3.10 aksk^{w}ək^{w}ant - Inkaneep Creek

Inkaneep Creek flows from the east side of the Okanagan Basin into suwiẇs (Osoyoos Lake). It lies between the towns of Oliver and Osoyoos, B.C. The Inkaneep Creek drainage area is approximately 179 km^2 (Associated 2019) and the main tributaries include McCuddy, Baldy, Gregoire, and Coteay Creeks (Associated 2016). The upper reaches drain a gently sloping plateau before flowing through a steep canyon and onto an alluvial fan before entering Osoyoos Lake. A summary of creek characteristics is found in Table 3-30 and additional stream-specific data is provided in Appendix B10.

The lowest reach of Inkaneep Creek has been subjected to some agricultural encroachment and some localized hydromodification and riparian function impairment especially near the road crossing at the WSC station 08NM200. Lower Inkaneep Creek (further downstream of the road crossing) has not been straightened or diked but is deeply entrenched with corresponding bank erosion. The stream in this section meanders with several side channels. The entrenchment of the creek reduces the creek's ability to regularly interact with riparian areas, and riparian vegetation varies from healthy to nonexistent. In highly entrenched areas with reduced riparian vegetation, agricultural encroachment has occurred, sometimes to the bankfull width of the stream.

The lowest permanent barrier to adult anadromous fish migration is approximately 4.5 km from the mouth (OBMEP 2016). Inkaneep Creek is known to support populations of adfluvial Rainbow and anadromous Steelhead (Folks et al. 2009). Historically, Inkaneep was used by Chinook for spawning (Ernst and Vedan 2000) and juvenile Chinook have been observed utilizing the lower reaches (OBMEP 2014). Other salmonid species that may occur in Inkaneep Creek and Osoyoos Lake include Kokanee, Sockeye and Coho (Associated 2016). Two riffle and 2 glide transects were installed in August 2016 in the lowest 1 km reach of Inkaneep Creek between the WSC hydrometric station (08NM200) and the confluence with the lake.

At present there are 94 points of diversion within the watershed; however, the actual volume extracted annually is unknown (Associated 2019). The Osoyoos Indian Band is the main water user in the watershed (Associated 2016). The only known water storage is Cassidy Lake (Waterdog Lake), which has no outlet. Paired streamflow measurements indicate streamflow losses to groundwater on the alluvial fan. Naturalized flow data provided by Associated (2019) indicate that Inkaneep Creek is not 'flow sensitive' during the summer and winter as naturalized flows are above 20% LTMAD (Table 3-31). However, due to the lower than average freshet compared to the size of the drainage basin, the LTMAD estimates by Associated (2019) are lower than expected; as a result, using the LTMAD with flow standards to recommend EFNs creates unrealistic low flow expectations.

Table 3-30: Inkaneep Creek description

Drainage Area	179 km^2
Median Elevation	1227 m
WSC station	08NM200 (Active) – Inkaneep Cr near the Mouth (1973-present) 08NM012 (Historic) – Inkaneep Cr near Oliver (Lower Stn) (1919-1950) 08NM082 (Historic) – Inkaneep Cr near Oliver (Upper Stn) (1941-1950)
LTMAD	0.362 m^3/s (Associated 2019)
Fish species expected	Rainbow, Steelhead, Eastern Brook Trout (ESSA & Solander 2009), Chinook (Ernst & Vedan 2000)
Land use	Agriculture, forestry. The middle and lower reaches are within the Osoyoos Indian Band Reserve

Naturalized, residual and maximum licensed flow data were provided by Associated (2019) with an estimated data quality rating of C (data error between 25% and 50%). The LTMAD estimate for Inkaneep Creek was lower than expected due to low freshet peak flows used in the hydrologic analysis. Estimated maximum licensed flows indicate that the creek would be dry from mid-July to mid-September if licensed withdrawal and storage volumes were maximized.

Okanagan Tennant EFNs for Inkaneep 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. Contrary to most other creeks, flow standard EFNs for juvenile fish rearing were lower than naturalized flows during the summer and fall season, a result of the low LTMAD estimate. WUWs at the flow standards were very low. Therefore, WUW information was used to adjust the Okanagan Tennant EFNs upwards during the summer and fall period. A summary of EFNs for Inkaneep Creek is provided in Table 3-32 including the median EFN and the range of weekly EFNs, with weekly details in Figure 3-22, Figure 3-23 and Appendix B10 and flow sensitives in Table 3-31. Critical flows were calculated as described in Section 2.4. Further information regarding EFN and critical flow setting in Inkaneep Creek is provided at the end of this section.

Table 3-31: Flow sensitivities in Inkaneep 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	0.081	22%		
Insect production				
Chinook spawning				
O. mykiss & Chinook overwintering			0.071	20%
Chinook egg incubation				

Source: Associated (2019)

Table 3-32: EFN summary table for Inkaneep 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	0.072	20%	0.136	0.136	38%	0.090	0.388	0.030	8%
Steelhead spawning	April 1 – Jun 25	0.771	213%	0.771	0.771	213%	0.130	1.86	0.468	129%
Rainbow spawning	May 20 – Jul 10	0.771	213%	0.771	0.771	213%	0.502	1.86	0.468	129%
Chinook migration	July 1 – Aug 26	0.180	50%	x	0.180	50%	0.109	0.766	0.180[b]	50%
Chinook spawning	Aug 27 – Sep 30	0.100	28%	0.100	0.100	28%	0.090	0.139	0.100[c]	28%
Overwintering salmonids	Nov 1 - March 31	0.082	23%	x	0.082	23%	0.075	0.108	0.030	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

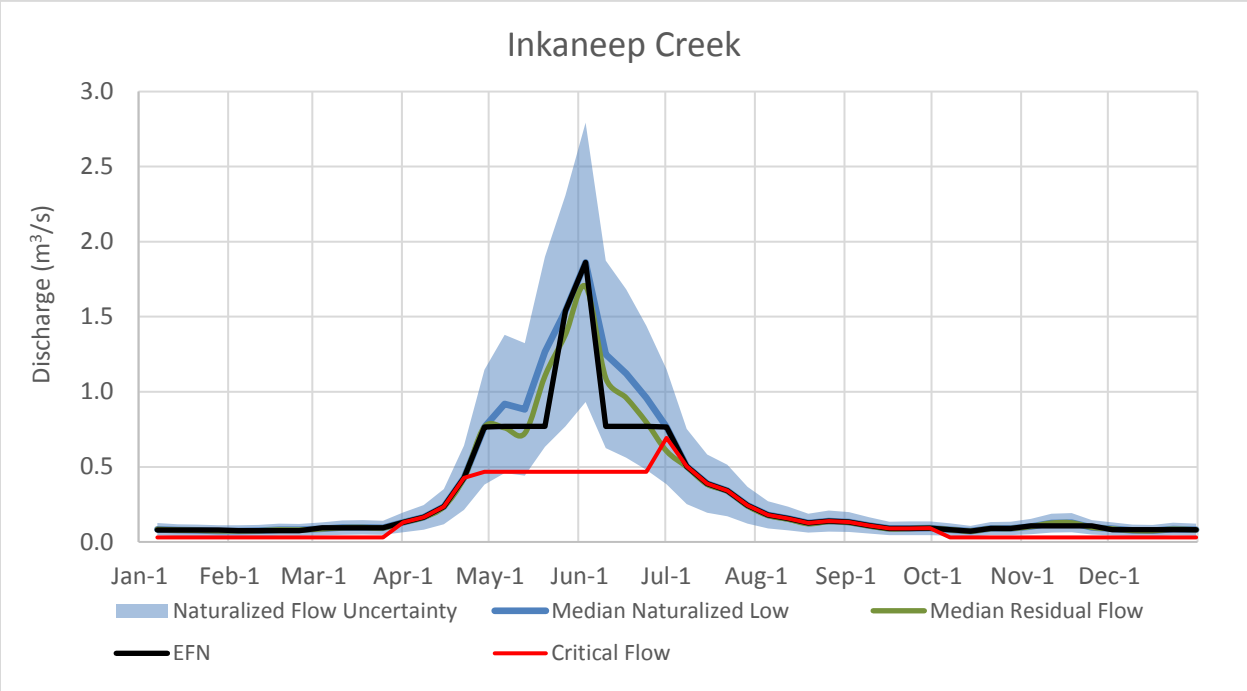


Figure 3-22: Weekly EFNs, critical flow and streamflows in Inkaneep Creek

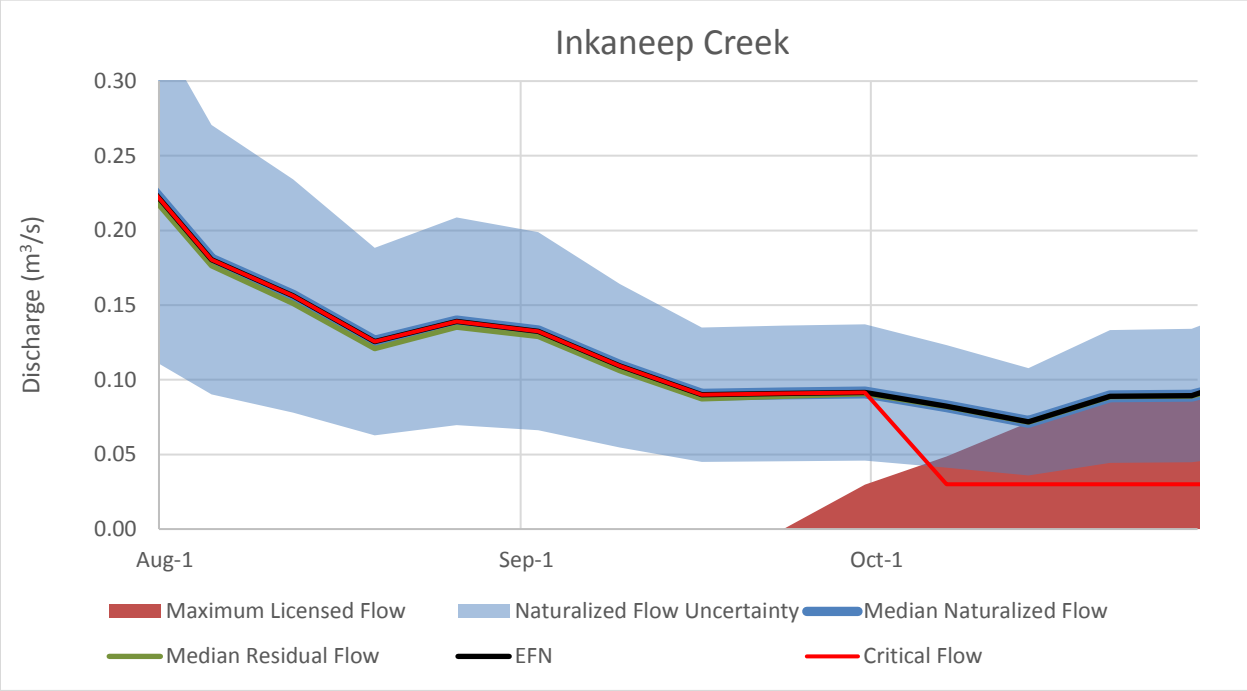


Figure 3-23: Weekly EFNs, critical flow and streamflows during the summer and fall period in Inkaneep Creek

O. mykiss parr and Chinook fry rearing

The recommended EFN for Steelhead and Rainbow (*O. mykiss*) parr and Chinook fry rearing is 0.136 m^3/s (38% LTMAD), which is equivalent to median naturalized flows during the summer low flow period and greater than the Okanagan Tennant EFN of 20% (0.072 m^3/s). This adjustment upward was made based on very low WUWs at the Okanagan Tennant EFN (<20% of maximum WUW). The recommended EFN is almost identical to that for Lower Shingle Creek, which has similar channel widths, and maintains approximately 40% of maximum WUW for *O. mykiss* parr rearing (Figure B10-5, Appendix B10) and 50% for Chinook fry rearing (Figure B10-6, Appendix B10), as well as 26% of maximum insect production WUW (Figure B10-7, Appendix B10). ESSA & Solander (2009) previously recommended an EFN of 0.2-0.3 m^3/s for *O. mykiss* rearing in Inkaneep Creek. Photos of habitat conditions in Inkaneep Creek at the recommended EFN flows are provided in Plate 3-21. The recommended critical flow for *O. mykiss* parr and Chinook fry rearing is 0.030 m^3/s (8% LTMAD; Table B10-2, Appendix B10) based on the riffle width criterion (Table 2-7).

Residual flows estimated by Associated (2019) are almost equal to naturalized flows; however, residual flows recorded at the currently operating (08NM200) and historical (08NM012) WSC hydrometric stations near the mouth were frequently below the EFN (0.03-0.04 m^3/s; Figures B10-2 and B10-3, Appendix B10) from early August to late October, therefore achieving EFNs may be problematic.

Summer water temperatures in Inkaneep Creek under residual flow conditions often exceed suitable rearing temperatures for juvenile *O. mykiss* and Chinook in July and August, reaching up to 24°C (Figure B10-4, Appendix B10; Rae 2005; OBMEP 2019). Maintaining sufficient flows is vital to maintain favorable thermal conditions in this creek though flow thresholds for temperature maintenance were not formally studied under this project.

Steelhead and Rainbow spawning

The recommended EFN for Steelhead and Rainbow spawning is 0.771 m^3/s (213% LTMAD), which is equivalent to the Okanagan Tennant EFN. The EFN maintains near maximum spawning WUW (90% of maximum for both; Figure B10-8 and B10-9, Appendix B10) while maximizing *O. mykiss* parr and Chinook fry rearing WUW during the freshet period, and maintaining high insect production from riffles. Flows greater than the recommended EFN are achieved under naturalized flows for a substantial portion of the freshet season (late April to late June); similarly, high residual flows from mid-May to mid-June indicate that these EFNs are achievable (Figure 3-22). Photos of habitat conditions in Inkaneep Creek at the recommended EFN flows are provided in Plate 3-22. ESSA & Solander (2009) previously recommended an EFN of 0.7–1.05 m^3/s for Steelhead and Rainbow spawning in Inkaneep Creek.

The recommended critical flow for Steelhead and Rainbow spawning is 0.468 m^3/s (129% LTMAD, Table B10-2, Appendix B10) from late April to late June, based on the minimum passage depth criterion (Table 2-7). Prior to this period, critical flows are set at the lower naturalized median weekly flows.

Spring Chinook spawning

Inkaneep Creek once provided spawning habitat for Spring Chinook (Rae 2005). However, none have been observed in recent years, likely due to low streamflows and high water temperatures in the creek during the migration (early July to mid-August) and spawning periods (late August to late September - though timing is unclear due to the low population abundance and records). Spawning conditions for spring Chinook in Inkaneep Creek are likely naturally limited by low summer and fall flows; however, a small amount of Chinook WUW (7%) could be maintained at EFNs that are equal to the naturalized weekly flows

throughout the migration and spawning period. In essence, any water use during mid-July to late September will have dire impacts on Chinook migration and spawning conditions in the creek. Thus, EFN flows for Chinook spawning are recommended at naturalized weekly flows throughout the migration and spawning period. The median spawning naturalized flow is 0.100 m^3/s (28% LTMAD, Figure 3-23, Figure B10-10, Appendix B10).

Riffle analysis indicates that 0.693 m^3/s (191% LTMAD) would be required to sustain safe riffle passage for Chinook (Table B10-2, Appendix B10). 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 near zero spawning WUW and likely total inability of Chinook to pass riffles because average water depths would be approximately 3 cm. It is thus recommended to set critical flows for Chinook spawning in Inkaneep Creek to naturalized flows. Photos of habitat conditions in Inkaneep Creek at the recommended EFN flows are provided in Plate 3-21.

Residual flows estimated by Associated (2019) are almost equal to naturalized flows; however, residual flows recorded at the currently operating (08NM200) and historical (08NM012) WSC hydrometric stations near the mouth were frequently below the EFN (0.03-0.04 m^3/s; Figures B10-2 and B10-3, Appendix B10) from early August to late October; therefore achieving Chinook spawning EFNs in Inkaneep Creek may be difficult. High water temperatures (24°C) recorded during July and August (Figure B10-4, Appendix B10) would also be problematic for Chinook spawners. ESSA & Solander (2009) previously recommended an EFN of 0.2 m^3/s during the Chinook spawning period in Inkaneep Creek.

Plate 3-21: Inkaneep Creek habitat conditions at flows near the recommended *O. mykiss* parr and Chinook fry rearing EFNs (0.136 m^3/s) and Chinook spawning EFN (0.100 m^3/s)

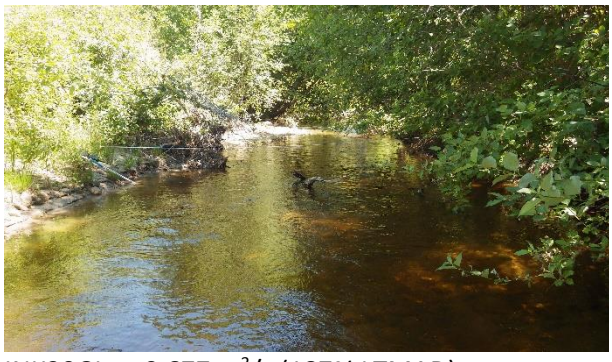
INK10SCR at 0.119 m^3/s (33% LTMAD)

INK45SCR at 0.139 m^3/s (38% LTMAD)

INK20GL at 0.119 m^3/s (33% LTMAD)

INK30GL at 0.139 m^3/s (33% LTMAD)

Plate 3-22: Inkaneep Creek habitat conditions at flows near the recommended Steelhead and Rainbow spawning EFNs (0.771 m^3/s)



INK20GL at 0.677 m^3/s (187% LTMAD)

INK20GL at 1.01 m^3/s (278% LTMAD)