

TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project

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Introduction

This technical memorandum summarizes the results for the 2017 public health monitoring for cyanobacteria species and an associated toxin, microcystin, from Upper Klamath Lake and within PacifiCorp's Klamath Hydroelectric Project (Project) from Keno reservoir to the Klamath River downstream Iron Gate Dam. Microcystin results from 2017 baseline monitoring are also included in the results summaries below. This monitoring is particularly focused on *Microcystis aeruginosa* (MSAE) which is known to produce microcystin. This monitoring also assesses the presence of other potentially-toxic cyanobacteria, including *Dolichospermum* sp., and others. Monitoring is being conducted pursuant to Interim Measure 15, Water Quality Monitoring Activities, contained in the Klamath Hydroelectric Settlement Agreement (KHSA) executed between the United States Department of Interior, the states of California and Oregon, PacifiCorp, and other parties.

Results from the baseline and public health sampling are used in coordination with the appropriate public health authority to determine if public health advisories are warranted^{1,2}. In addition to PacifiCorp's website (www.pacificorp.com/es/hydro/hl/kr.html#), these memos are also posted on the Klamath Basin Monitoring Program's (KBMP) website (www.kbmp.net) and inform the Blue Green Algae tracker on the KBMP website.

The data in Appendix 1 and Appendix 2 summarize results from all of the 2017 public health sampling events to date and microcystin results from the 2017 baseline sampling events.

¹ The California State Water Resources Control Board (SWRCB) provides guidelines for posting advisories in recreation water (California SWRCB 2016) for Project waters in California. SWRCB recommends posting advisories in recreation waters at three levels based on laboratory testing for microcystin. The posting levels are Caution, Warning, and Danger at microcystin concentrations of 0.8, 6, and 20 µg/L respectively. Toxin producing cells at concentrations of over 4,000 cells/ml or blooms, scums, or mats would result in posting at the Caution level.

² Postings of Project waters in Oregon are coordinated with the Oregon Health Authority (OHA; 2016). The health advisory guideline in Oregon waters is microcystin concentrations of 10 µg/L or more, over 100,000 cells/mL of all toxicogenic species combined, or over 40,000 cells/mL of *Microcystis* spp. or *Planktothrix* spp.

Methods

PacifiCorp and the Oregon Department of Environmental Quality (ODEQ) are conducting public health sampling at ten sites (Table 1). Samples are collected and sent for laboratory analysis of potentially toxigenic cyanobacteria, notably MSAE and microcystin, from:

- Three shoreline sites in Upper Klamath Lake, Oregon
- One shoreline site in Keno Reservoir, Oregon
- One shoreline site in J.C. Boyle Reservoir, Oregon
- Four shoreline sites in coves in Copco and Iron Gate reservoirs (i.e., two cove sites in each reservoir), California
- One Klamath River site below Iron Gate Dam near the hatchery bridge, California

Table 1. Sites of cyanobacteria and microcystin public health monitoring in Upper Klamath Lake, Keno Reservoir, J.C Boyle Reservoir, Copco Reservoir, Iron Gate Reservoir, and the Klamath River during 2017.			
Location	Approximate River Mile	Sampling Entity	Site ID
Upper Klamath Lake at Eagle Ridge County Park	N/A	ODEQ	UKEP
Upper Klamath Lake at Howard's Bay Park	N/A	ODEQ	UKHP
Upper Klamath Lake at Moore Park	N/A	ODEQ	UKMP
Keno Reservoir at Keno Park	234.0	ODEQ	KEKP
J.C. Boyle Reservoir at Topsy Campground	225.0	ODEQ	BRTC
Copco Reservoir at Mallard Cove	201.5	PacifiCorp	CRMC
Copco Reservoir at Copco Cove	200.0	PacifiCorp	CRCC
Iron Gate Reservoir at Camp Creek	192.8	PacifiCorp	IRCC
Iron Gate Reservoir at Jay Williams Campground	192.4	PacifiCorp	IRJW
Klamath River below Iron Gate dam near Hatchery Bridge	189.7	PacifiCorp	KRBI

Samples are planned to be taken once in May, November and December and twice per month in June, July, August, September, and October.

In addition to public health sampling, monthly and bi-monthly baseline sampling for microcystin is conducted by PacifiCorp and the U.S. Bureau of Reclamation (BOR) from May through October at 12 locations extending from Link Dam to the Klamath River downstream of Iron Gate Reservoir (Table 2).

Table 2. Sites of microcystin baseline monitoring from Link Dam to the Klamath River downstream of Iron Gate reservoir during 2017.				
Site Description	Approximate River Mile	Depth (m)	Sampling Entity	Site ID
Link Dam	254.4	0.5	BOR	KR254.4
Keno Reservoir at Miller Island	246.0	0.5	BOR	KR246.0
Klamath River below Keno Dam near a USGS Gage	231.8	0.5	BOR	KBK
Klamath River below JC Boyle Reservoir	224.6	0.5	PacifiCorp	KR22460
Klamath River at USGS Gage	219.5	0.5	PacifiCorp	KR21950
Klamath River above Shovel Creek	206.4	0.5	PacifiCorp	KR20642
Copco Reservoir at Buoy Line (surface)	198.7	0.5	PacifiCorp	KR19874
Copco Reservoir at Buoy Line (integrated)	198.7	0-8	PacifiCorp	KR19874
Klamath River below Copco 2 Reservoir	196.5	0.5	PacifiCorp	KR19645
Iron Gate Reservoir at Log Boom (surface)	190.2	0.5	PacifiCorp	KR19019
Iron Gate Reservoir at Log Boom (integrated)	190.2	0-8	PacifiCorp	KR19019
Klamath River below Hatchery Bridge	189.7	0.5	PacifiCorp	KR18973

Public health samples are taken as grab samples offshore according to the standard operating procedure (SOP) developed by the Klamath Blue Green Algae Working Group (www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring). Samples collected for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. The samples are labeled "Rush" for timely analysis and only potentially toxic cyanobacteria are identified and enumerated. Results for cyanobacteria species are reported as individual cells per milliliter.

Samples for determination of microcystin toxin are placed in a cooler on ice and shipped to the U.S. Environmental Protection Agency (EPA) Region 9 Laboratory in Richmond, California. The samples are analyzed using the competitive Enzyme-Linked ImmunoSorbent Assay (ELISA) method based on the EnviroLogix QuantiPlate Kit with a detection limit of 0.10 µg/L and a quantification limit of 0.15 µg/L. This test method does not distinguish between the specific microcystin congeners, but detects their presence to differing degrees. That is, ELISA test results yield one value as the sum of measurable microcystin variants.

Results

All public health samples (Table 3) and baseline microcystin samples (Tables 4 and 5) were collected as planned. Appendix 3 includes the raw phytoplankton results for the samples reported in Table 3. Two public health samples (KR17821 and KR17823) were analyzed for anatoxin-a via LC-MS/MS and both samples showed no detectable concentration of this toxin.

Table 3. Summary of available public health laboratory algal identification and enumeration and microcystin results from sampling July 2017.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth	MSAE ⁽¹⁾	AFA ⁽²⁾	DKFA ⁽³⁾	Other ^{(4),(5),(6),(7),(8),(9),(10),(11), or (12)}	Microcystin (µg/L)
7/10/2017	18:30	CRMC	201.5	PacifiCorp	KR17815	SG	288	1,899	0	0	0.1 ^{C1, J}
7/10/2017	15:15	CRCC	200.0	PacifiCorp	KR17816	SG	4,252	23,919	0	201 ⁽⁸⁾	3
7/10/2017	14:00	IRCC	192.8	PacifiCorp	KR17817	SG	582,554	10,988	0	1,998 ⁽¹²⁾	47
7/10/2017	13:45	IRJW	192.4	PacifiCorp	KR17818	SG	3,644	53,118	0	228 ⁽⁶⁾	2.4
7/10/2017	19:55	KRBI	189.7	PacifiCorp	KR17819	SG	497	23,750	0	0	0.32
7/20/2017	11:04	UKEP	N/A	ODEQ	UKEP17004	SG	0	118,923	0	0	0.42
7/20/2017	11:24	UKHP	N/A	ODEQ	UKHP17004	SG	104,103	387,589	0	0	12
7/20/2017	11:44	UKMP	N/A	ODEQ	UKMP17004	SG	17,925	7,967	0	0	0.57
7/20/2017	10:19	KEKP	234.0	ODEQ	KEKP17004	SG	11,633	15,257	0	0	6.1
7/20/2017	10:07	BRTC	225.0	ODEQ	BRTC17004	SG	1,956	0	0	0	0.39
7/23/2017	12:45	CRMC	201.5	PacifiCorp	KR17820	SG	15,534	381,446	0	0	4.5
7/23/2017	11:40	CRCC	200.0	PacifiCorp	KR17821	SG	0	19,936,041	0	0	550
7/23/2017	11:15	IRCC	192.8	PacifiCorp	KR17822	SG	3,667	54,270	0	0	1.6
7/23/2017	10:55	IRJW	192.4	PacifiCorp	KR17823	SG	5,556	377,467	0	0	5.1
7/23/2017	13:30	KRBI	189.7	PacifiCorp	KR17824	SG	404	33,764	0	0	0.22

¹MSAE = *Microcystis aeruginosa* (cells/mL)

²AFA = *Aphanizomenon flos-aquae* (cells/mL)

³DKFA = *Dolichospermum flos-aquae* (cells/mL)

Other = Cells/mL of either ⁴*Planktothrix (Oscillatoria)* sp., ⁵*Gloeotrichia echinulata*, ⁶*Dolichospermum* sp., ⁷*Lyngbya* sp., ⁸*Dolichospermum circinalis*, ⁹*Dolichospermum planctonica*, ¹⁰*Planktothrix (Oscillatoria) limosa*, ¹¹*Pseudanabaena* spp., or ¹²*Limnothrix* sp.

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

"0" value indicates non-detect by analytical laboratory

"**" value indicates no result available

^{C1} indicates the reported concentration for this analyte is below the quantitation limit.

^J indicates the reported result for this analyte should be considered an estimated value.

Table 4. Summary of July 2017 baseline laboratory microcystin results for samples collected in Oregon.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/11/2017	7:00	KR254.4	254.4	BOR	2017KHSA-40	0.5	0.52
7/11/2017	9:50	KR246.0	246.0	BOR	2017KHSA-43	0.5	0.68
7/11/2017	8:55	KBK	231.8	BOR	2017KHSA-44	0.5	0.36
7/25/2017	8:45	KR254.4	254.4	BOR	2017KHSA-46	0.5	0.50
7/11/2017	7:55	KR22460	224.6	PacifiCorp	KR17068	0.5	ND
7/11/2017	8:45	KR21950	219.5	PacifiCorp	KR17069	0.5	ND

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

Table 5. Summary of July 2017 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/10/2017	17:15	KR20642	206.4	PacifiCorp	KR17071	0.5	ND
7/10/2017	15:40	KR19874	198.7	PacifiCorp	KR17077	0.5	ND
7/10/2017	15:50	KR19874	198.7	PacifiCorp	KR17078	0-8	0.13
7/10/2017	14:45	KR19645	196.5	PacifiCorp	KR17076	0.5	0.1 ^{C1, J}
7/10/2017	11:45	KR19019	190.2	PacifiCorp	KR17072	0.5	1.6 ^{C1, J}
7/10/2017	12:15	KR19019	190.2	PacifiCorp	KR17073	0-8	0.15
7/10/2017	19:30	KR18973	189.7	PacifiCorp	KR17070	0.5	0.22
7/10/2017	19:30	KR18973	189.7	PacifiCorp	KR17083	0.5	0.32
7/23/2017	13:15	KR18973	189.7	PacifiCorp	KR17085	0.5	0.12 ^{C1, J}

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

^{C1} indicates the reported concentration for this analyte is below the quantitation limit.

^J indicates the reported result for this analyte should be considered an estimated value.

References

California SWRCB 2016. Draft Statewide Voluntary Guidance on CyanoHABs in Recreational Waters. Available online at:

http://www.mywaterquality.ca.gov/monitoring_council/cyanohab_network/docs/triggers.pdf

Oregon Health Authority. 2016. Oregon Harmful Algal Bloom Surveillance (HABS) Program – Public Health Advisory Guidelines, Harmful Algae Blooms in Freshwater Bodies. 27 pp.

https://public.health.oregon.gov/HealthyEnvironments/Recreation/HarmfulAlgaeBlooms/Pages/resources_for_samplers.aspx

Appendix 1

Cyanobacteria Species and Microcystin Data for 2017 Public Health Samples

Table A1. Summary of 2017 public health laboratory algal identification and enumeration microcystin results.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth	MSAE ⁽¹⁾	AFA ⁽²⁾	DKFA ⁽³⁾	Other ^{(4),(5), (6), (7), (8), (9), (10), (11), or (12)}	Microcystin (µg/L)
5/30/2017	12:19	UKEP	N/A	ODEQ	UKEP17001	SG	0	0	2,662,890	0	15
5/30/2017	12:36	UKHP	N/A	ODEQ	UKHP17001	SG	0	0	44,670	0	ND
5/30/2017	12:53	UKMP	N/A	ODEQ	UKMP17001	SG	0	0	72,611	0	ND
5/30/2017	11:32	KEKP	234.0	ODEQ	KEKP17001	SG	0	0	2,075	0	ND
5/30/2017	11:14	BRTC	225.0	ODEQ	BRTC17001	SG	0	0	635	0	ND
5/31/2017	17:50	CRMC	201.5	PacifiCorp	KR17800	SG	0	0	0	0	ND
5/31/2017	17:10	CRCC	200.0	PacifiCorp	KR17801	SG	0	25	0	0	ND
5/31/2017	16:35	IRCC	192.8	PacifiCorp	KR17802	SG	0	0	0	0	ND
5/31/2017	16:05	IRJW	192.4	PacifiCorp	KR17803	SG	0	0	0	0	ND
5/31/2017	18:30	KRBI	189.7	PacifiCorp	KR17804	SG	0	0	0	0	ND
6/15/2017	11:06	UKEP	N/A	ODEQ	UKEP17002	SG	0	9,364	0	0	ND
6/15/2017	11:22	UKHP	N/A	ODEQ	UKHP17002	SG	0	11,226	9,371	0	0.16
6/15/2017	11:36	UKMP	N/A	ODEQ	UKMP17002	SG	0	18,798	12,764	0	ND
6/15/2017	10:23	KEKP	234.0	ODEQ	KEKP17002	SG	4,840	141,988	946	0	1.3
6/15/2017	10:09	BRTC	225.0	ODEQ	BRTC17002	SG	0	26,394	0	0	ND
6/13/2017	16:45	CRMC	201.5	PacifiCorp	KR17805	SG	0	0	0	185 ⁽⁴⁾	ND
6/13/2017	15:10	CRCC	200.0	PacifiCorp	KR17806	SG	0	117	201	0	ND
6/13/2017	12:20	IRCC	192.8	PacifiCorp	KR17807	SG	0	150	24	0	ND
6/13/2017	12:00	IRJW	192.4	PacifiCorp	KR17808	SG	0	135	0	0	ND
6/13/2017	17:50	KRBI	189.7	PacifiCorp	KR17809	SG	0	0	0	0	ND
6/25/2017	13:35	CRMC	201.5	PacifiCorp	KR17810	SG	0	0	0	0	0.18
6/25/2017	12:20	CRCC	200.0	PacifiCorp	KR17811	SG	16,161	11,300	0	0	6.7
6/25/2017	11:40	IRCC	192.8	PacifiCorp	KR17812	SG	0	0	0	255 ⁽⁶⁾ , 44 ⁽¹²⁾	ND
6/25/2017	11:15	IRJW	192.4	PacifiCorp	KR17813	SG	0	0	0	490 ⁽⁶⁾	ND
6/25/2017	14:35	KRBI	189.7	PacifiCorp	KR17814	SG	0	0	0	0	ND
6/27/2017	11:22	UKEP	N/A	ODEQ	UKEP17003	SG	2,966	137,243	0	0	1.2
6/27/2017	11:38	UKHP	N/A	ODEQ	UKHP17003	SG	0	2,469,675	0	31,761 ⁽⁵⁾	1.2
6/27/2017	11:59	UKMP	N/A	ODEQ	UKMP17003	SG	0	460,204	0	0	0.50
6/27/2017	10:20	KEKP	234.0	ODEQ	KEKP17003	SG	0	1,458,901	0	0	2.5
6/27/2017	10:01	BRTC	225.0	ODEQ	BRTC17003	SG	0	9,364	0	0	ND
7/10/2017	18:30	CRMC	201.5	PacifiCorp	KR17815	SG	288	1,899	0	0	0.1 ^{C1, J}
7/10/2017	15:15	CRCC	200.0	PacifiCorp	KR17816	SG	4,252	23,919	0	201 ⁽⁸⁾	3
7/10/2017	14:00	IRCC	192.8	PacifiCorp	KR17817	SG	582,554	10,988	0	1,998 ⁽¹²⁾	47
7/10/2017	13:45	IRJW	192.4	PacifiCorp	KR17818	SG	3,644	53,118	0	228 ⁽⁶⁾	2.4
7/10/2017	19:55	KRBI	189.7	PacifiCorp	KR17819	SG	497	23,750	0	0	0.32
7/20/2017	11:04	UKEP	N/A	ODEQ	UKEP17004	SG	0	118,923	0	0	0.42
7/20/2017	11:24	UKHP	N/A	ODEQ	UKHP17004	SG	104,103	387,589	0	0	12
7/20/2017	11:44	UKMP	N/A	ODEQ	UKMP17004	SG	17,925	7,967	0	0	0.57
7/20/2017	10:19	KEKP	234.0	ODEQ	KEKP17004	SG	11,633	15,257	0	0	6.1
7/20/2017	10:07	BRTC	225.0	ODEQ	BRTC17004	SG	1,956	0	0	0	0.39
7/23/2017	12:45	CRMC	201.5	PacifiCorp	KR17820	SG	15,534	381,446	0	0	4.5

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Table A1 (cont.)

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth	MSAE ⁽¹⁾	AFA ⁽²⁾	DKFA ⁽³⁾	Other ^{(4),(5),(6),(7),(8),(9),(10), or (11)}	Microcystin (µg/L)
7/23/2017	11:40	CRCC	200.0	PacifiCorp	KR17821	SG	0	19,936,041	0	0	550
7/23/2017	11:15	IRCC	192.8	PacifiCorp	KR17822	SG	3,667	54,270	0	0	1.6
7/23/2017	10:55	IRJW	192.4	PacifiCorp	KR17823	SG	5,556	377,467	0	0	5.1
7/23/2017	13:30	KRBI	189.7	PacifiCorp	KR17824	SG	404	33,764	0	0	0.22

¹MSAE = *Microcystis aeruginosa* (cells/mL)

²AFA = *Aphanizomenon flos-aquae* (cells/mL)

³DKFA = *Dolichospermum flos-aquae* (cells/mL)

Other = Cells/mL of either ⁴*Planktothrix (Oscillatoria) sp.*, ⁵*Gloeotrichia echinulata*, ⁶*Dolichospermum sp.*, ⁷*Lyngbya sp.*,

⁸*Dolichospermum circinalis*, ⁹*Dolichospermum planctonica*, ¹⁰*Planktothrix (Oscillatoria) limosa*, ¹¹*Pseudanabaena spp.*, or

¹²*Limnothrix sp.*

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

"0" value indicates non-detect by analytical laboratory

"*" value indicates no result available

^{C1} indicates the reported concentration for this analyte is below the quantitation limit.

^J indicates the reported result for this analyte should be considered an estimated value.

Appendix 2

Microcystin Data for 2017 Baseline Samples

Table A2-1. Summary of 2017 baseline laboratory microcystin results for samples collected in Oregon.							
Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/09/2017	10:00	KR246.0	246.0	BOR	2017KHSA-22	0.5	ND
5/09/2017	07:45	KBK	231.8	BOR	2017KHSA-23	0.5	ND
5/15/2017	9:40	KR22460	224.6	PacifiCorp	KR17033	0.5	ND
5/15/2017	8:59	KR21950	219.5	PacifiCorp	KR17034	0.5	ND
6/06/2017	09:45	KR246.0	246.0	BOR	2017KHSA-32	0.5	ND
6/06/2017	07:50	KBK	231.8	BOR	2017KHSA-33	0.5	ND
6/12/2017	13:50	KR22460	224.6	PacifiCorp	KR17050	0.5	ND
6/12/2017	13:15	KR21950	219.5	PacifiCorp	KR17051	0.5	ND
7/11/2017	7:00	KR254.4	254.4	BOR	2017KHSA-40	0.5	0.52
7/11/2017	9:50	KR246.0	246.0	BOR	2017KHSA-43	0.5	0.68
7/11/2017	8:55	KBK	231.8	BOR	2017KHSA-44	0.5	0.36
7/25/2017	8:45	KR254.4	254.4	BOR	2017KHSA-46	0.5	0.50
7/11/2017	7:55	KR22460	224.6	PacifiCorp	KR17068	0.5	ND
7/11/2017	8:45	KR21950	219.5	PacifiCorp	KR17069	0.5	ND

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

*** value indicates no result available

Table A2-2. Summary of 2017 baseline laboratory microcystin results for samples collected in California.							
Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/16/2017	16:20	KR20642	206.4	PacifiCorp	KR17036	0.5	ND
5/16/2017	14:30	KR19874	198.7	PacifiCorp	KR17042	0.5	ND
5/16/2017	14:45	KR19874	198.7	PacifiCorp	KR17043	0-8	ND
5/16/2017	13:40	KR19645	196.5	PacifiCorp	KR17041	0.5	ND
5/16/2017	10:55	KR19019	190.2	PacifiCorp	KR17037	0.5	ND
5/16/2017	10:45	KR19019	190.2	PacifiCorp	KR17038	0-8	ND
5/16/2017	17:15	KR18973	189.7	PacifiCorp	KR17035	0.5	ND
5/16/2017	17:25	KR18973	189.7	PacifiCorp	KR17048	0.5	ND
6/13//2017	16:10	KR20642	206.4	PacifiCorp	KR17053	0.5	ND
6/13//2017	13:55	KR19874	198.7	PacifiCorp	KR17059	0.5	ND
6/13//2017	14:10	KR19874	198.7	PacifiCorp	KR17060	0-8	ND
6/13//2017	12:50	KR19645	196.5	PacifiCorp	KR17058	0.5	ND
6/13//2017	9:30	KR19019	190.2	PacifiCorp	KR17054	0.5	ND
6/13//2017	9:45	KR19019	190.2	PacifiCorp	KR17055	0-8	ND
7/10/2017	17:15	KR20642	206.4	PacifiCorp	KR17071	0.5	ND
7/10/2017	15:40	KR19874	198.7	PacifiCorp	KR17077	0.5	ND
7/10/2017	15:50	KR19874	198.7	PacifiCorp	KR17078	0-8	0.13
7/10/2017	14:45	KR19645	196.5	PacifiCorp	KR17076	0.5	0.1 ^{C1,J}
7/10/2017	11:45	KR19019	190.2	PacifiCorp	KR17072	0.5	1.6 ^{C1,J}
7/10/2017	12:15	KR19019	190.2	PacifiCorp	KR17073	0-8	0.15
7/10/2017	19:30	KR18973	189.7	PacifiCorp	KR17070	0.5	0.22
7/10/2017	19:30	KR18973	189.7	PacifiCorp	KR17083	0.5	0.32
7/23/2017	13:15	KR18973	189.7	PacifiCorp	KR17085	0.5	0.12 ^{C1,J}

"ND" value indicates a result less than the laboratory analytical detection limit

^{C1} indicates the reported concentration for this analyte is below the quantitation limit.

^J indicates the reported result for this analyte should be considered an estimated value.

Appendix 3 Laboratory Phytoplankton Results

Analysis	Phytoplankton Sample	
	Sample:	Klamath Basin
	Sample ID:	KR17815
	Sample Depth:	
	Sample Date:	10-Jul-17 1830
	Total Density (#/mL):	107
	Total Biovolume (um³/mL):	121,940
	Trophic State Index:	34.7

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	90	84.2	119,634	98.1
2 Microcystis aeruginosa	17	15.8	2,306	1.9

Aphanizomenon flos-aquae cells/mL = 1,899

Microcystis aeruginosa cells/mL = 288

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
 Sample ID: KR17816
 Sample Depth:
 Sample Date: 10-Jul-17 1515

Total Density (#/mL): 1,421
 Total Biovolume (um³/mL): 1,555,217
 Trophic State Index: 53.0

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	1,329	93.5	1,506,904	96.9
2 Microcystis aeruginosa	89	6.2	34,018	2.2
3 Anabaena circinalis	4	0.3	14,295	0.9

Aphanizomenon flos-aquae cells/mL = 23,919

Microcystis aeruginosa cells/mL = 4,252

Dolichospermum circinalis cells/mL = 201

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR17817
Sample Depth:
Sample Date: 10-Jul-17 1400

Total Density (#/mL): 18,954
Total Biovolume (um³/mL): 5,442,566
Trophic State Index: 62.1

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Microcystis aeruginosa	18,205	96.0	4,660,433	85.6
2 Aphanizomenon flos-aquae	549	2.9	692,233	12.7
3 Limnothrix sp.	200	1.1	89,900	1.7

Microcystis aeruginosa cells/mL = 582,554
 Limnothrix sp. cells/mL = 1,998
 Aphanizomenon flos-aquae cells/mL = 10,988

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR17818
Sample Depth:
Sample Date: 10-Jul-17 1345

Total Density (#/mL): 2,802
Total Biovolume (um³/mL): 3,391,064
Trophic State Index: 58.7

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	2,414	86.2	3,346,420	98.7
2 Microcystis aeruginosa	364	13.0	29,156	0.9
3 Dolichospermum sp.	23	0.8	15,489	0.5

Microcystis aeruginosa cells/mL = 3,644
 Aphanizomenon flos-aquae cells/mL = 53,118
 Dolichospermum sp. cells/mL = 228

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Klamath
Sample: Basin
Sample ID: KR17819
Sample Depth:
Sample Date: 10-Jul-17 1955

Total Density (#/mL): 1,300
Total Biovolume (um³/mL): 1,500,246
Trophic State Index: 52.8

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	1,250	96.2	1,496,269	99.7
2 Microcystis aeruginosa	50	3.8	3,977	0.3

Aphanizomenon flos-aquae cells/mL = 23,750

Microcystis aeruginosa cells/mL = 497

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Klamath
Sample: Basin
Sample ID: KR17820
Sample Depth:
Sample Date: 23-Jul-17 1245

Total Density (#/mL): 18,892
Total Biovolume (um³/mL): 24,155,360
Trophic State Index: 72.8

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	17,338	91.8	24,031,084	99.5
2 Microcystis aeruginosa	1,553	8.2	124,276	0.5

Aphanizomenon flos-aquae cells/mL = 381,446

Microcystis aeruginosa cells/mL = 15,534

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR17821
Sample Depth:
Sample Date: 23-Jul-17 1140

Total Density (#/mL): 1,049,265
Total Biovolume (um³/mL): 1,255,970,571
Trophic State Index: 101.3

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	1,049,265	100.0	1,255,970,571	100.0

Aphanizomenon flos-aquae cells/mL = 19,936,041

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Klamath
Sample: Basin
Sample ID: KR17822
Sample Depth:
Sample Date: 23-Jul-17 1115

Total Density (#/mL): 3,190
Total Biovolume (um³/mL): 3,448,366
Trophic State Index: 58.8

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	2,856	89.5	3,419,031	99.1
2 Microcystis aeruginosa	333	10.5	29,335	0.9

Aphanizomenon flos-aquae cells/mL = 54,270

Microcystis aeruginosa cells/mL = 3,667

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Klamath
Sample: Basin
Sample ID: KR17823
Sample Depth:
Sample Date: 23-Jul-17 1055

Total Density (#/mL): 18,530
Total Biovolume (um³/mL): 23,824,892
Trophic State Index: 72.7

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	17,975	97.0	23,780,446	99.8
2 Microcystis aeruginosa	556	3.0	44,446	0.2

Aphanizomenon flos-aquae cells/mL = 377,467

Microcystis aeruginosa cells/mL = 5,556

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Klamath
Sample: Basin
Sample ID: KR17824
Sample Depth:
Sample Date: 23-Jul-17 1330

Total Density (#/mL): 1,817
Total Biovolume (um³/mL): 2,130,389
Trophic State Index: 55.3

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	1,777	97.8	2,127,158	99.8
2 Microcystis aeruginosa	40	2.2	3,231	0.2

Aphanizomenon flos-aquae cells/mL = 33,764

Microcystis aeruginosa cells/mL = 404

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: BRTC17004
Sample Depth:
Sample Date: 20-Jul-17 1001

Total Density (#/mL): 196
Total Biovolume (um³/mL): 15,644
Trophic State Index: 20.3

Species		Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-	-
1	Microcystis aeruginosa	196	100.0	15,644	100.0

Microcystis aeruginosa cells/mL = 1,956

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
 Sample Site: KEKP17004
 Sample Depth:
 Sample Date: 20-Jul-17 1019

Total Density (#/mL): 1,857
 Total Biovolume (um³/mL): 1,054,257
 Trophic State Index: 50.2

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Microcystis aeruginosa	1,163	62.7	93,063	8.8
2 Aphanizomenon flos-aquae	694	37.3	961,194	91.2

Microcystis aeruginosa cells/mL = 11,633

Aphanizomenon flos-aquae cells/mL = 15,257

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: UKMP17004
Sample Depth:
Sample Date: 20-Jul-17 1144

Total Density (#/mL): 905
Total Biovolume (um³/mL): 645,292
Trophic State Index: 46.7

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Microcystis aeruginosa	543	60.0	143,398	22.2
2 Aphanizomenon flos-aquae	362	40.0	501,894	77.8

Aphanizomenon flos-aquae cells/mL = 7,967

Microcystis aeruginosa cells/mL = 17,925

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: UKHP17004
Sample Depth:
Sample Date: 20-Jul-17 1124

Total Density (#/mL): 30,208
Total Biovolume (um³/mL): 25,250,914
Trophic State Index: 73.1

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	21,533	71.3	24,418,089	96.7
2 Microcystis aeruginosa	8,675	28.7	832,824	3.3

Aphanizomenon flos-aquae cells/mL = 387,589

Microcystis aeruginosa cells/mL = 104,103

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample: Klamath Basin
 Sample Site: UKEP17004
 Sample Depth:
 Sample Date: 20-Jul-17 1104

Total Density (#/mL): 5,406
 Total Biovolume (um³/mL): 7,492,166
 Trophic State Index: 64.4

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Aphanizomenon flos-aquae	5,406	100.0	7,492,166	100.0

Aphanizomenon flos-aquae cells/mL = 118,923

Note: Toxic Algae Only