Freshwater Algae Control Program

Lake Cyanobacteria Management Plan Template Guidance

Fiscal Year 2020 Guidance

Please review the Lake Cyanobacteria Management Plan template before applying to the Freshwater Algae Control Program (FACP). *This template lists numerous elements that might be included in a detailed Cyanobacteria Plan. Not all elements may be appropriate for your project. In the application, explain what elements are or are not applicable to your project and why.*

A. Title Page with Approvals
   a. *Lake name* Cyanobacteria Management Plan
   b. *Lake, County*
   c. *Your organization name*
   d. *Date*
   e. *Page with all key individuals listed and signatures*

B. Table of Contents

C. Table of Figures and Tables

D. Executive Summary - *briefly describe the problem, the results of the monitoring and analyses, and the recommended lake restoration plan.*

E. Background
   a. Study area
      i. Lake and watershed. *Describe the lake (acres, min and max depth, bathymetry, trophic status), shoreline (topography/slopes) and watershed (size in acres) with any tributary streams and significant wetlands; provide lake and watershed maps.*
      ii. Beneficial uses of the lake – *describe (quantify if possible) the use of the lake for swimming, fishing, boating, wildlife habitat and other uses.*
      iii. Current and historical land uses – *describe current and historical land uses or activities, such as homes, businesses, septic systems, livestock, etc. within the watershed or along tributary streams that may be impacting or have impacted the lake; also describe the level of development or alteration of the immediate shoreline of the lake (bulkheads, fills, etc.).*
      iv. Number and location of houses on septic – *provide a map if possible (https://www.doh.wa.gov/CommunityandEnvironment/WastewaterManagement/OnsiteSewageSystemsOSS). Also try searching for OSS at your county health dept. https://www.doh.wa.gov/AboutUs/PublicHealthSystem/LocalHealthJurisdictions*
      v. Water use – *explain whether any residents use the lake water as a drinking or domestic water source.*
      vi. Water withdrawals – *describe any surface water rights owned or used by residents* (https://fortress.wa.gov/ecy/waterresources/map/WaterResourcesExplorer.aspx)

vii. Fisheries – *describe the frequency of current and past fish stocking and how many fish have been stocked (in kg/ha); also estimate the numbers and types of fish caught. Describe the presence and general abundance of fish or other species that may disturb the lake sediments (bioturbation) such as carp.*

viii. Aquatic plants – *describe the relative density of aquatic plants in the lake (both submersed and emergent) and both historical and recent actions to control aquatic plants in the lake.*

ix. Endangered/rare species present (https://wdfw.wa.gov/conservation/endangered/All/#)

b. Water quality history

i. Past water quality conditions – *describe what is known about past water quality (problems or absence of problems, caused by algal blooms, toxic algae, fecal bacteria, invasive or nuisance aquatic plants, etc.). Provide summary data of past water quality conditions, such as water clarity, nutrient levels, toxic algae concentrations, nutrient loading, etc.*

ii. Efforts to improve water quality – *describe past and ongoing actions taken to reduce nutrients, control algae, reduce human health risks, etc., including BMPs, in-lake measures, capital projects and community involvement.*

c. Current conditions

i. Water quality – *describe in detail the current problems with toxic or nuisance algae and the impact on beneficial uses of the lake; provide a summary of any recent monitoring data or other information that explains the water quality conditions, the impacts to beneficial uses and known or suspected drivers of toxic algae production.*

ii. Contaminants of concern

1. Cyanotoxins – *describe cyanotoxins that have been a problem in the lake.*
2. 303d list status – *describe any state listing of pollutants (phosphorus, nitrogen, fecal bacteria, low DO, temperature, etc.) for the lake and tributary streams.*
3. TMDLs – *list any TMDL reports approved by Ecology and the EPA. List any TMDL plans that have been implemented.*
4. Regulatory criteria of contaminants and cyanotoxins – *list the regulatory criteria for the cyanotoxins and pollutants in the lake. Both federal and state standards.*

- EPA Nutrient Policy Guidelines – (*https://www.epa.gov/nutrient-policy-data/guidelines-and-recommendations#what3)*
- EPA Production Files –(*https://www.epa.gov/sites/production/files/2017-07/documents/08_july_3_monitoring_document_508c_7.5.17.pdf)*

iii. Public participation – *list the various stakeholders for this project and describe their participation in developing the proposed management plan, including monitoring, committees, public meetings, publicity, etc.*

iv. Public support – *describe public support for the proposed management plan as evidenced by political support, financial support, the level of public participation, the willingness of residents to implement BMPs, etc.*

F. Project Description

a.

b. Project goals and objectives

c. Project schedule

G. Monitoring Methods and Results

Notes:

- *Residents and other trained volunteer citizen scientists can perform most of the following monitoring tasks in order to keep the costs down and help with the education of residents and lake users.*
- *Some of the following monitoring elements may not be appropriate for your specific lake, but you should provide reasonable justification for excluding those elements.*
- *Monitoring elements a through d must be performed within the same one-year period in order to develop valid water and nutrient budgets for the lake. Monitoring elements e through g, although not required for the water and nutrient budgets, should also be performed within the same one-year period if at all possible because they reflect or may impact the nutrient levels in the lake for that one-year period. Monitoring elements h through j can be performed in a subsequent year, or under a separate grant if they cannot be funded under the original grant.*

a. Lake level, stream inflows/outflows, groundwater, and precipitation/evaporation

i. Monitoring methods – *describe the methods used to measure or estimate lake levels, steam inflows, outlet flows, groundwater inflows/outflows and precipitation/evaporation. These components of the water budget must be monitored for at least one year to develop a lake water budget that corresponds with the period of water quality monitoring.*

ii. Monitoring results – *describe the results and significance of lake level, steam inflows/outflows, groundwater, and precipitation/evaporation monitoring; provide data tables and graphs where appropriate. If the monitoring year is unusual (extremely wet or dry) describe how this may have affected the water quality conditions of the lake.*

b. Lake water quality profile monitoring – Field measurements

i. Monitoring methods – *describe the methods used to collect field monitoring data within the lake.*

- Timing – *lake profile data should be collected for at least one full year, with biweekly measurements during the growing season (approx. March – early November for many lakes) and monthly measurements during the remainder of the year (approximately late November – March).*
- Location – *for most lakes, profile measurements can be taken at one location at the deepest point in the lake. For larger, or more complex lake systems, two or more profile monitoring locations may be appropriate*.
- Depths – *profile measurements should be collected at each meter down through the entire water column unless the lake depth is greater than 20 meters, in which case measurements in the hypolimnion may be taken every two to five meters down to one meter above the lake bottom, depending on the depth of the lake. (Note: profile measurements should be taken at the same depths during both the mixed and stratified periods).*
- Parameters – profile monitoring should include the following parameters:
  - Temperature
  - Dissolved oxygen
  - pH
  - Conductivity
  - Secchi depth *should also be measured at every sampling event.*

ii. Monitoring results – *describe the results and significance of water quality profile monitoring; provide data tables and graphs where appropriate. In particular, describe the timing and strength of lake stratification and associated anoxia in the hypolimnion.*

c. Lake water quality sampling – Lab samples

i. Monitoring methods – *describe the methods used to collect and analyze water samples from the lake.*

- Timing – *lake samples should be collected every month for at least one full year.*
- Location – *sampling should be performed at one location in the deepest point of the lake, unless the lake is large or complex.*
- Depths – *at a minimum, discrete samples of the epilimnion and hypolimnion should be collected from one meter deep and from one meter above the lake bottom. In addition, during the stratified period, a sample should be taken from the metalimnion. For lakes greater than 20 meters deep, at least one additional epilimnion sample and one or more additional hypolimnion samples should be taken at depths that will help characterize the conditions throughout the lake water column.*

- *In some cases, (funding or comparability with past data) the discrete epilimnion samples may be composited into a single sample and the hypolimnion samples may be composited into a second sample, provided that the samples from discrete depths that will be composited are spaced so as to be representative of the entire epilimnion and the entire hypolimnion, respectively. During the stratified period, a separate discrete or composited metalimnion sample should also be collected.*
- Parameters – Lake monitoring should include the following parameters:
  - Phosphorus (TP and SRP)
  - Nitrogen (ammonium (NH4) and nitrate-nitrite (NO3 – NO2 or total persulfate N)
  - Chlorophyll a/Phaeophytin *(discrete samples should be collected from 1 meter deep and from the metalimnion, no hypolimnion samples necessary)*

ii. Monitoring results – *describe the results and significance of lake water quality monitoring; provide data tables and graphs where appropriate. Part of the description of water quality sampling results should address phosphorus versus nitrogen limitation (or other environmental limiters) throughout the year in the production of algae in the lake.*

d. Stream water quality sampling – Lab samples and field measurements

i. Monitoring methods – *describe the methods used to collect (typically grab samples) and analyze water samples from inflowing streams. The lake outflow does not need to be sampled because the results are normally very similar to the near-surface lake samples.*

- Timing – *inflow stream grab samples should be collected at regular intervals (at least monthly) during the portion of the year when the streams are flowing. In addition, grab samples during periods of storm flows are recommended to help characterize the impacts of peak flows on the lake.*
- Location – *stream sampling should be conducted in each significant inflowing stream at one location that corresponds with the location used to measure the velocity and cross section for stream flows. Samples should be taken from the center of each stream at wrist depth.*
- Parameters – *stream monitoring should include the following parameters:*
  - Phosphorus *(TP and SRP)*
  - Temperature
  - Dissolved oxygen
  - pH
  - Conductivity *(all measured with a field probe in the same location as water samples were collected)*

ii. Monitoring results – *describe the results and significance of stream water quality monitoring; provide data tables and graphs where appropriate.*

e. Phytoplankton sampling

i. Monitoring methods – *describe the methods used to collect and analyze phytoplankton in the lake.*

- Timing – *phytoplankton samples should be collected monthly during the growing season from March through October (or over a longer period if the lake is known to produce algal blooms outside of this period). During algal blooms, shoreline grab samples may also be taken to augment monthly sampling.*
- Location – *sampling should be performed at one location in the deepest point of the lake, provided that additional shoreline grab samples may be collected during algal blooms.*
- Sample depths – *discrete samples should be collected from one meter deep and from the metalimnion (no samples from the hypolimnion); alternatively, discrete samples may be collected from multiple depths within the photic zone and composited into one sample.*
- Parameters –
  - Species present – *identification to specie (where possible), genus or division of the phytoplankton found in the sample.*
  - Concentration – *counts of numbers of individual cells or colonies per liter of each algal specie/genus/division identified in the sample.*

ii. Monitoring results –*describe the results and significance of phytoplankton sampling; provide data tables and graphs where appropriate.*

f. Zooplankton sampling

i. Monitoring methods - *describe the methods used to collect and analyze zooplankton in the lake.*

- Timing – *zooplankton samples should be collected monthly during the growing season from March through October.*
- Location – *sampling should be performed at one location in the deepest point of the lake.*
- Sample depth – *a single zooplankton sample should be collected by a continuous net tow (80 µ net) from one meter above the lake bottom to the lake surface.*
- Parameters
  - Species present – *identification to specie, genus or division (whichever is appropriate) of the zooplankton found in the sample.*
  - Concentration – *counts of numbers of individuals per liter of each zooplankton specie/genus/division identified in the sample.*

ii. Monitoring results –*describe the results and significance of zooplankton sampling; provide data tables and graphs where appropriate.*

g. Waterfowl survey – *record the types and number of waterfowl observed on the lake; weekly early morning and/or early evening observations should be conducted; provide average monthly waterfowl usage.*

The following tasks may be performed in a subsequent year and/or a subsequent grant:

h. Vegetation surveys – *provide maps where appropriate.*
   i. Submersed plants – *explain the sampling/observation methods used and describe the plant species present and percent cover or relative density of plant species or groups of species that grow primarily underwater within the lake; indicate native versus invasive species.*
   ii. Emergent plants – *explain the sampling/observation methods used and describe the plant species present and percent cover or relative density of plant species or groups of species that grow primarily above the water of the lake; indicate native versus invasive species.*
   iii. Shoreline plants – *explain the sampling/observation methods used and describe the plant types (tree/shrub/herb/lawn) present and the percent cover or relative density of plant types around the lake shore; indicate native versus invasive species.*

i. Shoreline modification survey – *conduct a survey of the lake shore to determine the length or percent of the shoreline that has been modified with bulkheads, fill, or other changes to the natural shoreline.*

j. Lake sediment sampling
   i. Monitoring methods – *describe the methods used to collect and analyze sediment cores from the lake bottom.*
      - Location – *one sediment core should be taken from the deepest portion of the lake; in addition, at least one sediment core should be collected from a site closer to the shore, representing the mid-depth littoral area; depending on the size and complexity of the lake, additional cores may be warranted.*
      - Depths – *sediment cores should be at least 30 cm in length and should be segmented by the lab into 5 cm thick sections for analysis.*
      - Parameters – *sediment core sections should be analyzed for the following parameters:*

- TP, Loosely sorbed P, Fe-P, Al-P, Ca-P, Org P, Biogenic P, Total Calcium, Total Fe, Total Al, % water, % solid

ii. Monitoring results – *describe the results and significance of the sediment core analyses, including the changes in phosphorus concentrations with depth (back in time); provide data tables and graphs where appropriate.*

The following elements of the plan may be completed under a subsequent grant if necessary or may be completed by limnology graduate students as part of their graduate work:

H. Hydrologic Budget

a. Description of water budget components – *describe how each of the components of the lake water budget were derived for the monitoring year (either through direct measurement, estimations, or calculations of unmonitored components). If the monitoring year was unusually wet or dry, explain how that may have affected water quality conditions in the lake.*

b. Inflows – *describe the inflow side of the water budget and the significance of the components to conditions in the lake; provide graphs, charts, and data tables as appropriate. Inflows should include the following components:*

- stream/inlet flows
- surface runoff and shallow groundwater inflows *(This is water that runs off directly into the lake from surrounding properties, either over the surface or just underground, without flowing through monitored streams. This is typically estimated from land use runoff tables.)*
- precipitation
- groundwater inputs

c. Outflows – *describe the outflow side of the water budget and the significance of the components to conditions in the lake; describe the residence time of water entering and leaving the lake; provide graphs, charts, and data tables as appropriate. Outflows should include the following components:*

- lake outlet flows
- evaporation
- groundwater losses *(these outflows are normally calculated as the remaining unknown portion of the water budget)*

I. Nutrient Budget and Phosphorus Model

Notes: In almost all cases, the lake nutrient budget will focus on phosphorus because phosphorus is the nutrient that drives production of toxic cyanobacteria. Even if algal production is limited by nitrogen or other factors during much of the year, reduction of phosphorus will be the primary mechanism for controlling toxic blooms.

a. External phosphorus loading – *describe and quantify the sources of phosphorus entering the lake; provide data tables and graphs as appropriate. For a phosphorus budget, external loading from individual sources should be summarized for the entire year. External loading should include the following components:*

- inlet streams *(calculated from measured stream flows and water sample results; results should be provided for individual streams or reaches of streams if data are available)*
- direct precipitation on the lake surface
- surface runoff and shallow groundwater *(normally estimated)*
- groundwater *(unless groundwater flows and nutrient concentrations were actually measured, this component is normally calculated as the remaining unknown portion of phosphorus loading)*
- other sources – *characterize and quantify other specific sources of phosphorus that contribute to the external loading components described above, including estimates of loading from septic systems based on the density and age of systems and topography surrounding the lake, waterfowl around the lake, pet waste in the watershed, fish stocked in the lake, and unique land uses (such as livestock or other farm, commercial or industrial land uses) that may be particular sources of nutrients.*

b. Internal phosphorus loading – *describe and quantify the amount of phosphorus entering the lake from the lake sediments; provide data tables and graphs as appropriate. The release of phosphorus from lake sediments should be calculated from the results of the sediment cores and the variations in hypolimnetic phosphorus concentrations throughout the year. For a phosphorus budget, internal loading from the sediments should be summarized for the entire year.*

c. Phosphorus model – *the purpose of a phosphorus model is to quantify the changes in phosphorus mass and concentration within the lake (or ideally within the epilimnion and hypolimnion) throughout the year and to evaluate the effects of various algae control methods on phosphorus concentrations in the lake. The phosphorus model may be a simple spreadsheet or a more sophisticated construct.*

i. Model description – *describe the phosphorus model developed for this lake; the model should produce calculations of phosphorus concentrations and the changes in phosphorus mass in the lake for each month (or at more frequent time steps if data are available) and should be summarized for the stratified period and the mixed period of the year. Where possible, the model should look at phosphorus concentrations in both the epilimnion and hypolimnion layers. In addition to external and internal phosphorus loading, the model should take into consideration the movements (flux) of phosphorus through sediment release,*

sedimentation, and lake outlet outflow. Diffusion and entrainment are two other movements of phosphorus that may be estimated if the model is set up to calculate the flux between the epilimnion and hypolimnion.

ii. Model results – *describe the results of the phosphorus model in replicating the actual changes in phosphorus concentrations measured throughout the year and any calibrations that were needed to improve the model. Also, describe the impacts of various algae control methods on future phosphorus concentrations in the lake as predicted by the model. The model should look at the impacts in the first year after implementation as well as at the potential impacts several years later.*

J. Management Methods for Cyanobacteria Control and Lake Restoration

a. Direct Algae Control Methods – *describe common methods of direct algae control, including algaecides and physical inhibitors.*

b. Internal Loading Control Methods – *describe common methods of internal loading control, including dredging, artificial circulation (aeration), hypolimnetic aeration, hypolimnetic withdrawal, iron application, alum treatment, lanthanum treatment, etc.*

c. External Loading Control Methods – *describe common methods of external loading control, including: landowner and public agency BMPs, aeration, mechanical mixing, alum injection, wetland treatment, floating treatment wetlands, biomanipulation of foodweb, etc. You may consider reviewing this document –* Examples of Control Methods – (*http://www.globalhab.info/files/Cyano_mitigation_GlobalHAB2019.pdf)*

K. Management/Restoration Methods Rejected – *list cyanobacteria control/lake restoration methods rejected and explain why these methods are inappropriate for your lake.*

L. Recommended Management/Lake Restoration Plan – *describe the individual elements of the recommended lake restoration plan; for each element address:*

- *how this element will be implemented in your lake;*
- *the timing of implementation;*
- *the costs of implementation and maintenance;*
- *the estimated effectiveness and longevity;*
- *the potential adverse effects on zooplankton, fish and wildlife; and*
- *the potential impacts on residents, lake users, and the downstream watershed.*

M. Future Monitoring and Adaptive Management

   a. Evaluation – describe what methods will be used to evaluate the success of the Recommended Management/Lake Restoration Plan, including:

      - *water quality monitoring;*
      - *progress in implementing each element of the plan;*
      - *costs of implementation and maintenance; and*
      - *adverse impacts of the implemented methods.*

   b. Adaptive changes – *describe the process for considering changes to the Management/Lake Restoration Plan in light of new monitoring results or plan progress.*

N. Funding Strategy – *describe the sources of funding to be used to implement the Management/Lake Restoration Plan and to track changes in water quality conditions.*

O. Roles and Responsibilities – *describe what agencies and/or groups or individuals that will be responsible for implementing the plan and monitoring progress.*

P. References