Elk Valley Water Quality Plan

Annex I.2

Modelled Total Phosphorus Concentrations in the Elk and Fording Rivers

Teck

TECHNICAL MEMORANDUM

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TO Kirsten Gillespie
Teck Coal Ltd.

CC Marko Adzic

FROM Dennis Kramer and J.P. Bechtold **EMAIL** dkramer@golder.com

MODELLED TOTAL PHOSPHORUS CONCENTRATIONS IN THE ELK AND FORDING RIVERS

Introduction

Teck Coal Ltd. (Teck) will shortly commission a biological treatment system to reduce selenium and nitrate concentrations in runoff water from the Line Creek Operations (LCO). For the purposes of the Elk Valley Water Quality Plan (the Plan), additional active water treatment facilities using similar biological treatment technologies are being considered. Biological water treatment systems are anticipated to reduce total selenium and nitrate concentrations to 20 µg/L and 0.3 mg/L, respectively, removing over 90% of the total mass of these constituents reporting to the treatment plants. As part of the treatment train, biological water treatment systems also have the potential to discharge total phosphorus (TP) concentrations of between 0.3 and 0.1 mg/L. This technical memorandum assesses changes in TP concentrations at Order stations in the Fording and Elk rivers that would result from the biological treatment plants proposed in the Plan, and the potential of such changes to affect these rivers' trophic status (i.e., quantities of TP).

Treatment Scenario

Consistent with the Plan, this memorandum focuses on biological treatment plants outlined in the initial implementation plan (Table 1). The initial implementation plan assumes that all plants will use biological treatment technology. It is further assumed that the effluent TP concentration for the WLC water treatment plant (WTP) will be 0.3 mg/L, and effluent TP concentrations for other plants will be 0.1 mg/L[1].

[1] Concentrations in future WTPs are assumed to be lower than at the WLC WTP, because it is assumed that additional phosphorus treatment will be added to the treatment train.

Table 1: Water Treatment Plants Outlined in the Initial Implementation Plan for the Elk Valley Water Quality Plan

Water Treatment Plant	Capacity [m^3/d]	Commissioning
Line Creek Operations West Line Creek (LCO I) Phase I	7,500	Q2 2014[(a)]
Fording River Operations South (FRO S)	20,000	2018
Elkview Operations (EVO) Phase I	30,000	2020
Fording River Operations North (FRO N) Phase I	15,000	2022
EVO Phase II	20,000	2024
Greenhills Operations (GHO)	7,500	2026
LCO Dry Creek (LCO II)	7,500	2028
FRO N Phase II	15,000	2030
LCO I Phase II	7,500	2032

(a) In the model, the LCO I plant is commissioned in January 2014. The difference between this date and the actual commissioning date (i.e., Q2 2014) will have negligible effects on predicted water quality conditions for the planning period.

Methods

Water Quality Modeling and Evaluation

TP concentrations were modelled at Order stations in the Fording and Elk rivers using the water quality model developed for the Plan. The details of the model set-up are presented in Teck 2014. For TP predictions, the following model inputs were used:

- background TP concentrations of 0.009 mg/L and 0.003 mg/L in the Fording and Elk rivers[2], respectively;
- waste rock and coal reject concentrations set to equal background TP concentrations; and
- a TP concentration of 0.3 mg/L in treated effluent from the WLC WTP, and 0.1 mg/L in all other WTPs evaluated in the BCIP.

Results were evaluated for the average over the entire growing season (June 15 to September 30) and the average over the summer low-flow period (August 1 to September 30). The August to September period was included as it is generally the period of the growing season with the lowest flows, and hence be the most influenced by future treatment plants. The average over each period was examined, because plant growth is influenced by conditions over time frames longer than a month. Concentrations were modelled for the two periods for of low-, average- and high-flow years.

Modelled TP concentrations were compared to trophic levels defined in the Canadian guidance framework for the management of phosphorus in freshwater systems (CCME 2004; Table 2).

[2] Background concentrations in the Elk River were estimated using the geometric mean of the data collected from the Elk River upstream of Greenhills Operations (Teck 2013; GH_ER1). Background concentrations in the Fording River were estimated using the geometric mean of the data collected from a number of undisturbed locations in the Fording River watershed (Teck 2013; LC_LC1, FR_UFR1, LC_GC1, LC_DC1).

Table 2: Canadian Guidance Framework for Long-Term Phosphorus Concentrations in Freshwater

Trophic Level Designation	Total Phosphorus [mg/L]
Ultra-oligotrophic	<0.004
Oligotrophic	0.004 to <0.010
Mesotrophic	0.010 to <0.020
Meso-eutrophic	0.020 to <0.035
Eutrophic	0.035 to <0.10
Hyper-eutrophic	>0.10

Source: CCME (2004).

Results

The results presented in Table 3 include maximum predicted TP concentrations for current conditions, as well as for the growing seasons (June 15 to September 30) and summer low-flow periods (August 1 to September 30) in 2019 and in 2034. Concentrations in 2019 are of interest, because they represent predicted conditions once the WLC and FRO South WTPs have been commissioned (at total capacity of 27,500 m^3/d); these WTPs have the most certainty regarding selected technology. Concentrations in 2034 reflect modelled conditions under the assumption that the initial implementation plan is implemented (a total capacity of 130,000 m^3/d). The rest of this section discusses how the predicted TP concentrations may affect trophic status.

Fording River

Current modelled TP concentrations at Order stations in the Fording River indicate that the river can be classified as oligotrophic (Table 2; Figures 1 and 2). This is consistent with observed data in the Fording River (Teck 2013).

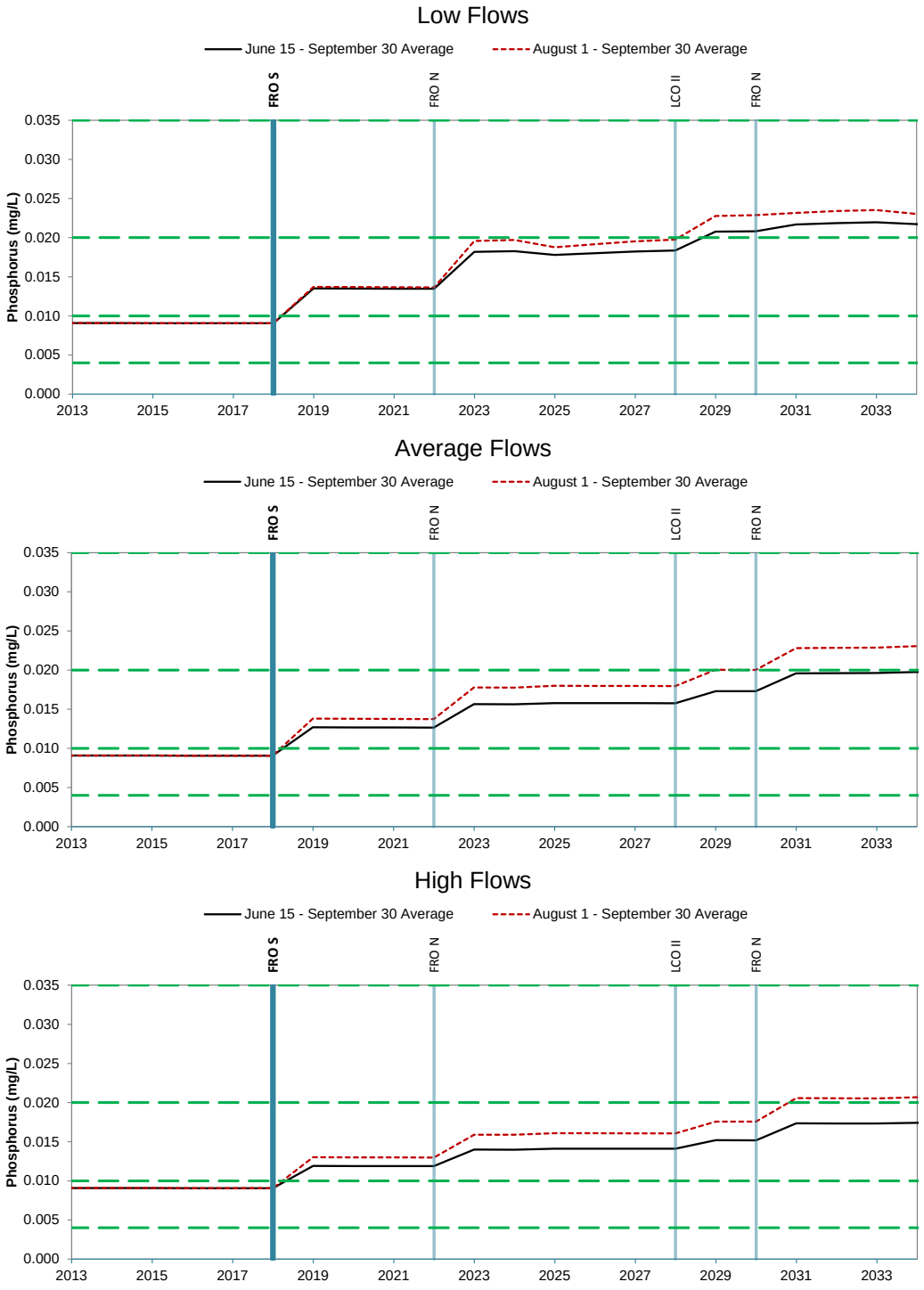
At the Fording River downstream of Greenhills Creek, TP concentrations may increase to levels indicative of mesotrophic conditions once the FRO South WTP is commissioned by 2018. TP concentrations are anticipated to remain at mesotrophic levels until 2028, when the LCO II WTP is built at Dry creek (Figure 1). Following commissioning of the LCO II WTP, modelled concentrations are predicted to rise to levels indicative of meso-eutrophic conditions and remain at these levels. These results indicate that, based on the set-up described in the Initial Implementation Plan, TP concentrations are expected to reach mesotrophic levels once treatment capacity upstream of this location reaches 20,000 m^3/d, and meso-eutrophic levels once the capacity reaches 42,500 m^3/d.

At the mouth of the Fording River, TP concentrations follow a similar pattern; however, the timing of potential trophic shifts are predicted to occur at an earlier date, as conditions at the mouth of the Fording River are under the influence of a greater number of potential WTPs. Upon implementation of the LCO I WTP (i.e., when 7,500 m^3/d of treatment capacity has been added upstream of this location), concentrations are modelled to increase to levels indicative of mesotrophic conditions. TP concentrations are expected to remain at mesotrophic levels until 2022, when the FRO North WTP is commissioned (Figure 2). They are then predicted to rise to levels indicative of meso-eutrophic conditions, and to remain at these levels. These results indicate that, based on the set-up described in the Initial Implementation Plan, TP concentrations are expected to reach mesotrophic levels once the total capacity in the Fording River watershed reaches 7,500 m^3/d, and meso-eutrophic levels once treatment capacity reaches 42,500 m^3/d.

Table 3: Maximum Predicted Total Phosphorus Concentrations (mg/L) at Order Stations in the Elk and Fording Rivers

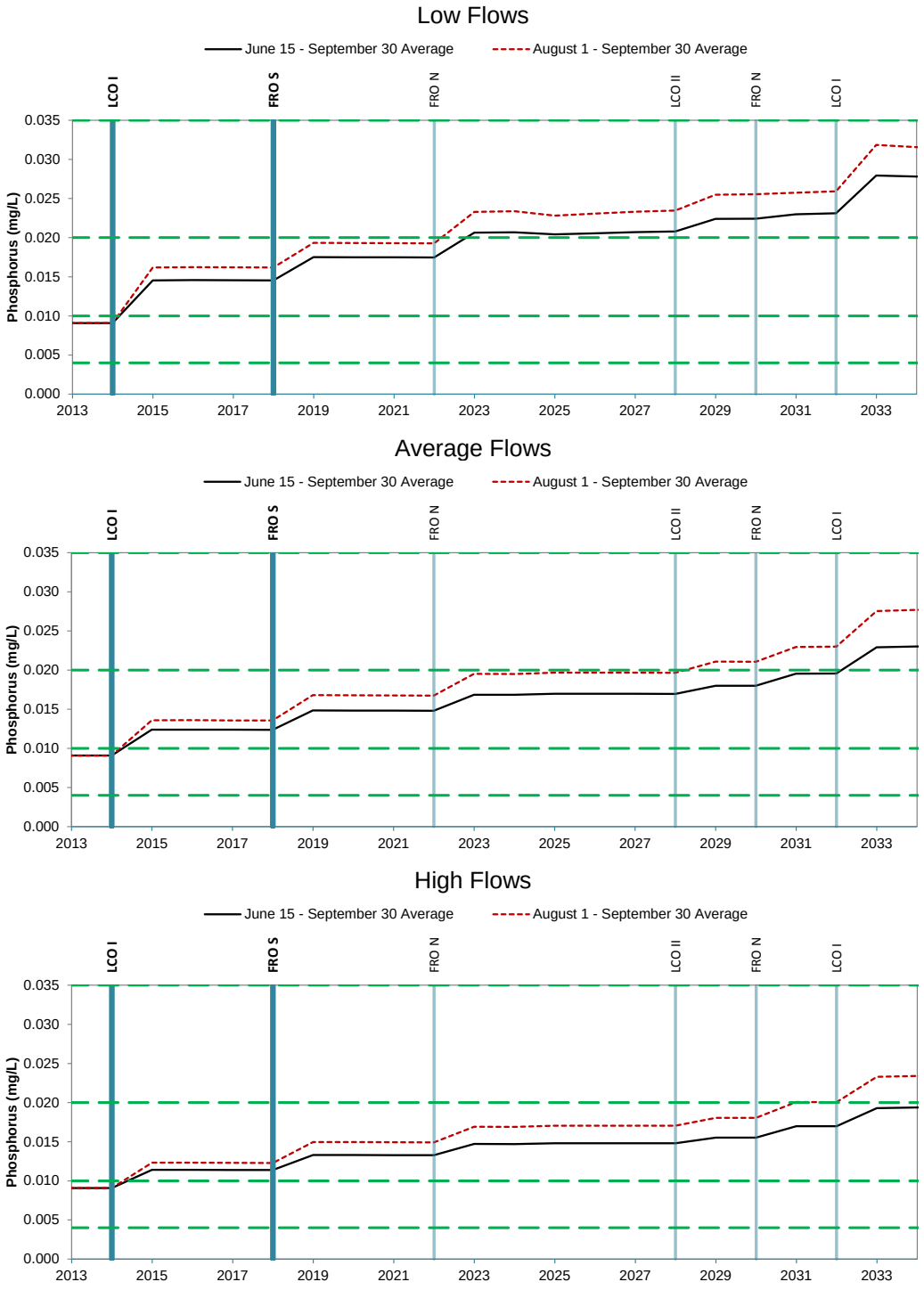
Location	Current Conditions			2019			2034		
	June 15 to September 30	August 1 to September 30	Trophic Status	June 15 to September 30	August 1 to September 30	Trophic Status	June 15 to September 30	August 1 to September 30	Trophic Status
Fording River Downstream of Greenhills Creek (FR4 - EMS# 0200378)	0.009	0.009	Oligotrophic	0.013	0.014	Mesotrophic	0.022	0.023	Meso-eutrophic
Fording River at the Mouth (FR5 - EMS# 0200396)	0.009	0.009	Oligotrophic	0.018	0.019	Mesotrophic	0.028	0.032	Meso-eutrophic
Elk River Downstream of Greenhills Operations (ER1 - EMS# E206661)	0.003	0.003	Ultra-oligotrophic	0.003	0.003	Ultra-oligotrophic	0.003	0.003	Ultra-oligotrophic
Elk River Downstream of the Fording River (ER2 - EMS# 0200389)	0.005	0.005	Oligotrophic	0.006	0.007	Oligotrophic	0.009	0.010	Oligotrophic
Elk River Downstream of Michel Creek (ER3 - EMS# 0200393)	0.005	0.005	Oligotrophic	0.006	0.006	Oligotrophic	0.009	0.010	Oligotrophic
Elko Reservoir (ER4 - EMS# E294312)	0.005	0.005	Oligotrophic	0.005	0.005	Oligotrophic	0.008	0.008	Oligotrophic

Figure 1: Average Predicted Total Phosphorus Concentrations over the Specified Periods in the Fording River Downstream of Greenhills Creek (FR4)



Note: Vertical blue lines represent the commissioning of water treatment plants that affect this location; thick lines represent plants with a high level of certainty. Dashed green lines represent trophic status boundaries: Ultra-oligotrophic (<0.04 mg/L); Oligotrophic (0.04 to 0.01 mg/L); Mesotrophic (0.01 to 0.02 mg/L); and Meso-eutrophic (0.02 to 0.035 mg/L.).

Figure 2: Average Predicted Total Phosphorus Concentrations over the Specified Periods in the Fording River at the Mouth (FR5)



Note: Vertical blue lines represent the commissioning of water treatment plants that affect this location; thick lines represent plants with a high level of certainty. Dashed green lines represent trophic status boundaries: Ultra-oligotrophic (<0.04 mg/L); Oligotrophic (0.04 to 0.01 mg/L); Mesotrophic (0.01 to 0.02 mg/L); and Meso-eutrophic (0.02 to 0.035 mg/L.).

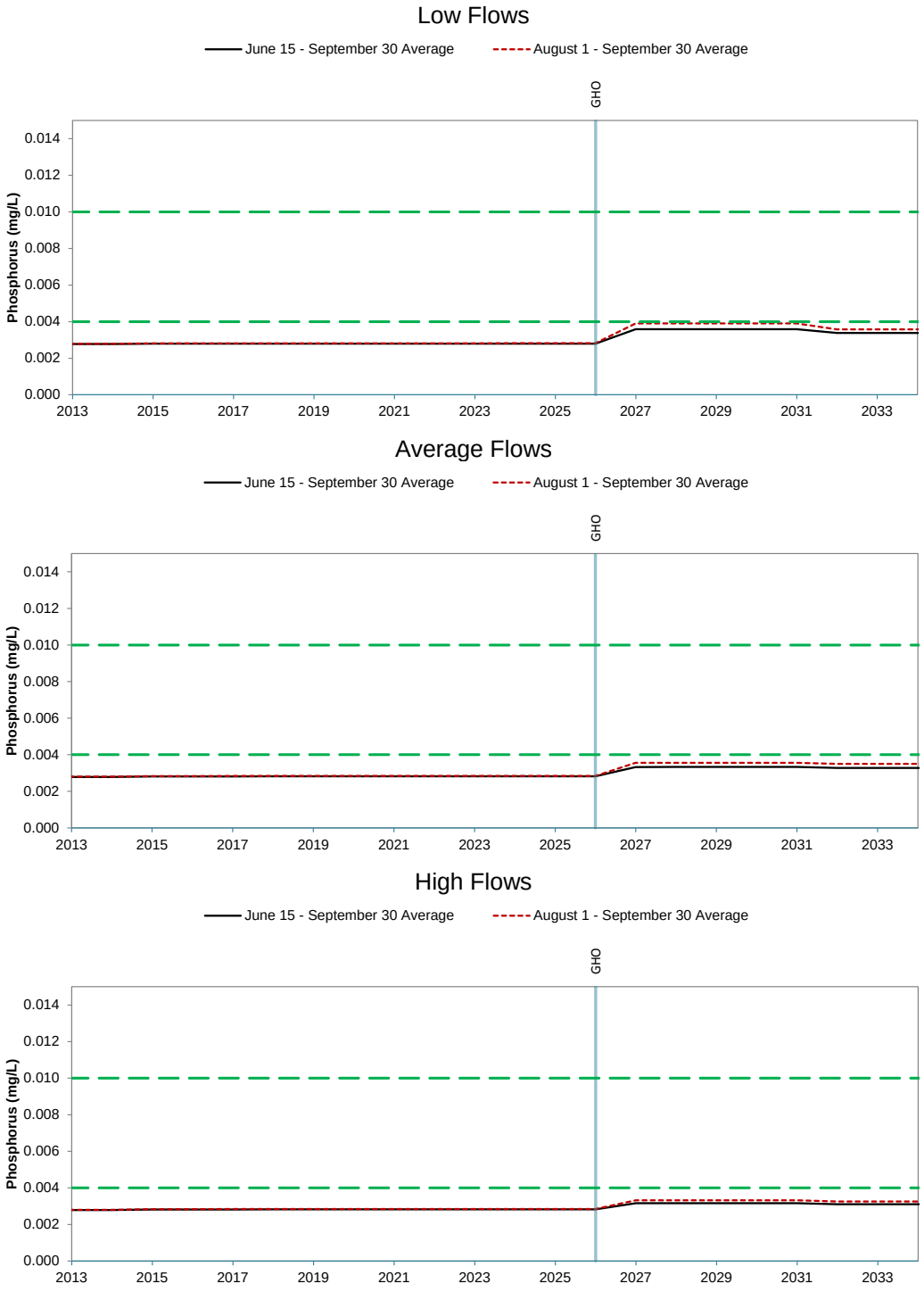
When the Fording River is at levels indicative of mesotrophic conditions, there is the potential for some enrichment and increased primary productivity. Once concentrations increase to levels that indicate meso-eutrophic conditions (i.e., >0.020 mg/L), there is the potential for further increases in primary productivity. However, productivity increases are not only dependent on in-stream TP concentrations; other conditions, including water velocity, light, temperature and invertebrate grazing pressure, also influence algal growth, and nutrient availability only becomes the most limiting factor to algal growth if all other conditions are less limiting (Nordin 2001). As such, there is uncertainty in the level of response that may occur as a result of increasing TP concentrations. In other words, there is a high level of confidence that the TP concentrations reported herein do not underestimate potential future conditions, based on the configuration of the Initial Implementation Plan; however, the effect they have on algal growth is uncertain. Hence, this analysis focuses on potential shifts in trophic status, without detailed interpretation of how existing level of algal biomass may change. To address this uncertainty, it is recommended that Teck monitor potential changes in productivity in the Fording River. The data collected should be used to evaluate the potential for unacceptable increases in primary production and guide adaptive management decisions related to phosphorus.

Elk River

Modelled current TP concentrations in the Elk River indicate that the river can be classified as ultra-oligotrophic upstream of the Fording River, and oligotrophic downstream of the Fording River (Table 2; Figures 3 to 6). This is consistent with observed data in the Elk River (Teck 2013), as well as previous assessments of phosphorus concentrations in the Elk River (Dessouki and Ryan 2010).

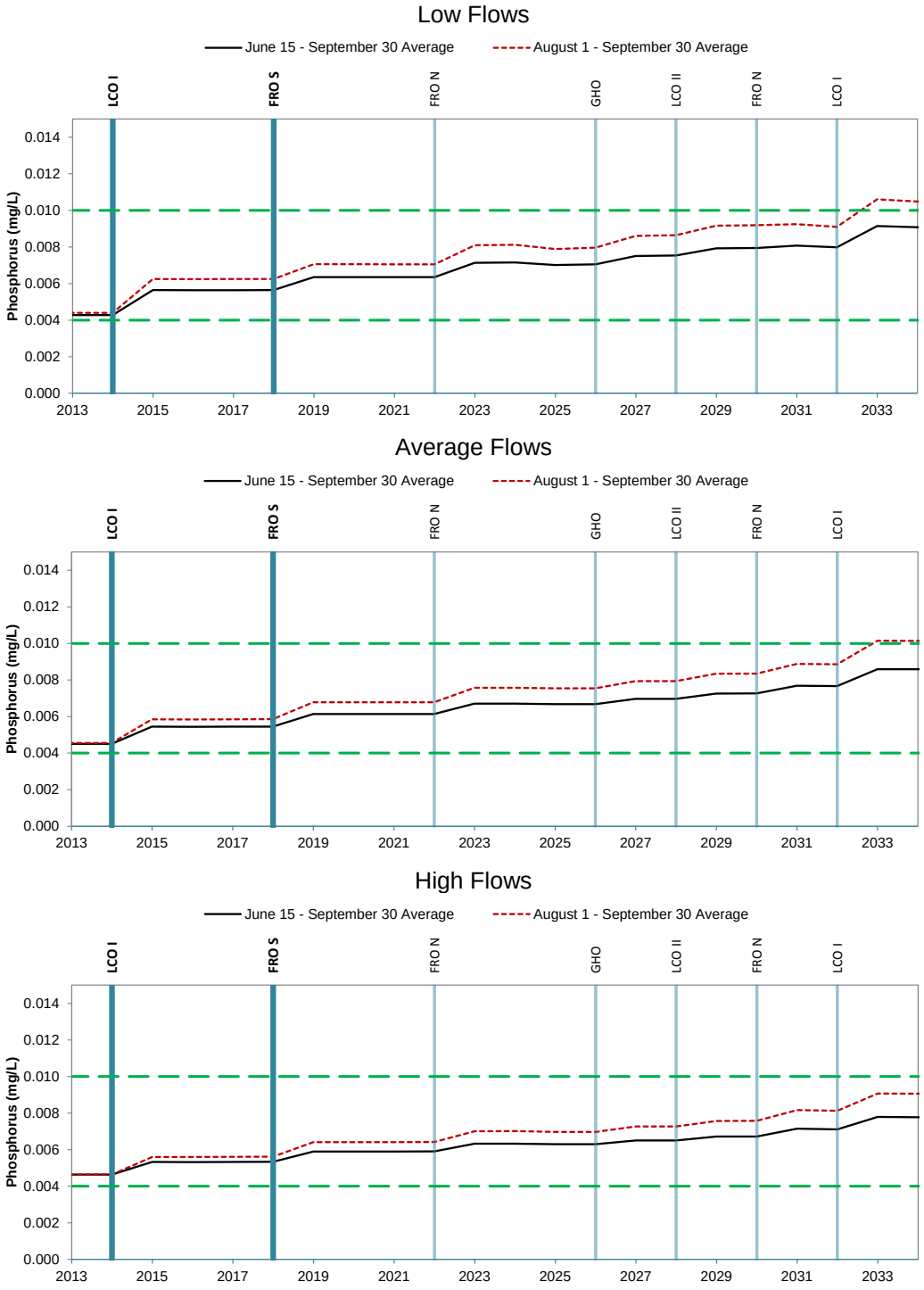
Downstream of GHO, the Elk River is predicted to remain ultra-oligotrophic (Figure 3). Downstream of the Fording River, Michel Creek and in Elko Reservoir, TP concentrations are anticipated to remain oligotrophic (Figures 4 to 6); although once Phase II of the WLC WTP is commissioned, concentrations are modelled to reach the trophic status boundary downstream of the Fording River and Michel Creek. Consequently, a shift to mesotrophic conditions could occur. This indicates that increases in TP may result in some enrichment and increased primary productivity, but, given the lack of trophic shifts predicted in the Elk River, broad or large-scale effects are not expected.

Figure 3: Average Predicted Total Phosphorus Concentrations over the Specified Periods in the Elk River Downstream of Greenhills Operations (ER1)



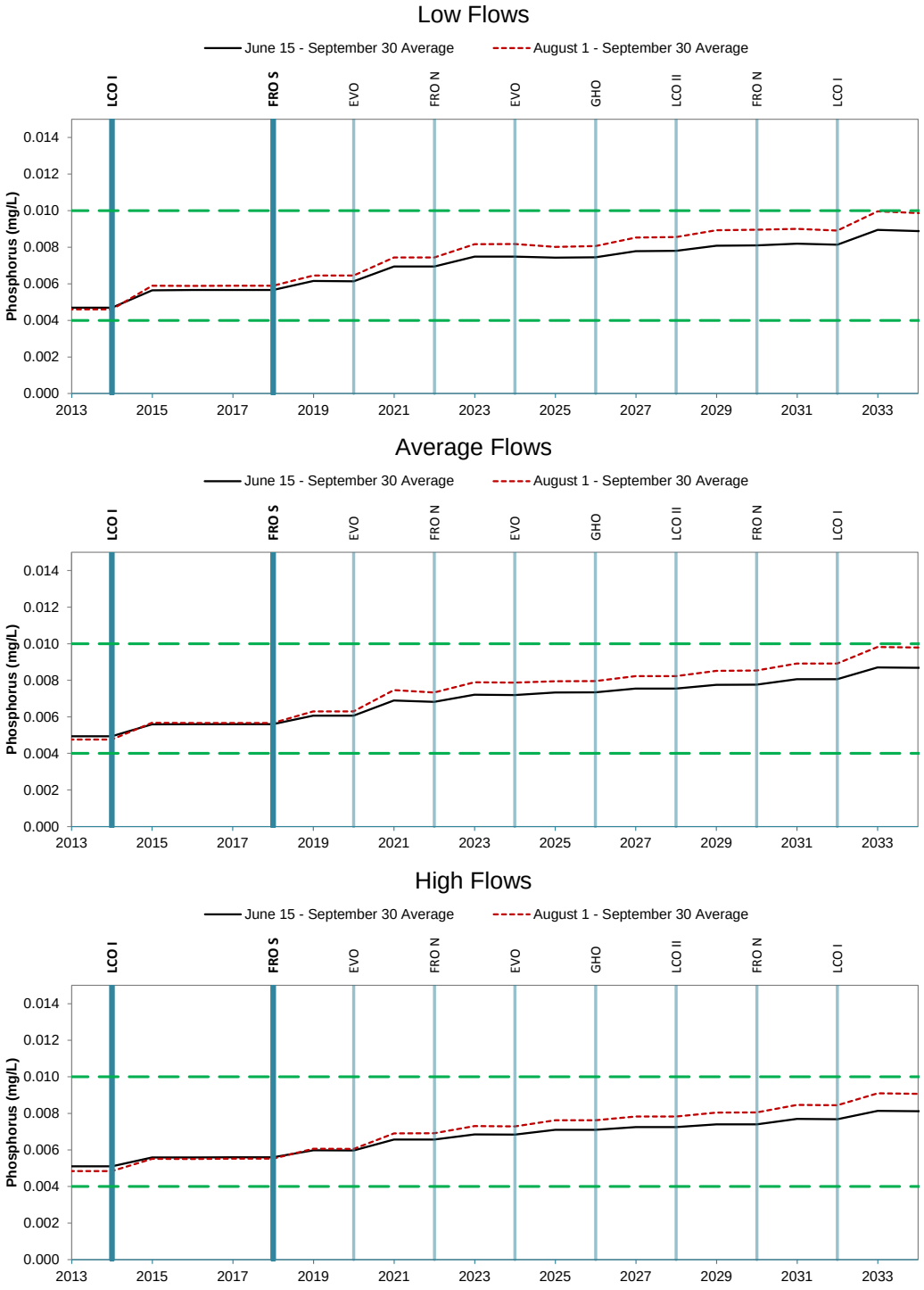
Note: Vertical blue lines represent the commissioning of water treatment plants that affect this location. Dashed green lines represent trophic status boundaries: Ultra-oligotrophic (<0.04 mg/L); Oligotrophic (0.04 to 0.01 mg/L); and Mesotrophic (0.01 to 0.02 mg/L).

Figure 4: Average Predicted Total Phosphorus Concentrations over the Specified Periods in the Elk River Downstream of the Fording River (ER2)



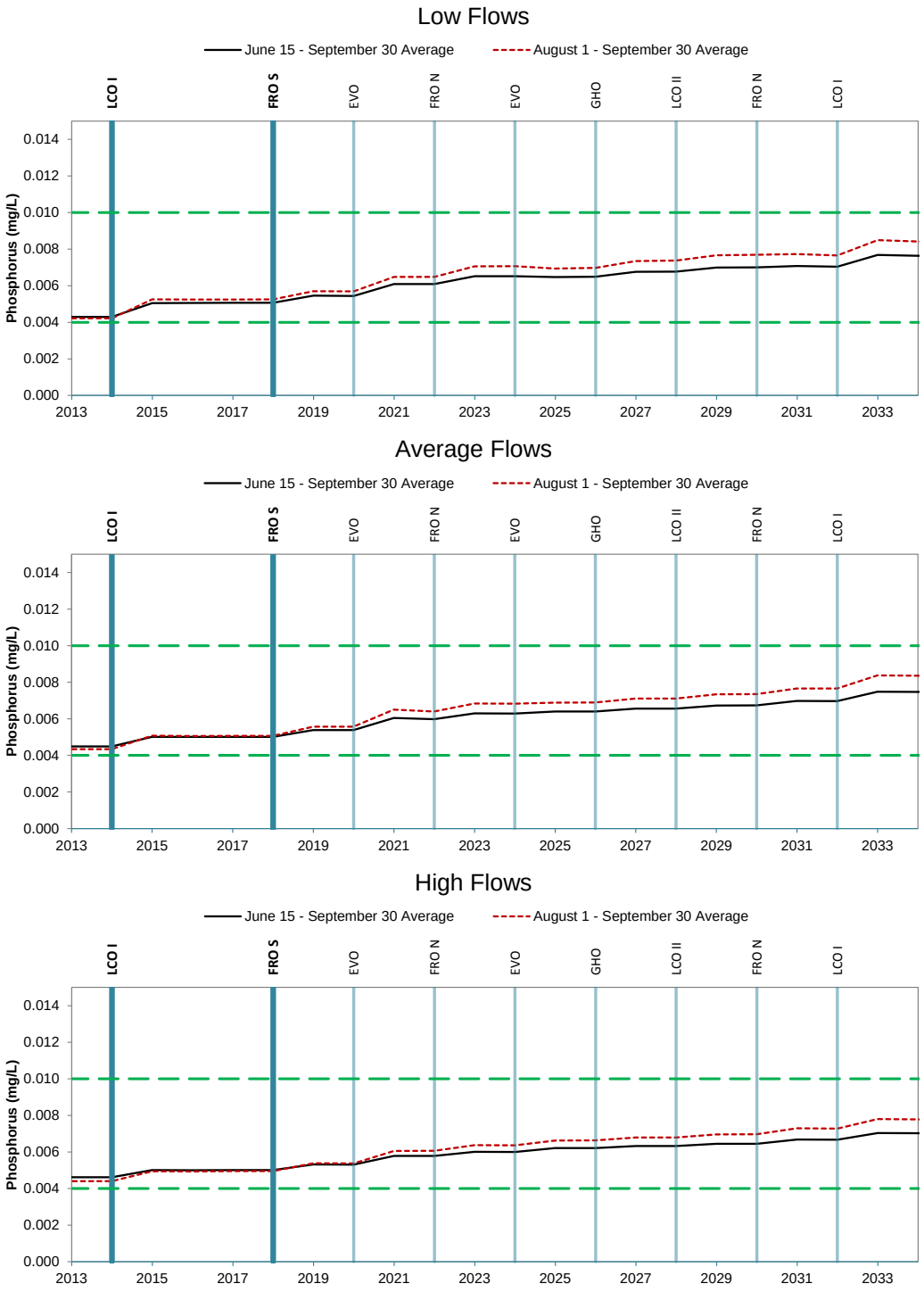
Note: Vertical blue lines represent the commissioning of water treatment plants that affect this location; thick lines represent plants with a high level of certainty. Dashed green lines represent trophic status boundaries: Ultra-oligotrophic (<0.04 mg/L); Oligotrophic (0.04 to 0.01 mg/L); and Mesotrophic (0.01 to 0.02 mg/L).

Figure 5: Average Predicted Total Phosphorus Concentrations over the Specified Periods in the Elk River Downstream of Michel Creek (ER3)



Note: Vertical blue lines represent the commissioning of water treatment plants that affect this location; thick lines represent plants with a high level of certainty. Dashed green lines represent trophic status boundaries: Ultra-oligotrophic (< 0.04 mg/L); Oligotrophic (0.04 to 0.01 mg/L); and Mesotrophic (0.01 to 0.02 mg/L).

Figure 6: Average Predicted Total Phosphorus Concentrations over the Specified Periods in Elko Reservoir (ER4)



Note: Vertical blue lines represent the commissioning of water treatment plants that affect this location; thick lines represent plants with a high level of certainty. Dashed green lines represent trophic status boundaries: Ultra-oligotrophic (<0.04 mg/L); Oligotrophic (0.04 to 0.01 mg/L); and Mesotrophic (0.01 to 0.02 mg/L).

Closure

We trust that this memorandum meets your expectations; if you have any questions or comments, please contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.

Dennis Kramer, M.Sc.
Water Quality Specialist

J.P. Bechtold., M.A.Sc., P. Biol.
Principal, Senior Water Quality Specialist

DK/JB

https://capws.golder.com/sites/p313490006elkvalleyareabasedplan/6200_wq_additionalrequests/m20_totalphosphorus/g-05-16 eutrophication memo fording and elk rivers.docx

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