## TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: July 6, 2010

Environmental Chemistry, Inc.

**Prepared for:** Tim Hemstreet (PacifiCorp)
Linda Prendergast (PacifiCorp)

**Prepared by:** Richard Raymond

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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 July 6, 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 reservoir (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 integrated sample 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.

**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 |
| 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 July 6, 2010

Five samples, one replicate, and one blank were collected for public health purposes on July 6, 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. Results from microcystin analyses for samples collected on July 6 are not yet available. Results for microcystin analysis for earlier samples are included in Appendix 1. Samples collected on May 12, May 27, and June 7 were analyzed by LC/MS for nine congeners of microcystin, anatoxin a, Domoic acid, and okadaic acid, and all results have been below the method reporting limit.

The results of cyanobacteria species identification and enumeration are summarized in Table 2. Five cyanobacteria species capable of producing potentially harmful toxins were observed the the samples collected on July 6. *Anabaena flos-aquae* was observed in every sample. *Microcystis aeruginos*a was observed only in the sample below Iron Gate dam (KRBI). All species in all samples were present at less than 10,000 cells/mL.

**Table 2**. Summary of cyanobacteria public health monitoring on July 6, 2010.

| Date | Sample | Location | Species | Biovolume, $\mu m^3/mL$ | Cells/mL |
|---|---|---|---|---|---|
| 07/06010 | KR10117 | KRBI | *Anabaena flos-aquae* | 230,529 | 3,441 |
| | | | *Aphanizomenon flos-aquae* | 108,049 | 1,715 |
| | | | *Microcystis aeruginosa* | 2,117 | 256 |
| | | | *Anabaena planctonica* | 9,687 | 53 |
| 07/06010 | KR10118 | IRJW | *Anabaena flos-aquae* | 498,696 | 7,443 |
| | | | *Anabaena planctonica* | 136,085 | 744 |
| 07/06010 | KR10119 | IRCC | *Anabaena flos-aquae* | 643,510 | 9,605 |
| | | | *Aphanizomenon flos-aquae* | 19,731 | 313 |
| | | | *Anabaena sp.* | 16,565 | 244 |
| 07/06010 | KR10120 | CRCC | *Anabaena flos-aquae* | 76,049 | 568 |
| | | | *Aphanizomenon flos-aquae* | 35,755 | 1,135 |
| 07/06010 | KR10121 | CRMC | *Oscillatoria sp.* | 23,644 | 381 |
| | | | *Aphanizomenon flos-aquae* | 3,482 | 55 |
| | | | *Anabaena flos-aquae* | 7,406 | 111 |
| 07/06010 | KR10123 | KRBI (dup) | *Anabaena flos-aquae* | 166,633 | 2,487 |
| | | | *Aphanizomenon flos-aquae* | 74,370 | 1,180 |
| | | | *Microcystis aeruginosa* | 1,816 | 227 |

# 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 | |
| 07/06010 | KR10117 | KRBI | *Anabaena flos-aquae* | 230,529 | 3,441 | |
| | | | *Aphanizomenon flos-aquae* | 108,049 | 1,715 | |
| | | | *Microcystis aeruginosa* | 2,117 | 256 | |
| | | | *Anabaena planctonica* | 9,687 | 53 | |
| 07/06010 | KR10118 | IRJW | *Anabaena flos-aquae* | 498,696 | 7,443 | |
| | | | *Anabaena planctonica* | 136,085 | 744 | |
| 07/06010 | KR10119 | IRCC | *Anabaena flos-aquae* | 643,510 | 9,605 | |
| | | | *Aphanizomenon flos-aquae* | 19,731 | 313 | |
| | | | *Anabaena sp.* | 16,565 | 244 | |
| 07/06010 | KR10120 | CRCC | *Anabaena flos-aquae* | 76,049 | 568 | |
| | | | *Aphanizomenon flos-aquae* | 35,755 | 1,135 | |
| 07/06010 | KR10121 | CRMC | *Oscillatoria sp.* | 23,644 | 381 | |
| | | | *Aphanizomenon flos-aquae* | 3,482 | 55 | |
| | | | *Anabaena flos-aquae* | 7,406 | 111 | |
| 07/06010 | KR10123 | KRBI (blank) | *NA* | NA | NA | |
| 07/06010 | KR10123 | KRBI (dup) | *Anabaena flos-aquae* | 166,633 | 2,487 | |
| | | | *Aphanizomenon flos-aquae* | 74,370 | 1,180 | |
| | | | *Microcystis aeruginosa* | 1,816 | 227 | |

# Appendix 2

## Laboratory Data Sheets for July 6, 2010 Public Health Samples.

## Phytoplankton Sample Analysis

| | |
|---|---|
| **Sample:** | Klamath Basin |
| **Sample Site:** | KR 10117 |
| **Sample Depth:** | |
| **Sample Date:** | 6-Jul-10 |
| **Total Density (#/mL):** | 275 |
| **Total Biovolume (um$^3$/mL):** | 350,383 |
| **Trophic State Index:** | 42.3 |

| | Species | Density #/mL | Density Percent | Biovolume um$^3$/mL | Biovolume Percent | Group |
|---|---|---|---|---|---|---|
| 1 | Anabaena flos-aquae | 172 | 62.5 | 230,529 | 65.8 | bluegreen |
| 2 | Aphanizomenon flos-aquae | 95 | 34.6 | 108,049 | 30.8 | bluegreen |
| 3 | Microcystis aeruginosa | 5 | 1.9 | 2,117 | 0.6 | bluegreen |
| 4 | Anabaena planctonica | 3 | 1.0 | 9,687 | 2.8 | bluegreen |

| | |
|---|---|
| Anabaena flos-aquae cells/mL = | 3,441 |
| Aphanizomenon flos-aquae cells/mL = | 1,715 |
| Anabaena planctonica cells/mL = | 53 |
| Microcystis aeruginosa cells/mL = | 265 |

Note: Toxic Algae Only.

**Aquatic Analysts** **Sample ID:** NP72

## Phytoplankton Sample Analysis

| | |
|---|---|
| **Sample:** | Klamath Basin |
| **Sample Site:** | KR 10118 |
| **Sample Depth:** | |
| **Sample Date:** | 6-Jul-10 |
| **Total Density (#/mL):** | 365 |
| **Total Biovolume ($um^3$/mL):** | 634,781 |
| **Trophic State Index:** | 46.6 |

| | Species | Density #/mL | Density Percent | Biovolume $um^3$/mL | Biovolume Percent | Group |
|---|---|---|---|---|---|---|
| 1 | Anabaena flos-aquae | 324 | 88.7 | 498,696 | 78.6 | bluegreen |
| 2 | Anabaena planctonica | 41 | 11.3 | 136,085 | 21.4 | bluegreen |

| | |
|---|---|
| Anabaena planctonica cells/mL = | 744 |
| Anabaena flos-aquae cells/mL = | 7,443 |

Note: Toxic Algae Only.

Note: very much debris and "other" algae in sample (mostly periphytic species).

**Aquatic Analysts** **Sample ID:** NP73

## Phytoplankton Sample Analysis

| | |
|---|---|
| **Sample:** | Klamath Basin |
| **Sample Site:** | KR 10119 |
| **Sample Depth:** | |
| **Sample Date:** | 6-Jul-10 |
| **Total Density (#/mL):** | 418 |
| **Total Biovolume (um$^3$/mL):** | 679,806 |
| **Trophic State Index:** | 47.1 |

| | Species | Density #/mL | Density Percent | Biovolume um$^3$/mL | Biovolume Percent | Group |
|---|---|---|---|---|---|---|
| 1 | Anabaena flos-aquae | 400 | 95.8 | 643,510 | 94.7 | bluegreen |
| 2 | Aphanizomenon flos-aquae | 10 | 2.5 | 19,731 | 2.9 | bluegreen |
| 3 | Anabaena sp. | 7 | 1.7 | 16,565 | 2.4 | bluegreen |

| | |
|---|---|
| Anabaena flos-aquae cells/mL = | 9,605 |
| Anabaena sp. cells/mL = | 244 |
| Aphanizomenon flos-aquae cells/mL = | 313 |

Note: Toxic Algae Only.

**Aquatic Analysts** **Sample ID:** NP74

## Phytoplankton Sample Analysis

| | |
|---|---|
| **Sample:** | Klamath Basin |
| **Sample Site:** | KR 10120 |
| **Sample Depth:** | |
| **Sample Date:** | 6-Jul-10 |
| **Total Density (#/mL):** | 95 |
| **Total Biovolume ($um^3$/mL):** | 111,804 |
| **Trophic State Index:** | 34.1 |

| | Species | Density #/mL | Density Percent | Biovolume $um^3$/mL | Biovolume Percent | Group |
|---|---|---|---|---|---|---|
| 1 | Anabaena flos-aquae | 57 | 60.0 | 76,049 | 68.0 | bluegreen |
| 2 | Aphanizomenon flos-aquae | 38 | 40.0 | 35,755 | 32.0 | bluegreen |

Aphanizomenon flos-aquae cells/mL = 568

Anabaena flos-aquae cells/mL = 1,135

Note: Toxic Algae Only.

Note: very high debris and "other" algae (mostly periphytic species).

**Aquatic Analysts** **Sample ID:** NP75

## Phytoplankton Sample Analysis

| | |
|---|---|
| **Sample:** | Klamath Basin |
| **Sample Site:** | KR 10121 |
| **Sample Depth:** | |
| **Sample Date:** | 6-Jul-10 |
| **Total Density (#/mL):** | 28 |
| **Total Biovolume ($um^3$/mL):** | 34,532 |
| **Trophic State Index:** | 25.8 |

| | Species | Density #/mL | Density Percent | Biovolume $um^3$/mL | Biovolume Percent | Group |
|---|---|---|---|---|---|---|
| 1 | Oscillatoria sp. | 17 | 60.0 | 23,644 | 68.5 | bluegreen |
| 2 | Aphanizomenon flos-aquae | 6 | 20.0 | 3,482 | 10.1 | bluegreen |
| 3 | Anabaena flos-aquae | 6 | 20.0 | 7,406 | 21.4 | bluegreen |

| | |
|---|---|
| Oscillatoria sp. cells/mL = | 381 |
| Aphanizomenon flos-aquae cells/mL = | 55 |
| Anabaena flos-aquae cells/mL = | 111 |

Note: Toxic Algae Only.

Note: much debris and "other" algae.

**Aquatic Analysts** **Sample ID:** NP76

## Phytoplankton Sample Analysis

| | |
|---|---|
| **Sample:** | Klamath Basin |
| **Sample Site:** | KR 10123 |
| **Sample Depth:** | |
| **Sample Date:** | 6-Jul-10 |
| **Total Density (#/mL):** | 250 |
| **Total Biovolume ($um^3$/mL):** | 242,819 |
| **Trophic State Index:** | 39.7 |

| | Species | Density #/mL | Density Percent | Biovolume $um^3$/mL | Biovolume Percent | Group |
|---|---|---|---|---|---|---|
| 1 | Anabaena flos-aquae | 146 | 58.6 | 166,633 | 68.6 | bluegreen |
| 2 | Aphanizomenon flos-aquae | 98 | 39.4 | 74,370 | 30.6 | bluegreen |
| 3 | Microcystis aeruginosa | 5 | 2.0 | 1,816 | 0.7 | bluegreen |

| | |
|---|---|
| Anabaena flos-aquae cells/mL = | 2,487 |
| Aphanizomenon flos-aquae cells/mL = | 1,180 |
| Microcystis aeruginosa cells/mL = | 227 |

Note: Toxic Algae Only.

**Aquatic Analysts** **Sample ID:** NP77