

Technical Memorandum

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: November 11th and November 19th

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Introduction

This technical memorandum summarizes the results for the public health monitoring conducted during 2013 for cyanobacteria species and the associated toxin, microcystin, in Copco and Iron Gate reservoirs within 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-toxic cyanobacteria, including *Anabaena* spp., *Planktothrix* (*Oscillatoria*) spp. 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.

The data summarized in this memorandum also include results the previous 2013 public health sampling events (see Appendix 1).

Methods

PacifiCorp is conducting phytoplankton sampling at 5 sites (Table 1) for laboratory analysis of potentially toxic 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.

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.

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Samples for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. 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.

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 coves (CRMC and CRCC) in Copco Reservoir are the only sites that are currently being monitored. The November 11th sampling results were above California public health posting guidelines¹ (see Table 2). Although the November 19th results show evidence that the bloom in Copco Reservoir has diminished, another sampling event will occur the week of November 25th to verify that the health advisory signs can be removed. Laboratory data sheets for the November 11th and November 19th sampling are provided in Appendix 2. The health advisory signs at all the other PacifiCorp monitoring sites (Table 1) have been removed.

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.

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Table 2. Summary of public health monitoring (November 11th and November 19th 2013).

Date	Time	Location	RM	Sample ID	Depth	MSAE ⁽¹⁾	AFA ⁽²⁾	ANA ⁽³⁾	Other ^{(6), (7), (8), (9), or (10)}	Microcystin (µg/L)
11/11/2013	13:00	CRMC	201.5	KR13934	SG	5,527	3,536,481	0	19,897 ⁽⁷⁾	210
11/11/2013	11:00	CRCC	200.0	KR13935	SG	0	10,576,917	0	0	87
11/19/2013	10:25	CRMC	201.5	KR13941	SG	0	0	0	0	*
11/19/2013	13:20	CRCC	200.0	KR13942	SG	0	572	0	0	*

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

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

³ANA = *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

“*” value indicates results were not available upon the date this memo was submitted and will be included in subsequent memos as availability allows

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).

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Appendix 1 Cumulative Cyanobacteria Species data for 2013 Public Health Samples

Table 3. Summary of public health monitoring: 2013

Date	Time	Location	RM	Sample ID	Depth	MSAE ⁽¹⁾	AFA ⁽²⁾	ANA ⁽³⁾	Other ^{(6), (7), (8), (9), or (10)}	Microcystin (µg/L)
5/20/2013	9:40	CRMC	201.5	KR13800	SG	0	0	0	0	ND
5/20/2013	11:15	CRCC	200.0	KR13801	SG	0	0	90	0	ND
5/20/2013	10:45	IRCC	192.8	KR13802	SG	0	0	0	0	ND
5/20/2013	10:30	IRJW	192.4	KR13803	SG	0	0	0	0	ND
5/20/2013	11:20	CRCC _{dup}	201.5	KR13804	SG	0	0	0	0	ND
6/06/2013	14:15	CRMC	201.5	KR13805	SG	9,429	0	379,340	0	10
6/06/2013	16:00	CRCC	200.0	KR13806	SG	12,403	0	88,088	0	2.4
6/06/2013	15:30	IRCC	192.8	KR13807	SG	839	0	5,264	0	0.22
6/06/2013	15:15	IRJW	192.4	KR13808	SG	29	0	615	0	0
6/06/2013	15:20	IRJW _{dup}	201.5	KR13809	SG	18	0	483	0	0.15
6/20/2013	16:30	CRMC	201.5	KR13811	SG	802,969	4,205	475,179	0	240
6/20/2013	15:45	CRCC	200.0	KR13812	SG	13,903	303	454	0	2.1
6/20/2013	13:05	IRCC	192.8	KR13813	SG	3,679	0	300,667	0	2.6
6/20/2013	12:45	IRJW	192.4	KR13814	SG	61,419	2,967	665,967	14,539	24
6/20/2013	15:45	CRCC _{dup}	201.5	KR13815	SG	3,794	0	3,502	0	2.0
7/11/2013	14:35	KRBI	189.7	KR13821	SG	16,443	0	0	0	9.9
7/16/2013	12:20	KRBI	189.7	KR13828	SG	10,585	537	0	0	1.2
7/29/2013	11:15	KRBI	189.7	KR13835	SG	8,093	916	0	72 ⁽⁶⁾	6.4
7/29/2013	12:40	KRBI	189.7	KR13841	SG	11,615	4,832	0	0	6.6
8/05/2013	14:15	KRBI	189.7	KR13848	SG	15,967	33,451	0	128 ⁽⁷⁾ / 448 ⁽⁹⁾	4.0
8/13/2013	11:50	KRBI	189.7	KR13855	SG	2,549	20,501	0	784 ⁽⁹⁾	1.8
8/21/2013	15:00	KRBI	189.7	KR13862	SG	11,227	29,145	141	768 ⁽⁷⁾ / 1,024 ⁽⁹⁾	3.5
8/26/2013	13:25	KRBI	189.7	KR13869	SG	16,356	22,730	0	1,684 ⁽⁷⁾ / 1,789 ⁽⁹⁾	5.6
9/02/2013	11:50	KRBI	189.7	KR13876	SG	19,086	25,933	0	1,199 ⁽⁹⁾ / 2,583 ⁽⁷⁾	6.9
9/10/2013	11:40	KRBI	189.7	KR13883	SG	45,741	12,108	0	1,948 ⁽⁷⁾	14
9/19/2013	15:00	KRBI	189.7	KR13886	SG	36,080	884	0	295 ⁽⁷⁾	6.5
9/25/2013	17:00	KRBI	189.7	KR13891	SG	44,155	209	0	472 ⁽⁷⁾	0.36
9/30/2013	11:40	KRBI	189.7	KR13892	SG	2,190	0	0	0	0.56
10/09/2013	12:50	KRBI	189.7	KR13905	SG	820	0	0	0	1.0
10/14/2013	16:25	KRBI	189.7	KR13913	SG	510	0	0	0	0.21
10/23/2013	15:20	CRMC	201.5	KR13915	SG	14,432,000	551,812	0	0	18,000
10/23/2013	17:00	CRCC	200.0	KR13916	SG	8,493	0	0	0	6.0
10/23/2013	17:30	IRCC	192.8	KR13917	SG	0	0	0	0	1.2
10/23/2013	17:45	IRJW	192.4	KR13918	SG	0	0	0	0	1.1
10/23/2013	18:00	KRBI	189.7	KR13919	SG	0	0	0	0	0.15
10/29/2013	18:20	CRMC	201.5	KR13922	SG	26,458,667	2,201,732	0	0	5,200
10/29/2013	16:30	CRCC	200.0	KR13923	SG	20,377,000	6,970,000	0	0	440
10/29/2013	15:45	IRCC	192.8	KR13924	SG	177	0	0	0	0.17

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10/29/2013	15:30	IRJW	192.4	KR13925	SG	0	0	0	0	0.17
10/29/2013	14:40	KRBI	189.7	KR13926	SG	0	0	0	0	0.20
11/04/2013	11:30	CRMC	201.5	KR13928	SG	0	0	0	0	0.29
11/04/2013	13:20	CRCC	200.0	KR13929	SG	14,099,444	3,674,815	0	0	12
11/04/2013	12:50	IRCC	192.8	KR13930	SG	0	0	0	0	0.36
11/04/2013	12:35	IRJW	192.4	KR13931	SG	0	0	0	0	0.17
11/04/2013	12:15	KRBI	189.7	KR13932	SG	0	0	0	0	ND
11/11/2013	13:00	CRMC	201.5	KR13934	SG	5,527	3,536,481	0	19,897 ⁽⁷⁾	210
11/11/2013	11:00	CRCC	200.0	KR13935	SG	0	10,576,917	0	0	87
11/19/2013	10:25	CRMC	201.5	KR13941	SG	0	0	0	0	*
11/19/2013	13:20	CRCC	200.0	KR13942	SG	0	572	0	0	*

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

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

³ANA = *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*

“0” value indicates non-detect by analytical laboratory

“*” value indicates results were not available upon the date this memo was submitted and will be included in subsequent memos as availability allows

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Appendix 2

Laboratory Data Sheets November 11th and November 19th 2013 Public Health Sampling

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13934			
Sample Depth:					
Sample Date:		11-Nov-13			
Total Density (#/mL):		155,308			
Total Biovolume (um ³ /mL):		224,195,527			
Trophic State Index:		88.9			
Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Aphanizomenon flos-aquae	153,760	99.0	222,798,311	99.4	bluegreen
2 Anabaena sp.	995	0.6	1,353,000	0.6	bluegreen
3 Microcystis aeruginosa	553	0.4	44,216	0.0	bluegreen
Aphanizomenon flos-aquae cells/mL =		3,536,481			
Microcystis aeruginosa cells/mL =		5,527			
Anabaena sp. cells/mL =		19,897			
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX31		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13935			
Sample Depth:					
Sample Date:		11-Nov-13			
Total Density (#/mL):		556,680			
Total Biovolume (um ³ /mL):		666,345,802			
Trophic State Index:		96.8			
Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Aphanizomenon flos-aquae	556,680	100.0	666,345,802	100.0	bluegreen
Aphanizomenon flos-aquae cells/mL =		10,576,917			
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX32		

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Phytoplankton Sample Analysis					
	Sample:	Klamath Basin			
	Sample Site:	KR 13941			
	Sample Depth:				
	Sample Date:	19-Nov-13			
	Total Density (#/mL):	1,966			
	Total Biovolume (um ³ /mL):	915,649			
	Trophic State Index:	49.2			
Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Rhoicosphenia curvata	347	17.6	44,649	4.9	diatom
2 Rhodomonas minuta	308	15.7	6,168	0.7	cryptophyte
3 Cocconeis placentula	193	9.8	88,658	9.7	diatom
4 Gomphonema subclavatum	154	7.8	92,513	10.1	diatom
5 Fragilaria construens	116	5.9	55,693	6.1	diatom
6 Nitzschia frustulum	116	5.9	16,652	1.8	diatom
7 Fragilaria construens venter	96	4.9	39,781	4.3	diatom
8 Nitzschia communis	77	3.9	3,469	0.4	diatom
9 Fragilaria capucina mesolepta	77	3.9	78,636	8.6	diatom
10 Gomphoneis herculeana	58	2.9	312,231	34.1	diatom
11 Melosira varians	39	2.0	25,056	2.7	diatom
12 Nitzschia palea	39	2.0	6,938	0.8	diatom
13 Cryptomonas erosa	39	2.0	20,044	2.2	cryptophyte
14 Nitzschia amphibia	39	2.0	3,701	0.4	diatom
15 Asterionella formosa	19	1.0	4,240	0.5	diatom
16 Amphora ovalis	19	1.0	11,140	1.2	diatom
17 Synedra mazamaensis	19	1.0	4,934	0.5	diatom
18 Nitzschia recta	19	1.0	6,457	0.7	diatom
19 Fragilaria vaucheria	19	1.0	11,102	1.2	diatom
20 Cymbella tumida	19	1.0	48,184	5.3	diatom
21 Fragilaria pinnata	19	1.0	1,156	0.1	diatom
22 Gomphonema clevei	19	1.0	1,735	0.2	diatom
23 Navicula cryptocephala veneta	19	1.0	1,831	0.2	diatom
24 Gomphonema ventricosum	19	1.0	16,382	1.8	diatom
25 Nitzschia dissipata	19	1.0	5,185	0.6	diatom
26 Chlamydomonas sp.	19	1.0	6,264	0.7	green
27 Achnanthes minutissima	19	1.0	964	0.1	diatom
28 Nitzschia paleacea	19	1.0	1,889	0.2	diatom
Aquatic Analysts			Sample ID:	RX33	

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Phytoplankton Sample Analysis					
	Sample:	Klamath Basin			
	Sample Site:	KR 13942			
	Sample Depth:				
	Sample Date:	19-Nov-13			
	Total Density (#/mL):	429			
	Total Biovolume (um ³ /mL):	106,284			
	Trophic State Index:	33.7			
Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Rhoicosphenia curvata	61	14.3	7,886	7.4	diatom
2 Rhodomonas minuta	48	11.1	953	0.9	cryptophyte
3 Synedra rumpens	41	9.5	5,719	5.4	diatom
4 Nitzschia frustulum	41	9.5	4,902	4.6	diatom
5 Cocconeis placentula	27	6.3	12,528	11.8	diatom
6 Aphanizomenon flos-aquae	27	6.3	36,031	33.9	bluegreen
7 Ankistrodesmus falcatus	20	4.8	511	0.5	green
8 Nitzschia amphibia	20	4.8	1,961	1.8	diatom
9 Navicula cryptocephala veneta	20	4.8	1,940	1.8	diatom
10 Gomphonema subclavatum	20	4.8	12,255	11.5	diatom
11 Gomphonema angustatum	14	3.2	2,451	2.3	diatom
12 Fragilaria construens venter	14	3.2	2,614	2.5	diatom
13 Nitzschia palea	14	3.2	2,451	2.3	diatom
14 Cryptomonas erosa	7	1.6	3,540	3.3	cryptophyte
15 Achnanthes minutissima	7	1.6	340	0.3	diatom
16 Stephanodiscus hantzschii	7	1.6	817	0.8	diatom
17 Fragilaria vaucheria	7	1.6	1,961	1.8	diatom
18 Synedra fasciculata truncata	7	1.6	511	0.5	diatom
19 Stephanodiscus astraea minutula	7	1.6	2,383	2.2	diatom
20 Chlamydomonas sp.	7	1.6	2,213	2.1	green
21 Nitzschia sp.	7	1.6	817	0.8	diatom
22 Asterionella formosa	7	1.6	1,498	1.4	diatom
	Aphanizomenon flos-aquae cells/mL =	572			
Aquatic Analysts			Sample ID:	RX34	