3.5 Mission Creek

Mission Creek is the largest tributary to Okanagan Lake, flowing from the east side of the Okanagan Basin through Kelowna, B.C. The Mission Creek watershed is the largest in the Okanagan Basin at approximately 845 km^2, and the main tributaries include Pearson, Joe Rich, Belgo, Hydraulic, and KLO Creeks (Associated 2016). Its headwaters drain gently sloping plateaus before flowing through a steep canyon and finally over a large alluvial fan in the Kelowna area before entering Okanagan Lake. Developed storage exists in multiple headwater lakes and flows in Mission Creek are heavily regulated. A summary of creek characteristics is found in Table 3-13 and additional stream-specific data is provided in Appendix B5.

Mission Creek flows from its forested headwaters through agricultural and rural residential areas in its mid-elevation reaches, prior to flowing through a canyon and through the City of Kelowna. The most downstream barrier to fish migration is Gallagher's Falls located 19 km from the mouth in the canyon (Eyjolfson & Dunn 2016). The lower reaches within the city have been heavily straightened and diked in the past for flood control. This has resulted in ongoing sediment deposition problems in the lower reaches, requiring repeated dredging activities in the past to alleviate sediment buildup in the channel and reduce the risk of flooding (Burge 2009). Many bridges cross the creek, with some urban and agricultural influence, and low levels of pollution visible (Eyjolfson & Dunn 2016). There is some riparian cover throughout this section but habitat complexity is lacking.

Despite the extensive fish habitat losses that resulted from channelization and diking (Burge 2009), the majority of Kokanee spawning occurs in the lower reaches, primarily in the spawning channel that was specifically constructed for this purpose in 1988 (Webster 2016). Mission Creek once supported the largest stream-spawning Kokanee population in the Okanagan basin and still is the most important Kokanee producing tributary to Okanagan Lake. Historic escapements on record reached a high of 380,000 in 1971 (Wightman & Taylor 1978). Escapements over the past decade are lower between 7,000 and 32,000 (Webster 2010-2017). Mission Creek also supports a population of large adfluvial Rainbow from Okanagan Lake that migrate into the upstream reaches in and below the canyon to spawn, as well as a resident smaller bodied population. The majority of Rainbow spawning habitat is located approximately 13 to 19 km from the mouth in the mainstem as well as KLO and Hydraulic creeks (Wightman & Taylor 1978). Summer water temperatures in Mission Creek tend to exceed suitable rearing temperatures for Rainbow near the mouth, reaching up to 22°C in the reaches below the canyon and up to 26°C near the mouth (Figure B5-9 to B5-14, Appendix B5).

A total of six glide and five riffle WUW transects were established in Mission Creek in August 2016 (Figure B5-1, Appendix B5). Transects were located throughout the fish accessible portion of the creek below Gallagher's Falls. WUW data was previously collected in Mission Creek from 2005-2009 (Epp 2008a; Epp 2009; Epp 2010a) to aid with the Mission Creek Water Use Plan development (Water Management Consultants 2010) and assess the impacts of sediment dredging. Some transects in this study were in the same reaches as previously monitored (i.e., transects 1 and 3) by Epp (2008a) and Glide 3 was re-established at a transect location previously used by Epp (2008a).

Table 3-13: Mission Creek description

Drainage Area	845 km^2
Median Elevation	1345 m
WSC stations	08NM116 (Active) Mission Creek near E. Kelowna (1949-present) 08NM232 (Active) Belgo Creek Below Hilda Creek (1976-present) Historic records include: 08NM057 Mission Creek Rutland Diversion (1922-1930) 08NM016 Mission Creek near Rutland (1919-1946) 08NM010 Hydraulic Creek near the Mouth (1919-1982) 08NM039 Hydraulic Creek Diversion near Kelowna (1919- 1968) 08NM060 KLO Creek Diversion near Kelowna (1923-1968) 08NM040 Hydraulic Creek SE Kelowna Diversion (1920-1930) 08NM226 KLO Creek at McCulloch Road (1976-1982) 08NM004 KLO Creek near Kelowna (1919-1922) 08NM239 Mission Creek Below B.M.I.D. Intake (1980-1980) 08NM137 Daves Creek near Rutland (1965-1986) 08NM207 Myra Ditch Below KLO Creek (1973-1985) 08NM210 Pooley Creek Above Pooley Ditch (1973-1979) 08NM213 McCulloch Reservoir at McCulloch Dam (1973- 1986) 08NM011 Hydraulic Creek at Outlet of McCulloch Res. (1919-1986) 08NM215 Fish Lake at the Outlet (1973-1977) 08NM217 Long Meadow Lk Reservoir Above the Dam (1973-1977) 08NM216 Browne Lake Reservoir Above the Dam (1973- 1977) 08NM129 Joe Rich Creek near Rutland (1964-1987) 08NM225 Belgo Creek near the Mouth (1976-1982) 08NM172 Pearson Creek near the Mouth (1970-1987) 08NM233 Mission Creek Above Pearson Creek (1977-1982) 08NM018 Hilda Creek near Rutland (1920-1920) 08NM017 Belgo near Rutland (1920- 1920) 08NM231 Ideal Lake near the Outlet (1963-1980) 08NM229 Loch Katrine Cr at Outlet of Graystone Lake (1977-1998) 08NM230 Graystone Lake at the Outlet (1977-1998)
ONA stations	08NM551 Mission Creek above Gordon Drive (Hydromet 1) (2016-present) 08NM552 Mission Creek at Casorso Road (Hydromet 2) (2016-2017) 08NM553 Mission Creek upstream of KLO Road (Hydromet 3) (2016-2017) 08NM554 Mission Creek at Ziprick Road (Hydromet 4) (2016-2017) 08NM555 Mission Creek at Gerstmar Road (Hydromet 4a) (2016-2017) 08NM556 Mission Creek at Hollywood Road (Hydromet 6) (2016-2017) 08NM557 Mission Creek at 12 km Bridge (Hydromet 7) (2016-2017) 08NM558 Mission Creek below KLO Creek (Hydromet 8) (2016-2017) 08NM559 Mission Creek above BMID Intake (Hydromet 10) (2016-2017)
LTMAD	6.35 m^3/s
Fish species expected	Rainbow, Kokanee, Eastern Brook Trout, Burbot, Mountain Whitefish, Redside Shiner, Northern Pikeminnow, Sucker (general), Longnose Dace, Prickly Sculpin, Sculpin (general), Peamouth Chub, and Slimy Sculpin (ESSA & Solander 2009)
Land use	The lower watershed is dominated by urban development. The upper watershed is used for agriculture, forestry, and livestock grazing. A small reserve of the Westbank First Nation sits alongside Mission Creek in its lowest reaches and larger reserves are located in Gallagher's Canyon and the headwaters of Hydraulic Creek.

The Black Mountain Irrigation District and Southeast Kelowna Irrigation District are the major water suppliers within the Mission Creek watershed and operate nine storage reservoirs in the headwaters. In addition, smaller providers include the Falconridge Water Utility, Benvoulin Water Users Community, Mission Creek Water Users Community, Rutland Water Works, and South Kelowna Water Users Community (Associated 2016). The Black Mountain Irrigation district operates storage on Loch Long on behalf of the Province of B.C. for instream flow requirements (Associated 2019) and FLNRORD also holds several conservation licences on Mission Creek. There are 426 points of diversion within the watershed and 10 water licence applications pending (Associated 2019). Interbasin transfers into the watershed can occur between Mission Creek and the West Kettle River, as well as, Mill Creek (Associated 2016).

In 2000, Mission Creek was a candidate for designation as a 'Sensitive Stream' under the *Fish Protection Act* (MOE 2000). Particular concerns were a generally high water demand only partially supported by storage, as well as low summer and fall flows during the Kokanee spawning season and during the winter, leading to reduced egg survival. The stream is currently fully recorded for irrigation unless supported by storage (FLNRORD 2016). Mission Creek is 'flow sensitive' during summer and winter as naturalized flows are below 20% LTMAD (Table 3-14). The Mission Creek Water Use Plan was developed in 2008 (Water Management Consultants 2010) and specifies fisheries conservation flows for the summer months based on a proportion of LTMAD (July - 2.25 m^3/s, August – 2.25 m^3/s, September – 1.9 m^3/s, October – 1.5 m^3/s). The plan allows fish flow releases to vary during wet and dry years by using a multiplier of natural streamflows in the unregulated tributary of Pearson Creek to estimate what natural flows would be in Mission Creek. However, this component was never implemented because it requires re-establishment of a real-time hydrometric station on Pearson Creek.

Eight hydrometric stations were installed throughout the fish accessible portion of the creek in 2016 for the Mission Creek Groundwater and Surface Water Interaction project (Neumann 2018) and the data was utilized for EFN development; the lowermost hydrometric station near Gordon Road continues to operate (Figure B5-1, Appendix B5). The project identified that Mission Creek gained water from groundwater in the intermediate reaches where it flows through the canyon, but gaining and losing conditions were more variable on the alluvial fan in the lower reaches.

Naturalized flow data were provided by Associated (2019) and residual flow data was obtained from the active WSC hydrometric station 08NM116 (Mission Creek near east Kelowna). The naturalized flows have a data quality rating of B (estimated 10 - 25% error) and residual flows have a data quality rating of A (estimated error <10%); maximum licensed flow estimates were not available at the time of reporting.

Okanagan Tennant EFNs for Mission 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. However, as per the Mission Creek Water Use Plan, storage releases are used to augment flows during the summer and fall and residual flows are therefore typically greater than naturalized flows during September and October. Local fish populations have adapted to augmented flows; therefore, final EFN setting in Mission Creek was based on a combination of residual and naturalized flows, informed by WUW curves.

A summary of the recommended EFNs is provided in Table 3-15, including the median and the range of weekly EFNs, with weekly details in Figure 3-9, Figure 3-10 and Appendix B5. The recommended EFNs are intended to maintain current levels of fish production in Mission Creek by protecting flow conditions that local populations have become adapted to. Naturalized flow sensitives are listed in Table 3-14. Critical flows were calculated as described in Section 2.4. However, riffle data from riffle transect 4 and 7 were

not considered for the critical flow analysis as the range of flow data collected at these transects was insufficient to complete the analysis. Further information regarding EFN and critical flow setting in Mission Creek is provided at the end of this section.

Table 3-14: Flow sensitivities in Mission 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
Rainbow rearing	1.10	17%		
Insect production				
Kokanee spawning				
Rainbow overwintering			0.702	11%
Kokanee egg incubation				

Source: Associated (2019)

Table 3-15: EFN Summary table for Mission Creek

Species & life stage	Time period	Okanagan Tennant EFN		WUW EFN (m^3/s)	Recommended EFN (m^3/s)				Critical flows	
		Median (m^3/s)	% LTMAD		Median	% LTMAD	Min	Max	Flow (m^3/s)	% LTMAD
Rainbow rearing & insect production[a]	April 1 – Oct 31	1.26	20%	1.40	1.40	22%	1.40	4.83	0.635	10%
Rainbow spawning	May 20 – July 10	6.35	100%	4.83	4.83	76%	4.83	32.39	1.12	18%
Kokanee spawning	Aug 31 – Oct 5	1.11	17%	1.40	1.40	22%	1.40	1.40	0.635	10%
Rainbow overwintering	Nov 1 – March 31	0.925	15%	x	0.925	15%	0.790	1.27	0.635	10%

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

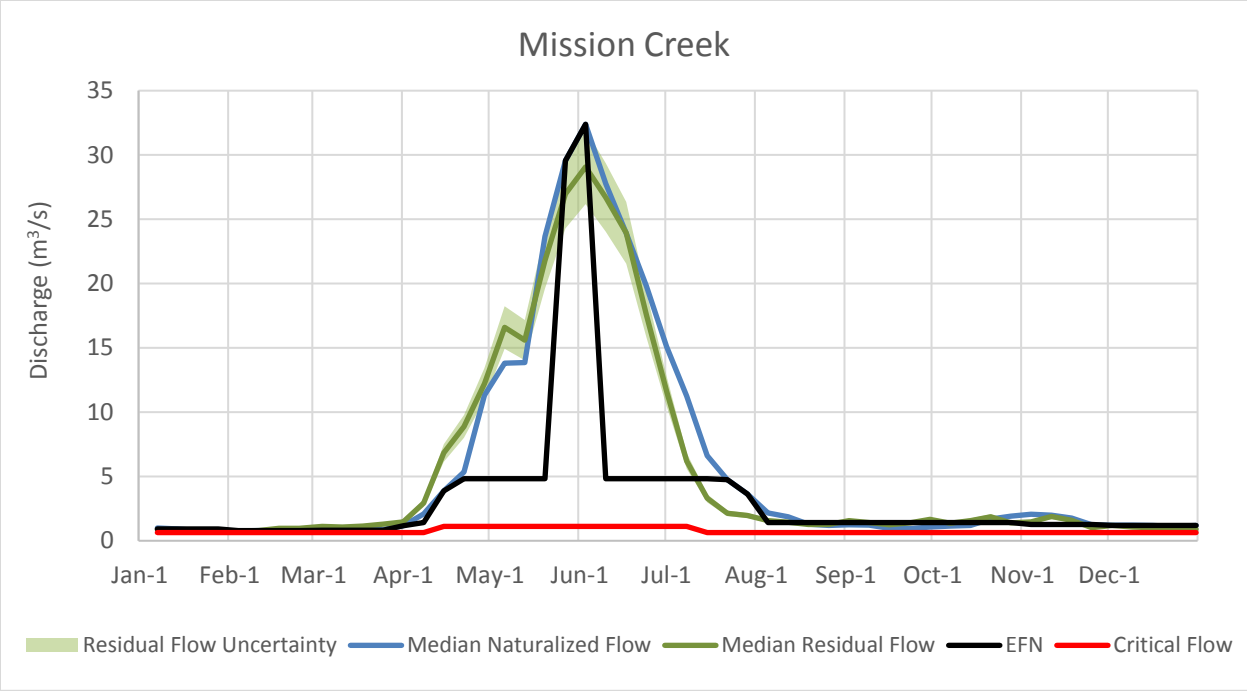

Figure 3-9: Weekly EFN, critical flow, and streamflows in Mission Creek

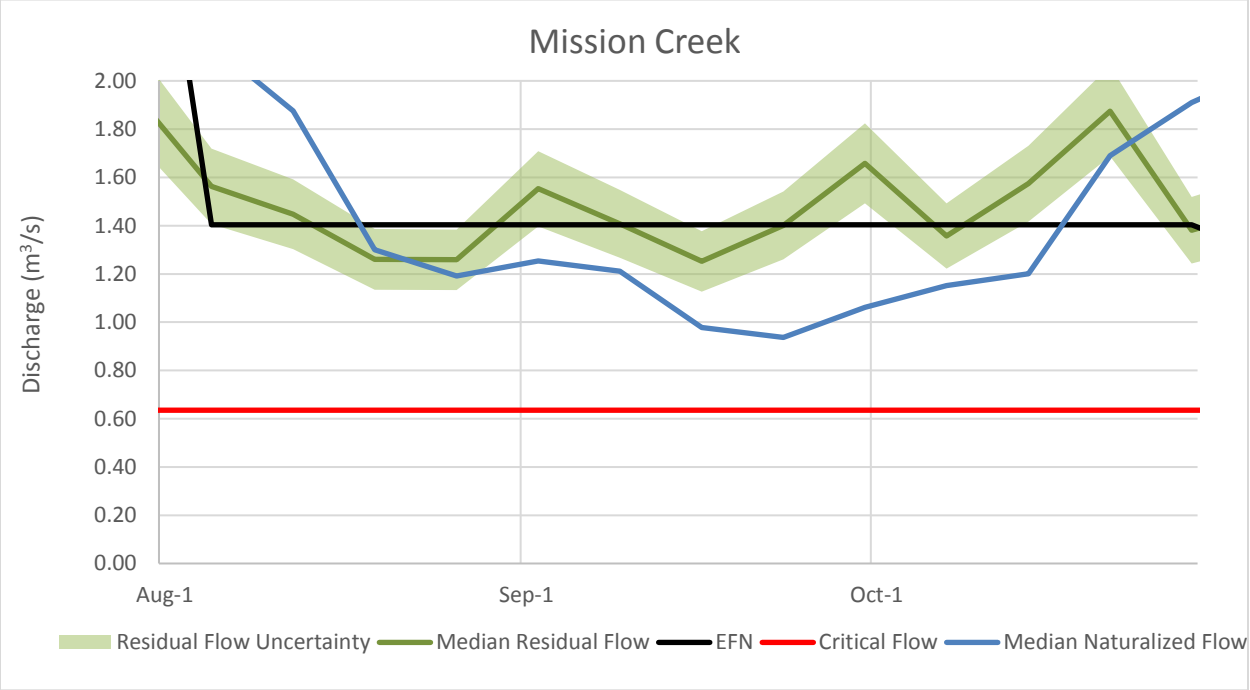

Figure 3-10: Weekly EFN, critical flow, and streamflows during summer and fall in Mission Creek

Rainbow parr rearing

WUW transects for Rainbow parr rearing were situated throughout the entire fish accessible extent of Mission Creek. Due to the wide range of channel conditions with varying gradient, substrate size and levels of channelization, the resulting WUW curve shows a moderate amount of uncertainty (Figure B5-15, Appendix B5). Parr rearing WUW peaked around 2 m^3/s similar to findings by Epp (2009). The recommended EFN for Rainbow parr rearing is 1.40 m^3/s (22% LTMAD), a value that is between the median Okanagan Tennant EFN (1.26 m^3/s, 20% LTMAD; based on naturalized flows) and median residual flows (1.50 m^3/s, 24% LTMAD) for the summer and fall low flow period (mid-July from end of Rainbow spawning to end of September). This EFN maintains approximately 90% of maximum Rainbow parr rearing WUW in glides and 80% in riffles, and 50% of maximum insect production WUW (Figure B5-16, Appendix B5). Though median residual flows are slightly higher than the recommended EFN, the value of 1.40 m^3/s strikes a balance between naturalized and residual flows and is also equal to the recommended Kokanee spawning EFN, which eliminates the need for multiple EFN values through the summer and fall. The Rainbow parr rearing EFN is expected to be met during most years due to extensive headwater storage. Photos of habitat conditions in Mission Creek at the recommended EFN flows are provided in Plate 3-9.

The recommended critical flow for Rainbow parr is 0.635 m^3/s (10% LTMAD; Table B5-2, Appendix B5). Critical riffle analysis indicated that riffle widths decline to <60% at flows of 0.790 m^3/s (12% LTMAD). Channelization and diking in Mission Creek have resulted in large variability in channel conditions ranging from narrow and deep to wide and shallow, which led to higher uncertainty in the critical riffle analysis; thus, slightly lower critical flows of 10% LTMAD are recommended to conform with those recommended for Kokanee spawning. Critical flows of 10% LTMAD rather than the default 5% LTMAD are further recommended because insect WUW declines from about 25% of maximum WUW to less than 10% between those flows (Figure B5-16, Appendix B5). Further, already high summer stream temperatures are more likely to escalate under very low flows.

The recommended EFN is lower than flows specified in the Water Use Plan for August (2.25 m^3/s) and September (1.9 m^3/s) (Water Management Consultants 2010). However, Rainbow parr would benefit from some additional WUW available at those higher flows. Further, greater flows may aid in moderating high summer stream temperatures in the lower reaches of Mission Creek, which are frequently beyond the suitable range for Rainbow rearing reaching up to 26°C (Figure B5-9 to B5-14, Appendix B5). Historically recommended EFNs for parr rearing range from 1.13 m^3/s (Shepherd & Ptolemy 1999; Dobson 1990) to 3 m^3/s (ESSA and Solander 2009). Optimal flow recommendations of 1.42 m^3/s (Tredger 1989a; Shepherd & Ptolemy 1999) are similar to our recommended EFN.

Residual flows recorded at the hydrometric stations near the mouth in 2016 fluctuated but were generally greater than the recommended EFN. In 2017 (a drought year), flows were at or below the recommended EFN from early July throughout most of the summer and fall (Figures B5-2 to B5-7, Appendix B5). Historically, median flows at the WSC station 08NM116 (1949-2017) are near the recommended EFN (Figure B5-8, Appendix B5). However, summer and fall flows below the EFN have occurred periodically in eight of the last 10 years despite significantly higher flows specified in the Mission Creek Water Use Plan.

Rainbow spawning

The recommended EFN for Rainbow spawning is 4.83 m^3/s (76% LTMAD), which corresponds to the Okanagan Tennant EFN flow standard and the peak of the WUW curve. The EFN is well below the median

weekly naturalized flows during the Rainbow spawning period (23.79 m^3/s, 375% LTMAD; Figure 3-9) and also below the residual flows. While WUW measurements at such flows were not possible because the stream was not wadeable, WUW curves from other streams suggest that the amount of WUW available likely declines at such high flows. The recommended EFN maintains the maximum Rainbow spawning WUW (100%) and relatively high (>80%) Rainbow parr rearing WUW in riffles and glides. Photos of habitat conditions in Mission Creek at the recommended EFN flows are provided in Plate 3-10. The recommended critical flow for Rainbow spawning is 1.12 m^3/s (18% LTMAD, Table B5-2, Appendix B5) based on the passage depth criterion (Table 2-7). A previous Rainbow spawning EFN recommendation of 7 m^3/s was made by ESSA and Solander (2009).

Kokanee spawning

The recommended EFN for Kokanee spawning is 1.40 m^3/s (22% LTMAD), which maintains near 100% of maximum WUW (Figure B5-18, Appendix B5). The EFN corresponds to the median residual weekly flows during the Kokanee spawning period and is slightly higher than the Okanagan Tennant EFN (1.11 m^3/s; 17% LTMAD), which is based on median naturalized flows. The EFN was adjusted upward from the Okanagan Tennant EFN because flows in Mission Creek are specifically managed for Kokanee spawning and maintaining maximum production of this important Kokanee stock is of high priority. Further, previous studies also showed maximum habitat capacity at 1.42 m^3/s (Tredger 1989a). Very small (<5%) gains in WUW are made between our recommended EFN and Kokanee spawning flows stipulated by the Water Use Plan (1.9 m^3/s). Photos of habitat conditions in Mission Creek at the recommended EFN flows are provided in Plate 3-9. The recommended critical flow for Kokanee spawning is 0.635 m^3/s (10% LTMAD) based on critical riffle analysis (Table B5-1, Appendix B5).

Residual flows during the 2016 Kokanee spawning season were fluctuating above and below the recommended EFN, and in 2017 were well below the EFN and dropped below the critical flow on one occasion (Figures B5-3 and B5-4, Appendix B5). Median daily flows at the WSC hydrometric station 08NM116 (1949-2017) were consistently near the EFN; however, flows below the EFN have occurred periodically in 8 of the last 10 years despite significantly higher flows specified in the Mission Creek Water Use Plan.

Previous EFN recommendations for Kokanee spawning ranged from 0.9 m^3/s (Houston n.d.; Dobson 1990) to 4 m^3/s (ESSA & Solander 2009). Overwinter incubation flow recommendations from previous studies ranged from 0.6 m^3/s (Dobson 2004) to 0.99 m^3/s (CBCOBA 1974; Houston n.d.), which is in agreement with the recommended overwintering EFN of 0.925 m^3/s (Table 3-15).

Plate 3-9: Mission Creek habitat conditions at flows near the recommended Rainbow parr rearing and Kokanee spawning EFNs (1.40 m^3/s)

Glide 1 at 1.38 m^3/s (22% LTMAD)

Glide 3 at 1.40 m^3/s (22% LTMAD)

Riffle 3 at 1.40 m^3/s (22% LTMAD)

Riffle 6 at 1.37 m^3/s (22% LTMAD)

Plate 3-10: Mission Creek habitat conditions at flows near the recommended Rainbow spawning EFN (4.83 m^3/s)

Glide 2 at 4.40 m^3/s (69% LTMAD)

Glide 3 at 6.47 m^3/s (102% LTMAD)