TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Lower Klamath and Klamath Hydroelectric Projects

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Introduction

This technical memorandum summarizes the results for the 2023 public health monitoring for cyanobacteria species and an associated toxin, microcystin, from Upper Klamath Lake and within the Klamath River from Keno Reservoir to the Klamath River downstream Iron Gate Dam and including Iron Gate and Copco reservoirs. Microcystin results from 2023 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. 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 (https://www.pacificorp.com/energy/hydro/klamath-river.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 2023 public health sampling events to date and microcystin results from the 2023 baseline sampling events, respectively.

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[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 downstream of 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 2023.

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 from May through October at 12 locations extending from Link River Dam to the Klamath River downstream of Iron Gate Dam (Table 2).

Table 2. Sites of microcystin baseline monitoring from Link River Dam to the Klamath River downstream of Iron Gate reservoir during 2023.

Site Description	Approximate River Mile	Depth (m)	Sampling Entity	Site ID
Link River Dam	254.4	0.5	PacifiCorp	KR25411
Keno Reservoir at Miller Island	246.0	0.5	PacifiCorp	KR24600
Klamath River below Keno Dam near a USGS Gage	231.8	0.5	PacifiCorp	KR23340
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 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.

Table 3. Summary of available public health laboratory microcystin results from sampling July 2023. Samples collected by ODEQ on July 11 were originally reported in the previous public health memo and are included in Appendix 1.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/11/2023	17:15	CRMC	201.5	PacifiCorp	KR23815	SG	0.76
7/11/2023	13:15	CRCC	200.0	PacifiCorp	KR23816	SG	31
7/11/2023	13:50	IRCC	192.8	PacifiCorp	KR23817	SG	0.54
7/11/2023	14:00	IRJW	192.4	PacifiCorp	KR23818	SG	0.43
7/11/2023	15:35	KRBI	189.7	PacifiCorp	KR23819	SG	0.25
7/25/2023	11:00	UKEP	N/A	ODEQ	UKEP23012	SG	3.5
7/25/2023	11:25	UKHP	N/A	ODEQ	UKHP23012	SG	5.7
7/25/2023	12:00	UKMP	N/A	ODEQ	UKMP23012	SG	0.79
7/25/2023	12:30	KEKP	234	ODEQ	KEKP23012	SG	0.71
7/25/2023	12:45	BRTC	225	ODEQ	BRTC23012	SG	0.28
7/25/2023	14:30	CRMC	201.5	PacifiCorp	KR23820	SG	0.34
7/25/2023	8:30	CRCC	200.0	PacifiCorp	KR23821	SG	0.48
7/25/2023	9:10	IRCC	192.8	PacifiCorp	KR23822	SG	10
7/25/2023	9:30	IRJW	192.4	PacifiCorp	KR23823	SG	0.28
7/25/2023	10:00	KRBI	189.7	PacifiCorp	KR23824	SG	0.13[C1, J]

"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 2023 baseline laboratory microcystin results for samples collected in Oregon.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/10/2022	14:20	KR22460	224.6	PacifiCorp	KR23091	0.5	ND
7/10/2022	15:15	KR21950	219.5	PacifiCorp	KR23092	0.5	0.10[C1, J]
7/10/2022	16:20	KR23340	233.4	PacifiCorp	KR23093	0.5	0.32
7/10/2022	17:15	KR24600	246	PacifiCorp	KR23094	0.5	1.5
7/10/2022	17:50	KR25411	254.4	PacifiCorp	KR23090	0.5	0.23
7/10/2022	18:05	KR25411	254.4	PacifiCorp	KR23097	0.5	0.21
7/24/2023	16:25	KR25411	254.4	PacifiCorp	KR23099	0.5	1.0
7/24/2023	16:50	KR25411	254.4	PacifiCorp	KR23103	0.5	1.1

"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 July 2023 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/11/2023	14:40	KR18973	189.7	PacifiCorp	KR23076	0.5	0.28
7/11/2023	14:50	KR18973	189.7	PacifiCorp	KR23089	0.5	0.30
7/11/2023	8:05	KR19019	190.1	PacifiCorp	KR23077	0.5	0.36
7/11/2023	8:20	KR19019	190.1	PacifiCorp	KR23078	0-8	0.11[C1, J]
7/11/2023	10:35	KR19645	196.4	PacifiCorp	KR23081	0.5	ND
7/11/2023	11:35	KR19874	198.7	PacifiCorp	KR23082	0.5	0.24
7/11/2023	11:55	KR19874	198.7	PacifiCorp	KR23083	0-8	0.10[C1, J]
7/11/2023	17:45	KR20642	206.4	PacifiCorp	KR23086	0.5	ND

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

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/HARMFULALGAEBLOOMS/Documents/Advisory-Guidelines-Harmful-Cyanobacterial-Blooms-Recreational-Waters.pdf

Appendix 1
Cyanobacteria Species and Microcystin Data for 2023 Public Health Samples

Table A1. Summary of available public health laboratory microcystin results from 2023 sampling.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/1/2023	11:40	UKEP	N/A	ODEQ	UKEP23001	SG	ND
5/1/2023	12:06	UKHP	N/A	ODEQ	UKHP23001	SG	ND
5/1/2023	12:24	UKMP	N/A	ODEQ	UKMP23001	SG	ND
5/1/2023	10:32	BRTC	225	ODEQ	BRTC23001	SG	ND
5/15/2023	11:19	UKEP	N/A	ODEQ	UKEP23011*	SG	ND
5/15/2023	11:51	UKHP	N/A	ODEQ	UKHP23011*	SG	ND
5/15/2023	12:09	UKMP	N/A	ODEQ	UKMP23011*	SG	ND
5/15/2023	10:21	BRTC	225	ODEQ	BRTC23011*	SG	ND
5/24/2023	10:55	CRMC	201.5	PacifiCorp	KR23800	SG	ND
5/24/2023	11:40	CRCC	200.0	PacifiCorp	KR23801	SG	ND
5/24/2023	8:00	IRCC	192.8	PacifiCorp	KR23802	SG	ND
5/24/2023	8:20	IRJW	192.4	PacifiCorp	KR23803	SG	ND
5/24/2023	8:45	KRBI	189.7	PacifiCorp	KR23804	SG	ND
6/6/2023	19:10	CRMC	201.5	PacifiCorp	KR23805	SG	ND
6/6/2023	10:15	CRCC	200.0	PacifiCorp	KR23806	SG	ND
6/6/2023	10:55	IRCC	192.8	PacifiCorp	KR23807	SG	ND
6/6/2023	11:15	IRJW	192.4	PacifiCorp	KR23808	SG	ND
6/6/2023	18:10	KRBI	189.7	PacifiCorp	KR23809	SG	ND
6/9/2023	11:47	UKEP	N/A	ODEQ	UKEP23011*	SG	ND[A2]
6/9/2023	12:05	UKHP	N/A	ODEQ	UKHP23011*	SG	ND[A2]
6/9/2023	12:20	UKMP	N/A	ODEQ	UKMP23011*	SG	ND[A2]
6/9/2023	10:56	KEKP	234	ODEQ	KEKP23011*	SG	ND[A2]
6/9/2023	10:35	BRTC	225	ODEQ	BRTC23011*	SG	ND[A2]
6/20/2023	9:35	CRMC	201.5	PacifiCorp	KR23810	SG	ND
6/20/2023	8:15	CRCC	200.0	PacifiCorp	KR23811	SG	ND
6/20/2023	12:55	IRCC	192.8	PacifiCorp	KR23812	SG	ND
6/20/2023	12:45	IRJW	192.4	PacifiCorp	KR23813	SG	ND
6/20/2023	10:30	KRBI	189.7	PacifiCorp	KR23814	SG	ND
6/27/2023	11:00	UKEP	N/A	ODEQ	UKEP23011*	SG	0.24
6/27/2023	11:25	UKHP	N/A	ODEQ	UKHP23011*	SG	10
6/27/2023	11:45	UKMP	N/A	ODEQ	UKMP23011*	SG	16
6/27/2023	12:40	KEKP	234	ODEQ	KEKP23011*	SG	0.19
6/27/2023	12:15	BRTC	225	ODEQ	BRTC23011*	SG	0.20
7/11/2023	11:15	UKEP	N/A	ODEQ	UKEP23011*	SG	1.5
7/11/2023	11:45	UKHP	N/A	ODEQ	UKHP23011*	SG	41
7/11/2023	12:00	UKMP	N/A	ODEQ	UKMP23011*	SG	0.40
7/11/2023	12:30	KEKP	234	ODEQ	KEKP23011*	SG	2.6
7/11/2023	13:00	BRTC	225	ODEQ	BRTC23011*	SG	0.15
7/11/2023	17:15	CRMC	201.5	PacifiCorp	KR23815	SG	0.76
7/11/2023	13:15	CRCC	200.0	PacifiCorp	KR23816	SG	31
7/11/2023	13:50	IRCC	192.8	PacifiCorp	KR23817	SG	0.54
7/11/2023	14:00	IRJW	192.4	PacifiCorp	KR23818	SG	0.43
7/11/2023	15:35	KRBI	189.7	PacifiCorp	KR23819	SG	0.25
7/25/2023	11:00	UKEP	N/A	ODEQ	UKEP23012	SG	3.5
7/25/2023	11:25	UKHP	N/A	ODEQ	UKHP23012	SG	5.7

Table A1 cont.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/25/2023	12:00	UKMP	N/A	ODEQ	UKMP23012	SG	0.79
7/25/2023	12:30	KEKP	234	ODEQ	KEKP23012	SG	0.71
7/25/2023	12:45	BRTC	225	ODEQ	BRTC23012	SG	0.28
7/25/2023	14:30	CRMC	201.5	PacifiCorp	KR23820	SG	0.34
7/25/2023	8:30	CRCC	200.0	PacifiCorp	KR23821	SG	0.48
7/25/2023	9:10	IRCC	192.8	PacifiCorp	KR23822	SG	10
7/25/2023	9:30	IRJW	192.4	PacifiCorp	KR23823	SG	0.28
7/25/2023	10:00	KRBI	189.7	PacifiCorp	KR23824	SG	0.13[C1, J]

“ND” value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)
“A2” indicates the sample was received above the recommended temperature range.
* Duplicate Sample ID differentiated by sample date and time.
"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 2023 Baseline Samples

Table A2-1. Summary of 2023 baseline laboratory microcystin results for samples collected in Oregon.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/10/2023	8:45	KR22460	224.6	PacifiCorp	KR23037	0.5	ND
5/10/2023	8:05	KR21950	219.5	PacifiCorp	KR23038	0.5	ND
5/10/2023	9:30	KR23340	233.4	PacifiCorp	KR23039	0.5	ND
5/10/2023	10:45	KR24600	246	PacifiCorp	KR23040	0.5	ND
6/5/2023	18:00	KR22460	224.6	PacifiCorp	KR23063	0.5	ND
6/5/2023	17:15	KR21950	219.5	PacifiCorp	KR23064	0.5	ND
6/5/2023	16:20	KR23340	233.4	PacifiCorp	KR23065	0.5	ND
6/5/2023	15:30	KR24600	246	PacifiCorp	KR23066	0.5	ND
7/10/2022	14:20	KR22460	224.6	PacifiCorp	KR23091	0.5	ND
7/10/2022	15:15	KR21950	219.5	PacifiCorp	KR23092	0.5	0.10[C1, J]
7/10/2022	16:20	KR23340	233.4	PacifiCorp	KR23093	0.5	0.32
7/10/2022	17:15	KR24600	246	PacifiCorp	KR23094	0.5	1.5
7/10/2022	17:50	KR25411	254.4	PacifiCorp	KR23090	0.5	0.23
7/10/2022	18:05	KR25411	254.4	PacifiCorp	KR23097	0.5	0.21
7/24/2023	16:25	KR25411	254.4	PacifiCorp	KR23099	0.5	1.0
7/24/2023	16:50	KR25411	254.4	PacifiCorp	KR23103	0.5	1.1

"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 2023 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/9/2023	11:00	KR19019	190.1	PacifiCorp	KR23023	0.5	ND
5/9/2023	11:20	KR19019	190.1	PacifiCorp	KR23024	0-8	ND
5/9/2023	13:50	KR19645	196.4	PacifiCorp	KR23027	0.5	ND
5/9/2023	XX:XX	KR19874	198.7	PacifiCorp	KR23028	0.5	NS
5/9/2023	XX:XX	KR19874	198.7	PacifiCorp	KR23029	0-8	NS
5/9/2023	15:50	KR20642	206.4	PacifiCorp	KR23032	0.5	ND
6/6/2023	12:15	KR19019	190.1	PacifiCorp	KR23049	0.5	ND
6/6/2023	12:30	KR19019	190.1	PacifiCorp	KR23050	0-8	ND
6/6/2023	14:45	KR19645	196.4	PacifiCorp	KR23053	0.5	ND
6/6/2023	8:45	KR19874	198.7	PacifiCorp	KR23054	0.5	ND
6/6/2023	9:00	KR19874	198.7	PacifiCorp	KR23055	0-8	ND
6/6/2023	15:55	KR20642	206.4	PacifiCorp	KR23058	0.5	ND
7/11/2023	14:40	KR18973	189.7	PacifiCorp	KR23076	0.5	0.28
7/11/2023	14:50	KR18973	189.7	PacifiCorp	KR23089	0.5	0.30
7/11/2023	8:05	KR19019	190.1	PacifiCorp	KR23077	0.5	0.36
7/11/2023	8:20	KR19019	190.1	PacifiCorp	KR23078	0-8	0.11[C1, J]
7/11/2023	10:35	KR19645	196.4	PacifiCorp	KR23081	0.5	ND
7/11/2023	11:35	KR19874	198.7	PacifiCorp	KR23082	0.5	0.24
7/11/2023	11:55	KR19874	198.7	PacifiCorp	KR23083	0-8	0.10[C1, J]
7/11/2023	17:45	KR20642	206.4	PacifiCorp	KR23086	0.5	ND

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)
“NS” indicates Not Sampled.
"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