TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: June 8, 2009

E&S Environmental Chemistry, Inc.

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Introduction

This technical memorandum summarizes the latest results of monitoring during 2009 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 with a recent history of summertime blooms in Copco and Iron Gate reservoirs 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 12, Water Quality Monitoring, contained in the Klamath Hydroelectric Project Agreement in Principle (AIP) executed between the United States Department of Interior, the States of California and Oregon, and PacifiCorp.

The results specifically addressed in this memorandum are for samples collected on June 8, 2009. Subsequent memoranda such as this will be prepared every two weeks to report the results of continued monitoring. PacifiCorp plans to prepare a final report summarizing the results of the complete set of collected data after the conclusion of the sampling effort in winter 2009-2010.

Methods

PacifiCorp is conducting phytoplankton sampling for public health monitoring based on 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:

- Two open-water reservoir sites in the lower ends of Iron Gate and Copco reservoirs (near the log booms).

- 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.

Sampling will occur at the two open-water monitoring sites once per month in June through December and twice per month in June through October. 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.

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 (in draft). At the open-water reservoir sites public health samples will be collected according to the published SOP. Additional samples, including a grab sample at 0.5 meter (m) depth and an integrated sample over 8 m depth, will be collected as part of the baseline water quality monitoring.

Samples for phytoplankton speciation, density, and biovolume are preserved in Lugol's solution and sent to Aquatic Analysts in White Salmon, Washington for analysis. The laboratory analysis of phytoplankton speciation and density 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 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.

Table 1. Sites of Cyanobacteria and Microcystin Public Health Monitoring in Copco and Iron Gate Reservoirs during 2009

Location	Approximate River Mile	Site ID
Copco reservoir at Mallard Cove ramp	201.5	CRMC
Copco reservoir at Copco Cove ramp	200.0	CRCC
Copco reservoir near dam at log boom	198.6	CR01
Iron Gate reservoir at Camp Creek ramp	192.8	IRCC
Iron Gate reservoir at Williams campground	192.4	IRJW
Iron Gate reservoir near dam at log boom	190.2	IR01
Klamath River at Iron Gate Hatchery bridge	189.7	KRBI

Results

Samples of June 8, 2009

Five samples were collected for public health purposes on June 8, 2009. Samples were collected from Mallard Cove and Copco Cove in Copco reservoir, from Jay Williams campground and Camp Creek campground in Iron Gate reservoir, and from the Klamath River below Iron Gate dam near the Iron Gate hatchery bridge. Samples were sent to the EPA Region 9 laboratory for analysis for microcystin, and to Aquatic Analysts for cyanobacteria species identification and enumeration. Results for microcystin analysis are not yet available.

The results of cyanobacteria species identification and enumeration are summarized in Table 2. Two cyanobacteria species were present in the samples collected on June 8, 2009; *Anabaena flos-aquae*, and *Aphanizomenon flos-aquae*. Both species have been reported to produce anatoxin, a potentially dangerous neurotoxin (Codd et al 2005), although *Aphanizomenon* does not appear to produce toxins in Upper Klamath Lake or the Klamath River. *Aphanizomenon* was present at low abundance in Copco reservoir at Copco Cove, and in the Klamath River below Iron Gate dam near the hatchery bridge. *Anabaena flos-aquae* was present at all sites sampled. At the concentrations present, Anabaena could present a low to moderate risk of adverse health effects to individuals engaging in water contact recreation.[1] The abundance of *Anabaena flos-aquae* at Mallard Cove in Copco reservoir and at the Jay Williams campground in Iron Gate reservoir exceeds the California health advisory guidelines.[2] The abundance of cyanobacteria in the Klamath River below Iron Gate dam near the hatchery bridge was relatively low.

Table 2. Summary of cyanobacteria and microcystin public health monitoring results in Copco and Iron Gate Reservoirs on June 8, 2009.

Date	Location	Species	Biovolume, $\mu m^3/mL$	Rank	Cells/mL
6/8/09	CRMC	*Anabaena flos-aquae*	271,627,386	1	4,054,140
6/8/09	CRCC	*Anabaena flos-aquae*	1,019,824	2	15,221
		Aphanizomenon flos-aquae	9,471	26	150
6/8/09	IRJW	*Anabaena flos-aquae cells/mL*	18,829,827	1	281,042
6/8/09	IRCC	*Anabaena flos-aquae*	83,936	2	1,253
6/8/09	KRBI	*Aphanizomenon flos-aquae*	12,353	26	196
		Anabaena flos-aquae	9,306	27	139
CRMC = Copco reservoir at Mallard Cove ramp, CRCC = Copco reservoir at Copco Cove ramp, IRCC = Iron Gate reservoir at Camp Creek ramp, IRJW = Iron Gate reservoir at Williams campground, KRBI = Klamath River at Iron Gate Hatchery bridge					

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).

World Health Organization (WHO). 2003. Guidelines for safe recreational waters, Volume 1 – Coastal and fresh waters, Chapter 8: Algae and cyanobacteria in fresh water. WHO Publishing, Geneva, pp. 136-158.

[1] The World Health Organization (WHO) has recommended guidelines for safe recreational water environments based on a low, moderate, or high probability of adverse health effects from exposure to concentrations of cyanobacterial cells and microcystin toxins in recreational waters (WHO 2003). The WHO guideline values for low and moderate probability of adverse health in recreational waters are 20,000 and 100,000 cyanobacterial cells/mL, respectively. WHO equates these cell count values to microcystin toxin concentrations of 4 µg/L and 20 µg/L, respectively (WHO 2003). The WHO guideline for high probability of adverse health effects is a narrative; i.e., "Cyanbacterial scum formation in areas where whole-body contact and/or risk of ingestion/aspiration occur". No specific cyanobacterial cell or microcystin concentrations are provided by WHO for high probability of adverse health effects. The WHO (2003) guidance values were derived from calculations based on a 20 kg child that would swim for up to two hours (in a day) and would accidentally ingest 0.05 L of water per hour.

[2] The California State Water Resources Control Board (SWRCB 2007) and Oregon Department of Health Services (ODHS 2005) provide guidelines for posting advisories in recreation waters. These guidelines were developed using information provided in WHO (2003). Both SWRCB (2007) and ODHS (2005) recommend 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. Based on WHO (2003) information, SWRCB (2007) and ODHS (2005) indicate that cell counts of 40,000 and 100,000 cells/ml equate to microcystin toxin concentrations of 8 µg/L and 20 µg/L, respectively.