TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: August 30, 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 August 30, 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).

Table 1. Sites of Cyanobacteria and Microcystin Public Health Monitoring in Copco and Iron Gate reservoirs during 2010.

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 August 30, 2010

Five samples and one replicate, plus one blank for microcystin, were collected for public health purposes on August 30, 2010 from shoreline stations in Copco and Iron Gate reservoirs and the Klamath River below Iron Gate dam. An additional sample was collected on August 23 from 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 August 23 and 30. *Microcystis aeruginosa* was observed at every location sampled. *Anabaena flos-aquae* was observed below Iron Gate dam on August 23 and 30 and in Copco reservoir on August 30. *Gloeotrichia echinulata* was observed at both sites in Iron Gate reservoir. *Microcystis aeruginosa* exceeded 100,000 cells/mL in both samples from Copco reservoir and in the sample from Jay Williams camp in Iron Gate reservoir. *Aphanizomenon flos-aquae* exceeded 100,000 cells/mL in the samples from Copco reservoir. *Gloeotrichia echinulata* exceeded 100,000 cells/mL in the sample from Jay Williams Camp in Iron Gate reservoir.

Results from microcystin analyses for samples collected on August 30 are not yet available. Results for ELISA analysis of microcystin analysis through August 23 are provided in Appendix 1. In samples collected May 27 and June 7 and analyzed by LC/MS for nine congeners of microcystin, anatoxin a, domoic acid, and okadaic acid all results have been below the method reporting limit.

Table 2. Summary of cyanobacteria public health monitoring on August 30, 2010.

Date	Sample	Sample Site	Species	Biovolume $\mu m^3/mL$	Cells/mL
8/23/10	KR10204	KRBI	*Microcystis aeruginosa*	300,088	37,511
			Aphanizomenon flos-aquae	1,557,251	24,718
8/30/10	KR10205	KRBI	*Microcystis aeruginosa*	267,490	33,436
			Aphanizomenon flos-aquae	465,385	7,387
8/30/10	KR10206	CRMC	*Aphanizomenon flos-aquae*	165,512,621	2,627,184
			Microcystis aeruginosa	11,769,786	1,471,223
8/30/10	KR10207	CRCC	*Microcystis aeruginosa*	4,414,905	551,863
			Aphanizomenon flos-aquae	14,536,884	230,744
8/30/10	KR10208	IRJW	*Microcystis aeruginosa*	42,240,000	5,280,000
			Gloeotrichia echinulata	28,611,000	420,750
8/30/10	KR10209	IRCC	*Microcystis aeruginosa*	300,435	37,554
			Gloeotrichia echinulata	11,795	173
8/30/10	KR10210	KRBI (dup)	*Microcystis aeruginosa*	149,943	18,743
			Aphanizomenon flos-aquae	531,360	8,434

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

			Anabaena sp.	10,077	148	
07/19/10	KR 10154	CRMC	*Microcystis aeruginosa*	18,080	2,260	1.0
			Anabaena flos-aquae	33,800	504	
			Aphanizomenon flos-aquae	5,085	81	
			Oscillatoria sp.	2,502	40	
07/19/10	KR 10155	CRCC	*Anabaena flos-aquae*	91,080	1,359	0.51
			Aphanizomenon flos-aquae	57,431	912	
			Microcystis aeruginosa	1,279	160	
07/19/10	KR10156	KRBI (dup)	*No toxic algae present*			0.33
07/19/10	KR10157	KRBI (blnk)	*Toxic algae not measured*			ND
08/02/10	KR10161	IRJW	*Microcystis aeruginosa*	6,676,874	834,609	280
			Aphanizomenon flos-aquae	17,635,655	279,931	
			Anabaena flos-aquae	12,989,837	193,878	
08/02/10	KR10159	KRBI	*Aphanizomenon flos-aquae*	13,319	211	0.82
08/02/10	KR10160	IRCC	*Aphanizomenon flos-aquae*	4,582,742	72,742	4.7
			Microcystis aeruginosa	209,497	26,187	
			Anabaena flos-aquae	268,054	4,001	
08/02/10	KR10162	CRMC	*Microcystis aeruginosa*	18,766	2,346	0.68
			Aphanizomenon flos-aquae	33,371	530	
			Anabaena flos-aquae	48,165	719	
08/02/10	KR10163	CRCC	*Microcystis aeruginosa*	2,573,707	321,713	200
			Aphanizomenon flos-aquae	10,437,042	165,667	
			Anabaena flos-aquae	10,152,912	151,536	
08/02/10	KR10164	KRBI (dup)	*Aphanizomenon flos-aquae*	52,254	829	0.97
			Anabaena sp.	33,841	498	
			Anabaena flos-aquae	6,946	104	
08/09/10	KR10167	KRBI	*Microcystis aeruginosa*	3,723	465	1.3
			Aphanizomenon flos-aquae	1,074	17	
			Anabaena sp.	1,159	17	
			Anabaena flos-aquae	2,284	34	
08/16/10	KR10168	KRBI	*Microcystis aeruginosa*	39,975	4,997	ND
			Aphanizomenon flos-aquae	137,222	2,178	
			Anabaena sp.	11,617	171	
08/16/10	KR10169	IRCC	*Microcystis aeruginosa*	721,600	90,200	21
			Aphanizomenon flos-aquae	2,859,631	45,391	
			Gloeotrichia echinulata	41,550,194	611,032	
			Anabaena sp.	49,465	727	
08/16/10	KR10170	IRJW	*Microcystis aeruginosa*	257,714	32,214	4.0
			Aphanizomenon flos-aquae	956,764	15,187	
			Gloeotrichia echinulata	93,882	1,381	
			Anabaena sp.	79,799	1,174	
08/16/10	KR10171	CRMC	*Aphanizomenon flos-aquae*	633,420,480	10,054,293	1500
			Microcystis aeruginosa	62,238,000	7,779,750	
			Anabaena flos-aquae	16,015,010	239,030	
08/16/10	KR10172	CRCC	*Aphanizomenon flos-aquae*	86,817,500	1,378,056	28
			Microcystis aeruginosa	641,422	80,178	
08/16/10	KR10173	KRBI (dup)	*Microcystis aeruginosa*	72,962	9,120	1.9
			Aphanizomenon flos-aquae	252,560	4,009	
			Anabaena sp.	13,630	200	
8/23/10	KR10204	KRBI	*Microcystis aeruginosa*	300,088	37,511	7.0
			Aphanizomenon flos-aquae	1,557,251	24,718	

8/30/10	KR10205	KRBI	*Microcystis aeruginosa*	267,490	33,436	
			Aphanizomenon flos-aquae	465,385	7,387	
8/30/10	KR10206	CRMC	*Aphanizomenon flos-aquae*	165,512,621	2,627,184	
			Microcystis aeruginosa	11,769,786	1,471,223	
8/30/10	KR10207	CRCC	*Microcystis aeruginosa*	4,414,905	551,863	
			Aphanizomenon flos-aquae	14,536,884	230,744	
8/30/10	KR10208	IRJW	*Microcystis aeruginosa*	42,240,000	5,280,000	
			Gloeotrichia echinulata	28,611,000	420,750	
8/30/10	KR10209	IRCC	*Microcystis aeruginosa*	300,435	37,554	
			Gloeotrichia echinulata	11,795	173	
8/30/10	KR10210	KRBI (dup)	*Microcystis aeruginosa*	149,943	18,743	
			Aphanizomenon flos-aquae	531,360	8,434	
8/30/10	KR10211	KRBI (blnk)	*Toxic algae not measured*			

Appendix 2

Laboratory Data Sheets for August 30, 2010 Public Health Samples.

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10204
Sample Depth:
Sample Date: 23-Aug-10

Total Density (#/mL): 5,052
Total Biovolume (um^3/mL): 1,857,339
Trophic State Index: 54.3

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	3,751	74.2	300,088	16.2	bluegreen
2	Aphanizomenon flos-aquae	1,301	25.8	1,557,251	83.8	bluegreen

Microcystis aeruginosa cells/mL = 37,511

Aphanizomenon flos-aquae cells/mL = 24,718

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ27

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10205
Sample Depth:
Sample Date: 30-Aug-10

Total Density (#/mL): 3,732
Total Biovolume (um^3/mL): 732,875
Trophic State Index: 47.6

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	3,344	89.6	267,490	36.5	bluegreen
2	Aphanizomenon flos-aquae	389	10.4	465,385	63.5	bluegreen

Microcystis aeruginosa cells/mL = 33,436

Aphanizomenon flos-aquae cells/mL = 7,387

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ28

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10206
Sample Depth:
Sample Date: 30-Aug-10

Total Density (#/mL): 170,767
Total Biovolume (um^3/mL): 177,282,408
Trophic State Index: 87.2

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	109,466	64.1	165,512,621	93.4	bluegreen
2	Microcystis aeruginosa	61,301	35.9	11,769,786	6.6	bluegreen

Aphanizomenon flos-aquae cells/mL = 2,627,184

Microcystis aeruginosa cells/mL = 1,471,223

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ29

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10207
Sample Depth:
Sample Date: 30-Aug-10

Total Density (#/mL): 60,658
Total Biovolume (um^3/mL): 18,951,789
Trophic State Index: 71.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	50,169	82.7	4,414,905	23.3	bluegreen
2	Aphanizomenon flos-aquae	10,488	17.3	14,536,884	76.7	bluegreen

Microcystis aeruginosa cells/mL = 551,863

Aphanizomenon flos-aquae cells/mL = 230,744

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ30

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10208
Sample Depth:
Sample Date: 30-Aug-10

Total Density (#/mL): 332,750
Total Biovolume (um^3/mL): 70,851,000
Trophic State Index: 80.6

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	330,000	99.2	42,240,000	59.6	bluegreen
2	Gloeotrichia echinulata	2,750	0.8	28,611,000	40.4	bluegreen

Microcystis aeruginosa cells/mL = 5,280,000

Gloeotrichia echinulata cells/mL = 420,750

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ31

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10209
Sample Depth:
Sample Date: 30-Aug-10

Total Density (#/mL): 3,764
Total Biovolume (um^3/mL): 312,231
Trophic State Index: 41.5

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	3,755	99.8	300,435	96.2	bluegreen
2	Gloeotrichia echinulata	9	0.2	11,795	3.8	bluegreen

Microcystis aeruginosa cells/mL = 37,554

Gloeotrichia echinulata cells/mL = 173

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** NQ32

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10210
Sample Depth:
Sample Date: 30-Aug-10

Total Density (#/mL): 2,343
Total Biovolume (um^3/mL): 681,303
Trophic State Index: 47.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	1,874	80.0	149,943	22.0	bluegreen
2	Aphanizomenon flos-aquae	469	20.0	531,360	78.0	bluegreen

Microcystis aeruginosa cells/mL = 18,743

Aphanizomenon flos-aquae cells/mL = 8,434

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ33