TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: October 30th and November 6th, 2012

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Date: November 13th, 2012

Introduction

This technical memorandum summarizes the results for the public health monitoring conducted October 30th and November 12th, 2012 for cyanobacteria species and the associated toxin, microcystin, in Copco and Iron Gate reservoirs in PacifiCorp's Klamath Hydroelectric Project (Project) and at one monitoring station in the Klamath River below Iron Gate Dam. This monitoring is particularly focused on *Microcystis aeruginosa* (MSAE), a cyanobacterium with a recent history of summertime blooms in Copco and Iron Gate reservoirs and that is known to produce microcystin. This monitoring also estimates the presence of other potentially-toxigenic cyanobacteria, including *Anabaena* spp. and *Planktothrix (Oscillatoria)* spp. 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.

The data summarized in this memorandum also include results the previous 2012 public health sampling events (see Appendix 1). Subsequent memoranda will be prepared approximately every two weeks to report the results of continued monitoring.

Methods

PacifiCorp is conducting phytoplankton sampling at 5 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 August; and twice per month in June, July, October, and November. Samples for the river site below Iron Gate Dam are scheduled to be collected twice per month in June, July and October and weekly in August and September, but the sampling schedule may change due to river and/or reservoir conditions.

Phytoplankton samples from the river sites are taken as grab samples offshore according to the standard operating procedure (SOP) developed by the Klamath Blue Green Algae Working Group (http://www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring). Additional samples, collected at open water sites in Copco and Iron Gate reservoirs, including a grab sample at 0.5 m depth and an integrated sample over 8 m depth, will be collected as part of the baseline water quality monitoring.

Samples for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. The laboratory analysis of phytoplankton speciation and abundance is performed on prepared microscope slides of filtered samples using phase contrast microscopy. Species are counted as algal units of cell, filament, or colony depending on the natural growth form of the species. Algal forms are identified to species or otherwise to the lowest practicable taxonomic level. 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.

Table 1. Sites of cyanobacteria and microcystin public health monitoring in Copco and Iron Gate reservoirs and the Klamath River during 2012.

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

Results

The July 11th sampling had cell counts at Copco Reservoir at Copco Cove and microcystin levels at Iron Gate Reservoir (John Williams campground) above the California posting guidelines[1] (SWRCB 2010). Both reservoirs are currently posted with health advisory guidelines. Weekly public health sampling has resumed in the reservoirs starting Oct 28 for the purpose of lifting the health advisories. The public health advisory was removed at the KRBI site on October 26, 2012.

The October 28 sampling results indicate that all 4 reservoir cove sites were still above the posting guidelines (Table 2). It appears that the MSAE bloom is declining since all but one cove (CRMC) had cell counts above the criteria results for the November sampling. Laboratory data sheets for the recent sampling events are provided in Appendix 2.

[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.

Table 2. Summary of public health monitoring on October 30th and November 6th, 2012.

Date	Time	Location	RM	Sample ID	Depth	MSAE	AFA	ANA	Other	Microcystin (µg/l)
10/28/2012	10:20	CRMC	201.5	KR12846b	SG	434,219	13,984	62,930	29,367([7])	*
10/28/2012	9:30	CRCC	200.0	KR12847	SG	3,555,383	541,200	12,898,600	112,750([7])	*
10/28/2012	11:30	IRCC	192.8	KR12848	SG	170,959	0	0	0	*
10/28/2012	11:20	IRJW	192.4	KR12849	SG	5,116,031	125,636	0	36,241[(9)]	*
10/28/2012	11:00	KRBI	189.7	KR12850	SG	3,028	59	0	0	*
11/06/2012	15:50	CRMC	201.5	KR12851	SG	133,339	700,946	0	27,452([7])	*
11/06/2012	14:15	CRCC	200.0	KR12852	SG	0	9,594		273([7])	*
11/06/2012	17:30	IRCC	192.8	KR12853	SG	1,800	32	0	0	*
11/06/2012	17:20	IRJW	192.4	KR12854	SG	8,556	3,975	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)
"0" value indicates non-detect by analytical laboratory

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

Cumulative Cyanobacteria Species data for 2012 Public Health Samples

Table 3. Summary of public health monitoring (2012).

Date	Time	Location	RM	Sample ID	Depth	MSAE	AFA	ANA	Other	Microcystin (µg/L)
5/21/2012	12:40	CRMC	201.5	KR12800	SG	0	0	26	290[5] / 329[8]	**
5/21/2012	13:10	CRCC	200.0	KR12801	SG	0	0	0	58[5]	**
5/21/2012	11:30	IRCC	192.8	KR12802	SG	0	0	0	0	ND
5/21/2012	11:50	IRJW	192.4	KR12803	SG	0	0	0	0	ND
6/12/2012	15:00	CRMC	201.5	KR12804	SG	2,832	0	2,124	1,035[5]	0.29
6/12/2012	16:00	CRCC	200.0	KR12805	SG	8,575	0	0	0	0.74
6/12/2012	13:50	IRCC	192.8	KR12806	SG	0	0	0	0	0.3
6/12/2012	14:00	IRJW	192.4	KR12807	SG	0	0	67	0	ND
6/12/2012	14:10	KRBI	189.7	KR12809	SG	0	0	0	0	ND
6/25/2012	13:25	CRMC	201.5	KR12810	SG	119	0	0	24[5]	ND
6/25/2012	12:45	CRCC	200.0	KR12811	SG	284	0	56	111[5]	0.37
6/25/2012	14:15	IRCC	192.8	KR12812	SG	0	0	0	28[5]	0.16
6/25/2012	14:05	IRJW	192.4	KR12813	SG	117	0	87	0	0.19
6/25/2012	13:50	KRBI	189.7	KR12815	SG	0	0	0	0	ND
7/11/2012	11:50	CRMC	201.5	KR12816	SG	2,019	0	2,042	0	5.9
7/11/2012	12:30	CRCC	200.0	KR12817	SG	694,479	0	1,173,209	0	460
7/11/2012	14:00	IRCC	192.8	KR12818	SG	821	0	1,195	112[7]	0.86
7/11/2012	14:15	IRJW	192.4	KR12819	SG	26,670	0	3,196	499[7]	9.8
7/11/2012	14:30	KRBI	189.7	KR12821	SG	0	0	0	0	0.17
7/17/2012	18:15	CRMC	201.5	KR12822	SG	7,362	0	0	0	1.6
7/17/2012	18:45	CRCC	200.0	KR12823	SG	9,095	167	543	0	2.7
7/17/2012	19:15	IRCC	192.8	KR12824	SG	259	0	0	35[7]	0.32
7/17/2012	19:30	IRJW	192.4	KR12825	SG	0	893	3,046	7,527[6]	0.32
7/24/2012	11:00	CRMC	201.5	KR12826	SG	1,973,811	0	11,504	0	660
7/24/2012	12:35	CRCC	200.0	KR12827	SG	9,616,424	0	156,930	0	2,300
7/24/2012	12:00	IRCC	192.8	KR12828	SG	8,016	0	0	847[7]	2.3
7/24/2012	11:45	IRJW	192.4	KR12829	SG	6,497	43	107	64[7]	1.4
7/24/2012	11:30	KRBI	189.7	KR12831	SG	322	107	43	0	0.44
8/06/2012	18:30	KRBI	189.7 ***	KR12832	SG	22,812	2,619	0	83[7]	3.8
8/08/2012	12:15	CRMC	200.0	KR12833	SG	1,903,433	3,833,500	0	0	2,400
8/08/2012	13:00	CRCC	192.8	KR12834	SG	59,757,500	183,937	0	45,100[7]	43,000
8/08/2012	14:10	IRCC	192.4	KR12835	SG	63,140	26,914	649	487[7]	14
8/08/2012	14:30	IRJW	189.7	KR12836	SG	355,455	269,932	0	1,114[7]	98
8/13/2012	9:20	KRBI	189.7	KR12837	SG	31,839	1,616	0	224[7]	1.4
8/19/2012	15:50	KRBI	189.7	KR12838	SG	20,412	2,793	0	0	0.48
8/27/2012	14:20	KRBI	189.7	KR12839	SG	60,188	12,983	0	0	1.8
9/03/2012	11:00	KRBI	189.7	KR12840	SG	112,782	6,592	0	0	13
9/11/2012	15:45	KRBI	189.7	KR12841	SG	78,880	1,263	0	0	14
9/17/2012	18:30	KRBI	189.7	KR12842	SG	139,420	320	0	51[7]	18
9/25/2012	11:00	KRBI	189.7	KR12843	SG	51,305	0	0	95[5]/76[7]	14
10/08/2012	16:15	KRBI	189.7	KR12844	SG	22,516	0	0	870[7]	8.6
10/17/2012	18:15	KRBI	189.7	KR12846a	SG	11,592	111	0	0	*
10/22/2012	11:50	KRBI	189.7	KR12845	SG	5,092	149	0	0	*

Date	Time	Location	RM	Sample ID	Depth	MSAE	AFA	ANA	Other	Microcystin (µg/L)
10/28/2012	10:20	CRMC	201.5	KR12846b	SG	434,219	13,984	62,930	29,367([7])	*
10/28/2012	9:30	CRCC	200.0	KR12847	SG	3,555,383	541,200	12,898,600	112,750([7])	*
10/28/2012	11:30	IRCC	192.8	KR12848	SG	170,959	0	0	0	*
10/28/2012	11:20	IRJW	192.4	KR12849	SG	5,116,031	125,636	0	36,241[(9)]	*
10/28/2012	11:00	KRBI	189.7	KR12850	SG	3,028	59	0	0	*
11/06/2012	15:50	CRMC	201.5	KR12851	SG	133,339	700,946	0	27,452([7])	*
11/06/2012	14:15	CRCC	200.0	KR12852	SG	0	9,594		273([7])	*
11/06/2012	17:30	IRCC	192.8	KR12853	SG	1,800	32	0	0	*
11/06/2012	17:20	IRJW	192.4	KR12854	SG	8,556	3,975	0	0	*

* Results were not available upon release of this memo and will be release with the subsequent memo
**Bottles were damaged during shipping and could not be analyzed
*** Previously listed incorrectly as 201.5

Appendix 2

Laboratory Data Sheets October 30th and November 6th, 2012 Public Health Sampling

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12846
Sample Depth:	
Sample Date:	28-Oct-12
Total Density (#/mL):	20,103
Total Biovolume (um^3/mL):	10,568,084
Trophic State Index:	66.9

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Anabaena flos-aquae	12,586	62.6	4,216,326	39.9	bluegreen
2	Microcystis aeruginosa	4,720	23.5	3,473,749	32.9	bluegreen
3	Aphanizomenon flos-aquae	1,748	8.7	881,023	8.3	bluegreen
4	Anabaena sp.	1,049	5.2	1,996,986	18.9	bluegreen

Microcystis aeruginosa cells/mL =	434,219
Anabaena flos-aquae cells/mL =	62,930
Aphanizomenon flos-aquae cells/mL =	13,984
Anabaena sp. cells/mL =	29,367

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG46

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12847
Sample Depth:	
Sample Date:	28-Oct-12
Total Density (#/mL):	1,450,717
Total Biovolume (um^3/mL):	934,411,867
Trophic State Index:	99.2

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Anabaena flos-aquae	1,074,883	74.1	864,206,200	92.5	bluegreen
2	Microcystis aeruginosa	323,217	22.3	28,443,067	3.0	bluegreen
3	Aphanizomenon flos-aquae	45,100	3.1	34,095,600	3.6	bluegreen
4	Anabaena sp.	7,517	0.5	7,667,000	0.8	bluegreen

Anabaena flos-aquae cells/mL =	12,898,600
Microcystis aeruginosa cells/mL =	3,555,383
Anabaena sp. cells/mL =	112,750
Aphanizomenon flos-aquae cells/mL =	541,200

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG47

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12848
Sample Depth:	
Sample Date:	28-Oct-12
Total Density (#/mL):	13,151
Total Biovolume (um^3/mL):	1,367,668
Trophic State Index:	52.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	13,151	100.0	1,367,668	100.0	bluegreen

Microcystis aeruginosa cells/mL =	170,959

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG48

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12849
Sample Depth:	
Sample Date:	28-Oct-12
Total Density (#/mL):	72,079
Total Biovolume (um^3/mL):	51,416,416
Trophic State Index:	78.3

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	66,442	92.2	40,928,250	79.6	bluegreen
2	Aphanizomenon flos-aquae	5,235	7.3	7,915,050	15.4	bluegreen
3	Anabaena circinalis	403	0.6	2,573,116	5.0	bluegreen

Microcystis aeruginosa cells/mL = 5,116,031

Aphanizomenon flos-aquae cells/mL = 125,636

Anabaena circinalis cells/mL = 36,241

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG49

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12850
Sample Depth:	
Sample Date:	28-Oct-12
Total Density (#/mL):	278
Total Biovolume (um^3/mL):	27,915
Trophic State Index:	24.3

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	275	98.9	24,225	86.8	bluegreen
2	Aphanizomenon flos-aquae	3	1.1	3,690	13.2	bluegreen

Microcystis aeruginosa cells/mL = 3,028

Aphanizomenon flos-aquae cells/mL = 59

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG50

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12851
Sample Depth:	
Sample Date:	6-Nov-12
Total Density (#/mL):	55,950
Total Biovolume (um^3/mL):	47,093,028
Trophic State Index:	77.6

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	50,068	89.5	44,159,567	93.8	bluegreen
2	Microcystis aeruginosa	3,922	7.0	1,066,713	2.3	bluegreen
3	Anabaena sp.	1,961	3.5	1,866,748	4.0	bluegreen

Microcystis aeruginosa cells/mL =	133,339
Aphanizomenon flos-aquae cells/mL =	700,946
Anabaena sp. cells/mL =	27,452

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG51

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12852
Sample Depth:	
Sample Date:	6-Nov-12
Total Density (#/mL):	417
Total Biovolume (um^3/mL):	623,009
Trophic State Index:	46.4

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	400	95.9	604,422	97.0	bluegreen
2	Anabaena sp.	17	4.1	18,587	3.0	bluegreen

Aphanizomenon flos-aquae cells/mL =	9,594
Anabaena sp. cells/mL =	273

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG52

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12853
Sample Depth:	
Sample Date:	6-Nov-12
Total Density (#/mL):	59
Total Biovolume (um^3/mL):	16,440
Trophic State Index:	20.6

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	55	93.1	14,403	87.6	bluegreen
2	Aphanizomenon flos-aquae	4	6.9	2,037	12.4	bluegreen

Microcystis aeruginosa cells/mL =	1,800
Aphanizomenon flos-aquae cells/mL =	32

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG53

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 12854
Sample Depth:	
Sample Date:	6-Nov-12
Total Density (#/mL):	697
Total Biovolume (um^3/mL):	318,953
Trophic State Index:	41.6

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	476	68.3	68,527	21.5	bluegreen
2	Aphanizomenon flos-aquae	221	31.7	250,426	78.5	bluegreen

Microcystis aeruginosa cells/mL =	8,566
Aphanizomenon flos-aquae cells/mL =	3,975

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** QG54