TECHNICAL MEMORANDUM

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

Prepared for: Tim Hemstreet (PacifiCorp)
Demian Ebert (PacifiCorp)

Prepared by: E&S Environmental Chemistry, Inc.

Date: June 3, 2016

Introduction

This technical memorandum summarizes the results for the 2016 public health monitoring for cyanobacteria species and an associated toxin, microcystin, in Copco and Iron Gate reservoirs within PacifiCorp's Klamath Hydroelectric Project (Project) and in the Klamath River below Iron Gate Dam. Microcystin results from 2016 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-toxigenic cyanobacteria, including *Dolichospermum* sp., and others. This 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 2016 public health sampling events to date and microcystin results from the 2016 baseline sampling events.

Methods

PacifiCorp is conducting public health sampling at five sites (Table 1) for laboratory analysis of potentially toxigenic cyanobacteria, notably MSAE, and microcystin at:

---

[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 toxigenic species combined, or over 40,000 cells/mL of *Microcystis* spp. *or Planktothirix* spp.

- Four shoreline sites in coves in Copco and Iron Gate reservoirs (i.e., two cove sites in each reservoir).

- One Klamath River site below Iron Gate Dam near the hatchery bridge.

Table 1. Sites of cyanobacteria and microcystin public health monitoring in Copco and Iron Gate reservoirs and the Klamath River during 2016.

Location	Approximate River Mile	Site ID
Copco Reservoir at Mallard Cove	201.5	CRMC
Copco Reservoir at Copco Cove	200.0	CRCC
Iron Gate Reservoir at Camp Creek	192.8	IRCC
Iron Gate Reservoir at John Williams campground	192.4	IRJW
Klamath River below Iron Gate dam near hatchery bridge	189.7	KRBI

Samples are planned to be taken at shoreline locations in the reservoirs once in May and twice per month in June, July, August, September, October, and November. Samples to be collected from the river site below Iron Gate Dam are scheduled to be collected according to the discretion of the sampling entity (PacifiCorp) based on river conditions.

In addition to public health sampling, monthly and bi-monthly baseline sampling for microcystin is conducted from May through October at eleven locations extending from above J.C Boyle Reservoir to below Iron Gate Reservoir (Table 2).

Table 2. Sites of microcystin baseline monitoring in J.C. Boyle, Copco, and Iron Gate reservoirs and the Klamath River during 2016.

Site Description	Approximate River Mile	Depth (m)	Site ID
Klamath River above JC Boyle Reservoir	228.2	0.5	KR22822
JC Boyle Reservoir at Log Boom (surface)	224.8	0.5	KR22478
Klamath River below JC Boyle Reservoir	224.6	0.5	KR22460
Klamath River at USGS Gage	219.5	0.5	KR21950
Klamath River above Shovel Creek	206.4	0.5	KR20642
Copco Reservoir at Buoy Line (surface)	198.7	0.5	KR19874
Copco Reservoir at Buoy Line (integrated)	198.7	0-8	KR19874
Klamath River below Copco 2 Reservoir	196.5	0.5	KR19645
Iron Gate Reservoir at Log Boom (surface)	190.2	0.5	KR19019
Iron Gate Reservoir at Log Boom (integrated)	190.2	0-8	KR19019
Klamath River below Hatchery Bridge	189.7	0.5	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. However, once the reservoirs are posted with health advisories signs, the reservoir samples are collected but not rushed until it visually appears that the algae bloom conditions have waned. 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 for microcystins. The detection limit for microcystin using this method is 0.15 µg/L or parts per billion (ppb) while the quantitation limit is 0.18 µg/L or ppb. 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 from May 23, 2016 (Table 3) and baseline microcystin samples from May 10, 11, and 23, 2016 (Tables 4 and 5) were collected as planned. There were no potentially toxic algae found in the public health samples and all microcystin concentrations were either not detected or below the laboratory quantitation limit (< 0.18 µg/L). Appendix 3 includes the raw phytoplankton results for the samples reported in Table 3.

Table 3. Summary of May 23, 2016 public health laboratory algal identification and enumeration and microcystin results.

Date	Time	Site ID	RM	Sample ID	Depth	MSAE[1]	AFA[2]	DKFA[3]	Other [4],[5], [6], [7], [8], [9], [10], or [11]	Microcystin (µg/L)
5/23/16	14:05	CRMC	201.5	KR16800	SG	0	0	0	0	ND
5/23/16	13:15	CRCC	200.0	KR16801	SG	0	0	0	0	ND
5/23/16	12:45	IRCC	192.8	KR16802	SG	0	0	0	0	ND
5/23/16	12:25	IRJW	192.4	KR16803	SG	0	0	0	0	ND
5/23/16	11:55	KRBI	189.7	KR16804	SG	0	0	0	0	ND

[1]MSAE = *Microcystis aeruginosa* (cells/mL)
[2]AFA = *Aphanizomenon flos-aquae* (cells/mL)
[3]DKFA = *Dolichospermum flos-aquae*
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*, or [11]*Pseudanabaena* spp.
"ND" value indicates a result less than the laboratory analytical detection limit (0.15 µg/L)
"0" value indicates non-detect by analytical laboratory

Table 4. Summary of May 10, 11, and 23, 2016 baseline laboratory microcystin results for samples collected in Oregon.

Date	Time	Site ID	RM	Sample ID	Depth (m)	Microcystin (µg/L)
5/10/16	9:50	KR22822	228.2	KR16062	0.5	0.16[1]
5/10/16	12:35	KR22478	224.8	KR16064	0.5	ND
5/10/16	13:15	KR22460	224.6	KR16061	0.5	0.16[1]
5/10/16	11:20	KR21950	219.5	KR16063	0.5	0.16[1]

[1]The reported result for this analyte should be considered an estimated value because although the result was above the laboratory detection limit (0.15 µg/L) it was below the laboratory quantitation limit (0.18 µg/L).

"ND" value indicates a result less than the laboratory analytical detection limit (0.15 µg/L)

Table 5. Summary of May 10, 11, and 23, 2016 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sample ID	Depth (m)	Microcystin (µg/L)
5/11/16	15:10	KR20642	206.4	KR16078	0.5	ND
5/11/16	12:50	KR19874	198.7	KR16074	0.5	0.15[1]
5/11/16	13:00	KR19874	198.7	KR16075	0-8	ND
5/11/16	12:05	KR19645	196.5	KR16073	0.5	0.17[1]
5/11/16	9:45	KR19019	190.2	KR16069	0.5	ND
5/11/16	9:55	KR19019	190.2	KR16070	0-8	ND
5/11/16	16:35	KR18973	189.7	KR16068	0.5	ND
5/23/16	11:50	KR18973	189.7	KR16082	0.5	ND

[1]The reported result for this analyte should be considered an estimated value because although the result was above the laboratory detection limit (0.15 µg/L) it was below the laboratory quantitation limit (0.18 µg/L).

"ND" value indicates a result less than the laboratory analytical detection limit (0.15 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. 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 2016 Public Health Samples

Table A1. Summary of 2016 laboratory algal identification and enumeration.

Date	Time	Site ID	RM	Sample ID	Depth	MSAE[1]	AFA[2]	DKFA[3]	Other [4],[5], [6], [7], [8], [9], [10], or [11]	Microcystin (µg/L)
5/23/16	14:05	CRMC	201.5	KR16800	SG	0	0	0	0	ND
5/23/16	13:15	CRCC	200.0	KR16801	SG	0	0	0	0	ND
5/23/16	12:45	IRCC	192.8	KR16802	SG	0	0	0	0	ND
5/23/16	12:25	IRJW	192.4	KR16803	SG	0	0	0	0	ND
5/23/16	11:55	KRBI	189.7	KR16804	SG	0	0	0	0	ND

[1]MSAE = *Microcystis aeruginosa* (cells/mL)
[2]AFA = *Aphanizomenon flos-aquae* (cells/mL)
[3]DKFA = *Dolichospermum flos-aquae*
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,* or [11]*Pseudanabaena* spp.
"ND" value indicates a result less than the laboratory analytical detection limit (0.15 µg/L)
"0" value indicates non-detect by analytical laboratory

Appendix 2
Microcystin Data for 2016 Baseline Samples

Table A2-1. Summary of 2016 baseline laboratory microcystin results for samples collected in Oregon.

Date	Time	Site ID	RM	Sample ID	Depth (m)	Microcystin (µg/L)
5/10/16	9:50	KR22822	228.2	KR16062	0.5	0.16[1]
5/10/16	12:35	KR22478	224.8	KR16064	0.5	ND
5/10/16	13:15	KR22460	224.6	KR16061	0.5	0.16[1]
5/10/16	11:20	KR21950	219.5	KR16063	0.5	0.16[1]

[1]The reported result for this analyte should be considered an estimated value because although the result was above the laboratory detection limit (0.15 µg/L) it was below the laboratory quantitation limit (0.18 µg/L).

"ND" value indicates a result less than the laboratory analytical detection limit (0.15 µg/L)

Table A2-2. Summary of 2016 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sample ID	Depth (m)	Microcystin (µg/L)
5/11/16	15:10	KR20642	206.4	KR16078	0.5	ND
5/11/16	12:50	KR19874	198.7	KR16074	0.5	0.15[1]
5/11/16	13:00	KR19874	198.7	KR16075	0-8	ND
5/11/16	12:05	KR19645	196.5	KR16073	0.5	0.17[1]
5/11/16	9:45	KR19019	190.2	KR16069	0.5	ND
5/11/16	9:55	KR19019	190.2	KR16070	0-8	ND
5/11/16	16:35	KR18973	189.7	KR16068	0.5	ND
5/23/16	11:50	KR18973	189.7	KR16082	0.5	ND

[1]The reported result for this analyte should be considered an estimated value because although the result was above the laboratory detection limit (0.15 µg/L) it was below the laboratory quantitation limit (0.18 µg/L).

"ND" value indicates a result less than the laboratory analytical detection limit (0.15 µg/L)

Appendix 3
Laboratory Phytoplankton Results

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample ID: KR16800
Sample Depth:
Sample Date: 23-May-16 1405

Total Density (#/mL): <5
Total Biovolume (um^3/mL):
Trophic State Index:

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent
1	No Toxic Algae Present	<5			

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample:	Klamath Basin	
Sample ID:	KR16801	
Sample Depth:		
Sample Date:	23-May-16	1315
Total Density (#/mL):	<5	
Total Biovolume (um^3/mL):		
Trophic State Index:		

Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent
-	-	-	-	-
No Toxic Algae Present	<5			

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample:	Klamath Basin	
Sample ID:	KR16802	
Sample Depth:		
Sample Date:	23-May-16	1245
Total Density (#/mL):	<8	
Total Biovolume (um^3/mL):		
Trophic State Index:		

Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent
-	-	-	-	-
No Toxic Algae Present	<8			

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample:	Klamath Basin	
Sample ID:	KR16803	
Sample Depth:		
Sample Date:	23-May-16	1225
Total Density (#/mL):	<4	
Total Biovolume (um^3/mL):		
Trophic State Index:		

Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent
-	-	-	-	-
No Toxic Algae Present	<4			

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample:	Klamath Basin	
Sample ID:	KR16804	
Sample Depth:		
Sample Date:	23-May-16	1155
Total Density (#/mL):	<5	
Total Biovolume (um^3/mL):		
Trophic State Index:		

Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent
-	-	-	-	-
No Toxic Algae Present	<5			

Note: Toxic Algae Only