Information Bulletin

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Information For: Missezula Lake Water Licence Holders and Local Residents

This bulletin provides information about:

- British Columbia's water licencing system and current allocations for Missezula Lake, Summers Creek, and Allison Creek.
- The Environmental Flow Need (EFN) for Summers Creek and design of a dam release schedule that meets licence holder and environmental allocation needs.
- Fisheries Management's role in water management and dam operations at Missezula Lake.
- The Missezula Water User Community's role and recent issues regarding the operations of their water withdrawl, treatement, and distribution system.
- Proposed operational plan for water releases through the dam and subsequent water level fluctuations in the the Missezula reservoir.

Section 1. British Columbia's Water Licencing System

The dam located at the mouth of Summers Creek and the Missezula reservoir is authorized by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development, under the *Water Sustainability Act*. There are seven licence holders authorized to store water in Missezula Lake and each water licence has a priority date based on when the licence was applied for. This date determines who takes priority in times of scarcity through the First In Time, First In Right (FITFIR) system. In times of scarcity, water may be released in order to supply a landowner with a more senior priority date with water and subsequently a more junior licence holder may have to reduce water usage. While the FITFIR section of the *Water Sustainability Act* has never been implemented for Summers Creek, water scarcity is an ongoing concern amongst all stakeholders. In response to recent drought conditions and concerns from licensed users, the Province is reviewing the operations of several storage reservoirs, including Missezula. This review will seek to ensure that the reservoirs are operating within the terms and conditions of their licences, while maintaining a safe and sustainable water supply for the licensees and environment.

Section 2. Environmental Flow Need (EFN) Summers Creek study

Understanding Environmental Flow Needs

The definition of environmental flow needs is "the volume and timing of water required for the proper functioning of the aquatic ecosystem of the stream". This requires that both the proper timing and volumes be determined for the creek in question.

Environmental Flow Needs for Summers Creek

Summers Creek is a small creek that is fed by discharge from the outlet of Missezula Lake. The flows from Missezula are regulated by the Missezula Lake dam in the seasonal community of Missezula. The licence conditions, governing the operation of the outlet control structure, specify that the reservoir may store water from the beginning of April till the end of June annually. The remainder of the year dam operators are required to release a volume equal to or greater than the inflow.

In order to establish EFNs for Summer Creek we answered three principle questions:

1) How much water do we have?
2) How much water have we licensed?
3) How much water does the environment require?

Based upon the answers to these questions, we established a suitable EFN value for Summers Creek and propose a dam operations plan that can help achieve the requirements for both licensees and the environment.

1. How much water do we have?

Summers Creek has a long history of hydrologic assessment. At several points during the last century, seasonal discharge measurements have been made at points in the creek. All of these records are considered "residual" discharge, following the removal of any licensed demand and/or the modifications of flow from the dam at the outlet of Missezula Lake. In order to establish a conservative EFN value for Summers Creek, we required an accurate estimate of natural hydrology, specifically mean annual discharge (MAD). Recognizing that uncertainty exists with any estimate, we employed a precautionary approach by estimating the natural MAD using three different methods: area based comparisons, empirical based equations, and attempting to naturalize the measured residual discharges.

Method 1 – Estimation of MAD using comparable Ecosection values

Method 2 – Estimation of MAD using regionalization approach detailed in Obedkoff (1998)

Method 3 – Estimation of MAD using corrected residual values, detailed in Epp (2015)

The general watershed characteristics upon which the empirical estimates are based are presented in Table 1.

Table 1. Summers Creek watershed characteristics

	Summers Creek at the outlet of Missezula Lake	Summer s Creek upstream of Allison Creek
Drainage Area (km2)	116	322.5
Minimum Elevation (m)	1005	714
Median Elevation (m)	1285	1336
Maximum Elevation (m)	1769	1769

The three methods produced a range of potential MAD estimates. The lowest of the estimates were produced through a process to extend and naturalize seasonal measurements gathered by the Water Survey of Canada (Appendix 1). It is likely these estimates contain some serious limitations surrounding the potential influence of dam operations, which are difficult to account for. These are not the preferred estimates to proceed with as they appear to be a dangerous underestimate.

The estimation methods that relied upon comparison amongst Ecosections and regionalization would not be influenced by withdrawals or dam management in the watershed. When the MAD is estimated with comparisons between other stations located in comparable Ecosections (Appendix 1), we end up with a fairly small range of estimates (Table 2). The regionalization method (Appendix 1) provided an estimate of MAD that was lower than the estimates produced with the Ecosection comparison.

Table 2. Summary of the hydrologic estimates MAD for Summers Creek

Method	Ecosection Comparison (L/sec)			Regionalization (Obedkoff, 1998) (L/sec)		Naturalization of measured Data (L/sec)
	Nicola Basin	Okanagan Upland	Okanagan Range	MAD	7Q10 low flow	MAD
Missezula Lake outlet	508	647	725	***312***	***25***	125
Allison Creek confluence	1412	1799	2015	***967***	***105***	667

In this situation, the estimates calculated using the regionalization approach (Obedkoff, 1998) are believed to be the most rigorous. This approach represents a published and defensible method that fits with FLNRORD staff's observations in the watershed. This method also provides a valuable low flow estimate. A complete description of all three methods, used to estimate MAD for Summers Creek, can be found in Appendix 1.

2. How much water have we licenced?

There are eight irrigation licences on Summers Creek and Alison Creek that are backed by storage in Missezula Lake. The combined volume of the irrigation licenses is 773 ML. All of these licenses permit the withdrawal of water between April 1st and September 31st. If this licensed volume is portioned over the irrigation season at estimated monthly proportions (table 1), the monthly average release volumes to support irrigation range between 0.015 m^3/sec in April and 0.072 m^3/sec in July and August (Table 8).

Table 3. Estimated average monthly irrigation demand In Summer and Alison Creek

	Total estimated monthly demand based upon current irrigation licenses of 773,000 m^3/year (backed by storage)					
	April	May	June	July	August	September
Estimated % of annual use	5	10	20	25	25	15
Monthly usage (m^3/month)	38650	77300	154600	193250	193250	115950
Avg. Monthly usage (m^3/sec)	0.015	0.029	0.060	0.072	0.072	0.045
	Total estimated monthly demand based upon current irrigation licenses of 81,000 m^3/year (not backed by storage)					
Estimated % of annual use	5	10	20	25	25	15
Monthly usage (m^3/month)	4050	8100	16200	20250	20250	12150
Avg. Monthly usage (m^3/sec)	0.002	0.003	0.006	0.008	0.008	0.005
Total Diversions from Summer's Creek (m^3/sec)	0.017	0.032	0.066	0.080	0.080	0.050

There is one storage-non power licence on Missezula Lake for 617 ML for an associated Waterworks Local Authority diversion from the Lake. This license supplies the residents of the community of Missezula with domestic water. A large portion of this licence is consumed during the summer months when residents are visiting their seasonal residencies. There is one conservation water licence on Missezula Lake for 617 ML. This licence is maintained by the provincial government to maintain suitable water levels in Missezula Lake and Summers Creek during the typical low flow periods of the year. The total licenced storage in Missezula Lake is 2,007 ML. Relative to the constructed volume of 2,719 ML there is 712 ML of unlicenced storage, but estimates from 2015 suggest that useable unlicenced storage is reduced to 206 ML due to the sediment ridge blocking the lower portion of the outlet. See Figure 2 for a graphical presentation of the licenses and associated water levels.

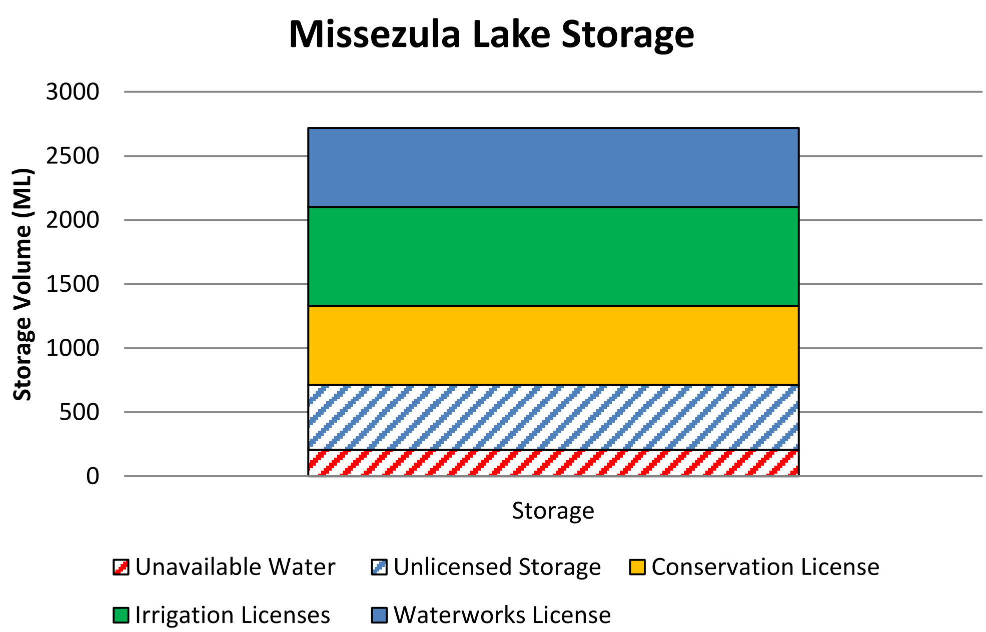

Figure 1. Graphical presentation of the storage volume and associated staff gauge readings

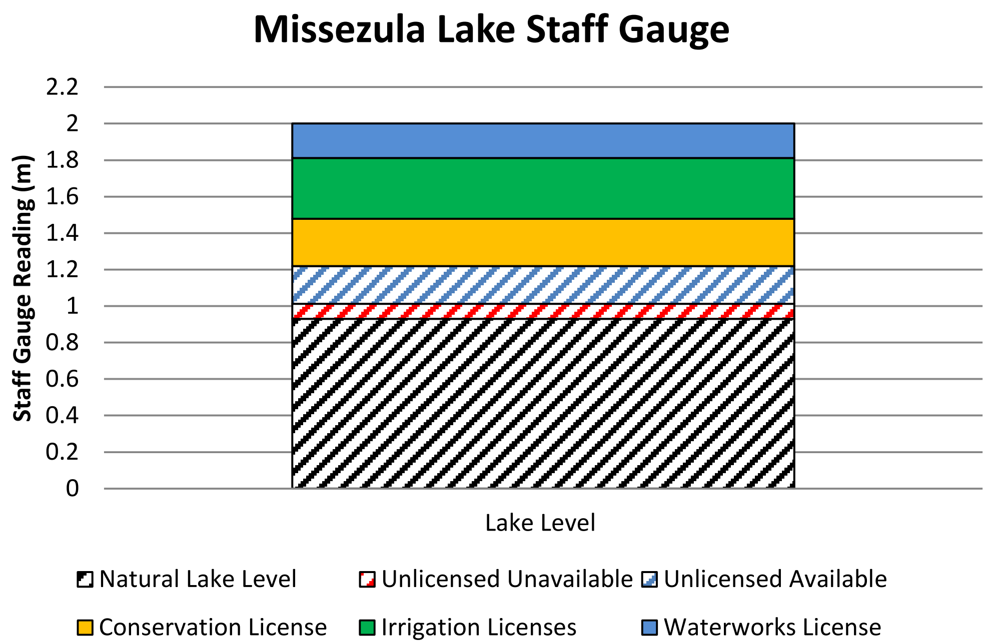

Figure 2. Graphical presentation of the storage volume and associated staff gauge readings

3. How much water does the environment need?

The Summers Creek watershed supports documented populations of rainbow trout (*Onchorhynchus mykiss*), kokanee salmon (*Onchorhynchus nerka*), brook trout (*Salvelinus confluentis*), mountain whitefish (*Proposium williamsoni*) as well as other native *Cyprinids*, *Cottids and Catastomids*. Of the species documented in the watershed, the chiselmouth (*Acrocheilus alutaceus*) is classified as Blue Listed by the BC Conservation Data Center, suggesting that it is a species of special concern in the Province.

These species are principally located in Missezula Lake and potentially other ponds and lakes in the watershed. The Kokanee in the watershed are restricted to Missezula Lake and stream inlets, confirming that they should not be impacted by the operation of the Missezula dam. Documented populations of Rainbow and Brook Trout do inhabit Summers Creek downstream of the dam, suggesting that dam operations should be considerate of these important game species. It is unclear how distributed the Chiselmouth are in the watershed, however, we should meet the general species management objectives if we successfully manage flows for Rainbow Trout. A complete explanation of determining EFN for Summers Creek fish stocks can be found in Appendix 2.

Release Schedule

The recommended releases from Missezula Lake are monitored at a staff gauge immediately downstream of the dam. The discharges reflect a combination of recommended conservation flow targets as well as estimated irrigation demand backed by storage (Table 4). Flows at the staff gauge downstream of the dam have been calibrated with the outlet control to provide operators with an indication of whether the correct volume of water is being released (Table 5). Similarly, the lake staff gauge has been calibrated with the remaining volume of water in the lake to allow operators to understand when they are within the license terms and conditions (Table 5).

Table 4. Recommended flow targets downstream of the Missezula Lake outlet control structure

Month	Irrigation requirements (L/sec)	Environmental flow Requirements (L/sec)	Conservation Release (L/sec)	Instream Flow Target (L/sec)
January		62	62 L/sec – Inflows	62
February		62	62 L/sec – Inflows	62
March		62	62 L/sec – Inflows	62
April	15	62	62 L/sec – Inflows	77
May	29	62	62 L/sec – Inflows	91
June	60	62	62 L/sec – Inflows	122
July	72	62	62 L/sec – Inflows	134
August	72	125	125 L/sec - Inflows	197
September	45	125	125 L/sec - Inflows	160
October		125	125 L/sec - Inflows	125
November		125	125 L/sec - Inflows	125
December		62	62 L/sec – Inflows	62

The best case scenario at Missezula is to maintain the greatest possible lake levels, while adhering to the terms and conditions in the water licences. To this end, it is recommended that we limit the release of conservation storage water to periods where the environmental flows are not being met naturally. The range of lake staff gauge target values presented in Table 5 represents the envelope between the points where no conservation storage is required (inflows > environmental flow needs) and maximum available conservation storage is required to supplement flows. The gap between these values increases as we progress away from the dam filling period because the monthly differences are cumulative.

Table 5. Missezula Lake outflows and associated staff gauge targets

Month	Instream Flow Target (L/sec)	Flow Staff Gauge Target (m)	Lake Staff Gauge Target (end of month) (m)
January	62	≥0.351	1.65 ≥ 1.46
February	62	≥0.351	1.64 ≥ 1.44
March	62	≥0.351	1.63 ≥ 1.42
April	77	≥0.361	Filling
May	91	≥0.370	Filling
June	122	≥0.391	2.00
July	134	≥0.398	1.89 ≥ 1.87
August	197	≥0.440	1.75 ≥ 1.70
September	160	≥0.416	1.68 ≥ 1.59
October	125	≥0.392	1.67 ≥ 1.55
November	125	≥0.392	1.66 ≥ 1.50
December	62	≥0.351	1.65 ≥ 1.48

This table assumes that the requirement for supplementation by conservation storage does not exceed a monthly average of 11.5 L/sec during the months of December to July and 34.5 L/sec during August to November. If consecutive dry months occur or high quantities of flow supplementation is required shortly after filling is completed (July) the monthly conservation storage amount specified could be exhausted and the lake level would reach the lowest value for the monthly envelope. In this situation I would recommend reducing the release of conservation storage to avoid consuming other licensees water and prolonged periods without suitable flows.

In situations where conservation storage has not been required for several consecutive months it is possible to build up a surplus of conservation storage allowing operators to sustainably release conservation flows greater than the assumed amounts of 11.5 L/sec and 34.5 L/sec without impinging on the subsequent months requirements. As a general rule, I recommend releasing a volume as close to monthly environmental flow need as possible that maintains the drawdown of the lake as close to the upper limit of the monthly envelope as possible. This will maintain the maximum water levels in the Lake for as long as possible.

It is recommended that the operators of the Missezula Lake Dam begin to manage the releases according to the schedule in Table 5. It is also recommended that the operator maintains a log of the operations that details the relevant levels.

Section 3. Fishery Management's Role

The Fisheries Management Section of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development's mandate is to conserve the natural diversity of fish and fish habitat and to sustainably manage the freshwater sport fishing in B.C. The province exercises delegated authority, under the federal *Fisheries Act*, for the management of non-salmon freshwater fisheries. In the context of water management at Missezula reservoir, our focus is on maintaining both a healthy in-lake aquatic ecosystem, as well as healthy in-stream systems downstream in Summers and Allison Creeks. This includes not only resident fish stocks, but all components of these ecosystems.

Licencing

Fisheries Management holds a conservation storage licence for 616,740 cubic meters of water in Missezula reservoir. This storage is intended for downstream release to sustain adequate flows for fish and aquatic ecosystem values in Summers and Allison Creeks. This volume of water is 27% of the total licenced storage for the reservoir, making fisheries management the second largest licence holder, after the Missezula Water User Community (MWUC).

Dam Operations

In 2015, the Water Stewardship Branch flagged the Missezula reservoir as being operated outside the conditions of its water licences. At this time, the Fisheries Management Section, in cooperation with the Water Stewardship and Ecosystem Sections of FLNRORD began working with the local water user community to remediate a number of structural and operational issues with the Missezula dam. Based on a review of relevant water allocation licences and a hydrologic assessment of the Missezula reservoir and Summers Creek, a release schedule was built to manage discharge at the dam (See Section 2). This schedule is designed to ensure that the needs of all water licence holders are met, while ensuring the environmental flow needs for downstream aquatic systems are maintained. In 2017, the release schedule was followed closely in response to summer drought conditions that significantly compressed the allowable margins of error for managing storage in the reservoir.

Decision Making Process

The Fisheries Management Section operates in a collaborative role with all other licence holders to make decisions around dam operations. During this summer's challenging environmental conditions, FLNRORD staff became more actively involved with the dam, at the request of downstream irrigation licence holders who were unable to access their water allocations, due to lower than recommended discharge from the reservoir. Eventually adherence to the release schedule was successful in ensuring downstream irrigators were able to access their water allocations, as well as meeting the targets for maintaining environmental flow needs. All decisions around releases from the reservoir were discussed with the Missezula Water User Community. On a number of occasions the MWUC expressed concerns regarding the lower than usual reservoir level and the impact on their water withdrawl system. At no point did Fisheries Management make a decision or initiate action without the agreement of the MWUC. It eventually became clear that the community's water system could not function adequately at lower reservoir levels, and a public health and safety concern was identified. Discharge from the reservoir was reduced. This reduction was a portion of the conservation storage licence for downstream environmental flow needs and was a prioritization of public health and safety concerns over providing the preferred flows for downstream environmental health.

Section 4. Missezula Lake Water User Community's Role

Water user communities in British Columbia are incorprated and named by the Comptroller of Water Rights. They are governed by the *Water Users' Communities Act*, which is Part 3 of the *Water Sustainability Act.*

Licencing

The Missezula Water User Community's (MWUC) water allocation licences are held under the community name and they are the owner and operator of the water withdrawl, treatment, and distribution system at Missezula Lake which provides domestic water services to approximately 200 properties. The Water User Community holds 31% of the licenced storage for Missezula Lake, making them the majority licence holder, and subsequently a one third owner of the dam and associated liabilities.

Original Water Intake / System Overview

A review of the domestic water system is in progress; the following information was provided by the professional engineering firm, TRUE Consulting.

"The Missezula Lake water system was originally built in 1972 by Arvec Construction. Originally, there was a creek intake which drew source water from Dillard Creek. A chlorination building and a chlorine contact main were also present in the Dillard Creek area to provide a single barrier of treatment and a chlorine residual throughout the distribution system. The creek intake system was sited to be at the equivalent elevation of a wood stave reservoir located at the high point at the end of Prospect Drive. Therefore, the original water system was a gravity system with no pumping requirements.

In 2002 an upgrading project was carried out which replaced the creek intake with a raw water intake in Missezula Lake. This 2002 upgrading project also included the construction of the following infrastructure:

- chlorination building,
- chlorine contact chamber,
- high lift pump station, and
- emergency power supply generator building.

The design of these upgrading works allowed for a gravity supply into the chlorine contact chamber. Therefore, low lift pumps are not required for this system. Concurrent with the 2002 upgrades, the existing creek intake and the wood stave reservoir were abandoned (Sean Curry, P. Eng., TRUE Consulting, email communication, 17-Oct-2017)."

Operational Issues

In early October, the WUC experienced issues with air being drawn into their water distribution system's lines. This was caused by cavitation in the pumphouse, a result of the raw water intake being inadequate in design and function to deal with the current reservoir level. This cavitation issue may also have contributed to the burn out of one of the high lift pumps used to distribute water throughout the Missezula community.

TRUE Consulting's engineering review of the water system found "there is an issue with cavitation of the high lift pumps when the reservoir (chlorine contact chamber) level is too low. It has been recommended that a low lift pump station be installed to ensure an adequate water level within this reservoir. Note that this solution is not a straight-forward installation and will be expensive for the owner to implement if they decide to proceed in that direction (Sean Curry, P. Eng., TRUE Consulting, email communication, 17-Oct-2017)." The functionality of the system is a matter of public health and safety and one that the Water User Community is solely responsible for.

Boil- Water-Advisories

On August 13th, 2017, a Boil-Water-Advisory was issued for the Missezula Lake community. The advisory was lifted on September 5th, 2017. On September 30th, 2017, a Boil-Water-Advisory was again issued. This advisory was triggered by E. Coli and Background Growth parameter levels being outside the allowable range. This advisory was lifted on October 23rd, 2017. In 2016, similar unacceptable results from August 4th and August 11th water samples lead to Boil-Water-Advisories for the community. It is unclear, at this time, if there are specific environmental conditions in the late summer and fall which lead to declines in water quality, or if there is a direct correlation with reservoir levels.

Frequently Asked Questions:

1) **How are the licences for Missezula prioritized by the First in Time, First in Right (FITFIR) system?**

   In terms of water storage in Missezula Lake, the aforementioned irrigation licences have the earliest priority dates, followed by the Water User Community's water works , and lastly the conservation licence held by British Columbia Fish and Wildlife.

2) **How can it be appropriate to prioritize irrigation licences over those for human consumption under this framework?**

   The FITFIR system does not facilitate prioritization, based on water purpose, except in cases where the licences in question have the same application date. Water diversion, use, and storage is authorized under the *Water Sustainability Act*, which provides users with a household allocation of 250 litres per day, for essentials. One of the complications at Missezula Lake relates to the water withdrawl, treatment, and distribution system. The current water system cannot adequately withdraw water across the full range of drawdown, particularly lower levels where the reservoir level should be when managed within its license conditions.

3) **How is water use by each individual licence holder tracked?**

   Each licence holder is allocated water based on the type of use they require. Irrigation users are issued water based on the area of land being irrigated and the climate they are living in, while domestic use is based on average amount of water a household is likely to use, 2-3 cubic metres per day. Licences are reviewed when a water scarcity issue is identified, or when the system has not been reviewed for a long period of time.

4) **Why is this the first time, in recent history, the lake has been drawn down so low?**

   In 2015, a review was completed for all of the current licences for Summers Creek, to determine if they were accurate and being used. During this review it was determined that the storage licences on Missezula Lake were not being applied within the appropriate timing window. This means water was being stored when it should not have been, resulting in a higher reservoir level. Beginning in 2016, the dam was operated under the licence parameters, which involved releasing more water during the low flow months. This caused the lake level to drop below what had been seen in the past, compounded by an extremely warm summer with very little precipitation.

5) **What's wrong with the way the dam has been operated until now?**

Historically the dam has not been operated within the parameters of its licence conditions. This has contributed to water shortages downstream in Summers Creek, Allison Creek and the Similkameen River, as irrigators were withdrawing water that should be coming from in-lake storage, but instead was a portion of in-stream base flows. Given the large quantity of storage in the reservoir, that can be released during low flow periods, these creeks will see less stress on their aquatic ecosystems and fish stocks while still providing for downstream irrigation licences that are backed by the in-lake storage.

6) **If there is a surplus of water entering the reservoir outside the April 1 to June 15 storage period, why would we release this water rather than storing it? Particularly in times of increased water scarcity and drought.**

Releasing the excess water outside of the storage window allows for the entire drainage (Summers Creek, Allison Creek and the Similkameen River) to benefit from these flows. April 1 to June 15 is the freshet or spring runoff time, where large volumes of water are flowing into the lake. If the reservoir is at full pool during this period, it increases the risk of flooding and the probablility of the dam being damaged or destroyed.

If you have any additional questions or concerns, please contact Eric Hegerat, with the Fisheries Management Section, at eric.hegerat@gov.bc.ca.

Appendix 1. Three methods for determining Mean Annual Discharge in Summers Creek

Method 1 - Estimation of MAD based upon comparison amongst Ecosection averages
Over the last 100 years seasonal and continuous discharge records have been gathered by discharge monitoring stations around the province. By compiling and averaging records from stations in the same Ecosection, we can estimate the mean annual unit runoff for ungauged stations within that Ecosection.

The Summers Creek watershed is located within or close to three separate Ecosections; the calculated average runoff values for each of these Ecosections is presented in Table 7. These average runoff values are then multiplied by the area of the watersheds detailed in (Table 1). Based upon this approach the estimated mean annual discharge for the watershed upstream of the Missezula Lake dam structure would be between 508 and 725 L/sec (Table 7). This value is likely high because it does not consider anticipated evaporative losses that can occur over open water. Similarly, the estimated natural MAD at the mouth of Summers Creek ranges between 1412 and 2015 L/sec.

Table 6. Summers Creek watershed characteristics

	Summers Creek at the outlet of Missezula Lake	Summer s Creek upstream of Allison Creek
Drainage Area (km2)	116	322.5
Minimum Elevation (m)	1005	714
Median Elevation (m)	1285	1336
Maximum Elevation (m)	1769	1769

Table 7. Estimated Mean Annual Discharges in Summers Creek, based upon comparable Ecosection comparisons

Ecosection	**Mean Runoff for Ecosection (L/Km^2sec)**	**Drainage Area upstream of Missezula Lake outlet (km^2)**	**Estimated MAD at Missezula Lake outlet (L/sec)**	**Estimated MAD at Missezula Lake outlet (m^3/sec)**
Nicola Basin	4.38	116	508	0.508
Western Okanagan Upland	5.38	116	647	0.647
Okanagan Range	6.25	116	725	0.725
Ecosection	**Mean Runoff for Ecosection (L/Km^2sec)**	**Drainage Area upstream of Allison Creek confluence (km^2)**	**Estimated MAD at Allison Creek confluence (L/sec)**	**Estimated MAD at Allison Creek confluence (m^3/sec)**

Nicola Basin	4.38	322.5	1412	1.412
Western Okanagan Upland	5.38	322.5	1799	1.799
Okanagan Range	6.25	322.5	2015	2.015

Method 2 - Estimation of MAD using hydrologic subzone data (Obedkoff, 1998)
Summers Creek falls within hydrologic sub-zone b in the western portion of the Southern Interior Region described in Obedkoff (1998). Using elevation dependent runoff values for this subzone, the watershed upstream of the outlet of Missezula Lake, with a median elevation of 1285m (Table 1), would have a normal annual runoff of approximately 2.69 L/sec/km^2. The entire Summers Creek watershed, with a median elevation of 1336m would have annual runoff of approximately 3.00 L/sec/km^2(Table 8).

Table 8. Estimated Mean Annual Discharge and Low Flow 7Q10 during the summer months

Drainage Area upstream of Missezula Lake outlet				
Median Elevation	Drainage Area (km^2)	Estimated Mean Annual Unit Runoff (L/s/km^2)	**Estimated Mad (L/sec)**	**Estimated Summer 7Q10 low flow (L/sec)**
1285	116	2.69	312	25
Drainage Area upstream of Allison Creek confluence				
Median Elevation	Drainage Area (km^2)	Estimated Mean Annual Unit Runoff (L/s/km^2)	**Estimated Mad (L/sec)**	**Estimated Summer 7Q10 low flow (L/sec)**
1336	322.5	3.00	967	105 L/sec

When the estimated runoff values are extrapolated across the areas of the water sheds presented in Table 1, we calculate an estimated MAD at the outlet of Missezula Lake of 312 L/sec and a natural MAD of 967 L/sec at the mouth of Summers Creek. Obedkoff (1998) also provides an estimate of 7Q10 low flows 25 L/sec at the outlet of Missezula Lake and 105 L/sec at the mouth of the Summers Creek (Table 8).

Method 3 - Estimation of MAD using measured data (Epp, 2015)
Water Survey of Canada has operated hydrometric stations at 3 locations on Summers Creek. One station was at the outlet of Missezula Lake with seasonal flow records from 1970 to 1980, while the other two were located at the mouth of Summers Creek seasonal flow records from 1919 to 1921 and 1960 to 1966 and near the mouth with mostly seasonal records from 1973 to 1985. None of the stations are currently active. Monthly flow records for the outlet of Missezula Lake (Table 9) and Summers Creek near the mouth (

Table 10) are summarized below.

Table 9. Historical Hydrology for Summers Creek at the outlet of Missezula Creek

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
Min	-	-	-	0	0	0.001	0	0	0	-	-	-
P25	-	-	-	0	0.028	0.011	0.016	0.008	0.004	-	-	-
Mean	-	-	-	0.028	0.230	0.297	0.071	0.057	0.032	-	-	-
P75	-	-	-	0.037	0.265	0.477	0.093	0.069	0.034	-	-	-
Max	-	-	-	0.088	0.997	1.060	0.247	0.241	0.092	-	-	-

Table 10. Historical hydrology for Summers creek near the confluence with Alison Creek

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
Min	-	-	0.256	0.256	1.060	0.365	0.188	0.093	0.096	0.115	-	-
P25	-	-	0.335	0.359	1.910	1.295	0.392	0.160	0.153	0.138	-	-
Mean	-	-	0.433	0.578	3.068	1.950	0.676	0.319	0.214	0.207	-	-
P75	-	-	0.480	0.620	4.043	2.183	0.764	0.365	0.261	0.266	-	-
Max	-	-	0.620	1.510	7.050	5.930	1.980	1.060	0.417	0.317	-	-

The average monthly flows observed between April and September downstream of the Missezula Lake dam was 119 L/sec, which is lower than expected. The suspiciously low average may be the result of flow manipulation during the standard water storage period. If we assume that 85% of the annual flow occurs between April and September, we can estimate the residual MAD to be 70 L/sec. For reference the estimated downstream irrigation amount during July and August is 72 L/sec. When we add the estimated 6 L/sec estimated withdrawal from the Lake by Missezula water users (Discussed in section below), we estimate the naturalized MAD to be 76 L/sec (Table 11). As mentioned earlier this does not take into account flow control at the Missezula Lake dam.

In order to calculate inflows to Missezula Lake we need to factor in the hydrologic losses to evaporation from the lake surface. Epp (2015) estimated the average annual loss to be 49 L/sec. This value represents an approximately loss of 2 acre feet of loss from the entire surface of the 635 acre lake, over the course of the entire year. When the estimated losses from evaporation are added to the naturalized discharge at the mouth of Missezula Lake inflows are estimated to be 125 L/sec (Table 11).

Table 11. Hydrology estimates for the Summers Creek watershed

Outflows from Missezula (Annual avg. L/sec)	Evaporation from Missezula (Annual avg. L/sec)	Inflows to Missezula (Annual avg. L/sec)	Discharge at Mouth of Summers (Annual avg. L/sec)
76	49	125	667

Assuming that 85% of the annual flows occur between April and September, the historic residual discharge measurements gathered at the mouth of Summer Creek would suggest that the residual MAD would be 667 L/sec (Table 11). This value does not include the licensed demand or the potential irrigation withdrawals that are and are not backed by storage.

MAD estimates from both the dam and the mouth of Summers creek are well below the hydrologic estimates made using comparisons of Ecosections and regionalization (Obedkoff, 1998). I would suggest that unknowns pertaining to the influence of the Missezula Lake Dam are leading to an underestimate of the MAD. This underestimate might be the result of higher than typical flows between October and March (greater than 15% of the annual discharge) which could be supported by the storage behind the dam and consistent releases over the fall and winter.

Appendix 2. Determining Environmental Flow Need in Summers Creek based on Fish Stock Parameters.

Periodicity and Presumptive Standards

When developing EFNs we attempt to establish flow guidelines that protect the different activities and life stages of the fish inhabiting the stream. This often requires establishing several EFNs for different periods throughout the year. For this assessment, the life stages and activities of the rainbow trout and bull trout populations were used to develop these seasonal flow thresholds. As a general practice EFNs are established based upon flow guidelines published in Ptolemy and Lewis (2002). These presumptive standards are calculated and reported as a percentage of MAD, for the relevant fish activities and fish life stages utilizing the creek. In situations where detailed channel geometry and hydraulic information is available, detailed assessment may provide justification for a departure from the presumptive standards.

Migration

Rainbow trout will migrate into the Summers Creek watershed during the spring, reaching the spawning areas by mid-May. This migration is not typically constrained by flows, as the migration period coincides with higher spring flows (Table 12). The brook trout migration period in the watershed likely begins around mid-August and may run through to mid-September. brook trout will migrate opportunistically as conditions permit, with fish movements upstream coinciding with discharge pulses associated with precipitation. Typically, the brook trout migration will end when the individuals reach a section of channel with consistent cool and clean flows.

Ptolemy and Lewis (2002) recommend an EFN target equal to $148*(MAD)^{-0.36}$, which for Summers Creek at the outlet of Missezula Lake would equal 225% of MAD or 702 L/sec. During the fall of 2016, Summers Creek never reached this flow level at the outlet of Missezula Lake indicating that either fish did not successfully migrate into the reach or they are able to migrate at a lower flow. At the mouth of Summers Creek the presumptive migration threshold would be 149% of MAD or 1440 L/sec. These thresholds are commonly met during the spring of the year and therefore are satisfied for the migrating rainbow trout. During the migration period of the brook trout 2016 flows in the Creek did not surpass 349 L/sec, which is well below the 1440 L/sec suggested by the presumptive thresholds. Based upon this it is clear that brook trout are migrating at lower than optimal flows.

Detailed measurements gathered at a riffle near the mouth provide some understanding of how fish migration potential changes with flow (Figure 3). For this passage assessment I assumed that migrating adult brook trout require a minimum of 14cm of water to accomplish migration. A general guideline is to maintain at least 25% of contiguous passage width to ensure safe and successful migration through a reach (CDFG, 2013).

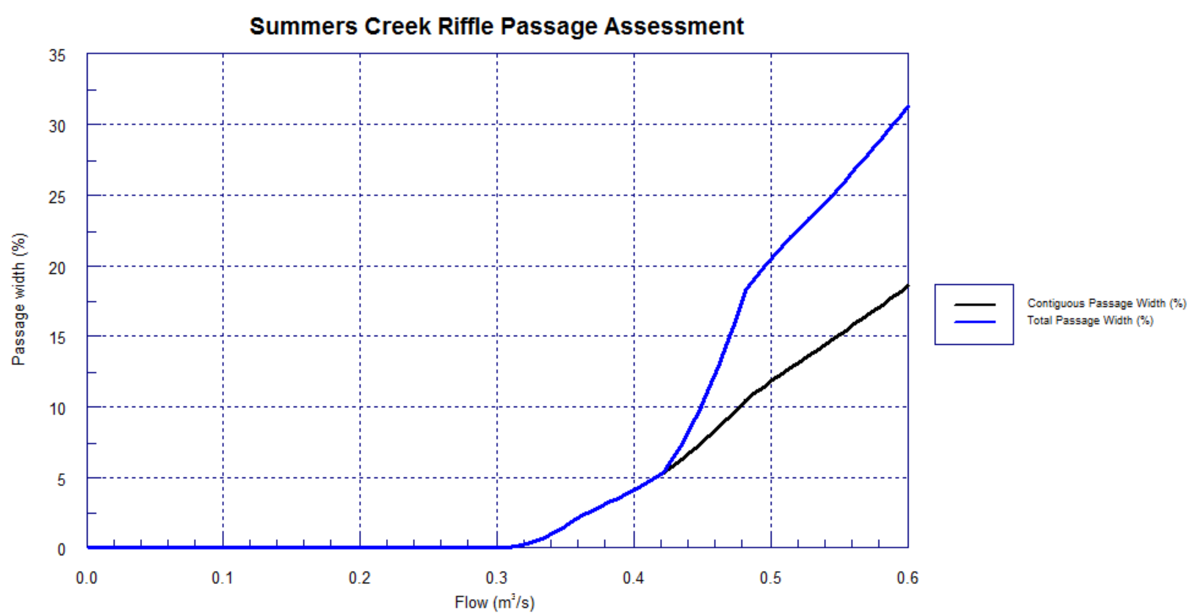

Figure 3. Summers Creek riffle passage assessment

Based upon the hydraulic modelling Summers Creek is unlikely to reach 25% of contiguous passage width below 600 L/sec. In this situation it is unreasonable to establish a migration EFN that exceeds the natural range of flows. Recognizing the apparent flow limitations, migration may happen to a limited extent between 0.4 m^3/sec and 0.5m^3/sec (400 and 500 L/sec). This may be the best situation we can expect to achieve at the mouth of Summers Creek.

The ministry recommends releasing a volume equal to 40% of MAD from the Missezula Lake outlet during the brook trout spawning period. While this will not likely correspond to a discharge of 40% MAD at the mouth of Summers Creek, it will provide some base flow. In the event that the watershed receives some precipitation this base flow would help the Creek reach appropriate discharge levels.

For a rainbow trout spawning target, we recommend the presumptive target of 149% of MAD at the mouth of the Summers Creek. This should not be too difficult to achieve as the local watershed downstream of Missezula Lake should be sufficient to meet these requirements. Recognizing that this is an important time for refilling the reservoir we recommend releasing a volume equal to 20% MAD from the outlet of Missezula Lake, based upon the understanding that flows from Dillard Creek would provide suitable migration flows approximately 200m downstream of the dam.

Table 12. Migration periods and associated EFNs

Species and Activity	Time period	EFN
Brook Trout Migration	August 15th – September 30th	40% of MAD
Rainbow Trout Migration	May 1st –June 31st	149% of MAD (at mouth)

Spawning

Brook trout spawning typically occurs between September and November and may coincide with short duration high discharge events associated with precipitation. Rainbow trout spawn during periods of consistently higher flows in May and June. In regards to Environmental Flow Needs (EFNs), Ptolemy and Lewis (2002) recommend spawning flow targets equal to that of migration. For Summers Creek this equals 40% of MAD (see discussion in migration section for details) or 125 L/sec (Table 13).

Detailed measurements gathered at a riffle near the mouth of Summers Creek provides some understanding of how fish spawning potential changes with flow (Figure 4). For the spawning assessment, area weighted suitability reflects the amount of suitable spawning habitat that may be present in run and glide habitats. This modelling is informed by the measured depth and velocity characteristics at discrete points across representative transects and is based upon the habitat preferences of rainbow trout. As flows change, the depth and velocity characteristics change across the transect leading a change in the habitat suitability score. The result is a cumulative score for potential habitat and varying flows.

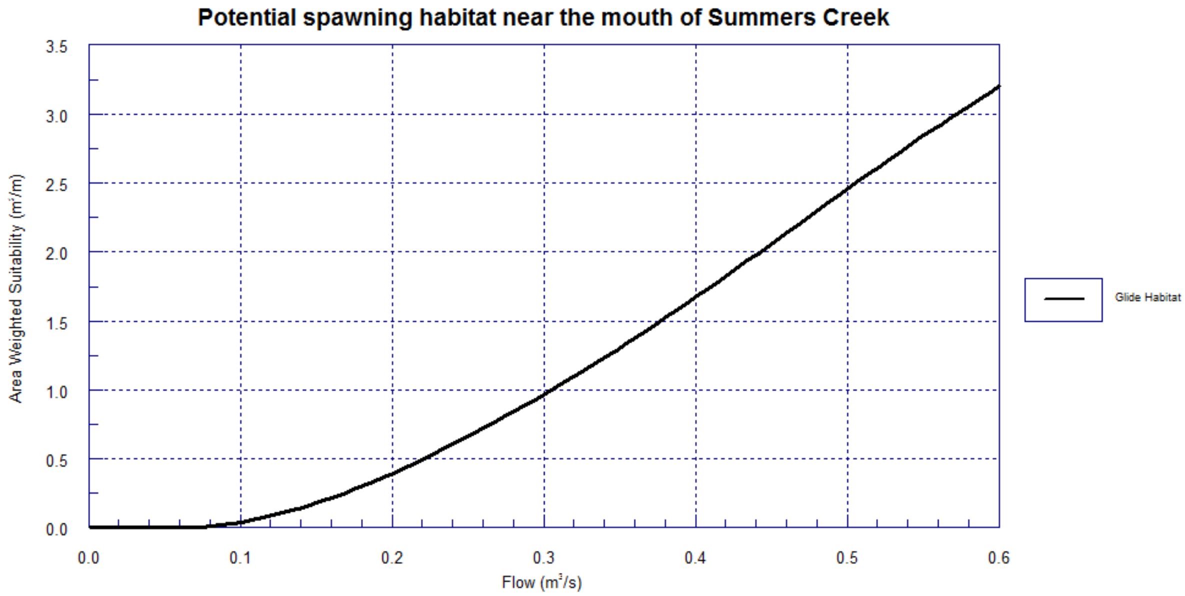

Figure 4. Summers Creek spawning habitat and flow assessment

Based upon the hydraulic modelling of Summers Creek, there appears to be some potential habitat at flows around 0.4 m^3/sec (equal to 400 L/sec and ~40% MAD at the mouth) at the mouth of the Creek. This discharge would certainly not provide optimal conditions, however, recognizing the flow challenges in Summers Creek it may be an optimistic target for the mouth of the Creek.

As with the migration flows, a volume equal to 40% of MAD should be released from the Missezula Lake outlet during the brook trout spawning period. While this will likely not correspond to a discharge of 40% MAD at the mouth of Summers Creek, it will provide some base flow. In the event that the watershed receives some precipitation this base flow would help the Creek discharge reach appropriate levels.

If a rainbow trout spawning target was established, a presumptive target of 149% of MAD should be met. This should not be difficult to achieve as the local watershed downstream of Missezula Lake should meet these requirements. Recognizing that this is an important time for refilling the reservoir, a volume equal to 20% MAD should be released from the outlet of Missezula Lake, based upon the understanding that flows from Dillard Creek would provide suitable migration flows approximately 200m downstream of the dam.

Table 13. Spawning periods and associated EFNs

Species and Activity	Time period	EFN
Brook Trout Spawning	September 1st – November 30th	40% of MAD
Rainbow Trout Spawning	May 1st –June 31st	149% of MAD (at mouth)

Rearing

Rearing flow targets have been established to maintain riffle wetted width and ensure proper development and transport of aquatic insects for rearing fry and juveniles. In Summers Creek they apply to rearing rainbow and brook trout juveniles but will also support other non-game species. In this assessment the flow targets for rearing have been applied to all periods that were not considered critical migration or spawning periods. Ptolemy and Lewis (2002) recommend 20% of MAD to maintain healthy aquatic community functioning during rearing periods, this equals 62L/sec at the outlet of the lake and 193 L/sec at the mouth of Summers Creek (Table 1).

Table 14. Rearing periods and associated EFNs

Species and Activity	Time period	EFN
Bull Trout Rearing	July 1st to August 14th	20% of MAD (62 L/sec) outlet
Rainbow Trout Rearing	July 1st to August 14th	20% of MAD (62 L/sec) outlet

Overwintering

For Summers Creek, we established the EFNs at 20% of the MAD or 62 L/sec at the outlet of the lake, which is equal to the rearing flow requirements and the flow targets specified in Ptolemy and Lewis (2002).

Table 15. Overwintering periods and associated EFNs

Species and Activity	Time period	EFN
Bull Trout Overwintering	November 1st to April 31st	20% of MAD (62 L/sec)
Rainbow Trout Overwintering	November 1st to April 31st	20% of MAD (62 L/sec)

References

Ptolemy RA and A Lewis. (2002) Rationale for Multiple Instream Flow Standards to Maintain Ecosystem Function and Biodiversity. Draft for Agency Review. Prepared for Ministry of Water, Land and Air Protection and Ministry of Sustainable Resource Management.

Obedkoff, W. (1998) Streamflow in the Southern Interior Region. Province of British Columbia, Ministry of Sustainable Resource Management, Water Information Section, Aquatic Information Branch.