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 2015 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. 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 *Anabaena* 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 public health sampling are used to determine if public health advisories are warranted[1]. 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 summarize results from all of the 2015 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:

- 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.

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.

[1] The California State Water Resources Control Board provides guidelines for posting advisories in recreation water (SWRCB 2010). SWRCB recommends posting advisories in recreation waters under three circumstances: (1) if "scum is present associated with toxigenic species"; (2) if scum is not present, but the density of *Microcystis* or *Planktothrix* is 40,000 cells/ml or greater; and (3) if scum is not present, but the density of all potentially toxigenic BGA is 100,000 cells/ml or greater, or 4) if microcystin is 8 µg/L or greater.

Table 1. Sites of cyanobacteria and microcystin public health monitoring in Copco and Iron Gate reservoirs and the Klamath River during 2015.		
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

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 rushed 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 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 quantitation limit is 0.18 µg/L or parts per billion (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

On July 1, 2015, Copco reservoir was posted with health advisories based on the public health sampling results from samples collected at Copco Cove (CRCC) on June 22, 2015, and in accordance with California posting guidelines (SWRCB 2010) (see Appendix 1). Samples collected from Iron Gate reservoir on July 21, 2015 at the Camp Creek (IRCC) public health monitoring location had microcystis cell counts of 45,100 cells/mL, which exceed the posting guidelines. Public health samples from both reservoirs will continue to be collected but these samples will not be rushed for analysis since both reservoirs are now posted. Results will be available in the end of the year summary database.

Table 2. Summary of July 21, 2015 laboratory algal identification and enumeration.

Date	Time	Location	RM	Sample ID	Depth	MSAE[1]	AFA[2]	ANA[3]	Other [5], [6], [7], [8], [9], or [10]	Microcystin (µg/L)
07/21/2015		CRMC	201.5	KR15819	SG	*	*	*	*	*
07/21/2015		CRCC	200.0	KR15820	SG	*	*	*	*	*
07/21/2015	13:30	IRCC	192.8	KR15821	SG	45,100	4,997	973	324[6]	*
07/21/2015	13:40	IRJW	192.4	KR15822	SG	13,877	10,616	0	0	*
07/21/2015	14:05	KRBI	189.7	KR15823	SG	12,916	0	0	0	*

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

[2]AFA = *Aphanizomenon flos-aquae* (cells/mL)
[3]ANA = *Anabaena flos-aquae* (cells/mL)
Other = either [5]*Planktothrix (Oscillatoria) sp.* or [6]*Gloeotrichia echinulata* or [7]*Anabaena sp.* or [8]*Lyngbya sp.* (cells/mL) or [9]*Anabaena circinalis* (cells/mL) or [10]*Anabaena planctonica* (cells/mL)
"0" value indicates non-detect by analytical laboratory
***** Results were not available upon the date this memo was submitted and will be included in Appendix 1 of subsequent memos

References

SWRCB. 2010. Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. July 2010. Document provided as part of Blue-green Algae Work Group of State Water Resources Control Board (SWRCB) and Office of Environmental Health and Hazard Assessment (OEHHA).

Appendix 1
Cyanobacteria Species data for 2015 Public Health Samples

Table 3. Summary of 2015 laboratory algal identification and enumeration

Date	Time	Location	RM	Sample ID	Depth	MSAE[1]	AFA[2]	ANA[3]	Other [5], (6), (7), (8), (9), or (10)	Microcystin (µg/L)
5/18/2015	16:00	CRMC	201.5	KR15800	SG	0	0	0	0	ND
5/18/2015	17:00	CRCC	200.0	KR15801	SG	0	0	0	0	ND
5/18/2015	17:40	IRCC	192.8	KR15802	SG	0	0	0	0	ND
5/18/2015	18:05	IRJW	192.4	KR15803	SG	0	0	0	0	ND
06/08/2015	9:00	CRMC	201.5	KR15804	SG	0	139	104	0	.20
06/08/2015	10:20	CRCC	200.0	KR15805	SG	0	0	967	0	ND
06/08/2015	11:00	IRCC	192.8	KR15806	SG	0	0	841	0	ND
06/08/2015	11:10	IRJW	192.4	KR15807	SG	0	0	324	1,060[7]	ND
06/08/2015	18:30	KRBI	189.7	KR15808	SG	0	0	163	0	ND
06/22/2015	10:30	CRMC	201.5	KR15809	SG	0	0	0	0	*
06/22/2015	12:05	CRCC	200.0	KR15810	SG	2,373,318	0	218,262	0	1,000[12]
06/22/2015	12:29	IRCC	192.8	KR15811	SG	0	0	18,401	0	ND[12]
06/22/2015	12:40	IRJW	192.4	KR15812	SG	0	0	678	0	ND[12]
06/22/2015	16:30	KRBI	189.7	KR15813	SG	0	18	335	0	ND[12]
07/08/2015	14:40	CRMC	201.5	KR15814	SG	*	*	*	*	12,000
07/08/2015	12:30	CRCC	200.0	KR15815	SG	*	*	*	*	3,300[13]
07/08/2015	11:40	IRCC	192.8	KR15816	SG	5,315	4,905	121	0	0.66
07/08/2015	11:20	IRJW	192.4	KR15817	SG	841	2,322	0	0	0.26
07/08/2015	10:35	KRBI	189.7	KR15818	SG	0	249	33	0	0.31
07/21/2015		CRMC	201.5	KR15819	SG	*	*	*	*	*
07/21/2015		CRCC	200.0	KR15820	SG	*	*	*	*	*
07/21/2015	13:30	IRCC	192.8	KR15821	SG	45,100	4,997	0	324[6] 973[7]	*
07/21/2015	13:40	IRJW	192.4	KR15822	SG	13,877	10,616	0	0	*
07/21/2015	14:05	KRBI	189.7	KR15823	SG	12,916	0	0	0	*

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

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

[3] ANA = *Anabaena flos-aquae* (cells/mL)

Other = either [5]*Planktothrix (Oscillatoria) sp.* or [6]*Gloeotrichia echinulata* or [7]*Anabaena sp.* or [8]*Lyngbya sp.* (cells/mL) or [9]*Anabaena circinalis* (cells/mL) or [10]*Anabaena planctonica* or [11]*Planktothrix (Oscillatoria) limosa*

[12] The sample was received above the recommended temperature range

[13] The reported concentration for this analyte is above the calibration range of the instrument and should be considered an estimated value

"0" value indicates non-detect by analytical laboratory

"NA" value indicates sample loss

"ND" value indicates result less than quantitation limit (0.18 µg/L) by analytical laboratory

* Results were not available upon the date this memo was submitted and will be included in subsequent memos

Appendix 2 – Laboratory Phytoplankton Results

Phytoplankton Sample Analysis

Sample:	Klamath Basin	
Sample Site:	KR 15821	
Sample Depth:		
Sample Date:	21-Jul-15	1330

Total Density (#/mL):	4,964
Total Biovolume (um^3/mL):	763,845
Trophic State Index:	47.9

Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**
Microcystis aeruginosa	4,510	90.8	360,800	47.2
Aphanizomenon flos-aquae	357	7.2	314,792	41.2
Anabaena sp.	65	1.3	66,190	8.7
Gloeotrichia echinulata	32	0.7	22,063	2.9

Microcystis aeruginosa cells/mL =	45,100
Aphanizomenon flos-aquae cells/mL =	4,997
Anabaena sp. cells/mL =	973
Gloeotrichia echinulata cells/mL =	324

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample:	Klamath Basin	
Sample Site:	KR 15822	
Sample Depth:		
Sample Date:	21-Jul-15	1340

Total Density (#/mL):	2,012
Total Biovolume (um^3/mL):	779,814
Trophic State Index:	48.1

Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**
Microcystis aeruginosa	1,388	69.0	111,015	14.2
Aphanizomenon flos-aquae	624	31.0	668,798	85.8

Microcystis aeruginosa cells/mL =	13,877
Aphanizomenon flos-aquae cells/mL =	10,616

Note: Toxic Algae Only

Phytoplankton Sample Analysis

Sample:	Klamath Basin	
Sample Site:	KR 15823	
Sample Depth:		
Sample Date:	21-Jul-15	1405

Total Density (#/mL):	1,292
Total Biovolume (um^3/mL):	103,328
Trophic State Index:	33.5

Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**
Microcystis aeruginosa	1,292	100.0	103,328	100.0

Microcystis aeruginosa cells/mL =	12,916

Note: Toxic Algae Only