFN during wetter years. Photos of habitat conditions in Upper Shingle Creek at the recommended EFN flows are provided in Plate 3-15. The recommended critical flow for *O. mykiss* parr and Chinook fry rearing is 0.020 m^3/s (7% LTMAD, Table B7-5, Appendix B7.2) based on the riffle width criterion (Table 2-7).

Naturalized flows approach critical flows in early September. Measured residual flows were above the recommended EFN until mid-July when a sudden drop to zero flow was observed during 2017 and 2018, suspected to be the result of known water withdrawals upstream of the station (Figure B7-16 Appendix B7.2). Water temperatures in Upper Shingle Creek recorded at the hydrometric station were generally favorable to *O. mykiss* and Chinook rearing though they approached the upper range of suitable rearing temperatures (20°C) in mid-July and slightly exceeded it in August (21°C) during 2016 when the creek remained wetted (Figure B7-17, Appendix B7.2).

Rainbow and Steelhead spawning

The recommended EFN for Steelhead spawning and Rainbow spawning is 0.900 m^3/s (330% LTMAD). This maintains spawning WUW near 80-85% for both and is slightly above the median naturalized flows during the Steelhead spawning period (Figure B7-22, Appendix B7.2) and slightly below the median naturalized flows for Rainbow spawning (Figure B7-23, Appendix B7.2). The WUW EFN is greater than the Okanagan Tennant EFN (236% LTMAD). The recommended EFN maximizes *O. mykiss* parr rearing and maintains high Chinook fry rearing WUW (>85%) during the freshet period, and maintains high insect production from riffles. Flows greater than the recommended EFN are observed under naturalized flows from mid-May to mid-June; similar flow rates were recorded at the hydrometric station from early May to mid-June (Figure B7-16, Appendix B7.2), and the recommended EFNs are thus considered achievable. Photos of habitat conditions in Upper Shingle Creek at the recommended EFN flows are provided in Plate 3-16.

The recommended critical flow for Rainbow and Steelhead spawning is 0.306 m^3/s (113% LTMAD) from late May to early July, based on the minimum passage depth criterion (Table 2-7) at one of the two riffle transects (the other riffle produced minimum passage flows near the EFN and naturalized flows and was excluded from analysis). Prior to this period (late April – mid May), critical flows are defaulted to the lower naturalized median weekly flows (Table B7-6, Appendix B7.2).

Chinook spawning

Spring Chinook spawning habitat conditions in Upper Shingle Creek are naturally constrained by summer low flows. If suitable conditions are to be maintained for spring Chinook spawning, it is recommended that EFNs during the migration and spawning period are set to naturalized flows. Median naturalized flows during the spawning period are 0.043 m^3/s (15% LTMAD). At these flows, <5% spawning WUW remains (Figure B7-23, Appendix B7.2) and riffle passage for Chinook is likely not possible. The ability of spring Chinook to successfully spawn in this reach is likely limited to wet years with flows greater than 0.15 m^3/s during the spawning period. Any water use during mid-July to late September will have serious consequences for Chinook migration and spawning conditions in the creek. The recommended critical

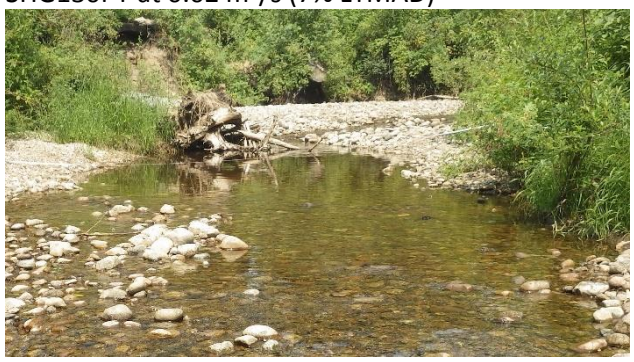
flow for Chinook is 0.054 m^3/s (20% LTMAD) for migration and 0.027 m^3/s for spawning (10% LTMAD; Table B7-6, Appendix B7.2) based on the LTMAD criteria (Table 2-7), though riffle passage at those flows is not likely possible. Photos of habitat conditions in Upper Shingle Creek at the recommended EFN flows are provided in Plate 3-15.

Residual flows recorded at the ONA hydrometric station were above the recommended EFN until mid-July when they suddenly dropped to zero flows during 2017 and 2018, likely the result of known water withdrawals upstream of the station (Figure B7-16, Appendix B7.2). Meeting the EFN for Chinook spawning in Upper Shingle Creek is likely problematic because of naturally low flows and water diversions.

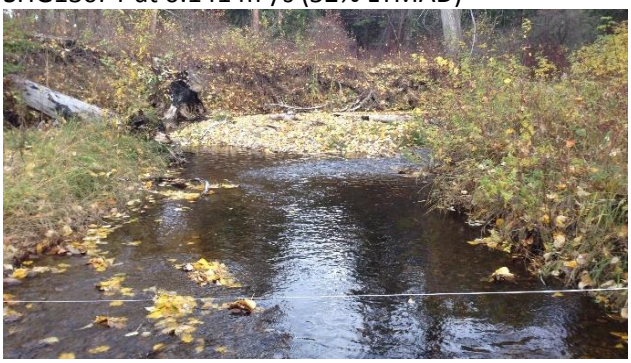
Plate 3-15: Upper Shingle Creek habitat conditions at flows near the recommended *O. mykiss* parr and Chinook fry rearing EFNs (0.064 m^3/s) as well as Chinook spawning EFNs (0.063 m^3/s)

SHG130PT at 0.02 m^3/s (7% LTMAD)

SHG130PT at 0.141 m^3/s (52% LTMAD)

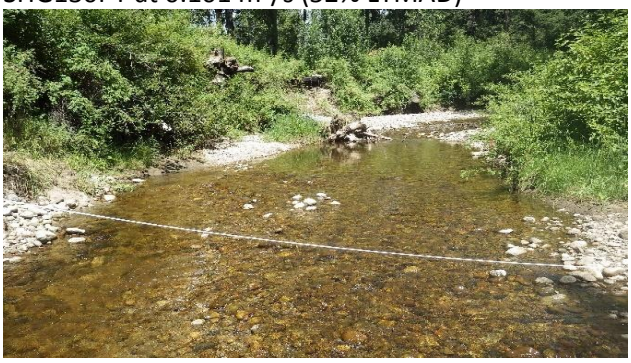


SHG130PT at 0.02 m^3/s (7% LTMAD)



SHG130PT at 0.101 m^3/s (52% LTMAD)

SHG120GL at 0.08 m^3/s (29% LTMAD)



SHG120GL at 0.135 m^3/s (50% LTMAD)

Plate 3-16: Upper Shingle Creek habitat conditions at flows near the recommended Rainbow and Steelhead spawning EFNs (0.900 m^3/s)

SHG40GL at 0.913 m^3/s (336% LTMAD)

SHG120GL at 0.967 m^3/s (356% LTMAD)