TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: August 16, 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 9 and August 16, 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 16, 2010

Five samples and one replicate, plus one blank for microcystin, were collected for public health purposes on August 16, 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 9 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.

The results of cyanobacteria species identification and enumeration are summarized in Table 2. Five cyanobacteria species capable of producing potentially harmful toxins were observed in the samples collected on August 9 and 16. *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* were observed at every location sampled. *Anabaena flos-aquae* was observed below Iron Gate dam on August 9 and in Copco reservoir at Mallard Cove on August 16. *Anabaena* sp. was observed below Iron Gate dam and in Iron Gate reservoir, but not in Copco reservoir. *Gloeotrichia echinulata* was observed at both cove sites in Iron Gate reservoir. In the sample from Mallard Cove in Copco reservoir *Microcystis aeruginosa*, *Aphanizomenon flos-aquae*, and *Anabaena flos-aquae* all exceeded 100,000 cells/mL. *Gloeotrichia echinulata* exceeded 100,000 cells/mL in the sample from Camp Creek in Iron Gate reservoir. At Camp Creek in Iron Gate reservoir and Copco Cove in Copco reservoir, *Microcystis aeruginosa* was near, but did not exceed, 100,000 cells/mL. All of the cell counts for the sampling location below Iron Gate dam were well below the public health guidelines.

Results from microcystin analyses for samples collected on August 16 are not yet available. Results for ELISA analysis of microcystin analysis through July 6 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 16, 2010.

Date	Sample	Location	Species	Biovolume, $\mu m^3/mL$	Cells/mL
08/09/10	KR10167	KRBI	*Microcystis aeruginosa*	3,723	465
			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
			Aphanizomenon flos-aquae	137,222	2,178
			Anabaena sp.	11,617	171
08/16/10	KR10169	IRCC	*Microcystis aeruginosa*	721,600	90,200
			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
			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
			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
			Microcystis aeruginosa	641,422	80,178
08/16/10	KR10173	KRBI (dup)	*Microcystis aeruginosa*	72,962	9,120
			Aphanizomenon flos-aquae	252,560	4,009
			Anabaena sp.	13,630	200

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
08/02/10	KR10161	IRJW	*Microcystis aeruginosa*	6,676,874	834,609	
			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	
08/02/10	KR10160	IRCC	*Aphanizomenon flos-aquae*	4,582,742	72,742	
			Microcystis aeruginosa	209,497	26,187	
			Anabaena flos-aquae	268,054	4,001	
08/02/10	KR10162	CRMC	*Microcystis aeruginosa*	18,766	2,346	
			Aphanizomenon flos-aquae	33,371	530	
			Anabaena flos-aquae	48,165	719	
08/02/10	KR10163	CRCC	*Microcystis aeruginosa*	2,573,707	321,713	
			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	
			Anabaena sp.	33,841	498	
			Anabaena flos-aquae	6,946	104	
08/09/10	KR10167	KRBI	*Microcystis aeruginosa*	3,723	465	
			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	
			Aphanizomenon flos-aquae	137,222	2,178	
			Anabaena sp.	11,617	171	
08/16/10	KR10169	IRCC	*Microcystis aeruginosa*	721,600	90,200	
			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	
			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	
			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	
			Microcystis aeruginosa	641,422	80,178	
08/16/10	KR10173	KRBI (dup)	*Microcystis aeruginosa*	72,962	9,120	
			Aphanizomenon flos-aquae	252,560	4,009	
			Anabaena sp.	13,630	200	

Appendix 2

Laboratory Data Sheets for August 16, 2010 Public Health Samples.

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10167
Sample Depth:
Sample Date: 9-Aug-10

Total Density (#/mL): 17
Total Biovolume (um^3/mL): 8,239
Trophic State Index: 16.0

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	12	70.0	3,723	45.2	bluegreen
2	Aphanizomenon flos-aquae	2	10.0	1,074	13.0	bluegreen
3	Anabaena sp.	2	10.0	1,159	14.1	bluegreen
4	Anabaena flos-aquae	2	10.0	2,284	27.7	bluegreen

Microcystis aeruginosa cells/mL = 465

Aphanizomenon flos-aquae cells/mL = 17

Anabaena sp. cells/mL = 17

Anabaena flos-aquae cells/mL = 34

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ04

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10168
Sample Depth:
Sample Date: 16-Aug-10

Total Density (#/mL): 636
Total Biovolume (um^3/mL): 188,814
Trophic State Index: 37.9

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	500	78.5	39,975	21.2	bluegreen
2	Aphanizomenon flos-aquae	128	20.1	137,222	72.7	bluegreen
3	Anabaena sp.	9	1.3	11,617	6.2	bluegreen

Microcystis aeruginosa cells/mL = 4,997

Aphanizomenon flos-aquae cells/mL = 2,178

Anabaena sp. cells/mL = 171

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ05

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10169
Sample Depth:
Sample Date: 16-Aug-10

Total Density (#/mL): 11,493
Total Biovolume (um^3/mL): 45,180,889
Trophic State Index: 77.3

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	9,020	78.5	721,600	1.6	bluegreen
2	Aphanizomenon flos-aquae	1,891	16.5	2,859,631	6.3	bluegreen
3	Gloeotrichia echinulata	509	4.4	41,550,194	92.0	bluegreen
4	Anabaena sp.	73	0.6	49,465	0.1	bluegreen

Microcystis aeruginosa cells/mL = 90,200

Aphanizomenon flos-aquae cells/mL = 45,391

Anabaena sp. cells/mL = 727

Gloeotrichia echinulata cells/mL = 611,032

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** NQ06

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10170
Sample Depth:
Sample Date: 16-Aug-10

Total Density (#/mL): 4,188
Total Biovolume (um^3/mL): 1,388,160
Trophic State Index: 52.2

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	3,221	76.9	257,714	18.6	bluegreen
2	Aphanizomenon flos-aquae	759	18.1	956,764	68.9	bluegreen
3	Gloeotrichia echinulata	138	3.3	93,882	6.8	bluegreen
4	Anabaena sp.	69	1.6	79,799	5.7	bluegreen

Microcystis aeruginosa cells/mL = 32,214

Aphanizomenon flos-aquae cells/mL = 15,187

Gloeotrichia echinulata cells/mL = 1,381

Anabaena sp. cells/mL = 1,174

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ07

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10171
Sample Depth:
Sample Date: 16-Aug-10

Total Density (#/mL): 565,253
Total Biovolume (um^3/mL): 711,673,490
Trophic State Index: 97.2

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	457,013	80.9	633,420,480	89.0	bluegreen
2	Microcystis aeruginosa	103,730	18.4	62,238,000	8.7	bluegreen
3	Anabaena flos-aquae	4,510	0.8	16,015,010	2.3	bluegreen

Microcystis aeruginosa cells/mL = 7,779,750

Aphanizomenon flos-aquae cells/mL = 10,054,293

Anabaena flos-aquae cells/mL = 239,030

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ08

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10172
Sample Depth:
Sample Date: 16-Aug-10

Total Density (#/mL): 70,657
Total Biovolume (um^3/mL): 87,458,922
Trophic State Index: 82.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	62,639	88.7	86,817,500	99.3	bluegreen
2	Microcystis aeruginosa	8,018	11.3	641,422	0.7	bluegreen

Aphanizomenon flos-aquae cells/mL = 1,378,056

Microcystis aeruginosa cells/mL = 80,178

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ09

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10173
Sample Depth:
Sample Date: 16-Aug-10

Total Density (#/mL): 1,173
Total Biovolume (um^3/mL): 339,152
Trophic State Index: 42.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	912	77.8	72,962	21.5	bluegreen
2	Aphanizomenon flos-aquae	251	21.4	252,560	74.5	bluegreen
3	Anabaena sp.	10	0.9	13,630	4.0	bluegreen

Microcystis aeruginosa cells/mL = 9,120

Aphanizomenon flos-aquae cells/mL = 4,009

Anabaena sp. cells/mL = 200

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ10