

TECHNICAL MEMORANDUM

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

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Date: September 18, 2019



Introduction

This technical memorandum summarizes the results for the 2019 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 2019 baseline monitoring program 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-toxigenic 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 2019 public health sampling events to date and microcystin results from the 2019 baseline sampling events, respectively.

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). The health advisory guideline for recreational use in Oregon waters is microcystin concentrations of 8 µg/L (OHA 2019).

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 2019.			
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 John 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 2019.				
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

Public health samples (Table 3) and baseline microcystin samples (Tables 4 and 5) were collected as planned, except the second set of August samples planned for collection by ODEQ were not collected. Appendix 3 includes the raw phytoplankton results for the samples reported in Table 3.

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Table 3. Summary of available public health laboratory algal identification and enumeration and microcystin results from sampling August and September 2019.

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)
8/5/2019	15:00	CRMC	201.5	PacifiCorp	KR19825	SG	73,496	7,517	0	0	17
8/5/2019	11:40	CRCC	200.0	PacifiCorp	KR19826	SG	2,439,836	115,485,574	0	0	4600
8/5/2019	10:40	IRCC	192.8	PacifiCorp	KR19827	SG	134,810	161,772	0	0	38
8/5/2019	10:30	IRJW	192.4	PacifiCorp	KR19828	SG	106,753	343,048	0	0	38
8/5/2019	15:45	KRBI	189.7	PacifiCorp	KR19829	SG	3,551	4,439	0	0	4.3
8/13/2019	11:56	UKEP	N/A	ODEQ	UKEP19007	SG	6,342	50,315	0	0	0.51
8/13/2019	12:13	UKHP	N/A	ODEQ	UKHP19007	SG	0	2,756,526	0	0	7.5
8/13/2019	12:30	UKMP	N/A	ODEQ	UKMP19007	SG	0	440,512	0	0	0.25
8/13/2019	11:09	KEKP	234	ODEQ	KEKP19007	SG	0	35,234	0	415 ⁸ , 415 ¹²	0.10 ^{C1, J}
8/13/2019	10:53	BRTC	225	ODEQ	BRTC19007	SG	0	6,759	0	791 ¹⁰ , 226 ¹²	ND
8/19/2019	10:30	CRMC	201.5	PacifiCorp	KR19830	SG	233,440	0	0	4,446 ⁴	57
8/19/2019	9:15	CRCC	200.0	PacifiCorp	KR19831	SG	707,168	7,202,290	0	0	12000
8/19/2019	8:45	IRCC	192.8	PacifiCorp	KR19832	SG	59,710	45,291	0	953 ¹²	18
8/19/2019	8:30	IRJW	192.4	PacifiCorp	KR19833	SG	179,622	785,984	0	0	39
8/19/2019	11:05	KRBI	189.7	PacifiCorp	KR19834	SG	13,022	318	0	0	5.4
9/11/2019	10:54	UKEP	N/A	ODEQ	UKEP19008	SG	*	*	*	*	4.0
9/11/2019	11:08	UKHP	N/A	ODEQ	UKHP19008	SG	*	*	*	*	32
9/11/2019	11:24	UKMP	N/A	ODEQ	UKMP19008	SG	*	*	*	*	10
9/11/2019	10:15	KEKP	234	ODEQ	KEKP19008	SG	*	*	*	*	ND
9/11/2019	10:00	BRTC	225	ODEQ	BRTC19008	SG	*	*	*	*	ND
9/9/2019	15:50	CRMC	201.5	PacifiCorp	KR19835	SG	6,647	839,719	0	0	1.4
9/9/2019	12:50	CRCC	200.0	PacifiCorp	KR19836	SG	965	23,110	0	0	2.6
9/9/2019	12:00	IRCC	192.8	PacifiCorp	KR19837	SG	297,399	46,734	0	3,268 ¹²	55
9/9/2019	11:35	IRJW	192.4	PacifiCorp	KR19838	SG	24,309	15,481	0	480 ¹²	9.8
9/9/2019	16:25	KRBI	189.7	PacifiCorp	KR19839	SG	0	0	0	0	0.54

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)

“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.

“0” value indicates non-detect by analytical laboratory

“*” value indicates no result available

“NS” indicates Not Sampled

Table 4. Summary of August and September 2019 baseline laboratory microcystin results for samples collected in Oregon.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
8/7/2019	9:00	KR254.4	254.4	BOR	2019KHSA-51	0.5	0.24
8/7/2019	11:55	KR246.0	246.0	BOR	2019KHSA-54	0.5	0.20
8/7/2019	10:40	KBK	231.8	BOR	2019KHSA-55	0.5	0.13 ^{C1, J}
8/6/2019	8:15	KR22460	224.6	PacifiCorp	KR19100	0.5	0.10 ^{C1, J}
8/6/2019	8:50	KR21950	219.5	PacifiCorp	KR19101	0.5	0.12 ^{C1, J}
8/20/2019	9:00	KR254.4	254.4	BOR	2019KHSA-57	0.5	0.21
9/10/2019	8:20	KR22460	224.6	PacifiCorp	KR19118	0.5	ND
9/10/2019	9:00	KR21950	219.5	PacifiCorp	KR19119	0.5	ND

"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.

Table 5. Summary of August and September 2019 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
8/5/2019	14:30	KR20642	206.4	PacifiCorp	KR19096	0.5	0.10 ^{C1, J}
8/5/2019	12:10	KR19874	198.7	PacifiCorp	KR19092	0.5	86
8/5/2019	12:40	KR19874	198.7	PacifiCorp	KR19093	0-8	13
8/5/2019	11:00	KR19645	196.5	PacifiCorp	KR19091	0.5	120
8/5/2019	8:10	KR19019	190.2	PacifiCorp	KR19087	0.5	11
8/5/2019	8:30	KR19019	190.2	PacifiCorp	KR19088	0-8	3.0
8/5/2019	15:45	KR18973	189.7	PacifiCorp	KR19086	0.5	2.6
8/5/2019	15:45	KR18973	189.7	PacifiCorp	KR19099	0.5	2.3
8/19/2019	11:00	KR18973	189.7	PacifiCorp	KR19102	0.5	3.4
9/9/2019	15:15	KR20642	206.4	PacifiCorp	KR19114	0.5	ND
9/9/2019	13:20	KR19874	198.7	PacifiCorp	KR19110	0.5	0.23
9/9/2019	13:45	KR19874	198.7	PacifiCorp	KR19111	0-8	0.25
9/9/2019	12:20	KR19645	196.5	PacifiCorp	KR19109	0.5	56
9/9/2019	9:40	KR19019	190.2	PacifiCorp	KR19105	0.5	15
9/9/2019	10:00	KR19019	190.2	PacifiCorp	KR19106	0-8	3.3
9/9/2019	16:30	KR18973	189.7	PacifiCorp	KR19104	0.5	1.2
9/9/2019	16:45	KR18973	189.7	PacifiCorp	KR19116	0.5	ND
9/9/2019	16:40	KR18973	189.7	PacifiCorp	KR19117	0.5	1.0

"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. 2019. Oregon Harmful Algal Bloom Surveillance (HABS) Program – Recreational Use Public Health Advisory Guidelines, Cyanobacterial Blooms in Freshwater Bodies. 27 pp. Available online at:

<https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/HARMFULALGAEBL/OOMS/Documents/Advisory-Guidelines-Harmful-Cyanobacterial-Blooms-Recreational-Waters.pdf>

Appendix 1 Cyanobacteria Species and Microcystin Data for 2019 Public Health Samples

Table A1. Summary of 2019 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)
5/21/2019	10:53	UKEP	N/A	ODEQ	UKEP19001	SG	0	0	347	0	0.11 ^{C1, J}
5/21/2019	11:09	UKHP	N/A	ODEQ	UKHP19001	SG	0	0	399	0	0.13 ^{C1, J}
5/21/2019	11:24	UKMP	N/A	ODEQ	UKMP19001	SG	0	11,318	139,555	0	4.1
5/21/2019	10:19	KEKP	234	ODEQ	KEKP19001	SG	0	2,042	6,967	449 ¹⁰	0.10 ^{C1, J}
5/21/2019	10:04	BRTC	225	ODEQ	BRTC19001	SG	0	0	0	0	ND
5/18/2019	13:05	CRMC	201.5	PacifiCorp	KR19800	SG	0	0	0	0	ND
5/18/2019	12:30	CRCC	200.0	PacifiCorp	KR19801	SG	0	0	0	0	ND
5/18/2019	12:00	IRCC	192.8	PacifiCorp	KR19802	SG	0	0	0	0	ND
5/18/2019	11:50	IRJW	192.4	PacifiCorp	KR19803	SG	0	0	0	0	ND
5/18/2019	13:50	KRBI	189.7	PacifiCorp	KR19804	SG	0	0	0	0	ND
5/30/2019	11:20	UKEP	N/A	ODEQ	UKEP19002	SG	0	9,698	29,671	0	0.22
5/30/2019	11:38	UKHP	N/A	ODEQ	UKHP19002	SG	0	0	4,747	0	0.14 ^{C1, J}
5/30/2019	11:53	UKMP	N/A	ODEQ	UKMP19002	SG	0	12,300	8,279	0	0.10 ^{C1, J}
5/30/2019	10:37	KEKP	234	ODEQ	KEKP19002	SG	0	1,793	12,361	0	0.17
5/30/2019	10:23	BRTC	225	ODEQ	BRTC19002	SG	0	480	3,060	0	0.10 ^{C1, J}
6/8/2019	16:15	CRMC	201.5	PacifiCorp	KR19805	SG	0	508	0	36 ¹⁰	ND
6/8/2019	12:30	CRCC	200.0	PacifiCorp	KR19806	SG	0	2,113	58	0	0.11 ^{C1, J}
6/8/2019	11:15	IRCC	192.8	PacifiCorp	KR19807	SG	0	0	58	0	ND
6/8/2019	11:00	IRJW	192.4	PacifiCorp	KR19808	SG	0	0	0	0	ND
6/8/2019	17:05	KRBI	189.7	PacifiCorp	KR19809	SG	0	0	0	0	ND
6/12/2019	12:09	UKEP	N/A	ODEQ	UKEP19003	SG	0	36,864	3,922	0	0.16
6/12/2019	12:31	UKHP	N/A	ODEQ	UKHP19003	SG	0	0	479,787	159,929 ⁵	1.4
6/12/2019	12:49	UKMP	N/A	ODEQ	UKMP18003	SG	0	641,028	83,443	0	0.10 ^{C1, J}
6/12/2019	11:26	KEKP	234	ODEQ	KEKP19003	SG	0	16,751	321,627	0	0.91
6/12/2019	11:09	BRTC	225	ODEQ	BRTC19003	SG	0	8,150	564	0	ND
6/24/2019	09:50	CRMC	201.5	PacifiCorp	KR19810	SG	0	809	0	0	ND
6/24/2019	08:40	CRCC	200.0	PacifiCorp	KR19811	SG	0	10,036	0	0	0.21
6/24/2019	08:15	IRCC	192.8	PacifiCorp	KR19812	SG	0	339	113	0	0.18
6/24/2019	07:50	IRJW	192.4	PacifiCorp	KR19813	SG	0	0	0	0	0.13 ^{C1, J}
6/24/2019	10:20	KRBI	189.7	PacifiCorp	KR19814	SG	0	738	0	0	ND
6/25/2019	12:15	UKEP	N/A	ODEQ	UKEP19004	SG	0	231,138	0	0	ND
6/25/2019	12:35	UKHP	N/A	ODEQ	UKHP19004	SG	0	269,202	0	0	0.18
6/25/2019	12:53	UKMP	N/A	ODEQ	UKMP18004	SG	0	106,802	1,622	0	0.18
6/25/2019	11:26	KEKP	234	ODEQ	KEKP19004	SG	0	133,339	0	0	0.15
6/25/2019	11:03	BRTC	225	ODEQ	BRTC19004	SG	0	18,227	0	636 ¹⁰	ND
7/10/2019	13:21	UKEP	N/A	ODEQ	UKEP19005	SG	0	7,937,600	0	0	38
7/10/2019	13:37	UKHP	N/A	ODEQ	UKHP19005	SG	0	149,617	0	0	0.16
7/10/2019	13:53	UKMP	N/A	ODEQ	UKMP19005	SG	0	197,735	0	0	0.44
7/10/2019	12:39	KEKP	234	ODEQ	KEKP19005	SG	8,054	2,053,178	0	0	3.2
7/10/2019	12:25	BRTC	225	ODEQ	BRTC19005	SG	632	16,739	0	0	0.18
7/8/2019	16:10	CRMC	201.5	PacifiCorp	KR19815	SG	12,836	139	0	0	2.0
7/8/2019	13:00	CRCC	200.0	PacifiCorp	KR19816	SG	22,908	40,590	0	0	4.8
7/8/2019	12:00	IRCC	192.8	PacifiCorp	KR19817	SG	52,858	17,378	0	0	10

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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)
7/8/2019	17:40	KRBI	189.7	PacifiCorp	KR19819	SG	0	0	0	0	ND
7/30/2019	12:05	UKEP	N/A	ODEQ	UKEP19006	SG	0	4,160,224	0	0	0.13 ^{C1, J}
7/30/2019	12:21	UKHP	N/A	ODEQ	UKHP19006	SG	92,556	3,546,576	0	0	36
7/30/2019	12:35	UKMP	N/A	ODEQ	UKMP19006	SG	0	876,323	0	0	0.14 ^{C1, J}
7/30/2019	11:19	KEKP	234	ODEQ	KEKP19006	SG	8,613	408,797	0	0	2.1
7/30/2019	11:01	BRTC	225	ODEQ	BRTC19006	SG	0	6,901	0	0	ND
7/22/2019	11:00	CRMC	201.5	PacifiCorp	KR19820	SG	589,555	27,974	0	0	100
7/22/2019	9:30	CRCC	200.0	PacifiCorp	KR19821	SG	2,150,923	126,255,715	0	0	4200
7/22/2019	9:00	IRCC	192.8	PacifiCorp	KR19822	SG	14,798	135,089	0	0	4.5
7/22/2019	8:50	IRJW	192.4	PacifiCorp	KR19823	SG	1,634	75,493	0	0	2.7
7/22/2019	11:30	KRBI	189.7	PacifiCorp	KR19824	SG	0	0	0	0	0.54
8/5/2019	15:00	CRMC	201.5	PacifiCorp	KR19825	SG	73,496	7,517	0	0	17
8/5/2019	11:40	CRCC	200.0	PacifiCorp	KR19826	SG	2,439,836	115,485,574	0	0	4600
8/5/2019	10:40	IRCC	192.8	PacifiCorp	KR19827	SG	134,810	161,772	0	0	38
8/5/2019	10:30	IRJW	192.4	PacifiCorp	KR19828	SG	106,753	343,048	0	0	38
8/5/2019	15:45	KRBI	189.7	PacifiCorp	KR19829	SG	3,551	4,439	0	0	4.3
8/13/2019	11:56	UKEP	N/A	ODEQ	UKEP19007	SG	6,342	50,315	0	0	0.51
8/13/2019	12:13	UKHP	N/A	ODEQ	UKHP19007	SG	0	2,756,526	0	0	7.5
8/13/2019	12:30	UKMP	N/A	ODEQ	UKMP19007	SG	0	440,512	0	0	0.25
8/13/2019	11:09	KEKP	234	ODEQ	KEKP19007	SG	0	35,234	0	415 ⁸ , 415 ¹²	0.10 ^{C1, J}
8/13/2019	10:53	BRTC	225	ODEQ	BRTC19007	SG	0	6,759	0	791 ¹⁰ , 226 ¹²	ND
8/19/2019	10:30	CRMC	201.5	PacifiCorp	KR19830	SG	233,440	0	0	4,446 ⁴	57
8/19/2019	9:15	CRCC	200.0	PacifiCorp	KR19831	SG	707,168	7,202,290	0	0	12000
8/19/2019	8:45	IRCC	192.8	PacifiCorp	KR19832	SG	59,710	45,291	0	953 ¹²	18
8/19/2019	8:30	IRJW	192.4	PacifiCorp	KR19833	SG	179,622	785,984	0	0	39
8/19/2019	11:05	KRBI	189.7	PacifiCorp	KR19834	SG	13,022	318	0	0	5.4
9/11/2019	10:54	UKEP	N/A	ODEQ	UKEP19008	SG	*	*	*	*	4.0
9/11/2019	11:08	UKHP	N/A	ODEQ	UKHP19008	SG	*	*	*	*	32
9/11/2019	11:24	UKMP	N/A	ODEQ	UKMP19008	SG	*	*	*	*	10
9/11/2019	10:15	KEKP	234	ODEQ	KEKP19008	SG	*	*	*	*	ND
9/11/2019	10:00	BRTC	225	ODEQ	BRTC19008	SG	*	*	*	*	ND
9/9/2019	15:50	CRMC	201.5	PacifiCorp	KR19835	SG	6,647	839,719	0	0	1.4
9/9/2019	12:50	CRCC	200.0	PacifiCorp	KR19836	SG	965	23,110	0	0	2.6
9/9/2019	12:00	IRCC	192.8	PacifiCorp	KR19837	SG	297,399	46,734	0	3,268 ¹²	55
9/9/2019	11:35	IRJW	192.4	PacifiCorp	KR19838	SG	24,309	15,481	0	480 ¹²	9.8
9/9/2019	16:25	KRBI	189.7	PacifiCorp	KR19839	SG	0	0	0	0	0.54

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)

“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.

“0” value indicates non-detect by analytical laboratory

“*” value indicates no result available

Appendix 2

Microcystin Data for 2019 Baseline Samples

Table A2-1. Summary of 2019 baseline laboratory microcystin results for samples collected in Oregon.							
Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/7/2019	08:45	KR246.0	246.0	BOR	2019KHSA-22	0.5	ND
5/7/2019	11:00	KBK	231.8	BOR	2019KHSA-23	0.5	ND
5/5/2019	08:15	KR22460	224.6	PacifiCorp	KR19047	0.5	0.10 ^{C1, J}
5/5/2019	09:20	KR21950	219.5	PacifiCorp	KR19048	0.5	ND
6/4/2019	09:00	KR246.0	246.0	BOR	2019KHSA-32	0.5	0.12 ^{C1, J}
6/4/2019	11:20	KBK	231.8	BOR	2019KHSA-33	0.5	ND
6/9/2019	8:35	KR22460	224.6	PacifiCorp	KR19064	0.5	0.14 ^{C1, J}
6/9/2019	9:20	KR21950	219.5	PacifiCorp	KR19065	0.5	0.10 ^{C1, J}
7/9/2019	8:30	KR254.4	254.4	BOR	2019KHSA-40	0.5	0.13 ^{C1, J}
7/9/2019	11:40	KR246.0	246.0	BOR	2019KHSA-43	0.5	0.12 ^{C1, J}
7/9/2019	10:45	KBK	231.8	BOR	2019KHSA-44	0.5	ND
7/9/2019	9:15	KR22460	224.6	PacifiCorp	KR19082	0.5	ND
7/9/2019	10:15	KR21950	219.5	PacifiCorp	KR19083	0.5	ND
7/23/2019	9:45	KR254.4	254.4	BOR	2019KHSA-46	0.5	0.14 ^{C1, J}
8/7/2019	9:00	KR254.4	254.4	BOR	2019KHSA-51	0.5	0.24
8/7/2019	11:55	KR246.0	246.0	BOR	2019KHSA-54	0.5	0.20
8/7/2019	10:40	KBK	231.8	BOR	2019KHSA-55	0.5	0.13 ^{C1, J}
8/6/2019	8:15	KR22460	224.6	PacifiCorp	KR19100	0.5	0.10 ^{C1, J}
8/6/2019	8:50	KR21950	219.5	PacifiCorp	KR19101	0.5	0.12 ^{C1, J}
8/20/2019	9:00	KR254.4	254.4	BOR	2019KHSA-57	0.5	0.21
9/10/2019	8:20	KR22460	224.6	PacifiCorp	KR19118	0.5	ND
9/10/2019	9:00	KR21950	219.5	PacifiCorp	KR19119	0.5	ND

"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.

Table A2-2. Summary of 2019 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/4/2019	15:30	KR20642	206.4	PacifiCorp	KR19043	0.5	ND
5/4/2019	13:30	KR19874	198.7	PacifiCorp	KR19039	0.5	ND
5/4/2019	13:40	KR19874	198.7	PacifiCorp	KR19040	0-8	ND
5/4/2019	12:30	KR19645	196.5	PacifiCorp	KR19038	0.5	ND
5/4/2019	09:30	KR19019	190.2	PacifiCorp	KR19034	0.5	ND
5/4/2019	9:55	KR19019	190.2	PacifiCorp	KR19035	0-8	ND
6/8/2019	15:45	KR20642	206.4	PacifiCorp	KR19060	0.5	0.16
6/8/2019	13:00	KR19874	198.7	PacifiCorp	KR19056	0.5	ND
6/8/2019	13:15	KR19874	198.7	PacifiCorp	KR19057	0-8	0.12 ^{C1, J}
6/8/2019	11:45	KR19645	196.5	PacifiCorp	KR19055	0.5	ND
6/8/2019	9:00	KR19019	190.2	PacifiCorp	KR19051	0.5	ND
6/8/2019	9:20	KR19019	190.2	PacifiCorp	KR19052	0-8	ND
6/8/2019	17:15	KR18973	189.7	PacifiCorp	KR19063	0.5	ND
6/24/2019	10:30	KR18973	189.7	PacifiCorp	KR19066	0.5	ND
7/8/2019	15:40	KR20642	206.4	PacifiCorp	KR19078	0.5	ND
7/8/2019	13:30	KR19874	198.7	PacifiCorp	KR19074	0.5	0.59
7/8/2019	13:50	KR19874	198.7	PacifiCorp	KR19075	0-8	0.41
7/8/2019	12:30	KR19645	196.5	PacifiCorp	KR19073	0.5	2.5
7/8/2019	9:20	KR19019	190.2	PacifiCorp	KR19069	0.5	1.4
7/8/2019	9:45	KR19019	190.2	PacifiCorp	KR19070	0-8	0.20
7/8/2019	17:00	KR18973	189.7	PacifiCorp	KR19068	0.5	0.11 ^{C1, J}
7/8/2019	17:10	KR18973	189.7	PacifiCorp	KR19081	0.5	0.1 ^{C1, J}
7/22/2019	11:40	KR18973	189.7	PacifiCorp	KR19084	0.5	0.56
8/5/2019	14:30	KR20642	206.4	PacifiCorp	KR19096	0.5	0.10 ^{C1, J}
8/5/2019	12:10	KR19874	198.7	PacifiCorp	KR19092	0.5	86
8/5/2019	12:40	KR19874	198.7	PacifiCorp	KR19093	0-8	13
8/5/2019	11:00	KR19645	196.5	PacifiCorp	KR19091	0.5	120
8/5/2019	8:10	KR19019	190.2	PacifiCorp	KR19087	0.5	11
8/5/2019	8:30	KR19019	190.2	PacifiCorp	KR19088	0-8	3.0
8/5/2019	15:45	KR18973	189.7	PacifiCorp	KR19086	0.5	2.6
8/5/2019	15:45	KR18973	189.7	PacifiCorp	KR19099	0.5	2.3
8/19/2019	11:00	KR18973	189.7	PacifiCorp	KR19102	0.5	3.4
9/9/2019	15:15	KR20642	206.4	PacifiCorp	KR19114	0.5	ND
9/9/2019	13:20	KR19874	198.7	PacifiCorp	KR19110	0.5	0.23
9/9/2019	13:45	KR19874	198.7	PacifiCorp	KR19111	0-8	0.25
9/9/2019	12:20	KR19645	196.5	PacifiCorp	KR19109	0.5	56
9/9/2019	9:40	KR19019	190.2	PacifiCorp	KR19105	0.5	15
9/9/2019	10:00	KR19019	190.2	PacifiCorp	KR19106	0-8	3.3
9/9/2019	16:30	KR18973	189.7	PacifiCorp	KR19104	0.5	1.2
9/9/2019	16:45	KR18973	189.7	PacifiCorp	KR19116	0.5	ND
9/9/2019	16:40	KR18973	189.7	PacifiCorp	KR19117	0.5	1.0

"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.

Appendix 3 Laboratory Phytoplankton Results

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: BRTC19007
Sample Depth:
Sample Date: 13-Aug-19 1053

Total Density (#/mL): 362
Total Biovolume (um³/mL): 485,068
Trophic State Index: 44.6

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	294	81.3	425,839	87.8
Oscillatoria limosa	57	15.6	49,056	10.1
Limnothrix sp.	11	3.1	10,173	2.1

Limnothrix sp. cells/mL = 226
 Aphanizomenon flos-aquae cells/mL = 6,759
 Oscillatoria limosa cells/mL = 791

Aquatic Analysts

**Sample
 ID:** VF81

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KEKP19007
Sample Depth:
Sample Date: 13-Aug-19 1109

Total Density (#/mL): 1,451
Total Biovolume (um³/mL): 2,267,850
Trophic State Index: 55.8

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	1,409	97.1	2,219,766	97.9
Dolichospermum circinalis	21	1.4	29,431	1.3
Limnothrix sp.	21	1.4	18,653	0.8

Aphanizomenon flos-aquae cells/mL = 35,234
 Dolichospermum circinalis cells/mL = 415
 Limnothrix sp. cells/mL = 415

Aquatic Analysts

**Sample
 ID:** VF82

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: UKEP19007
Sample Depth:
Sample Date: 13-Aug-19 1156

Total Density (#/mL): 3,030
Total Biovolume (um³/mL): 3,220,563
Trophic State Index: 58.3

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	2,396	79.1	3,169,825	98.4
Microcystis aeruginosa	634	20.9	50,738	1.6

Microcystis aeruginosa cells/mL = 6,342
 Aphanizomenon flos-aquae cells/mL = 50,315

Aquatic Analysts

**Sample
 ID:** VF83

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: UKHP19007
Sample Depth:
Sample Date: 13-Aug-19 1213

Total Density (#/mL): 125,297
Total Biovolume (um³/mL): 173,661,111
Trophic State Index: 87.0

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	125,297	100.0	173,661,111	100.0

Aphanizomenon flos-aquae cells/mL = 2,756,526

Aquatic Analysts

Sample ID: VF84

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: UKMP19007
Sample Depth:
Sample Date: 13-Aug-19 1230

Total Density (#/mL): 20,977
Total Biovolume (um³/mL): 27,752,233
Trophic State Index: 73.8

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	20,977	100.0	27,752,233	100.0

Aphanizomenon flos-aquae cells/mL = 440,512

Aquatic Analysts

**Sample
 ID:** VF85

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR19830
Sample Depth:
Sample Date: 19-Aug-19 1030

Total Density (#/mL): 20,009
Total Biovolume (um³/mL): 1,938,665
Trophic State Index: 54.6

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Microcystis aeruginosa	19,453	97.2	1,867,521	96.3
Planktolyngbya sp.	556	2.8	71,144	3.7

Microcystis aeruginosa cells/mL = 233,440

Planktolyngbya sp. cells/mL = 4,446

Note: Toxic Algae Only

Aquatic Analysts

**Sample
 ID:** WD79

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR19831
Sample Depth:
Sample Date: 19-Aug-19 915

Total Density (#/mL): 405,178
Total Biovolume (um³/mL): 459,401,589
Trophic State Index: 94.1

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	400,127	98.8	453,744,245	98.8
Microcystis aeruginosa	5,051	1.2	5,657,344	1.2

Aphanizomenon flos-aquae cells/mL = 7,202,290

Microcystis aeruginosa cells/mL = 707,168

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: WD80

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR19832
Sample Depth:
Sample Date: 19-Aug-19 845

Total Density (#/mL): 8,004
Total Biovolume (um³/mL): 3,373,861
Trophic State Index: 58.6

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Microcystis aeruginosa	5,971	74.6	477,679	14.2
Aphanizomenon flos-aquae	1,969	24.6	2,853,305	84.6
Limnothrix sp.	64	0.8	42,877	1.3

Microcystis aeruginosa cells/mL = 59,710
 Aphanizomenon flos-aquae cells/mL = 45,291
 Limnothrix sp. cells/mL = 953

Note: Toxic Algae Only

Aquatic Analysts

**Sample
 ID:** WD81

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR19833
Sample Depth:
Sample Date: 19-Aug-19 830

Total Density (#/mL): 57,697
Total Biovolume (um³/mL): 50,953,980
Trophic State Index: 78.2

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	41,368	71.7	49,517,001	97.2
Microcystis aeruginosa	16,329	28.3	1,436,979	2.8

Microcystis aeruginosa cells/mL = 179,622
 Aphanizomenon flos-aquae cells/mL = 785,984

Note: Toxic Algae Only

Aquatic Analysts

**Sample
 ID:** WD82

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR19834
Sample Depth:
Sample Date: 19-Aug-19 1105

Total Density (#/mL): 1,334
Total Biovolume (um³/mL): 124,184
Trophic State Index: 34.8

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Microcystis aeruginosa	1,302	97.6	104,175	83.9
Aphanizomenon flos-aquae	32	2.4	20,009	16.1

Microcystis aeruginosa cells/mL = 13,022
 Aphanizomenon flos-aquae cells/mL = 318

Note: Toxic Algae Only

Aquatic Analysts

**Sample
 ID:** WD83

Phytoplankton Sample Analysis

Klamath
Sample: Basin
Sample ID: KR19835
Sample Depth:
Sample Date: 9-Sep-19 1550

Total Density (#/mL): 40,651
Total Biovolume (um³/mL): 52,955,479
Trophic State Index: 78.5

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	39,987	98.4	52,902,300	99.9
Microcystis aeruginosa	665	1.6	53,179	0.1

Aphanizomenon flos-aquae cells/mL = 839,719

Microcystis aeruginosa cells/mL = 6,647

Note: Toxic Algae Only

Aquatic Analysts

**Sample
 ID:** WD84

Phytoplankton Sample Analysis

Klamath
Sample: Basin
Sample ID: KR19836
Sample Depth:
Sample Date: 9-Sep-19 1250

Total Density (#/mL): 1,197
Total Biovolume (um³/mL): 1,463,646
Trophic State Index: 52.6

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
Aphanizomenon flos-aquae	1,100	91.9	1,455,923	99.5
Microcystis aeruginosa	97	8.1	7,723	0.5

Aphanizomenon flos-aquae cells/mL = 23,110

Microcystis aeruginosa cells/mL = 965

Note: Toxic Algae Only

Aquatic Analysts

**Sample
 ID:** WD85

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR19837
Sample Depth:
Sample Date: 9-Sep-19 1200

Total Density (#/mL): 32,136
Total Biovolume (um³/mL): 5,470,499
Trophic State Index: 62.1

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
-	-	-	-	-
Microcystis aeruginosa	29,740	92.5	2,379,188	43.5
Aphanizomenon flos-aquae	2,124	6.6	2,944,246	53.8
Limnothrix sp.	272	0.8	147,065	2.7

Microcystis aeruginosa cells/mL = 297,399
 Aphanizomenon flos-aquae cells/mL = 46,734
 Limnothrix sp. cells/mL = 3,268

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: WD86

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR19838
Sample Depth:
Sample Date: 9-Sep-19 1135

Total Density (#/mL): 3,167
Total Biovolume (um³/mL): 1,191,376
Trophic State Index: 51.1

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
-	-	-	-	-
Microcystis aeruginosa	2,431	76.8	194,474	16.3
Aphanizomenon flos-aquae	704	22.2	975,311	81.9
Limnothrix sp.	32	1.0	21,590	1.8

Microcystis aeruginosa cells/mL = 24,309
 Limnothrix sp. cells/mL = 480
 Aphanizomenon flos-aquae cells/mL = 15,481

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: WD87

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR19839
Sample Depth:
Sample Date: 9-Sep-19 1625

Total Density (#/mL): <10
Total Biovolume (um³/mL):
Trophic State Index:

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
No Toxic Algae Present	<10			

Note: Toxic Algae Only

Aquatic Analysts

**Sample
 ID:** WD88