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ELOHA Environmental Flow Conversion Values at MGS and Fredericton

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DISCLAIMER

This report is a supplemental document for MAES Report Series 2017-035 (***Proposed holistic environmental flows framework for the Saint John River with a focus on operations at the Mactaquac Generating Station***). It was produced at the request of NB Power and is intended solely for use by NB Power and their designates. This report is not intended to be a stand-alone document and no attempt should be made to use its contents without full comprehension of the parent report. As per the Disclaimer within MAES Report Series 2017-035, the information presented here is not intended as an alternative to proactive consultation with regulatory authorities and does not necessarily represent the opinion of the Canadian Rivers Institute.

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1 Introduction

Monk et al., 2017 presented a proposed environmental flows framework for the Saint John River based on an application of a holistic (watershed scale) approach that explicitly incorporates ice processes. The proposed framework was focused on application at the Mactaquac Generating Station (MGS) but could be applied in other habitats within the watershed. MAES Report 2017-35 describes the first stage of the ELOHA-based environmental flows framework for the Mactaquac Project as the development of the framework is now moving into the next phase with the integration of social, cultural and economic components. The environmental framework provides flow recommendations tailored to a particular part of the watershed based on data and expert knowledge recommendations. The resulting initial hydrographs were presented as water level over time as this allowed for comparisons across the watershed. However, for the purpose of projecting the potential operational and financial adjustments that would be required to accommodate the proposed framework at the Mactaquac Generating Station (MGS), the current report presents the proposed hydrographs for the MGS as cubic-feet-per-second (CFS), which is the current unit of measurement. It should be noted that the outputs generated in MAES Report 2017-035 are only the first stage of the framework development and should not be considered as the final environmental flows recommendation for future MGS operation given the ongoing integration of the social components. Additional factors and processes, including those described in Section 6.1 of that report, may alter the recommended flows from those contained herein.

2 Methods

Proposed environmental flows for the Saint John River were presented graphically in Figures 20 and 21 in ***Proposed holistic environmental flows framework for the Saint John River with a focus on operations at the Mactaquac Generating Station*** (Monk et al., 2017) (Figure 2 and Figure 3 in this report). The development, discussion, and application of these variable flows are explained in detail in the report. Note that the flow targets were developed at the weekly scale but are presented at the monthly scale in the individual flow target figures for ease of interpretation (Figure 3). The ELOHA framework was developed at the watershed scale so this allows users to tailor their flow recommendations to their area. For example, the proposed hydrograph for the MGS is based on a tailored framework for mainstem habitats (Figure 2). Behind the proposed hydrograph are a series of flow needs that integrate the ecosystem-level needs for the river. In the proposed hydrograph for MGS, there are ten core flow needs identified for mainstem habitats and these are broadly represented by the hydrographs in Figure 3. Note that these flow needs would vary depending on the spatial and temporal scope of interest and have been developed for all of the identified habitats within the watershed, including headwaters and small tributaries, medium tributaries, mainstem habitats, island habitats, wetland and riparian areas, and floodplain forests.

The proposed flow hydrographs have been converted from ones that indicate *Water Level at Fredericton (m)* into *Discharge at the Mactaquac Dam (cfs).* To do this, an approximate stage-discharge relationship was developed for the Saint John River using historical water levels in Fredericton and flow data provided by NB Power for the Mactaquac Generating Station (MGS). Water levels have been recorded by Environment Canada at Station 01AK003 (Saint John River at Fredericton) starting in 1929, continuing until present day real time. To capture the high flow end of the relationship, daily data presented on the NB RiverWatch website from the 2018 spring flood giving discharge at MGS and water levels at Fredericton were included, as well as values from the large spring freshet in 1973 (Dineen, 1974).

Water level and discharge values were extracted from the given data sets at 7:00am, 3:00pm, and 11:00pm daily from January 1995 until November 2017 and plotted in Figure 1. Using Excel, a fourth-order polynomial trendline ($y = 120.28x^4 - 1497.4x^3 + 9696x^2 - 5437.8x + 966.64$) was found to best fit the data (least-squares R^2 value = 0.9026). This equation was used to convert given water levels in the *Proposed holistic environmental flows framework report* into discharge values. Values plotted represent data from three times per day (7:00, 15:00, and 23:00) from 1995 to 2017, with high values from 1974 and 2018 freshets added.

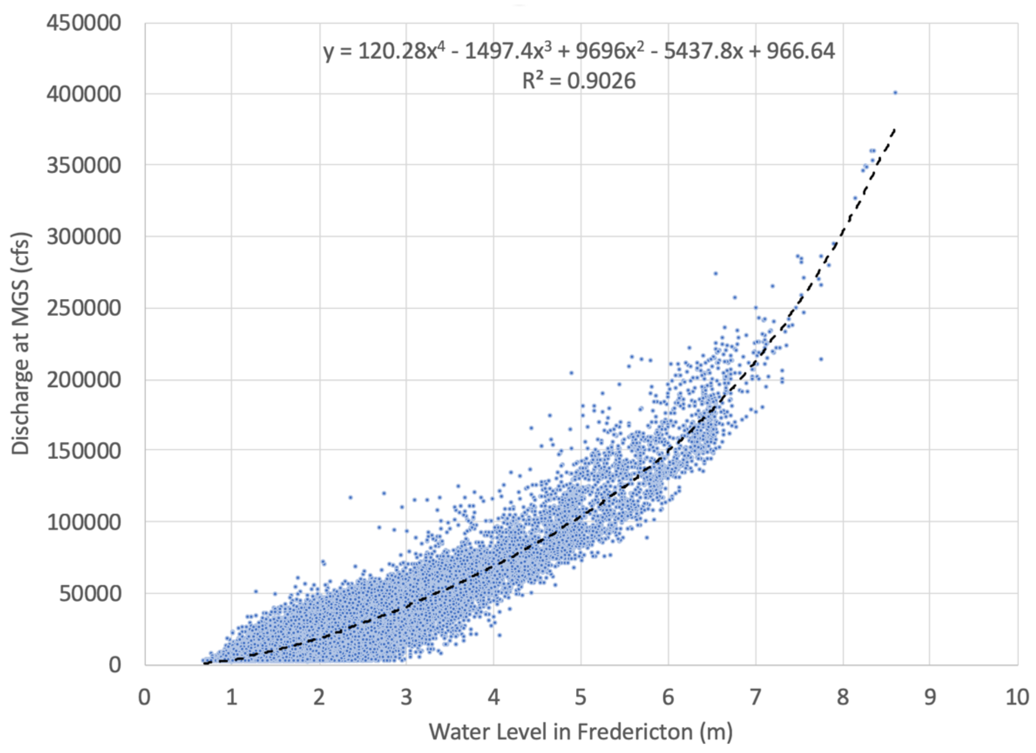
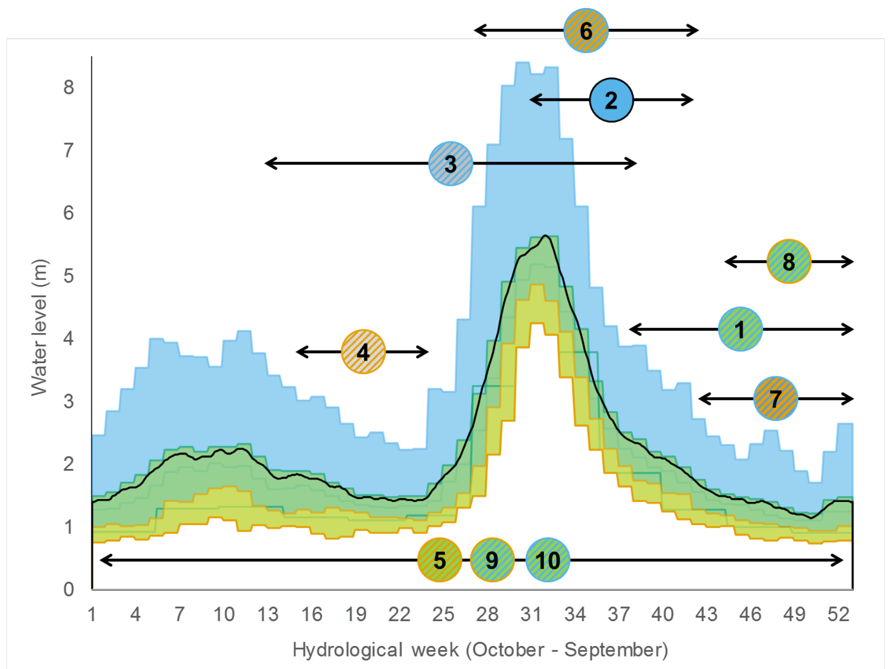


Figure 1: Stage-discharge relationship between the Water Level in Fredericton (m) and the Discharge at MGS (cfs)

3 Results

Figures 20 and 21 (Figure 2) from ***Proposed holistic environmental flows framework for the Saint John River with a focus on operations at the Mactaquac Generating Station*** (Monk et al., 2017) describe the flow requirements based on water level (m) at Fredericton.



1	Cue spawning migration and maintain access to and quality of shallow-slow margin and backwater spawning and nursery habitats
2	Establish ecosystem connectivity to critical habitat refugia during high flow events
3	Maintain ice processes, disturbance events and habitat connectivity during freeze-up, overwinter and break-up
4	Maintain overwinter habitats for resident fish and benthic macroinvertebrates including egg and larval development
5	Maintain thermal habitat heterogeneity and water quality
6	Maintain valley and island formation, channel morphology, and sediment distribution
7	Promote macroinvertebrate growth and insect emergence
8	Support establishment and growth of floodplain, riparian and aquatic vegetation
9	Support mussel spawning, glochidia transfer, juvenile colonisation and growth
10	Support nutrient cycling, and food web productivity and complexity

Figure 2: Proposed weekly hydrograph for WSC 01AK003 gauge in Fredericton (representing large river, mainstem habitat)

Blue shading represents the high flow range (Q10 to Q50), green represents the seasonal range (Q50 to Q75), and orange represents the low flow range (Q75 to Q90). Ice-affected flow range is not shown on this figure. The solid black line represents the median water level. Circles represent individual flow needs, with arrows representing the dominant temporal scale for the particular flow need. Shading reflects flow components represented by each flow need: high flows (blue), seasonal flows (green), low flows (orange), and ice-affected flows (grey). Patterned shading occus where flow needs incorporate more than one flow component. Note that additional flow components for each flow need (e.g. frequency and duration of events) are not shown here.

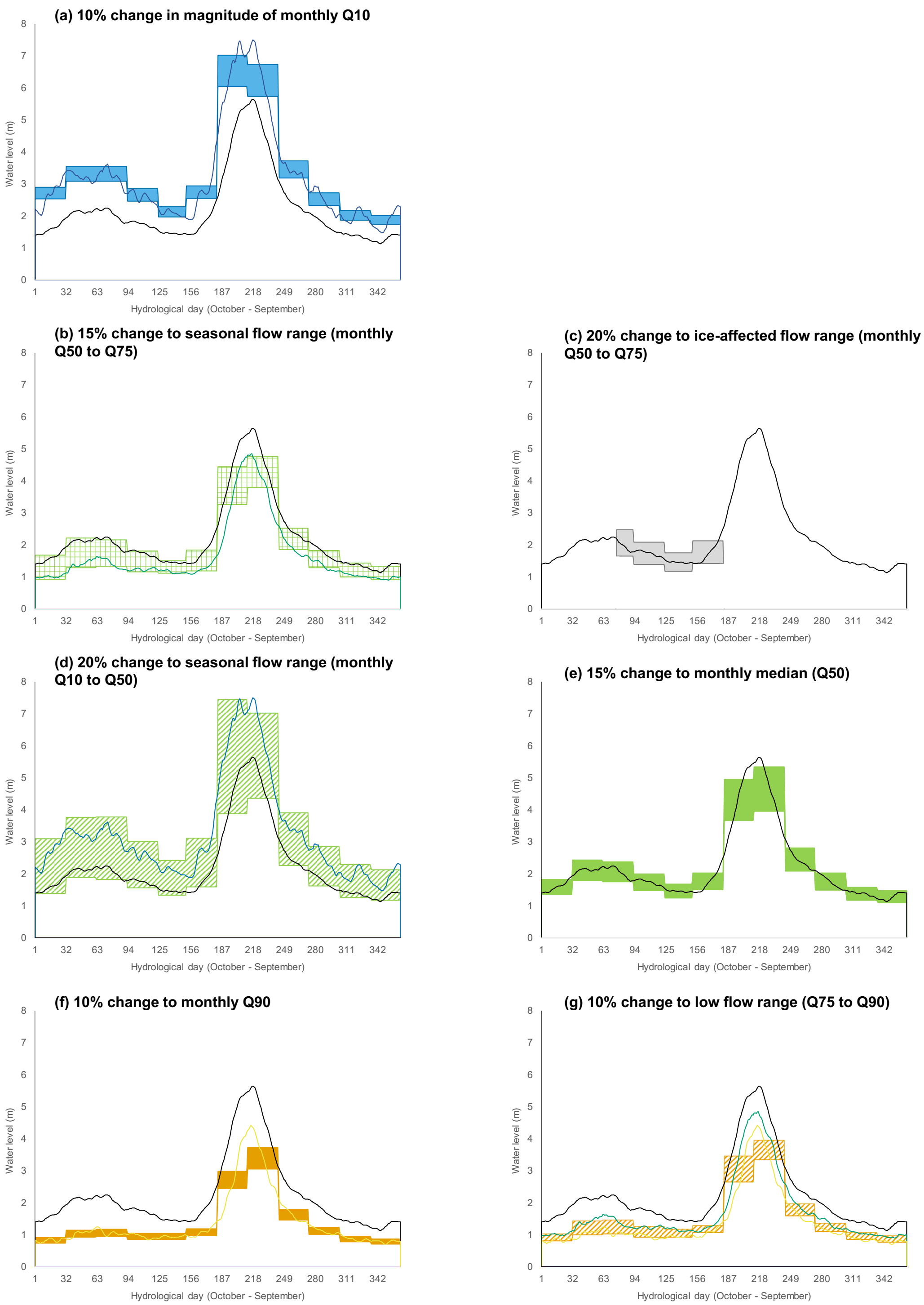


Figure 3: Target flow variables for mainstem habitats, paired with each core flow need (Figure 21; Monk et al. 2017).

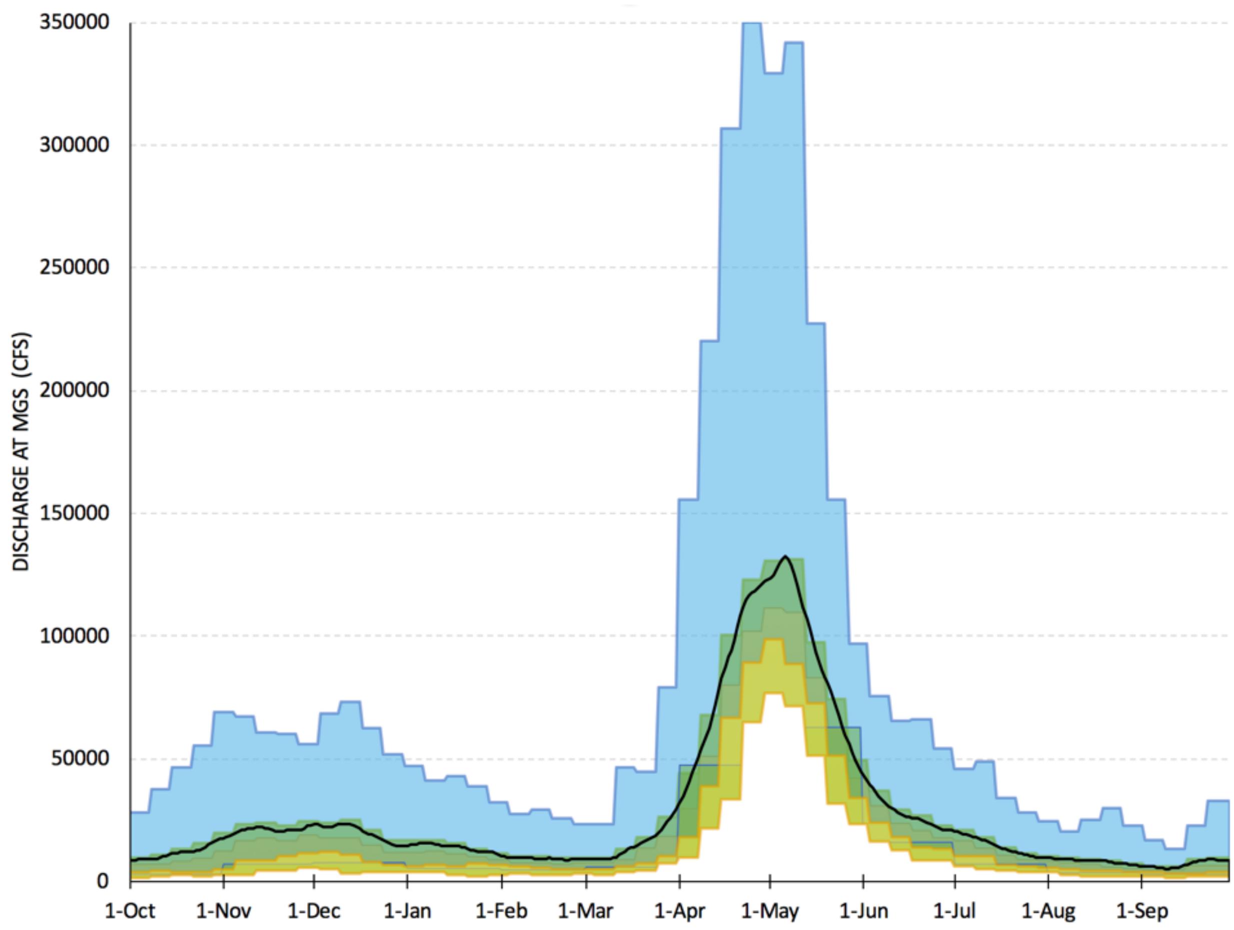
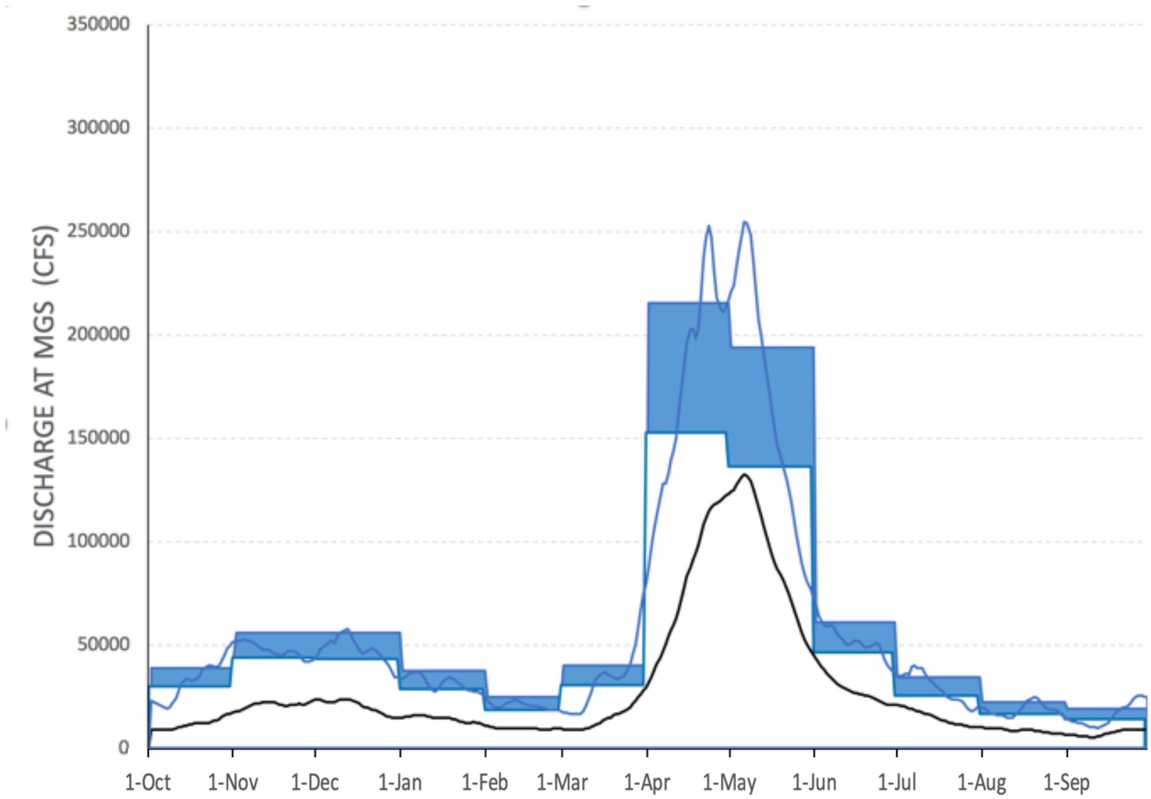


Figure 4: Converted Figure 20 – Proposed weekly hydrograph

Figure 4 is the conversion to discharge at MGS (cfs). The seven target flow for MGS (a-g; Figure 21; Monk et al. 2017) are adjusted and presented twice (Figures 5-11): the first figure shown has a constant maximum discharge of 350,000 cfs; the second figure shown has a variable maximum discharge on the y-axis to allow the graphs to be more easily viewed.



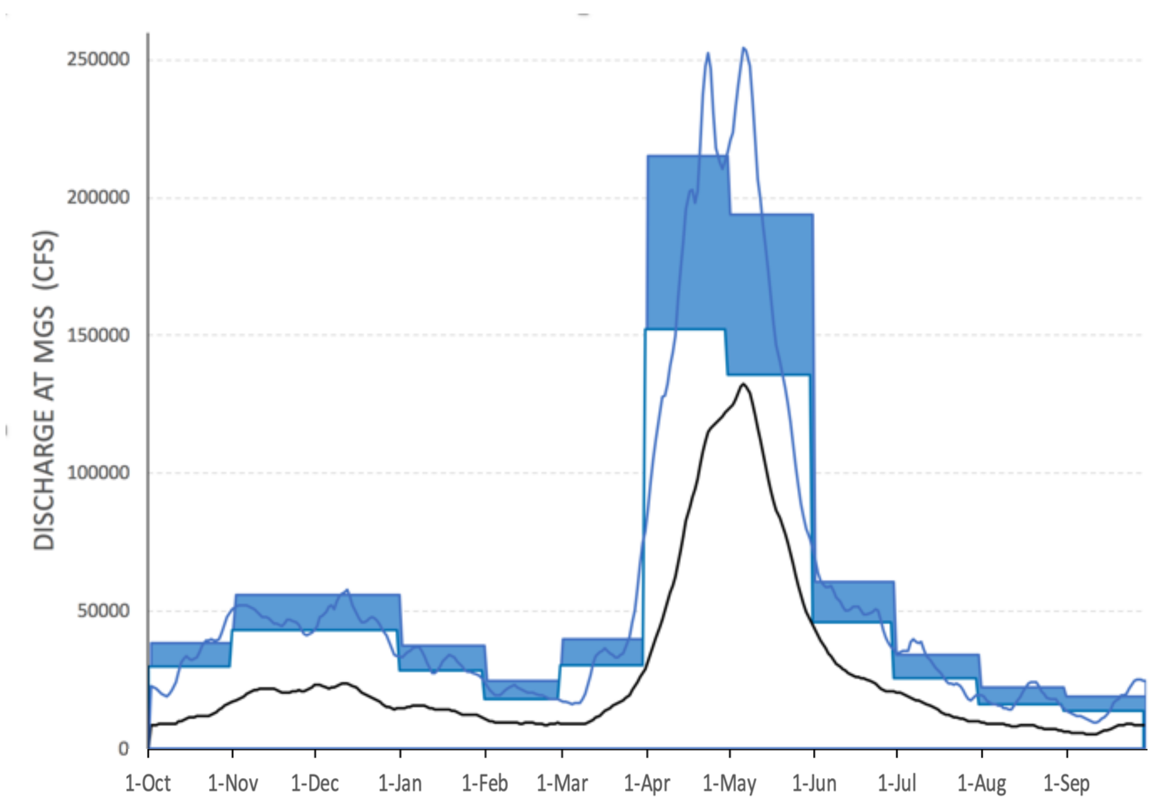


Figure 5: Converted Figure 21 (a) – 10% change in magnitude of monthly Q10

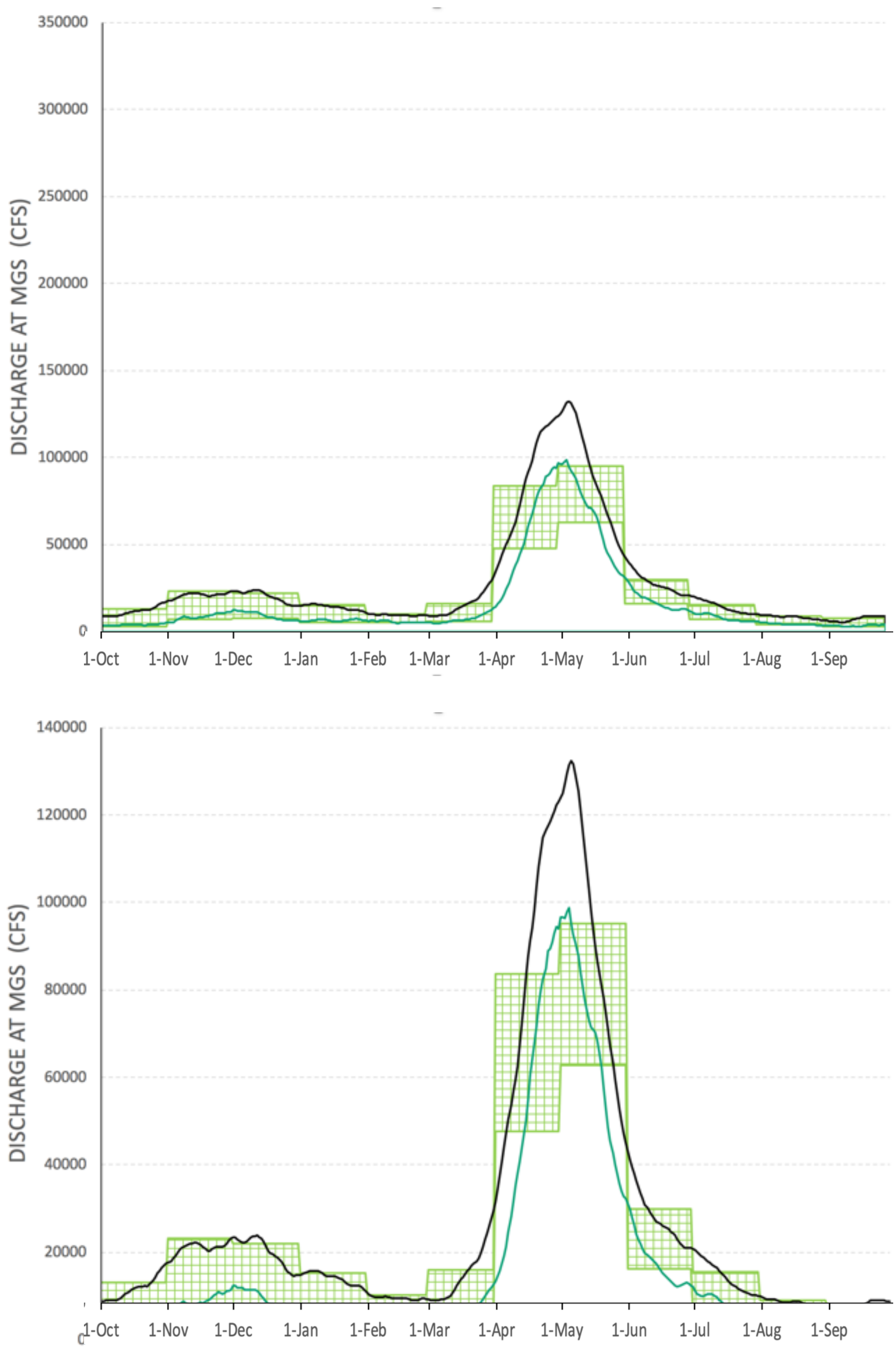


Figure 6: Converted Figure 21 (b) – 15% change to seasonal flow range (monthly Q50 to Q75)

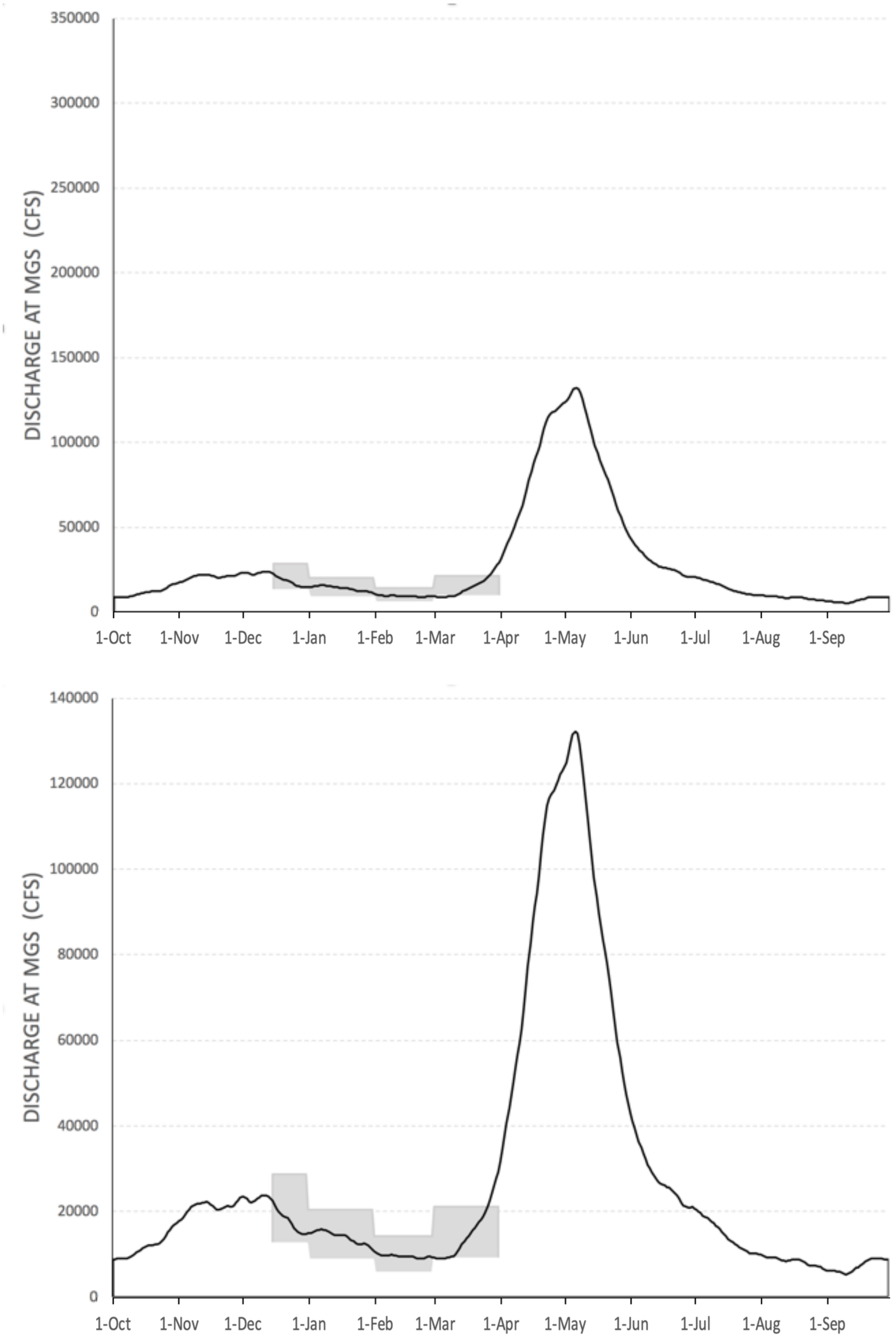


Figure 7: Converted Figure 21 (c) – 20% change to ice-affected flow range (monthly Q50 to Q75)

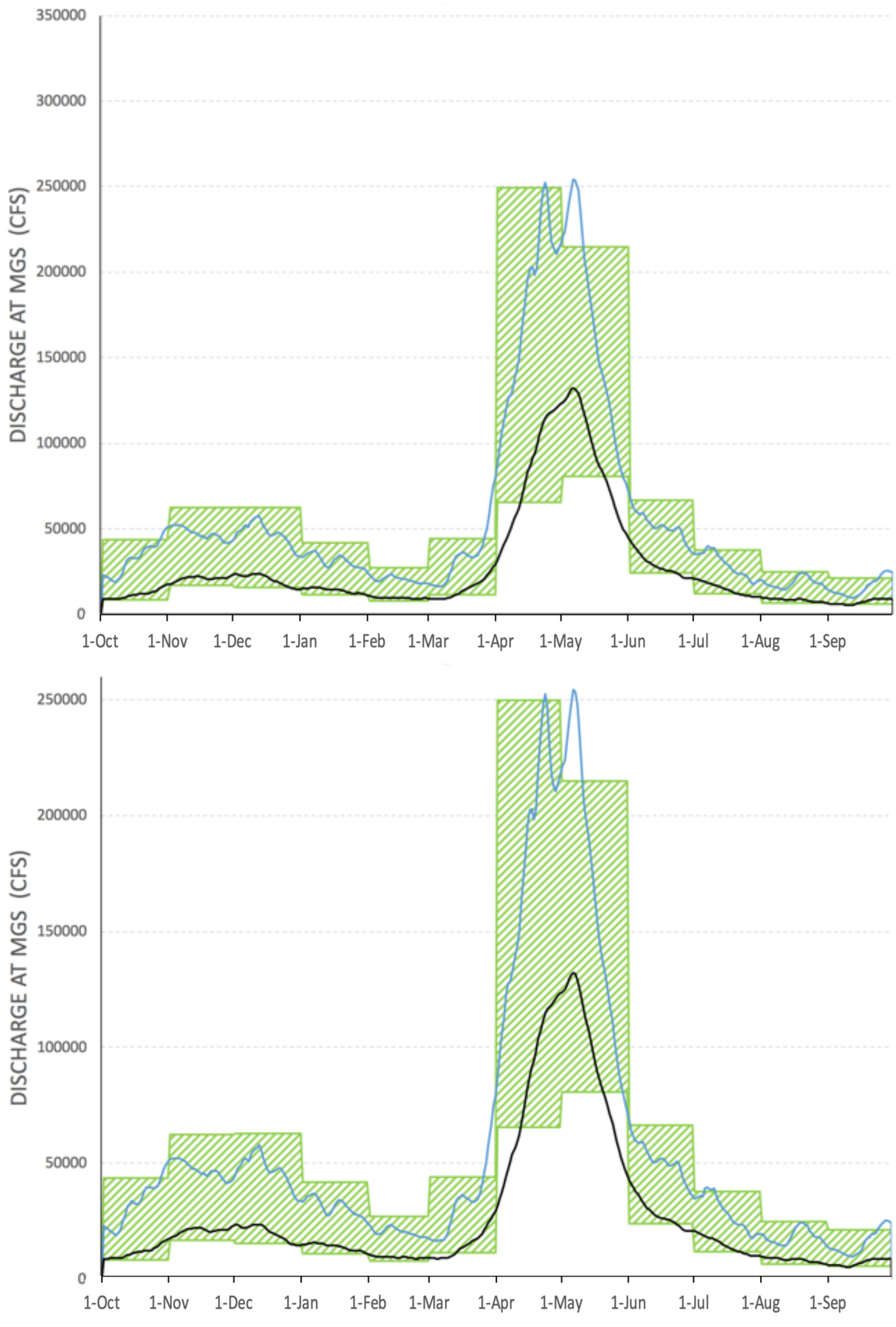


Figure 8: Converted Figure 21 (d) – 20% change to seasonal flow range (monthly Q10 to Q50)

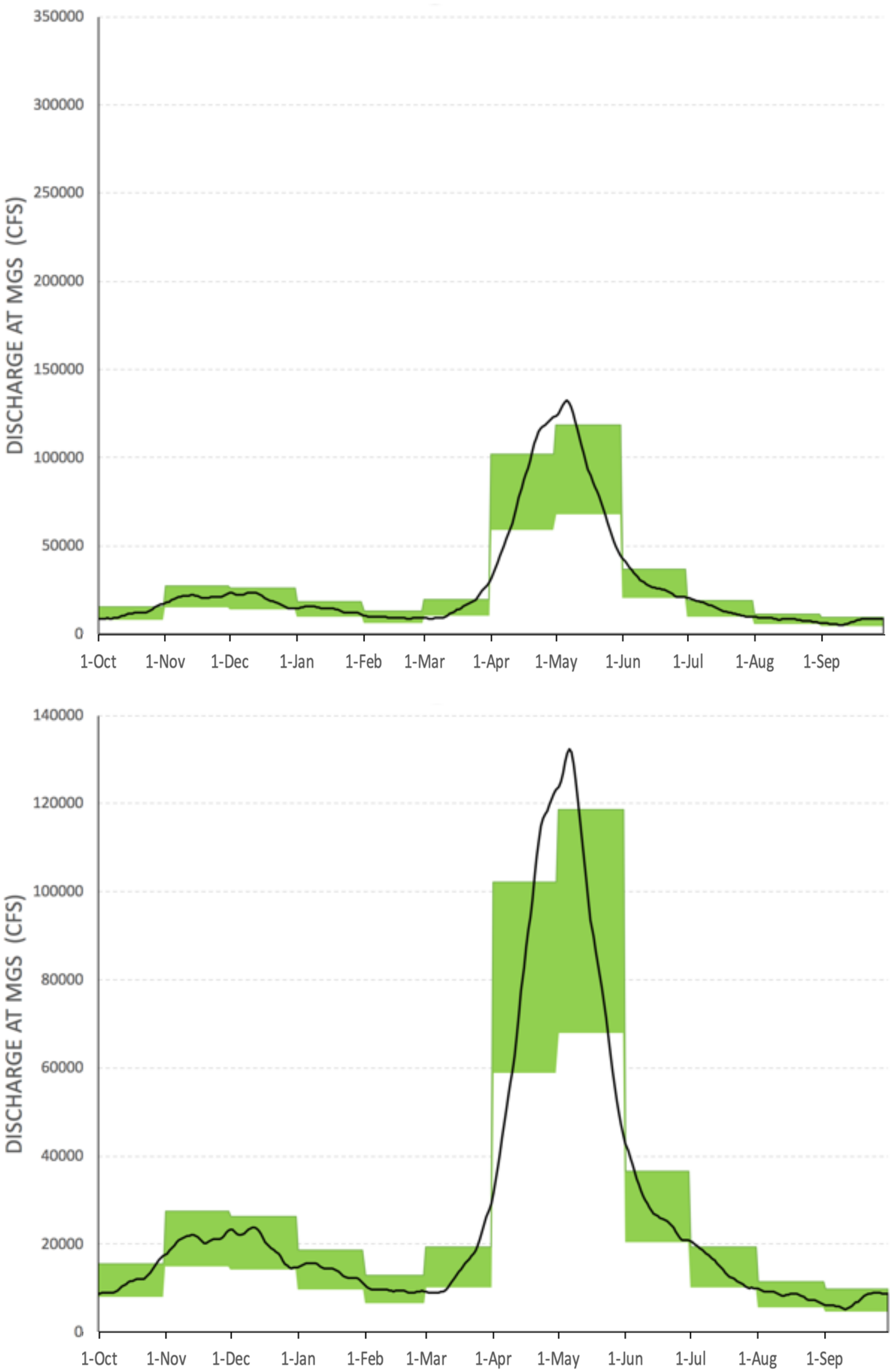
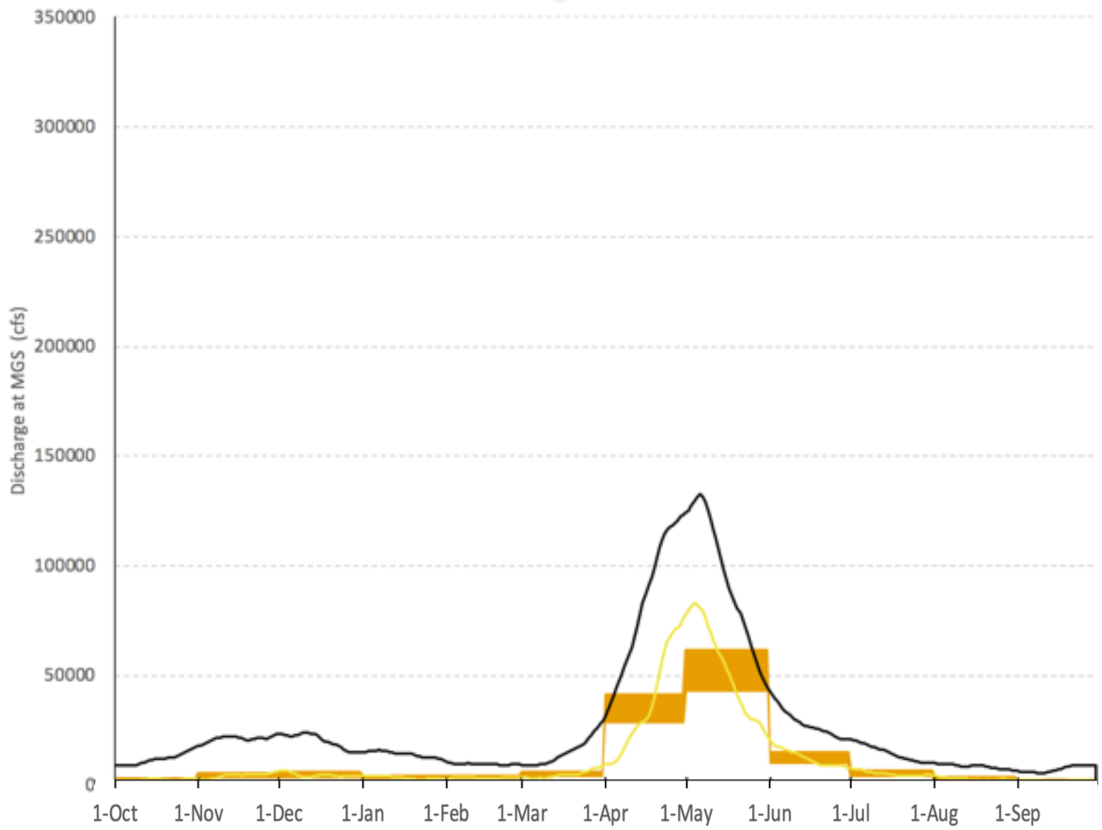


Figure 9: Converted Figure 21 (e) – 50% change to monthly median (Q50)



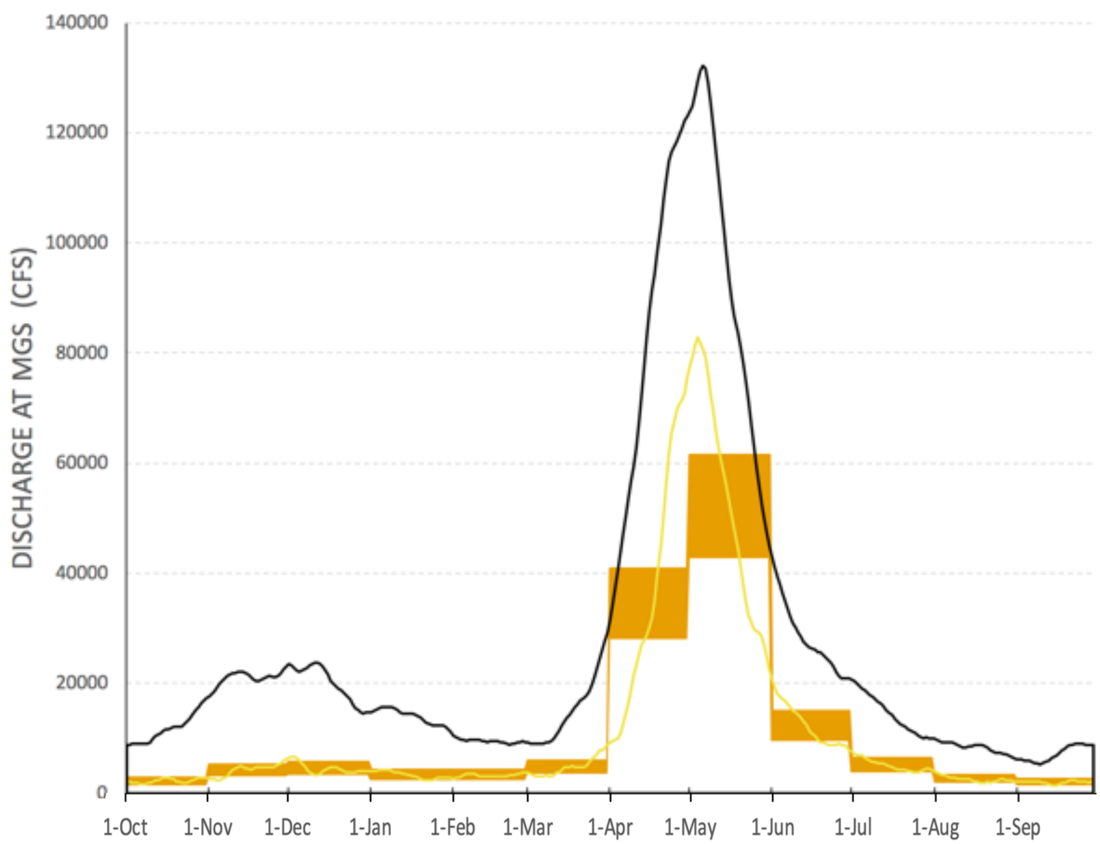
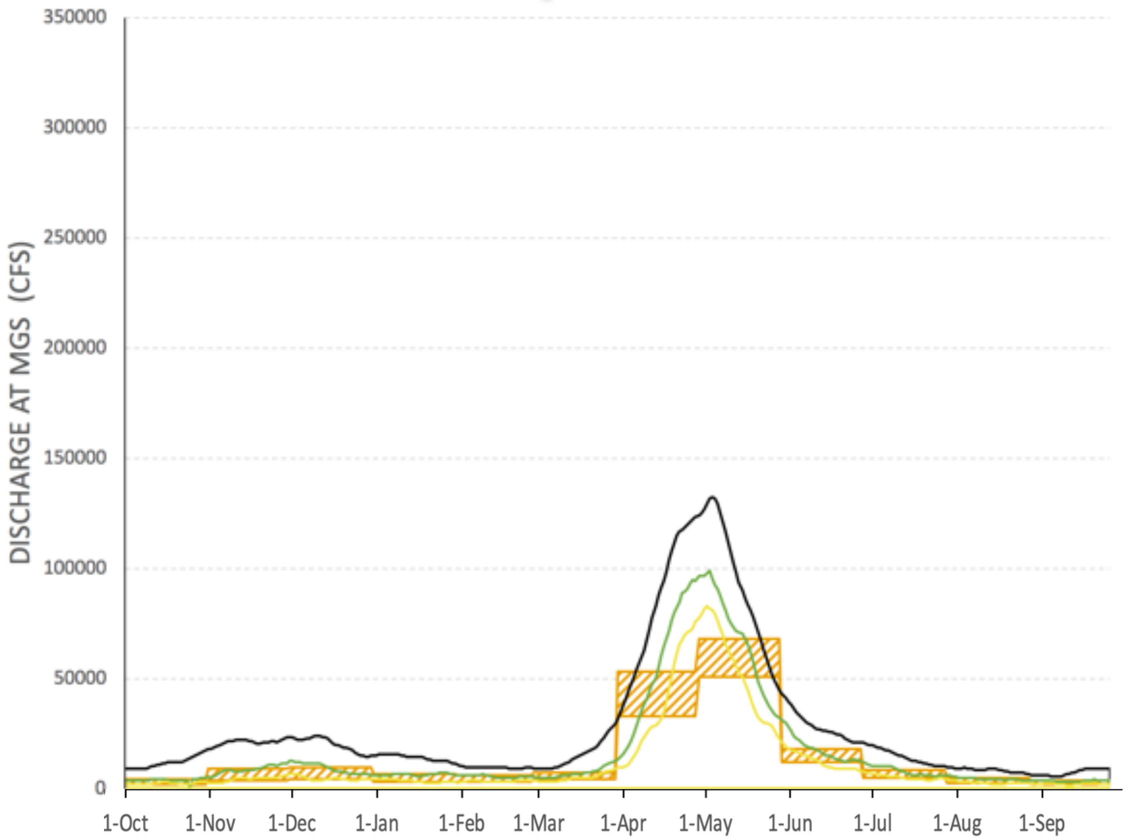


Figure 10: Converted Figure 21 (f) – 10% change to monthly Q90



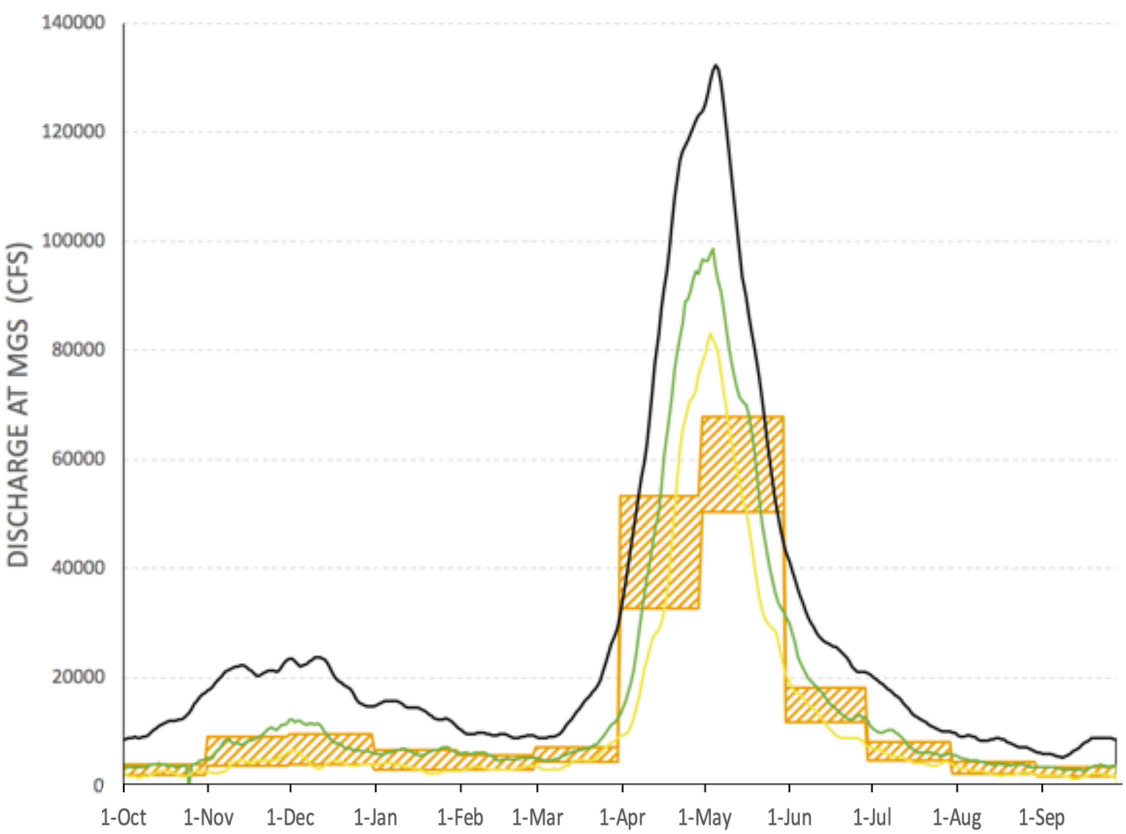


Figure 11: Converted Figure 21 (g) – 10% change to low flow range (Q75 to Q90)

4 References

Monk, W.A., Z.G. Compson, D.G. Armanini and A. Idígoras Chaumel. 2017. Proposed holistic environmental flows framework for the Saint John River with a focus on operations at the Mactaquac Generating Station. Mactaquac Aquatic Ecosystem Report 2017-035. Canadian Rivers Institute, University of New Brunswick. 115 p.