

TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project:

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Introduction

This technical memorandum summarizes the results for the 2015 public health monitoring for cyanobacteria species and an associated toxin, microcystin, in Copco and Iron Gate reservoirs within PacifiCorp's Klamath Hydroelectric Project (Project) and in the Klamath River below Iron Gate Dam. This monitoring is particularly focused on *Microcystis aeruginosa* (MSAE), which is known to produce microcystin. This monitoring also assesses the presence of other potentially-toxic cyanobacteria, including *Anabaena* sp., and others. 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.

Results from the public health sampling are used to determine if public health advisories are warranted¹. In addition to PacifiCorp's website (www.pacificorp.com/es/hydro/hl/kr.html#), these memos are also posted on the Klamath Basin Monitoring Program's (KBMP) website (www.kbmp.net) and inform the Blue Green Algae tracker on the KBMP website.

The data in Appendix 1 summarize results from all of the 2015 sampling events.

Methods

PacifiCorp is conducting public health sampling at five sites (Table 1) for laboratory analysis of potentially toxic cyanobacteria, notably MSAE, and microcystin at:

- 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.

Samples are planned to be taken at shoreline locations in the reservoirs once in May; and twice per month in June, July, August, September, October, and November. Samples to be collected from the river site below Iron Gate Dam are scheduled to be collected according to the discretion of the sampling entity (PacifiCorp) based on river conditions.

¹ The California State Water Resources Control Board provides guidelines for posting advisories in recreation water (SWRCB 2010). SWRCB recommends 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 toxic BGA is 100,000 cells/ml or greater, or 4) if microcystin is 8 µg/L or greater.

Table 1. Sites of cyanobacteria and microcystin public health monitoring in Copco and Iron Gate reservoirs and the Klamath River during 2015.

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

Public health samples are taken as grab samples offshore according to the standard operating procedure (SOP) developed by the Klamath Blue Green Algae Working Group (www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring). Samples collected for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. The samples are labeled rushed for timely analysis and only potentially toxic cyanobacteria are identified and enumerated. However, once the reservoirs are posted with health advisories signs, the reservoir samples are collected but not rushed until it visually appears that the algae bloom conditions have waned. 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 0.18 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 measurable microcystin variants.

Results

| Date | Time | Location | RM | Sample ID | Depth | MSAE ⁽¹⁾ | AFA ⁽²⁾ | ANA ⁽³⁾ | Other ^{(5), (6), (7), (8), (9), or (10)} | Microcystin (µg/L) |
|------------|-------|----------|-------|-----------|-------|---------------------|--------------------|--------------------|---|--------------------|
| 06/22/2015 | 10:30 | CRMC | 201.5 | KR15809 | SG | 0 | 0 | 0 | 0 | * |
| 06/22/2015 | 12:05 | CRCC | 200.0 | KR15810 | SG | 2,373,318 | 0 | 218,262 | 0 | * |
| 06/22/2015 | 12:29 | IRCC | 192.8 | KR15811 | SG | 0 | 0 | 18,401 | 0 | * |
| 06/22/2015 | 12:40 | IRJW | 192.4 | KR15812 | SG | 0 | 0 | 678 | 0 | * |
| 06/22/2015 | 16:30 | KRBI | 189.7 | KR15813 | SG | 0 | 18 | 335 | 0 | * |

¹MSAE = *Microcystis aeruginosa* (cells/mL)

²AFA = *Aphanizomenon flos-aquae* (cells/mL)

³ANA = *Anabaena flos-aquae* (cells/mL)

Other = either ⁵*Planktothrix (Oscillatoria) sp.* or ⁶*Gloeotrichia echinulata* or ⁷*Anabaena sp.* or ⁸*Lyngbya sp.* (cells/mL) or

⁹*Anabaena circinalis* (cells/mL) or ¹⁰*Anabaena planctonica* (cells/mL)

“0” value indicates non-detect by analytical laboratory

* Results were not available upon the date this memo was submitted and will be included in Appendix 1 of subsequent memos

References

SWRCB. 2010. Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. July 2010. 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

Cyanobacteria Species data for 2015 Public Health Samples

Table 3. Summary of 2015 laboratory algal identification and enumeration

| Date | Time | Location | RM | Sample ID | Depth | MSAE ⁽¹⁾ | AFA ⁽²⁾ | ANA ⁽³⁾ | Other ^{(5), (6), (7), (8), (9), or (10)} | Microcystin (µg/L) |
|------------|-------|----------|-------|-----------|-------|---------------------|--------------------|--------------------|---|--------------------|
| 5/18/2015 | 16:00 | CRMC | 201.5 | KR15800 | SG | 0 | 0 | 0 | 0 | ND |
| 5/18/2015 | 17:00 | CRCC | 200.0 | KR15801 | SG | 0 | 0 | 0 | 0 | ND |
| 5/18/2015 | 17:40 | IRCC | 192.8 | KR15802 | SG | 0 | 0 | 0 | 0 | ND |
| 5/18/2015 | 18:05 | IRJW | 192.4 | KR15803 | SG | 0 | 0 | 0 | 0 | ND |
| 06/08/2015 | 9:00 | CRMC | 201.5 | KR15804 | SG | 0 | 139 | 104 | 0 | .20 |
| 06/08/2015 | 10:20 | CRCC | 200.0 | KR15805 | SG | 0 | 0 | 967 | 0 | ND |
| 06/08/2015 | 11:00 | IRCC | 192.8 | KR15806 | SG | 0 | 0 | 841 | 0 | ND |
| 06/08/2015 | 11:10 | IRJW | 192.4 | KR15807 | SG | 0 | 0 | 324 | 1,060 ⁷ | ND |
| 06/08/2015 | 18:30 | KRBI | 189.7 | KR15808 | SG | 0 | 0 | 163 | 0 | ND |
| 06/22/2015 | 10:30 | CRMC | 201.5 | KR15809 | SG | 0 | 0 | 0 | 0 | * |
| 06/22/2015 | 12:05 | CRCC | 200.0 | KR15810 | SG | 2,373,318 | 0 | 218,262 | 0 | * |
| 06/22/2015 | 12:29 | IRCC | 192.8 | KR15811 | SG | 0 | 0 | 18,401 | 0 | * |
| 06/22/2015 | 12:40 | IRJW | 192.4 | KR15812 | SG | 0 | 0 | 678 | 0 | * |
| 06/22/2015 | 16:30 | KRBI | 189.7 | KR15813 | SG | 0 | 18 | 335 | 0 | * |

¹MSAE = *Microcystis aeruginosa* (cells/mL)

²AFA = *Aphanizomenon flos-aquae* (cells/mL)

³ANA = *Anabaena flos-aquae* (cells/mL)

Other = either ⁵*Planktothrix (Oscillatoria) sp.* or ⁶*Gloeotrichia echinulata* or ⁷*Anabaena sp.* or

⁸*Lyngbya sp.* (cells/mL) or ⁹*Anabaena circinalis* (cells/mL) or ¹⁰*Anabaena planctonica* or

¹¹*Planktothrix (Oscillatoria) limosa*

“0” value indicates non-detect by analytical laboratory

“NA” value indicates sample loss

“ND” value indicates result less than quantitation limit (0.18 µg/L) by analytical laboratory

* Results were not available upon the date this memo was submitted and will be included in subsequent memos

Appendix 2 – Laboratory Phytoplankton Results

| Phytoplankton Sample Analysis | | | | | |
|--|---------------|---------|---------------------|-----------|-------|
| Sample: | Klamath Basin | | | | |
| Sample Site: | KR 15809 | | | | |
| Sample Depth: | | | | | |
| Sample Date: | 22-Jun-15 | 1030 | | | |
| Total Density (#/mL): | <4 | | | | |
| Total Biovolume (um ³ /mL): | | | | | |
| Trophic State Index: | | | | | |
| | Density | Density | Biovolume | Biovolume | |
| Species | #/mL | Percent | um ³ /mL | Percent | Group |
| ----- | | | | | |
| 1 No Toxic Algae Present | <4 | | | | |

| Phytoplankton Sample Analysis | | | | | |
|--|---------------|---------|---------------------|-----------|-----------|
| Sample: | Klamath Basin | | | | |
| Sample Site: | KR 15810 | | | | |
| Sample Depth: | | | | | |
| Sample Date: | 22-Jun-15 | 1205 | | | |
| Total Density (#/mL): | 245,127 | | | | |
| Total Biovolume (um ³ /mL): | 33,610,079 | | | | |
| Trophic State Index: | 75.2 | | | | |
| | Density | Density | Biovolume | Biovolume | |
| Species | #/mL | Percent | um ³ /mL | Percent | Group |
| ----- | | | | | |
| 1 Microcystis aeruginosa | 237,332 | 96.8 | 18,986,543 | 56.5 | bluegreen |
| 2 Anabaena flos-aquae | 7,795 | 3.2 | 14,623,536 | 43.5 | bluegreen |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Microcystis aeruginosa cells/mL = | 2,373,318 | | | | |
| Anabaena flos-aquae cells/mL = | 218,262 | | | | |

| Phytoplankton Sample Analysis | | | | | |
|--|--------------------------------|---------------|---------|---------------------|-----------|
| Sample: | | Klamath Basin | | | |
| Sample Site: | | KR 15811 | | | |
| Sample Depth: | | | | | |
| Sample Date: | | 22-Jun-15 | 1225 | | |
| Total Density (#/mL): | | 657 | | | |
| Total Biovolume (um ³ /mL): | | 1,232,854 | | | |
| Trophic State Index: | | 51.4 | | | |
| | | Density | Density | Biovolume | Biovolume |
| Species | | #/mL | Percent | um ³ /mL | Percent |
| ----- | | | | | |
| 1 | Anabaena flos-aquae | 657 | 100.0 | 1,232,854 | 100.0 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | Anabaena flos-aquae cells/mL = | 18,401 | | | |

| Phytoplankton Sample Analysis | | | | | |
|--|--------------------------------|---------------|---------|---------------------|-----------|
| Sample: | | Klamath Basin | | | |
| Sample Site: | | KR 15812 | | | |
| Sample Depth: | | | | | |
| Sample Date: | | 22-Jun-15 | 1240 | | |
| Total Density (#/mL): | | 34 | | | |
| Total Biovolume (um ³ /mL): | | 45,439 | | | |
| Trophic State Index: | | 27.7 | | | |
| | | Density | Density | Biovolume | Biovolume |
| Species | | #/mL | Percent | um ³ /mL | Percent |
| ----- | | | | | |
| 1 | Anabaena flos-aquae | 34 | 100.0 | 45,439 | 100.0 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | Anabaena flos-aquae cells/mL = | 678 | | | |

| Phytoplankton Sample Analysis | | | | | |
|---|---------------------|------------------------|------------------------------------|--------------------------|--------------|
| Sample: Klamath Basin | | | | | |
| Sample Site: KR 15813 | | | | | |
| Sample Depth: | | | | | |
| Sample Date: 22-Jun-15 | | 1630 | | | |
| Total Density (#/mL): | | 18 | | | |
| Total Biovolume (um³/mL): | | 23,542 | | | |
| Trophic State Index: | | 23.1 | | | |
| Species | Density #/mL | Density Percent | Biovolume um³/mL | Biovolume Percent | Group |
| 1 Anabaena flos-aquae | 16 | 88.9 | 22,413 | 95.2 | bluegreen |
| 2 Aphanizomenon flos-aquae | 2 | 11.1 | 1,129 | 4.8 | bluegreen |
| Anabaena flos-aquae cells/mL = | | 335 | | | |
| Aphanizomenon flos-aquae cells/mL = | | 18 | | | |