

TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: October 18, 2010

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Introduction

This technical memorandum summarizes the latest results of monitoring during 2010 for cyanobacteria species and the associated toxin microcystin in Copco and Iron Gate reservoirs in PacifiCorp's Klamath Hydroelectric Project (Project) and in one monitoring station in the Klamath River below Iron Gate Dam. This monitoring is particularly focused on *Microcystis aeruginosa* (MSAE), a cyanobacterium that is known to produce microcystin, with a recent history of summertime blooms in Copco and Iron Gate reservoirs. 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 results addressed in this memorandum are specifically for samples collected on October 18, 2010. Subsequent memoranda such as this will be prepared every two weeks to report the results of continued monitoring.

Methods

PacifiCorp is conducting phytoplankton sampling for laboratory analysis of potentially toxigenic cyanobacteria, notably MSAE, and microcystin at six sites in Copco and Iron Gate reservoirs and one site below Iron Gate Dam as listed in Table 1, including:

- 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.
- Two open-water reservoir sites in the lower ends of Iron Gate and Copco reservoirs (near the log booms). These sites are part of the basic water quality monitoring that is being performed under the 2010 KHSA Measure 15 water quality monitoring plan. The plan is available on the Regional Board's website.¹

Samples will be taken at the shoreline locations in the reservoirs twice per month in June through October. Samples for the river site below Iron Gate Dam will be collected twice per month in June, July and October and weekly in August and September. Sampling will occur at the two open-water monitoring sites once per month in April through December.

¹ http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/

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. This SOP is an appendix to the 2010 KHSA Measure 15 water quality monitoring plan. Additional samples at open-water sites in Copco and Iron Gate reservoirs, including a grab sample at 0.5 m depth and an additional sample integrated 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. Biovolumes are estimated by multiplying the cell counts by the average geometric dimensions of the cells for a given phytoplankton taxa. 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 0.16 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 all measurable microcystin variants. Samples are also sent to the California Department of Fish and Game laboratory in Rancho Cordova, California for analysis for microcystin congeners and other toxins by liquid chromatography and mass spectrometry (LC/MS).

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

Results

Samples of October 18, 2010

Five samples and one replicate, plus one blank for microcystin, were collected for public health purposes on October 18, 2010 from shoreline stations in Copco and Iron Gate reservoirs and the Klamath River below Iron Gate dam. Aliquots were sent to Aquatic Analysts for cyanobacteria species identification and enumeration, to the EPA Region 9 laboratory for analysis for microcystin by ELISA methodology, and to the California Fish and Game laboratory for microcystin analysis by LC/MS.

The results of cyanobacteria species identification and enumeration are summarized in Table 2. Three cyanobacteria species capable of producing potentially harmful toxins were observed in the samples collected on October 18. *Microcystis aeruginosa* was observed at every location sampled. *Aphanizomenon flos-aquae* was observed at every location sampled except site IRCC. *Aphanizomenon* was observed in the duplicate sample at KRBI, but not in the regular sample. *Anabaena* sp. was observed at site CRCC. *Microcystis aeruginosa* exceeded 40,000 cells/mL in all samples collected, although at site KRBI it was barely above 40,000 cells/mL.

Results from microcystin analyses for samples collected on October 18 are not yet available. Results for ELISA analysis of microcystin through October 8 are provided in Appendix 1.

Table 2. Summary of cyanobacteria public health monitoring on October 18, 2010.

Date	Sample	Sample Site	Species	Biovolume $\mu\text{m}^3/\text{mL}$	Cells/mL
10/18/10	KR10266	KRBI	<i>Microcystis aeruginosa</i>	443,893	55,487
			<i>Aphanizomenon flos-aquae</i>	7,749	123
10/18/10	KR10267	IRCC	<i>Microcystis aeruginosa</i>	40,182,705	5,022,838
10/18/10	KR10268	IRJW	<i>Microcystis aeruginosa</i>	1,383,067	172,883
			<i>Aphanizomenon flos-aquae</i>	115,971	1,841
10/18/10	KR10269	CRMC	<i>Microcystis aeruginosa</i>	19,089,095	2,386,137
			<i>Aphanizomenon flos-aquae</i>	5,464,038	86,731
10/18/10	KR10270	CRCC	<i>Aphanizomenon flos-aquae</i>	39,634,076	629,112
			<i>Microcystis aeruginosa</i>	5,961,043	745,130
			<i>Anabaena</i> sp.	900,039	13,236
10/18/10	KR10271	KRBI (dup)	<i>Microcystis aeruginosa</i>	322,047	40,256

References

SWRCB. 2007. Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. June 2007. 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 Species data for 2010 Public Health Samples.

Date	Sample	Location	Species	Biovolume, $\mu\text{m}^3/\text{mL}$	Cells/mL	Microcystin, $\mu\text{g/L}$ (ELISA)
05/27/10	KR10070	KRBI	NA	0	0	
05/27/10	KR10072	CRMC	NA	0	0	
05/27/10	KR10073	CRCC	<i>Anabaena flos-aquae</i>	8,324	124	
05/27/10	KR10074	IRJW	NA	0	0	
05/27/10	KR10075	IRCC	NA	0	0	
06/07/10	KR10076	KRBI	NA	0	0	0.26
06/07/10	KR10078	CRMC	NA	0	0	0.25
06/07/10	KR10079	CRCC	<i>Anabaena flos-aquae</i>	4,700	70	0.47
06/07/10	KR10080	IRJW	NA	0	0	ND
06/07/10	KR10081	IRCC	NA	0	0	ND
06/21/10	KR10112	KRBI	<i>Anabaena flos-aquae</i>	13,021	164	
06/21/10	KR10110	CRMC	<i>Anabaena flos-aquae</i>	3,672,205	54,809	0.44
06/21/10	KR10109	CRCC	<i>Anabaena flos-aquae</i>	7,408,676	110,582	0.46
06/21/10	KR10107	IRJW	<i>Anabaena flos-aquae</i>	343,999	5,134	0.16
			<i>Anabaena sp.</i>	35,906	643	
			<i>Anabaena planctonica</i>	117,661	528	
06/21/10	KR10108	IRCC	<i>Anabaena flos-aquae</i>	97,509	1,455	0.21
			<i>Anabaena planktonica</i>	28,535	156	
07/06/10	KR10117	KRBI	<i>Anabaena flos-aquae</i>	230,529	3,441	ND
			<i>Aphanizomenon flos-aquae</i>	108,049	1,715	
			<i>Microcystis aeruginosa</i>	2,117	256	
			<i>Anabaena planctonica</i>	9,687	53	
07/06/10	KR10118	IRJW	<i>Anabaena flos-aquae</i>	498,696	7,443	ND
			<i>Anabaena planctonica</i>	136,085	744	
07/06/10	KR10119	IRCC	<i>Anabaena flos-aquae</i>	643,510	9,605	ND
			<i>Aphanizomenon flos-aquae</i>	19,731	313	
			<i>Anabaena sp.</i>	16,565	244	
07/06/10	KR10120	CRCC	<i>Anabaena flos-aquae</i>	76,049	568	ND
			<i>Aphanizomenon flos-aquae</i>	35,755	1,135	
07/06/10	KR10121	CRMC	<i>Oscillatoria sp.</i>	23,644	381	ND
			<i>Aphanizomenon flos-aquae</i>	3,482	55	
			<i>Anabaena flos-aquae</i>	7,406	111	
07/06/10	KR10123	KRBI (blank)	NA	NA	NA	ND
07/06/10	KR10123	KRBI (dup)	<i>Anabaena flos-aquae</i>	166,633	2,487	ND
			<i>Aphanizomenon flos-aquae</i>	74,370	1,180	
			<i>Microcystis aeruginosa</i>	1,816	227	
07/19/10	KR 10151	KRBI	<i>Aphanizomenon flos-aquae</i>	3,748	59	0.25
07/19/10	KR 10152	IRCC	<i>Anabaena flos-aquae</i>	1,498,364	22,364	1.7
			<i>Microcystis aeruginosa</i>	35,285	4,411	
			<i>Aphanizomenon flos-aquae</i>	11,741	186	
07/19/10	KR 10153	IRJW	<i>Aphanizomenon flos-aquae</i>	47,626	756	0.50
			<i>Anabaena flos-aquae</i>	31,656	472	
			<i>Anabaena sp.</i>	10,077	148	
07/19/10	KR 10154	CRMC	<i>Microcystis aeruginosa</i>	18,080	2,260	1.0

			<i>Anabaena flos-aquae</i>	33,800	504	
			<i>Aphanizomenon flos-aquae</i>	5,085	81	
			<i>Oscillatoria sp.</i>	2,502	40	
07/19/10	KR 10155	CRCC	<i>Anabaena flos-aquae</i>	91,080	1,359	0.51
			<i>Aphanizomenon flos-aquae</i>	57,431	912	
			<i>Microcystis aeruginosa</i>	1,279	160	
07/19/10	KR10156	KRBI (dup)	<i>No toxic algae present</i>			0.33
07/19/10	KR10157	KRBI (blnk)	<i>Toxic algae not measured</i>			ND
08/02/10	KR10161	IRJW	<i>Microcystis aeruginosa</i>	6,676,874	834,609	280
			<i>Aphanizomenon flos-aquae</i>	17,635,655	279,931	
			<i>Anabaena flos-aquae</i>	12,989,837	193,878	
08/02/10	KR10159	KRBI	<i>Aphanizomenon flos-aquae</i>	13,319	211	0.82
08/02/10	KR10160	IRCC	<i>Aphanizomenon flos-aquae</i>	4,582,742	72,742	4.7
			<i>Microcystis aeruginosa</i>	209,497	26,187	
			<i>Anabaena flos-aquae</i>	268,054	4,001	
08/02/10	KR10162	CRMC	<i>Microcystis aeruginosa</i>	18,766	2,346	0.68
			<i>Aphanizomenon flos-aquae</i>	33,371	530	
			<i>Anabaena flos-aquae</i>	48,165	719	
08/02/10	KR10163	CRCC	<i>Microcystis aeruginosa</i>	2,573,707	321,713	200
			<i>Aphanizomenon flos-aquae</i>	10,437,042	165,667	
			<i>Anabaena flos-aquae</i>	10,152,912	151,536	
08/02/10	KR10164	KRBI (dup)	<i>Aphanizomenon flos-aquae</i>	52,254	829	0.97
			<i>Anabaena sp.</i>	33,841	498	
			<i>Anabaena flos-aquae</i>	6,946	104	
08/09/10	KR10167	KRBI	<i>Microcystis aeruginosa</i>	3,723	465	1.3
			<i>Aphanizomenon flos-aquae</i>	1,074	17	
			<i>Anabaena sp.</i>	1,159	17	
			<i>Anabaena flos-aquae</i>	2,284	34	
08/16/10	KR10168	KRBI	<i>Microcystis aeruginosa</i>	39,975	4,997	ND
			<i>Aphanizomenon flos-aquae</i>	137,222	2,178	
			<i>Anabaena sp.</i>	11,617	171	
08/16/10	KR10169	IRCC	<i>Microcystis aeruginosa</i>	721,600	90,200	21
			<i>Aphanizomenon flos-aquae</i>	2,859,631	45,391	
			<i>Gloeotrichia echinulata</i>	41,550,194	611,032	
			<i>Anabaena sp.</i>	49,465	727	
08/16/10	KR10170	IRJW	<i>Microcystis aeruginosa</i>	257,714	32,214	4.0
			<i>Aphanizomenon flos-aquae</i>	956,764	15,187	
			<i>Gloeotrichia echinulata</i>	93,882	1,381	
			<i>Anabaena sp.</i>	79,799	1,174	
08/16/10	KR10171	CRMC	<i>Aphanizomenon flos-aquae</i>	633,420,480	10,054,293	1500
			<i>Microcystis aeruginosa</i>	62,238,000	7,779,750	
			<i>Anabaena flos-aquae</i>	16,015,010	239,030	
08/16/10	KR10172	CRCC	<i>Aphanizomenon flos-aquae</i>	86,817,500	1,378,056	28
			<i>Microcystis aeruginosa</i>	641,422	80,178	
08/16/10	KR10173	KRBI (dup)	<i>Microcystis aeruginosa</i>	72,962	9,120	1.9
			<i>Aphanizomenon flos-aquae</i>	252,560	4,009	
			<i>Anabaena sp.</i>	13,630	200	
8/23/10	KR10204	KRBI	<i>Microcystis aeruginosa</i>	300,088	37,511	7.0
			<i>Aphanizomenon flos-aquae</i>	1,557,251	24,718	
8/30/10	KR10205	KRBI	<i>Microcystis aeruginosa</i>	267,490	33,436	8.4
			<i>Aphanizomenon flos-aquae</i>	465,385	7,387	

8/30/10	KR10206	CRMC	<i>Aphanizomenon flos-aquae</i>	165,512,621	2,627,184	670
			<i>Microcystis aeruginosa</i>	11,769,786	1,471,223	
8/30/10	KR10207	CRCC	<i>Microcystis aeruginosa</i>	4,414,905	551,863	230
			<i>Aphanizomenon flos-aquae</i>	14,536,884	230,744	
8/30/10	KR10208	IRJW	<i>Microcystis aeruginosa</i>	42,240,000	5,280,000	2300
			<i>Gloeotrichia echinulata</i>	28,611,000	420,750	
8/30/10	KR10209	IRCC	<i>Microcystis aeruginosa</i>	300,435	37,554	12
			<i>Gloeotrichia echinulata</i>	11,795	173	
8/30/10	KR10210	KRBI (dup)	<i>Microcystis aeruginosa</i>	149,943	18,743	12
			<i>Aphanizomenon flos-aquae</i>	531,360	8,434	
8/30/10	KR10211	KRBI (blnk)	<i>Toxic algae not measured</i>			ND
9/7/10	KR10214	KRBI	<i>Microcystis aeruginosa</i>	447,733	55,967	8.2
			<i>Aphanizomenon flos-aquae</i>	228,199	3,622	
9/13/10	KR10215	KRBI	<i>Microcystis aeruginosa</i>	515,792	64,474	23
			<i>Aphanizomenon flos-aquae</i>	192,088	3,049	
9/13/10	KR10216	CRMC	<i>Microcystis aeruginosa</i>	23,812,800	2,976,600	2100
			<i>Aphanizomenon flos-aquae</i>	511,946	8,126	
9/13/10	KR10217	CRCC	<i>Microcystis aeruginosa</i>	101,616,618	12,702,077	7200
			<i>Aphanizomenon flos-aquae</i>	142,065,000	2,255,000	
9/13/10	KR10218	IRCC	<i>Microcystis aeruginosa</i>	902,000	112,750	24
			<i>Aphanizomenon flos-aquae</i>	42,093	668	
9/13/10	KR10219	IRJW	<i>Microcystis aeruginosa</i>	2,672,927	334,116	120
			<i>Aphanizomenon flos-aquae</i>	130,226	2,067	
9/13/10	KR10220	KRBI (dup)	<i>Microcystis aeruginosa</i>	789,559	98,695	25
			<i>Aphanizomenon flos-aquae</i>	446,629	7,089	
9/13/10	KR10221	KRBI (blnk)	<i>Toxic algae not measured</i>			ND
9/20/10	KR10249	KRBI	<i>Microcystis aeruginosa</i>	465,113	58,139	13
			<i>Aphanizomenon flos-aquae</i>	17,396	276	
9/27/10	KR10250	KRBI	<i>Microcystis aeruginosa</i>	447,160	55,865	16
			<i>Aphanizomenon flos-aquae</i>	80,642	1,280	
9/27/10	KR10251	CRMC	<i>Microcystis aeruginosa</i>	32,204,914	4,025,614	2,300
			<i>Aphanizomenon flos-aquae</i>	221,400	3,514	
9/27/10	KR10252	CRCC	<i>Microcystis aeruginosa</i>	57,654,367	7,206,796	5,400
			<i>Aphanizomenon flos-aquae</i>	30,442,500	483,214	
9/27/10	KR10253	IRJW	<i>Microcystis aeruginosa</i>	10,633,760	1,329,220	420
			<i>Aphanizomenon flos-aquae</i>	405,900	6,443	
9/27/10	KR10254	IRCC	<i>Microcystis aeruginosa</i>	426,862	53,358	11
9/27/10	KR10255	KRBI (dup)	<i>Microcystis aeruginosa</i>	468,265	58,533	16
			<i>Aphanizomenon flos-aquae</i>	116,729	1,853	
9/27/10	KR10256	KRBI (blnk)	<i>Toxic algae not measured</i>			ND
10/6/10	KR10257	KRBI	<i>Microcystis aeruginosa</i>	1,102,444	137,806	23
			<i>Aphanizomenon flos-aquae</i>	61,902	983	
			<i>Anabaena sp.</i>	33,407	491	
10/6/10	KR10259	CRMC	<i>Microcystis aeruginosa</i>	25,256,000	3,157,000	5700
			<i>Aphanizomenon flos-aquae</i>	1,198,673	19,027	
10/6/10	KR10260	CRCC	<i>Microcystis aeruginosa</i>	321,710	40,214	21
			<i>Aphanizomenon flos-aquae</i>	1,033,819	16,410	
			<i>Anabaena sp.</i>	38,225	562	
10/6/10	KR10261	IRJW	<i>Microcystis aeruginosa</i>	7,729,251	966,156	570
			<i>Aphanizomenon flos-aquae</i>	84,038	1,334	
			<i>Anabaena sp.</i>	95,028	1,397	

10/6/10	KR10262	IRCC	<i>Microcystis aeruginosa</i>	1,031,242	128,905	55
			<i>Anabaena sp.</i>	25,175	370	
10/6/10	KR10263	KRBI (dup)	<i>Microcystis aeruginosa</i>	541,726	67,716	21
			<i>Anabaena sp.</i>	41,725	614	
10/6/10	KR10264	KRBI (blnk)	<i>Toxic algae not measured</i>			ND
10/18/10	KR10266		<i>Microcystis aeruginosa</i>	443,893	55,487	
			<i>Aphanizomenon flos-aquae</i>	7,749	123	
10/18/10	KR10267		<i>Microcystis aeruginosa</i>	40,182,705	5,022,838	
10/18/10	KR10268		<i>Microcystis aeruginosa</i>	1,383,067	172,883	
			<i>Aphanizomenon flos-aquae</i>	115,971	1,841	
10/18/10	KR10269		<i>Microcystis aeruginosa</i>	19,089,095	2,386,137	
			<i>Aphanizomenon flos-aquae</i>	5,464,038	86,731	
10/18/10	KR10270		<i>Aphanizomenon flos-aquae</i>	39,634,076	629,112	
			<i>Microcystis aeruginosa</i>	5,961,043	745,130	
			<i>Anabaena sp.</i>	900,039	13,236	
10/18/10	KR10271		<i>Microcystis aeruginosa</i>	322,047	40,256	
10/18/10	KR10272		<i>Toxic algae not measured</i>			

Appendix 2

Laboratory Data Sheets for October 18, 2010 Public Health Samples.

Phytoplankton Sample Analysis						
Sample:		Klamath Basin				
Sample Site:		KR 10267				
Sample Depth:						
Sample Date:		18-Oct-10				
Total Density (#/mL):		386,372				
Total Biovolume (um³/mL):		40,182,705				
Trophic State Index:		76.5				
Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group	
1 Microcystis aeruginosa	386,372	100.0	40,182,705	100.0	bluegreen	
Microcystis aeruginosa cells/mL =		5,022,838				
Note: Toxic Algae Only						
Aquatic Analysts			Sample ID: NQ69			

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 10268			
Sample Depth:					
Sample Date:		18-Oct-10			
Total Density (#/mL):		7,578			
Total Biovolume (um³/mL):		1,499,038			
Trophic State Index:		52.8			
Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent	Group
1 Microcystis aeruginosa	7,517	99.2	1,383,067	92.3	bluegreen
2 Aphanizomenon flos-aquae	61	0.8	115,971	7.7	bluegreen
Microcystis aeruginosa cells/mL =		172,883			
Aphanizomenon flos-aquae cells/mL =		1,841			
Note: Toxic Algae Only					
Aquatic Analysts		Sample ID: NQ70			

Phytoplankton Sample Analysis					
Sample: Klamath Basin					
Sample Site: KR 10269					
Sample Depth:					
Sample Date: 18-Oct-10					
Total Density (#/mL): 16,652					
Total Biovolume (um³/mL): 24,553,134					
Trophic State Index: 72.9					
Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent	Group
1 Microcystis aeruginosa	13,183	79.2	19,089,095	77.7	bluegreen
2 Aphanizomenon flos-aquae	3,469	20.8	5,464,038	22.3	bluegreen
Microcystis aeruginosa cells/mL =	2,386,137				
Aphanizomenon flos-aquae cells/mL =	86,731				
Note: Toxic Algae Only					
Aquatic Analysts				Sample ID: NQ71	

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 10271			
Sample Depth:					
Sample Date:		18-Oct-10			
Total Density (#/mL):		4,026			
Total Biovolume (um ³ /mL):		322,047			
Trophic State Index:		41.7			
Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	4,026	100.0	322,047	100.0	bluegreen
Microcystis aeruginosa cells/mL =		40,256			
Note: Toxic Algae Only					
Aquatic Analysts		Sample ID: NQ73			