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Research Brief

From the Okanagan Bioregion Food System Project 2021

Water Supply, Demand and Availability in the Okanagan Bioregion: *Case Study Assessments for Trout Creek, Mission Creek and Shingle Creek*

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Abstract

The Okanagan is among the hottest and driest regions in Canada. While the bioregion has many large lakes and numerous streams, low precipitation, high temperatures, variable streamflow and increasing human activities make water availability a growing concern. Historically, the Okanagan has been home to many aquatic species, adapted to the native conditions in the region. Human activities since colonization, including increasing water diversions and land use changes, have deteriorated aquatic habitats and caused population declines in many native species. Stewarding aquatic environments and providing for the water needs of communities into the future is a critical and imminent sustainability challenge in the region.

This study examines water supply, demand and ecological water needs in three sub-basins in the Okanagan watershed to assess water availability under "typical" and dry year conditions. The assessment highlights the potential for water stress in the region, and how high water stress conditions are likely to occur in droughts years. Climate change projections anticipate increased frequency and intensity of drought, and this study reinforces the need for coordinated water management to support ecological stewardship and human wellbeing into the future.

Context

The Okanagan Bioregion Food System Project explores the food self-reliance, ecological and economic potential of advancing a regionalized food system in the Okanagan. The project models a suite of scenarios that change the mix of crop and livestock produced on the cultivated land base, varying the total agricultural water demand in the bioregion. Scenarios model crop and livestock production for the existing cultivated land base (2016) as well as a theoretical expanded land base. While agriculture in these hypothetical expanded land base scenarios is limited to land that is reasonably close to a water supplier, it is recognized that proximity to a water source is not sufficient to ensure access to water. Water availability, considering both human and ecological needs, must be considered in food system decisions. Therefore, this assessment examines water availability in the region and comments on the potential for, and risk associated with, increased water demand from agriculture.

Case Study Sub-basins

This study assesses water availability in three sub-basins within the Okanagan watershed; Trout Creek, Mission Creek, and Shingle Creek. Case study sub-basins were selected to represent a significant portion of the region's land base, while reflecting typical land use patterns and activities. Mission Creek and Trout Creek are the two largest watersheds in the Okanagan basin. Collectively the selected sub-basins comprise approximately 25% of the Okanagan Basin. Forestry and grazing are prominent in the watersheds' upper reaches, while agriculture and urban development are prominent in the lower reaches. Table 1 provides a brief description of each sub-basin.

Declines in Fish Populations

Freshwater ecosystems in the Okanagan support diverse species of culturally and ecologically important plants and animals. These include populations of Kokanee, Chinook, and Sockeye salmon, and Steelhead and Rainbow trout. Salmon and trout have relatively sensitive habitat requirements, and these species are often used as indicators of overall aquatic ecosystem health. Salmon and trout populations in the Okanagan have declined substantially over the last few decades. This has been attributed to habitat degradation from human activities such as water withdrawals, stream channelization, land development, diking, and streamside vegetation removal. For example, Mission Creek, which has historically supported the largest stream-spawning Kokanee salmon population in the Okanagan, has seen significant declines of spawning salmon. While historic data on spawning salmon populations is sparse, records report 50,000 (Wightman & Taylor, 1978) to 380, 000 (ONA, 2020; Wightman & Taylor, 1978) Kokanee returning to spawn in Mission Creek in the 1970s. Between 2010 and 2017, these estimates are substantially lower, ranging from 7,000 to 32,000 (ONA, 2020). Furthermore, it's estimated that 90% of salmon spawning habitat in streams north of Penticton was lost by the 1950s (FOC, ONA, BC Ministry WLAP, 2005).

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Table 1: Description of three case study sub-basins. Source: ONA, 2016

Sub-basin	Drainage Area	Location of Mouth	Primary Land Use Activities	Primary Water Suppliers
Mission Creek	845 km²	Okanagan Lake, at Kelowna	Agriculture, forestry, grazing, urban development	Black Mountain Irrigation District, Southeast Kelowna Irrigation District
Trout Creek	745 km²	Okanagan Lake, at Summerland	Agriculture, forestry, grazing, urban development	District of Summerland
Shingle Creek	300 km²	Okanagan River, between Okanagan Lake and Skaha Lake	Agriculture, forestry	Penticton Indian Band

Methods

Water Supply and Demand

The Okanagan Hydrologic Modelling Environment [OHME] (Associated, 2020a), developed for the Okanagan Basin Water Board, provided modelled naturalized streamflow data for the mouth of each stream. Naturalized, or natural, streamflow data refers to water flow rates without alterations or withdrawals. Hydrographs depicting weekly median streamflow were derived from long-term mean weekly flow calculated for the 1996-2017 period.

Modelled weekly water demand data was obtained from the Okanagan Basin Water Board (OBWB, 2020) using the Agricultural Water Demand Model (Ministry of Agriculture, 2015), updated to reflect the 2016 land use inventory. Water demand is estimated as the sum of demand for the following water uses: agricultural crops, livestock, commercial indoor, industrial indoor, institutional indoor, recreational, residential indoor, and domestic outdoor. Weekly demand data was modelled for climate years 2003 and 2010. These years represent a hot-dry and 'typical' (not anomalously hot-dry nor wet-cool) conditions, respectively. Water demand data includes demand from surface water sources only. In the case study basins, approximately 70-95% of water demand is supplied by surface water sources (Table 2).

Environmental Flow Needs

Environmental Flow Needs (EFNs) aim to describe the streamflow required to ensure that the needs of aquatic species are met throughout their lifecycle. Risk to aquatic species increases as flow rates decrease below EFN thresholds. The sustainable boundaries approach estimates EFNs as a percentage of natural flows (Richter et al., 2012), assigning increasing levels of risk to greater alterations in natural flow. The approach suggests the least ecological risk can be achieved if flow alterations do not exceed 10% of natural flow, and that moderate levels of risk are associated with alterations between 11%-20% of natural flows (Figure 1) . The framework suggests that alterations greater than 20% will result in moderate to major changes in ecological function, with greater risk associated with greater changes to flow (Richter et al., 2012). While alterations include both flow reductions and increases, this study examines reductions.

The sustainable boundary approach aims to preserve the natural variability of streams by recognizing the importance for aquatic ecosystems of sustaining high flow periods as well as meeting minimum flows. A notable limitation of this generalized, or presumptive, approach is that it does not consider site-specific requirements that may be presented by at-risk species or unique ecological conditions that exist in the Okanagan.

The sustainable boundaries approach was selected for this high-level assessment in order to describe the potential to mitigate ecological risk. It is important to note that the Okanagan Nation Alliance recently completed environmental flow assessments for 19 streams in the Okanagan (ONA, 2020). These assessments, which consider local species and ecologies, are more appropriate in developing site-specific water management strategies. This study, while informed by the recently developed site-specific EFNs, uses the sustainable boundaries approach to illustrate the capacity to mitigate risk to aquatic ecosystems under typical and drought conditions.

Sub-basin	Annual Water Demand (million m3)	Water Source	Annual Water Demand by source (million m3)	% of Annual Demand by Source
Mission Creek	13.96	ground	0.65	5%
		surface	13.31	95%
Trout Creek	3.84	ground	0.72	19%
		surface	3.12	81%
Shingle Creek	0.62	ground	0.18	29%
		surface	0.44	71%

Table 2: . Total annual water demand from surface and ground water sources for three case study sub-basins. Data source: OBWB, 2020

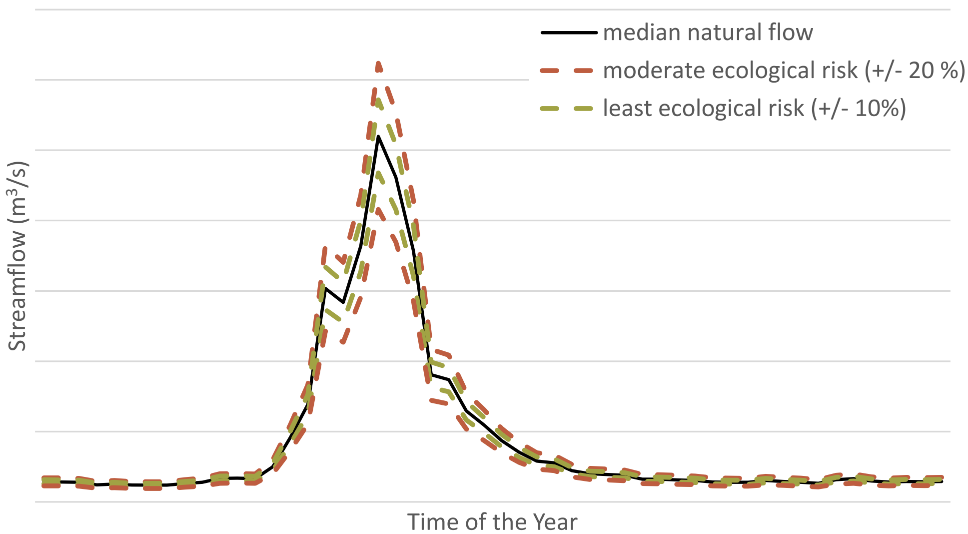


Figure 1: Illustration of sustainable boundary approach for estimating ecological flow needs, adapted from Richter (2010).

EFN volumes for typical conditions were derived from median weekly natural streamflow data modelled for 1996-2017. EFN volumes for dry year conditions were derived from natural flows modelled for the year 2003. It is important to note that, while native species may be adapted to natural low flow conditions in the Okanagan, drought years present additional stress and the sustainable boundaries approach may underestimate EFN thresholds. For example, flow reductions of 10%, while still presenting favorable conditions relative to flow reductions of 20%, may not provide adequate protection for freshwater species during drought years, when natural conditions present considerable stress.

Water Balance

A weekly water balance was calculated by subtracting both EFN flows and water demand from natural streamflow. To do this, weekly natural streamflow and EFN flows (m^3/s) were converted into weekly volumes and reported as Inflow (million m^3) and EFN flows (million m^3), respectively. For each sub-basin, four weekly water balances were calculated, representing two different EFN flows and two different climate conditions.

The first EFN flow represents stream conditions associated with the least ecological risk, defined by a maximum of 10% reduction of natural flow. The second represents stream conditions associated with moderate ecological risk, defined by flow a maximum of 20% reduction of natural flow.

Weekly water balances were calculated for each sub-basin for both typical and dry year conditions. A typical year is represented by a) the median modelled weekly streamflow based on the 1996-2017 period and b) water demand modelled for the 2010 climate year. A dry year is represented by a) modelled weekly streamflow for the year 2003, and b) water demand modelled for the 2003 climate year.

Annual potential water for storage and annual overshoot

Given that peak water demand consistently coincides with periods of low summer streamflow, the Okanagan relies on water storage early in the year, when streamflow is highest and demand is relatively low, to meet water demand later in the year. This study assessed the potential of early season water storage to meet both human demand and mitigate risk to aquatic ecosystems. The annual potential available water for storage was assumed to be the sum of weekly positive water balances from week 1-19, or week 1-20, depending on the sub-basin. While the period of high streamflow from snowmelt, or the freshet, typically lasts until mid-June, site-specific EFN assessments for all sub-basins show a substantial increase in EFN flows in late May (ONA, 2020b). During this period, EFN rates increase to match natural streamflow values to ensure that sufficient streamflow is available during the freshet for stream channel maintenance. This includes linking side channels, flooding wetlands, transporting sediment, and other processes that maintain the physical habitat attributes important for these aquatic ecosystems (Schmidt & Potyondy,2004; ONA, 2020). For Mission Creek and Shingle Creek, EFN flows increase in week 20. For Trout Creek, this occurs in week 19 (ONA, 2020b).

Positive weekly water balances occurring after the spring freshet did not contribute to potential water for storage. This conservative approach was adopted to account for the relatively high variability of summer streamflow. Therefore, the annual period for storage accumulation was limited to weeks 1-19 for Trout Creek, and weeks 1-20 for Mission and Shingle Creek.

Annual overshoot was therefore defined as the sum of negative weekly water balances from week 20– 52 for Trout Creek, and from week 21– 52 for Mission Creek and Shingle Creek.

Water Availability

Water availability was determined by comparing the annual potential available water for storage to the annual overshoot. For each year and sub-basin, water availability conditions were determined as follows:

- **Low water stress conditions:** Annual potential available water for storage > annual overshoot using EFN flows for least risk to aquatic ecosystems (90% natural flow)
- **Moderate water stress conditions:** Annual potential available water for storage > annual overshoot using EFN flows for moderate risk to aquatic ecosystems (80% natural flow) but less than the annual overshoot using EFN flows for least risk to aquatic ecosystems (90% natural flow)
- **High water stress conditions:** Annual potential available water for storage < annual overshoot using EFN flows for moderate risk to aquatic ecosystems (80% natural flow)

Water availability, or the capacity of stored water to meet both extractive and instream water needs, was assessed for a typical year and a dry year. Comparing these two scenarios highlighted the impact of natural streamflow variations on water availability.

Results & Discussion

Water Supply and Demand

In the Okanagan, most precipitation falls during the winter months, accumulating as snow at high altitudes. Consequently, the majority of runoff occurs during April, May and June as the snowpack melts. Discharge rates throughout the rest of the year are comparatively quite low. This flow pattern puts water supply out of step with water demand, which peaks during the agricultural growing season. In the Okanagan, agriculture accounts for approximately 70% of water demand for human uses (OWSC, 2020). In the three case study sub-basins, agriculture accounts for 80%-90% of water demand (OBWB,2020). Figure 2 illustrates weekly streamflow and water demand for Trout Creek, highlighting both the mismatch between peak streamflow and peak water demand, and the portion of total water demand dedicated to agricultural use. Analogous representations of weekly natural streamflow and water demand for Mission Creek and Shingle Creek are provided in Appendix A and B, respectively. Figure 2 also illustrates the high degree of inter-annual variability in streamflow, which is typical for the region. For example, in Trout Creek the mean annual discharge ranged from a minimum of 0.95 m^3/s in 2003, to a maximum of 8.34 m^3/s in 2017.

Environmental Flow Needs

EFNs aim to describe the streamflow required to sustain freshwater species throughout their lifecycles, including spawning, incubation and rearing of young, migration of adults and juveniles, over-wintering, and maintenance of aquatic habitats (ONA, 2020). The sustainable boundaries framework (Richter, 2010) assigns increasing levels of risk to increasing alterations of natural flow. The framework defines zones of least and moderate ecological risk as flow alterations of less than 10% and 10-20%, respectively. Figure 3 illustrates the ecological flows associated with these two levels of ecological risk for Trout Creek, based on median naturalized streamflow 1996-2017.

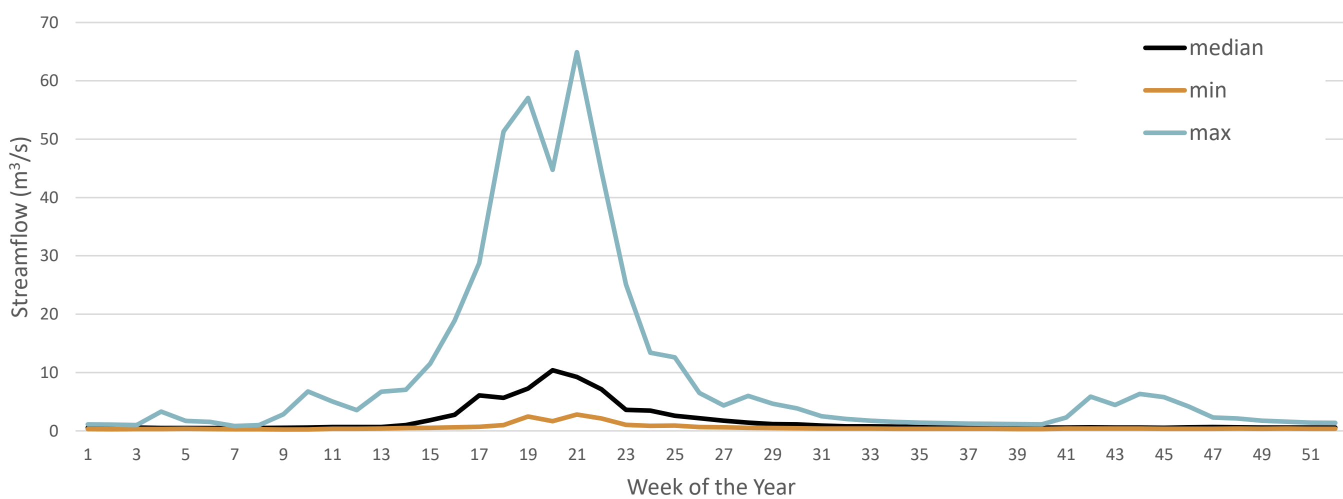
Water Balance and Availability

Typical Climate Conditions Scenario

Figure 4 illustrates the components of a water balance for Trout Creek including weekly water volumes for inflow (positive blue values), demand (negative red values) and EFN flows (negative yellow values) . Water balance components are shown for least ecological risk (Figure 4A) and moderate ecological risk (Figure 4B). Weekly inflow and EFN volumes peak in late May, during the spring freshet. In Trout Creek, total annual inflow under typical conditions is 54.3 million m³ (Table 4).

Water demand is driven by agricultural water needs, and peaks in late July at 0.3 million m³ per week. During the months of July and August (week 26 – 34), when demand is highest and streamflow is low, water demand for human uses ranges from 15%-50% of

Trout Creek: Median Natural Streamflow 1996-2017



Trout Creek: Weekly Water Demand by Use Category

Modelled for 2010 climate conditions

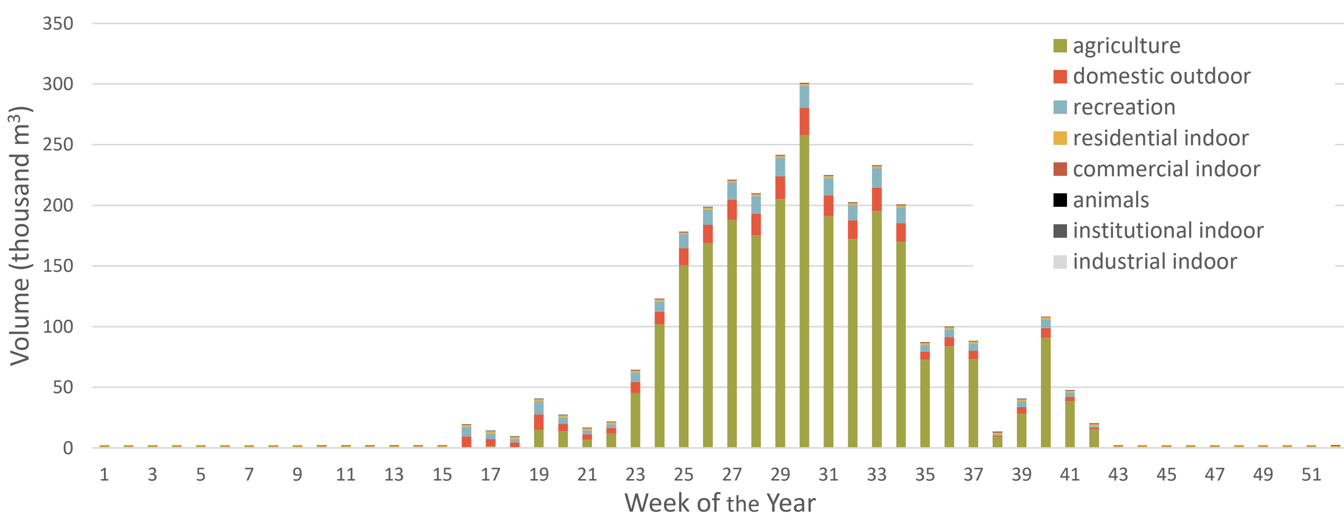


Figure 2: TOP: Median, minimum, and maximum naturalized streamflow (m³/s) (modelled) for Trout Creek, derived from weekly flow 1996-2017. Data Source OHME naturalized streamflow (Associated, 2020). BOTTOM: Weekly water demand (thousand m³) for Trout Creek by use category, modelled using 2010 climate data. Data Source OBWB, 2020.

inflow. This mismatch between water supply and demand is reflected in negative water balances (Figure 4A & 4B, bottom), or overshoot, that must be compensated for by early season water storage. EFN conditions for least ecological risk require relatively larger EFN flows. This is reflected in the more frequent and larger negative water balance volumes for EFN conditions for least ecological risk (Figure 4A, bottom), relative to EFN conditions for moderate ecological risk (Figure 4B, bottom). Appendix A and B provide analogous water balance figures for Mission Creek and Shingle Creek.

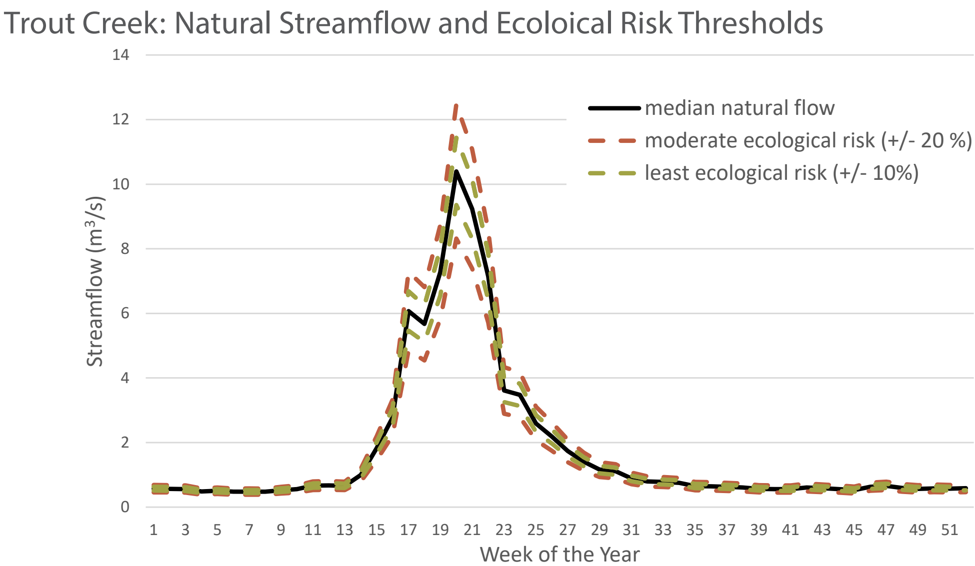


Figure 3. Trout Creek median natural flow (m3/s) and sustainable boundaries corresponding to least ecological risk (10% alternation of natural flow) and moderate ecological risk (20% alteration of natural flow).

Table 3 summarizes the annual water balances under typical climate conditions for all case study sub-basins by reporting the annual potential available water for storage and the annual overshoot. Sustaining EFN conditions for least ecological risk requires more water relative to EFN conditions for moderate ecological risk. Therefore, annual overshoot volumes are greater (more strongly negative) for EFN conditions with least ecological risk relative to those with moderate ecological risk. Appendix C reports weekly water volume and balance values for all sub-basins.

In Trout Creek, when water balance calculations use EFN flows corresponding to moderate ecological risk, the annual potential available water for storage is estimated as 3.7 million m³. Annual overshoot in this scenario is estimated as -0.9 million m³. When water balance calculations use EFN flows corresponding to least ecological risk, the potential available water for storage and annual overshoot are 1.8 million m³ and -1.7 million m³, respectively. Under the assumptions for typical climate conditions, the potential available water for storage is sufficient to meet human demand and EFN flows associated with the least ecological risk. Therefore, low water stress conditions are assigned to Trout Creek in the typical climate conditions scenario. It should be noted here that overshoot is almost equivalent to annual potential available water for storage, suggesting limited “surplus” water in the system under typical climate conditions.

In Mission Creek, the annual potential water available for storage (9.8 million m³) is sufficient to meet annual overshoot for moderate ecological risk (- 3.8 million m³). However, when EFN flows for least ecological risk are used in the water balance, annual potential water available for storage (4.4 million m³) is insufficient to meet the associated annual overshoot (- 6.7 million m³). Therefore, under the assumptions for typical climate conditions, moderate water stress conditions are assigned to Mission Creek.

In Shingle Creek, the annual potential water available for storage using EFN flows for moderate ecological risk and least ecological risk are 0.8 million m³ and 0.4 million m³, respectively. These storage volumes are sufficient to meet annual overshoot for both moderate ecological risk (- 0.1 million m³) and least ecological risk (- 0.2 million m³). Therefore, low water stress conditions are assigned to Shingle Creek under typical climate conditions.

Dry Climate Conditions Scenario

The year 2003 was a notable drought year in British Columbia and the Okanagan. A combination of low snowpack, hot and dry summer conditions, and late fall rains reduced water levels and caused water shortages throughout the region. For example, the District of Summerland declared a state of emergency over insufficient water supplies for meeting both human and ecological needs (OWSC, 2008).

These conditions are reflected in all case study sub-basins; total annual inflow in the dry year scenarios are notably lower than inflow in typical conditions. In Trout Creek, total annual inflow in the dry year scenario is 55% of total annual inflow in typical conditions. For Mission Creek and

Trout Creek, Typical Year Climate Conditions

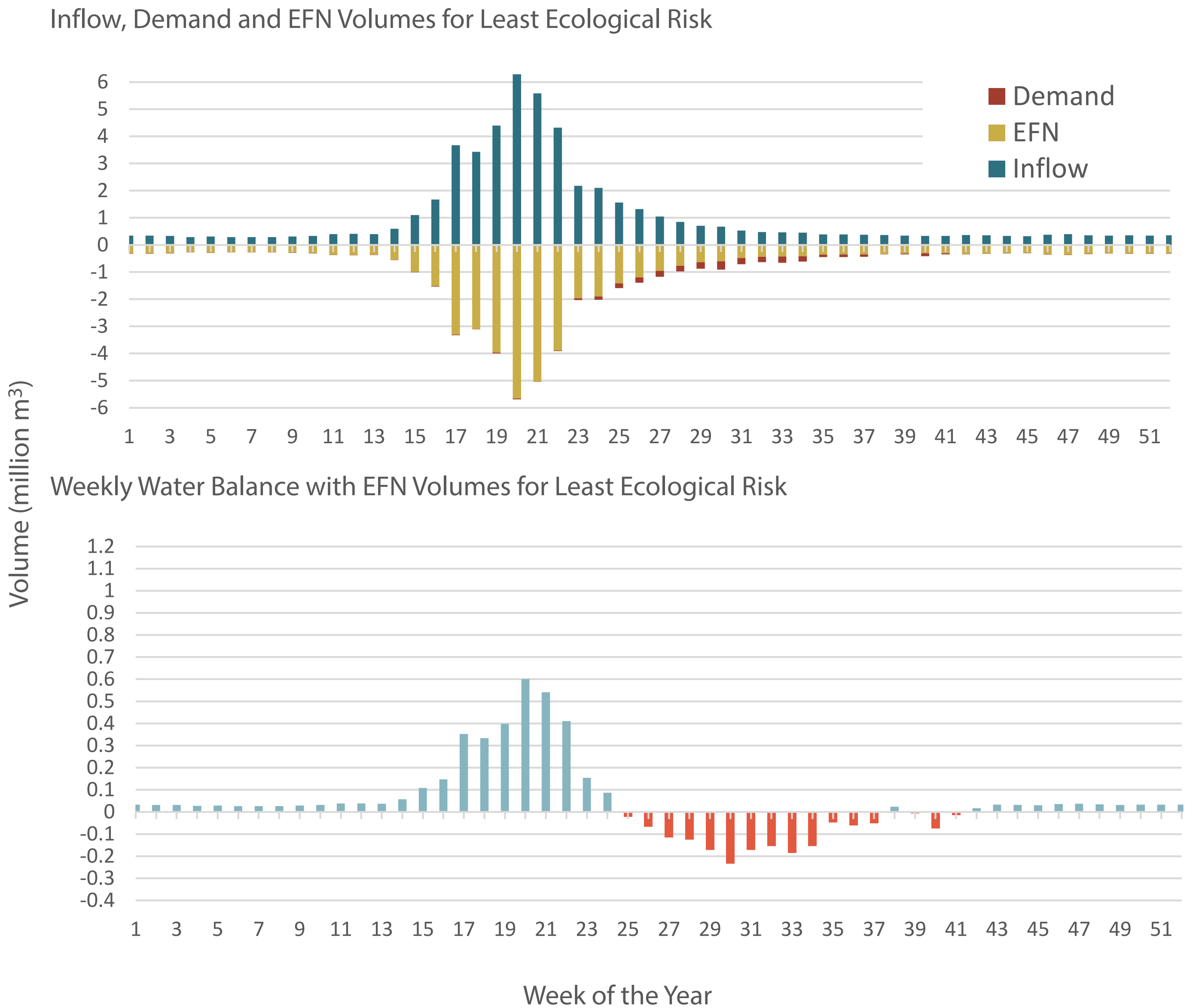


Figure 4A: TOP. Water balance components including weekly Inflow (blue), EFN volumes for least ecological risk (yellow) and demand (red) for Trout Creek, modelled for typical climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance in Trout Creek, modelled for typical conditions with EFN volumes for least ecological risk. Positive weekly water balance volumes indicated in blue and negative weekly water balances indicated in red.

Shingle Creek, total annual inflow for the dry year scenario is 85% and 35% of total annual inflow under typical conditions, respectively (Table 4). Across all case study basins, total annual water demand in the dry year scenario is approximately 40% greater than total annual water demand under typical conditions.

In Trout Creek, during the period of peak water demand in the months of July and August (weeks 26-34), water demand for human uses ranges from 67%-112% of inflow. As such, weekly overshoot volumes (Figures 5A & 5B, bottom) are larger than those estimated for the typical climate conditions scenario (Figures 4A & 4B, bottom). As is the case in the previous scenario for typical climate conditions, overshoot volumes are greater (more strongly neagative) when the water balance accounts for EFNs volumes for least ecological risk relative to moderate ecological risk.

Trout Creek, Typical Year Climate Conditions

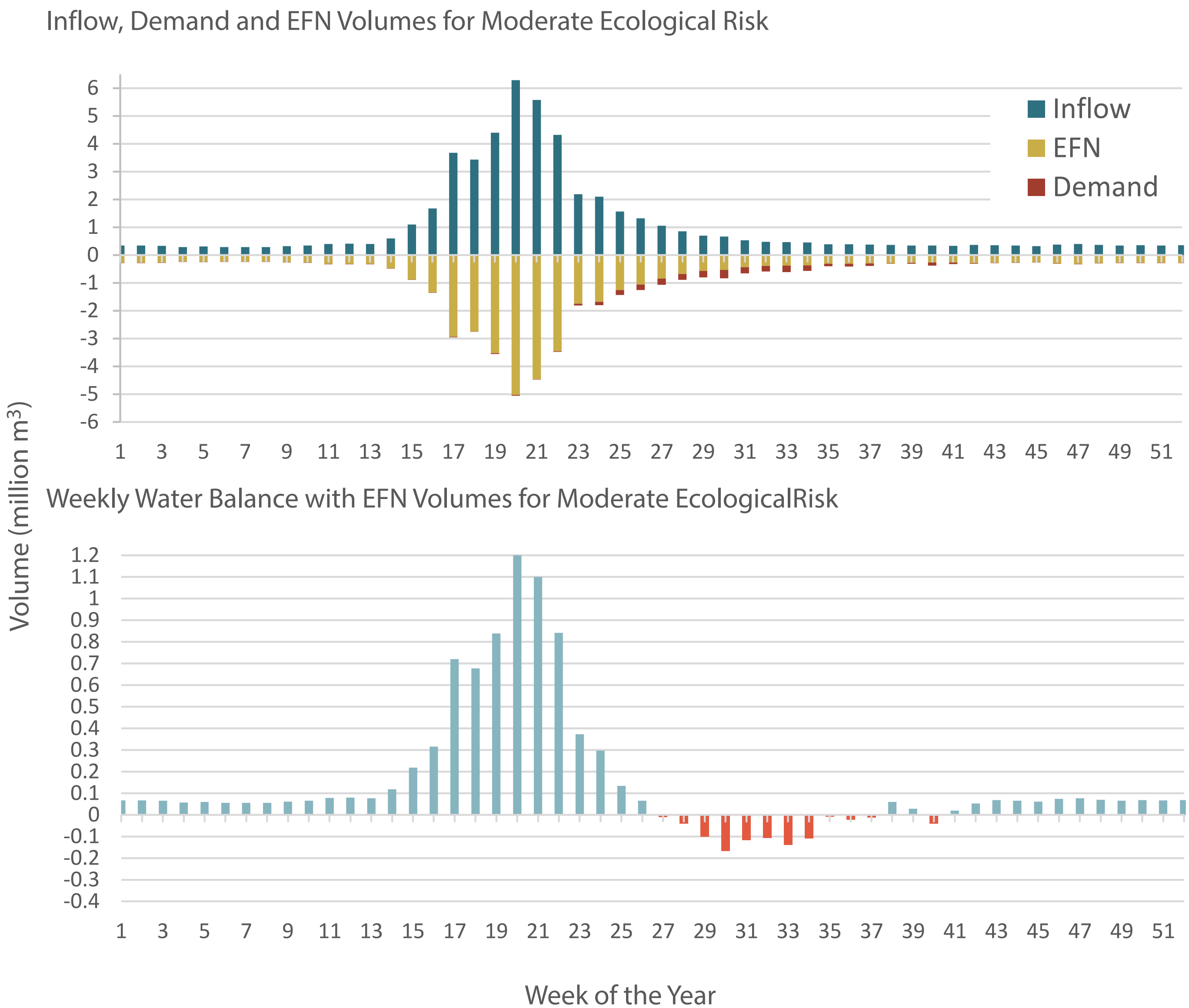


Figure 4B: TOP. Water balance components including weekly Inflow (blue), EFN volumes for moderate ecological risk (yellow) and demand (red) for Trout Creek, modelled for typical climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance in Trout Creek, modelled for typical conditions with EFN volumes for moderate ecological risk. Positive weekly water balance volumes indicated in blue and negative weekly water balances indicated in red.

Typical Conditions	EFN volumes for moderate ecological risk	EFN volumes for least ecological risk
Trout Creek		
Annual potential available water for storage (million m³)	3.7	1.8
Annual overshoot (million m³)	- 0.9	- 1.7
Mission Creek		
Annual potential available water for storage (million m³)	9.8	4.4
Annual overshoot (million m³)	- 3.8	- 6.7
Shingle Creek		
Annual potential available water for storage (million m³)	0.8	0.4
Annual overshoot (million m³)	- 0.1	- 0.2

Table 3: Typical year climate conditions: Annual potential available water for storage and annual overshoot (million m^3) for case study sub-basins using EFN flows for moderate and least ecological risk.

	Mission Creek (million m³)		Trout Creek (million m³)		Shingle Creek (million m³)	
	Typical	Dry	Typical	Dry	Typical	Dry
Supply						
Total annual inflow	163.7	136.3	54.3	29.8	15.1	5.2
Peak weekly inflow	17.8	14.8	6.3	3.6	2.2	0.7
Demand						
Total annual demand	-13.3	-18.1	-3.1	-4.4	-0.4	- 0.6

Table 4: Summary of changes in water supply and demand between typical and dry year scenarios. All inflow values are recorded as positive and all water demand values are recorded as negative.

Dry Conditions	EFN with Moderate Ecological Risk (million m3)	EFN with Least Ecological Risk (million m3)
Trout Creek		
Annual potential available water for storage (million m3)	2.7	1.3
Annual overshoot (million m3)	-2.8	-3.4
Mission Creek		
Annual potential available water for storage (million m3)	6.5	2.7
Annual overshoot (million m3)	-9.4	-11.4
Shingle Creek		
Annual potential available water for storage (million m3)	0.4	0.2
Annual overshoot (million m3)	-0.3	-0.4

Table 5: Dry year climate conditions: Annual potential available water for storage and annual overshoot for case study sub-basins using EFN flows for moderate and least ecological risk.

Table 5 reports the annual potential available water for storage and the annual overshoot for all case study basins when dry year climate conditions are modelled. Appendix C provides weekly water volumes and water balance values for reference. In Trout Creek, when the water balance uses EFN flows corresponding to least ecological risk, the annual potential available water for storage is estimated as 1.3 million m³. Annual overshoot in this scenario estimated as - 3.4 million m³. If the water balance accounts for EFN volumes that correspond to moderate ecological risk, then the potential available water for storage and annual overshoot are 2.7 million m³ and -2.8 million m³, respectively. Under the assumptions for dry year climate conditions, the potential available water for storage is therefore insufficient to meet human demand and EFN flows with moderate ecological risk. The dry year scenario therefore presents high water stress conditions in Trout Creek.

In Mission Creek, the annual potential water available for storage is insufficient to meet human demand and EFN flows for both moderate and least ecological risk. Therefore, high water stress conditions apply to Mission Creek under the assumptions for the drought year scenario.

In Shingle Creek, the annual water available for storage is sufficient to meet human demand and EFN flows for moderate ecological risk, but not for least ecological risk. While moderate water stress conditions are assigned to Shingle Creek for dry year conditions, it should be noted that the annual potential available water for storage is almost equivalent to the annual overshoot, suggesting that the system narrowly meets the conditions associated with moderate ecological risk in the dry year scenario.

Implications for future water availability and climate change

The Okanagan relies on water storage to meet ecological and human water needs. This high- level water availability assessment highlights how, under typical conditions, there may be sufficient water available for storage early in the year to meet human demand and mitigate ecological risk later in the year. However, streamflow in the Okanagan has a high degree of inter-annual variability. As such, water availability can be insufficient to meet human demand and mitigate ecological risk during dry years.

Trout Creek, Dry Year Climate Conditions

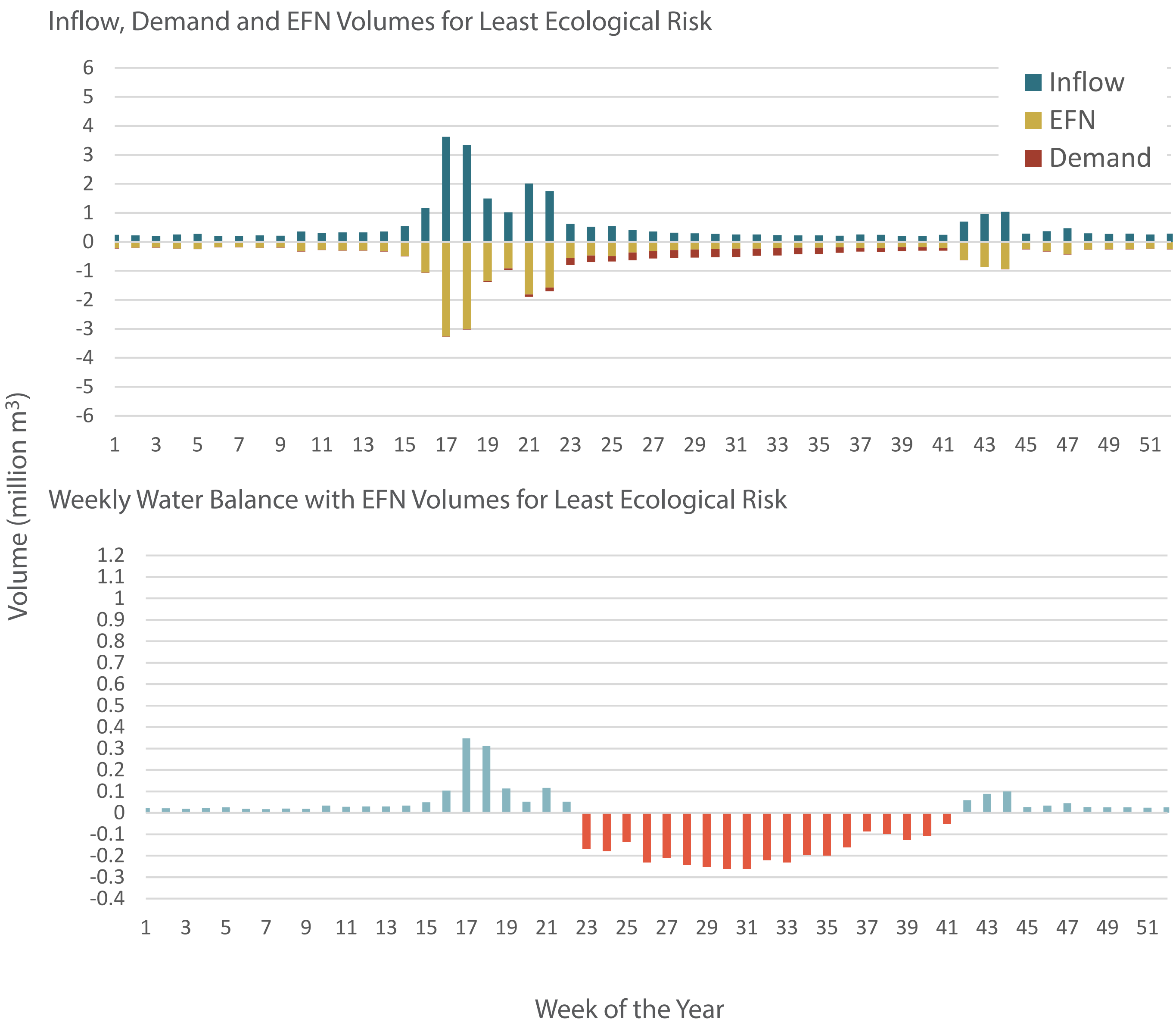


Figure 5A: TOP. Water balance components including weekly Inflow (blue), EFN volumes for least ecological risk (yellow) and demand (red) for Trout Creek, modelled for dry year conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance in Trout Creek, modelled for dry year conditions with EFN volumes for least ecological risk. Positive weekly water balance volumes indicated in blue and negative weekly water balances indicated in red.

Trout Creek, Dry Year Climate Conditions

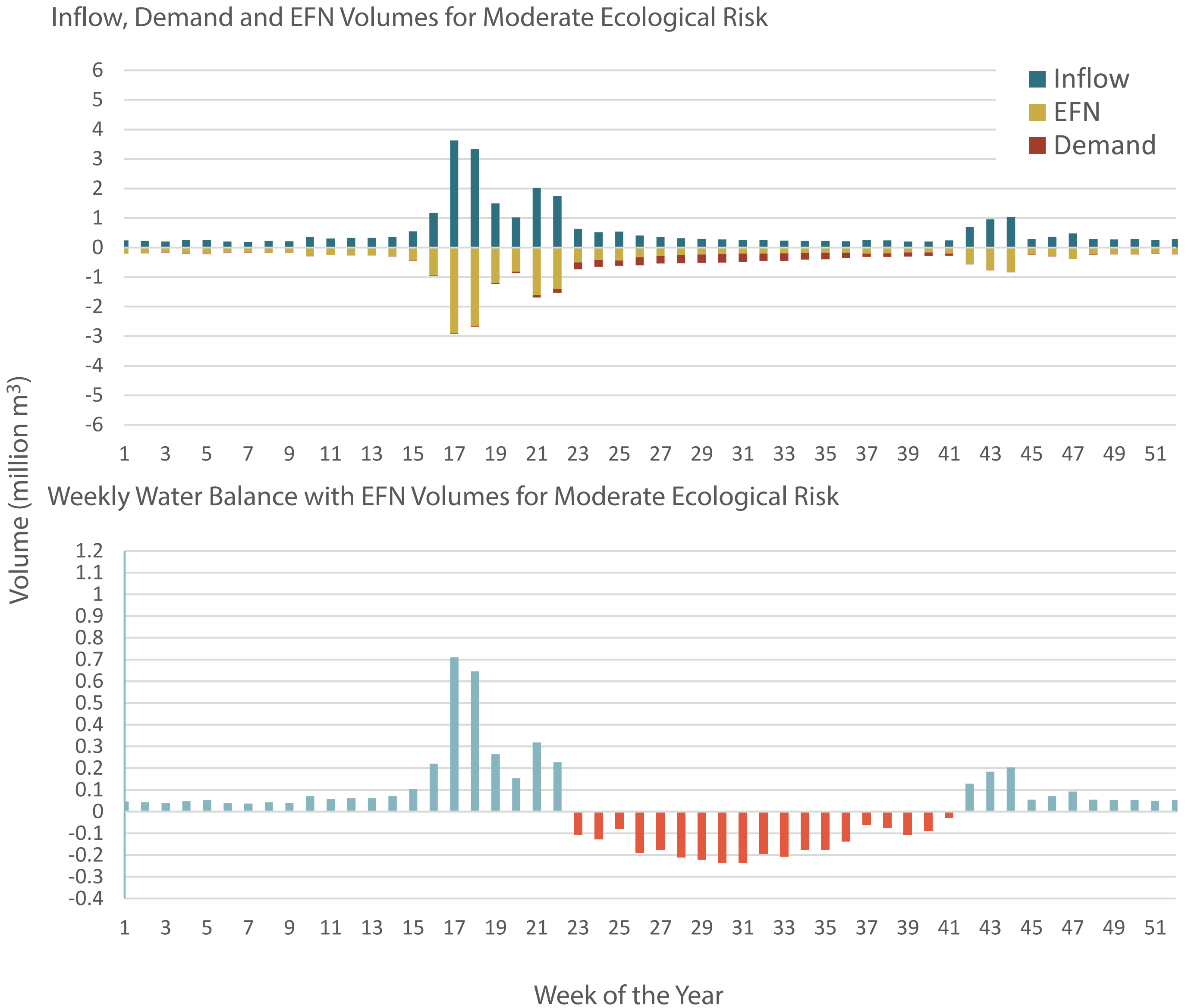


Figure 5B: TOP. Water balance components including weekly Inflow (blue), EFN volumes for moderate ecological risk (yellow) and demand (red) for Trout Creek, modelled for dry year conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance in Trout Creek, modelled for dry year conditions with EFN volumes for moderate ecological risk. Positive weekly water balance volumes indicated in blue and negative weekly water balances indicated in red.

Climate change is projected to impact water supply and demand by increasing the frequency of droughts and floods and reducing winter snowpack (Pinna Sustainability, 2020). Longer and hotter summers are expected to increase water demand. At the same time, warmer winters are expected to reduce winter snowpack, which sustains the spring freshet and facilitates water storage. Changes in mountain snowpack are cited as the "most important factor controlling the timing and amount of water that is available in the Okanagan basin" (Merrit et al., 2006. p85.) These projected changes emphasize the potential for increased future water stress, and the need for coordinated, future-focused water management planning. According to a 2017 survey of water purveyors in the Okanagan, 65% have not formally considered climate change in their planning, and those that have done so have focused on projected changes in demand, excluding anticipated changes in supply (OBWB, 2017).

Water availability and a bioregional food system

The Okanagan Bioregion Food System Project explores the food self-reliance, ecological and economic potential of advancing a regionalized food system in the Okanagan. The investigation explores a selection of scenarios that increase agricultural water demand in the Okanagan by changing the mix of crops and livestock produced and/or expanding the cultivated land base. These scenarios illustrate the potential for increased food self-reliance and related economic opportunities. While agricultural expansion in these scenarios is limited to land that is reasonably close to a water supplier, proximity does not imply water availability. As such, this assessment highlights the importance of considering water availability in decisions that increase water demand in the region. Given the natural inter-annual variability of water sources in the Okanagan, the existing potential for water stress and risk to aquatic species, and anticipated changes to water supply and demand with climate change, this study reinforces calls for land use planning to carefully consider water availability and the associated impacts to aquatic ecosystems, community wellbeing and livelihoods.

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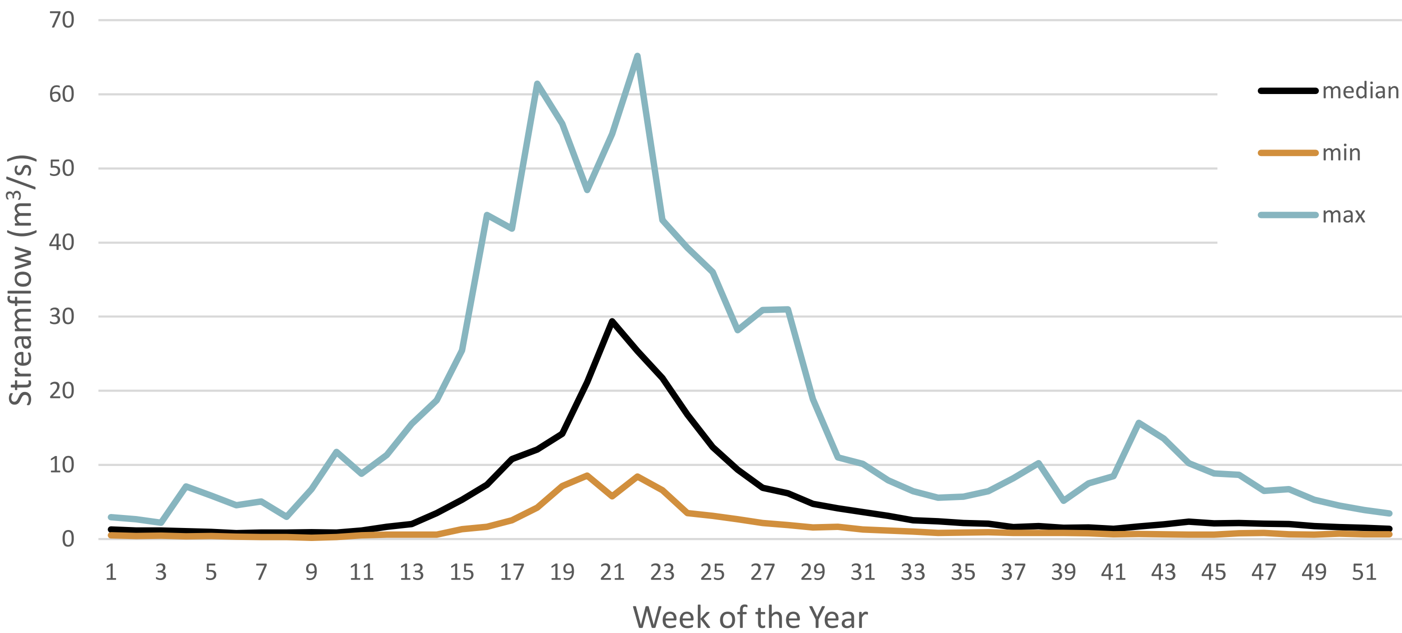
Appendix A. Mission Creek

Mission Creek: Median Natural Streamflow 1996-2017



Mission Creek: Weekly Water Demand by Use Category
Modelled for 2010 climate conditions

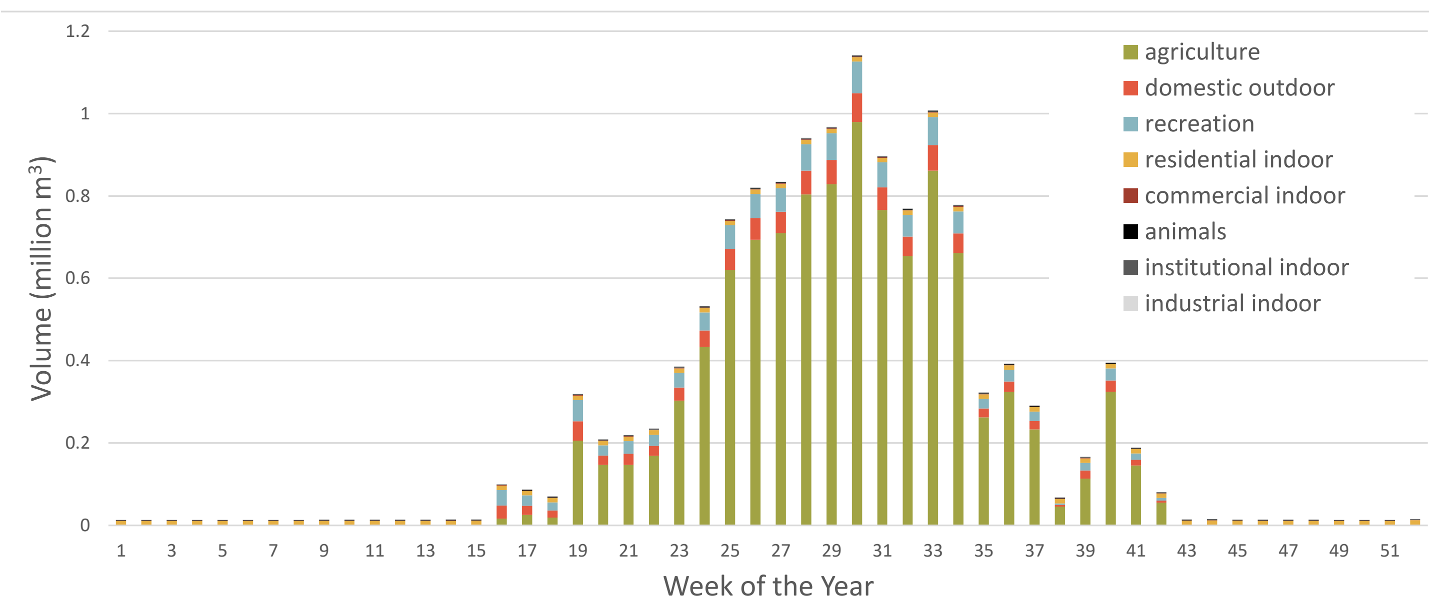


Figure A-1. TOP: Median, minimum, and maximum naturalized streamflow (m^3/s) (modelled) for Mission Creek, derived from weekly flow 1996-2017. Data Source OHME naturalized streamflow (Associated, 2020). BOTTOM: Weekly water demand (million m^3) for Mission Creek by use category, modelled using 2010 climate data. Data Source OBWB, 2020.

Mission Creek: Natural Streamflow and Ecological Risk Thresholds

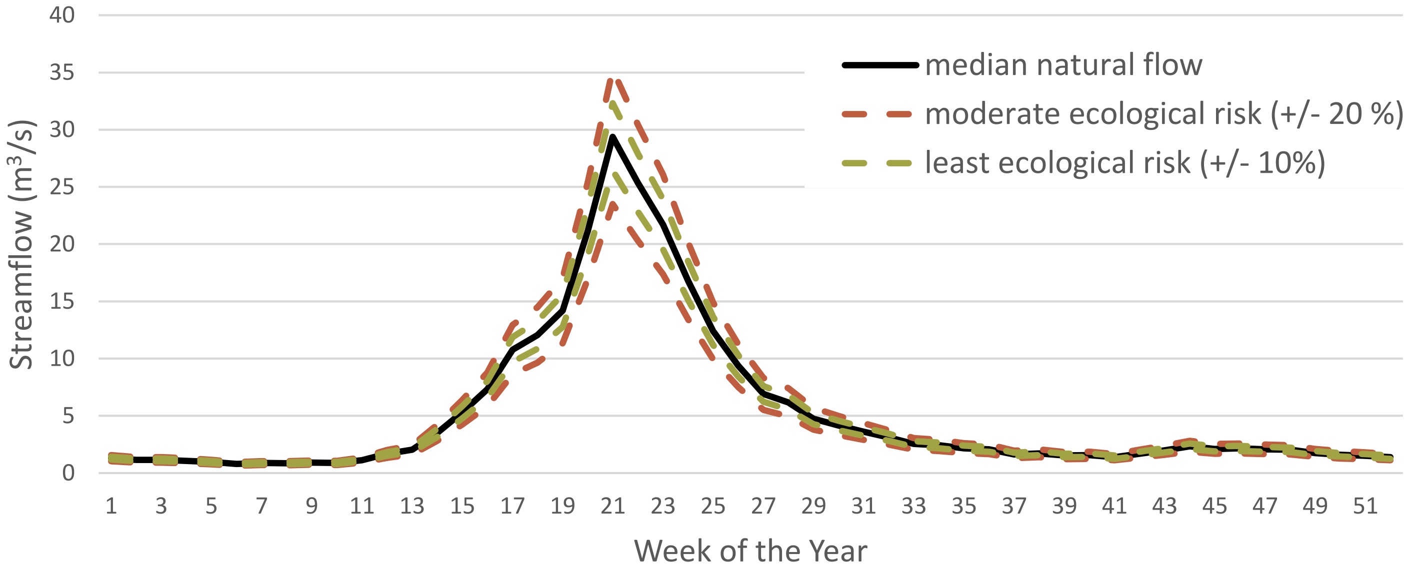


Figure A-2. Mission Creek median natural flow (m^3/s) and sustainable boundaries corresponding to least ecological risk (10% alternation of natural flow) and moderate ecological risk (20% alteration of natural flow).

Typical Climate Year Conditions

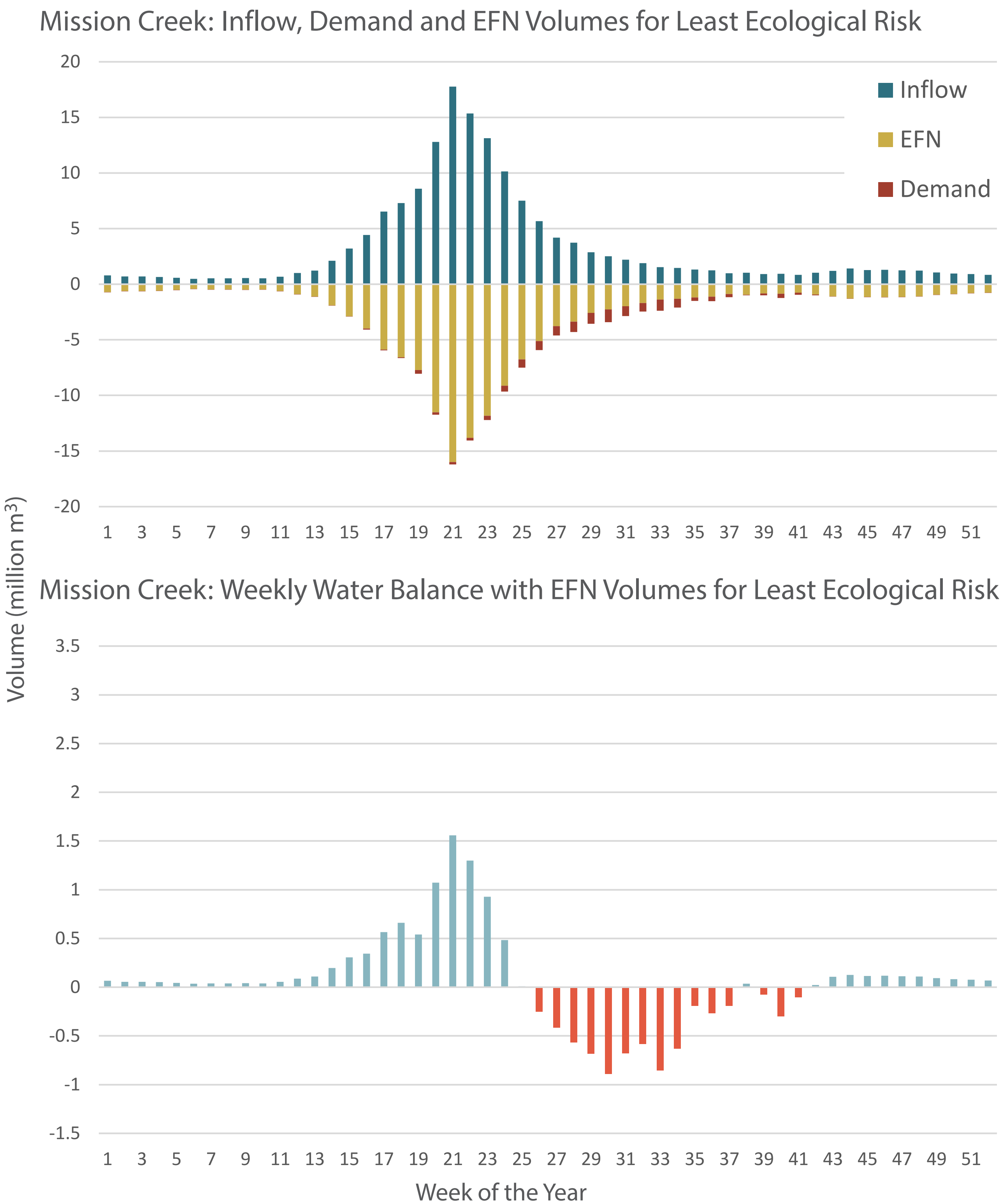


Figure A-3. TOP: Water balance components including weekly Inflow (blue), EFN volumes for least ecological risk (yellow) and demand (red) for Mission Creek, modelled for typical year climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance for Mission Creek, modelled for typical year climate conditions with positive weekly water balance volumes in blue and negative weekly water balances indicated in red.

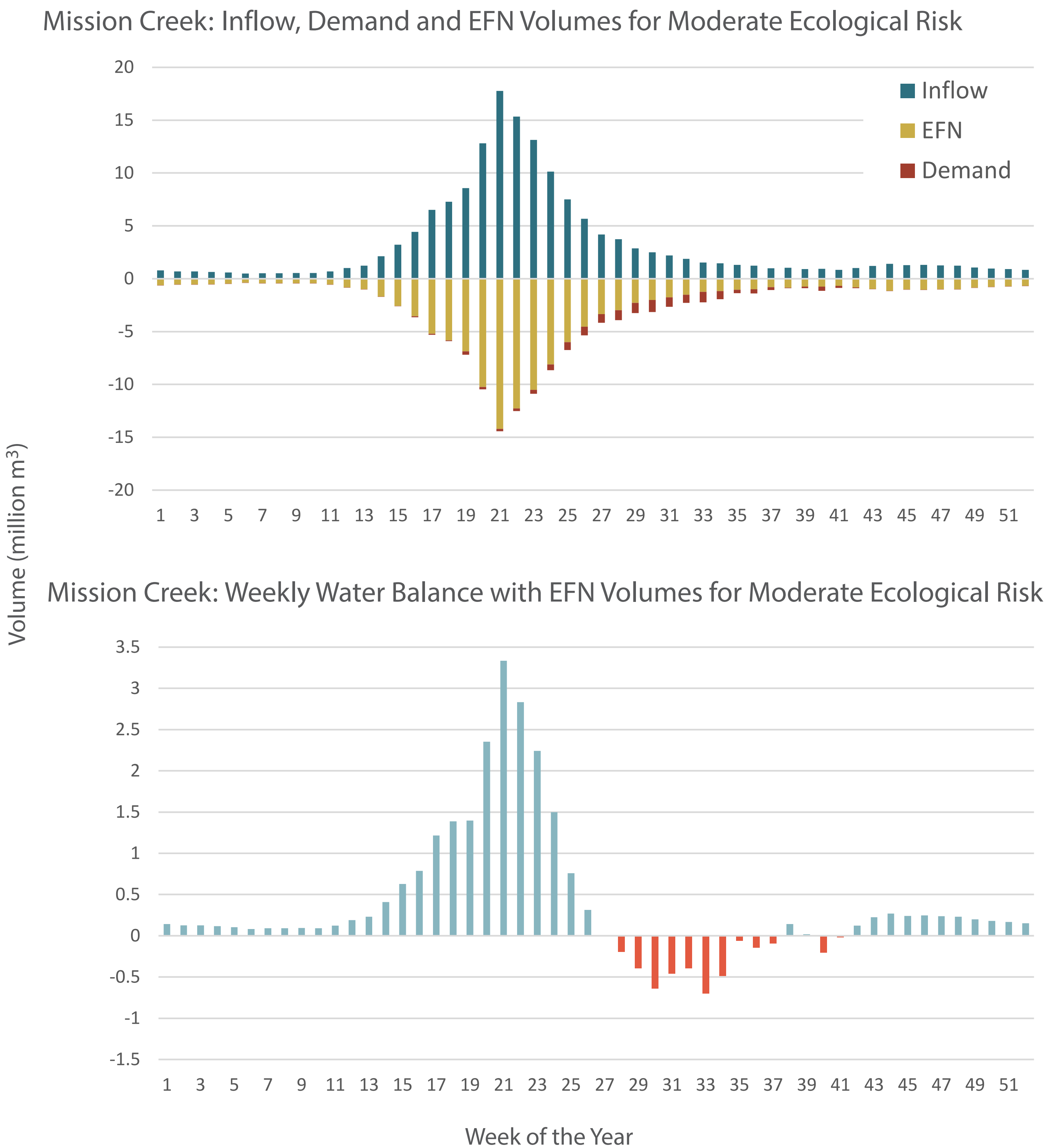


Figure A-4. TOP: Water balance components including weekly Inflow (blue), EFN volumes for moderate ecological risk (yellow) and demand (red) for Mission Creek, modelled for typical year climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance for Mission Creek, modelled for typical year climate conditions with positive weekly water balance volumes in blue and negative weekly water balances indicated in red.

Dry Climate Year Conditions

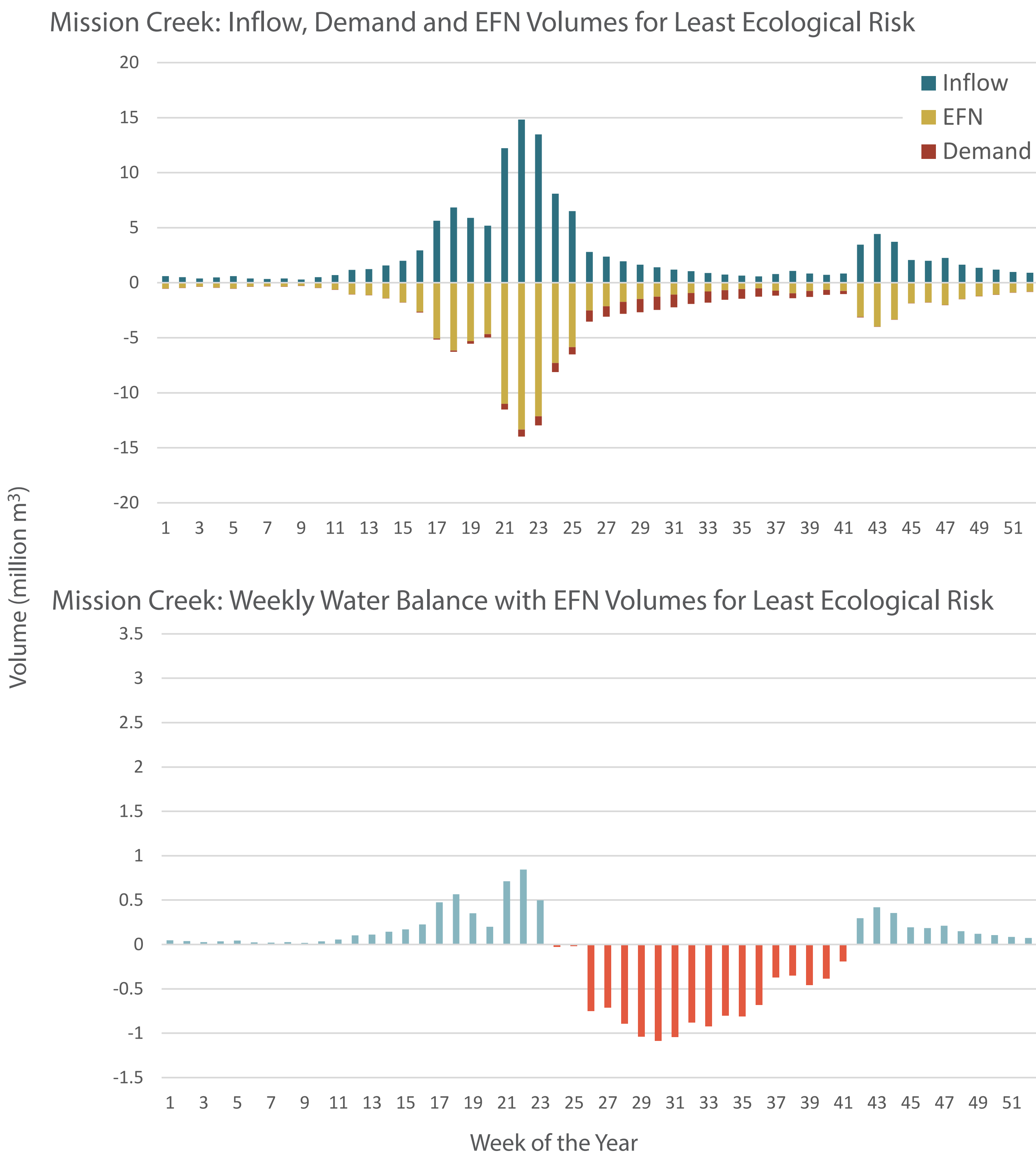


Figure A-5. TOP: Water balance components including weekly Inflow (blue), EFN volumes for least ecological risk (yellow) and demand (red) for Mission Creek, modelled for dry year climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance for Mission Creek, modelled for dry year climate conditions with positive weekly water balance volumes in blue and negative weekly water balances indicated in red.

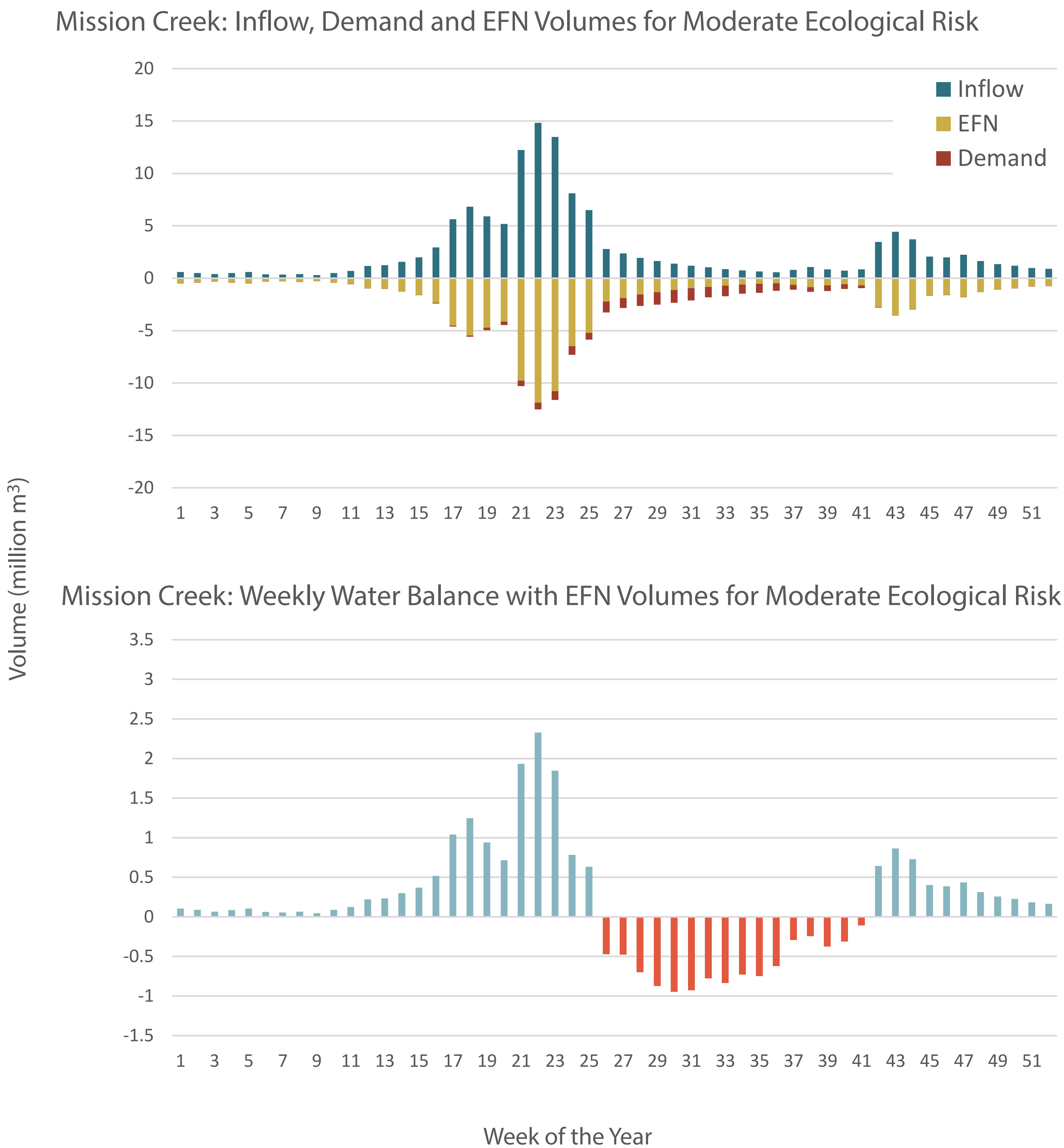
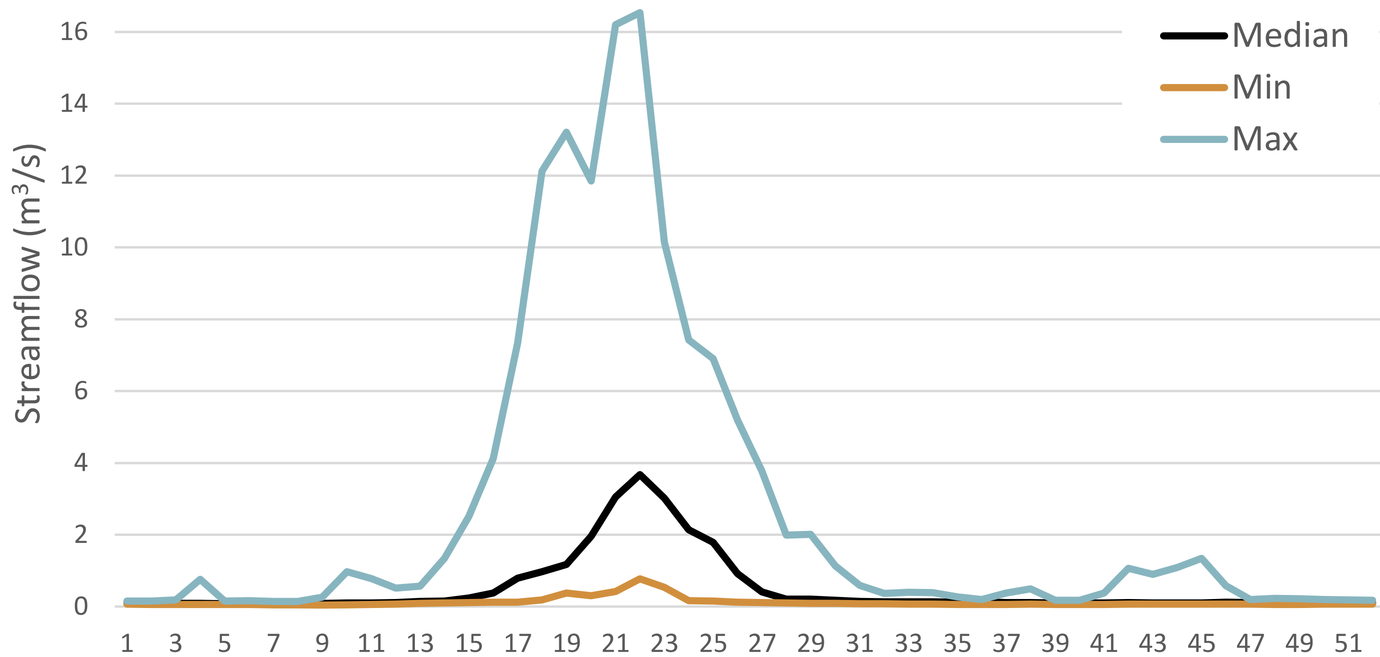


Figure A-6. TOP: Water balance components including weekly Inflow (blue), EFN volumes for moderate ecological risk (yellow) and demand (red) for Mission Creek, modelled for dry year climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance for Mission Creek, modelled for dry year climate conditions with positive weekly water balance volumes in blue and negative weekly water balances indicated in red.

Appendix B. Shingle Creek

Shingle Creek: Median Natural Streamflow 1996-2017



Shingle Creek: Weekly Water Demand by Use Category

Modelled for 2010 climate conditions

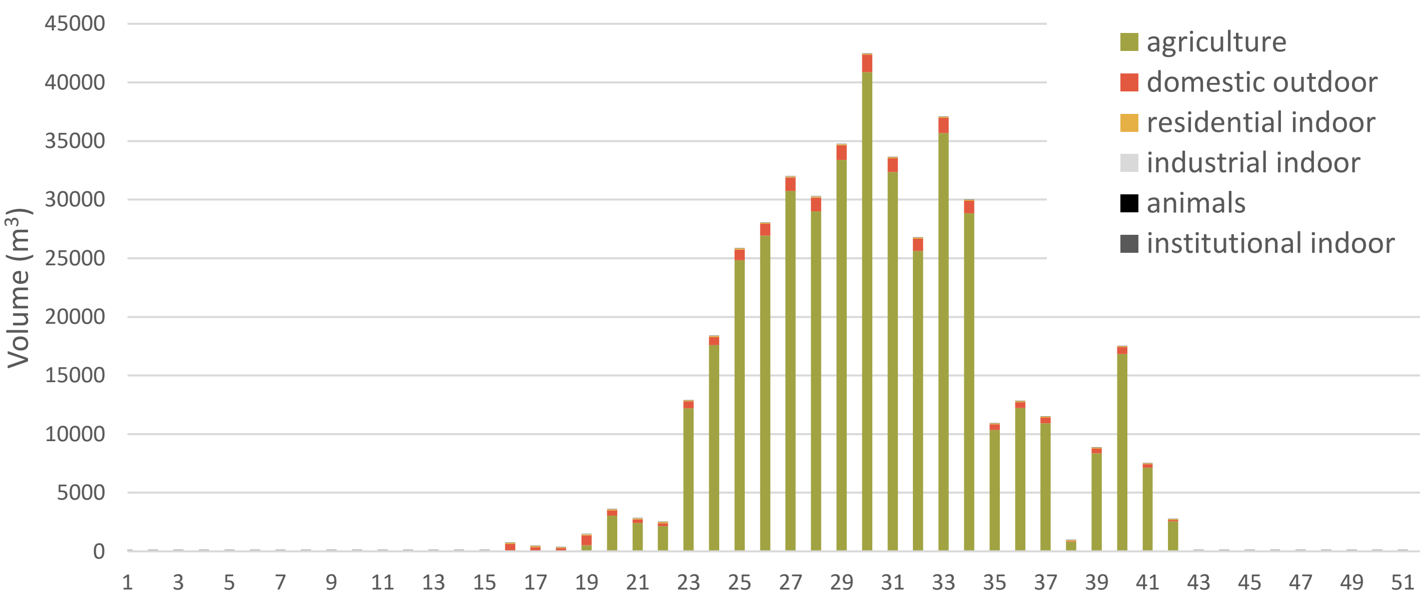


Figure B-1. TOP: Median Naturalized streamflow (m³/s) (modelled) for Shingle Creek, derived from weekly flow 1996-2017. Data Source OHME naturalized streamflow (Associated, 2020). BOTTOM: Weekly water demand for Shingle Creek by use category, modelled using 2010 climate data. Data Source OBWB, 2020.

Shingle Creek: Natural Streamflow and Ecological Risk Thresholds

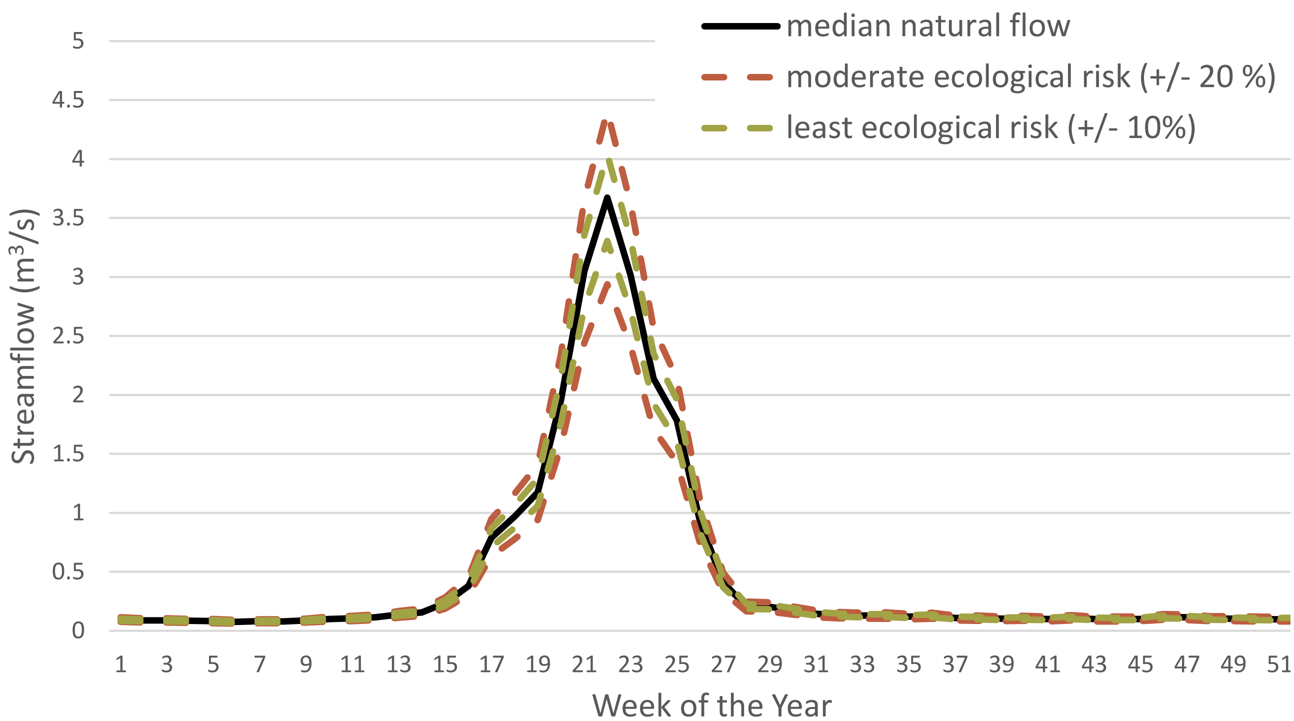


Figure B-2. Shingle Creek median natural flow (m^3/s) and sustainable boundaries corresponding to least ecological risk (10% alternation of natural flow) and moderate ecological risk (20% alteration of natural flow).

Typical Climate Year Conditions

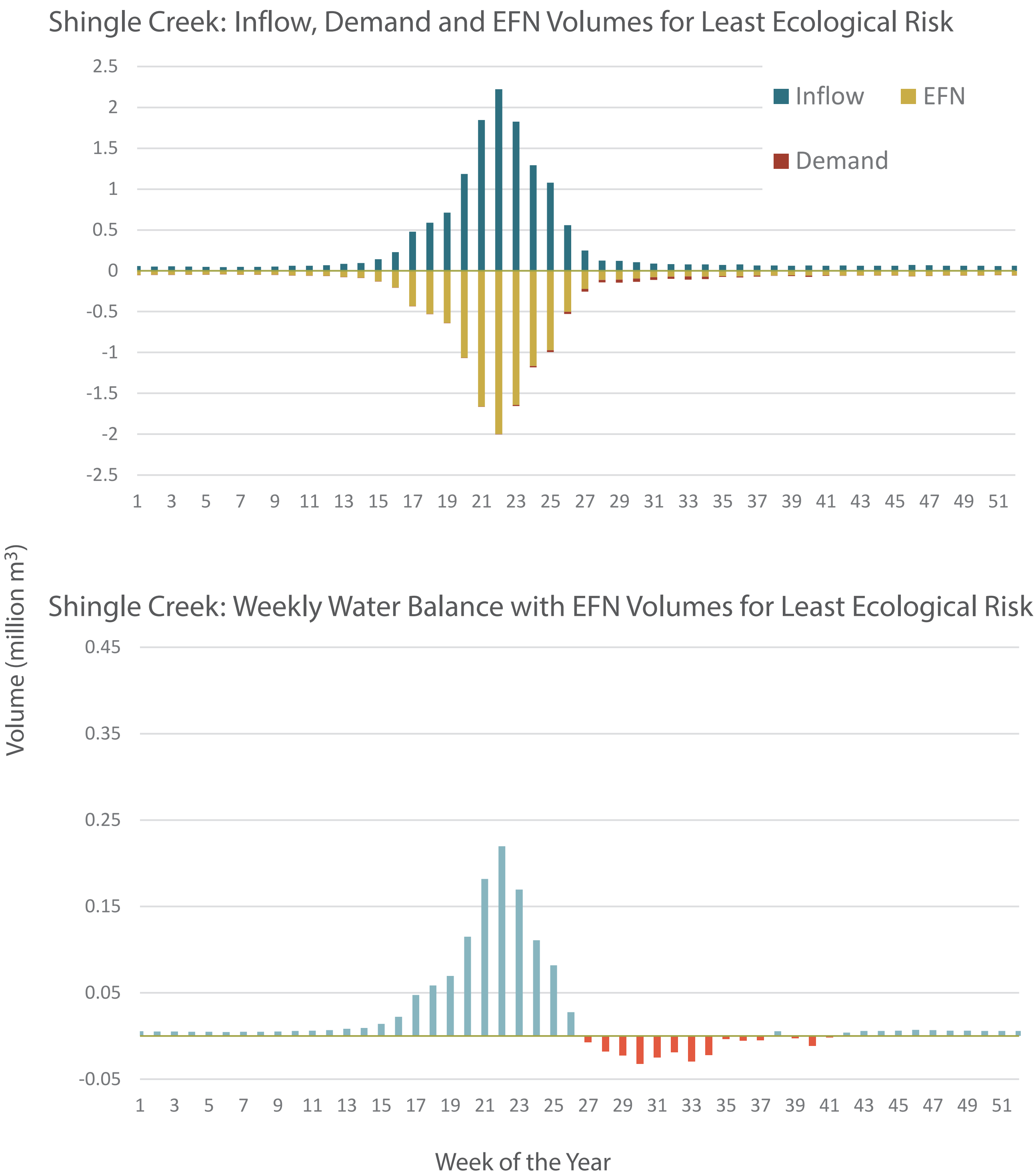


Figure B-3. TOP: Water balance components including weekly Inflow (blue), EFN volumes for least ecological risk (yellow) and demand (red) for Shingle Creek, modelled for typical year climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance for Shingle Creek, modelled for typical year climate conditions with positive weekly water balance volumes in blue and negative weekly water balances indicated indicated in red.

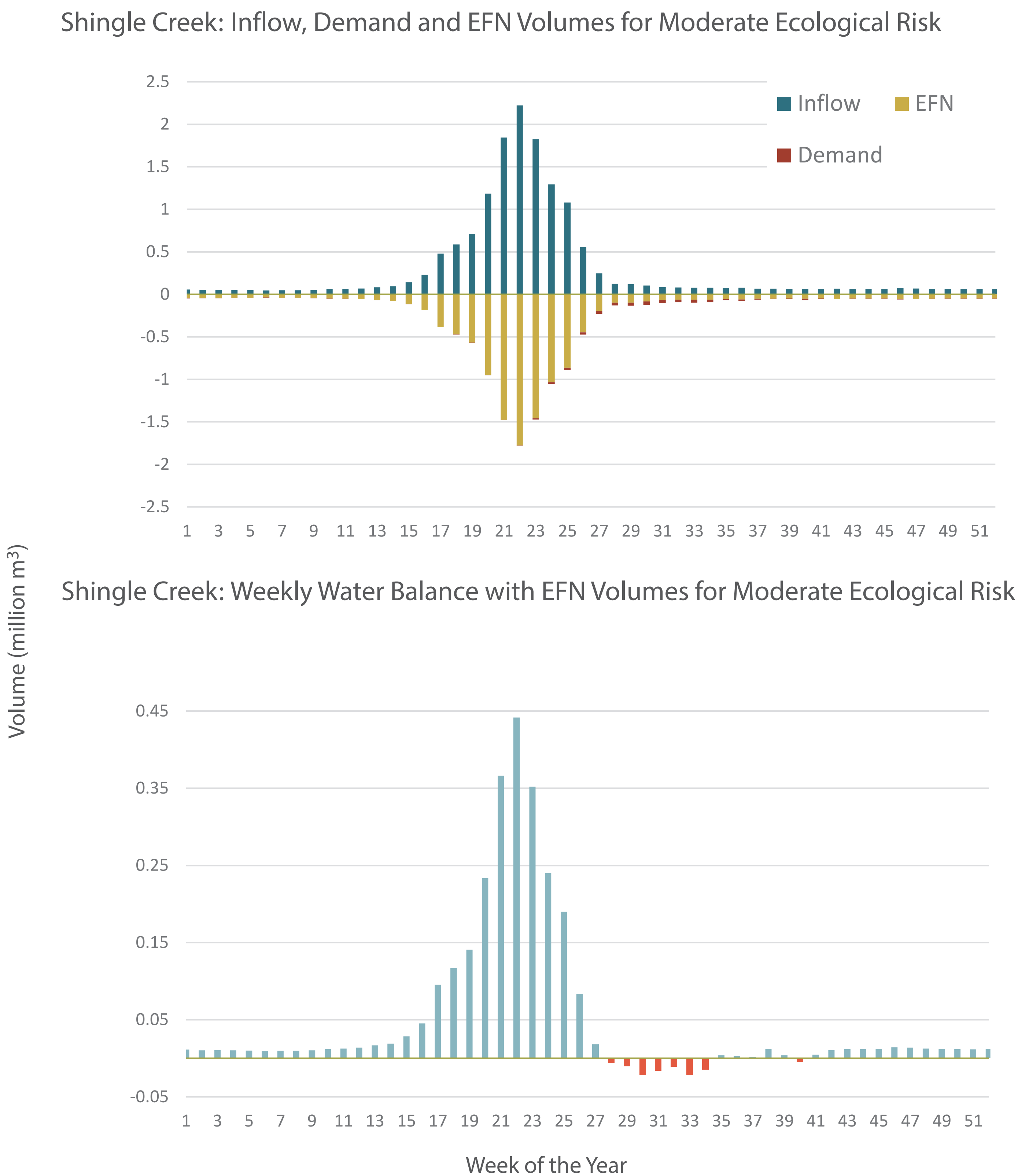


Figure B-4. TOP: Water balance components including weekly Inflow (blue), EFN volumes for moderate ecological risk (yellow) and demand (red) for Shingle Creek, modelled for typical year climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance for Shingle Creek, modelled for typical year climate conditions with positive weekly water balance volumes in blue and negative weekly water balances indicated indicated in red.

Dry Climate Year Conditions

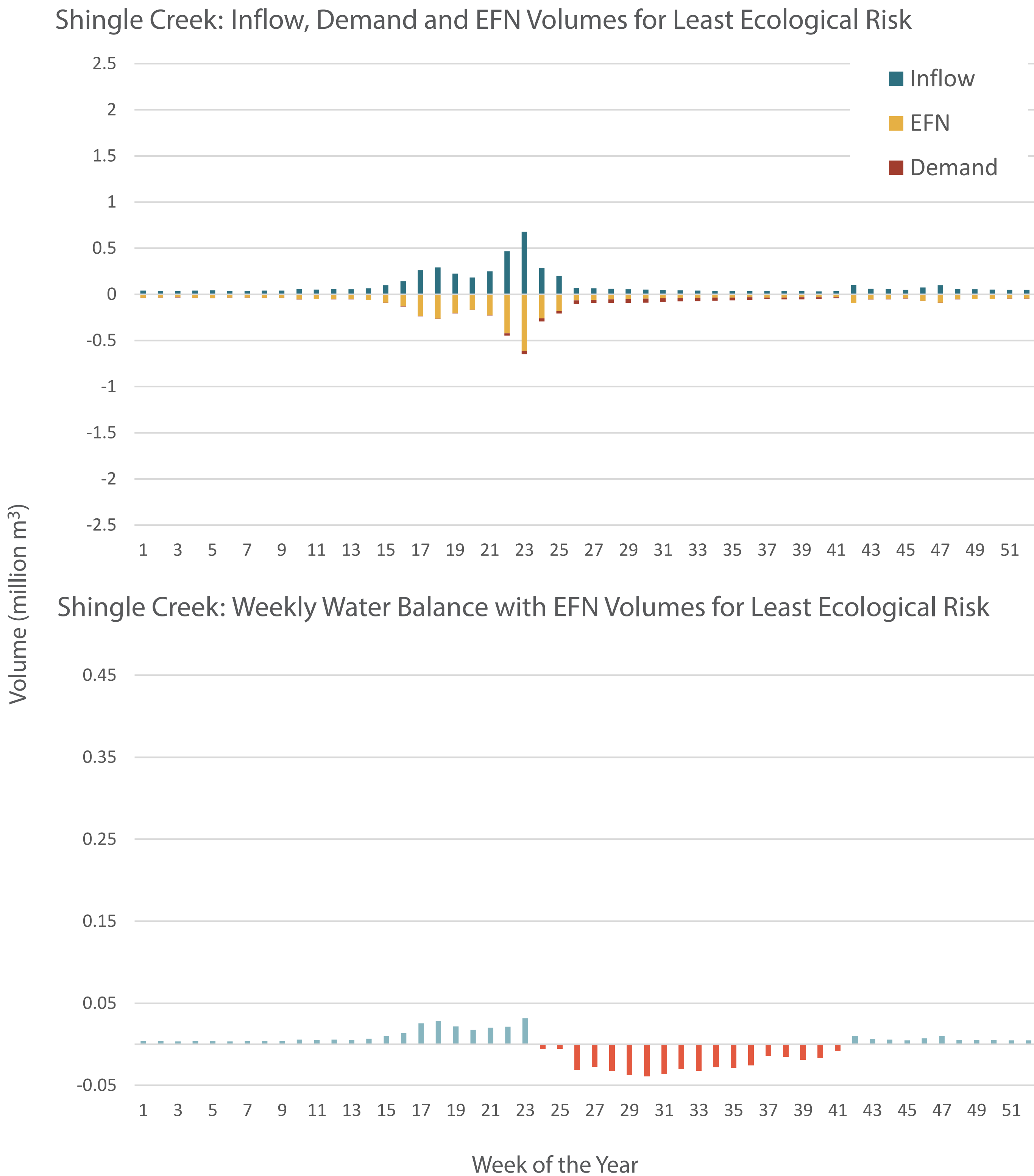


Figure B-5. TOP: Water balance components including weekly Inflow (blue), EFN volumes for least ecological risk (yellow) and demand (red) for Shingle Creek, modelled for dry year climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance for Shingle Creek, modelled for dry year climate conditions with positive weekly water balance volumes in blue and negative weekly water balances indicated in red.

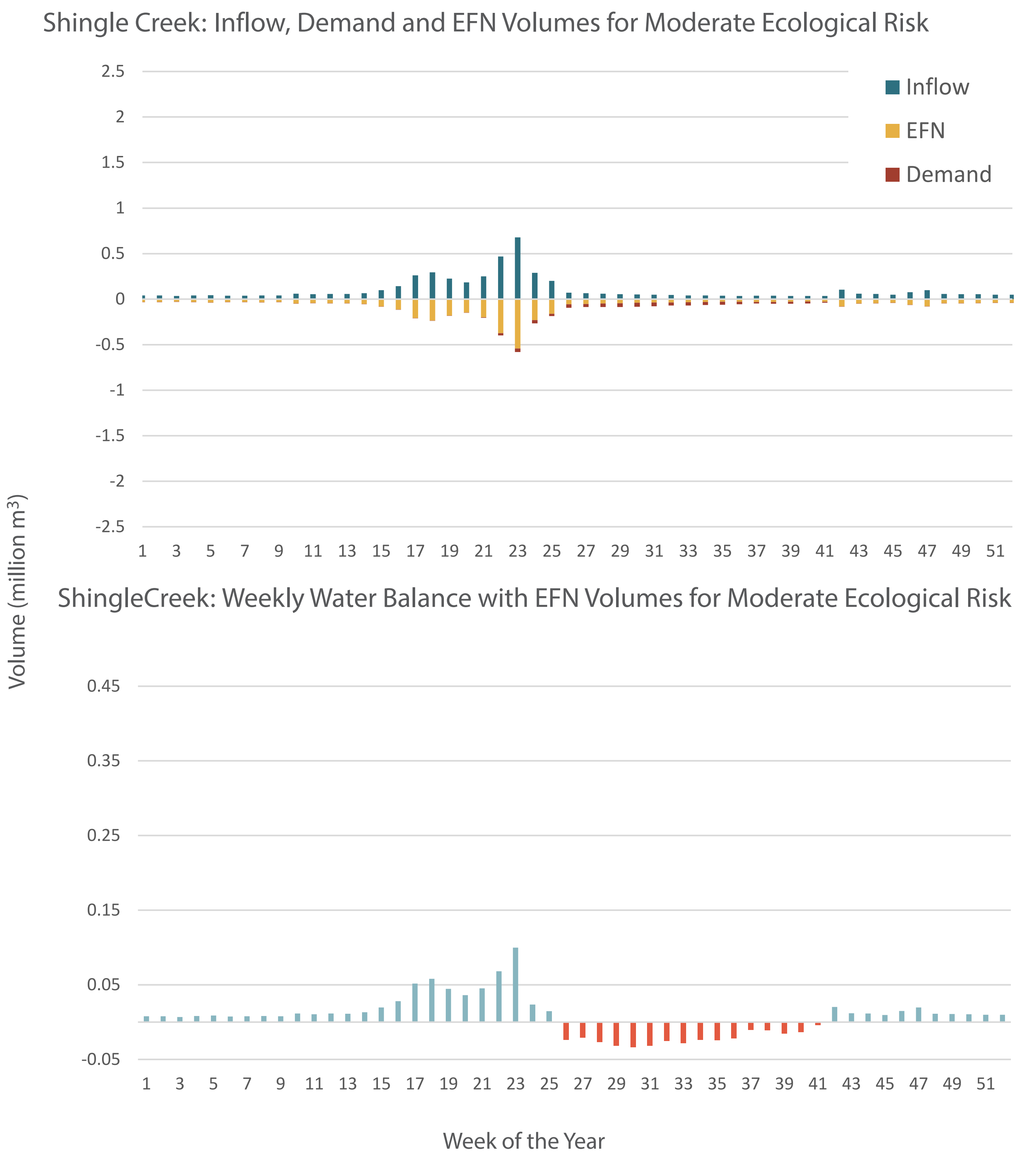


Figure B-6. TOP: Water balance components including weekly Inflow (blue), EFN volumes for moderate ecological risk (yellow) and demand (red) for Shingle Creek, modelled for dry year climate conditions. Data Source: OHME, 2020; OBWB, 2020. BOTTOM: Weekly water balance for Shingle Creek, modelled for dry year climate conditions with positive weekly water balance volumes in blue and negative weekly water balances indicated in red.

Appendix C. Water Balance Tables

C-1 Trout Creek

	Typical year climate conditions (m^3)						Dry year climate conditions (m^3)					
Week	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk
1	345,875	-2,243	-276,700	-311,287	66,932	32,344	243,582	-2,243	-194,866	-219,224	46,473	22,115
2	342,887	-2,243	-274,310	-308,599	66,334	32,046	227,528	-2,243	-182,023	-204,775	43,263	20,510
3	337,508	-2,243	-270,007	-303,758	65,259	31,508	206,229	-2,243	-164,983	-185,606	39,003	18,380
4	293,022	-2,243	-234,418	-263,720	56,361	27,059	253,664	-2,243	-202,931	-228,297	48,490	23,123
5	307,151	-2,244	-245,721	-276,436	59,186	28,471	270,117	-2,244	-216,094	-243,105	51,779	24,767
6	289,995	-2,245	-231,996	-260,995	55,754	26,754	204,783	-2,245	-163,827	-184,305	38,712	18,233
7	290,343	-2,245	-232,275	-261,309	55,824	26,789	198,408	-2,245	-158,726	-178,567	37,437	17,596
8	290,008	-2,245	-232,007	-261,007	55,757	26,756	222,250	-2,245	-177,800	-200,025	42,205	19,980
9	317,191	-2,265	-253,753	-285,472	61,173	29,454	213,548	-2,265	-170,839	-192,194	40,445	19,090
10	338,891	-2,280	-271,113	-305,002	65,499	31,609	360,608	-2,280	-288,486	-324,547	69,842	33,781
11	401,881	-2,280	-321,505	-361,693	78,097	37,908	302,765	-2,280	-242,212	-272,489	58,273	27,997
12	407,743	-2,280	-326,195	-366,969	79,269	38,495	323,347	-2,280	-258,678	-291,013	62,390	30,055
13	398,963	-2,304	-319,170	-359,067	77,489	37,593	323,757	-2,304	-259,006	-291,381	62,448	30,072
14	602,303	-2,448	-481,842	-542,073	118,013	57,783	362,686	-2,447	-290,148	-326,417	70,090	33,821
15	1,104,851	-2,453	-883,881	-994,366	218,517	108,032	548,714	-5,924	-438,971	-493,842	103,819	48,947
16	1,677,059	-19,820	-1,341,647	-1,509,353	315,592	147,886	1,173,942	-14,293	-939,153	-1,056,548	220,495	103,101
17	3,672,932	-14,580	-2,938,345	-3,305,639	720,006	352,713	3,630,715	-15,369	-2,904,572	-3,267,643	710,774	347,703
18	3,433,096	-9,899	-2,746,477	-3,089,787	676,721	333,411	3,334,761	-21,384	-2,667,809	-3,001,285	645,568	312,092
19	4,398,349	-41,063	-3,518,679	-3,958,514	838,607	398,772	1,498,235	-35,898	-1,198,588	-1,348,411	263,749	113,925
20	6,286,940	-27,704	-5,029,552	-5,658,246	1,229,684	600,990	1,016,543	-50,112	-813,235	-914,889	153,197	51,543
21	5,583,823	-17,094	-4,467,059	-5,025,441	1,099,670	541,288	2,014,104	-84,766	-1,611,283	-1,812,694	318,055	116,645
22	4,321,671	-22,106	-3,457,336	-3,889,503	842,228	410,061	1,751,364	-123,514	-1,401,091	-1,576,228	226,759	51,623
23	2,185,424	-64,658	-1,748,340	-1,966,882	372,427	153,884	628,408	-232,303	-502,726	-565,567	-106,621	-169,462
24	2,102,732	-123,354	-1,682,186	-1,892,459	297,192	86,919	520,441	-231,653	-416,353	-468,397	-127,565	-179,609

C-1 Trout Creek

	Typical year climate conditions (m³)						Dry year climate conditions (m³)					
Week	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk
25	1,565,475	-178,538	-1,252,380	-1,408,928	134,557	-21,990	544,019	-189,620	-435,215	-489,617	-80,816	-135,218
26	1,322,936	-199,007	-1,058,349	-1,190,642	65,580	-66,713	404,594	-272,219	-323,675	-364,135	-191,300	-231,759
27	1,052,948	-221,402	-842,358	-947,653	-10,812	-116,107	359,354	-247,706	-287,483	-323,419	-175,835	-211,771
28	851,237	-210,228	-680,990	-766,113	-39,980	-125,104	320,851	-276,341	-256,681	-288,766	-212,171	-244,256
29	702,896	-241,779	-562,317	-632,606	-101,200	-171,489	292,970	-279,978	-234,376	-263,673	-221,384	-250,681
30	671,067	-301,192	-536,854	-603,960	-166,979	-234,085	270,958	-288,361	-216,766	-243,862	-234,169	-261,265
31	537,364	-225,222	-429,892	-483,628	-117,749	-171,486	256,129	-287,926	-204,903	-230,516	-236,700	-262,313
32	482,355	-202,845	-385,884	-434,120	-106,374	-154,609	254,274	-246,932	-203,419	-228,847	-196,078	-221,505
33	470,363	-233,338	-376,290	-423,327	-139,266	-186,302	235,141	-255,120	-188,113	-211,627	-208,092	-231,606
34	456,631	-201,003	-365,305	-410,968	-109,676	-155,339	228,301	-220,763	-182,641	-205,471	-175,103	-197,933
35	392,689	-87,470	-314,151	-353,420	-8,932	-48,201	220,038	-220,337	-176,030	-198,034	-176,330	-198,333
36	389,416	-100,338	-311,533	-350,474	-22,455	-61,396	216,347	-182,046	-173,077	-194,712	-138,777	-160,411
37	379,426	-88,531	-303,541	-341,484	-12,646	-50,588	251,345	-112,435	-201,076	-226,210	-62,166	-87,301
38	369,679	-13,700	-295,743	-332,711	60,236	23,268	242,519	-122,879	-194,015	-218,267	-74,375	-98,627
39	343,275	-41,005	-274,620	-308,947	27,650	-6,678	202,363	-147,870	-161,891	-182,127	-107,398	-127,634
40	338,974	-108,460	-271,179	-305,077	-40,665	-74,563	200,485	-128,627	-160,388	-180,436	-88,530	-108,579
41	337,615	-47,981	-270,092	-303,854	19,542	-14,219	248,143	-77,619	-198,515	-223,329	-27,990	-52,805
42	367,186	-20,571	-293,748	-330,467	52,866	16,148	695,944	-10,722	-556,755	-626,349	128,467	58,872
43	352,567	-2,410	-282,054	-317,310	68,104	32,847	953,437	-6,500	-762,750	-858,094	184,187	88,844
44	338,641	-2,338	-270,913	-304,777	65,391	31,526	1,036,890	-3,523	-829,512	-933,201	203,854	100,165
45	319,381	-2,284	-255,505	-287,443	61,593	29,654	286,119	-2,284	-228,895	-257,507	54,940	26,328
46	381,841	-2,284	-305,472	-343,657	74,085	35,900	363,678	-2,284	-290,942	-327,310	70,452	34,084
47	398,039	-2,284	-318,431	-358,235	77,324	37,520	474,440	-2,284	-379,552	-426,996	92,604	45,160
48	360,711	-2,282	-288,569	-324,640	69,860	33,789	290,641	-2,282	-232,513	-261,577	55,846	26,782
49	341,780	-2,279	-273,424	-307,602	66,077	31,899	279,084	-2,279	-223,267	-251,176	53,538	25,630
50	352,198	-2,279	-281,758	-316,978	68,161	32,941	282,959	-2,279	-226,367	-254,663	54,313	26,017
51	347,379	-2,279	-277,903	-312,641	67,197	32,459	257,173	-2,279	-205,738	-231,456	49,156	23,438
52	352,747	-2,604	-282,197	-317,472	67,945	32,670	284,570	-2,604	-227,656	-256,113	54,310	25,853

Appendix C. Water Balance Tables

C-2 Mission Creek

	Typical year climate conditions (m³)						Dry year climate conditions (m³)					
Week	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk
1	784,899	-13,576	-627,919	-706,409	143,404	64,914	595,121	-13,576	-476,097	-535,609	105,448	45,936
2	693,231	-13,576	-554,585	-623,908	125,070	55,747	509,038	-13,576	-407,230	-458,134	88,232	37,328
3	694,677	-13,576	-555,742	-625,209	125,360	55,892	388,269	-13,576	-310,616	-349,442	64,078	25,251
4	650,195	-13,576	-520,156	-585,176	116,463	51,444	491,232	-13,576	-392,986	-442,109	84,671	35,547
5	584,182	-13,555	-467,345	-525,763	103,281	44,863	592,753	-13,555	-474,203	-533,478	104,996	45,720
6	482,157	-13,539	-385,725	-433,941	82,892	34,676	378,306	-13,539	-302,645	-340,476	62,122	24,291
7	526,345	-13,539	-421,076	-473,710	91,730	39,095	346,519	-13,539	-277,215	-311,867	55,764	21,113
8	521,836	-13,539	-417,469	-469,652	90,828	38,644	395,649	-13,539	-316,519	-356,084	65,590	26,025
9	545,321	-13,689	-436,257	-490,789	95,375	40,843	301,830	-13,689	-241,464	-271,647	46,677	16,494
10	533,379	-13,802	-426,703	-480,041	92,874	39,536	507,079	-13,802	-405,663	-456,371	87,614	36,906
11	685,058	-13,802	-548,047	-616,552	123,210	54,704	696,788	-13,802	-557,430	-627,109	125,556	55,877
12	1,015,000	-13,802	-812,000	-913,500	189,199	87,699	1,176,218	-13,802	-940,975	-1,058,597	221,442	103,820
13	1,229,013	-13,885	-983,210	-1,106,112	231,918	109,017	1,242,149	-13,885	-993,719	-1,117,934	234,545	110,330
14	2,118,083	-14,393	-1,694,466	-1,906,275	409,223	197,415	1,568,673	-14,383	-1,254,939	-1,411,806	299,351	142,484
15	3,217,501	-14,734	-2,574,001	-2,895,751	628,766	307,016	1,984,446	-29,453	-1,587,556	-1,786,001	367,436	168,992
16	4,427,652	-99,868	-3,542,121	-3,984,887	785,663	342,898	2,930,720	-67,514	-2,344,576	-2,637,648	518,630	225,558
17	6,521,408	-87,159	-5,217,126	-5,869,267	1,217,122	564,982	5,638,315	-90,073	-4,510,652	-5,074,483	1,037,590	473,759
18	7,297,519	-70,384	-5,838,016	-6,567,767	1,389,120	659,368	6,831,954	-118,360	-5,465,563	-6,148,758	1,248,031	564,836
19	8,583,108	-318,993	-6,866,486	-7,724,797	1,397,629	539,318	5,900,409	-238,919	-4,720,327	-5,310,368	941,163	351,122
20	12,807,176	-208,944	-10,245,741	-11,526,458	2,352,491	1,071,773	5,179,493	-319,610	-4,143,595	-4,661,544	716,289	198,339
21	17,765,983	-219,115	-14,212,786	-15,989,384	3,334,081	1,557,483	12,227,547	-511,617	-9,782,037	-11,004,792	1,933,893	711,138
22	15,345,228	-235,010	-12,276,182	-13,810,705	2,834,035	1,299,512	14,836,029	-637,976	-11,868,823	-13,352,426	2,329,230	845,627
23	13,137,474	-385,468	-10,509,979	-11,823,727	2,242,027	928,279	13,474,477	-847,699	-10,779,582	-12,127,030	1,847,197	499,749
24	10,148,397	-532,090	-8,118,718	-9,133,557	1,497,589	482,750	8,094,809	-835,263	-6,475,847	-7,285,328	783,698	-25,782

C-2 Mission Creek

	Typical year climate conditions (m³)						Dry year climate conditions (m³)					
Week	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk
25	7,511,977	-743,593	-6,009,581	-6,760,779	758,802	7,605	6,499,698	-667,364	-5,199,759	-5,849,729	632,576	-17,394
26	5,671,725	-819,851	-4,537,380	-5,104,552	314,494	-252,679	2,788,137	-1,030,090	-2,230,509	-2,509,323	-472,462	-751,276
27	4,181,167	-834,380	-3,344,933	-3,763,050	1,854	-416,263	2,373,059	-950,196	-1,898,447	-2,135,753	-475,584	-712,890
28	3,735,888	-940,846	-2,988,711	-3,362,300	-193,668	-567,257	1,938,872	-1,085,630	-1,551,098	-1,744,985	-697,855	-891,742
29	2,866,840	-967,590	-2,293,472	-2,580,156	-394,222	-680,906	1,642,463	-1,204,741	-1,313,971	-1,478,217	-876,249	-1,040,495
30	2,513,251	-1,141,741	-2,010,601	-2,261,926	-639,090	-890,415	1,396,954	-1,226,787	-1,117,563	-1,257,259	-947,396	-1,087,091
31	2,195,656	-897,007	-1,756,525	-1,976,091	-457,876	-677,441	1,191,322	-1,164,315	-953,058	-1,072,190	-926,051	-1,045,183
32	1,883,214	-769,623	-1,506,571	-1,694,892	-392,980	-581,302	1,042,229	-983,490	-833,783	-938,006	-775,045	-879,267
33	1,538,183	-1,007,307	-1,230,546	-1,384,365	-699,670	-853,488	879,104	-1,012,426	-703,284	-791,194	-836,605	-924,516
34	1,461,186	-777,958	-1,168,949	-1,315,068	-485,721	-631,840	752,058	-879,036	-601,647	-676,853	-728,625	-803,830
35	1,311,450	-322,727	-1,049,160	-1,180,305	-60,437	-191,582	644,026	-877,495	-515,221	-579,623	-748,689	-813,092
36	1,246,905	-392,950	-997,524	-1,122,215	-143,569	-268,259	580,613	-739,417	-464,491	-522,552	-623,295	-681,356
37	983,730	-291,127	-786,984	-885,357	-94,381	-192,754	794,468	-451,026	-635,574	-715,021	-292,133	-371,579
38	1,045,343	-68,314	-836,275	-940,809	140,755	36,221	1,064,699	-456,116	-851,759	-958,229	-243,176	-349,646
39	925,216	-166,772	-740,173	-832,695	18,271	-74,250	837,981	-543,576	-670,385	-754,183	-375,980	-459,778
40	944,118	-395,034	-755,294	-849,706	-206,211	-300,622	719,262	-458,214	-575,409	-647,336	-314,362	-386,288
41	840,890	-188,767	-672,712	-756,801	-20,589	-104,678	838,637	-275,658	-670,910	-754,774	-107,931	-191,794
42	1,023,332	-80,763	-818,666	-920,999	123,904	21,571	3,462,183	-49,966	-2,769,746	-3,115,965	642,470	296,252
43	1,204,445	-14,645	-963,556	-1,084,001	226,244	105,799	4,438,559	-24,797	-3,550,847	-3,994,703	862,915	419,059
44	1,415,080	-15,011	-1,132,064	-1,273,572	268,005	126,497	3,724,468	-16,714	-2,979,575	-3,352,021	728,180	355,733
45	1,279,962	-14,321	-1,023,970	-1,151,966	241,671	113,675	2,073,103	-13,805	-1,658,483	-1,865,793	400,815	193,505
46	1,301,175	-13,805	-1,040,940	-1,171,058	246,430	116,312	1,989,926	-13,805	-1,591,941	-1,790,933	384,180	185,187
47	1,256,913	-13,805	-1,005,530	-1,131,222	237,577	111,886	2,251,618	-13,805	-1,801,294	-2,026,456	436,518	211,356
48	1,227,549	-13,748	-982,039	-1,104,794	231,762	109,007	1,631,962	-13,748	-1,305,570	-1,468,766	312,645	149,449
49	1,062,260	-13,602	-849,808	-956,034	198,850	92,624	1,351,992	-13,602	-1,081,594	-1,216,793	256,796	121,597
50	964,016	-13,602	-771,213	-867,615	179,201	82,799	1,200,957	-13,602	-960,766	-1,080,862	226,589	106,493
51	907,182	-13,602	-725,746	-816,464	167,834	77,116	982,507	-13,602	-786,006	-884,256	182,899	84,648
52	838,014	-15,546	-670,411	-754,212	152,057	68,256	899,691	-15,546	-719,753	-809,722	164,392	74,423

Appendix C. Water Balance Tables

C-3 Shingle Creek

	Typical year climate conditions (m^3)						Dry year climate conditions (m^3)					
Week	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk
1	57103	-109	-45683	-51393	11312	5601	40030	-109	-32024	-36027	7897	3894
2	52591	-109	-42073	-47332	10409	5150	39450	-109	-31560	-35505	7781	3836
3	53832	-109	-43066	-48449	10657	5274	35004	-109	-28003	-31503	6892	3391
4	50992	-109	-40794	-45893	10089	4990	40802	-109	-32642	-36722	8051	3971
5	49631	-109	-39705	-44668	9817	4854	44297	-109	-35438	-39868	8750	4321
6	45986	-109	-36789	-41387	9088	4490	37641	-109	-30113	-33877	7419	3655
7	48839	-109	-39072	-43955	9659	4775	39075	-109	-31260	-35168	7706	3799
8	48778	-109	-39022	-43900	9647	4769	41310	-109	-33048	-37179	8153	4022
9	52409	-109	-41927	-47168	10373	5132	40277	-109	-32221	-36249	7946	3919
10	60420	-109	-48336	-54378	11975	5933	58478	-109	-46783	-52630	11587	5739
11	63152	-109	-50521	-56837	12521	6206	53043	-109	-42435	-47739	10500	5195
12	69421	-109	-55537	-62479	13775	6833	57398	-109	-45918	-51658	11371	5631
13	83970	-109	-67176	-75573	16685	8288	56002	-109	-44802	-50402	11091	5491
14	94579	-109	-75663	-85121	18807	9349	66485	-109	-53188	-59837	13188	6540
15	142787	-109	-114230	-128508	28448	14170	99549	-182	-79639	-89594	19728	9773
16	229205	-745	-183364	-206285	45096	22176	142084	-541	-113667	-127875	27875	13667
17	478305	-474	-382644	-430474	95187	47357	260223	-460	-208179	-234201	51584	25562
18	587559	-370	-470047	-528803	117142	58386	293265	-656	-234612	-263939	57997	28670
19	710615	-1469	-568492	-639553	140654	69593	226199	-811	-180959	-203579	44429	21809
20	1184478	-3597	-947582	-1066030	233298	114850	183843	-734	-147074	-165459	36034	17650
21	1845058	-2833	-1476046	-1660552	366179	181673	250966	-4879	-200773	-225869	45314	20218
22	2221282	-2513	-1777025	-1999154	441743	219615	467309	-25333	-373847	-420578	68129	21398
23	1823818	-12894	-1459054	-1641436	351870	169488	679054	-36167	-543243	-611149	99644	31738
24	1293145	-18391	-1034516	-1163830	240238	110923	289192	-34492	-231353	-260273	23347	-5573

C-3 Shingle Creek

	Typical year climate conditions (m³)						Dry year climate conditions (m³)					
Week	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk	Inflow	Demand	EFN for Moderate Ecological Risk	EFN for Least Ecological Risk	Balance for Moderate Ecological Risk	Balance for Least Ecological Risk
25	1078318	-25851	-862655	-970486	189813	81981	200972	-25543	-160778	-180875	14652	-5445
26	557208	-28044	-445766	-501487	83398	27677	71560	-38351	-57248	-64404	-24039	-31195
27	248026	-31995	-198421	-223224	17610	-7192	65164	-33892	-52131	-58647	-20859	-27375
28	123956	-30279	-99165	-111561	-5488	-17884	59798	-38740	-47838	-53818	-26780	-32760
29	121973	-34745	-97579	-109776	-10350	-22547	55120	-42942	-44096	-49608	-31918	-37430
30	104430	-42469	-83544	-93987	-21583	-32026	51012	-44013	-40809	-45910	-33811	-38912
31	87096	-33635	-69677	-78387	-16216	-24926	47503	-41213	-38003	-42753	-31713	-36463
32	80426	-26775	-64341	-72383	-10690	-18732	45171	-34559	-36137	-40654	-25525	-30042
33	77488	-37081	-61990	-69739	-21584	-29333	41869	-36479	-33495	-37682	-28105	-32292
34	78036	-30002	-62429	-70232	-14395	-22199	39230	-31803	-31384	-35307	-23957	-27880
35	72849	-10940	-58279	-65564	3630	-3655	36839	-31949	-29471	-33155	-24581	-28265
36	76748	-12829	-61398	-69073	2521	-5154	35299	-29161	-28240	-31770	-22101	-25631
37	65771	-11506	-52617	-59194	1648	-4929	38135	-18031	-30508	-34321	-10404	-14218
38	65342	-981	-52273	-58808	12088	5554	38756	-18771	-31004	-34880	-11019	-14895
39	61409	-8865	-49128	-55269	3417	-2724	35236	-22257	-28189	-31712	-15210	-18733
40	63721	-17525	-50977	-57349	-4781	-11153	33665	-20175	-26932	-30298	-13442	-16809
41	60691	-7537	-48553	-54622	4601	-1468	36137	-11122	-28910	-32523	-3895	-7509
42	66348	-2769	-53079	-59713	10501	3866	102889	-167	-82311	-92600	20411	10122
43	60624	-109	-48499	-54562	12016	5953	60475	-138	-48380	-54427	11957	5910
44	60347	-109	-48277	-54312	11960	5926	57582	-116	-46065	-51823	11400	5642
45	61092	-109	-48874	-54983	12109	6000	48870	-109	-39096	-43983	9665	4778
46	70558	-109	-56447	-63502	14003	6947	75544	-109	-60435	-67990	15000	7445
47	69642	-109	-55714	-62678	13819	6855	99161	-109	-79329	-89245	19723	9807
48	62902	-109	-50322	-56612	12471	6181	56870	-109	-45496	-51183	11265	5578
49	61665	-109	-49332	-55498	12224	6057	55060	-109	-44048	-49554	10903	5397
50	60350	-109	-48280	-54315	11961	5926	52959	-109	-42367	-47663	10483	5187
51	59013	-109	-47210	-53111	11694	5792	49107	-109	-39286	-44197	9712	4802
52	60972	-125	-48777	-54875	12070	5973	49563	-125	-39650	-44606	9788	4832

About the Institute for Sustainable Food Systems

The Institute for Sustainable Food Systems (ISFS) is an applied research and extension unit at Kwantlen Polytechnic University that investigates and supports sustainable agriculture and regional food systems as key elements of sustainable communities. We focus predominantly on British Columbia but also extend our programming to other regions.

Our applied research focuses on the potential of regional food systems in terms of agriculture and food, economics, community health, policy, and environmental integrity. Our extension programming provides information and support for farmers, communities, business, policy makers, and others. Community collaboration is central to our approach.

About the Okanagan Bioregion Food System Project

Communities and governments are increasingly looking to strengthen regional food systems as a way to address many complex agriculture and food challenges. The Okanagan Bioregion Food System Project explores the social, economic, and ecological outcomes of a regional food system in the Okanagan. This multidisciplinary research project, initiated by ISFS and regional partners, can guide conversations among communities and decision-makers seeking to advance their regional food system.

The Okanagan Bioregion Food System Project considers and builds upon existing food system planning and other related work to support local and regional food systems in the bioregion.

For the full report and more research briefs visit: www.kpu.ca/isfs/okanagan-bioregion

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