Spokane River Modeling Scenarios Report 2009

Water Quality Research Group
Department of Civil and Environmental Engineering
Maseeh College of Engineering and Computer Science

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Environmental Protection Agency

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Introduction

Spokane River Total Maximum Daily Load (TMDL) scenarios were simulated using the CE-QUAL-W2 models developed for the Washington Department of Ecology and the Environmental Protection Agency. The scenarios were run with varying concentrations for tributaries and point sources.

The Upper Spokane River system is located in the Northeastern part of Washington State and flows from Coeur d'Alene Lake, Idaho at RM (River Mile) 111.3 downstream to Long Lake dam at RM 32.5. The Washington Department of Ecology will issue a dissolved oxygen TMDL for the Spokane River from the Idaho border to Long Lake Dam. EPA will issue NPDES permits to wastewater treatment plants on the Idaho portion of the Spokane River, and the Idaho Department of Environmental Quality will issue 401 certifications for those permits. The Spokane Tribe is currently developing a model of Spokane Arm, downstream of the project area, to assess water quality impacts in its jurisdictional waters. The TMDL, along with a 401 certification for the FERC relicensing of Spokane River dams, will reduce phosphorus loadings and affect minimum in-stream flows in the Spokane River.

Existing CE-QUAL-W2 water quality models (Washington and Idaho) of Upper Spokane River were updated to the more recent version 3.6 (Berger et al.,2009). These models were used to help determine the impact of the TMDL and the FERC relicensing on the Spokane River water quality. The models were originally developed by Portland State University for the Washington Department of Ecology and EPA to simulate temperature, dissolved oxygen, nutrients, algae, and organic matter. The updated model simulates the year 2001, and the calibration has also been checked for the year 2000.

Prior reports prepared for the Spokane River modeling in Washington and Idaho include:

- Annear et al. (2001) - Upper Spokane River Model: Boundary Conditions and Model Setup for 1991 and 2000
- Berger et al. (2002) - Upper Spokane River Model: Calibration for 1991 and 2000
- Slominski et al. (2002) - Upper Spokane River Model: Boundary Conditions and Model Setup for 2001 where information such as the following were detailed:
    1. Inflows, temperatures, and water quality
    2. Meteorological conditions
    3. Bathymetry of the Spokane River and Long Lake and the model grid
    4. Reservoir operations and structure information
- Berger et al. (2003) - Upper Spokane River Model: Calibration for 2001
- Annear et al. (2005)- Upper Spokane River Model in Idaho: Boundary Conditions and Model Setup for 2001 and 2004.
- Wells and Berger (2009)- Spokane River in Idaho and Washington TMDL Water Quality and Hydrodynamic Modeling, Quality Assurance Project Plan.
- Berger et al. (2009)- Spokane River Modeling Report 2009, Model Update and Calibration Check.

The focus of this present study was to perform the following tasks:

- Converting the Upper Spokane River CE-QUAL-W2 models (Washington and Idaho) to version 3.6
- Reviewing and updating model boundary conditions

- Check model calibration
- Meet with stakeholders
- Develop and Run Modeling Scenarios
- Create reports on calibration and scenario runs

In this study Portland State University was responsible for updating the model, checking model calibration, applying the model to the scenarios runs, and writing a final report.

Modeling Scenarios

Description

Four modeling scenarios were simulated. These included a no source scenario and three TMDL scenarios. The no source scenario technical specifications were listed in Table 1. Technical specification for TMDL alternatives 1 through 3 were listed in Table 2 through Table 4.

Hangman Creek and Little Spokane River constituent concentrations for the no source scenario and the TMDL scenarios were listed in Table 5 through Table 8. Constituent concentrations of Hangman Creek and the Little Spokane River were assumed to be identical for TMDL alternatives #1 through #3. Coulee Creek concentrations were assumed to the same as those for Hangman Creek. For constituent not specified (DO, alkalinity, etc.), the concentrations were assumed to be equal to 2001 concentrations.

For the TMDL alternatives storm water inflows were included for Idaho and Washington. The Idaho storm water flows were placed in model segment 4 (idaho model). The Washington storm water flows were placed in model segment 114 (Washington model). Combined sewer overflows (CSOs) were also included in the Washington model at segment 114. The constituent concentrations used for storm water and CSOs in the TMDL alternatives were listed in Table 2 through Table 4.

Table 1. Technical specifications for no source scenario (EPA).

		Scenario name	NO SOURCE												
Description:	This is the natural condition baseline for the TMDL. No point sources, estimated natural tributary and upstream boundary inputs, estimated natural sediment oxygen demand (SOD). Upstream boundary, flow, and SOD conditions remain constant for all subsequent TMDL scenarios.														
	MUNICIPAL AND INDUSTRIAL POINT SOURCES									**SW & CSO**		NONPOINT SOURCES			
Parameter	Descriptor for NPDES sources	Coeur d' Alene	HARSB	Post Falls	Liberty Lake	Inland Empire Paper	Kaiser Aluminum	Spokane	Spokane County	Storm Water	CSO	Ground Water	Little Spokane River	Hangman/Coulee Creek	Upstream Boundary
Shaded cells are user-input values that are used to calculate other values in this table															
	Design Flow and Estimated Permit Limits									*WLAs*		*Nonpoint Source Load Allocations*			
Discharge (MGD) F2	design flow	0 F1	0 F1	0 F1	0 F1	0 F1	0 F1	0 F1	0 F1	0.0	0.0	2001 F1	2001	2001	2001
Estimated TP Limit (mg/l)	na	na	na	na	na	na	na	na	na	na	na	0.006	Natural	Natural	Natural
Estimated CBOD5 Limit (mg/l)	na	na	na	na	na	na	na	na	na	na	na	0.0	Natural	Natural	Natural
Estimated NH4 Limit (mg/l)	na	na	na	na	na	na	na	na	na	na	na	0.005	Natural	Natural	Natural
	Model Input Values = Wasteload Allocations = Long Term Average Discharge									*Model Inputs*		*Model Inputs*			
TP WLA (mg/l)	na	na	na	na	na	na	na	na	na	na	na	same as above	same as above	same as above	same as above
PO4 (mg/L) F4	na	na	na	na	na	na	na	na	na	na	na	same as above	same as above	same as above	same as above
CBODult WLA (mg/L)	na	na	na	na	na	na	na	na	na	na	na	same as above	same as above	same as above	same as above
NH4 WLA (mg/l)	na	na	na	na	na	na	na	na	na	na	na	same as above	same as above	same as above	same as above
Water and Wastewater Characteristic Ratios															
KBOD (/day) F3	na	na	na	na	na	na	na	na	na	na	na	2001	2001	2001	2001
PO4 ratio	na	na	na	na	na	na	na	na	na	na	na	2001	2001	2001	2001
BODP F5	na	na	na	na	na	na	na	na	na	na	na	2001	2001	2001	2001
Estimated Limit Factor	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
NOTES															
hydrologic setting:	River flows are 2001 conditions (critical TMDL design year). They are characteristic of a 1-in-10 low flow year.														
WWTP discharges	NA														
Other	SOD set to improved level = 0.25 g DO/m2-day														
Nonpoint characteristics	Tributaries are set to 2001 flows and estimated natural pollutant concentrations based on headwater concentrations.														
F1	Mean 2001 flow from each WWTP is re-located to groundwater, specifically to the nearest, downstream, gaining groundwater reach														
F2															
F3															
F4	PO4 = TP * (% PO4)														
F5	(PO4+(BODP*CBODu) = TP														
F6	CBODult = CBOD5/(1-e^(-5*KBOD))														
F7															
F8															
F9															

Table 2. Technical specifications for TMDL Alternative#1 (EPA).

	Scenario name	TMDL Alternative #1													
Description:	This is a TMDL alternative scenario for comparison to the NO SOURCE baseline. Point sources set at 50 ppb TP (maximum monthly average) and nonpoint sources are set to achievable reductions.														
	MUNICIPAL AND INDUSTRIAL POINT SOURCES									**SW & CSO**		NONPOINT SOURCES			
Parameter	Descriptor for NPDES sources	Coeur d' Alene	HARSB	Post Falls	Liberty Lake	Inland Empire Paper	Kaiser Aluminum	Spokane	Spokane County	Storm Water	CSO	Ground Water	Little Spokane River	Hangman/Coulee Creek	Upstream Boundary
Shaded cells are user-input values that are used to calculate other values in this table															
	Design Flow and Estimated Permit Limits									*WLAs*		*Nonpoint Source Load Allocations*			
Discharge (MGD) F2	design flow	7.6	3.2	5.0	1.5	4.1	15.4	50.8	8.0	WA 2.36 / ID 0.93	0.12	2001	2001	2001	2001
Estimated TP Limit (mg/l)	F8	0.050	0.050	0.050	0.050	0.050	0.035	0.050	0.050	0.31	0.95	2001	% of 2001	% of 2001	2001
Estimated CBOD5 Limit (mg/l)	F8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0	30.0	2001	% of 2001	% of 2001	2001
Estimated Spring NH4 Limit (mg/l)	March-May; Oct. F8	1.00	1.00	1.00	1.00	1.00	0.10	1.00	1.00	0.05	1.0	2001	% of 2001	% of 2001	2001
Estimated Summer NH4 Limit (mg/l)	June-Sept. F8	1.00	1.00	1.00	0.25	1.00	0.10	0.25	0.25	0.05	1.0	2001	% of 2001	% of 2001	2001
	Model Input Values = Wasteload Allocations = Long Term Average Discharge									*Model Inputs*		*Model Inputs*			
TP WLA (mg/l)	Avg Performance	0.036	0.036	0.036	0.036	0.036	0.025	0.042	0.042	0.310	0.950	same as above	same as above	same as above	same as above
PO4 (mg/L) F4	calculated	0.013	0.013	0.013	0.013	0.025	0.005	0.015	0.015	0.062	0.190	same as above	same as above	same as above	same as above
CBODult WLA (mg/L) F6	Avg Performance	16.1	16.1	16.1	16.1	37.5	7.5	18.8	12.6	13.6	47.5	same as above	same as above	same as above	same as above
NH4 WLA Spring (mg/l) F1	March-May; Oct.	0.71	0.71	0.71	0.71	0.71	0.07	0.83	0.83	0.05	1.00	same as above	same as above	same as above	same as above
NH4 WLA Summer (mg/l) F1	June-Sept.	0.71	0.71	0.71	0.18	0.71	0.07	0.21	0.21	0.05	1.00	same as above	same as above	same as above	same as above
Water and Wastewater Characteristic Ratios															
KBOD (/day) F3	available data	0.05	0.05	0.05	0.05	0.02	0.13	0.05	0.08	0.05	0.2	2001	2001	2001	2001
PO4 ratio	available data	0.35	0.35	0.35	0.35	0.7	0.2	0.35	0.35	0.2	0.2	2001	2001	2001	2001
BODP F5	calculated from TP, OP, CBOD	0.0014	0.0014	0.0014	0.0014	0.0003	0.0027	0.0014	0.0021	0.0183	0.0160	2001	2001	2001	2001
Estimated Limit Factor F7	TSD method; CV=0.6	1.4	1.4	1.4	1.4	1.4	1.4	1.2	1.2	1.0	1.0	na	na	na	na
NOTES															
hydrologic setting:	River flows are 2001 conditions (critical TMDL design year). They are characteristic of a 1-in-10 low flow year. WWTF flows are set to design flows.														
WWTP max monthly discharges	Maximum monthly average TP = 50 ppb; CBOD5 = 5 ppm; NH3 = 0.25 - 1.0 ppm (varies by facility and season)														
Other	SOD set to improved level = 0.25 g DO/m2-day														
Nonpoint characteristics	Time series concentrations for TP, NH3, and CBOD5 are found in separate spreadsheet documents. NPS % reductions in difference between 2001 and natural conditions: Hangman and Coulee: 20% (Mar-May), 40% (June), 50% (Jul - Oct) // Little Spokane: 36% (Mar - Oct)														
F1	Seasonal WLAs for Municipal WWTPs in Washington														
F2	Municipal WWTP design flows are projected flows for 2027														
F3	KBOD rates are based on lowest current municipal rate, data/analysis submitted by HDR for Spokane County, and 2001 rate for industrials														
F4	PO4 = TP * (% PO4)														
F5	(PO4+(BODP*CBODu) = TP														
F6	CBODult = CBOD5/(1-e^(-5*KBOD))														
F7	Factors are from EPA's Tech Support Doc (TSD) for NPDES permitting. Pg. 103, Table 5-2. Spokane factors lower due to more frequent monitoring														
F8	The listed concentration is multiplied by the flow and a units conversion factor (8.34) to obtain the estimated loading limit														

Table 3. Technical specifications for TMDL Alternative#2 (EPA).

		Scenario name	TMDL Alternative #2												
Description:	This is a TMDL alternative scenario identical to TMDL alternative #1 except point source phosphorus is set to TP = 50 ppb as a long term average rather than a maximum monthly average for all facilities other than Kaiser.														
	MUNICIPAL AND INDUSTRIAL POINT SOURCES									**SW & CSO**		NONPOINT SOURCES			
Parameter	Descriptor for NPDES sources	Coeur d' Alene	HARSB	Post Falls	Liberty Lake	Inland Empire Paper	Kaiser Aluminum	Spokane	Spokane County	Storm Water	CSO	Ground Water	Little Spokane River	Hangman/Coulee Creek	Upstream Boundary
Shaded cells are user-input values that are used to calculate other values in this table															
	Design Flow and Estimated Permit Limits									*WLAs*		*Nonpoint Source Load Allocations*			
Discharge (MGD) F2	design flow	7.6	3.2	5.0	1.5	4.1	15.4	50.8	8.0	WA 2.36 / ID 0.93	0.12	2001	2001	2001	2001
Estimated TP Limit (mg/l)	F8	0.070	0.070	0.070	0.070	0.070	0.035	0.060	0.060	0.31	0.95	2001	% of 2001	% of 2001	2001
Estimated CBOD5 Limit (mg/l)	F8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0	30.0	2001	% of 2001	% of 2001	2001
Estimated Spring NH4 Limit (mg/l)	March-May; Oct. F8	1.00	1.00	1.00	1.00	1.00	0.10	1.00	1.00	0.05	1.0	2001	% of 2001	% of 2001	2001
Estimated Summer NH4 Limit (mg/l)	June-Sept. F8	1.00	1.00	1.00	0.25	1.00	0.10	0.25	0.25	0.05	1.0	2001	% of 2001	% of 2001	2001
	Model Input Values = Wasteload Allocations = Long Term Average Discharge									*Model Inputs*		*Model Inputs*			
TP WLA (mg/l)	Avg Performance	0.050	0.050	0.050	0.050	0.050	0.025	0.050	0.050	0.310	0.950	same as above	same as above	same as above	same as above
PO4 (mg/L) F4	calculated	0.018	0.018	0.018	0.018	0.035	0.005	0.018	0.018	0.062	0.190	same as above	same as above	same as above	same as above
CBODult WLA (mg/L) F6	Avg Performance	16.1	16.1	16.1	16.1	37.5	7.5	18.8	12.6	13.6	47.5	same as above	same as above	same as above	same as above
NH4 WLA Spring (mg/l) F1	March-May; Oct.	0.71	0.71	0.71	0.71	0.71	0.07	0.83	0.83	0.05	1.00	same as above	same as above	same as above	same as above
NH4 WLA Summer (mg/l) F1	June-Sept.	0.71	0.71	0.71	0.18	0.71	0.07	0.21	0.21	0.05	1.00	same as above	same as above	same as above	same as above
Water and Wastewater Characteristic Ratios															
KBOD (/day) F3	available data	0.05	0.05	0.05	0.05	0.02	0.13	0.05	0.08	0.05	0.2	2001	2001	2001	2001
PO4 ratio	available data	0.35	0.35	0.35	0.35	0.7	0.2	0.35	0.35	0.2	0.2	2001	2001	2001	2001
BODP F5	calculated from TP, OP, CBOD	0.0020	0.0020	0.0020	0.0020	0.0004	0.0027	0.0017	0.0026	0.0183	0.0160	2001	2001	2001	2001
Estimated Limit Factor F7	TSD method; CV=0.6	1.4	1.4	1.4	1.4	1.4	1.4	1.2	1.2	1.0	1.0	na	na	na	na
NOTES															
hydrologic setting:	River flows are 2001 conditions (critical TMDL design year). They are characteristic of a 1-in-10 low flow year. WWTF flows are set to design flows.														
WWTP max monthly discharges	Long term average TP = 50 ppb; other limits unchanged from Scenario #1.														
Other	SOD set to improved level = 0.25 g DO/m2-day														
Nonpoint characteristics	Time series concentrations for TP, NH3, and CBOD5 are found in separate spreadsheet documents. NPS % reductions in difference between 2001 and natural conditions: Hangman and Coulee: 20% (Mar-May), 40% (June), 50% (Jul - Oct) // Little Spokane: 36% (Mar - Oct)														
F1	Seasonal WLAs for Municipal WWTPs in Washington														
F2	Municipal WWTP design flows are projected flows for 2027														
F3	KBOD rates are based on lowest current municipal rate, data/analysis submitted by HDR for Spokane County, and 2001 rate for industrials														
F4	PO4 = TP * (% PO4)														
F5	(PO4+(BODP*CBODu) = TP														
F6	CBODult = CBOD5/(1-e^(-5*KBOD))														
F7	Factors are from EPA's Tech Support Doc (TSD) for NPDES permitting. Pg. 103, Table 5-2. Spokane factors lower due to more frequent monitoring														
F8	The listed concentration is multiplied by the flow and a units conversion factor (8.34) to obtain the estimated loading limit														

Table 4. Technical specifications for TMDL Alternative#3 (EPA).

		Scenario name	TMDL Alternative #3												
Description:	This is a TMDL alternative scenario identical to TMDL alternative #1 except total phosphorus is seasonally varied to reflect significant re-use of effluent in the summer (Hayden facility)														
	MUNICIPAL AND INDUSTRIAL POINT SOURCES									SW & CSO		NONPOINT SOURCES			
Parameter	Descriptor for NPDES sources	Coeur d' Alene	HARSB	Post Falls	Liberty Lake	Inland Empire Paper	Kaiser Aluminum	Spokane	Spokane County	Storm Water	CSO	Ground Water	Little Spokane River	Hangman/Coulee Creek	Upstream Boundary
Shaded cells are user-input values that are used to calculate other values in this table															
	Design Flow and Estimated Permit Limits									*WLAs*		*Nonpoint Source Load Allocations*			
Discharge (MGD) F2	design flow	7.6	3.2	5.0	1.5	4.1	15.4	50.8	8.0	WA 2.36 / ID 0.93	0.12	2001	2001	2001	2001
Estimated Spring TP Limit (mg/l)	March-June; Oct. F8	0.050	0.150	0.050	0.050	0.050	0.035	0.050	0.050	0.31	0.95	2001	% of 2001	% of 2001	2001
Estimated Summer TP Limit (mg/l)	July-Sept. F8	0.050	0.010	0.050	0.050	0.050	0.035	0.050	0.050	0.31	0.95	2001	% of 2001	% of 2001	2001
Estimated CBOD5 Limit (mg/l)	F8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0	30.0	2001	% of 2001	% of 2001	2001
Estimated Spring NH4 Limit (mg/l)	March-May; Oct. F8	1.00	1.00	1.00	1.00	1.00	0.10	1.00	1.00	0.05	1.0	2001	% of 2001	% of 2001	2001
Estimated Summer NH4 Limit (mg/l)	June-Sept. F8	1.00	1.00	1.00	0.25	1.00	0.10	0.25	0.25	0.05	1.0	2001	% of 2001	% of 2001	2001
	Model Input Values = Wasteload Allocations = Long Term Average Discharge									*Model Inputs*		*Model Inputs*			
Spring TP WLA (mg/l)	Avg Performance	0.036	0.107	0.036	0.036	0.036	0.025	0.042	0.042	0.310	0.950	same as above	same as above	same as above	same as above
Summer TP WLA (mg/l)	Avg Performance	0.036	0.007	0.036	0.036	0.036	0.025	0.042	0.042	0.310	0.950	same as above	same as above	same as above	same as above
Spring PO4 (mg/L) F4	calculated	0.013	0.038	0.013	0.013	0.025	0.005	0.015	0.015	0.062	0.190	same as above	same as above	same as above	same as above
Summer PO4 (mg/L) F4	calculated	0.013	0.003	0.013	0.013	0.025	0.005	0.015	0.015	0.062	0.190	same as above	same as above	same as above	same as above
CBODult WLA (mg/L) F6	Avg Performance	16.1	16.1	16.1	16.1	37.5	7.5	18.8	12.6	13.6	47.5	same as above	same as above	same as above	same as above
NH4 WLA Spring (mg/l) F1	March-May; Oct.	0.71	0.71	0.71	0.71	0.71	0.07	0.83	0.83	0.05	1.00	same as above	same as above	same as above	same as above
NH4 WLA Summer (mg/l) F1	June-Sept.	0.71	0.71	0.71	0.18	0.71	0.07	0.21	0.21	0.05	1.00	same as above	same as above	same as above	same as above
Water and Wastewater Characteristic Ratios															
KBOD (/day) F3	available data	0.05	0.05	0.05	0.05	0.02	0.13	0.05	0.08	0.05	0.2	2001	2001	2001	2001
PO4 ratio	available data	0.35	0.35	0.35	0.35	0.7	0.2	0.35	0.35	0.2	0.2	2001	2001	2001	2001
BODP F5	calculated from TP, OP, CBOD	0.0014	0.0043	0.0014	0.0014	0.0003	0.0027	0.0014	0.0021	0.0183	0.0160	2001	2001	2001	2001
Estimated Limit Factor F7	TSD method; CV=0.6	1.4	1.4	1.4	1.4	1.4	1.4	1.2	1.2	1.0	1.0	na	na	na	na
NOTES															
hydrologic setting:	River flows are 2001 conditions (critical TMDL design year). They are characteristic of a 1-in-10 low flow year. WWTF flows are set to design flows.														
WWTP max monthly discharges	Same as Scenario #1 except: Hayden TP is seasonal: March - June = 150 ppb; July - Sept = 10 ppb; Oct = 150 ppb; (all maximum monthly averages)														
Other	SOD set to improved level = 0.25 g DO/m2-day														
Nonpoint characteristics	Time series concentrations for TP, NH3, and CBOD5 are found in separate spreadsheet documents. NPS % reductions in difference between 2001 and natural conditions: Hangman and Coulee: 20% (Mar-May), 40% (June), 50% (Jul - Oct) // Little Spokane: 36% (Mar - Oct)														
F1	Seasonal WLAs for Municipal WWTPs in Washington														
F2	Municipal WWTP design flows are projected flows for 2027														
F3	KBOD rates are based on lowest current municipal rate, data/analysis submitted by HDR for Spokane County, and 2001 rate for industrials														
F4	PO4 = TP * (% PO4)														
F5	(PO4+(BODP*CBODu) = TP														
F6	CBODult = CBOD5/(1-e^(-5*KBOD))														
F7	Factors are from EPA's Tech Support Doc (TSD) for NPDES permitting. Pg. 103, Table 5-2. Spokane factors lower due to more frequent monitoring														
F8	The listed concentration is multiplied by the flow and a units conversion factor (8.34) to obtain the estimated loading limit														

Table 5. Hangman and Coulee Creek concentrations for the no source scenario (EPA).

Month	Mid-month Julian Day	Soluble Reactive P (mg/l)	Total P (mg/l)	CBOD ultimate (mg/l)	CBODP (mg/l)	Ammonia Nitrogen (mg/l)
Jan	14	0.013	0.021	1.4	0.0054	0.010
Feb	44	0.017	0.037	1.4	0.0143	0.013
Mar	74	0.024	0.075	1.4	0.0366	0.010
Apr	105	0.013	0.030	1.4	0.0119	0.005
May	135	0.022	0.039	1.4	0.0119	0.012
Jun	166	0.013	0.026	1.4	0.0119	0.006
Jul	197	0.013	0.024	1.4	0.0107	0.009
Aug	227	0.013	0.021	1.4	0.0086	0.005
Sep	258	0.013	0.021	1.4	0.0103	0.005
Oct	288	0.016	0.023	1.4	0.0050	0.010
Nov	319	0.015	0.022	1.4	0.0050	0.010
Dec	350	0.024	0.034	1.4	0.0075	0.010
Mean		0.016	0.031	1.4	0.012	0.009

Table 6. Hangman and Coulee Creek concentrations for TMDL alternatives #1 through #3 (EPA).

Month	Mid-month Julian Day	Soluble Reactive P (mg/l)	Total P (mg/l)	CBOD ultimate (mg/l)	CBODP (mg/l)	Ammonia Nitrogen (mg/l)
Jan	14	0.023	0.058	3.320	0.0105	0.010
Feb	44	0.056	0.094	3.320	0.0113	0.044
Mar	74	0.077	0.120	3.320	0.0132	0.066
Apr	105	0.029	0.066	3.320	0.0111	0.010
May	135	0.048	0.085	3.320	0.0111	0.026
Jun	166	0.020	0.050	2.840	0.0107	0.012
Jul	197	0.018	0.043	2.408	0.0101	0.015
Aug	227	0.013	0.032	2.071	0.0091	0.005
Sep	258	0.013	0.034	2.343	0.0089	0.005
Oct	288	0.016	0.033	2.300	0.0074	0.010
Nov	319	0.015	0.035	2.300	0.0085	0.010
Dec	350	0.024	0.044	2.300	0.0087	0.010
Mean		0.029	0.058	2.8		0.019

Table 7. Little Spokane River concentrations for the no source scenario (EPA).

Month	Mid-month Julian Day	Soluble Reactive P (mg/l)	Total P (mg/l)	CBOD ultimate (mg/l)	CBODP (mg/l)	Ammonia Nitrogen (mg/l)
Jan	14	0.012	0.015	1.4	0.0020	0.010
Feb	44	0.010	0.016	1.4	0.0042	0.010
Mar	74	0.011	0.014	1.4	0.0021	0.010
Apr	105	0.009	0.011	1.4	0.0015	0.005
May	135	0.008	0.011	1.4	0.0021	0.005
Jun	166	0.006	0.008	1.4	0.0013	0.005
Jul	197	0.006	0.009	1.0	0.0031	0.005
Aug	227	0.006	0.009	1.0	0.0023	0.005
Sep	258	0.006	0.009	1.4	0.0025	0.005
Oct	288	0.006	0.006	1.4	0.0001	0.005
Nov	319	0.005	0.008	1.4	0.0020	0.005
Dec	350	0.009	0.012	1.4	0.0019	0.005
Mean		0.008	0.011	1.3	0.002	0.006

Table 8. Little Spokane River concentrations for TMDL alternatives #1 through #3 (EPA).

Month	Mid-month Julian Day	Soluble Reactive P (mg/l)	Total P (mg/l)	CBOD ultimate (mg/l)	CBODP (mg/l)	Ammonia Nitrogen (mg/l)
Jan	14	0.013	0.032	2.104	0.0090	0.010
Feb	44	0.013	0.033	2.104	0.0095	0.011
Mar	74	0.015	0.034	2.104	0.0090	0.050
Apr	105	0.014	0.033	2.104	0.0089	0.042
May	135	0.012	0.031	2.104	0.0087	0.011
Jun	166	0.007	0.026	2.104	0.0088	0.005
Jul	197	0.009	0.019	1.186	0.0086	0.005
Aug	227	0.009	0.019	1.179	0.0083	0.008
Sep	258	0.007	0.021	1.660	0.0084	0.005
Oct	288	0.007	0.019	1.592	0.0077	0.005
Nov	319	0.009	0.022	1.592	0.0083	0.005
Dec	350	0.015	0.028	1.592	0.0082	0.009
Mean		0.011	0.026	1.8	0.009	0.014

TMDL Riverine and Reservoir Assessment

The riverine and reservoir assessment outputs were specified by EPA and Ecology as summarized below:

Riverine Assessment

Model Output Location

Two options – both will be selected for model output

1. Preferred assessment location = LL5 monitoring location (model segment 157)
2. Backup location = Nine Mile tailrace (model segment 154)

Discussion

The preferred location is segment 157, because it is downstream of Little Spokane confluence and direct model estimate would include its contribution. A potential drawback would be algal activity elevating the total phosphorus concentration. An alternative is segment 154, directly below Nine Mile dam. This is a more riverine location and not influenced by Long Lake productivity. The drawback for 154 is its location upstream of the Little Spokane. If there is a need to include Little Spokane in the riverine assessment, flow-weighted averages of Little Spokane and segment 154 phosphorus can be calculated.

A rolling 30 day average is used to reflect the longer time frame of concern for nutrient pollution. Nutrients are not toxins that can impact biota over shorter time frames (hours, days); rather, they gradually degrade waters over monthly or seasonal time frames.

Reservoir Assessment

Location

Reservoir assessment encompasses the impaired portion of the reservoir from monitoring location LL2 (segment 157) to the dam (segment 188).

DO Target

No more than 0.2 ppm below natural conditions

Metrics and Data Analysis

The following metrics and analytical procedures are identical for each model scenario (e.g., NO SOURCE, TMDL Alternative Scenarios).

Core Model Output Parameter

- Output time step – every 4 hours
- Vertical cells included – all cells with depth greater than or equal to 8 meters
- Compute the volume weighted average in each segment, at each time step
- Daily minimum value is the core parameter from the model

Aggregated TMDL Parameter

- Semi-monthly (twice a month) average of the daily minimum, volume-averaged DO in the hypolimnion of each segment (157-188)

Discussion

The analysis of water quality impacts associated with dams is an evolving area of water quality management. The proposed vertical and temporal aggregation of Long Lake model output is designed to provide relatively straightforward measures of impact and responsibility for improvement. While specific locations within the vertical water column will show higher and lower estimated impacts than the aggregate impact, all individual impacts are integrated into the aggregate results. The goal is improvement in the waterbody as a whole. Cell-by-cell comparisons of simulated parameters tend to carry higher uncertainty due to model anomalies than larger scale averages, because the model may not accurately capture small scale effects.

Results

River

Total phosphorus concentrations for the no source scenario and the TMDL alternatives were plotted for the Idaho-Washington state line, segment 154 in Long Lake, and segment 157 in Long Lake. The total phosphorus concentrations plotted were a 30 day running average. Figure 1 shows the predicted total phosphorus concentrations for the state line. The increasing trend over time is a reflection of the upstream boundary condition for the model (see Figure 4).

Figure 2 and Figure 3 show the total phosphorus concentrations for segments 154 and 157 in Long Lake. Concentrations for segment 157 were higher than those of segment 154 because of surface currents moving algae biomass upstream.

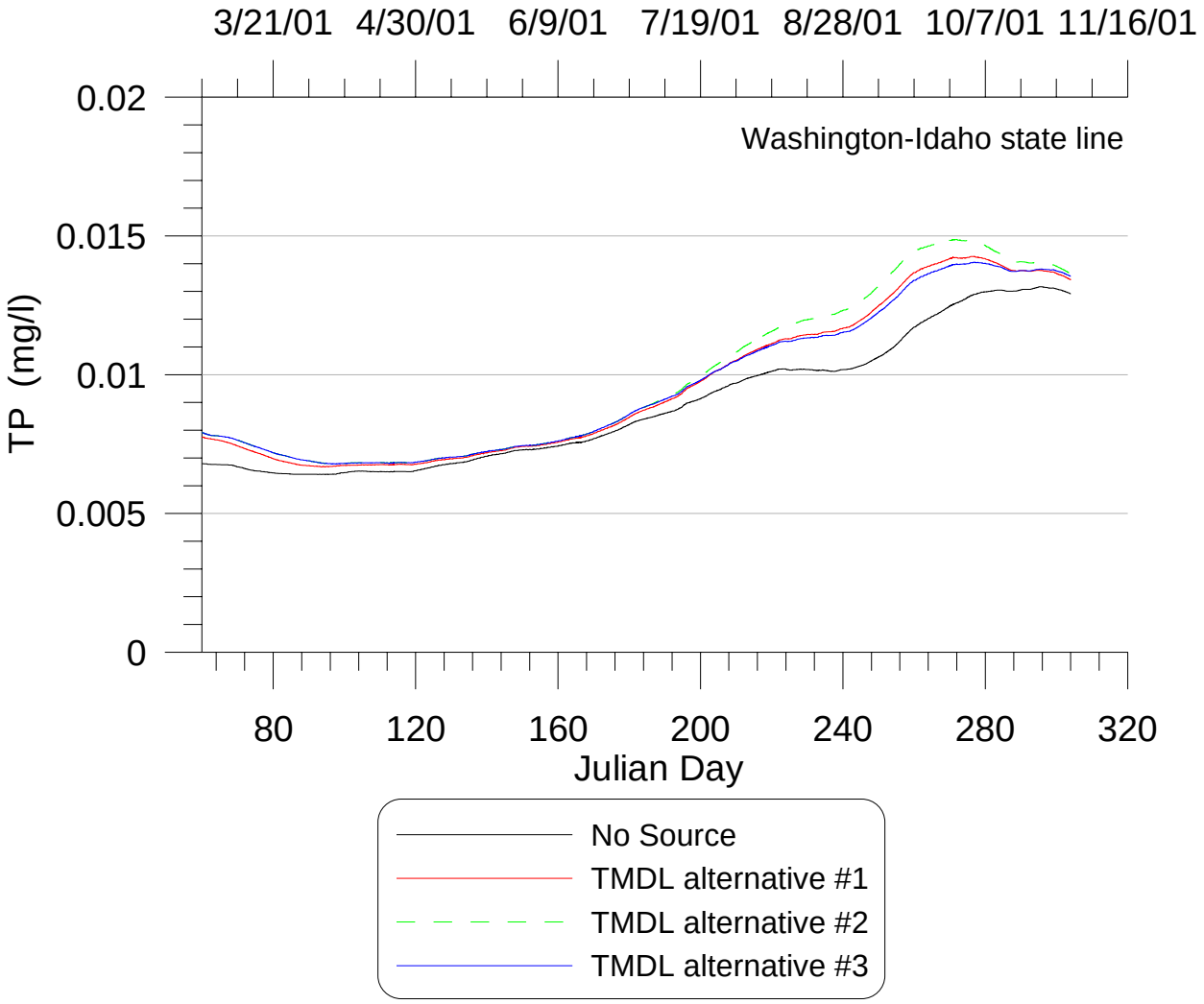

Figure 1. 30-day running average total phosphorus concentrations of the no source scenario and the TMDL alternatives at the Idaho-Washington state line.

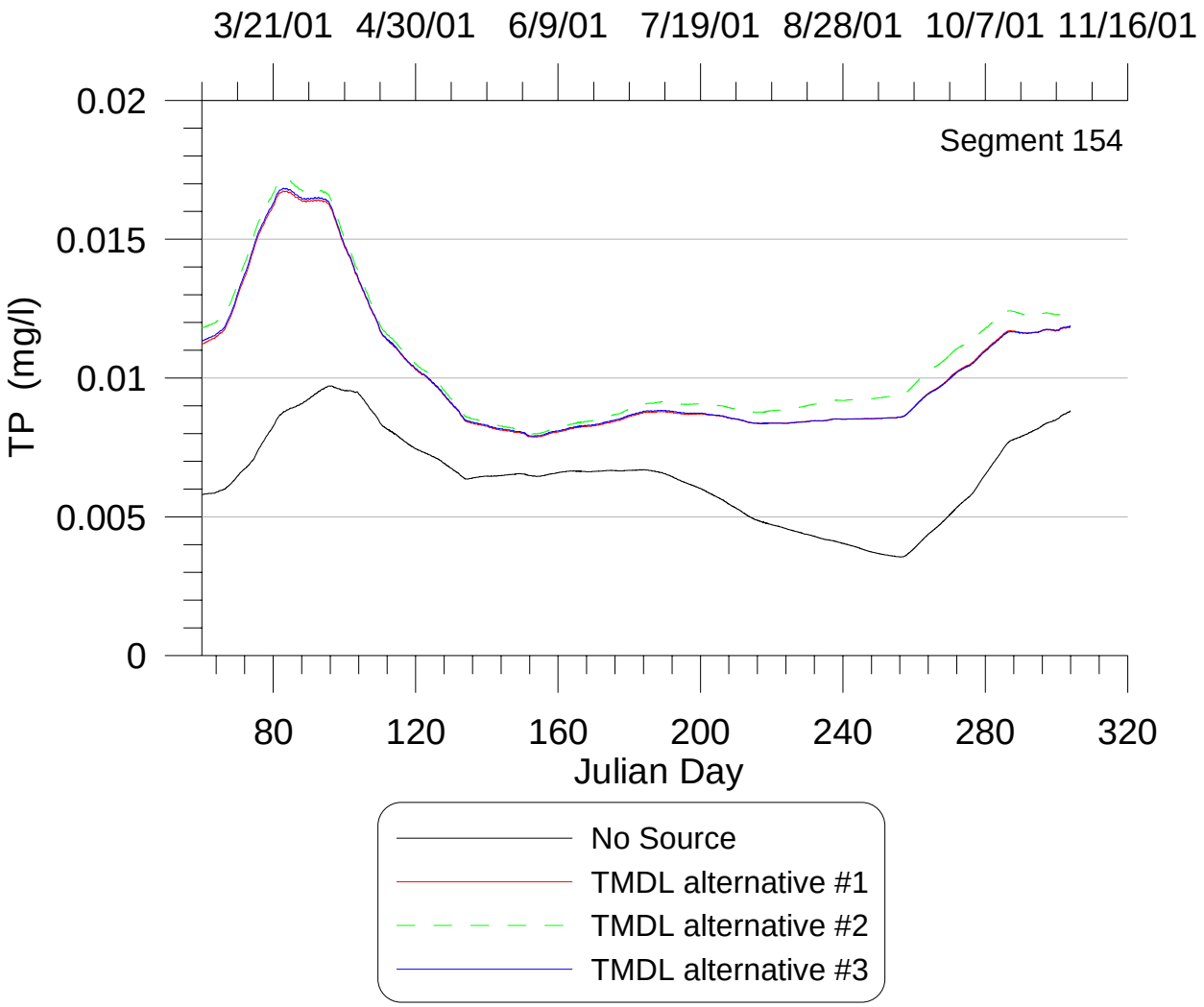

Figure 2. 30-day running average total phosphorus concentrations of the no source scenario and the TMDL alternatives at segment 154 in Long Lake.

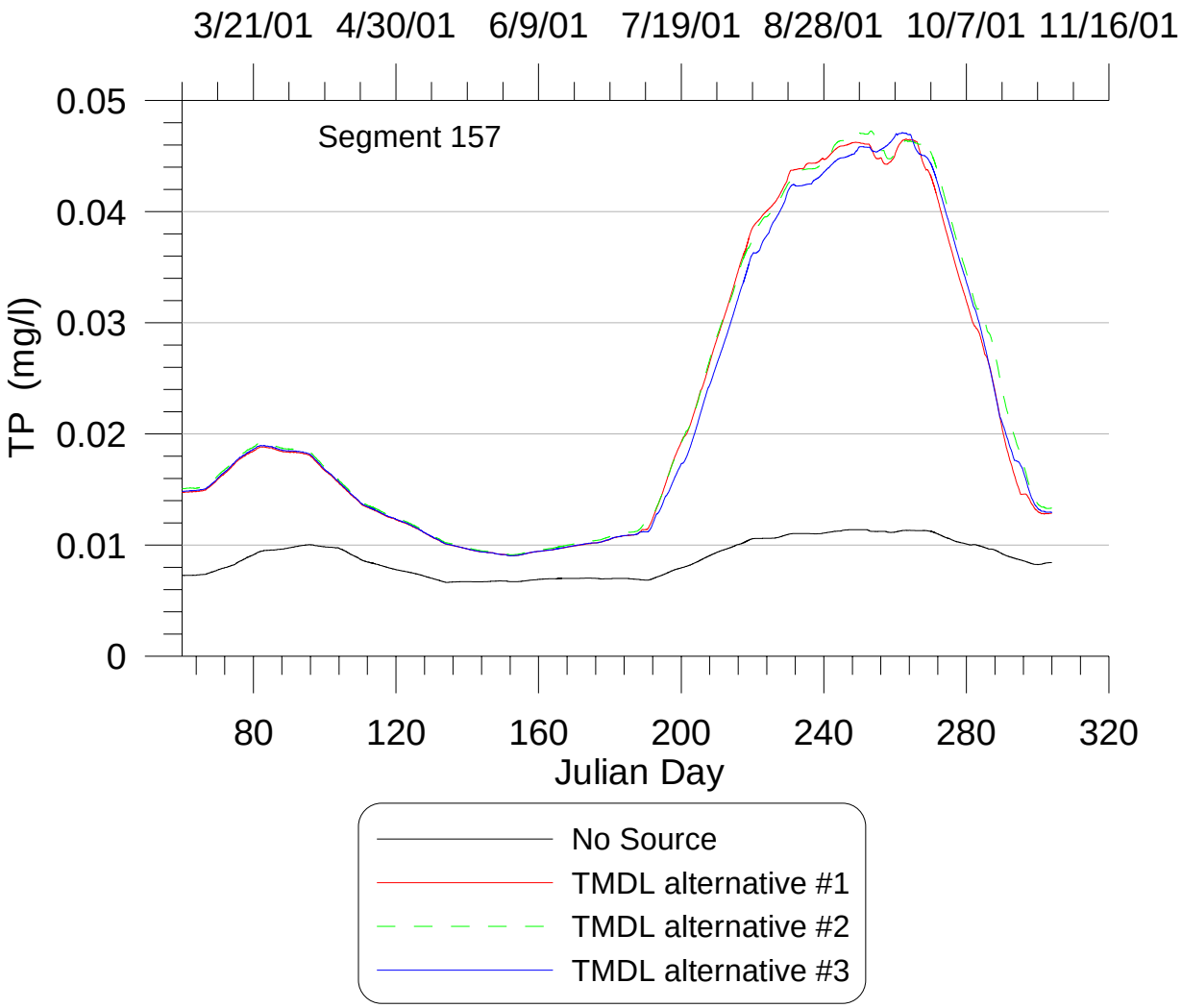

Figure 3. 30-day running average total phosphorus concentrations of the no source scenario and the TMDL alternatives at segment 157 in Long Lake. The high total phosphorus concentrations of the TMDL alternatives are the result of algae biomass moving upstream in the reservoir due to surface currents.

Reservoir

The semi-monthly averages of the daily minimum, volume-averaged DO in the hypolimnion (greater than 8 m depth) of each Long Lake segment (157-188) for TMDL alternatives #1 through #3 were listed in Table 9 through Table 11. For comparison the no source concentrations were also listed along with the difference in dissolved oxygen concentration between the TMDL alternatives and the no source scenario. The greatest DO difference with respect to the no source scenario were 1.5 mg/l, and occurred during the August 16-31 time period in the model segments adjacent to Long Lake dam. TMDL alternative #2 had slightly lower dissolved oxygen concentrations than those for TMDL#1 and TMDL#3.

Table 9. TMDL#1 scenario dissolved oxygen concentrations compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the TMDL#1 predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*June 1-15*			*June 15-30*			*July 1-15*			*July 16-31*			*Aug 1-15*			*Aug 16-31*			*Sept 1-15*			*Sept 16-30*			*Oct 1-15*			*Oct 16-31*		
157	**9.4**	*9.5*	-0.1	**9.4**	*9.8*	-0.4	**9.1**	*9.3*	-0.2	**9.2**	*9.5*	-0.3	**9.3**	*9.5*	-0.2	**9.6**	*9.9*	-0.4	**9.7**	*10.0*	-0.3	**9.8**	*10.0*	-0.2	**10.2**	*10.1*	0.0			
158	**9.5**	*9.6*	-0.1	**9.6**	*9.8*	-0.2	**9.3**	*9.5*	-0.2	**9.4**	*9.6*	-0.2	**9.4**	*9.6*	-0.2	**9.6**	*9.8*	-0.2	**9.8**	*10.0*	-0.2	**9.9**	*9.9*	-0.1	**10.2**	*10.1*	0.0	**10.7**	*10.6*	0.1
159	**9.7**	*9.8*	-0.1	**9.6**	*9.9*	-0.2	**9.4**	*9.5*	-0.1	**9.4**	*9.5*	-0.1	**9.4**	*9.5*	-0.1	**9.6**	*9.7*	-0.1	**9.8**	*9.9*	-0.1	**9.8**	*9.9*	0.0	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
160	**9.7**	*9.8*	-0.1	**9.6**	*9.8*	-0.2	**9.3**	*9.4*	-0.1	**9.4**	*9.5*	0.0	**9.4**	*9.4*	0.0	**9.6**	*9.6*	-0.1	**9.7**	*9.8*	-0.1	**9.8**	*9.8*	0.0	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
161	**9.7**	*9.8*	-0.1	**9.7**	*9.9*	-0.2	**9.4**	*9.4*	-0.1	**9.4**	*9.4*	0.0	**9.4**	*9.4*	0.0	**9.6**	*9.6*	0.0	**9.7**	*9.8*	-0.1	**9.8**	*9.7*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
162	**9.7**	*9.9*	-0.2	**9.8**	*9.9*	-0.2	**9.4**	*9.4*	-0.1	**9.4**	*9.4*	0.0	**9.4**	*9.4*	0.0	**9.5**	*9.5*	0.0	**9.7**	*9.7*	0.0	**9.8**	*9.7*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
163	**9.7**	*9.9*	-0.2	**9.8**	*10.0*	-0.2	**9.4**	*9.4*	0.0	**9.4**	*9.4*	0.0	**9.4**	*9.3*	0.1	**9.4**	*9.3*	0.1	**9.6**	*9.5*	0.0	**9.7**	*9.6*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
164	**9.8**	*10.0*	-0.2	**9.8**	*10.0*	-0.2	**9.4**	*9.4*	0.0	**9.4**	*9.3*	0.0	**9.3**	*9.2*	0.1	**9.3**	*9.1*	0.2	**9.4**	*9.4*	0.0	**9.6**	*9.5*	0.1	**10.1**	*10.0*	0.1	**10.7**	*10.6*	0.1
165	**9.8**	*10.0*	-0.3	**9.8**	*10.0*	-0.2	**9.3**	*9.2*	0.0	**9.3**	*9.2*	0.1	**9.3**	*9.1*	0.2	**9.1**	*8.8*	0.3	**9.3**	*9.2*	0.1	**9.5**	*9.4*	0.1	**10.0**	*9.9*	0.1	**10.6**	*10.5*	0.1
166	**9.8**	*10.0*	-0.2	**9.7**	*9.9*	-0.2	**9.0**	*8.9*	0.1	**9.2**	*9.0*	0.2	**9.1**	*8.9*	0.3	**9.0**	*8.6*	0.4	**9.3**	*9.1*	0.1	**9.4**	*9.3*	0.1	**9.9**	*9.8*	0.1	**10.6**	*10.4*	0.1
167	**9.8**	*10.0*	-0.2	**9.7**	*9.9*	-0.2	**8.9**	*8.7*	0.2	**9.0**	*8.7*	0.3	**9.0**	*8.6*	0.4	**8.8**	*8.3*	0.5	**9.2**	*9.0*	0.2	**9.4**	*9.2*	0.2	**9.8**	*9.7*	0.1	**10.5**	*10.4*	0.1
168	**9.8**	*10.1*	-0.3	**9.6**	*9.8*	-0.2	**8.7**	*8.4*	0.3	**8.7**	*8.3*	0.4	**8.8**	*8.2*	0.5	**8.5**	*7.9*	0.6	**9.1**	*8.9*	0.3	**9.3**	*9.0*	0.2	**9.7**	*9.6*	0.1	**10.4**	*10.3*	0.1
169	**9.8**	*10.1*	-0.3	**9.6**	*9.7*	-0.1	**8.6**	*8.2*	0.3	**8.5**	*8.0*	0.5	**8.6**	*7.9*	0.6	**8.3**	*7.6*	0.7	**9.0**	*8.6*	0.4	**9.2**	*8.9*	0.3	**9.6**	*9.5*	0.1	**10.3**	*10.2*	0.1
170	**9.8**	*10.1*	-0.4	**9.5**	*9.6*	-0.1	**8.5**	*8.2*	0.4	**8.4**	*7.8*	0.5	**8.4**	*7.8*	0.7	**8.2**	*7.3*	0.8	**8.8**	*8.3*	0.5	**9.2**	*8.8*	0.4	**9.5**	*9.4*	0.1	**10.1**	*10.0*	0.1
171	**9.7**	*10.1*	-0.4	**9.4**	*9.5*	-0.1	**8.5**	*8.2*	0.4	**8.3**	*7.8*	0.6	**8.4**	*7.7*	0.7	**8.1**	*7.2*	0.9	**8.7**	*8.1*	0.5	**9.1**	*8.7*	0.4	**9.4**	*9.3*	0.1	**10.0**	*9.9*	0.1
172	**9.7**	*10.0*	-0.3	**9.2**	*9.3*	-0.1	**8.4**	*7.9*	0.4	**8.0**	*7.4*	0.7	**8.0**	*7.2*	0.8	**7.7**	*6.7*	1.0	**8.4**	*7.7*	0.7	**9.0**	*8.5*	0.5	**9.4**	*9.2*	0.1	**9.9**	*9.9*	0.0
173	**9.5**	*9.9*	-0.3	**9.1**	*9.2*	0.0	**8.2**	*7.8*	0.5	**7.9**	*7.1*	0.7	**7.8**	*6.9*	0.9	**7.5**	*6.4*	1.1	**8.2**	*7.4*	0.8	**8.8**	*8.3*	0.6	**9.3**	*9.1*	0.2	**9.8**	*9.8*	0.0
174	**9.4**	*9.7*	-0.3	**9.0**	*9.0*	0.0	**8.1**	*7.5*	0.5	**7.6**	*6.8*	0.8	**7.6**	*6.6*	1.0	**7.2**	*6.0*	1.2	**7.9**	*7.0*	0.9	**8.6**	*8.0*	0.7	**9.2**	*9.0*	0.2	**9.8**	*9.7*	0.1
175	**9.3**	*9.6*	-0.3	**8.8**	*8.8*	0.0	**7.9**	*7.4*	0.5	**7.5**	*6.7*	0.8	**7.4**	*6.3*	1.0	**7.0**	*5.8*	1.2	**7.6**	*6.7*	0.9	**8.4**	*7.7*	0.7	**9.1**	*8.9*	0.2	**9.8**	*9.7*	0.1
176	**9.2**	*9.5*	-0.2	**8.8**	*8.7*	0.0	**7.9**	*7.3*	0.6	**7.4**	*6.6*	0.8	**7.4**	*6.3*	1.1	**7.0**	*5.8*	1.2	**7.5**	*6.6*	0.9	**8.3**	*7.6*	0.7	**9.0**	*8.7*	0.3	**9.7**	*9.6*	0.1
177	**9.0**	*9.2*	-0.2	**8.5**	*8.3*	0.1	**7.6**	*6.9*	0.6	**7.0**	*6.0*	0.9	**6.9**	*5.7*	1.2	**6.5**	*5.1*	1.3	**7.0**	*5.9*	1.1	**7.9**	*7.0*	0.9	**8.6**	*8.2*	0.4	**9.7**	*9.6*	0.1
178	**9.0**	*9.1*	-0.1	**8.4**	*8.2*	0.2	**7.5**	*6.8*	0.7	**6.9**	*5.9*	1.0	**6.8**	*5.7*	1.2	**6.4**	*5.1*	1.3	**6.8**	*5.7*	1.1	**7.7**	*6.7*	0.9	**8.5**	*8.0*	0.5	**9.7**	*9.6*	0.2
179	**8.9**	*9.0*	-0.1	**8.4**	*8.2*	0.2	**7.5**	*6.8*	0.7	**6.9**	*5.9*	1.0	**6.8**	*5.6*	1.2	**6.4**	*5.1*	1.4	**6.7**	*5.5*	1.2	**7.6**	*6.6*	1.0	**8.4**	*7.9*	0.5	**9.7**	*9.5*	0.2
180	**8.8**	*8.9*	-0.1	**8.3**	*8.1*	0.2	**7.4**	*6.8*	0.7	**6.8**	*5.8*	1.0	**6.8**	*5.6*	1.2	**6.4**	*5.1*	1.4	**6.6**	*5.4*	1.2	**7.4**	*6.3*	1.1	**8.3**	*7.7*	0.6	**9.7**	*9.5*	0.2
181	**8.7**	*8.8*	-0.1	**8.2**	*8.0*	0.2	**7.4**	*6.7*	0.7	**6.8**	*5.7*	1.1	**6.7**	*5.4*	1.2	**6.4**	*5.0*	1.4	**6.4**	*5.2*	1.2	**7.2**	*6.0*	1.1	**8.1**	*7.4*	0.7	**9.6**	*9.3*	0.2
182	**8.8**	*8.8*	-0.1	**8.3**	*8.0*	0.2	**7.5**	*6.8*	0.7	**6.8**	*5.8*	1.1	**6.7**	*5.5*	1.3	**6.5**	*5.1*	1.4	**6.4**	*5.2*	1.2	**7.0**	*5.8*	1.2	**7.9**	*7.2*	0.6	**9.4**	*9.1*	0.3
183	**8.6**	*8.7*	0.0	**8.1**	*7.8*	0.3	**7.3**	*6.6*	0.7	**6.7**	*5.6*	1.1	**6.5**	*5.2*	1.3	**6.3**	*4.9*	1.4	**6.2**	*4.9*	1.2	**6.6**	*5.4*	1.2	**7.5**	*6.7*	0.7	**9.3**	*8.9*	0.3
184	**8.6**	*8.6*	0.0	**8.1**	*7.8*	0.3	**7.4**	*6.6*	0.7	**6.8**	*5.7*	1.1	**6.6**	*5.3*	1.3	**6.4**	*5.0*	1.4	**6.2**	*5.0*	1.2	**6.4**	*5.2*	1.2	**7.2**	*6.4*	0.8	**9.1**	*8.7*	0.4
185	**8.6**	*8.5*	0.1	**8.0**	*7.7*	0.4	**7.4**	*6.6*	0.7	**6.8**	*5.7*	1.1	**6.5**	*5.2*	1.3	**6.4**	*5.0*	1.4	**6.1**	*5.0*	1.2	**6.2**	*5.0*	1.3	**6.9**	*6.1*	0.8	**8.8**	*8.3*	0.5
186	**8.4**	*8.3*	0.1	**7.9**	*7.5*	0.4	**7.3**	*6.5*	0.8	**6.6**	*5.5*	1.1	**6.3**	*5.0*	1.3	**6.2**	*4.7*	1.4	**5.9**	*4.6*	1.3	**5.8**	*4.5*	1.3	**6.6**	*5.5*	1.0	**8.6**	*8.0*	0.6
187	**8.4**	*8.3*	0.1	**7.9**	*7.6*	0.4	**7.3**	*6.5*	0.8	**6.6**	*5.5*	1.1	**6.3**	*4.9*	1.4	**6.2**	*4.7*	1.5	**5.9**	*4.6*	1.3	**5.8**	*4.4*	1.4	**6.3**	*5.2*	1.0	**8.4**	*7.9*	0.6
188	**8.4**	*8.1*	0.2	**7.8**	*7.4*	0.4	**7.2**	*6.4*	0.8	**6.6**	*5.4*	1.2	**6.1**	*4.8*	1.4	**6.0**	*4.5*	1.5	**5.7**	*4.3*	1.3	**5.5**	*4.1*	1.4	**5.8**	*4.8*	1.0	**7.8**	*7.2*	0.7

Table 10. TMDL#2 scenario dissolved oxygen concentrations compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the TMDL#2 predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*June 1-15*			*June 15-30*			*July 1-15*			*July 16-31*			*Aug 1-15*			*Aug 16-31*			*Sept 1-15*			*Sept 16-30*			*Oct 1-15*			*Oct 16-31*		
157	**9.4**	*9.4*	0.0	**9.4**	*9.5*	-0.1	**9.1**	*9.3*	-0.2	**9.2**	*9.5*	-0.3	**9.3**	*9.7*	-0.4	**9.6**	*9.9*	-0.4	**9.7**	*10.0*	-0.3	**9.8**	*10.0*	-0.2	**10.2**	*10.1*	0.1			
158	**9.5**	*9.6*	-0.1	**9.6**	*9.8*	-0.2	**9.3**	*9.5*	-0.2	**9.4**	*9.6*	-0.2	**9.4**	*9.6*	-0.2	**9.6**	*9.8*	-0.2	**9.8**	*10.0*	-0.2	**9.9**	*10.0*	-0.1	**10.2**	*10.2*	0.0	**10.7**	*10.6*	0.0
159	**9.7**	*9.8*	-0.1	**9.6**	*9.8*	-0.2	**9.4**	*9.5*	-0.2	**9.4**	*9.6*	-0.1	**9.4**	*9.6*	-0.1	**9.6**	*9.8*	-0.1	**9.8**	*9.9*	-0.2	**9.8**	*9.9*	0.0	**10.2**	*10.2*	0.0	**10.7**	*10.6*	0.0
160	**9.7**	*9.8*	-0.1	**9.6**	*9.8*	-0.2	**9.3**	*9.5*	-0.1	**9.4**	*9.5*	-0.1	**9.4**	*9.5*	-0.1	**9.6**	*9.7*	-0.1	**9.7**	*9.9*	-0.1	**9.8**	*9.8*	0.0	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
161	**9.7**	*9.8*	-0.1	**9.7**	*9.9*	-0.2	**9.4**	*9.5*	-0.1	**9.4**	*9.5*	0.0	**9.4**	*9.5*	0.0	**9.6**	*9.6*	0.0	**9.7**	*9.8*	-0.1	**9.8**	*9.8*	0.0	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
162	**9.7**	*9.9*	-0.2	**9.8**	*9.9*	-0.2	**9.4**	*9.5*	-0.1	**9.4**	*9.4*	0.0	**9.4**	*9.4*	0.0	**9.5**	*9.5*	0.0	**9.7**	*9.7*	-0.1	**9.8**	*9.7*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
163	**9.7**	*9.9*	-0.2	**9.8**	*10.0*	-0.2	**9.4**	*9.5*	-0.1	**9.4**	*9.4*	0.0	**9.4**	*9.4*	0.0	**9.4**	*9.3*	0.1	**9.6**	*9.6*	0.0	**9.7**	*9.6*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
164	**9.8**	*10.0*	-0.2	**9.8**	*10.0*	-0.2	**9.4**	*9.4*	-0.1	**9.4**	*9.4*	0.0	**9.3**	*9.3*	0.1	**9.3**	*9.1*	0.2	**9.4**	*9.4*	0.0	**9.6**	*9.5*	0.1	**10.1**	*10.0*	0.1	**10.7**	*10.6*	0.1
165	**9.8**	*10.0*	-0.2	**9.8**	*10.0*	-0.3	**9.3**	*9.3*	0.0	**9.3**	*9.2*	0.1	**9.3**	*9.1*	0.1	**9.1**	*8.8*	0.3	**9.3**	*9.3*	0.1	**9.5**	*9.4*	0.1	**10.0**	*9.9*	0.1	**10.6**	*10.6*	0.1
166	**9.8**	*10.0*	-0.2	**9.7**	*10.0*	-0.2	**9.0**	*9.0*	0.1	**9.2**	*9.0*	0.2	**9.1**	*8.9*	0.2	**9.0**	*8.6*	0.4	**9.3**	*9.2*	0.1	**9.4**	*9.3*	0.1	**9.9**	*9.8*	0.1	**10.6**	*10.5*	0.1
167	**9.8**	*10.0*	-0.2	**9.7**	*9.9*	-0.2	**8.9**	*8.8*	0.2	**9.0**	*8.7*	0.3	**9.0**	*8.7*	0.3	**8.8**	*8.3*	0.5	**9.2**	*9.0*	0.2	**9.4**	*9.2*	0.2	**9.8**	*9.7*	0.1	**10.5**	*10.4*	0.1
168	**9.8**	*10.1*	-0.3	**9.6**	*9.8*	-0.2	**8.7**	*8.4*	0.2	**8.7**	*8.3*	0.4	**8.8**	*8.3*	0.5	**8.5**	*7.8*	0.7	**9.1**	*8.9*	0.3	**9.3**	*9.1*	0.2	**9.7**	*9.6*	0.1	**10.4**	*10.3*	0.1
169	**9.8**	*10.1*	-0.3	**9.6**	*9.7*	-0.1	**8.6**	*8.3*	0.3	**8.5**	*8.0*	0.5	**8.6**	*8.0*	0.6	**8.3**	*7.5*	0.8	**9.0**	*8.6*	0.4	**9.2**	*9.0*	0.3	**9.6**	*9.6*	0.1	**10.3**	*10.2*	0.1
170	**9.8**	*10.1*	-0.3	**9.5**	*9.6*	-0.1	**8.5**	*8.2*	0.3	**8.4**	*7.9*	0.5	**8.4**	*7.8*	0.6	**8.2**	*7.3*	0.9	**8.8**	*8.3*	0.5	**9.2**	*8.8*	0.3	**9.5**	*9.4*	0.1	**10.1**	*10.1*	0.1
171	**9.7**	*10.1*	-0.4	**9.4**	*9.5*	-0.1	**8.5**	*8.2*	0.3	**8.3**	*7.8*	0.5	**8.4**	*7.8*	0.6	**8.1**	*7.1*	0.9	**8.7**	*8.1*	0.6	**9.1**	*8.7*	0.4	**9.4**	*9.3*	0.1	**10.0**	*9.9*	0.1
172	**9.7**	*10.0*	-0.3	**9.2**	*9.3*	-0.1	**8.4**	*8.0*	0.4	**8.0**	*7.4*	0.6	**8.0**	*7.3*	0.7	**7.7**	*6.6*	1.1	**8.4**	*7.7*	0.7	**9.0**	*8.5*	0.5	**9.4**	*9.2*	0.1	**9.9**	*9.9*	0.0
173	**9.5**	*9.9*	-0.3	**9.1**	*9.2*	-0.1	**8.2**	*7.8*	0.4	**7.9**	*7.2*	0.7	**7.8**	*7.0*	0.8	**7.5**	*6.3*	1.2	**8.2**	*7.4*	0.8	**8.8**	*8.3*	0.6	**9.3**	*9.1*	0.2	**9.8**	*9.8*	0.0
174	**9.4**	*9.7*	-0.3	**9.0**	*9.0*	0.0	**8.1**	*7.6*	0.5	**7.6**	*6.9*	0.8	**7.6**	*6.7*	0.9	**7.2**	*6.0*	1.3	**7.9**	*6.9*	0.9	**8.6**	*7.9*	0.7	**9.2**	*9.0*	0.2	**9.8**	*9.8*	0.1
175	**9.3**	*9.6*	-0.2	**8.8**	*8.8*	0.0	**7.9**	*7.5*	0.5	**7.5**	*6.7*	0.8	**7.4**	*6.5*	0.9	**7.0**	*5.7*	1.3	**7.6**	*6.7*	1.0	**8.4**	*7.7*	0.8	**9.1**	*8.9*	0.3	**9.8**	*9.7*	0.1
176	**9.2**	*9.5*	-0.2	**8.8**	*8.7*	0.0	**7.9**	*7.4*	0.5	**7.4**	*6.6*	0.8	**7.4**	*6.4*	1.0	**7.0**	*5.7*	1.3	**7.5**	*6.5*	1.0	**8.3**	*7.6*	0.8	**9.0**	*8.6*	0.3	**9.7**	*9.6*	0.1
177	**9.0**	*9.2*	-0.1	**8.5**	*8.4*	0.1	**7.6**	*7.0*	0.6	**7.0**	*6.0*	0.9	**6.9**	*5.8*	1.1	**6.5**	*5.1*	1.4	**7.0**	*5.8*	1.2	**7.9**	*6.9*	1.0	**8.6**	*8.2*	0.4	**9.7**	*9.6*	0.1
178	**9.0**	*9.1*	-0.1	**8.4**	*8.2*	0.1	**7.5**	*6.9*	0.6	**6.9**	*5.9*	1.0	**6.8**	*5.8*	1.1	**6.4**	*5.0*	1.4	**6.8**	*5.6*	1.2	**7.7**	*6.6*	1.0	**8.5**	*8.0*	0.5	**9.7**	*9.6*	0.1
179	**8.9**	*9.0*	-0.1	**8.4**	*8.2*	0.2	**7.5**	*6.9*	0.6	**6.9**	*5.9*	1.0	**6.8**	*5.7*	1.1	**6.4**	*5.0*	1.4	**6.7**	*5.5*	1.3	**7.6**	*6.5*	1.1	**8.4**	*7.8*	0.6	**9.7**	*9.6*	0.1
180	**8.8**	*8.9*	-0.1	**8.3**	*8.1*	0.2	**7.4**	*6.8*	0.6	**6.8**	*5.8*	1.0	**6.8**	*5.6*	1.1	**6.4**	*5.0*	1.4	**6.6**	*5.3*	1.3	**7.4**	*6.2*	1.1	**8.3**	*7.6*	0.6	**9.7**	*9.5*	0.2
181	**8.7**	*8.8*	-0.1	**8.2**	*8.0*	0.2	**7.4**	*6.8*	0.7	**6.8**	*5.7*	1.1	**6.7**	*5.5*	1.2	**6.4**	*5.0*	1.4	**6.4**	*5.1*	1.3	**7.2**	*6.0*	1.2	**8.1**	*7.3*	0.7	**9.6**	*9.3*	0.2
182	**8.8**	*8.8*	-0.1	**8.3**	*8.0*	0.2	**7.5**	*6.8*	0.7	**6.8**	*5.8*	1.1	**6.7**	*5.5*	1.2	**6.5**	*5.1*	1.4	**6.4**	*5.1*	1.3	**7.0**	*5.8*	1.2	**7.9**	*7.2*	0.7	**9.4**	*9.1*	0.3
183	**8.6**	*8.6*	0.0	**8.1**	*7.8*	0.3	**7.3**	*6.6*	0.7	**6.7**	*5.6*	1.1	**6.5**	*5.3*	1.2	**6.3**	*4.9*	1.4	**6.2**	*4.9*	1.3	**6.6**	*5.3*	1.3	**7.5**	*6.7*	0.8	**9.3**	*8.9*	0.3
184	**8.6**	*8.6*	0.0	**8.1**	*7.8*	0.3	**7.4**	*6.7*	0.7	**6.8**	*5.7*	1.1	**6.6**	*5.3*	1.3	**6.4**	*5.0*	1.4	**6.2**	*5.0*	1.2	**6.4**	*5.2*	1.2	**7.2**	*6.3*	0.9	**9.1**	*8.7*	0.4
185	**8.6**	*8.5*	0.1	**8.0**	*7.7*	0.4	**7.4**	*6.7*	0.7	**6.8**	*5.7*	1.1	**6.5**	*5.2*	1.3	**6.4**	*4.9*	1.4	**6.1**	*4.9*	1.2	**6.2**	*5.0*	1.3	**6.9**	*6.0*	0.9	**8.8**	*8.3*	0.5
186	**8.4**	*8.3*	0.1	**7.9**	*7.5*	0.4	**7.3**	*6.5*	0.7	**6.6**	*5.5*	1.1	**6.3**	*5.0*	1.3	**6.2**	*4.7*	1.5	**5.9**	*4.6*	1.3	**5.8**	*4.5*	1.4	**6.6**	*5.5*	1.1	**8.6**	*8.0*	0.6
187	**8.4**	*8.3*	0.1	**7.9**	*7.6*	0.4	**7.3**	*6.6*	0.7	**6.6**	*5.5*	1.1	**6.3**	*4.9*	1.3	**6.2**	*4.7*	1.5	**5.9**	*4.6*	1.3	**5.8**	*4.4*	1.4	**6.3**	*5.2*	1.1	**8.4**	*7.9*	0.6
188	**8.4**	*8.1*	0.2	**7.8**	*7.4*	0.4	**7.2**	*6.4*	0.8	**6.6**	*5.4*	1.2	**6.1**	*4.8*	1.4	**6.0**	*4.5*	1.5	**5.7**	*4.3*	1.3	**5.5**	*4.0*	1.5	**5.8**	*4.7*	1.1	**7.8**	*7.2*	0.7

Table 11. TMDL#3 scenario dissolved oxygen concentrations compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the TMDL#3 predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*June 1-15*			*June 15-30*			*July 1-15*			*July 16-31*			*Aug 1-15*			*Aug 16-31*			*Sept 1-15*			*Sept 16-30*			*Oct 1-15*			*Oct 16-31*		
157	**9.4**	*9.4*	0.0	**9.4**	*9.4*	0.0	**9.1**	*9.3*	-0.2	**9.2**	*9.5*	-0.2	**9.3**	*9.6*	-0.3	**9.6**	*9.9*	-0.3	**9.7**	*9.9*	-0.2	**9.8**	*10.0*	-0.2	**10.2**	*10.0*	0.2			
158	**9.5**	*9.6*	-0.1	**9.6**	*9.8*	-0.2	**9.3**	*9.5*	-0.2	**9.4**	*9.6*	-0.2	**9.4**	*9.6*	-0.2	**9.6**	*9.8*	-0.2	**9.8**	*10.0*	-0.2	**9.9**	*9.9*	0.0	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
159	**9.7**	*9.8*	-0.1	**9.6**	*9.8*	-0.2	**9.4**	*9.5*	-0.1	**9.4**	*9.5*	-0.1	**9.4**	*9.5*	-0.1	**9.6**	*9.7*	-0.1	**9.8**	*9.9*	-0.1	**9.8**	*9.9*	0.0	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
160	**9.7**	*9.8*	-0.1	**9.6**	*9.8*	-0.1	**9.3**	*9.4*	-0.1	**9.4**	*9.5*	0.0	**9.4**	*9.5*	-0.1	**9.6**	*9.6*	-0.1	**9.7**	*9.8*	-0.1	**9.8**	*9.8*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
161	**9.7**	*9.8*	-0.1	**9.7**	*9.9*	-0.2	**9.4**	*9.5*	-0.1	**9.4**	*9.4*	0.0	**9.4**	*9.4*	0.0	**9.6**	*9.6*	0.0	**9.7**	*9.8*	0.0	**9.8**	*9.7*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
162	**9.7**	*9.8*	-0.2	**9.8**	*9.9*	-0.2	**9.4**	*9.5*	-0.1	**9.4**	*9.4*	0.0	**9.4**	*9.4*	0.0	**9.5**	*9.5*	0.0	**9.7**	*9.7*	0.0	**9.8**	*9.7*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
163	**9.7**	*9.9*	-0.2	**9.8**	*10.0*	-0.2	**9.4**	*9.5*	0.0	**9.4**	*9.4*	0.0	**9.4**	*9.3*	0.1	**9.4**	*9.3*	0.1	**9.6**	*9.5*	0.0	**9.7**	*9.6*	0.1	**10.2**	*10.1*	0.1	**10.7**	*10.6*	0.1
164	**9.8**	*10.0*	-0.2	**9.8**	*10.0*	-0.2	**9.4**	*9.4*	0.0	**9.4**	*9.3*	0.0	**9.3**	*9.2*	0.1	**9.3**	*9.1*	0.2	**9.4**	*9.4*	0.1	**9.6**	*9.5*	0.1	**10.1**	*10.0*	0.1	**10.7**	*10.6*	0.1
165	**9.8**	*10.0*	-0.2	**9.8**	*10.0*	-0.3	**9.3**	*9.3*	0.0	**9.3**	*9.2*	0.1	**9.3**	*9.1*	0.1	**9.1**	*8.9*	0.3	**9.3**	*9.2*	0.1	**9.5**	*9.4*	0.1	**10.0**	*9.9*	0.1	**10.6**	*10.5*	0.1
166	**9.8**	*10.0*	-0.2	**9.7**	*10.0*	-0.2	**9.0**	*9.0*	0.1	**9.2**	*9.0*	0.1	**9.1**	*8.9*	0.2	**9.0**	*8.6*	0.3	**9.3**	*9.1*	0.1	**9.4**	*9.3*	0.1	**9.9**	*9.8*	0.1	**10.6**	*10.5*	0.1
167	**9.8**	*10.0*	-0.2	**9.7**	*9.9*	-0.2	**8.9**	*8.8*	0.1	**9.0**	*8.8*	0.2	**9.0**	*8.7*	0.3	**8.8**	*8.4*	0.4	**9.2**	*9.0*	0.2	**9.4**	*9.2*	0.2	**9.8**	*9.7*	0.1	**10.5**	*10.4*	0.1
168	**9.8**	*10.1*	-0.3	**9.6**	*9.8*	-0.2	**8.7**	*8.5*	0.2	**8.7**	*8.4*	0.3	**8.8**	*8.4*	0.4	**8.5**	*7.9*	0.6	**9.1**	*8.8*	0.3	**9.3**	*9.1*	0.2	**9.7**	*9.6*	0.1	**10.4**	*10.3*	0.1
169	**9.8**	*10.1*	-0.3	**9.6**	*9.7*	-0.2	**8.6**	*8.3*	0.2	**8.5**	*8.1*	0.4	**8.6**	*8.1*	0.5	**8.3**	*7.7*	0.6	**9.0**	*8.6*	0.4	**9.2**	*9.0*	0.3	**9.6**	*9.5*	0.1	**10.3**	*10.2*	0.1
170	**9.8**	*10.1*	-0.3	**9.5**	*9.6*	-0.1	**8.5**	*8.3*	0.3	**8.4**	*8.0*	0.4	**8.4**	*7.9*	0.5	**8.2**	*7.4*	0.7	**8.8**	*8.3*	0.5	**9.2**	*8.8*	0.3	**9.5**	*9.4*	0.1	**10.1**	*10.1*	0.1
171	**9.7**	*10.1*	-0.3	**9.4**	*9.6*	-0.1	**8.5**	*8.3*	0.3	**8.3**	*7.9*	0.5	**8.4**	*7.8*	0.5	**8.1**	*7.3*	0.8	**8.7**	*8.1*	0.6	**9.1**	*8.7*	0.4	**9.4**	*9.3*	0.1	**10.0**	*9.9*	0.1
172	**9.7**	*10.0*	-0.3	**9.2**	*9.4*	-0.1	**8.4**	*8.1*	0.3	**8.0**	*7.5*	0.5	**8.0**	*7.4*	0.7	**7.7**	*6.8*	0.9	**8.4**	*7.7*	0.7	**9.0**	*8.5*	0.5	**9.4**	*9.2*	0.1	**9.9**	*9.9*	0.0
173	**9.5**	*9.8*	-0.3	**9.1**	*9.2*	-0.1	**8.2**	*7.9*	0.3	**7.9**	*7.3*	0.6	**7.8**	*7.1*	0.7	**7.5**	*6.5*	1.0	**8.2**	*7.3*	0.9	**8.8**	*8.3*	0.6	**9.3**	*9.1*	0.2	**9.8**	*9.8*	0.0
174	**9.4**	*9.7*	-0.3	**9.0**	*9.0*	0.0	**8.1**	*7.7*	0.4	**7.6**	*7.0*	0.7	**7.6**	*6.7*	0.8	**7.2**	*6.1*	1.1	**7.9**	*6.9*	1.0	**8.6**	*7.9*	0.7	**9.2**	*9.0*	0.2	**9.8**	*9.7*	0.1
175	**9.3**	*9.6*	-0.2	**8.8**	*8.8*	0.0	**7.9**	*7.5*	0.4	**7.5**	*6.8*	0.7	**7.4**	*6.5*	0.9	**7.0**	*5.9*	1.2	**7.6**	*6.6*	1.0	**8.4**	*7.7*	0.8	**9.1**	*8.9*	0.2	**9.8**	*9.7*	0.1
176	**9.2**	*9.4*	-0.2	**8.8**	*8.7*	0.0	**7.9**	*7.4*	0.5	**7.4**	*6.7*	0.7	**7.4**	*6.5*	0.9	**7.0**	*5.8*	1.2	**7.5**	*6.5*	1.0	**8.3**	*7.5*	0.8	**9.0**	*8.7*	0.3	**9.7**	*9.6*	0.1
177	**9.0**	*9.2*	-0.1	**8.5**	*8.3*	0.1	**7.6**	*7.0*	0.5	**7.0**	*6.1*	0.8	**6.9**	*5.9*	1.0	**6.5**	*5.2*	1.3	**7.0**	*5.8*	1.2	**7.9**	*6.8*	1.0	**8.6**	*8.2*	0.4	**9.7**	*9.6*	0.1
178	**9.0**	*9.1*	-0.1	**8.4**	*8.2*	0.2	**7.5**	*6.9*	0.6	**6.9**	*6.0*	0.9	**6.8**	*5.8*	1.0	**6.4**	*5.1*	1.3	**6.8**	*5.6*	1.2	**7.7**	*6.6*	1.1	**8.5**	*8.0*	0.5	**9.7**	*9.6*	0.2
179	**8.9**	*9.0*	-0.1	**8.4**	*8.2*	0.2	**7.5**	*6.8*	0.6	**6.9**	*5.9*	0.9	**6.8**	*5.8*	1.0	**6.4**	*5.1*	1.3	**6.7**	*5.5*	1.3	**7.6**	*6.4*	1.1	**8.4**	*7.9*	0.5	**9.7**	*9.5*	0.2
180	**8.8**	*8.9*	-0.1	**8.3**	*8.1*	0.2	**7.4**	*6.8*	0.7	**6.8**	*5.9*	1.0	**6.8**	*5.7*	1.1	**6.4**	*5.1*	1.3	**6.6**	*5.3*	1.3	**7.4**	*6.2*	1.2	**8.3**	*7.7*	0.6	**9.7**	*9.5*	0.2
181	**8.7**	*8.8*	-0.1	**8.2**	*8.0*	0.2	**7.4**	*6.7*	0.7	**6.8**	*5.8*	1.0	**6.7**	*5.6*	1.1	**6.4**	*5.0*	1.4	**6.4**	*5.1*	1.3	**7.2**	*5.9*	1.3	**8.1**	*7.4*	0.7	**9.6**	*9.3*	0.2
182	**8.8**	*8.8*	-0.1	**8.3**	*8.0*	0.2	**7.5**	*6.8*	0.7	**6.8**	*5.8*	1.0	**6.7**	*5.6*	1.1	**6.5**	*5.1*	1.4	**6.4**	*5.2*	1.2	**7.0**	*5.7*	1.3	**7.9**	*7.2*	0.7	**9.4**	*9.1*	0.3
183	**8.6**	*8.6*	0.0	**8.1**	*7.8*	0.3	**7.3**	*6.6*	0.7	**6.7**	*5.6*	1.0	**6.5**	*5.4*	1.2	**6.3**	*4.9*	1.4	**6.2**	*4.9*	1.3	**6.6**	*5.3*	1.3	**7.5**	*6.7*	0.8	**9.3**	*8.9*	0.3
184	**8.6**	*8.6*	0.0	**8.1**	*7.8*	0.3	**7.4**	*6.6*	0.7	**6.8**	*5.7*	1.1	**6.6**	*5.4*	1.2	**6.4**	*5.0*	1.4	**6.2**	*5.0*	1.2	**6.4**	*5.2*	1.3	**7.2**	*6.4*	0.8	**9.1**	*8.7*	0.4
185	**8.6**	*8.5*	0.1	**8.0**	*7.7*	0.4	**7.4**	*6.6*	0.7	**6.8**	*5.7*	1.1	**6.5**	*5.3*	1.2	**6.4**	*5.0*	1.4	**6.1**	*4.9*	1.2	**6.2**	*5.0*	1.3	**6.9**	*6.1*	0.9	**8.8**	*8.3*	0.5
186	**8.4**	*8.3*	0.1	**7.9**	*7.5*	0.4	**7.3**	*6.5*	0.8	**6.6**	*5.5*	1.1	**6.3**	*5.1*	1.2	**6.2**	*4.7*	1.4	**5.9**	*4.6*	1.3	**5.8**	*4.5*	1.3	**6.6**	*5.5*	1.1	**8.6**	*8.0*	0.6
187	**8.4**	*8.3*	0.2	**7.9**	*7.6*	0.4	**7.3**	*6.5*	0.8	**6.6**	*5.5*	1.1	**6.3**	*5.0*	1.3	**6.2**	*4.7*	1.5	**5.9**	*4.6*	1.3	**5.8**	*4.4*	1.3	**6.3**	*5.2*	1.1	**8.4**	*7.9*	0.6
188	**8.4**	*8.1*	0.3	**7.8**	*7.3*	0.5	**7.2**	*6.4*	0.8	**6.6**	*5.4*	1.2	**6.1**	*4.8*	1.3	**6.0**	*4.5*	1.5	**5.7**	*4.3*	1.4	**5.5**	*4.1*	1.4	**5.8**	*4.8*	1.0	**7.8**	*7.2*	0.6

Revised Scenarios

Based on information from the first round of scenarios and issues raised by the project team and stakeholder modelers, several features of the model were revised. These changes were minor and relate to the model setup for scenario runs, not the core model (2001 calibrated model). The following changes were made, and the reasons are outlined below for each change:

1. Model output changes (extended simulation time period and added dissolved oxygen saturation variable)
2. Groundwater ammonia nitrogen (NH3-N) changed to zero (zero anthropogenic NH3).
3. Number of CPU option included for simulations
4. Pump operation for Nine Mile Dam turned off after Julian Day 185, and output frequency of model files linking Washington (minus Long Lake model) with Long Lake model increased

Model Output Changes

The original TMDL scenarios were run with reservoir output ending on October 15th. The results indicated that dissolved oxygen impacts that were pertinent to TMDL development (greater than 0.2 mg/l) continued past this end date, and the model was revised to provide this output for the entire year.

For riverine locations, the model was revised to output the dissolved oxygen saturation (DOsat). This parameter allows comparison of simulated DO to the 100% saturation level.

Groundwater Ammonia Nitrogen

The groundwater ammonia nitrogen concentrations used in the revised no source and TMDL #1 scenarios were set to zero. Evaluation of the groundwater ammonia nitrogen data showed that concentrations were generally below minimum detection limits. Because groundwater is generally well-oxygenated and travel times are long, the project team believed that it was reasonable to assume that there is zero ammonia in the groundwater (in other words, any ammonia has been converted to nitrate). Ammonia nitrogen concentrations in the original simulations had been set to the detection level and were not consistent for the TMDL and no source simulations.

Number of CPU's

A new parameter was added to the Spokane River models allowing users to specify the number of processors used by the computer. When running the model using multiple processors it was found that on average duplicate model runs give the same answer, but sometimes the number is not exact to the nth decimal place. For example, when comparing dissolved oxygen for 2 duplicate runs, 99.7% to 97.2% of all DO model values were within 0.009 mg/l of each other, and 99.99% are usually within 0.09 mg/l. In order to ensure 'exact' numerical precision in values, when 1 processor was used there was 100% compatibility. The 1 cpu option was used for the revised scenario simulations.

The number of processors can be specified near the top of the control file in the 'GRID' card using the NPROC parameter. For example, the top of the control file for the Idaho model would look like the following:

```
                                    Spokane River Model Version 3.6

TITLE C ...............................TITLE...................................
        Version 3.6 Spokane River Upper Boundary Couer d'Alene
        WB1: Lake Coeur d'Alene to Post Falls Dam
        WB2: Spokane River below Post Falls Dam to State line

        Spokane River Idaho


        Scott Wells, PSU; Rob Annear, PSU; Chris Berger, PSU



GRID         NWB     NBR     IMX     KMX   NPROC
               2       2      63      15       1

IN/OUTFL     NTR     NST     NIW     NWD     NGT     NSP     NPI     NPU
               4       2       0       0       0       1       0       0

CONSTITU     NGC     NSS     NAL     NEP    NBOD     NMC     NZP
               5       1       3       3      10       0       1
```

If the field containing the NPROC parameter is left blank, only one processor will be used.

Nine Mile Pump Feature

The pump algorithm in CE-QUAL-W2 was used to keep water levels upstream of Upriver dam, Upper Falls dam and Nine Mile dam in the scenarios close to water level data measured in 2001. This was implemented in the 2009 model update to make changing inflows to the model much less work intensive (the other option is redoing the water balance and outflow files for each of the reservoirs). In the initial scenarios, the pumps became slightly out of phase. This phase shift, along with a coarse output frequency of the output files for Nine Mile dam (which are used as input files to the Long Lake model), resulted in velocity and flow differences occurring in the upstream end of Long Lake. These differences in turn resulted in small, artificial discrepancies in water quality outcomes under different scenarios. To make the comparison of model scenarios more accurate and consistent, pumps for Nine Mile Dam were turned off at Julian Day 185. Water level data after this time were flat and water not flowing through the turbines was spilled. This change eliminated the water quality discrepancies.

Revised No Source and TMDL #1 Scenarios

After making the change described above, the No Source baseline and TMDL #1 simulations were re-run with the revised model. As expected, the effect of these changes on water quality was minor, as seen in the plots comparing the original and revised simulations. Vertical profiles of model predicted dissolved concentrations were shown for the initial no source, revised no source, initial TMDL #1, and revised TMDL#1 scenarios in Figure 4 and Figure 5.

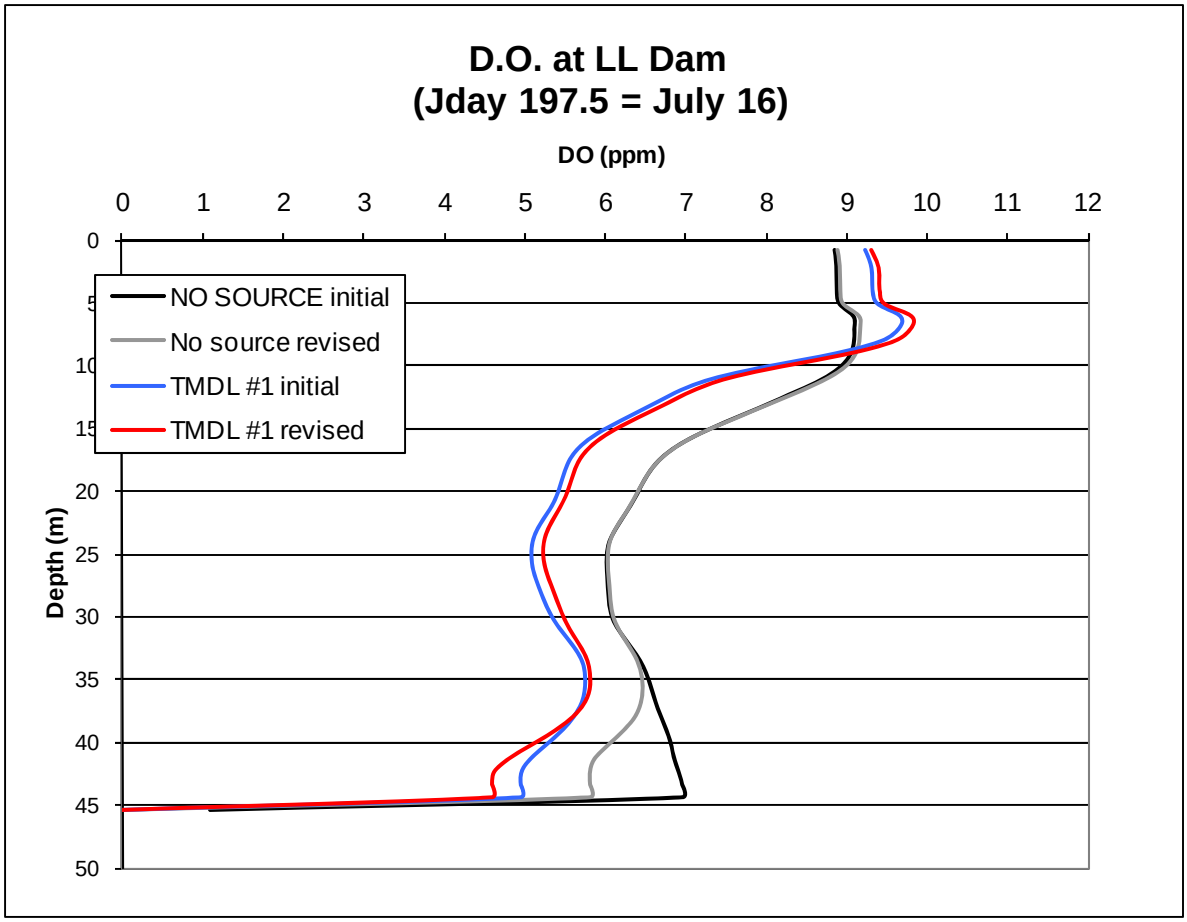

Figure 4. Model predicted vertical profiles of dissolved oxygen concentrations on July 16 (Julian Day 197.5) for the initial no source, revised no source, initial TMDL #1, and revised TMDL#1 scenarios.

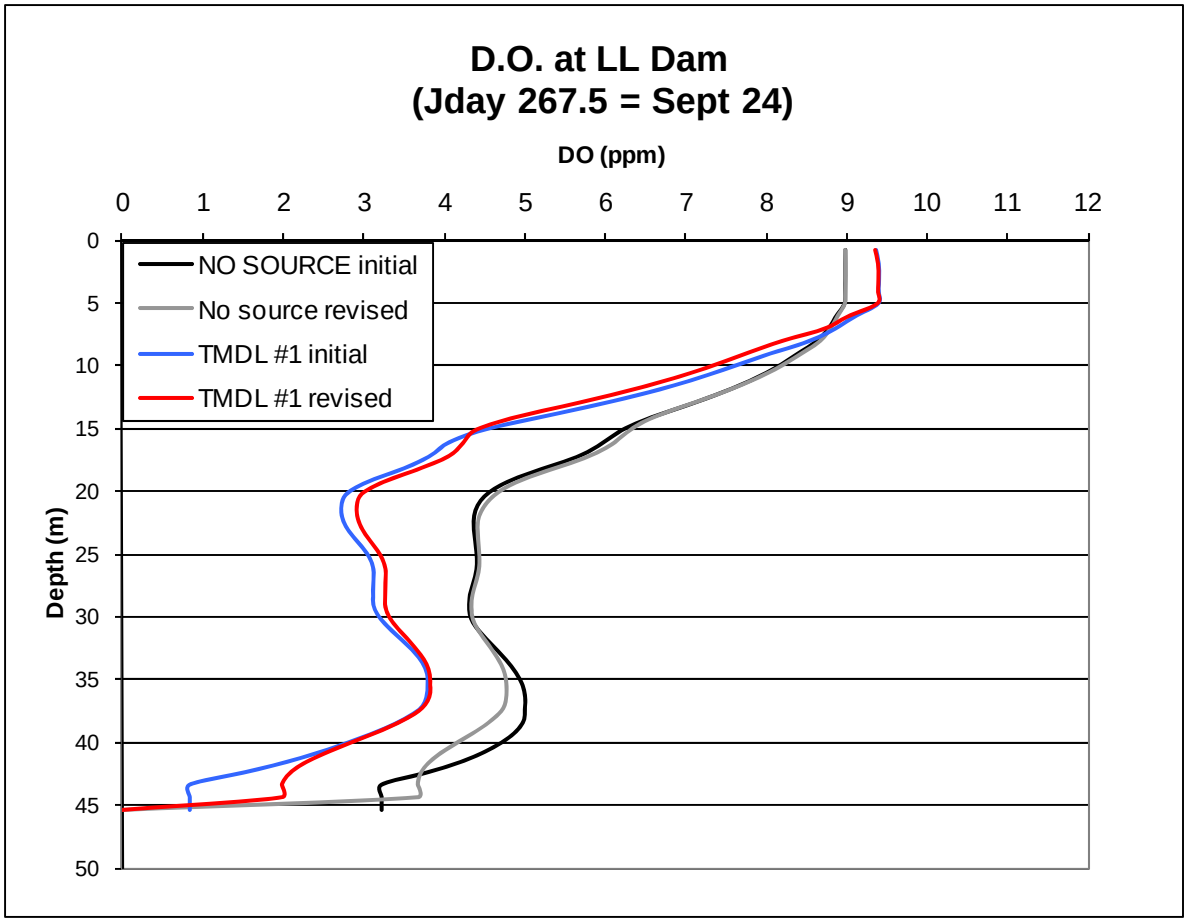

Figure 5. Model predicted vertical profiles of dissolved oxygen concentrations on September 24 (Julian Day 267.5) the initial no source, revised no source, initial TMDL #1, and revised TMDL#1 scenarios.

Results

The semi-monthly averages of the daily minimum, volume-averaged DO in the hypolimnion (greater than 8 m depth) of each Long Lake segment (157-188) for the revised TMDL alternative #1were listed in Table 12 and Table 13. The greatest difference in dissolved oxygen concentration between the no source and the revised TMDL#1 scenario was 1.4 mg/l, occurring in the August 16-31 time period, compared to 1.5 mg/l in the first round of scenarios.

Table 12. Revised TMDL#1 scenario dissolved oxygen concentrations for June 1 to September 15 compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the TMDL#1 predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*June 1-15*			*June 15-30*			*July 1-15*			*July 16-31*			*Aug 1-15*			*Aug 16-31*			*Sept 1-15*		
157	**9.32**	*9.35*	-0.02	**9.55**	*9.49*	0.07	**9.06**	*9.45*	-0.39	**9.14**	*9.41*	-0.27	**9.30**	*9.51*	-0.21	**9.48**	*9.88*	-0.40	**9.63**	*9.93*	-0.30
158	**9.51**	*9.61*	-0.10	**9.60**	*9.76*	-0.17	**9.25**	*9.45*	-0.21	**9.33**	*9.52*	-0.19	**9.37**	*9.56*	-0.20	**9.56**	*9.76*	-0.20	**9.69**	*9.92*	-0.23
159	**9.65**	*9.80*	-0.15	**9.64**	*9.83*	-0.19	**9.33**	*9.47*	-0.14	**9.41**	*9.50*	-0.10	**9.40**	*9.53*	-0.13	**9.56**	*9.69*	-0.14	**9.69**	*9.86*	-0.17
160	**9.68**	*9.85*	-0.17	**9.63**	*9.79*	-0.16	**9.32**	*9.40*	-0.08	**9.40**	*9.46*	-0.06	**9.38**	*9.46*	-0.08	**9.53**	*9.61*	-0.09	**9.66**	*9.79*	-0.13
161	**9.68**	*9.85*	-0.17	**9.70**	*9.88*	-0.18	**9.37**	*9.45*	-0.08	**9.41**	*9.44*	-0.03	**9.40**	*9.43*	-0.04	**9.53**	*9.57*	-0.05	**9.67**	*9.76*	-0.09
162	**9.68**	*9.90*	-0.21	**9.74**	*9.95*	-0.21	**9.37**	*9.45*	-0.07	**9.40**	*9.42*	-0.02	**9.39**	*9.39*	0.00	**9.48**	*9.48*	0.00	**9.63**	*9.68*	-0.05
163	**9.73**	*9.98*	-0.25	**9.79**	*10.02*	-0.23	**9.39**	*9.47*	-0.09	**9.39**	*9.42*	-0.03	**9.38**	*9.35*	0.03	**9.40**	*9.34*	0.06	**9.52**	*9.56*	-0.04
164	**9.77**	*10.04*	-0.27	**9.79**	*10.04*	-0.25	**9.36**	*9.45*	-0.09	**9.37**	*9.40*	-0.03	**9.33**	*9.28*	0.05	**9.31**	*9.18*	0.13	**9.40**	*9.42*	-0.02
165	**9.80**	*10.08*	-0.28	**9.78**	*10.07*	-0.29	**9.26**	*9.31*	-0.05	**9.30**	*9.30*	0.00	**9.27**	*9.16*	0.10	**9.16**	*8.92*	0.24	**9.31**	*9.29*	0.02
166	**9.77**	*10.05*	-0.28	**9.73**	*10.00*	-0.27	**9.05**	*9.00*	0.05	**9.18**	*9.09*	0.09	**9.15**	*8.97*	0.18	**9.00**	*8.68*	0.32	**9.26**	*9.19*	0.07
167	**9.77**	*10.06*	-0.29	**9.70**	*9.95*	-0.26	**8.89**	*8.80*	0.09	**9.03**	*8.86*	0.17	**9.04**	*8.79*	0.25	**8.85**	*8.46*	0.40	**9.19**	*9.08*	0.11
168	**9.80**	*10.12*	-0.33	**9.65**	*9.88*	-0.23	**8.67**	*8.51*	0.15	**8.72**	*8.42*	0.30	**8.82**	*8.44*	0.38	**8.58**	*8.02*	0.56	**9.12**	*8.93*	0.20
169	**9.81**	*10.17*	-0.36	**9.57**	*9.77*	-0.20	**8.54**	*8.35*	0.19	**8.52**	*8.15*	0.37	**8.62**	*8.18*	0.43	**8.38**	*7.75*	0.63	**9.02**	*8.73*	0.29
170	**9.79**	*10.18*	-0.38	**9.48**	*9.67*	-0.19	**8.51**	*8.31*	0.20	**8.42**	*8.01*	0.41	**8.51**	*8.04*	0.47	**8.24**	*7.55*	0.69	**8.84**	*8.48*	0.37
171	**9.76**	*10.16*	-0.39	**9.43**	*9.61*	-0.19	**8.53**	*8.33*	0.20	**8.38**	*7.95*	0.43	**8.43**	*7.93*	0.51	**8.14**	*7.40*	0.75	**8.71**	*8.26*	0.45
172	**9.68**	*10.05*	-0.37	**9.26**	*9.41*	-0.14	**8.35**	*8.10*	0.24	**8.09**	*7.57*	0.51	**8.09**	*7.47*	0.62	**7.78**	*6.92*	0.86	**8.47**	*7.89*	0.58
173	**9.57**	*9.91*	-0.34	**9.13**	*9.25*	-0.11	**8.23**	*7.93*	0.30	**7.91**	*7.32*	0.58	**7.88**	*7.19*	0.70	**7.58**	*6.63*	0.95	**8.26**	*7.59*	0.67
174	**9.45**	*9.75*	-0.30	**8.97**	*9.05*	-0.08	**8.06**	*7.71*	0.36	**7.69**	*7.04*	0.65	**7.63**	*6.86*	0.77	**7.30**	*6.26*	1.04	**7.93**	*7.17*	0.76
175	**9.36**	*9.63*	-0.28	**8.84**	*8.90*	-0.05	**7.95**	*7.58*	0.38	**7.54**	*6.86*	0.68	**7.46**	*6.64*	0.81	**7.12**	*6.05*	1.07	**7.68**	*6.87*	0.81
176	**9.26**	*9.51*	-0.25	**8.77**	*8.81*	-0.03	**7.92**	*7.51*	0.41	**7.48**	*6.77*	0.71	**7.44**	*6.58*	0.85	**7.08**	*5.96*	1.12	**7.61**	*6.75*	0.85
177	**9.06**	*9.24*	-0.18	**8.48**	*8.43*	0.05	**7.57**	*7.09*	0.48	**7.03**	*6.23*	0.80	**6.94**	*5.99*	0.95	**6.56**	*5.35*	1.21	**7.03**	*6.06*	0.97
178	**8.98**	*9.14*	-0.16	**8.39**	*8.31*	0.08	**7.50**	*6.99*	0.52	**6.95**	*6.11*	0.84	**6.90**	*5.92*	0.97	**6.50**	*5.27*	1.23	**6.90**	*5.88*	1.01
179	**8.91**	*9.06*	-0.15	**8.35**	*8.26*	0.09	**7.48**	*6.94*	0.54	**6.90**	*6.04*	0.86	**6.88**	*5.87*	1.00	**6.49**	*5.25*	1.24	**6.80**	*5.74*	1.06
180	**8.84**	*8.97*	-0.13	**8.31**	*8.19*	0.12	**7.45**	*6.89*	0.55	**6.85**	*5.97*	0.88	**6.82**	*5.79*	1.03	**6.47**	*5.22*	1.25	**6.66**	*5.58*	1.08
181	**8.77**	*8.88*	-0.11	**8.26**	*8.12*	0.14	**7.42**	*6.84*	0.58	**6.79**	*5.86*	0.93	**6.73**	*5.65*	1.09	**6.44**	*5.15*	1.29	**6.49**	*5.36*	1.13
182	**8.78**	*8.89*	-0.11	**8.27**	*8.13*	0.14	**7.47**	*6.89*	0.59	**6.85**	*5.92*	0.93	**6.78**	*5.69*	1.09	**6.53**	*5.26*	1.27	**6.50**	*5.36*	1.14
183	**8.66**	*8.72*	-0.06	**8.10**	*7.89*	0.20	**7.31**	*6.71*	0.60	**6.70**	*5.76*	0.95	**6.57**	*5.45*	1.12	**6.33**	*5.08*	1.25	**6.24**	*5.09*	1.15
184	**8.64**	*8.69*	-0.05	**8.08**	*7.85*	0.23	**7.35**	*6.75*	0.60	**6.76**	*5.80*	0.96	**6.61**	*5.48*	1.14	**6.38**	*5.12*	1.26	**6.26**	*5.16*	1.10
185	**8.56**	*8.57*	0.00	**8.02**	*7.77*	0.26	**7.33**	*6.74*	0.60	**6.77**	*5.80*	0.97	**6.55**	*5.40*	1.16	**6.36**	*5.07*	1.29	**6.18**	*5.08*	1.10
186	**8.43**	*8.38*	0.05	**7.91**	*7.64*	0.28	**7.22**	*6.61*	0.61	**6.62**	*5.64*	0.98	**6.33**	*5.16*	1.17	**6.18**	*4.85*	1.33	**5.90**	*4.72*	1.19
187	**8.40**	*8.35*	0.05	**7.92**	*7.65*	0.27	**7.27**	*6.66*	0.61	**6.64**	*5.63*	1.00	**6.31**	*5.10*	1.21	**6.20**	*4.82*	1.38	**5.90**	*4.68*	1.22
188	**8.27**	*8.17*	0.10	**7.73**	*7.43*	0.30	**7.13**	*6.50*	0.63	**6.50**	*5.50*	1.00	**6.10**	*4.90*	1.20	**6.00**	*4.62*	1.38	**5.66**	*4.44*	1.23

Table 13. Revised TMDL#1 scenario dissolved oxygen concentrations for September 16 to December 31 compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the TMDL#1 predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*Sept 16-30*			*Oct 1-15*			*Oct 16-31*			*Nov 1-15*			*Nov 16-30*			*Dec 1-15*			*Dec 16-31*		
157	**9.75**	*9.88*	-0.13	**9.94**	*10.07*	-0.13	**10.47**	*10.54*	-0.06	**10.67**	*10.74*	-0.07	**10.85**	*10.79*	0.07	**11.43**	*11.43*	0.00			
158	**9.80**	*9.86*	-0.06	**10.11**	*10.06*	0.05	**10.57**	*10.52*	0.05	**10.73**	*10.71*	0.02	**10.84**	*10.79*	0.04	**11.45**	*11.42*	0.03	**11.51**	*11.50*	0.01
159	**9.78**	*9.80*	-0.02	**10.13**	*10.07*	0.06	**10.59**	*10.54*	0.05	**10.77**	*10.73*	0.04	**10.86**	*10.80*	0.06	**11.45**	*11.42*	0.03	**11.52**	*11.52*	0.00
160	**9.75**	*9.73*	0.02	**10.14**	*10.07*	0.07	**10.60**	*10.52*	0.08	**10.76**	*10.71*	0.05	**10.85**	*10.78*	0.08	**11.45**	*11.41*	0.04	**11.51**	*11.51*	0.00
161	**9.75**	*9.70*	0.05	**10.15**	*10.07*	0.09	**10.60**	*10.51*	0.09	**10.76**	*10.69*	0.06	**10.87**	*10.77*	0.09	**11.46**	*11.41*	0.05	**11.50**	*11.49*	0.01
162	**9.73**	*9.64*	0.09	**10.17**	*10.07*	0.10	**10.64**	*10.54*	0.09	**10.74**	*10.65*	0.09	**10.86**	*10.75*	0.11	**11.45**	*11.40*	0.05	**11.51**	*11.50*	0.01
163	**9.68**	*9.60*	0.08	**10.14**	*10.05*	0.09	**10.66**	*10.57*	0.09	**10.73**	*10.62*	0.10	**10.85**	*10.72*	0.13	**11.45**	*11.39*	0.06	**11.51**	*11.49*	0.02
164	**9.57**	*9.51*	0.06	**10.04**	*9.99*	0.05	**10.65**	*10.57*	0.09	**10.72**	*10.61*	0.11	**10.84**	*10.69*	0.15	**11.43**	*11.36*	0.07	**11.50**	*11.47*	0.02
165	**9.46**	*9.43*	0.03	**9.89**	*9.90*	-0.01	**10.57**	*10.51*	0.05	**10.72**	*10.61*	0.11	**10.85**	*10.69*	0.17	**11.42**	*11.35*	0.07	**11.49**	*11.46*	0.03
166	**9.41**	*9.32*	0.09	**9.82**	*9.82*	0.00	**10.51**	*10.44*	0.07	**10.67**	*10.52*	0.14	**10.83**	*10.65*	0.18	**11.40**	*11.32*	0.09	**11.47**	*11.44*	0.04
167	**9.34**	*9.21*	0.13	**9.74**	*9.76*	-0.01	**10.46**	*10.38*	0.08	**10.66**	*10.51*	0.15	**10.84**	*10.65*	0.19	**11.39**	*11.30*	0.09	**11.45**	*11.42*	0.03
168	**9.28**	*9.09*	0.19	**9.67**	*9.67*	-0.01	**10.36**	*10.32*	0.04	**10.66**	*10.52*	0.14	**10.85**	*10.64*	0.21	**11.37**	*11.27*	0.10	**11.45**	*11.41*	0.04
169	**9.22**	*8.99*	0.23	**9.59**	*9.60*	0.00	**10.25**	*10.23*	0.01	**10.68**	*10.55*	0.13	**10.84**	*10.62*	0.23	**11.30**	*11.17*	0.13	**11.43**	*11.39*	0.04
170	**9.15**	*8.86*	0.29	**9.50**	*9.49*	0.01	**10.11**	*10.11*	-0.01	**10.62**	*10.52*	0.10	**10.84**	*10.59*	0.24	**11.22**	*11.04*	0.18	**11.40**	*11.34*	0.06
171	**9.07**	*8.72*	0.35	**9.41**	*9.37*	0.03	**9.98**	*10.00*	-0.02	**10.54**	*10.44*	0.10	**10.80**	*10.56*	0.24	**11.23**	*11.04*	0.19	**11.38**	*11.30*	0.08
172	**8.96**	*8.51*	0.45	**9.35**	*9.30*	0.05	**9.88**	*9.93*	-0.05	**10.41**	*10.34*	0.07	**10.75**	*10.52*	0.23	**11.32**	*11.14*	0.18	**11.45**	*11.37*	0.08
173	**8.84**	*8.32*	0.52	**9.29**	*9.21*	0.08	**9.82**	*9.85*	-0.03	**10.32**	*10.23*	0.09	**10.71**	*10.47*	0.24	**11.32**	*11.13*	0.19	**11.48**	*11.39*	0.09
174	**8.64**	*8.02*	0.61	**9.24**	*9.08*	0.16	**9.80**	*9.80*	0.01	**10.30**	*10.19*	0.11	**10.69**	*10.44*	0.24	**11.29**	*11.09*	0.20	**11.47**	*11.37*	0.10
175	**8.44**	*7.78*	0.66	**9.15**	*8.96*	0.19	**9.78**	*9.75*	0.02	**10.27**	*10.14*	0.13	**10.67**	*10.42*	0.24	**11.29**	*11.08*	0.21	**11.48**	*11.37*	0.10
176	**8.33**	*7.63*	0.70	**9.00**	*8.76*	0.24	**9.70**	*9.67*	0.03	**10.18**	*10.03*	0.15	**10.61**	*10.37*	0.24	**11.26**	*11.04*	0.22	**11.52**	*11.39*	0.13
177	**7.82**	*7.00*	0.83	**8.70**	*8.33*	0.37	**9.73**	*9.65*	0.07	**10.17**	*10.01*	0.16	**10.59**	*10.35*	0.24	**11.23**	*11.01*	0.23	**11.52**	*11.38*	0.14
178	**7.62**	*6.73*	0.89	**8.53**	*8.10*	0.43	**9.71**	*9.62*	0.09	**10.14**	*9.96*	0.18	**10.56**	*10.32*	0.25	**11.21**	*10.98*	0.23	**11.54**	*11.39*	0.15
179	**7.54**	*6.61*	0.94	**8.47**	*8.00*	0.47	**9.69**	*9.59*	0.10	**10.09**	*9.90*	0.19	**10.53**	*10.28*	0.26	**11.19**	*10.96*	0.23	**11.60**	*11.43*	0.17
180	**7.36**	*6.37*	0.99	**8.32**	*7.79*	0.53	**9.66**	*9.53*	0.12	**10.06**	*9.85*	0.21	**10.50**	*10.24*	0.26	**11.18**	*10.94*	0.24	**11.63**	*11.44*	0.19
181	**7.16**	*6.09*	1.07	**8.12**	*7.49*	0.63	**9.56**	*9.39*	0.18	**10.04**	*9.81*	0.23	**10.49**	*10.21*	0.27	**11.16**	*10.91*	0.25	**11.61**	*11.42*	0.19
182	**7.00**	*5.90*	1.10	**7.96**	*7.33*	0.63	**9.43**	*9.20*	0.22	**10.04**	*9.80*	0.24	**10.48**	*10.21*	0.28	**11.16**	*10.90*	0.26	**11.58**	*11.39*	0.20
183	**6.62**	*5.46*	1.16	**7.57**	*6.84*	0.73	**9.29**	*9.03*	0.26	**10.03**	*9.76*	0.27	**10.47**	*10.19*	0.29	**11.15**	*10.89*	0.26	**11.60**	*11.39*	0.21
184	**6.45**	*5.32*	1.13	**7.26**	*6.51*	0.75	**9.14**	*8.82*	0.33	**10.02**	*9.73*	0.29	**10.47**	*10.17*	0.30	**11.14**	*10.88*	0.26	**11.61**	*11.40*	0.21
185	**6.25**	*5.10*	1.15	**6.98**	*6.16*	0.82	**8.90**	*8.47*	0.43	**10.01**	*9.71*	0.30	**10.47**	*10.17*	0.30	**11.13**	*10.86*	0.27	**11.60**	*11.39*	0.21
186	**5.87**	*4.68*	1.19	**6.60**	*5.61*	0.99	**8.64**	*8.14*	0.50	**9.97**	*9.65*	0.33	**10.46**	*10.16*	0.31	**11.11**	*10.84*	0.28	**11.56**	*11.35*	0.20
187	**5.81**	*4.59*	1.22	**6.33**	*5.31*	1.02	**8.50**	*8.02*	0.48	**9.95**	*9.60*	0.35	**10.45**	*10.14*	0.31	**11.09**	*10.81*	0.28	**11.53**	*11.33*	0.20
188	**5.49**	*4.27*	1.21	**5.81**	*4.89*	0.92	**7.95**	*7.39*	0.56	**9.92**	*9.52*	0.40	**10.42**	*10.10*	0.32	**11.08**	*10.79*	0.29	**11.56**	*11.35*	0.21

Source Assessment Scenarios

Two additional source assessment scenarios were simulated in addition to the revised No Source and TMDL #1 scenarios. These are described below:

1. Idaho only

All Washington sources (point sources, stormwater, CSOs, groundwater, and tributaries) were set to no source conditions. All Idaho sources (Coeur d'Alene, Hayden, Post Falls, and stormwater) were set to TMDL #1 conditions.

2. FERC Flow Impact

Flows released from Post Falls Dam were adjusted in accordance with new FERC minimum flow requirements. The license for Post Falls dam specifies that flows should not drop below 600 cfs between June 7 and Labor Day (FERC, 2009). Simulated outflows from Post Falls dam for this time period did not drop below 600 cfs. All other conditions were unchanged from TMDL #1 levels.

Results

The semi-monthly averages of the daily minimum, volume-averaged DO in the hypolimnion (greater than 8 m depth) of each Long Lake segment (157-188) for the revised Idaho only source assessment scenario were listed in Table 14 and Table 15. The DO averages for the FERC flow impact scenario were listed in Table 16 and Table 17.

Table 14. Idaho-only source assessment scenario dissolved oxygen concentrations for June 1 to September 15 compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the Idaho only source assessment scenario predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*June 1-15*			*June 15-30*			*July 1-15*			*July 16-31*			*Aug 1-15*			*Aug 16-31*			*Sept 1-15*		
157	**9.32**	*9.34*	-0.01	**9.55**	*9.44*	0.11	**9.06**	*9.06*	0.00	**9.14**	*9.13*	0.01	**9.30**	*9.26*	0.03	**9.48**	*9.51*	-0.03	**9.63**	*9.62*	0.00
158	**9.51**	*9.49*	0.02	**9.60**	*9.57*	0.02	**9.25**	*9.25*	-0.01	**9.33**	*9.32*	0.01	**9.37**	*9.36*	0.01	**9.56**	*9.55*	0.01	**9.69**	*9.69*	0.00
159	**9.65**	*9.63*	0.02	**9.64**	*9.63*	0.01	**9.33**	*9.32*	0.01	**9.41**	*9.39*	0.01	**9.40**	*9.39*	0.01	**9.56**	*9.55*	0.01	**9.69**	*9.68*	0.01
160	**9.68**	*9.67*	0.01	**9.63**	*9.61*	0.02	**9.32**	*9.31*	0.02	**9.40**	*9.38*	0.01	**9.38**	*9.37*	0.01	**9.53**	*9.52*	0.01	**9.66**	*9.66*	0.00
161	**9.68**	*9.68*	0.00	**9.70**	*9.68*	0.01	**9.37**	*9.36*	0.01	**9.41**	*9.40*	0.01	**9.40**	*9.38*	0.02	**9.53**	*9.52*	0.01	**9.67**	*9.66*	0.01
162	**9.68**	*9.71*	-0.02	**9.74**	*9.73*	0.02	**9.37**	*9.36*	0.02	**9.40**	*9.39*	0.01	**9.39**	*9.37*	0.01	**9.48**	*9.48*	0.01	**9.63**	*9.63*	0.00
163	**9.73**	*9.74*	0.00	**9.79**	*9.77*	0.02	**9.39**	*9.37*	0.01	**9.39**	*9.38*	0.01	**9.38**	*9.37*	0.01	**9.40**	*9.40*	0.01	**9.52**	*9.52*	0.00
164	**9.77**	*9.77*	0.00	**9.79**	*9.77*	0.02	**9.36**	*9.35*	0.01	**9.37**	*9.36*	0.01	**9.33**	*9.32*	0.01	**9.31**	*9.31*	0.00	**9.40**	*9.40*	0.00
165	**9.80**	*9.80*	0.00	**9.78**	*9.76*	0.02	**9.26**	*9.24*	0.02	**9.30**	*9.29*	0.01	**9.27**	*9.25*	0.01	**9.16**	*9.15*	0.01	**9.31**	*9.31*	0.00
166	**9.77**	*9.77*	0.00	**9.73**	*9.71*	0.02	**9.05**	*9.02*	0.03	**9.18**	*9.16*	0.02	**9.15**	*9.13*	0.02	**9.00**	*8.98*	0.02	**9.26**	*9.26*	0.00
167	**9.77**	*9.76*	0.01	**9.70**	*9.67*	0.02	**8.89**	*8.86*	0.03	**9.03**	*9.01*	0.02	**9.04**	*9.02*	0.02	**8.85**	*8.83*	0.02	**9.19**	*9.19*	0.00
168	**9.80**	*9.79*	0.01	**9.65**	*9.62*	0.02	**8.67**	*8.63*	0.03	**8.72**	*8.69*	0.03	**8.82**	*8.78*	0.03	**8.58**	*8.56*	0.02	**9.12**	*9.12*	0.00
169	**9.81**	*9.80*	0.01	**9.57**	*9.56*	0.01	**8.54**	*8.51*	0.04	**8.52**	*8.49*	0.04	**8.62**	*8.58*	0.04	**8.38**	*8.35*	0.03	**9.02**	*9.02*	0.00
170	**9.79**	*9.79*	0.00	**9.48**	*9.47*	0.02	**8.51**	*8.46*	0.04	**8.42**	*8.38*	0.04	**8.51**	*8.46*	0.05	**8.24**	*8.21*	0.03	**8.84**	*8.85*	0.00
171	**9.76**	*9.77*	0.00	**9.43**	*9.41*	0.02	**8.53**	*8.48*	0.05	**8.38**	*8.33*	0.04	**8.43**	*8.38*	0.05	**8.14**	*8.10*	0.04	**8.71**	*8.71*	0.00
172	**9.68**	*9.68*	0.00	**9.26**	*9.25*	0.01	**8.35**	*8.30*	0.04	**8.09**	*8.04*	0.05	**8.09**	*8.03*	0.06	**7.78**	*7.73*	0.05	**8.47**	*8.46*	0.00
173	**9.57**	*9.58*	-0.01	**9.13**	*9.12*	0.01	**8.23**	*8.19*	0.04	**7.91**	*7.85*	0.06	**7.88**	*7.82*	0.06	**7.58**	*7.52*	0.06	**8.26**	*8.25*	0.01
174	**9.45**	*9.46*	-0.01	**8.97**	*8.96*	0.02	**8.06**	*8.02*	0.04	**7.69**	*7.63*	0.06	**7.63**	*7.56*	0.07	**7.30**	*7.23*	0.07	**7.93**	*7.92*	0.01
175	**9.36**	*9.37*	-0.01	**8.84**	*8.83*	0.01	**7.95**	*7.91*	0.04	**7.54**	*7.48*	0.06	**7.46**	*7.39*	0.07	**7.12**	*7.05*	0.07	**7.68**	*7.67*	0.02
176	**9.26**	*9.27*	-0.01	**8.77**	*8.76*	0.01	**7.92**	*7.87*	0.04	**7.48**	*7.41*	0.07	**7.44**	*7.37*	0.07	**7.08**	*7.01*	0.07	**7.61**	*7.58*	0.02
177	**9.06**	*9.06*	0.00	**8.48**	*8.47*	0.01	**7.57**	*7.53*	0.05	**7.03**	*6.95*	0.08	**6.94**	*6.86*	0.08	**6.56**	*6.47*	0.09	**7.03**	*6.99*	0.04
178	**8.98**	*8.98*	0.00	**8.39**	*8.37*	0.01	**7.50**	*7.45*	0.05	**6.95**	*6.86*	0.08	**6.90**	*6.82*	0.08	**6.50**	*6.41*	0.09	**6.90**	*6.85*	0.04
179	**8.91**	*8.92*	-0.01	**8.35**	*8.34*	0.02	**7.48**	*7.42*	0.06	**6.90**	*6.82*	0.08	**6.88**	*6.79*	0.08	**6.49**	*6.40*	0.10	**6.80**	*6.75*	0.05
180	**8.84**	*8.85*	-0.01	**8.31**	*8.29*	0.02	**7.45**	*7.39*	0.06	**6.85**	*6.76*	0.09	**6.82**	*6.74*	0.08	**6.47**	*6.37*	0.10	**6.66**	*6.60*	0.06
181	**8.77**	*8.78*	-0.01	**8.26**	*8.24*	0.02	**7.42**	*7.35*	0.07	**6.79**	*6.69*	0.09	**6.73**	*6.65*	0.09	**6.44**	*6.34*	0.10	**6.49**	*6.42*	0.07
182	**8.78**	*8.79*	-0.01	**8.27**	*8.25*	0.02	**7.47**	*7.41*	0.07	**6.85**	*6.76*	0.09	**6.78**	*6.70*	0.08	**6.53**	*6.44*	0.09	**6.50**	*6.42*	0.08
183	**8.66**	*8.67*	-0.01	**8.10**	*8.08*	0.02	**7.31**	*7.24*	0.07	**6.70**	*6.61*	0.09	**6.57**	*6.48*	0.08	**6.33**	*6.24*	0.09	**6.24**	*6.16*	0.08
184	**8.64**	*8.67*	-0.03	**8.08**	*8.08*	0.00	**7.35**	*7.30*	0.05	**6.76**	*6.69*	0.07	**6.61**	*6.55*	0.06	**6.38**	*6.32*	0.07	**6.26**	*6.20*	0.06
185	**8.56**	*8.61*	-0.04	**8.02**	*8.05*	-0.02	**7.33**	*7.31*	0.02	**6.77**	*6.73*	0.04	**6.55**	*6.51*	0.04	**6.36**	*6.32*	0.04	**6.18**	*6.13*	0.05
186	**8.43**	*8.47*	-0.04	**7.91**	*7.93*	-0.02	**7.22**	*7.19*	0.03	**6.62**	*6.57*	0.05	**6.33**	*6.27*	0.06	**6.18**	*6.11*	0.06	**5.90**	*5.83*	0.07
187	**8.40**	*8.44*	-0.04	**7.92**	*7.94*	-0.02	**7.27**	*7.24*	0.03	**6.64**	*6.58*	0.06	**6.31**	*6.24*	0.07	**6.20**	*6.13*	0.07	**5.90**	*5.81*	0.09
188	**8.27**	*8.41*	-0.13	**7.73**	*7.85*	-0.12	**7.13**	*7.19*	-0.06	**6.50**	*6.53*	-0.02	**6.10**	*6.12*	-0.02	**6.00**	*6.01*	-0.01	**5.66**	*5.65*	0.02

Table 15. Idaho-only source assessment scenario dissolved oxygen concentrations for September 16 to December 31 compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the Idaho only source assessment scenario predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*Sept 16-30*			*Oct 1-15*			*Oct 16-31*			*Nov 1-15*			*Nov 16-30*			*Dec 1-15*			*Dec 16-31*		
157	**9.75**	*9.74*	0.01	**9.94**	*9.91*	0.03	**10.47**	*10.44*	0.03	**10.67**	*10.65*	0.02	**10.85**	*10.82*	0.04	**11.43**	*11.47*	-0.04			
158	**9.80**	*9.78*	0.02	**10.11**	*10.07*	0.04	**10.57**	*10.54*	0.03	**10.73**	*10.72*	0.02	**10.84**	*10.82*	0.01	**11.45**	*11.44*	0.01	**11.51**	*11.50*	0.01
159	**9.78**	*9.75*	0.02	**10.13**	*10.09*	0.04	**10.59**	*10.56*	0.03	**10.77**	*10.75*	0.02	**10.86**	*10.85*	0.01	**11.45**	*11.44*	0.01	**11.52**	*11.51*	0.01
160	**9.75**	*9.73*	0.03	**10.14**	*10.10*	0.04	**10.60**	*10.57*	0.03	**10.76**	*10.74*	0.02	**10.85**	*10.84*	0.02	**11.45**	*11.44*	0.01	**11.51**	*11.51*	0.01
161	**9.75**	*9.72*	0.03	**10.15**	*10.12*	0.04	**10.60**	*10.56*	0.04	**10.76**	*10.74*	0.02	**10.87**	*10.85*	0.02	**11.46**	*11.44*	0.01	**11.50**	*11.50*	0.01
162	**9.73**	*9.70*	0.03	**10.17**	*10.13*	0.04	**10.64**	*10.60*	0.04	**10.74**	*10.71*	0.02	**10.86**	*10.84*	0.02	**11.45**	*11.44*	0.01	**11.51**	*11.51*	0.01
163	**9.68**	*9.65*	0.02	**10.14**	*10.11*	0.04	**10.66**	*10.62*	0.04	**10.73**	*10.70*	0.03	**10.85**	*10.83*	0.02	**11.45**	*11.44*	0.01	**11.51**	*11.50*	0.01
164	**9.57**	*9.55*	0.02	**10.04**	*10.01*	0.03	**10.65**	*10.62*	0.04	**10.72**	*10.70*	0.03	**10.84**	*10.82*	0.02	**11.43**	*11.41*	0.02	**11.50**	*11.49*	0.01
165	**9.46**	*9.43*	0.02	**9.89**	*9.86*	0.03	**10.57**	*10.53*	0.04	**10.72**	*10.69*	0.03	**10.85**	*10.83*	0.03	**11.42**	*11.40*	0.02	**11.49**	*11.48*	0.01
166	**9.41**	*9.38*	0.02	**9.82**	*9.79*	0.03	**10.51**	*10.47*	0.04	**10.67**	*10.63*	0.03	**10.83**	*10.80*	0.03	**11.40**	*11.39*	0.02	**11.47**	*11.46*	0.01
167	**9.34**	*9.32*	0.02	**9.74**	*9.71*	0.03	**10.46**	*10.42*	0.04	**10.66**	*10.62*	0.04	**10.84**	*10.81*	0.03	**11.39**	*11.37*	0.02	**11.45**	*11.45*	0.01
168	**9.28**	*9.25*	0.03	**9.67**	*9.64*	0.03	**10.36**	*10.33*	0.03	**10.66**	*10.62*	0.04	**10.85**	*10.82*	0.03	**11.37**	*11.35*	0.02	**11.45**	*11.44*	0.01
169	**9.22**	*9.19*	0.03	**9.59**	*9.57*	0.03	**10.25**	*10.22*	0.03	**10.68**	*10.64*	0.04	**10.84**	*10.81*	0.04	**11.30**	*11.28*	0.02	**11.43**	*11.42*	0.01
170	**9.15**	*9.12*	0.03	**9.50**	*9.47*	0.03	**10.11**	*10.08*	0.03	**10.62**	*10.58*	0.04	**10.84**	*10.80*	0.04	**11.22**	*11.20*	0.03	**11.40**	*11.39*	0.01
171	**9.07**	*9.04*	0.03	**9.41**	*9.38*	0.03	**9.98**	*9.95*	0.02	**10.54**	*10.50*	0.03	**10.80**	*10.76*	0.04	**11.23**	*11.20*	0.03	**11.38**	*11.37*	0.01
172	**8.96**	*8.93*	0.03	**9.35**	*9.32*	0.03	**9.88**	*9.86*	0.02	**10.41**	*10.38*	0.03	**10.75**	*10.72*	0.04	**11.32**	*11.29*	0.03	**11.45**	*11.44*	0.01
173	**8.84**	*8.81*	0.03	**9.29**	*9.26*	0.03	**9.82**	*9.80*	0.02	**10.32**	*10.30*	0.03	**10.71**	*10.67*	0.04	**11.32**	*11.29*	0.03	**11.48**	*11.47*	0.02
174	**8.64**	*8.61*	0.02	**9.24**	*9.21*	0.03	**9.80**	*9.78*	0.03	**10.30**	*10.27*	0.03	**10.69**	*10.65*	0.04	**11.29**	*11.26*	0.03	**11.47**	*11.46*	0.02
175	**8.44**	*8.42*	0.01	**9.15**	*9.13*	0.02	**9.78**	*9.75*	0.03	**10.27**	*10.24*	0.03	**10.67**	*10.63*	0.04	**11.29**	*11.25*	0.03	**11.48**	*11.46*	0.02
176	**8.33**	*8.31*	0.02	**9.00**	*8.98*	0.02	**9.70**	*9.68*	0.03	**10.18**	*10.15*	0.03	**10.61**	*10.58*	0.03	**11.26**	*11.23*	0.03	**11.52**	*11.50*	0.02
177	**7.82**	*7.81*	0.01	**8.70**	*8.68*	0.02	**9.73**	*9.70*	0.03	**10.17**	*10.14*	0.03	**10.59**	*10.56*	0.03	**11.23**	*11.20*	0.03	**11.52**	*11.50*	0.02
178	**7.62**	*7.60*	0.02	**8.53**	*8.50*	0.03	**9.71**	*9.68*	0.03	**10.14**	*10.11*	0.03	**10.56**	*10.53*	0.03	**11.21**	*11.18*	0.03	**11.54**	*11.52*	0.02
179	**7.54**	*7.53*	0.02	**8.47**	*8.44*	0.03	**9.69**	*9.66*	0.03	**10.09**	*10.06*	0.03	**10.53**	*10.50*	0.03	**11.19**	*11.16*	0.03	**11.60**	*11.57*	0.02
180	**7.36**	*7.34*	0.03	**8.32**	*8.29*	0.03	**9.66**	*9.63*	0.03	**10.06**	*10.03*	0.03	**10.50**	*10.47*	0.04	**11.18**	*11.15*	0.03	**11.63**	*11.60*	0.03
181	**7.16**	*7.13*	0.03	**8.12**	*8.10*	0.03	**9.56**	*9.52*	0.04	**10.04**	*10.01*	0.03	**10.49**	*10.45*	0.04	**11.16**	*11.13*	0.03	**11.61**	*11.58*	0.03
182	**7.00**	*6.96*	0.04	**7.96**	*7.94*	0.02	**9.43**	*9.37*	0.06	**10.04**	*10.01*	0.03	**10.48**	*10.45*	0.04	**11.16**	*11.12*	0.04	**11.58**	*11.55*	0.03
183	**6.62**	*6.57*	0.05	**7.57**	*7.54*	0.03	**9.29**	*9.25*	0.04	**10.03**	*9.99*	0.04	**10.47**	*10.43*	0.04	**11.15**	*11.11*	0.04	**11.60**	*11.57*	0.03
184	**6.45**	*6.41*	0.04	**7.26**	*7.24*	0.02	**9.14**	*9.10*	0.04	**10.02**	*9.98*	0.04	**10.47**	*10.42*	0.04	**11.14**	*11.10*	0.04	**11.61**	*11.58*	0.03
185	**6.25**	*6.21*	0.03	**6.98**	*6.95*	0.02	**8.90**	*8.85*	0.05	**10.01**	*9.96*	0.05	**10.47**	*10.43*	0.04	**11.13**	*11.09*	0.04	**11.60**	*11.57*	0.03
186	**5.87**	*5.81*	0.06	**6.60**	*6.56*	0.04	**8.64**	*8.62*	0.02	**9.97**	*9.92*	0.06	**10.46**	*10.42*	0.05	**11.11**	*11.08*	0.04	**11.56**	*11.53*	0.03
187	**5.81**	*5.73*	0.08	**6.33**	*6.27*	0.05	**8.50**	*8.49*	0.01	**9.95**	*9.88*	0.06	**10.45**	*10.40*	0.05	**11.09**	*11.06*	0.04	**11.53**	*11.50*	0.03
188	**5.49**	*5.47*	0.02	**5.81**	*5.81*	0.00	**7.95**	*7.93*	0.02	**9.92**	*9.78*	0.15	**10.42**	*10.37*	0.05	**11.08**	*11.04*	0.04	**11.56**	*11.53*	0.03

Table 16. FERC flow impact source assessment scenario dissolved oxygen concentrations for June 1 to September 15 compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the FERC flow impact source assessment scenario predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*June 1-15*			*June 15-30*			*July 1-15*			*July 16-31*			*Aug 1-15*			*Aug 16-31*			*Sept 1-15*		
157	**9.32**	*9.35*	-0.02	**9.55**	*9.71*	-0.16	**9.06**	*9.42*	-0.36	**9.14**	*9.41*	-0.27	**9.30**	*9.41*	-0.11	**9.48**	*9.52*	-0.04	**9.63**	*9.67*	-0.05
158	**9.51**	*9.62*	-0.11	**9.60**	*9.79*	-0.20	**9.25**	*9.43*	-0.18	**9.33**	*9.53*	-0.20	**9.37**	*9.55*	-0.19	**9.56**	*9.56*	0.00	**9.69**	*9.71*	-0.02
159	**9.65**	*9.80*	-0.15	**9.64**	*9.86*	-0.22	**9.33**	*9.47*	-0.14	**9.41**	*9.50*	-0.10	**9.40**	*9.53*	-0.12	**9.56**	*9.50*	0.05	**9.69**	*9.65*	0.04
160	**9.68**	*9.86*	-0.18	**9.63**	*9.84*	-0.21	**9.32**	*9.41*	-0.09	**9.40**	*9.46*	-0.06	**9.38**	*9.46*	-0.08	**9.53**	*9.43*	0.09	**9.66**	*9.59*	0.07
161	**9.68**	*9.86*	-0.18	**9.70**	*9.91*	-0.22	**9.37**	*9.45*	-0.08	**9.41**	*9.44*	-0.03	**9.40**	*9.43*	-0.03	**9.53**	*9.40*	0.13	**9.67**	*9.57*	0.10
162	**9.68**	*9.90*	-0.22	**9.74**	*9.98*	-0.24	**9.37**	*9.46*	-0.08	**9.40**	*9.42*	-0.02	**9.39**	*9.39*	0.00	**9.48**	*9.32*	0.17	**9.63**	*9.50*	0.13
163	**9.73**	*9.98*	-0.24	**9.79**	*10.04*	-0.25	**9.39**	*9.48*	-0.10	**9.39**	*9.43*	-0.03	**9.38**	*9.35*	0.03	**9.40**	*9.21*	0.19	**9.52**	*9.43*	0.09
164	**9.77**	*10.04*	-0.27	**9.79**	*10.05*	-0.26	**9.36**	*9.45*	-0.09	**9.37**	*9.40*	-0.03	**9.33**	*9.29*	0.05	**9.31**	*9.09*	0.22	**9.40**	*9.33*	0.07
165	**9.80**	*10.08*	-0.28	**9.78**	*10.08*	-0.30	**9.26**	*9.31*	-0.05	**9.30**	*9.30*	0.00	**9.27**	*9.19*	0.08	**9.16**	*8.86*	0.29	**9.31**	*9.22*	0.09
166	**9.77**	*10.05*	-0.28	**9.73**	*10.00*	-0.27	**9.05**	*9.01*	0.04	**9.18**	*9.09*	0.09	**9.15**	*9.01*	0.14	**9.00**	*8.64*	0.36	**9.26**	*9.12*	0.14
167	**9.77**	*10.07*	-0.29	**9.70**	*9.96*	-0.26	**8.89**	*8.81*	0.09	**9.03**	*8.87*	0.16	**9.04**	*8.83*	0.21	**8.85**	*8.43*	0.42	**9.19**	*9.03*	0.17
168	**9.80**	*10.13*	-0.33	**9.65**	*9.89*	-0.24	**8.67**	*8.51*	0.16	**8.72**	*8.43*	0.29	**8.82**	*8.49*	0.33	**8.58**	*8.00*	0.58	**9.12**	*8.87*	0.25
169	**9.81**	*10.17*	-0.36	**9.57**	*9.77*	-0.20	**8.54**	*8.34*	0.20	**8.52**	*8.16*	0.36	**8.62**	*8.23*	0.39	**8.38**	*7.75*	0.63	**9.02**	*8.67*	0.35
170	**9.79**	*10.18*	-0.39	**9.48**	*9.67*	-0.18	**8.51**	*8.30*	0.21	**8.42**	*8.02*	0.40	**8.51**	*8.08*	0.43	**8.24**	*7.58*	0.66	**8.84**	*8.44*	0.40
171	**9.76**	*10.16*	-0.40	**9.43**	*9.60*	-0.17	**8.53**	*8.32*	0.21	**8.38**	*7.95*	0.43	**8.43**	*7.97*	0.47	**8.14**	*7.46*	0.68	**8.71**	*8.24*	0.47
172	**9.68**	*10.05*	-0.37	**9.26**	*9.40*	-0.13	**8.35**	*8.08*	0.27	**8.09**	*7.57*	0.52	**8.09**	*7.52*	0.57	**7.78**	*7.00*	0.78	**8.47**	*7.88*	0.59
173	**9.57**	*9.91*	-0.34	**9.13**	*9.23*	-0.10	**8.23**	*7.89*	0.34	**7.91**	*7.32*	0.59	**7.88**	*7.23*	0.66	**7.58**	*6.70*	0.87	**8.26**	*7.58*	0.68
174	**9.45**	*9.75*	-0.30	**8.97**	*9.04*	-0.07	**8.06**	*7.67*	0.39	**7.69**	*7.03*	0.66	**7.63**	*6.89*	0.73	**7.30**	*6.34*	0.96	**7.93**	*7.17*	0.77
175	**9.36**	*9.63*	-0.28	**8.84**	*8.89*	-0.05	**7.95**	*7.55*	0.41	**7.54**	*6.85*	0.69	**7.46**	*6.68*	0.78	**7.12**	*6.14*	0.98	**7.68**	*6.86*	0.82
176	**9.26**	*9.51*	-0.25	**8.77**	*8.81*	-0.03	**7.92**	*7.47*	0.45	**7.48**	*6.76*	0.72	**7.44**	*6.62*	0.81	**7.08**	*6.08*	1.01	**7.61**	*6.74*	0.87
177	**9.06**	*9.24*	-0.18	**8.48**	*8.43*	0.05	**7.57**	*7.05*	0.52	**7.03**	*6.22*	0.81	**6.94**	*6.03*	0.91	**6.56**	*5.47*	1.08	**7.03**	*6.06*	0.97
178	**8.98**	*9.14*	-0.16	**8.39**	*8.32*	0.07	**7.50**	*6.96*	0.54	**6.95**	*6.10*	0.85	**6.90**	*5.96*	0.94	**6.50**	*5.40*	1.11	**6.90**	*5.91*	0.98
179	**8.91**	*9.06*	-0.15	**8.35**	*8.26*	0.09	**7.48**	*6.93*	0.55	**6.90**	*6.03*	0.87	**6.88**	*5.90*	0.98	**6.49**	*5.37*	1.13	**6.80**	*5.78*	1.02
180	**8.84**	*8.98*	-0.13	**8.31**	*8.20*	0.11	**7.45**	*6.88*	0.56	**6.85**	*5.96*	0.89	**6.82**	*5.81*	1.01	**6.47**	*5.33*	1.14	**6.66**	*5.63*	1.03
181	**8.77**	*8.88*	-0.11	**8.26**	*8.12*	0.13	**7.42**	*6.83*	0.59	**6.79**	*5.85*	0.94	**6.73**	*5.66*	1.07	**6.44**	*5.25*	1.19	**6.49**	*5.42*	1.07
182	**8.78**	*8.89*	-0.11	**8.27**	*8.13*	0.14	**7.47**	*6.89*	0.58	**6.85**	*5.91*	0.94	**6.78**	*5.70*	1.08	**6.53**	*5.34*	1.19	**6.50**	*5.43*	1.07
183	**8.66**	*8.72*	-0.06	**8.10**	*7.90*	0.19	**7.31**	*6.71*	0.60	**6.70**	*5.75*	0.95	**6.57**	*5.46*	1.11	**6.33**	*5.15*	1.18	**6.24**	*5.15*	1.10
184	**8.64**	*8.69*	-0.05	**8.08**	*7.86*	0.22	**7.35**	*6.75*	0.60	**6.76**	*5.79*	0.97	**6.61**	*5.48*	1.13	**6.38**	*5.21*	1.18	**6.26**	*5.20*	1.06
185	**8.56**	*8.56*	0.00	**8.02**	*7.77*	0.25	**7.33**	*6.73*	0.60	**6.77**	*5.79*	0.98	**6.55**	*5.40*	1.15	**6.36**	*5.16*	1.21	**6.18**	*5.13*	1.04
186	**8.43**	*8.38*	0.05	**7.91**	*7.64*	0.28	**7.22**	*6.61*	0.61	**6.62**	*5.63*	0.98	**6.33**	*5.17*	1.16	**6.18**	*4.91*	1.26	**5.90**	*4.78*	1.13
187	**8.40**	*8.34*	0.06	**7.92**	*7.65*	0.26	**7.27**	*6.65*	0.62	**6.64**	*5.63*	1.01	**6.31**	*5.11*	1.20	**6.20**	*4.88*	1.32	**5.90**	*4.72*	1.18
188	**8.27**	*8.16*	0.11	**7.73**	*7.43*	0.30	**7.13**	*6.49*	0.64	**6.50**	*5.49*	1.01	**6.10**	*4.90*	1.20	**6.00**	*4.66*	1.34	**5.66**	*4.47*	1.19

Table 17. FERC flow impact source assessment scenario dissolved oxygen concentrations for September 16 to December 31 compared with no source scenario concentrations.

The results were reported for a semi-monthly time periods and Long Lake model segment numbers 157-188. The no source scenario predictions were in bold and the FERC flow impact source assessment scenario predictions were italicized. The difference in DO predictions between the scenarios were underlined.

Segment	*Sept 16-30*			*Oct 1-15*			*Oct 16-31*			*Nov 1-15*			*Nov 16-30*			*Dec 1-15*			*Dec 16-31*		
157	**9.75**	*9.83*	-0.07	**9.94**	*10.05*	-0.11	**10.47**	*10.48*	-0.01	**10.67**	*10.74*	-0.07	**10.85**	*10.78*	0.07	**11.43**	*11.43*	0.00			
158	**9.80**	*9.80*	0.00	**10.11**	*10.05*	0.06	**10.57**	*10.52*	0.05	**10.73**	*10.71*	0.02	**10.84**	*10.79*	0.04	**11.45**	*11.42*	0.03	**11.51**	*11.50*	0.01
159	**9.78**	*9.74*	0.04	**10.13**	*10.05*	0.07	**10.59**	*10.53*	0.06	**10.77**	*10.72*	0.05	**10.86**	*10.80*	0.06	**11.45**	*11.42*	0.03	**11.52**	*11.52*	0.00
160	**9.75**	*9.66*	0.09	**10.14**	*10.05*	0.09	**10.60**	*10.51*	0.09	**10.76**	*10.71*	0.05	**10.85**	*10.78*	0.08	**11.45**	*11.41*	0.04	**11.51**	*11.51*	0.00
161	**9.75**	*9.63*	0.12	**10.15**	*10.05*	0.11	**10.60**	*10.50*	0.10	**10.76**	*10.69*	0.07	**10.87**	*10.77*	0.09	**11.46**	*11.41*	0.05	**11.50**	*11.49*	0.01
162	**9.73**	*9.58*	0.15	**10.17**	*10.05*	0.12	**10.64**	*10.53*	0.10	**10.74**	*10.64*	0.09	**10.86**	*10.75*	0.11	**11.45**	*11.40*	0.05	**11.51**	*11.50*	0.01
163	**9.68**	*9.54*	0.14	**10.14**	*10.03*	0.12	**10.66**	*10.56*	0.10	**10.73**	*10.62*	0.11	**10.85**	*10.72*	0.13	**11.45**	*11.39*	0.06	**11.51**	*11.49*	0.02
164	**9.57**	*9.45*	0.12	**10.04**	*9.97*	0.07	**10.65**	*10.55*	0.10	**10.72**	*10.61*	0.12	**10.84**	*10.69*	0.15	**11.43**	*11.36*	0.07	**11.50**	*11.47*	0.02
165	**9.46**	*9.37*	0.09	**9.89**	*9.88*	0.01	**10.57**	*10.50*	0.06	**10.72**	*10.60*	0.12	**10.85**	*10.69*	0.16	**11.42**	*11.35*	0.07	**11.49**	*11.46*	0.03
166	**9.41**	*9.26*	0.15	**9.82**	*9.80*	0.02	**10.51**	*10.43*	0.08	**10.67**	*10.52*	0.15	**10.83**	*10.65*	0.18	**11.40**	*11.32*	0.09	**11.47**	*11.44*	0.04
167	**9.34**	*9.16*	0.18	**9.74**	*9.74*	0.00	**10.46**	*10.37*	0.08	**10.66**	*10.51*	0.15	**10.84**	*10.65*	0.19	**11.39**	*11.30*	0.09	**11.45**	*11.42*	0.03
168	**9.28**	*9.02*	0.25	**9.67**	*9.66*	0.01	**10.36**	*10.31*	0.05	**10.66**	*10.51*	0.15	**10.85**	*10.64*	0.21	**11.37**	*11.27*	0.10	**11.45**	*11.41*	0.04
169	**9.22**	*8.92*	0.31	**9.59**	*9.58*	0.01	**10.25**	*10.23*	0.02	**10.68**	*10.55*	0.13	**10.84**	*10.62*	0.23	**11.30**	*11.17*	0.13	**11.43**	*11.39*	0.04
170	**9.15**	*8.79*	0.36	**9.50**	*9.48*	0.02	**10.11**	*10.11*	0.00	**10.62**	*10.52*	0.10	**10.84**	*10.59*	0.24	**11.22**	*11.04*	0.18	**11.40**	*11.34*	0.06
171	**9.07**	*8.65*	0.42	**9.41**	*9.36*	0.04	**9.98**	*9.99*	-0.02	**10.54**	*10.44*	0.10	**10.80**	*10.56*	0.24	**11.23**	*11.04*	0.19	**11.38**	*11.30*	0.08
172	**8.96**	*8.42*	0.54	**9.35**	*9.29*	0.06	**9.88**	*9.93*	-0.05	**10.41**	*10.34*	0.07	**10.75**	*10.52*	0.23	**11.32**	*11.14*	0.18	**11.45**	*11.37*	0.08
173	**8.84**	*8.20*	0.64	**9.29**	*9.21*	0.09	**9.82**	*9.85*	-0.03	**10.32**	*10.23*	0.09	**10.71**	*10.48*	0.23	**11.32**	*11.13*	0.19	**11.48**	*11.39*	0.09
174	**8.64**	*7.88*	0.75	**9.24**	*9.08*	0.16	**9.80**	*9.79*	0.01	**10.30**	*10.19*	0.11	**10.69**	*10.45*	0.24	**11.29**	*11.09*	0.20	**11.47**	*11.37*	0.10
175	**8.44**	*7.62*	0.81	**9.15**	*8.97*	0.18	**9.78**	*9.75*	0.03	**10.27**	*10.15*	0.12	**10.67**	*10.42*	0.24	**11.29**	*11.08*	0.21	**11.48**	*11.37*	0.10
176	**8.33**	*7.49*	0.84	**9.00**	*8.77*	0.23	**9.70**	*9.67*	0.03	**10.18**	*10.04*	0.14	**10.61**	*10.38*	0.24	**11.26**	*11.04*	0.22	**11.52**	*11.39*	0.12
177	**7.82**	*6.83*	0.99	**8.70**	*8.34*	0.36	**9.73**	*9.65*	0.08	**10.17**	*10.01*	0.16	**10.59**	*10.35*	0.24	**11.23**	*11.01*	0.22	**11.52**	*11.38*	0.13
178	**7.62**	*6.59*	1.03	**8.53**	*8.11*	0.42	**9.71**	*9.62*	0.09	**10.14**	*9.97*	0.17	**10.56**	*10.32*	0.24	**11.21**	*10.98*	0.23	**11.54**	*11.39*	0.15
179	**7.54**	*6.48*	1.07	**8.47**	*8.00*	0.47	**9.69**	*9.58*	0.10	**10.09**	*9.91*	0.19	**10.53**	*10.28*	0.25	**11.19**	*10.96*	0.23	**11.60**	*11.43*	0.17
180	**7.36**	*6.25*	1.11	**8.32**	*7.79*	0.53	**9.66**	*9.53*	0.12	**10.06**	*9.86*	0.21	**10.50**	*10.25*	0.25	**11.18**	*10.94*	0.24	**11.63**	*11.44*	0.19
181	**7.16**	*6.00*	1.16	**8.12**	*7.49*	0.64	**9.56**	*9.39*	0.18	**10.04**	*9.82*	0.23	**10.49**	*10.22*	0.26	**11.16**	*10.92*	0.25	**11.61**	*11.42*	0.19
182	**7.00**	*5.83*	1.17	**7.96**	*7.32*	0.64	**9.43**	*9.21*	0.22	**10.04**	*9.81*	0.24	**10.48**	*10.21*	0.27	**11.16**	*10.91*	0.25	**11.58**	*11.39*	0.19
183	**6.62**	*5.41*	1.21	**7.57**	*6.83*	0.74	**9.29**	*9.04*	0.25	**10.03**	*9.76*	0.26	**10.47**	*10.19*	0.28	**11.15**	*10.89*	0.26	**11.60**	*11.40*	0.21
184	**6.45**	*5.29*	1.17	**7.26**	*6.50*	0.76	**9.14**	*8.83*	0.32	**10.02**	*9.74*	0.28	**10.47**	*10.18*	0.29	**11.14**	*10.88*	0.26	**11.61**	*11.40*	0.21
185	**6.25**	*5.09*	1.16	**6.98**	*6.14*	0.84	**8.90**	*8.48*	0.41	**10.01**	*9.71*	0.30	**10.47**	*10.17*	0.30	**11.13**	*10.87*	0.27	**11.60**	*11.39*	0.21
186	**5.87**	*4.69*	1.18	**6.60**	*5.59*	1.01	**8.64**	*8.15*	0.49	**9.97**	*9.65*	0.32	**10.46**	*10.16*	0.30	**11.11**	*10.84*	0.27	**11.56**	*11.36*	0.20
187	**5.81**	*4.61*	1.19	**6.33**	*5.29*	1.03	**8.50**	*8.02*	0.48	**9.95**	*9.60*	0.34	**10.45**	*10.14*	0.31	**11.09**	*10.82*	0.28	**11.53**	*11.33*	0.20
188	**5.49**	*4.29*	1.20	**5.81**	*4.87*	0.95	**7.95**	*7.40*	0.55	**9.92**	*9.53*	0.39	**10.42**	*10.10*	0.32	**11.08**	*10.79*	0.29	**11.56**	*11.35*	0.21

Constituent Concentration Plots of Revised Scenarios and Source Assessment Scenarios

Total phosphorus concentrations for the revised scenarios and the source assessment scenarios were plotted at the state line (Figure 6) and at segment 154 in Long Lake (Figure 7). Total phosphorus concentrations at the state line were strongly affected by data measured in Lake Coeur d'Alene, which was the model's upstream boundary condition. Simulated CBOD ultimate concentrations at segment 154 in Long Lake were plotted in Figure 8. Figure 9 and Figure 10 plot concentrations at segment 154 in Long Lake for dissolved oxygen and ammonia-nitrogen, respectively.

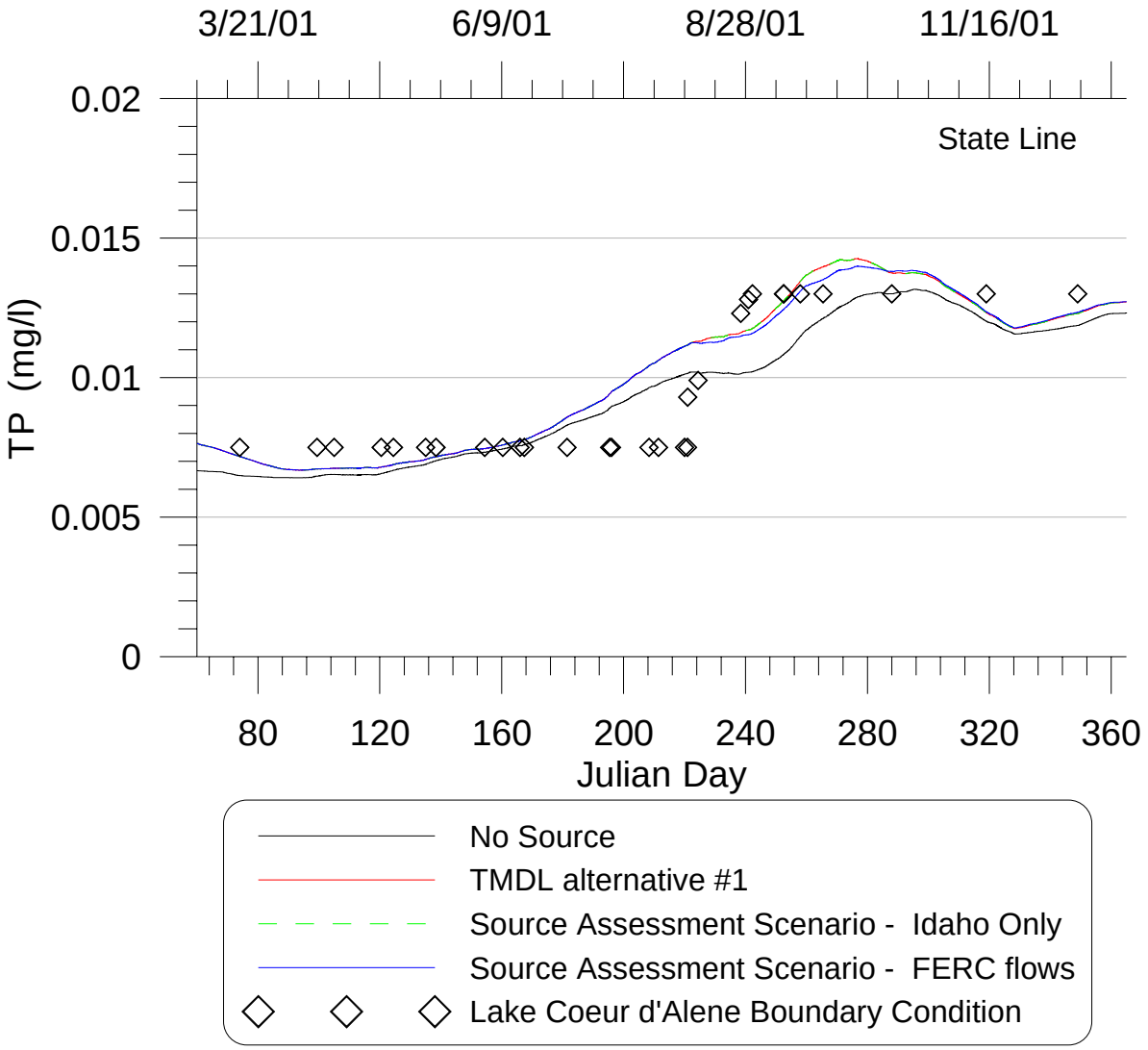

Figure 6. 30-day running average total phosphorus concentrations at the Idaho-Washington state line of the revised no source scenario, the revised TMDL scenario #1, and the source assessment scenarios. Also plotted are the total phosphorus concentrations originating from Lake Coeur d'Alene, the upstream boundary of the Idaho model.

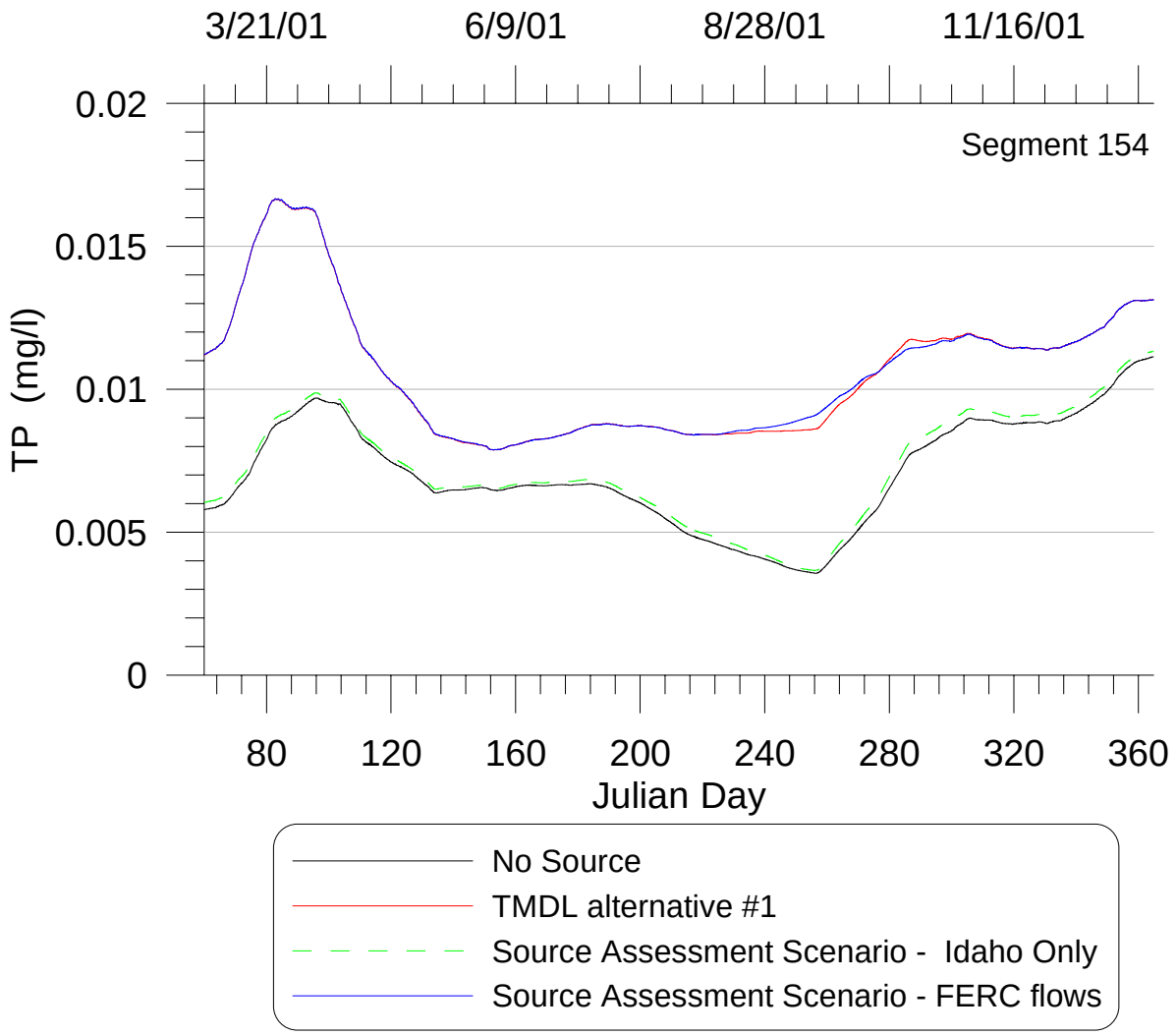

Figure 7. 30-day running average total phosphorus concentrations at segment 154 in Long Lake of the revised no source scenario, the revised TMDL scenario #1, and the source assessment scenarios.

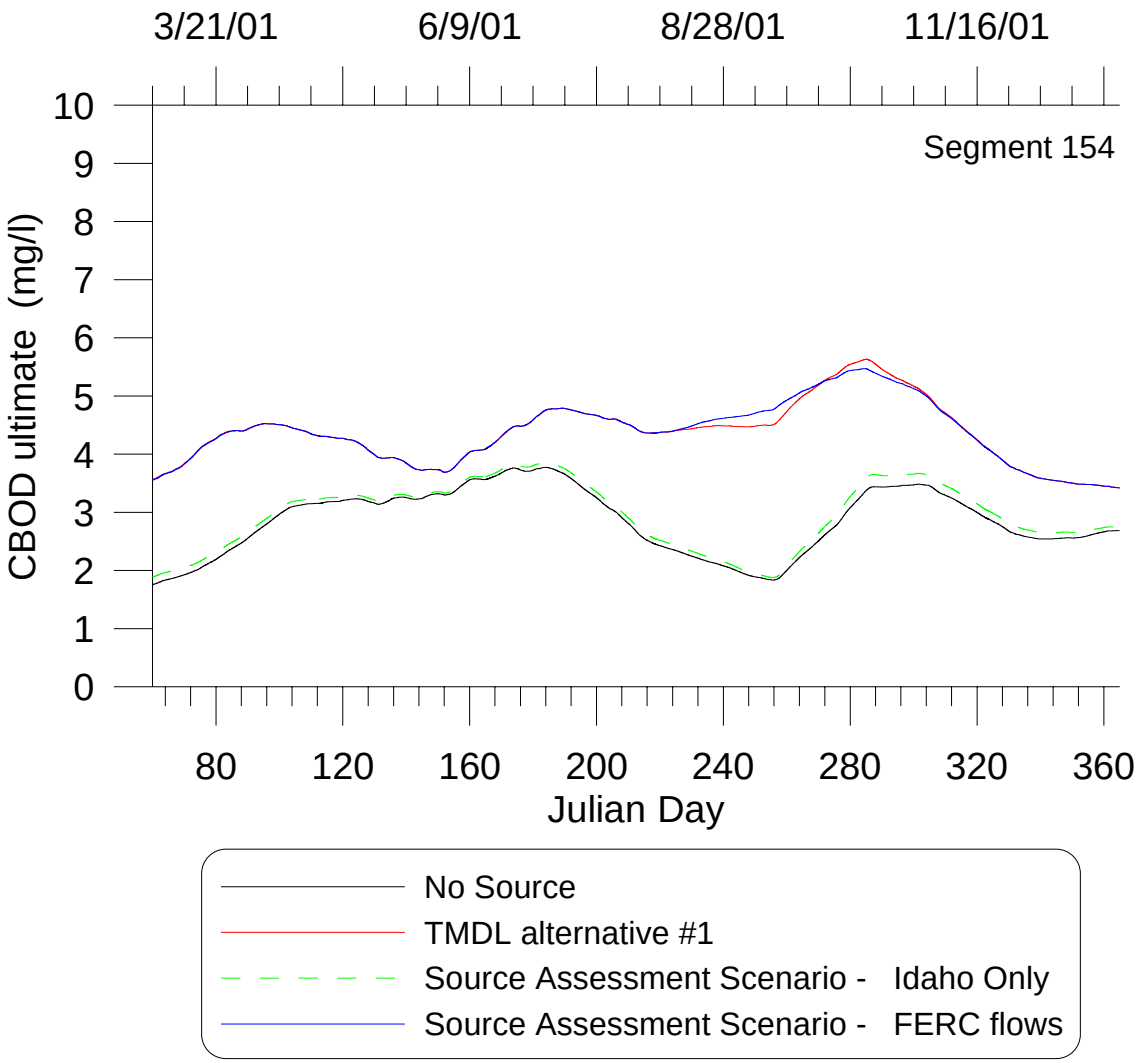

Figure 8. 30-day running average total CBOD ultimate concentrations at segment 154 in Long Lake of the revised no source scenario, the revised TMDL scenario #1, and the source assessment scenarios.

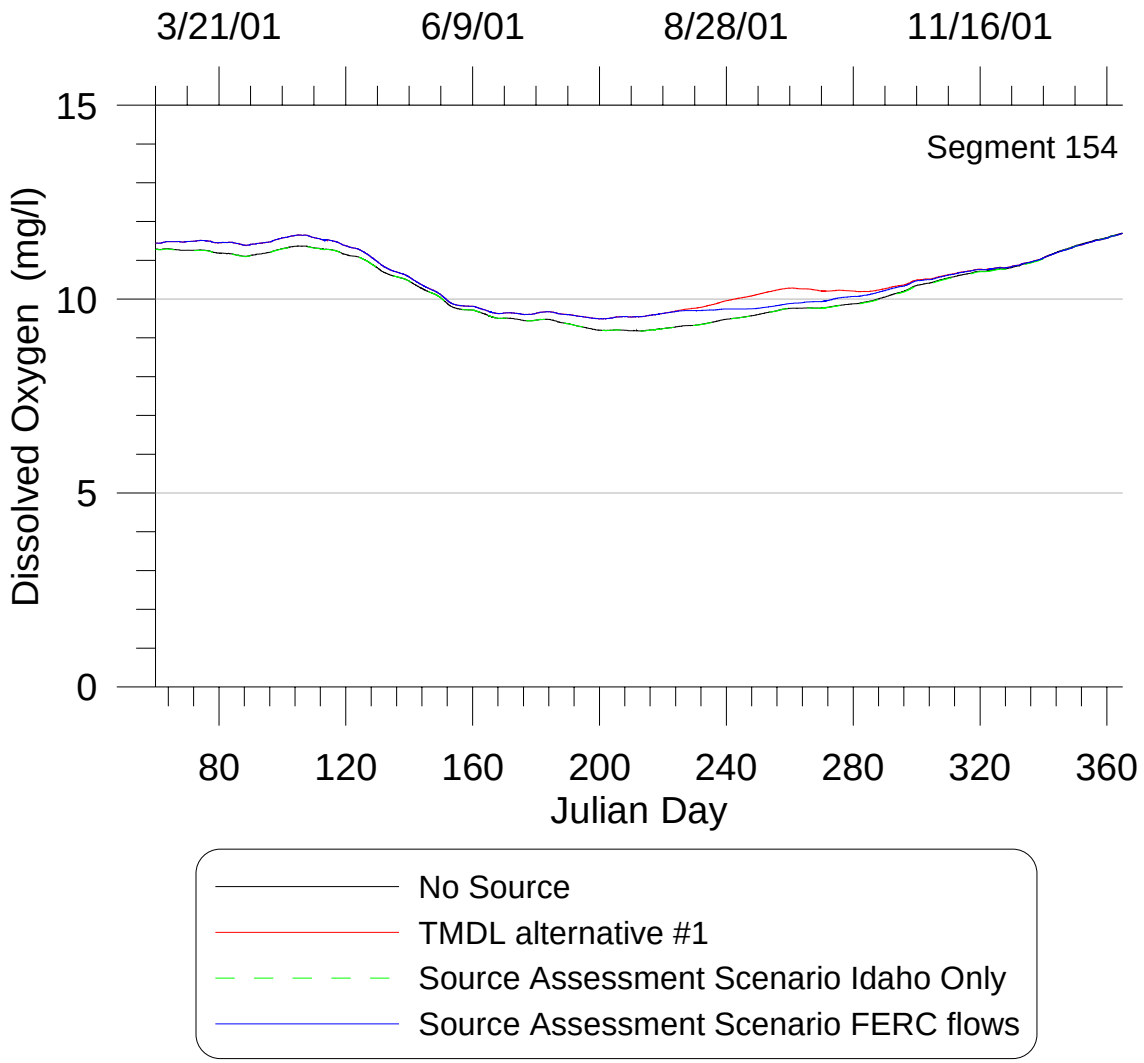

Figure 9. 30-day running average dissolved oxygen concentrations at segment 154 in Long Lake of the revised no source scenario, the revised TMDL scenario #1, and the source assessment scenarios.

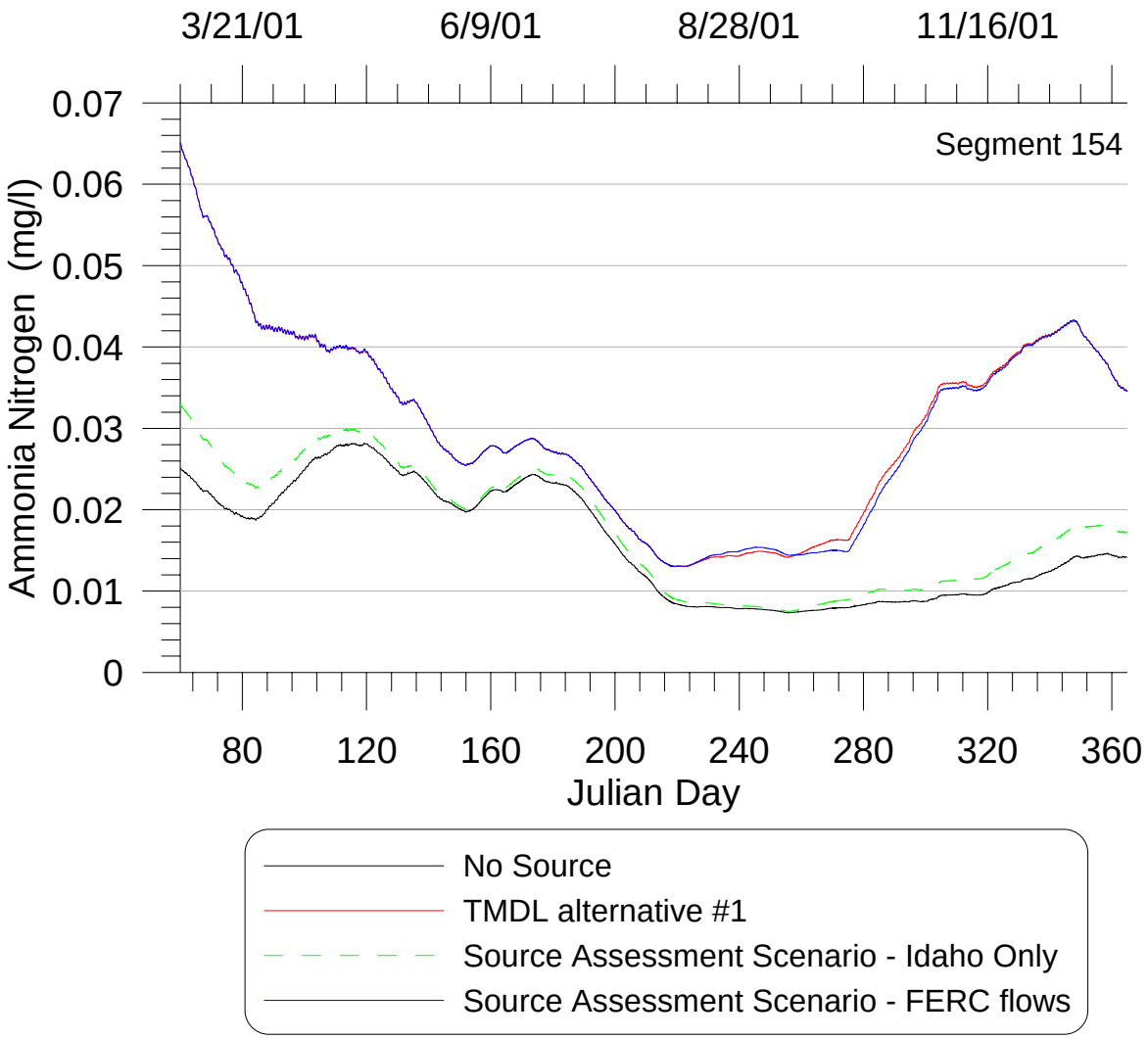

Figure 10. 30-day running average ammonia nitrogen concentrations at segment 154 in Long Lake of the revised no source scenario, the revised TMDL scenario #1, and the source assessment scenarios.

Summary

A water quality and hydrodynamic model, CE-QUAL-W2 Version 3.6 (Cole and Wells, 2008), was used to simulate modeling scenarios for the Spokane River from the outlet of Lake Coeur d'Alene, Idaho to the outlet of Long Lake in Washington.

The semi-monthly averages of the daily minimum, volume-averaged DO in the hypolimnion (greater than 8 m depth) of each Long Lake segment (157-188) for the scenarios were tabulated. The greatest difference in dissolved oxygen concentration between the no source and the revised TMDL#1 scenario was 1.4 mg/l, which occurred in the August 16-31 time period.

The 30-day running average of total phosphorus concentration was plotted for the state line and segments 154 and 157 in Long Lake. The phosphorus concentrations in segment 157 were affected by algae biomass being blown upstream, whereas the total phosphorus concentration for the riverine segment 154 reflected upstream conditions and outflows from Nine Mile dam.

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