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Response to Public Comments on the U.S. EPA's Draft Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin

Notice

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Introduction

This document summarizes public comments submitted regarding the U.S. Environmental Protection Agency (EPA) document titled *Draft Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin* (Recreational AWQC/SA) and the EPA's responses. The EPA published the draft Recreational AWQC/SA document in December 2016. The sections that follow provide summaries of the comments received and the EPA's responses, which are organized into categories.

Category 1 – General Comments

Category 1.1 - General Comments – Authority under the Clean Water Act

Comments Summary: Comments focused on the Clean Water Act (CWA) and its role in addressing natural hazards originating from cyanotoxin-producing cyanobacteria. Hall and Associates asserted that the CWA limits the EPA to considering only man-induced water pollution and not natural hazards. This commenter recommended that the EPA distinguish between levels of cyanotoxins which are natural, and those that are above natural levels, indicating a man-induced cyanotoxin pollution problem. The commenter concludes that the EPA can only regulate cyanobacteria when toxin levels are above natural levels, and only if said unnaturally high levels have a demonstrable adverse impact on human health.

Response:

The Agency has the authority to develop recommended criteria for water quality under section 304(a) [U.S. Code 33 section 1314(a)(1)] of the Clean Water Act accurately reflecting the latest scientific knowledge on the kind and extent of all identifiable effects on health and welfare which may be expected from the presence of pollutants in any body of water. Elevated levels of cyanobacteria and cyanotoxins may be expected to result from the presence in a waterbody of pollutants such as phosphorous and nitrogen and can result in adverse effects on human health, including for recreation uses. The values recommended by the EPA represent the latest scientific knowledge on the kind and extent of all identifiable effects on human health and welfare that might be expected from the presence of microcystins and cylindrospermopsin in a body of water. Section 304(a) does not restrict the EPA from developing recommended water quality criteria where naturally occurring pollutant concentrations may in some instances result in an effect on health and welfare.

Importantly, the publication of 304(a) criteria are not regulations, rather they are recommendations that states may consider in their development of water quality standards or otherwise use to manage water quality. These values may be adopted as water quality criteria to protect the recreational designated use, serve as the basis for swimming advisories to protect public health in recreational waters, or both. Even in jurisdictions where these section 304(a) recommended criteria are adopted as legally-binding water quality criteria consistent with the procedures set forth in section 303(c), under the Clean Water Act and the EPA's implementing regulations states have several options to provide regulatory flexibility for water bodies where natural conditions exceed these criteria. For example, pursuant to 40 CFR 130.10(g)(1), states may remove a designated use, which is not an existing use if the state can demonstrate that attaining the designated use is not feasible because naturally occurring pollutant concentrations prevent the attainment of the use. Alternatively, states have the option to develop site-specific criteria to reflect the presence of naturally occurring pollutants provided that those criteria are based on sound science and protect the designated use.

Category 1.2 - General Comments – Support for development of Recreational AWQC and swimming advisories (Recreational AWQC/SA)

Comments summary: Multiple groups submitted comments in support of the EPA's development of the Recreational AWQC/SA to protect public health in recreational waters affected by harmful algal blooms (HABs)[1] and the cyanotoxins, microcystins and cylindrospermopsin:

- The Association of Clean Water Act Administrators and nine states (California Natural resources Agency Department of Water Resources and State Water Resources Control Board, Massachusetts Department of Public Health and Department of Environmental Protection, New York State Department of Environmental Conservation and Department of Health, Oregon Department of Environmental Quality, Pennsylvania Department of Environmental Protection, Utah Department of Environmental Quality, Vermont Department of Environmental Conservation, Virginia Department of Environmental Quality and Department of Health, State of Wisconsin Department of Natural Resources).
- One tribe (Karuk Tribe).
- Other stakeholders consisting of the regulated community, researchers, citizen groups, and the general public (Surfrider Foundation, Connecticut Citizen-Led Environmental Observatory, Clean Water Action/Clean Water Fund, Clean Ocean Action, Great Lakes Environmental Law Center, Lake Erie Foundation, Mississippi River Collaborative, North Carolina Conservation Network et al. University of North Carolina at Chapel Hill's Institute of Marine Sciences).

Paraphrased comments with some quotations included the following.

- **Association of Clean Water Administrators** (ACWA) supports the EPA's efforts to address the issue of harmful algal blooms (HABs) in recreational waters. ACWA also acknowledged "the collaboration and dialogue that has occurred between ACWA and the EPA throughout 2016 and 2017 regarding HABs and recognizes the achievements that have emerged from that partnership." They "appreciate the flexibility that the EPA has extended to states to use the recommended values for swimming advisories only, as water quality standards, or neither."
- **California Water Boards, State Water Resources Control Board** acknowledged the "extensive effort EPA put into development of the microcystins and cylindrospermopsin criteria, and supports EPA's efforts to develop proposed human health recreational ambient water quality criteria for cyanotoxins."
- The **California Environment Protection Agency**, "Office of Environmental Health Hazard Assessment (OEHHA) commends the work that the U.S. Environment Protection Agency has undertaken to address the risks associated with recreational exposure to microcystins and cylindrospermopsin… Once finalized, the U.S. EPA's human health recreational criteria and swimming advisories for microcystins and cylindrospermopsin will provide critical support for public health officials and water managers nationally."
- The **Commonwealth of Massachusetts, Office of Health and Human Services and Massachusetts Department of Environmental Protection** (MassDEP) stated that "Through a comprehensive literature review of currently available relevant scientific studies, EPA generated

[1] In this and the Recreational AWQC/SA document, harmful cyanobacterial blooms are also known as harmful algal blooms or HABs.

draft criteria for both cyanotoxins to help ensure public safety during recreational activities… MassDEP appreciates EPA efforts to produce a document that summarizes the critical background information and identifies important issues attributed to HABs."

- **Oregon Department of Environment Quality** (ODEQ) supports the EPA's proposal approach to allow the recommended values to be used as either recreational advisory levels, water quality standards, or both. ODEQ stated that "Microcystins and cylindrospermopsin are not the same as typical water quality criteria. Unlike other water quality parameters, these toxins are not discharged directly into the environment; rather they occur at high levels most often during harmful algal blooms that form when waterbodies experience an increase in the level of nutrients, higher than normal water temperatures, low flows, or other issues. As a result, criteria for these toxins should not be treated as the same as other water quality criteria. It is critical for states to have tools and strategies to address elevated levels of these toxin in order to understand when public health is at risk and to act…"
- **Pennsylvania Department of Environmental Protection** wrote that "The EPA's document effectively explains the complex, ever-changing, and challenging subject of protecting public recreationists from HABs. A thorough scientific review resulted in the EPA selecting reasonable advisory levels for microcystins and cylindrospermopsin… It is expected that advisory levels for other cyanotoxins will also be determined in the future."
- The **Utah Division of Water Quality** "commends and supports EPA's continue efforts to address water quality concerns and human health effects resulting from harmful algal blooms (HABs). These draft criteria represent significant progress in that effort. The Utah Division of Water Quality (UDWQ) is supportive of EPA's draft criteria for cylindrospermopsin and microcystins… The draft criteria are based on the most recent and relevant scientific literature, and the techniques used in the criteria calculations are reasonable. Therefore, UDWQ believes these criteria to be scientifically defensible and appropriately protective of the specific human health concerns identified in the draft document."
- The **Wisconsin Department of Natural Resources** (WDNR) "supports the approach used to derive the criteria/advisory levels for microcystins and cylindrospermopsin. This approach is in keeping with EPA's Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health and the Water Quality Guidance for the Great Lakes System (40 CFR 132). Furthermore, WDNR understands and values the evaluation of children as the receptor for these pollutants. As children spend more time recreating in the water and tend to ingest more water while recreating, they are the most likely to be impacted by these toxins."
- The **Vermont Department of Environment Conservation** stated that "We support this effort to develop national guidance by which human health risks from cyanobacteria may be evaluated. National guidance will facilitate the development of consistent monitoring approaches and foster consistent messaging for the many stakeholders concerned about these organisms."
- **Commonwealth of Virginia, Virginia Department of Environmental Quality** (VDEQ) and Department of Health (VDH) stated that "There are no significant questions or concerns with the selected values. Should the recommended advisory thresholds from EPA become final, VDH will be prepared to amend current recreational advisory guidance for cyanobacteria toxins."
- The **Karuk Tribe, Karuk Community Health Clinic** stated that "Overall the Draft EPA Human Health Recreational Ambient Water Quality Criteria and/or Swimming Advisories for Microcystins and Cylindrospermopsin document is well structured and relies on sound science to

formulate the cyanotoxin advisories. We urge the EPA to finalize the advisories, so that States can use the data to update their cyanotoxin guidelines."

Several commenters (Connecticut Department of Energy and Environmental Protection, New York State Department of Environmental Conservation and Department of Health, Pennsylvania Department of Environmental Protection, Vermont Department of Environmental Conservation) suggested additional information or approaches that could be used to improve the document, including:

- suggesting the criteria be strengthened by mirroring the approach already being taken by a state with an existing HAB advisory program.
- encouraging the EPA to provide more explanation of the science behind the studies used to generate the criteria.
- recommending some additions to be made.

Specific points made by these commenters are summarized under the technical topic areas.

Response:

The EPA would like to thank all the states, tribes, and other stakeholders for providing their comments in support of the development of the Recreational AWQC/SA to protect public health in recreational waters affected by HABs and the cyanotoxins microcystins and cylindrospermopsin. The EPA understands the considerable efforts states have put forward to manage water quality and protect the public from HABs and appreciates them sharing their knowledge as part of the comment process.

The EPA considered the additional information and suggestions provided by all commenters as it made its final revisions to the document. The EPA is providing this information as recommendations; however, states have the flexibility to use these as AWQC if they decide to adopt them into their water quality standards (WQS), swimming advisories, or both. The EPA revised the document to be clear that the decision on how to use these values is up to the discretion of states. Also, the EPA has worked with states to develop implementation guidance for these Recreational AWQC/SA for microcystins and cylindrospermopsin.

Category 1.3 - General Comments – Support for development of swimming advisories, but not AWQC

Comments Summary: Five commenters supported the development of swimming advisories for cyanotoxins, but not national recommended 304(a) criteria:

- **Georgia Department of Natural Resources-Georgia Environmental Protection Division (Georgia EDP)** expressed concerns largely about implementation and indicated "Georgia EDP does not plan on adopting ambient water quality criteria for HABs, but would consider using the recommended guidance for swim advisories."
- **Kansas Department of Health and Environment (KDHE)** "supports EPA's recommended values that are protective of primary contact recreation, particularly for pre-teenage children derived from the published science addressing these toxins. KDHE supports the issuance of swimming advisories to protect the recreating public and intends to amend our current messaging approaches associated with issuing public notifications during HAB events to incorporate EPA's recommendations. Harmful Algal Blooms have become the critical water quality issue in Kansas, and KDHE appreciates EPA's effort to assist with this ever-challenging endeavor."

- **Ohio Environment Protection Agency** stated that "U.S. EPA's proposed numerical values for swimming advisories and recreational criteria were calculated using standard risk assumptions and are similar to Ohio's recreational advisory levels. Ohio is supportive of U.S. EPA's effort to establish numeric thresholds for cyanotoxins to guide recreational advisories. This information is important and will help state and local officials in their efforts to provide the public the most up-to-date advice regarding potential health risks encountered while swimming in our nation's waters."
- **The National Association of Clean Water Agencies** requested that the EPA clarify in the document that states have the "option to adopt only the swimming advisories without also adopting the AWQC."
- **Agricultural Retailers Association et al.** indicate that the EPA should consider publishing the information only as swimming advisories under 304(a)(2).

Response:

The EPA is providing this information as recommendations; however, states have the flexibility to use these as AWQC if they decide to adopt them into their WQS, as swimming advisories, or both. The EPA revised the document to be clear that the decision on how to use these values is up to the discretion of states.

The EPA appreciates the suggestions provided by states on how to implement these reactional criteria and swimming advisories and has worked with states to develop implementation guidance for these recreational criteria and swimming advisories for microcystins and cylindrospermopsin.

Category 1.4 – General Comments – Not supportive of approach

Comments Summary: The EPA received comments from states (Iowa Department of Natural Resources, Kentucky Division of Water, Texas Commission on Environmental Quality, the State of Wisconsin Department of Natural Resources) and multiple other stakeholders (Agricultural Retailers Association et al., City and County of Honolulu Department of Environmental Services Division of Environmental Quality, Hall and Associates, Mississippi River Collaborative, National Association of Clean Water Agencies, North Carolina Lower Neuse River Basin Association, North Carolina Neuse River Compliance Association, Virginia Association of Municipal Wastewater Agencies, American Water Works Association) that were not supportive of Recreational AWQC/SA.

Two states (Kentucky Division of Water and Wisconsin Department of Natural Resources) suggested the information be published only as 304(a)(2) information.

The Agricultural Retailers Association et al. cited the EPA's "court-ordered process" which included expert scientific workshop to define a science plan, epidemiology studies, multiple research and stakeholder meetings, and opportunities for stakeholder comment on the criteria and implementation guidance. The commenter requested that the EPA implement such an approach before taking final action on the criteria.

Commenters provided other specific concerns with the publication of the draft criteria. These included:

- **Wyoming Department of Environmental Quality** "has questions regarding: criteria implementation; the assumptions and statistical methodologies that were used during criteria and/or advisory value development; and missing or misleading information."

- **Iowa Department of Natural Resources** had questions about the derivation of the values and implementation, which are addressed further below. They asked the EPA to base criteria on an appropriately designed epidemiological study focusing on the acute effects of elevated cyanotoxins on human health during recreational water activities such as swimming.
- Two commenters (**Hall and Associates, Iowa Department of Natural Resources**) noted that the proposed criteria create an artificially stringent standard (or "overprotective criteria") resulting in unclear, and potentially unnecessary, burdens placed on states to implement them.
- The **Agricultural Retailers Association et al.** expressed concern with the overall nature of the draft document because it appears that the EPA is "blending" the concepts of non-regulatory health advisories for short-term exposure to microcystins in drinking water with Clean Water Act criteria for fecal indicator bacteria at freshwater and marine beaches.
- The **Virginia Association of Municipal Wastewater Agencies** unsupportive of the AWQC due to what they describe as the paucity of scientific data in support of the derivation of draft AWQC values.
- Two commenters (**Hall and Associates and Washington DC American Water Works Association**) expressed concern over the economic impact of the criteria. Hall and Associates voiced concern that the EPA would use the criteria to impose nutrient reduction requirements that would lead to detrimental economic impacts without benefit. This commenter stated that this effort represents the EPA's attempt to regulate a naturally occurring group of organisms in an effort to protect recreational uses that do not appear to be adversely affected by this parameter.
- Two commenters (**North Carolina Neuse River Compliance Association and North Carolina Lower Neuse River Basin Association**) voiced concern with the use of the draft criteria to stimulate rules and regulations, specifically those related to 303(d) listing decisions, exceedances, and the National Pollutant Discharge Elimination System (NPDES) permitting process. These commenters suggested that the EPA remove from the draft document any mention that numeric thresholds be used as the basis for regulation development.
- The **City and County of Honolulu Department of Environmental Services Division of Environmental Quality** believed that the EPA should not have issued the AWQC values for microcystins and cylindrospermopsin because of the lack of consideration of site-specific conditions, which may reduce the likelihood of formation of algal blooms that generate these cyanotoxins.
- The **National Association of Clean Water Agencies** expressed concerns about considerable implementation challenges.

Response:

The Recreational AWQC/SA are recommendations, not regulations. Unlike the EPA's 2012 *Recreational Water Quality Criteria* (RWQC) (U.S. EPA 2012), these recommendations are not subject to a consent decree resulting from litigation. States can choose to implement as SA, AWQC, both, or not at all. The EPA leveraged the science from its peer reviewed Health Effects Support Documents (HESDs) and provided the criteria for public comment. The EPA engaged with states through ACWA throughout this process. Detailed responses to specific concerns related to the exposure assumptions are discussed below.

The AWQC are based on the same peer reviewed, published science on the adverse health effects from exposure to microcystins and cylindrospermopsin that support the drinking water Health Advisories

(HAs) developed for these compounds, but differ in the exposure scenario. The Recreational AWQC/SAs include recreation-specific exposure parameters that reflect the increased exposure experienced by children during primary contact recreation. The EPA has revised the document to provide additional description of assumptions used in the derivation of the Recreational AWQC/SAs. The specific responses to comments about assumptions and approaches used for criteria derivation are addressed in other comment categories, including categories 6, 7, and 8. Scientific uncertainties have also been transparently addressed in the section on effects characterization in the document (section 7). The EPA has also clarified that these criteria were developed for freshwaters. The EPA notes that site-specific criteria can be developed.[2]

The Recreational AWQC/SA are recommendations available to states to help protect human health during primary contact recreation. As recommendations, they do not impose costs. The Recreational AWQC/SA were not developed as a result of a court-ordered action. Communities across the country have experienced loss of economic benefits due to beach closures resulting from HABs, and the majority of comments from states and other stakeholders indicate the need for such tools to assist states and tribes in managing recreational water quality. The EPA has been working collaboratively with states to develop implementation materials and has published materials for beach managers; see Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters (U.S. EPA 2017b).

Publishing this information under 304(a)(1) rather than 304(a)(2) provides clarity for those states who wish to use these as criteria to protect state-designated recreational uses in their WQS. The 304(a)(1) AWQC are recommendations only.

Sections 2.5.2.1 of the HAs for microcystins and cylindrospermopsin (U.S. EPA 2015e, 2015f), summarize human data for exposures to microcystins and cylindrospermopsin. As noted in the HAs, the human data on the oral toxicity of microcystins and cylindrospermopsin are limited by the potential co-exposure to other pathogens and toxins, by the lack of quantitative information, and by the failure to control for confounding factors. The Recreational AWQC/SA document also includes a discussion of additional recreational acute exposure case reports published since 2015 and human studies evaluating effects following exposures to cyanobacterial cells (see Recreational AWQC/SA section 7.5). Taken together, the weight of evidence for human studies supports the conclusion that microcystins and cylindrospermopsin exposures are a human health hazard. At this time, the EPA concludes that the human studies are adequate for use qualitatively in hazard identification but not for use quantitatively (see Recreational AWQC/SA section 7.5).

Finally, while it is widely accepted that excess nutrients are an important factor that contribute to algal bloom formation and occurrence of cyanotoxins, these Recreational AWQC/SA do not address nutrient contamination.

Category 1.5 - General Comments – Provide linkage to nutrients

Comments Summary: Several commenters (Agricultural Retailers Association et al., Association of Clean Water Administrators, Hall and Associates, State of Wisconsin Department of Natural Resources,

[2] The EPA's regulations state in 40 CFR section 131.11(b)(1) provide that "In establishing criteria, States should (1) Establish numerical values based on (i) 304(a) Guidance; or (ii) 304(a) Guidance modified to reflect site-specific conditions; or (iii) Other scientifically defensible methods."

National Association of Clean Water Agencies) stated that the link between nutrients and cyanobacteria and or cyanotoxins from algal blooms is not clear and has no direct quantitative correlation.

Two commenters (Clean Ocean Action, Clean Water Action/Clean Water Fund) stated that while naturally occurring environmental conditions may generate HABs, nutrient pollution and warming water temperatures are more likely the underlying causes of HAB outbreaks in marine waters. These two commenters acknowledged the EPA's studies of the links between HABs, nutrient pollution, warming water temperatures, and other environmental changes might make HABs more frequent and more intense.

The National Association of Clean Water Agencies noted that establishing AWQC-based permit requirements for cyanotoxins would be difficult because of the absence of related nutrient criteria. The State of Wisconsin Department of Natural Resources recommended that the EPA wait to finalize the criteria until they have developed guidance on how to manage a waterbody that does not meet the microcystins or cylindrospermopsin criteria and also have published nutrient criteria. Hall and Associates stated that the association between point source loads of nutrients and cyanotoxin concentration is weak and argued for a case-by-case assessment of that the relationship between nutrients and cyanobacteria or cyanotoxins. The Association of Clean Water Administrators requested additional information on resources and models used to relate levels of nutrients and cyanotoxins.

Several commenters (Hall and Associates, State of Wisconsin Department of Natural Resources) expressed concern over the challenges of meeting the proposed water quality criteria in waterbodies given natural conditions that impact nutrient concentration in U.S. waters. Two commenters (Kansas Department of Health and Environment, National Association of Clean Water Agencies) stated that controlling nutrient discharge will not be a reliably effective means of meeting the recreational criteria goals. One of these commenters (National Association of Clean Water Agencies) suggested that this challenge stems from different parameters affecting nutrients and cyanotoxins. The American Water Works Association requested additional information about how the criteria would be used; asking whether, for example, cyanotoxin ambient water quality criteria would be used to improve management of nutrient loadings from non-point sources. The Agricultural Retailers Association et al. noted that the EPA and states already have frameworks to address nutrient pollution, and states are already taking initiative to control nutrients. They suggest that given the lack of monitoring, the public would be better informed by guidance based on visual signs. This commenter indicated that nutrient pollution control from point and nonpoint sources might not solve the problem of algal blooms. The Iowa Farm Bureau Federation stated that the EPA should continue to support state partnerships, and that federal mandates to implement 304(a) criteria under 40 CFR section 131.20(a) will greatly strain available resources and viability and will potentially reverse progress that has already been made. The Kentucky Division of Water suggested 303(d) listings for excessive nutrients provide a more appropriate management strategy than 303(d) listings for cyanotoxins.

One commenter (Merced Irrigation District) provided reference to a study showing the association between *Microcystis* species and an inorganic nitrogen pool from a wastewater treatment facility.

The Lower Neuse Basin Association noted that the North Carolina Department of Health and Human Services (DHHS) provides a practical set of recommendations to protect the public "since most recreational waters are not and never will be monitored."

One commenter (Clean Ocean Action) supported development of numeric criteria for nutrients in saline waterbodies, noting that nutrient pollution and warming water temperatures are more likely the underlying cause of algal blooms rather than naturally occurring environmental conditions. Another commenter (Clean Water Action/Clean Water Fund) noted the increase in reported incidents of HABs in recent years, agreeing with the EPA's characterization of the environmental conditions contributing to these blooms. This commenter encouraged the EPA to continue to implement activities identified in the 2016 Nutrient Memorandum (U.S EPA 2016).

Response:

The Recreational AWQC/SA document does not rely on the availability of nutrient criteria to be implemented. The EPA recognizes that preventing harmful algal toxins production in the surface waters implies preventing or limiting the growth of toxin-producing algae and the nutrient supplies that support that growth. The EPA is working with states and with ACWA to develop additional information on resources and models to relate levels of nutrients and cyanotoxins. Specifically, the EPA is updating 304(a) criteria recommendations for nutrient pollution (i.e., nitrogen and phosphorus) for lakes that address designated uses for drinking water, recreation, and aquatic life uses. In the interim, states can rely on almost 20 years of the EPA's policies and regulatory guidance on state development of numeric nutrient criteria, as well as their CWA regulatory authorities under section 303(c), to pursue effective point source interventions that prevent excess nutrients that contribute to the occurrence of microcystins and cylindrospermopsin. The EPA agrees with comments that management frameworks (e.g., state nutrient reduction strategies, the Agency's guidance) exist for states to take action to reduce nutrient pollution. The EPA also agrees with comments that states are taking tangible actions to implement these frameworks. The EPA intends the Recreational AWQC/SA for cyanotoxins to provide states with new tools to manage recreational uses, to complement rather than to take the place of other state efforts related to nutrient pollution.

The EPA disagrees with the comments that the link between nutrients and cyanotoxins is not clear. The EPA refers the commenters to Recreational AWQC/SA section 3.1.1.1 for a summary of the scientific, peer reviewed literature describing relationships between nutrients and cyanotoxins.

The EPA is providing other tools that can be used to address algal toxins and recognizes that states have multiple approaches to address these issues. These tools are specified in category 8 (implementation).

Category 2 – Stressors

Category 2.1 - Stressors – Cyanobacterial cell density and other cyanobacterial-related measures

Comments Summary: Five states (Commonwealth of Massachusetts/Massachusetts Department of Public Health/Massachusetts Department of Environmental Protection, Connecticut Department of Energy and Environmental Protection, New York State Department of Environmental Conservation and Department of Health, Pennsylvania Department of Environmental Protection, State of Utah Department of Environmental Quality Division of Water Quality), one tribe (Karuk Tribe), and one non-governmental stakeholder (North Carolina Conservation Network) submitted comments that encouraged the EPA to include a recommendation for a cyanobacterial cell density or other biomass-related metric (including visual observations of a cyanobacterial bloom). The points they made include:

- Cell count is a valuable tool that states currently use in combination with toxin levels to evaluate lake quality and to manage beaches to protect public health (Pennsylvania Department of Environmental Protection).
- Measures of cells can provide a proactive approach to protect public health before toxins are produced (Pennsylvania Department of Environmental Protection).
- Measures of cells are easier to implement than toxin measurements and facilitate a more rapid response than toxin analysis (North Carolina Conservation Network).
- Because more than one cyanobacteria genera are able to produce microcystins, and the production of cyanotoxins is unpredictable, using only *Microcystis* species as the indicator of toxin production (and calculation of cell density) is limiting. Additional ways of evaluating risk are necessary (scum observation, total cyanobacteria) to protect recreational uses (Massachusetts Department of Public Health and Massachusetts Department of Environmental Protection).
- Even if dose-response cannot be established, the EPA could set an upper level of cyanobacterial density to mitigate risks of inflammatory responses. Utah uses the World Health Organization (WHO) level of 100,000 cells. The Karuk Tribe uses 5,000 cells. Commenters asked whether the EPA would support states continued use of cell benchmarks.
- Qualitative criteria of visual inspection of blooms (e.g., discolored water and surface scums) should also be recommended along with toxin recommendations to avoid observable blooms and can be more public health protective than monitoring only the two toxins (Vermont Department of Environmental Conservation, Connecticut Department of Energy and Environmental Protection, Massachusetts Department of Public Health and Massachusetts Department of Environmental Protection, New York State Department of Environmental Conservation and Department of Health).
- One state (Wisconsin Department of Environmental Protection) commented on the lack of current science to support a recommendation of cell count as criteria and recommended working toward evaluating inflammatory effects.
- Another state (Pennsylvania Department of Environmental Protection) requested the EPA develop guidance on cyanobacterial biovolume to monitor cyanotoxins using pigment detection and fluorescence.
- Another state (Vermont Department of Environmental Conservation) recommended deleting cell density information from the document. In their experience, there was no clear link between cell density and likelihood of exceedance of toxin criteria at the cell density limit identified qualitatively by the EPA (20,000 cells/mL) at which microcystins criteria "might" be exceeded. They do support use of visual cues as guidelines indicating the level of risk in public notification systems and for developing narrative criteria.
- The Mississippi River Collaborative asserted that the use of cyanobacterial cell densities continues to be highly unreliable for use in setting quantitative guidelines, since toxin levels vary over time and environmental conditions.

Many states supported additional research to better understand stressor response relationships with cells including inflammatory effects. Ohio Environmental Protection Agency suggested epidemiology studies be conducted to address dermal and inflammatory endpoints before establishing criteria for HABs.

Response:

The EPA did not include criteria based on total cyanobacterial density (or the related measures such as biovolume, chlorophyll *a*, or phycocyanin) values related to inflammatory health endpoints due to the variability in the evidence in the literature linking levels of cyanobacteria and health effects. The rationale for this decision is discussed in the Effects Characterization section of the document (Recreational AWQC/SA section 7.5).

The EPA understands that some states regard measures of cyanobacterial cells as a valuable tool for managing water quality and protecting public health. The EPA provides a comparison of cyanobacterial cell density values for toxin-producing, or toxigenic, cells related to the recommended toxin concentrations in the Effects Characterization section of the document (Recreational AWQC/SA section 7.5.3). This approach, used by the WHO and others, relies on information found in the scientific literature on toxin quotas—concentrations of toxin associated with cyanobacterial cells—to develop a cell density related to the toxin-associated endpoints. Australia and some U.S. states have used a similar approach to develop their recreational water guideline values for toxigenic cyanobacteria and total cyanobacterial density values. The EPA conducted a literature search to compile additional information on microcystins and cylindrospermopsin quotas to improve understanding of the relationship between toxin levels and cyanobacterial biomass. The EPA reviewed the literature to determine minimum, maximum, and mean microcystins and cylindrospermopsin quotas for some common cyanobacterial genera. The EPA has included the results of the literature search and this analysis in the revised document (Recreational AWQC/SA Appendix G) in lieu of criteria based on cell count as additional information for states to consider in evaluating water quality. The EPA is retaining the characterization of cell density associated with toxin concentration in this report and has updated the cell density based on updates made to toxin concentrations as a result of public comment. The EPA recognizes that states and others may estimate toxigenic cell density using different assumptions or local data that are also reasonable approaches.

The EPA clarified that visual inspection alone cannot differentiate between toxigenic species and non-toxigenic species of cyanobacteria (Recreational AWQC/SA sections 3.1 and 7.5.2) and has added reference to an approach adopted by Ohio that uses DNA markers to identify cyanobacterial cells (Recreational AWQC/SA section 7.5.2). The EPA agrees that research to improve and validate indicators of potential HABs and cyanotoxins exposures would be beneficial.

The EPA understands that many states use qualitative or visual inspection information as a component of their health protective criteria or monitoring programs. Implementation materials the EPA has published provide more information on how such indicators can be considered to manage water quality (see U.S. EPA 2017b). However, visual inspection alone is insufficient to serve as a criterion because elevated cyanotoxin levels may be present in the absence of a visual bloom (Recreational AWQC/SA section 3.2.5.2).

The EPA added summaries of research on alternative detection approaches and indicators for cyanobacteria and cyanotoxins to the revised document (Recreational AWQC/SA section 7.5.2). Please refer to responses in category 8, Implementation, of this report for the EPA's efforts and plans to provide further guidance for monitoring.

The EPA considered other scientific references the commenters provided and revised the text to improve clarity.

Category 2.2 - Stressors – Consideration of water velocity and other factors

Comments Summary: The California Department of Water Resources said that the proposed guidance fails to include water velocity as a contributing factor in HAB formation. They recommended that water velocity be included as a contributing environmental factor in HAB formation in all lists and statements within the draft.

The National Association of Clean Water Agencies noted that there are differences in the fate and transport of toxins in flowing rivers and lakes and these differences could impact the applicability of these Recreational AWQC/SA. Specifically, the residence time and concentration of toxins in rivers can differ from lakes. This difference might impact data applicability between these two waterbody types. The commenter asked if the criteria apply to all water bodies.

California's Merced Irrigation District commented that the California Sacramento-San Joaquin River Delta is a complex ecosystem and factors driving occurrence of cyanobacteria are poorly understood but influenced by temperature, streamflow, and other factors.

Response:

The EPA agrees that water flow rate may be a factor that affects the formation of HABs; this is noted in section 3.1.1 (Environmental Factors Influencing Occurrence) of the Recreational AWQC/SA document. The EPA also agrees that differences in the fate and transport of toxins, as well as ecosystem characteristics can influence the concentration of toxins to which people are exposed.

Category 2.3 - Stressors – Differential toxicity of microcystin congeners

Comments Summary: Three commenters (Commonwealth of Massachusetts/Massachusetts Department of Public Health/Massachusetts Department of Environmental Protection, Mississippi River Collaborative, State of Wyoming Department of Environmental Quality) raised concerns about the use of microcystin-LR to derive the microcystins reference dose. The Mississippi River Collaborative suggested that microcystin-LR may only be approximately 25 to 40 percent of the total microcystin concentration in a cyanobacteria bloom, and there are more than 100 microcystin congeners. The Wyoming Department of Environmental Quality questioned whether this value is overly stringent, given that microcystin-LR is considered to be as toxic as or more toxic than other congeners. Another commenter (Commonwealth of Massachusetts/Massachusetts Department of Public Health/ Massachusetts Department of Environmental Protection) questioned whether microcystin-LR is more toxic than other congeners, since a study conducted by Fischer et al. (2010) suggested that higher cellular uptake of microcystin-LW and -LF versus microcystin-LR might lead to higher toxic effects from these other congeners. The Wyoming Department of Environmental Quality requested additional information on the toxicity and distribution of microcystin congeners, and questioned whether the reference dose derived from microcystin-LR has limited applicability to certain states or ecoregions.

The Florida Department of Environmental Protection and the Mississippi River Collaborative commented on cylindrospermopsin congeners, requesting presentation of additional congeners in a table format and presentation of rationale for not considering the other known cylindrospermopsin cyanotoxins in developing the draft criteria.

Response:

The EPA is aware of available reliable data on the relative toxicity of different congeners of microcystins and refers the commenters to sections 3.2.1 (Physical Chemical Properties) and 5.1.1.1 (Animal Toxicity Studies for Microcystins) of the Recreational AWQC/SA for its rationale for using microcystin-LR to represent other congeners. Additional details can be found in section 4.1 of the EPA's HA for microcystins (U.S. EPA 2015e), which describes the basis for using microcystin-LR as a surrogate for total microcystins.

The EPA revised the Recreational AWQC/SA document to identify other congeners of cylindrospermopsin and clarified the lack of physical/chemical and health effects data for these congeners.

Category 2.4 - Stressors – Develop values for other cyanotoxins (anatoxin-a and nodularin)

Comments Summary: Six commenters (California State Water Resources Control Board, Commonwealth of Massachusetts/Massachusetts Department of Public Health/Massachusetts Department of Environmental Protection, Connecticut Department of Energy and Environmental Protection, Mississippi River Collaborative, New Jersey Department of Environmental Protection, Pennsylvania Department of Environmental Protection) encouraged the EPA to expand their research of additional cyanotoxins of concern, including anatoxin-a, saxitoxin, or nodularins, and develop recreational guidelines to protect the public from these other cyanotoxins.

Five of these commenters (California State Water Resources Control Board, Commonwealth of Massachusetts/Massachusetts Department of Public Health/Massachusetts Department of Environmental Protection, Connecticut Department of Energy and Environmental Protection, Mississippi River Collaborative, New Jersey Department of Environmental Protection) supported the development of criteria for anatoxin-a, citing its frequent occurrence in waterbodies throughout the United States and its lethality in both humans and animals. The Commonwealth of Massachusetts/Massachusetts Department of Public Health/Massachusetts Department of Environmental Protection specifically asked for clarification on why anatoxin was not evaluated as part of the criteria. New Jersey Department of Environmental Protection cited toxicity data and an approach for developing a Reference Dose (RfD) for anatoxin-a and emphasized that their health protective approach with the available data should be considered in developing criteria for anatoxin-a since it is a neurotoxin and can have a lethal endpoint.

Pennsylvania Department of Environmental Protection suggested that the EPA criteria should also include nodularin due to its co-occurrence with microcystins and the similar toxic effects it can have on organisms. They noted based on experience that microcystin detection ELISA kits detect both microcystins and nodularin.

Response:

The EPA published an HESD for anatoxin-a in 2015 (U.S. EPA 2015d). This document describes the available toxicity data for anatoxin-a, including the studies identified by New Jersey Department of Environmental Protection. After consideration of these data from studies by Astrachan and Archer (1981); Astrachan et al. (1980); and Fawell et al. (1994, 1999), the EPA determined that the uncertainties in the Fawell et al. (1994, 1999) results combined with the data reporting deficiencies of the Astrachan and Archer (1981) and Astrachan et al. (1980) studies were inadequate to develop an oral

toxicity value (RfD) for anatoxin-a. The EPA's HESD for anatoxin-a underwent peer review and the reviewers supported this conclusion. Based on that, the EPA did not develop an RfD for anatoxin-a. The EPA continues to evaluate the available information on human health risk associated with anatoxin-a. The EPA's *Algal Toxin Risk Assessment and Management Strategic Plan* (U.S. EPA 2015a) indicates that the Agency will continue to evaluate additional toxicity data that may become available for these three cyanotoxins.

Nodularin is frequently detected in surface waters in the United States, especially in the Great Salt Lake in Utah. Although nodularin and microcystin-LR are very similar in the structure, use the same transporters, inhibit the same proteins, and produce similar LD_{50} values in comparable toxicity tests, relevant toxicity data such as uptake and excretion of nodularin, and acute, sub-chronic and chronic adverse effects from oral exposure to nodularin are not available.

Category 2.5 - Stressors – Other comments

Comments Summary: Mississippi River Collaborative observed that synergistic and additive interactions among cyanotoxins (and other toxic substances) were not considered in the draft criteria. Mississippi River Collaborative strongly encouraged the EPA to address the question of data gaps regarding additive and synergistic effects of cyanotoxins in order to protect public health. They cited ecological and in vitro studies suggesting the cyanotoxins act additively and synergistically with each other and other toxic substances.

The North Carolina Conservation Network et al. noted that levels of cyanobacteria have been identified at counts above 100,000 cells/mL at multiple sample sites, signaling an increase in the frequency of blooms. This commenter added that data on toxin exposure via these blooms is not systematic due to the nature of data collection practices (i.e., collection on a complaint-driven basis).

Two commenters (Hall and Associates, Merced Irrigation District) noted the challenges associated with understanding the physical drivers associated with blooms and predicting their abundance, formation, distribution, and control; studies of these drivers are ongoing. One commenter (Merced Irrigation District) shared that warmer water temperature and streamflow appear to be important physical drivers for controlling the growth rate of cyanobacteria. The commenter (Merced Irrigation District) supported additional monitoring and modeling to develop a complex model to predict development of HABs. One commenter (Hall and Associates) noted the ubiquitous nature of cyanotoxins found in nearly every type of water body, even those in pristine or near-pristine watersheds. Hall and Associates concluded that cyanotoxin occurrence is not always associated with human activities and, for all practical purposes, cannot always be prevented. The Agricultural Retailers Association et al. said that in some instances, even the most effective point and nonpoint source controls will not be sufficient to prevent HABs.

Response:

Regarding the comment about synergistic and additive effects, the EPA identified key research gaps in its HESDs (see HESD section 8.0) for microcystins and cylindrospermopsin. Included on these lists were the potential health risks from exposure to mixtures of microcystins or cylindrospermopsin with other cyanotoxins and chemical stressors present in ambient or drinking water supplies. The studies cited by commenters inform potential for ecological toxicity, but are not relevant to human health hazard assessment.

The EPA acknowledges the complexity of bloom occurrence and cyanotoxin production. However, at this time the science is sufficient to develop a recommendation of microcystins and cylindrospermopsin levels in recreational waters to protect human health while recreating. Although cyanotoxin occurrence is not always preventable, human exposure to cyanotoxins through recreational activities can be managed using tools that include the EPA's Recreational AWQC/SA.

Category 3 – Sources

Category 3.1 - Sources – Application of values to marine waters

Comments Summary: Two commenters (Commonwealth of Massachusetts, Massachusetts Department of Public Health and Massachusetts Department of Environmental Protection, Florida Department of Environmental Protection) point out that the fact sheet accompanying the draft document states the recommended criteria apply to fresh and marine waters, while the document only addresses freshwaters. They requested clarification and additional supporting documentation regarding the occurrence of the two cyanotoxins in the marine environment and the difference in incidental ingestion rates for fresh and marine waters.

Response:

The recommended values for microcystins and cylindrospermopsin were developed for fresh recreational waters. The fact sheet that accompanied the draft document mistakenly stated that the criteria apply to fresh or marine waters. The fact sheet will be revised to make it clear that the values were developed for freshwaters. The EPA revised the document to further clarify that the values were developed for freshwaters.

The EPA is aware that it is possible for toxins produced by cyanobacteria in freshwaters to be carried downstream to estuarine and coastal marine waters, potentially affecting people recreating in those waters. The document does not provide recommendations for those waters, however, it was revised to include more information and new studies on occurrence of these cyanotoxins in estuarine and marine waters (Recreational AWQC/SA section 3.2.3). A study published in 2017 (Preece et al. 2017), after the draft Recreational AWQC/SA document was released, collates information from multiple studies demonstrating microcystins produced by cyanobacteria in fresh waters can affect estuarine and coastal waters and describing the potential for some cyanobacteria to be salt-tolerant and persist in marine waters.

The EPA also included available data on ingestion volumes for fresh and marine waters in the revised Recreational AWQC/SA document (Appendix F).

Category 3.2 - Sources – Recreational waters can be drinking water sources

Comment summary: The Clean Water Action/Clean Water Fund stated that blooms often occur in lakes and rivers used for both recreation and as sources of drinking water and cited the 2014 Toledo, Ohio and the 2016 City of Ingleside, Texas blooms.

Response:

The EPA agrees that toxigenic HABs in lakes and rivers can impact waters that are designated as both drinking water and recreational uses. Nationally, approximately 15 percent of drinking water intakes

overlap with recreational waters within the intake's source water protection area, representing over 10,000 recreational assessment units. Blooms or elevated concentrations of cyanotoxins in recreational waters may be a sentinel for drinking water treatment operators to enhance monitoring to ensure drinking water is protected. The EPA published materials for drinking water plant operators to provide information on treatment approaches that can be employed to reduce ambient water toxin concentrations that might be found in their sources waters. Refer to the EPA's *Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water* (U.S. EPA 2015b).

Category 3.3 - Sources – Application of Recreational AWQC/SA to all waters of the United States

Comment summary: Hall and Associates commented that because the criteria apply to toxic substances, the criteria would apply to all waters of the United States, including areas where recreational activity is unlikely, such as "ditches, puddles, dead end coves of lakes, mudflats, areas with extensive rooted aquatic vegetation." They argue that the criteria should not apply to these situations where there is no relationship between actual use protection needs and the criteria. They mention wetlands and bird sanctuaries where recreational activities occur, but that may never be able to meet the cyanotoxin criteria.

Response:

As stated in the introduction to the Recreational AWQC/SA, section 304(a) of the Clean Water Act (CWA) requires the Administrator of the EPA to publish water quality criteria that accurately reflect the latest scientific knowledge on the kind and extent of all identifiable effects on health and welfare that might be expected from the presence of pollutants in any body of water. States define in their water quality standards the water quality goals of a water body or portion thereof, which includes designating the use or uses to be made of the water. These Recreational AWQC/SA are recommendations for states who may adopt them, or other scientifically defensible information, into their state standards to protect the designated uses of state waters.

Category 4 – Exposure Routes

Category 4.1 - Exposure Routes – Incidental ingestion

Comments Summary: Commenters had mixed opinions regarding the incidental ingestion while recreating scenario used to derive the recommended toxin values. For example, the California Office of Environmental Health Hazard Assessment considered the inputs to be "very conservative but defensible." The Hampton Roads Sanitation district stated the children's recreation scenario is "acceptable." Six commenters (Hall and Associates, Agricultural Retailers Association et al., Iowa Department of Natural Resources, National Association of Clean Water Agencies, Florida Department of Environmental Protection, State of Wyoming Department of Environmental Quality) were concerned that the inputs were too conservative.

Several questions were raised regarding the EPA's approach for assessing incidental ingestion. The Florida Department of Environmental Protection suggested that the EPA use a probabilistic risk-based approach for calculating the ingestion rate, or at least provide increased documentation of the key computations and formulas used to estimate incidental ingestion in the R script. The Iowa Department of Natural Resources et al. stated that the EPA used an unrealistic ingestion scenario based on chronic

instead of acute exposures. Hall and Associates stated that pool water would not be consumed like marine water because salt content leads to abdominal distress. Similarly, people are more likely to avoid swallowing algal bloom water compared to pool water.

Response:

The EPA used an estimate of incidental ingestion of ambient water while swimming based on the Agency's *Exposure Factors Handbook* (U.S. EPA 2011) and new information for incidental ingestion from a new and larger study by Dufour et al. (2017). This study was published subsequent to the draft, and addresses many of the concerns identified in comments. See section 4.2.3.1 of the Recreational AWQC/SA. The EPA provided the R script in Appendix E of the draft document.

The EPA's 2000 M*ethodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* can be used for short- or long-term scenarios (section 4.3) (U.S. EPA 2000). The EPA used a short-term scenario for when people recreate. See responses in comment Category 7.3, Analysis - Derivation of the Reference Dose (RfD) for responses to the comments related to the RfD. The RfDs derived for microcystins and cylindrospermopsin are considered short-term values.

The EPA's recommendations apply to freshwaters with a recreational designated use. The EPA added clarifying language to the Recreational AWQC/SA document. The EPA also added language discussing the potential for cyanobacteria to affect downstream waters.

The EPA revised the Recreational AWQC/SA document to discuss in more detail swimming durations in different water types; see Appendix F.

Comments Summary: Other comments were focused on children's recreational exposure. The State of Wisconsin Department of Natural Resources questioned whether the children's scenario would cover high contact activities like water skiing and how such activity would impact exposure. The National Association of Clean Water Agencies stated that although studies agree that children ingest more than adults, these ingestion rates vary from study to study. The Agricultural Retailers Association et al. pointed out the EPA's Office of Pesticides Programs (OPP) uses 0.050 L/hour based on the assumption that non-competitive, adult swimmers ingest twice as much as competitive swimmers and that children ingest twice as much as (non-competitive) adults. The Mississippi River Collaborative stated that one to four year-olds might have a higher ingestion rate than the six to 11 year-olds and that the lack of quantitative data for the one to four year-olds prevents analysis of whether the EPA's approach was sufficiently conservative to protect that younger age group. The State of Wyoming Department of Environmental Quality suggested that using different age cohorts, especially those with small sample sizes, for each input value may result in misrepresentation of the target population.

Response:

The EPA described in section 4.2.3 its rationale for selecting incidental ingestion during primary contact activities (such as swimming) in derivation of the recreational criteria and swimming advisories. See section 7.4.1 of the Recreational AWQC/SA document for a discussion of limited information available related to water skiing exposure.

The EPA's SWIMODEL used by OPP in assessments is described in Recreational AWQC/SA section 7.2, and explains that competitive swimming duration practices (e.g., children swimming laps) are less relevant to children's recreational activities in lakes or rivers. The EPA discussed exposure factors for younger children (younger than six years old) in the Recreational AWQC/SA section 7.3.2. After the

draft Recreational AWQC/SA was released for public comment, a larger data set for measured incidental ingestion while recreating in a swimming pool was published in the peer reviewed literature by Dufour et al. (2017). This data set includes more participants than the study the EPA used in the draft for incidental ingestion estimation (Dufour et al. 2006) and provides information for younger children, older children, and adults. Relevant exposure factors data for children younger than six years old are limited to body weight values presented in the EPA's *Exposure Factors Handbook* (U.S. EPA 2011), and the available peer reviewed studies of incidental ingestion which included children did not provide data on incidental ingestion volume or duration specific to children younger than six years old (Schets et al. 2011; Dufour et al. 2017).

Comment Summary: Hall and Associates expressed concern that the ingestion rate is over one-third of the daily drinking water intake per unit body weight (as provided by the HAs), which seems excessive for incidental ingestion.

Response:

The EPA uses a 90th percentile exposure scenario to derive drinking water health advisories consistent with the EPA's 2000 *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health*, with a drinking water consumption rate from the EPA's *Exposure Factors Handbook* (U.S. EPA 2011, or most recently published version). The recreational exposure scenario used to develop these criteria is based on peer reviewed studies conducted on incidental ingestion while recreating and represents a 90th percentile exposure scenario for children aged six to 10 years of age. The incidental ingestion rate has been revised from 0.33 L/day to 0.21 L/day based on the EPA's analysis of a more robust data set provided by Dufour et al. (2017) and duration of exposure information in the EPA's *Exposure Factors Handbook* (U.S. EPA 2011); this analysis is documented in Appendix E of the Recreational AWQC/SA document.

Comment Summary: Some comments specifically addressed the key incidental ingestion study identified as the source of the exposure duration. The Agricultural Retailers Association et al. stated that the EPA should be transparent about the statistical weakness of the small sample size of Dufour et al. (2006). Hall and Associates suggested that the EPA's scaling of the duration from "at least 45 minutes" to one hour over estimates the duration. The Florida Department of Environmental Protection stated the EPA should use the 90th percentile instead of the 97th percentile for the ingestion rate. The Agricultural Retailers Association et al. asked the EPA to explain why the event duration from the 1997 *Exposure Factors Handbook* (with a sample size of 15) was used over the 2011 *Exposure Factors Handbook*.

Response:

The EPA revised the document to use the most current peer reviewed science, including a recreational water incidental ingestion study (Dufour et al. 2017) that was published after the draft Recreational AWQC/SA document was released. See section 4.2.3.1 of the Recreational AWQC/SA for revisions and clarifications of the EPA's calculation of the daily ingestion rate.

The EPA added additional language to discuss the duration data available and clarify how that data were considered. See sections 4.2.3.1 (Incidental Ingestion) and 7.2 (Recreational Exposure Duration).

Category 4.2 - Exposure Routes – Inclusion of fish/shellfish ingestion

Comments Summary: Several commenters focused on the route of exposure to cyanotoxins through ingestion of fish and shellfish.

The Florida Department of Environmental Protection asked why the document did not include information about the occurrence of cyanotoxins in fish and shellfish. They also asked whether the EPA examined differences in exposure from marine, estuarine, and fresh fish. The Florida Department of Environmental Protection asked if there was an effort made to determine if there were additional studies characterizing sources of microcystins and cylindrospermopsin that became available after the publication of the health effects documents and prior to the publication of the draft. This commenter also requested that the EPA provide documentation regarding the literature search for other sources of microcystins and cylindrospermopsin.

The Florida Department of Environmental Protection discussed the various modes of cyanotoxin transmission through ingestion, specifically that the cooking of shellfish can cause the transmission of high concentrations of toxins from organs to edible tissues. Furthermore, the commenter discussed aquaculture ponds, which are a potentially significant source of cyanotoxins due to their proneness for cyanobacteria blooms. They recommended that these sources of cyanotoxins should be considered when characterizing overall exposure and determining the relative source contribution (RSC) in the derivation of the criteria.

The New Jersey Department of Environmental Protection recommended that the EPA continue research about exposure to toxins through ingestion of fish and shellfish in order to fill knowledge gaps and provide better guidance for the consuming of recreationally caught fish and harvested oysters and mussels. North Carolina Conservation Network et al. noted that shellfish are not currently tested for cyanobacteria or their toxins. They recommended that the EPA weigh consumption of contaminated shellfish as an exposure pathway in setting the human health criteria.

Response:

The EPA acknowledges that fish and shellfish are potential sources of cyanotoxins. The EPA has developed recreational criteria, not human health criteria (which consider drinking water and fish consumption). Consistent with the development of the 2012 RWQC, the EPA reconsidered application of an RSC and did not address fish consumption at this time. Please refer to the category 7.2 for comments regarding the RSC. The criteria focus on the short-term recreational exposure experienced by people engaged in primary contact recreation. Additional language was added to the document to emphasize the potential for exposure to the cyanotoxins from fish and shellfish consumption and to discuss the occurrence of microcystins and cylindrospermopsin in other matrices (Recreational AWQC/SA sections 3.2.4 and 7.6).

Category 4.3 - Exposure Routes – Relationship to secondary contact

Comments Summary: The Kentucky Division of Water stressed the necessity for the EPA to recognize and provide guidance for tiered levels of exposure to toxins based on varied uses of water. The recommended values are based upon protecting primary contact recreation, which neglect secondary contact recreation.

Response:

The Recreational AWQC/SA apply to ambient waters designated for primary contact recreation.

The EPA recognizes that there is the potential for exposure to the toxins via secondary contact recreation (e.g., falling into the water from a boat, inhalation of aerosolized cells and toxins, dermal contact with cells and toxins via fishing and boating). The EPA determined that using a primary contact recreation scenario (swimming) for exposure as the basis for the criteria is protective of other aquatic activities including those related to secondary contact recreation (see section 4.2.3 of the Recreational AWQC/SA).

Effects Characterization (section 7 in the Recreational AWQC/SA) describes the potential relative risks of adverse human health effects for inhalation and dermal exposure to microcystins and cylindrospermopsin compared to the oral ingestion route. However, specific toxicity information for these two routes are currently unavailable. This section also describes the potential risks from contact with the cyanobacterial cells, where published data demonstrate that inhalation and dermal exposure can be important to consider compared to exposure to the toxins.

Category 4.4 – Exposure Routes – Characterization of dermal and inhalation exposure

Comments Summary: Commenters expressed concerns regarding the EPA's characterization of dermal and inhalation exposure of cyanotoxins. Four commenters (State of Wyoming Department of Environmental Quality, Virginia Department of Environmental Quality and Department of Health, Massachusetts Department of Public Health and Massachusetts Department of Environmental Protection, and Mississippi River Collaborative) stated that there was insufficient evidence to support the conclusions drawn by the EPA. The State of Wyoming Department of Environmental Quality suggested removing descriptors of dermal absorption until sufficient evidence is available. They were also concerned with the assumption that inhalation and ingestion pathways are directly comparable, since persistence and toxicity in the respiratory tract are likely to differ from the gastrointestinal tract. The Virginia Department of Environmental Quality and Department of Health suggested that the EPA should not base their analysis on limited data, but instead support the need for further research to better understand the extent of dermal exposure. The Massachusetts Department of Public Health and Massachusetts Department of Environmental Protection stated that greater clarification was needed to apply short-term exposure studies to situations involving long-term chronic exposure via inhalation.

The Virginia Department of Environmental Quality and Department of Health also voiced concerns regarding the tables, formulas, and calculations in sections 7.5.1.1 and 7.5.1.2 of the draft document. They pointed out that the ratios given in Table 7-5, Comparison of Recreational Exposure Ingested Dose to Inhaled Dose of Microcystin, could not be reproduced, and suggested it would be more helpful to demonstrate with an example calculation. Furthermore, they stated that Table 7-6, Comparison of Recreational Exposure Ingested Dose to Dermal Absorbed Dose of Microcystins, required clarification. They stated it was unclear if the ingested dose applied to children or adults, and that the lack of unit conversion values made it difficult to reproduce the calculations.

Response:

The EPA added language to the Problem Formulation (section 4) and Effects Characterization (section 7) sections of the Recreational AWQC/SA document to clarify that the EPA is not assessing risks from inhalation or dermal exposure to microcystins or cylindrospermopsin because there is not sufficient

information to quantify the risks. The EPA did not calculate a risk value, but provided a comparative characterization of potential exposures (Recreational AWQC/SA section 7.4).

The exposure scenario the EPA evaluated was limited to short-term recreational exposures. The EPA did not evaluate a long-term or chronic exposure via ingestion, inhalation, or dermal exposure, therefore it cannot make any conclusions about long-term recreational exposures.

The EPA identified typographical errors in Table 7-5 of the draft AWQC document that showed the comparison of recreational exposure ingested dose to inhaled dose of microcystins. The calculated ratios were correct, but certain input parameters were incorrectly shown. The EPA revised the Recreational AWQC/SA document to fix the errors.

Category 5 – Receptors

Category 5.1 - Receptors – Consideration of multiple lifestages

Comments Summary: Three commenters (State of Wisconsin Department of Natural Resources, North Carolina Conservation Network, Clean Water Action/Clean Water Fund) agreed with the use of the child as the appropriate receptor. The Ohio Environmental Protection Agency stated that they use "a tiered advisory approach: a recreational advisory for sensitive receptors, including children, and an elevated advisory for all receptors."

The Mississippi River Collaborative did not agree that the EPA's approach was adequately protective of children. This commenter suggested that the EPA should use a body weight for one- to five-year-old children as soon as appropriate ingestion data are available for this age group; this commenter stated that the body weight for five- to 11-year-old children results in a higher, less protective value. This commenter also cited a link that demonstrates that body weights differ between age groups.

The Mississippi River Collaborative provided an analysis of the derivation of each parameter in the equation used to calculate the draft guidelines. The commenter (Mississippi River Collaborative) stated that their analysis shows that the EPA's selected values for body weight and exposure duration which are not sufficiently protective of children, and the commenter requested modification in advance of the publication of the criteria.

The North Carolina, Upper Neuse River Basin Association suggested that numeric criteria be added that explicitly note the applicability of the rule to children ages five to 11 years old and that additional age-relevant tables should be added to the document.

Two commenters (North Carolina, Lower Neuse River Basin Association, North Carolina, Neuse River Compliance Association) stated that while children are the lifestage most vulnerable to the effects of cyanobacterial toxin, no reports of adverse health effects in children have been identified in their state.

Response:

The body weight parameter value selected is based on the information presented in the EPA's 2011 *Exposure Factors Handbook*. The body weight for children aged six to 10 years represents the weighted average for the children represented by each year in that age group.

The URL link cited by the commenter contains a table of height and weights for males and females from infancy to 20 years. It is the EPA's practice to use peer reviewed data whenever available. The source of

this information is not given, nor are the number of people in each category, which inhibits the calculation of a weighted average for boys and girls aged six to 11 years.

The qualitative comparison discussed in the Effects Characterization suggests that children younger than six years old may not contribute significantly to the ingestion distribution. Unfortunately, quantitative data for the younger children are not available, so it is not possible to definitively test the commenter's assumption that children under six years may be more highly exposed in a recreational scenario.

The EPA evaluated exposure of multiple lifestages and concluded that children six to 10 years have the highest exposures (see Recreational AWQC/SA sections 4.2.3.1 and 7.3). Quantitative data for children younger than six years old are not available.

Category 5.2 - Receptors – Protection for companion animals and livestock

Comments Summary: Two commenters (North Carolina, Lower Neuse River Basin Association, North Carolina, Neuse River Compliance Association) stated that dogs are vulnerable to cyanotoxins and that deaths of dogs associated with cyanotoxins have been reported. The North Carolina Conservation Network suggested that the EPA should either consider dogs when finalizing the criteria or make explicit note of this gap.

The New York State Department of Environmental Conservation and Department of Health suggested that the EPA should include recommendations for the public and their animals to avoid algal blooms. The Mississippi River Collaborative suggested that the EPA should derive quantitative guidelines for other mammals, such as dogs, livestock, and wildlife. The California Office of Environmental Health Hazard Assessment noted that their state has already developed health-based surface water concentrations for microcystins and cylindrospermopsin to protect pets and livestock.

The Karuk Tribe agreed with the EPA's analyses, noting their consistency with current local cyanotoxin guidelines to protect human and animal health.

Response:

The EPA included additional information on pets and livestock in the Recreational AWQC/SA section 7.8. Information on public communication, including HAB risks to pet exposures, was included in the recently published implementation support materials *Recreational Water Communication Toolbox for Cyanobacterial Blooms* (U.S. EPA 2017a). The toolbox provides examples of best practices, including ways to prevent pet and animal exposure.

Category 5.3 - Receptors – Other comments

Comments Summary: The Mississippi River Collaborative stated that the "draft guidelines may not adequately protect sensitive groups, such as immunocompromised people, people with liver or liver and kidney disease, people with nervous system disorders, pregnant women, nursing mothers, and the elderly" and that the federal agencies involved in cyanotoxin-related resource management (e.g., the EPA, Centers for Disease Control and Prevention, National Institutes of Health, and National Institute of Environmental Health Sciences) should fund studies that will enable guidelines to be written to protect sensitive groups from adverse impacts of these toxins.

Response:

Recreational exposure data is limited for the sensitive subgroups identified by the commenter. The recommended values for the toxins are derived using exposure factors for the subgroup with the highest exposure (i.e., children approximately six to 11 years-old). Sensitive populations such as those mentioned in the comment are taken into account in the derivation of the toxicity values for microcystins and cylindrospermopsin. Specifically, an uncertainty factor is applied to account for variability in the human population. No information was available to characterize inter-individual and age-related variability in the toxicokinetics or toxicodynamics among humans.

Category 6 – Endpoints

Category 6.1 - Endpoints – Consideration of inflammatory and other endpoints

Comments Summary: Three commenters (State of Wisconsin Department of Natural Resources, State of Utah Department of Environmental Quality, Division of Water Quality, and Association of Clean Water Administrators) stated that the proposed criteria do not protect the public from the more immediate inflammatory responses from acute exposures to cyanotoxins, sensitization of exposure, and repeated exposure events.

The Iowa Department of Natural Resources stated that the RfDs for microcystins and cylindrospermopsin, based upon liver or kidney impacts, should not be used in determining recreational criteria/guidelines, and that an acute endpoint such as inflammatory response is the relevant endpoint.

The Kentucky Division of Water stated that the EPA should continue to provide guidance and ultimately develop recommended advisory values that are protective of both the primary and secondary contact recreation uses for all routes of exposure, and for endpoints other than organ toxicity (dermal symptoms, eye/ear irritation, fever, gastrointestinal illness, and respiratory symptoms).

Three additional commenters (New York State Department of Environmental Conservation and Department of Health, Ohio Environmental Protection Agency, North Carolina Conservation Network) stated that evaluating toxins alone is inadequate for protecting recreators, noting that there is a link between recreational exposure to cyanobacterial cells and acute health effects such as allergic, dermal, eye or ear irritation, gastrointestinal, inflammatory, and respiratory effects. One of these commenters (North Carolina Conservation Network et al.) suggested the inclusion of a threshold cell concentration criteria to be protective of inflammatory and allergic reactions.

Response:

Acute endpoints such as inflammatory effects from clinical, epidemiological, and outbreak studies were not selected as the primary endpoint of concern due to data uncertainties. The EPA did provide a summary of available information on effects resulting from exposure to cyanobacterial cells. See Recreational AWQC/SA section 7.5.1 (Health Effects Associated with Cyanobacterial Cells and Uncertainties) and Appendix D (Review of the State of the Science on Cyanobacterial Cell Health Effects) that summarize the health studies reviewed for this effort and the EPA's conclusions regarding cyanobacterial cells and inflammatory effects. The EPA agrees that further research is needed to improve understanding of the toxicity associated with non-oral routes of exposure, with the inflammatory responses such as dermal symptoms, eye/ear irritation, fever, gastrointestinal illness,

respiratory symptoms, chronic health effects, and cancer. The EPA will evaluate new research as it becomes available.

The EPA does not agree that adverse effects on liver or kidney that may result from incidental ingestion during primary contact recreational activities should not be considered in establishing recreational criteria or swimming advisories. The Recreational AWQC/SA has been revised to include two case reports of liver toxicity reported in humans following acute recreational exposure.

Category 6.2 - Endpoints – Other

Comments Summary: The Mississippi River Collaborative agreed with the EPA's conclusion that there are insufficient data to determine whether microcystins or cylindrospermopsin are carcinogenic. Both the Mississippi River Collaborative and Kentucky Division of Water encouraged a coordinated federal research effort to investigate the carcinogenicity of cyanotoxins. Both commenters also noted that if sufficient carcinogenicity information is generated, the EPA would need to provide updated recommended values to account for carcinogenicity.

Response:

Applying the U.S. EPA (2005) *Guidelines for Carcinogen Risk Assessment*, the Agency concluded that there is inadequate information to assess carcinogenic potential of microcystins and cylindrospermopsin. The few available epidemiological studies on microcystins are limited by their study design, poor measures of exposure, potential co-exposure to other contaminants, and the lack of control for confounding factors. There are no epidemiological studies evaluating the carcinogenic potential of cylindrospermopsin. No long-term animal studies were available to evaluate dose-response for the tumorigenicity of either cyanotoxin. The EPA identified key research gaps in its HESDs (HESDs section 8.0) for microcystins and cylindrospermopsin. Included on these lists are the carcinogenic potential of microcystin-LR and cylindrospermopsin. The EPA acknowledges that updated analyses would be needed if new studies results indicated carcinogenic potential of either of these cyanotoxins.

Category 7 – Analysis

Category 7.1 - Analysis – Deviations from 2000 AWQC Methodology

Comments Summary: Two commenters (Iowa Department of Natural Resources, Iowa Farm Bureau Federation) stated that the EPA did not follow its 2000 AWQC *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (2000 AWQC Methodology). The Iowa Department of Natural Resources quoted an excerpt in the 2000 AWQC methodology, which the commenter interpreted to say that the EPA believes that average amount of incidental water ingestion while recreating is negligible and will not have any impact on the chemical criteria values representative of both drinking water and fish ingestion. Therefore, the commenter argued it is unnecessary to establish human health AWQC based on incidental ingestion of ambient water during recreational activities. The Iowa Farm Bureau Federation stated that the EPA deviated from the 2000 AWQC Methodology by extrapolating and mixing together chronic exposure health effects with short-term acute ingestion exposures.

Response:

The 2000 AWQC Methodology default approach is to use drinking water ingestion rates to estimate ingestion exposure. In that guidance, the EPA explains that incidental ingestion is not added to the drinking water rate because it is negligible *compared to drinking water ingestion* [emphasis added]. The EPA used available reliable data on incidental ingestion while recreating to derive recreational AWQC/SA for the cyanotoxins. Using the drinking water consumption rate would not be representative of a recreational exposure scenario.

In response to the comment regarding mixing chronic exposure health effects with short-term acute ingestion exposures, please refer to the EPA's responses in section 7.3 (Analysis – Derivation of the RfDs for Microcystins and Cylindrospermopsin), which clarify that the EPA derived a short-term RfDs, the justification and support for the selection of the critical toxicity studies.

Category 7.2 - Analysis – Relative Source Contribution

Comments Summary: Several commenters (Florida Department of Environmental Protection, Hall and Associates, State of Utah Department of Environmental Quality Division of Water Quality, Texas Commission on Environmental Quality, Mississippi River Collaborative) requested clarification on the assumption that the RSC value is equal to 0.8 and additional supporting documentation in order to prove its scientific defensibility. The Florida Department of Environmental Protection found the reference to the decision tree from the 2000 methodology to be inadequate and the RSC "section is lacking the needed details to assess whether or not a RSC of 0.80 is appropriate for these proposed criteria."

The Virginia Department of Environmental Quality and Virginia Department of Health stated that "in all likelihood the RSC value of 80% is adequate," however, they asked the EPA for further details for the rationale for the use of 80 percent. They also requested that the EPA add to the draft document a demonstration that this RSC value is adequate and not arbitrary, including a calculation that illustrates that "other exposure modes are/are not insignificant and text describing the potential/non-potential for additive exposure effects." In addition, "if further research is needed or would be helpful to the understanding, clearly articulating the need in the document would be preferred."

The California Office of Environmental Health Hazard Assessment "agrees that there are multiple sources of exposure and therefore supports the use of an RSC of 80 percent." The Mississippi River Collaborative stated that "the RSC used by the EPA in deriving the draft guidelines for both [microcystins] and [cylindrospermopsin], 0.8, is the highest allowed value. Rather than providing a "margin of safety" as asserted by the EPA, its use biased the analysis to yield higher, less protective draft guidelines. The RSC should be re-evaluated."

The New Jersey Department of Environmental Protection pointed out that the EPA's 2000 AWQC guidance methodology discusses the use of an RSC in drinking water exposure assessment, but not recreational criteria exposure assessment. The draft criteria appear to represent the first use of RSCs for recreational criteria exposure assessment. This commenter asked the EPA to acknowledge that this approach represents an extension to their previous methodology (2000 AWQC guidance) and provide further discussion in the draft document.

The Texas Commission on Environmental Quality asked the EPA to change the RSC value. Stating that "the use of an RSC of anything less than one in the draft criteria cannot be justified because there is not information to suggest that there is any significant exposure to microcystins and/or cylindrospermopsin

via other routes of exposure, such as dermal exposure, inhalation, ingestion of fish/shellfish, or drinking water."

Several commenters (Virginia Department of Environmental Quality, Florida Department of Environmental Protection, California Office of Environmental Health Hazard Assessment, Texas Commission on Environmental Quality, Hall and Associates, Agricultural Retailers Association et al., Mississippi River Collaborative) pointed out routes of exposure associated with recreating in addition to incidental ingestion. Several commenters (Agricultural Retailers Association et al., California Office of Environmental Health Hazard Assessment, Florida Department of Environmental Protection, Texas Commission on Environmental Quality, State of Utah Department of Environmental Quality Division of Water Quality, Mississippi River Collaborative) questioned why exposure to cyanotoxins via fish and shellfish were not discussed in the context of the derivation of the RSC. Two commenters (Florida Department of Environmental Protection, Hall and Associates) noted that the EPA's exclusion of fish and shellfish consumption as part of the RSC in the draft criteria is a deviation from the 2000 AWQC Methodology and previous assessments.

Response:

The EPA decided not to apply the RSC term as explained in the Recreational AWQC/SA section 4.2.4.

Category 7.3 - Analysis – Derivation of the reference doses (RfDs) for microcystins and cylindrospermopsin

General comments

Comments Summary: Two commenters (North Carolina Conservation Network, Clean Water Action/Clean Water Fund) agreed with the values the EPA presented for both microcystins and cylindrospermopsin. Another commenter (University of North Carolina at Chapel Hill's Institute of Marine Sciences) fully supported the endpoints of liver and kidney toxicity used to derive the criteria.

Response:

Thank you for your comments.

Adequacy of database

Comments Summary: Three commenters (Hall and Associates, National Association of Clean Water Agencies, Agricultural Retailers Association et al., Virginia Association of Municipal Wastewater Agencies) stated that there are limited human or animal studies that provide evidence to support the need for the proposed criteria. They stated that few of the available human studies reported adverse health effects from exposure to cyanotoxins, and the only effects were noted were at doses higher than the limits proposed by the EPA. The Agricultural Retailers Association et al. stated that criteria should not be recommended until adequate, peer reviewed, scientific information is provided. They also noted that it appears that no relevant health effects studies have been published since the publication of the HAs based on the citations in the draft document. The Virginia Association of Municipal Wastewater Agencies mentioned uncertainties associated with the available study data and commented that the available information is insufficient for the promulgation of 304(a) criteria.

One commenter (National Association of Clean Water Agencies) also stated concerns over the limited number of peer reviewed studies that the EPA used to derive the swimming advisories and recreational

AWQC, and stated that these values "do not appear to be based on any dose-response data from ambient exposures."

Response:

The recreational criteria development relied upon the EPA's HESDs released by the Office of Water in 2015. In developing these HESDs, the EPA conducted a comprehensive search of the literature for information on mechanisms of toxicity; acute, short-term, subchronic and chronic toxicity and cancer in humans and animals; and toxicokinetics.

For microcystins, oral and intraperitoneal (i.p.) acute and short-term studies in mice and rats, and subchronic studies in mice are available. Chronic data are also available for microcystins, however, they are limited by the lack of quantitative data provided. There are limited neurotoxicity studies and several i.p. reproductive and developmental toxicity studies (there is no multi-generation reproductive toxicity study). For cylindrospermopsin the database for studies in laboratory animals includes oral exposure acute, short-term and subchronic studies, but many of them lacked a comprehensive evaluation of a wide spectrum of effects. The database lacks chronic toxicity and multi-generation reproductive and developmental toxicity studies using the oral route of exposure.

Epidemiological studies related to outbreaks, clinical studies, and cases studies evaluating human health effects due to exposure to microcystins and cylindrospermopsin are described in detail in the EPA's HESDs (see section 6.1 of U.S. EPA 2015g and U.S. EPA 2015c). While the human data on the oral toxicity of microcystins and cylindrospermopsin are limited and confounded by potential co-exposure to other contaminants; a lack of quantitative information; and other confounding factors, these studies do provide support for the kidney and liver as targets of cyanotoxin-induced toxicity observed in the animal studies.

EPA's HESD and HA documents describe the selection of the critical study and effect in detail and provide the rationale for selection of the critical studies and endpoints for derivation of the short-term oral reference doses (see section 3.1 in the HAs and Chapter 7 in the HESDs). The EPA conducted an extensive independent external peer review of its HESDs that included charge questions requesting comment on whether there were sufficient data to derive reference doses for microcystins and cylindrospermopsin. The peer reviewers supported the development of reference values for these cyanotoxins.

The EPA conducted supplemental literature searches in September 2015 to identify additional data on human health effects related to exposures to cyanotoxins and cyanobacterial cells for consideration in developing the recreational values. Studies of human studies to cyanobacterial cells have been included in Appendix D.1.3 of the Recreational AWQC/SA document. The EPA did not identify any new toxicity studies for microcystins or cylindrospermopsin suitable for RfD derivation.

The severity of the endpoints of concern for microcystins and cylindrospermopsin precludes conducting a study that purposefully exposes children and adults to increasing levels of toxin-contaminated water in order to find the lowest observable adverse level for the purpose of deriving recreational AWQC/SA. Use of the animal model allows for evaluation of a wide range of doses to inform the adverse effect level. The EPA's recommendations represent a concentration at which one would not expect to have adverse health effects occur from short-term exposure to these toxins.

Duration of critical study for derivation of the RfD for microcystins

Comments Summary: The Agricultural Retailers Association et al. noted that the criteria are based on single animal studies with ingestion of drinking water for 28–77 days which is not consistent with risks associated with a single day, or even several days, of recreational exposure. The Iowa Department of Natural Resources considers swimming and recreational exposures to be short-term or acute, not a chronic exposure scenario in which they stated that the reference dose is normally used.

Response:

Section 4.2.2 of the Recreational AWQC/SA document describes that short-term RfDs were used in the criteria derivation. For microcystins, a short-term RfD was developed using a study in male rats exposed to microcystin-LR for 28 days via drinking water (Heinze, 1999). For cylindrospermopsin, an 11-week study by Humpage and Falconer (2002, 2003) was selected as the critical study for development of the RfD. The available short-term studies available for cylindrospermopsin (Shaw et al., 2001; Reisner et al., 2004), were evaluated and are considered supportive of the critical study, however the EPA concluded that they were not suitable for quantification based on limitations including the use of extract, lack of adequate numbers of animals, monitored endpoints, the limited number of doses tested and endpoints monitored. As described in the EPA's HESDs, similar effects were observed at a similar dose after three weeks comparable to the effects seen in the Humpage and Falconer (2002, 2003) study at a slightly lower dose after 11 weeks. The Humpage and Falconer (2002, 2003) study was determined to be the most appropriate for the quantitative assessment because the LOAEL at 11 weeks would be protective for the effects seen at three-weeks in the shorter duration study. For these reasons, this RfD was deemed suitable for development of the short-term drinking water health advisory and for use in recreational exposure scenarios. Peer reviewers agreed with this conclusion.

The EPA assumes that people who live close to a swimming area will most likely recreate frequently and those that travel to swimming areas typically spend time recreating over a week or weekend. Thus, the EPA does not believe that swimmers will only be exposed acutely (i.e., one day) and that kidney or liver effects are not possible after such a short exposure.

Comment Summary: One commenter (Hall and Associates) stated that the reference doses were overly conservative. This commenter stated that the Heinze (1999) study only evaluated effects at the end of the 28-day exposure period, and no effects were evaluated at an interim time period.

Response:

The methodology for deriving an RfD (including application of uncertainty factors) and the algorithm for deriving AWQC for noncarcinogens is presented in the EPA's 2002 *A Review of the Reference Dose and Reference Concentration Processes* (U.S. EPA 2002) and the 2000 *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (U.S. EPA 2000), respectively. The EPA's HESDs for both microcystins and cylindrospermopsin were subject to external peer review and the reviewers supported the derivation of the RfDs for these cyanotoxins.

A short-term RfD for microcystins was developed using a study in male rats exposed to microcystin-LR for 28 days via drinking water. Because the study lacked interim effects data, it is not known when during the 28-day study these effects were originally manifest. The human data from the dialysis clinic (Carmichael et al. 2001; Jochimsen et al. 1998; Soares et al. 2005) and the Australian study of an acute 2-hour exposure to water impacted by a bloom (Giannuzzi et al. 2011) clearly demonstrate that a brief

exposure duration can initiate the sequence of hepatic events that are terminally manifest as signs and symptoms for liver damage in humans.

Comments Summary: One commenter (Hall and Associates) argued that the lowest-observed-adverse-effect-level (LOAEL) should be multiplied by the 28-day exposure duration. Another commenter (Water and Environmental Testing, Inc. and South Valley Water Reclamation Facility) noted that the reference dose units should be changed from µg/kg/day to µg/L for a continuous 28-day exposure period.

Response:

Total dose across the study duration is not the appropriate point of departure for the quantification of risk. The Guzman and Solter (2002) i.p. injection study suggests the tissue damage that progresses to liver cell necrosis can occur within the first days of dosing arguing against summing the doses for quantification. In this study, there were signs of liver damage as early as two hours after an intraperitoneal injection of 45 µg/kg microcystin-LR and apoptosis was apparent in BALB/C mice given a the same i.p. dose for two days and sacrificed 24 hours after the second dose. These results clearly demonstrate early effects on the liver with very short-term doses roughly comparable to the doses in the Heinze (1999) longer term study. The dosing in Heinze (1999) was slightly higher than that in Guzman and Solter (2002) but had less direct delivery to the liver.

The Heinze (1999) study did not perform interim sacrifices to evaluate effects prior to the conclusion of the study (28 days). Given the lack of these data, the precise day the tissue damage that lead to the effects at sacrifice began is not known.

In the case of cylindrospermopsin, the available short-term study by Reisner et al. (2004) found an impact of on urine excretion rate and kidney weight at three weeks and is supportive of the renal effects seen in the critical study at 11 weeks.

Dose range of the critical study for derivation of the RfD for microcystins

Comments Summary: Four commenters (Florida Department of Environmental Protection, New Jersey Department of Environmental Protection, Hampton Roads Sanitation District, Mississippi River Collaborative) thought that the Heinze (1999) study had an inadequate dose range, expressing concern that this study did not find a no-observed-adverse-effect-level (NOAEL). Mississippi River Collaborative also stated that critical study (Heinze 1999) LOAEL was too high because the lowest microcystin-LR concentration tested (50 µg/kg/day) showed major effects—increased liver weight, slight to moderate liver lesions with hemorrhages, and increased serum enzyme levels.

Response:

Acute, short-term, and subchronic animal studies were identified and described in the EPA's HESD for microcystins (U.S. EPA 2015c). Of these studies, three oral exposures studies were identified as possible studies for the development of the short-term guidance value: Heinze (1999), a 28-day drinking water rat study, Fawell et al. (1999), a 90-day gavage study in mice, and Chen et al. (2011), a three to six month drinking water study using mice. After evaluation of Chen et al. (2011), the EPA determined that because of limitations in study design, report, and methods used, this study was not adequate for determining the point of departure for the derivation of the RfD for microcystins. Peer reviewers agreed with this conclusion.

The primary health effect following exposure to microcystin-LR in animal studies is liver damage. Multiple studies (short-term and subchronic) have reported effects on the liver including altered liver weight and enzyme levels, necrosis, and inflammation and hepatocyte vacuolization. Heinze (1999) was selected as the critical study because it used a broader dose range than other studies considered, used the most relevant route of administration, histopathological evaluation of endpoints, and observed dose-related liver effects at low doses. The findings of the critical study are supported by the Guzman and Solter (1999, 2002) and Fawell et al. (1999) studies. Although these studies used different species and strains of laboratory animal and differed in dose, duration, route of exposure, and description of liver histopathology, they all reported effects to the liver in the 30 to 50 μg/kg dose range. The selection of the critical study and description of supporting studies, including an explanation of the uncertainty factor the EPA applied to adjust the LOAEL to a NOAEL, is presented in the Agency's HESD for microcystins section 7.4.1. Peer reviewers agreed with this conclusion. Research gaps associated with the microcystin database are presented in section 8.0 of the EPA's HESD.

Comments Summary: The Virginia Association of Municipal Wastewater Agencies claimed that the microcystins reference dose is based on a study (Heinze 1999) that observed large percent differences between two microcystin exposure treatments, leading to high uncertainty regarding whether the RfD is accurate. They expressed a similar concern about the study used to derive the RfD for cylindrospermopsin (Humpage and Falconer 2002).

Response:

The EPA disagrees with the claim that there was a large difference in the response to the two doses in the Heinze (1999) study. Tables 6-2 and 6-3 of the EPA's HESD demonstrate that tripling the dose shifted the tissue damage from four animals with mild necrosis and six with moderate necrosis at the low dose to six with moderate necrosis, three with severe necrosis, and one with moderate tissue hemorrhage for the high dose. That is not a dramatic change. The greater concern is the fact that all animals exhibited necrosis of the liver at both doses. The differences in the enzymes indicative of liver damage are also not dramatically difference at the high dose from those at the low dose.

Rodent strain used in critical study for derivation of the RfD for microcystins

Comment Summary: American Water Works Association commented that the critical study by Heinze et al. (1999) used a rat breed that the commenter suggested might be more susceptible to liver impairments than other rodent strains typically used in risk assessments.

Response:

The primary health effect following exposure to microcystin-LR in animal studies is liver damage. Multiple studies (short-term and subchronic) have reported effects on the liver including altered liver weight and enzyme levels, necrosis, and inflammation and hepatocyte vacuolization.

As described in the EPA's HESD for microcystins (U.S. EPA 2015c), the available studies reported effects to the liver in the 30 to 50 μg/kg dose range, consistent with the hypothesis that the risk for liver damage is proportional to the exposure route and unrelated to the rats' breed. Neither of the two co-critical studies used the same strain of rat as Heinze et al. (1999), however, Sprague Dawley rats were used by Guzman and Solter (1999). The EPA concluded, based on the requirement for transport, that the Fawell et al. (1999) mice were less sensitive to the microcystin due to less liver exposure resulting from the once per day bolus dose delivery method. Although a NOAEL was not identified in Heinze (1999),

and these studies used different species and strains of laboratory animal and differed in dose, duration, and route of exposure, the changes in liver histopathology were similar and the exhibited LOAEL's for liver damage increased with route of dose delivery as predicted (i.p. infusion > drinking water > gavage). Evidence from these and other studies (Ito et al. 1997; Guzman and Solter 1999) suggest that the NOAEL is not very far below the lowest dose used by Heinze (1999). The fact that three different strains of laboratory animal had similar hepatic responses after allowing exposure route does not support the claim that the Heinze (1999) strain of rat is more sensitive than the others evaluated.

Measure of effect in critical study for derivation of the RfD for microcystins

Comment Summary: American Water Works Association commented on the EPA's "use of a secondary measure of toxicity without demonstrated linkages to direct measures of toxicological effect." They noted that this approach was different from other state and government agencies' approaches taken for cyanotoxins.

Response:

Most of the toxicity information on the adverse effects of microcystins is from animal studies. However, data from the episode in a dialysis clinic in Caruaru, Brazil where microcystins were not removed by treatment of dialysis water, identify liver effects: 100 of the affected patients developed acute liver failure and, of these, 76 died. At a similar incident in Brazil patients had markers of hepatic cellular injury including cholestasis and elevated levels of aspartate aminotransferase (AST), alanine transaminase (ALT), bilirubin, alkaline phosphatase (ALP), and gamma glutamyl transferase (GGT) in serum. These data support the selection of liver damage as the measure of toxicity.

Use of microcystin-LR as a surrogate for all microcystins

Comments Summary: North Carolina, Upper Neuse River Basin Association suggested clarifying the comprehensive magnitude of uncertainty and applying the criteria solely to microcystin-LR. Another commenter, American Water Works Association, expressed concern that the derivation of a level of concern for all microcystins based exclusively on microcystin-LR differed from approaches taken by other state and international governments. North Carolina, Upper Neuse River Basin Association recommended the EPA consider the use of microcystin-LR toxicity equivalency values for other microcystins, similar to dioxin congener approaches.

Response:

Section 4.1 of the EPA's HA for microcystins (U.S. EPA 2015e) describes the basis for using microcystin-LR as a surrogate for total microcystins. The data that support the quantitative assessment of risk are all based on studies of microcystin-LR. Little is known about the other microcystin congeners, and the data that exist are not consistent regarding relative potency. The EPA's HESD for microcystins (U.S. EPA 2015c) notes that researchers have explored toxicity equivalency factors for microcystin congeners (Wolf and Frank 2002). However, these calculations were based on intraperitoneal LD_{50} values, which have questionable application to evaluating risk from oral or dermal exposure given that differences in lipophilicity and polarity of the congeners may lead to variable absorption by non-injection routes of exposure.

Selection of critical study for derivation of the RfD for cylindrospermopsin

Comments Summary: Hampton Roads Sanitation District commented that the Humpage and Falconer (2002) study was insufficient, adding that the biological significance of the endpoints considered in that study was unclear.

Response:

For cylindrospermopsin, the 11-week study by Humpage and Falconer (2002, 2003) was selected as the critical study for development of the RfD. Kidney toxicity was the critical effect chosen for the point of departure. In both studies, Humpage and Falconer (2002, 2003) explained that although urine total protein was significantly decreased at doses above 60 μg/kg/day, the kidney was the more sensitive organ to this toxin and identified a NOAEL of 30 μg/kg/day.

The short-term studies available for cylindrospermopsin (Shaw et al. 2001; Reisner et al. 2004), were evaluated and are considered supportive of the critical study, however the EPA concluded that they were not suitable for quantification based on limitations including the use of extract, lack of adequate numbers of animals and monitored endpoints, and limited number of doses tested. The EPA's HESD and HA documents for cylindrospermopsin describe the selection of the critical study and effect in detail and provides the rationale for applicability of the longer-term duration study.

Briefly, similar effects to those observed in the critical study were observed in a 21-day study in mice by Reisner et al. (2004). Specifically, significant increases in hematocrit, acanthocytes (abnormal red blood cells), and liver and testes weights effects at a 66 μg/kg/day dose and a duration-related nonsignificant increase in and kidney weight were observed. This study was not selected for development of the 10-day HA because this study used a single dose and observed the biochemical and hematology effects at weekly intervals. The kidney and red blood cell effects at that dose after three-weeks were comparable to the effects seen in the Humpage and Falconer (2002, 2003) study at a slightly lower 60 mg/kg/day dose after 11 weeks. The red blood cell effects in Reisner et al. (2004) were seen as early as the end of the first week of dosing and were present in each of the three weekly blood samples collected. The Humpage and Falconer (2002, 2003) study was determined to be the most appropriate for the quantitative assessment because the LOAEL at 11 weeks would be protective for the effects seen at earlier time points in the Reisner et al. (2004) study. Peer reviewers agreed with this conclusion.

Comment summary: The Virginia Association of Municipal Wastewater Agencies described concern about high degree of uncertainty generated by the large effect differences between cylindrospermopsin exposures in the critical study (Humpage and Falconer 2002).

Response:

The Humpage and Falconer (2002, 2003) study utilized four dose groups, adequate numbers of animals per dose group and evaluated a variety of endpoints. Statistically significant, dose-related effects on the kidney, liver and serum chemistry were observed. The kidney was the most sensitive target of toxicity. The Humpage and Falconer (2002) data are supported by other studies (e.g., Reisner et al., 2004) where results showed increased kidney weights and hematological effects (acanthocytes) after a three-week exposure. Although this study has the limitation of a control with a single dose, it had the advantage of following the response to dose at weekly interval for those endpoints that did not require sacrifice for detection (e.g., urinary excretion rate and acanthocytes) rather than kidney weight.

Uncertainty factors

Comments Summary: Five commenters did not think the uncertainty factors utilized were appropriate. Mississippi River Collaborative thought that the uncertainty factors for database uncertainty (UF_D) and LOAEL to NOAEL extrapolation (UF_L) and were both too low for microcystins and cylindrospermopsin, and that these values should be increased to 10. New Jersey Department of Environmental Protection agreed that a UF_D of three was too low for both microcystins and cylindrospermopsin, and also recommended this value be increased to 10. California Office of Environmental Health Hazard Assessment agreed that the UF_L for microcystins was too low and should be increased to 10. Hall and Associates noted that no uncertainty factor was used for extrapolating subchronic to chronic exposure (UF_S). American Water Works Association commented that the EPA's approach to not reduce uncertainty factors when data is available related to mechanisms and modes of action for microcystin-LR differed from state and international government approaches.

Response:

The database for microcystins includes limited human data, oral and i.p. acute and short-term studies in mice and rats, and subchronic studies in mice. The database lacks a multi-generation reproductive toxicity study. There are limited neurotoxicity studies and several i.p. reproductive and developmental toxicity studies. The EPA considered the effects of microcystin on the male reproductive system and sperm development following oral exposures as a potential critical effect. Based on the limitations in study design, report and methods used by Chen et al. (2011), the EPA concluded, with peer reviewer support, that the quantitative data on decreased sperm counts and sperm motility were not appropriate for determining the point of departure for the derivation of the RfD for microcystins. The available reproductive and developmental toxicity studies have limitations in methods and reporting that limit their utility a measure of dose response for developmental/neurodevelopmental effects.

For cylindrospermopsin, the database includes limited human data and studies in laboratory animals including oral exposure acute, short-term and subchronic studies. The database includes evaluation of reproductive and developmental endpoint but lacks chronic toxicity and multi-generation reproductive and developmental toxicity studies using the oral route of exposure. There is a lack of data on neurological and immunological endpoints.

A database UF is warranted (i.e., a three) in situations where reproductive and developmental studies are limited and it is difficult to assess their potential to affect the point of departure (POD), as is the case for microcystins and cylindrospermopsin.

The EPA applied an uncertainty factor of three to account for the extrapolation from a LOAEL to a NOAEL based on the evidence suggesting that the uptake of microcystins by tissues requires membrane transporters. Heinze (1999) identified a LOAEL of 50 μg/kg/day based on increased liver weight, slight to moderate liver lesions with hemorrhages, and increased enzyme levels. Guzman and Solter (1999) used intraperitoneal implantation of osmotic pumps, a more direct delivery of dose to the liver, to administered purified microcystin-LR to groups of three male rats. The pumps delivered zero, 16, 32, or 48 μg/kg/day and identified a NOAEL of 16 μg/kg/day and a LOAEL of 32 μg/kg/day. Guzman and Solter (1999) observed necrosis at doses of 32 and 48 μg/kg/day, but not at a dose of 16 μg/kg/day, supporting for the critical effect and dose. Using three animals per dose group is a weakness of the Guzman and Solter study. However, not finding evidence for necrotic or pre-necrotic hepatic damage in the 16 μg/kg/day dose group and the use of a slow osmotic pump mode of delivery that bypassed the

need for intestinal transporters are its strengths. The EPA also evaluated Fawell et al. (1999), a gavage study in mice that found liver effects at a higher dose (200 µg/kg) than the LOAEL identified in Heinze et al. (1999). Through considering the data from all three studies, the EPA believes that there is no reason to believe that the less direct delivery from the intestines to the liver following oral exposures through drinking water (as was used in Heinze 1999) would have a more than three-fold separation between a NOAEL and LOAEL had there been one in the Heinze (1999) study. Therefore, the EPA concluded that a three-fold NOAEL/LOAEL uncertainty factor for Heinze et al. (1999) is appropriate.

There was no uncertainty factor (UF_S) applied to account for use of a less than chronic duration study since the EPA developed the RfDs for short-term exposures. See the key study and uncertainty factor descriptions in section 7.4 of the EPA's HESD for microcystins (U.S. EPA 2015c) for details.

Comments Summary: A commenter (North Carolina, Upper Neuse River Basin Association) stated that the document did not clearly highlight the magnitude of the comprehensive uncertainty in deriving the criteria.

Response:

The commenter mentions a number of factors related to the database for microcystins and cylindrospermopsin that are illustrative to the uncertainties in the assessment. Human studies and case reports are limited by potential co-exposure to other pathogens, cyanotoxins, and microorganisms; by the lack of quantitative information (microcystin concentrations); and by the failure to control for confounding factors. However, case studies of recreational exposures indicate human health effects; see the EPA's HESD for microcystins (U.S. EPA 2015c) and summaries of recent recreational exposure case reports of cyanobacteria and microcystin exposures that have been added to the Recreational AWQC/SA document. Other human studies are also supportive for potential liver damage following exposure to microcystins (Carmichael 2001; Falconer et al. 1983; Hilborn et al. 2013; Jochimsen et al. 1998; Li et al. 2011).

Acute and subchronic animal studies were identified and described in the EPA's HESD for microcystins (U.S. EPA 2015c). Of these studies, three oral exposures studies were identified as possible studies for the development of the short-term guidance value: Heinze (1999), a 28-day drinking water rat study, Fawell et al. (1999), a 90-day gavage study in mice, and Chen et al. (2011), a three to six month drinking water mice study. After evaluation and peer review of Chen et al. (2011) the EPA determined that because of limitations in study design, report and methods used, this study was not adequate for determining the point of departure for the derivation of the RfD for microcystins. Heinze (1999) was selected as the key study because of the study duration, the use of multiple doses, dose-related toxicological responses, and histopathological evaluations of toxicity. The uncertainty factors apples are consistent with those applied for interspecies and intraspecies uncertainties for many regulated and unregulated chemicals evaluated by the EPA. The factor of three applied for use of a LOAEL was based on the data from the Guzman and Solter (1999) study in Sprague Dawley rats.

As for cylindrospermopsin, the information on the human health effects is limited to the observations from the Australian Palm Island outbreak involving acute and short-term drinking water exposure to *Cylindrospermopsis raciborskii* (Byth 1980; Griffiths and Saker 2003). The clinical picture of the illness is well-defined and includes fever, headache, vomiting, bloody diarrhea, hepatomegaly and kidney damage with renal loss of water, electrolytes, and protein. However, as with many outbreaks and human case reports, no data are available on the exposure levels of cylindrospermopsin that induced these

effects. Nevertheless, these effects, especially kidney damage have been supported by animal studies (Humpage and Falconer 2002, 2003; Sukenik et al. 2006).

Use of animal data in derivation of the RfDs

Comments Summary: The State of Wyoming Department of Environmental Quality requested additional explanation as to how extended studies on experimental animals translate into a daily human exposure value that is not to be exceeded. This commenter also requested an explanation of how prolonged consumption of toxic drinking water in experimental animals translates into incidental ingestion in children.

Response:

The EPA used the best available, peer reviewed science to determine algal toxin levels that are protective of human health. A comprehensive evaluation of the available health effects information and derivation of these toxicity values (i.e., reference doses or RfDs) for both microcystins and cylindrospermopsin is included in the EPA's HESDs (U.S. EPA 2015a, 2015b). The HAs for both microcystins and cylindrospermopsin include an analysis plan which describes the methods used to develop these toxicity values (U.S. EPA 2015c, 2015d). Briefly, after the available studies were evaluated for inclusion in the EPA's HESD and HA, the critical study was selected based on consideration of factors including exposure duration (comparable to the duration of the guideline value being derived), route of exposure (oral exposure via drinking water, gavage, or diet is preferred), species sensitivity, comparison of the point of departure with other available studies demonstrating an effect, and confidence in the study (U.S. EPA 1999). Once a point of departure was chosen for quantification, uncertainty factors appropriate for the study selected were then applied to the point of departure to account for variability and uncertainty in the available data. This analysis was subject to independent expert peer review.

Human data on oral toxicity of microcystins and cylindrospermopsin are limited, but suggest the liver and kidney as the primary target organs. These studies were inadequate for use quantitatively in the assessment. Animal studies have shown that acute, short-term, and subchronic exposure can lead to adverse effects on the liver and kidney.

Animals and humans have both quantitative and qualitative differences that are accounted for when using animal models with the application of uncertainty factors (interspecies variability from extrapolating animal data to humans).

As the basis for the default incidental recreational ingestion values, the EPA used a study on children and adults and found that children age six to 10 ingested higher volumes of water while swimming than adults (Dufour et al. 2017). Children also spend more time in the water compared to adults (U.S. EPA 2011; Schets et al. 2011). Therefore, although the incidental ingestion volume is expected to be less than the default value for drinking water, children can be at greater risk from cyanotoxin exposure while recreating because they consume more water and spend more time in the water than adults.

Benchmark dose modeling

Comments Summary: One commenter (Florida Department of Environmental Protection) requested an explanation as to why the EPA did not utilize its preferred approach of Benchmark Dose Models (BMD) in deriving its microcystins and cylindrospermopsin reference doses.

Response:

For microcystins, the data set reported by Heinze (1999) was evaluated for BMD modeling (U.S. EPA 2015c, 2015e). A discussion of these considerations is presented in the HA and HESD for microcystins. Briefly, Heinze (1999) demonstrated dose-related liver changes and statistically significant effects at the lowest dose (50 μg/kg/day). The EPA did not choose to do dose-response for the Heinze et al. (1999) drinking water study because histological changes (necrosis, Kupffer Cell activation, and PAS staining) were observed in all animals in all dose-groups. For the EPA, the necrosis was the response of greatest concern. Although differences in the degree of necrosis were observed with or without hemorrhage related to dose, all the necrosis, Kupffer cell activation and Periodic Acid Schiff (PAS) staining showed no dose-response since all 10 animals at the low and high doses displayed liver damage associated with each effect. Therefore, the dose-response for the sum of the incidence categories (slight, moderate, and intensive damage), are not amenable to BMD modeling. As a result, the LOAEL of 50 μg/kg/day described by Heinze (1999) was used as the POD for development of the HA. In the Guzman and Solter (1999) study, there were more dose groups but it did not use oral exposure and there were only three animals per dose group. Thus, it was not appropriate for benchmark dose modeling and was utilized to help inform the uncertainty analysis. The fact that the 32 mg/kg/day and 48 mg/kg/day dose groups had hepatic tissue damage helped to support identification of the liver effects as critical as did other studies (e.g., Fawell et al. 1999) data in mice.

For cylindrospermopsin, Humpage and Falconer (2002, 2003) reported adverse effects on the kidney including significantly increased relative kidney weight at ≥ 60 μg/kg/day, decreased urinary protein and liver lesions at ≥ 120 μg/kg/day, and renal tubular lesions at 240 μg/kg/day. No significant renal changes were observed at 30 mg/kg/day. These adverse effects are potential indicators of suppressed hepatic protein synthesis or increased retention of low molecular weight of mouse urinary proteins by the kidney because of damage to the renal tubules. One aspect of determining the approach taken to derive the point of departure was consideration of whether there is a link between the decreased urinary protein observed and increased kidney weight. Decreased urinary protein is an adverse effect in mice because the urinary proteins act as pheromones for mating and tracking. In humans, protein should not be present in urine and excretion of protein in urine is an indication of kidney damage and is considered adverse. The magnitude of the response observed by Humpage and Falconer (2002, 2003) at the NOAEL was approximately 12 percent.

Category 7.4 - Analysis – Criteria duration and frequency

Comments Summary: Seven commenters (Agricultural Retailers Association et al., Hall and Associates, Mississippi River Collaborative, Ohio Environmental Protection Agency, Upper Neuse River Basin Association, Water and Environmental Testing, Inc. and South Valley Water Reclamation Facility, State of Wyoming Department of Environmental Quality) expressed concern about the scientific rationale and health relevancy of the frequency and the duration criteria. These commenters cited disapproval of the frequency, specifically the language "no more than 10 percent of days." The Upper Neuse River Basin Association requested that frequency be removed from the document because there is "no requirement that a 304(a) criteria document contain implementation decisions for regulatory programs such as the 303(d) [listing] process." Hall and Associates suggested that a set number of days to be protective in all situations, tied to definitive scientific evidence, would be preferable to the percent frequency. The Agricultural Retailers Association et al. stated that the state should have the flexibility to devise and defend appropriate methods to determine water body attainment status.

Several commenters maintained that the rationale of the new frequency being "similar to recommendations for other recreational criteria" was not sufficient. The Upper Neuse River Basin Association stated that the recommended single day exceedance, as well as alternative exceedance, frequencies might easily be misapplied. This commenter also pointed out that since the criteria are not proposing a regulatory threshold, there was no requirement to include regulatory frequencies such a single sample or single day thresholds.

Similarly, three commenters (Hall and Associates, Mississippi River Collaborative, Water and Environmental Testing, Inc., and South Valley Water Reclamation Facility) stated the recommended duration should reflect the conditions and implications of a definitive scientific test in order to be defensible. Hall and Associates stated it was not clear how the literature cited in defense of the proposed exposure period was relevant to the cyanotoxin criteria and that "since the effect of cyanotoxins is cumulative, continuous exposure should be the only relevant concern." The Mississippi River Collaborative stated that the duration should be reevaluated to include consideration of typical sampling/budgetary realities and that if the "EPA is recommending that 10% of the time, it is acceptable if the guideline is exceeded by any amount. Such excursions could commonly, seriously jeopardize public health."

The Water and Environmental Testing, Inc. and South Valley Water Reclamation Facility stated "The use of a percentage could be too restrictive for a waterbody with a short recreational period and too lenient for a waterbody with a long recreational period. For example, a period of three months or 90 days would allow nine days at the recommended magnitude which is excessively protective when compared to the 28-day definitive exposure period. On the other hand, a 12-month recreation period would allow 36 days which, in the event of a HAB could be consecutive days, which is over the 28-day duration of the definitive test and therefore has the real potential for the health exposures described in the definitive test to develop. Consider a recommendation using a set number of days to be protective in all situations and that is tied to the definitive test."

Response:

The EPA as clarified the logic and justification for the duration and frequency in the Recreational AWQC/SA sections 6.3 and 6.4. The EPA considered the public comments received and clarified recommendations consistent with the health effects data and HABS occurrence. In addition, the EPA built in flexibilities for state risk managers regarding exceedance frequency.

Category 7.5 - Analysis – Exposure duration and other exposure variables

Comments Summary: Several commenters (Florida Department of Environmental Protection, State of Wyoming Department of Environmental Quality, Texas Commission on Environmental Quality, Water and Environmental Testing, Inc. and South Valley Water Reclamation Facility, Hall and Associates, National Association of Clean Water Agencies, Virginia Association of Municipal Wastewater Agencies) questioned the exposure duration values used in the draft document. The Karuk Tribe fully supports the higher ingestion rates and water contact time utilized by the EPA.

Four commenters (Texas Commission on Environmental Quality, Water and Environmental Testing, Inc. and South Valley Water Reclamation Facility, National Association of Clean Water Agencies, Virginia Association of Municipal Wastewater Agencies) suggested using a different value for the exposure duration. The Texas Commission on Environmental Quality suggested that 1.3 hours would be

a more reasonable exposure duration, based a larger peer reviewed study. The National Association of Clean Water Agencies suggested that the EPA use the swimming durations published in the most recent *Exposure Factors Handbook* (U.S. EPA 2011) or in the Agency's Swimmers Exposure Assessment Model. The Water and Environmental Testing, Inc. and South Valley Water Reclamation Facility agreed that use of the 2.7 hours per day is somewhat logical; however, "the time spent swimming per month data" provides better clarity on how often children spend recreating and should not be discounted. The "time spent swimming per month" data coupled with the duration of recreational event of 2.7 hours per day suggests that the children only swim from one to one and a half days per month. The Virginia Association of Municipal Wastewater Agencies agreed that using monthly swimming values would be valuable. The use of a monthly swimming value would resolve what they argued is a mismatch between short-duration exposures and a longer-duration reference dose. They estimated this approach would generate health protective values more similar to those currently used by the WHO and several states.

The State of Wyoming Department of Environmental Quality was concerned with the underlying assumption that surface waters would be used for a similar duration as outdoor spas and pools, especially in colder climates. Hall and Associates argued that active swimming in a lake environment should not be equated to time spent in a pool either in duration or ingestion level.

Two commenters (Water and Environmental Testing, Inc. and South Valley Water Reclamation Facility, and Florida Department of Environmental Protection) requested that the EPA clarify the table in their *Exposure Factors Handbook* (U.S. EPA 1997) that the document referenced the mean exposure duration of five to 11 year olds time spent in home pools and spas.

Response:

The EPA used national data available on exposure duration. In the revised document, the EPA expanded the discussion of exposure duration data sets and uncertainties in the Effects Characterization section (Recreational AWQC/SA section 7.2). The EPA recognizes that states and tribes may decide to adapt recommendations based on local conditions, such as shorter duration times due to colder temperatures. In this case, substantiation of alternative duration parameter will facilitate evaluation of the resulting value.

The EPA used the duration of a recreational event from the Agency's 2011 *Exposure Factors Handbook* Table 16-20 (time spent per 24 hours in an outdoor spa or pool for different age groups) because the equation used to calculate the AWQC uses a daily ingestion rate (L/d). As the commenter notes, the 2011 *Exposure Factors Handbook* also includes the mean swimming in minutes/month for different age groups and a 95th percentile for all age groups of 181 minutes/month. This 95th percentile value is an artifact of the data collection survey and is not a usable number. The table had a footnote that says "A value of 181 for number of minutes signifies that more than 180 minutes were spent." The data collection approach did not quantify time spent at levels greater than 180 minutes.

Category 7.6 - Analysis – Other comments

Comment Summary: The Texas Commission on Environmental Quality asked the EPA to clarify whether the criteria apply to total microcystins or cylindrospermopsin, any of the known congeners, or whether congeners could be used as a surrogate for total toxins. The commenter noted that certain methods of analyses, such as enzyme-linked immunosorbent assays (ELISA), are not specific at identifying variants. The State of Wyoming Department of Environmental Quality recommended that

the EPA clarify more consistently across the document that the criteria are for total cyanotoxin concentration.

Response:

The EPA has added language clarifying that the values are for total microcystins.

Comment Summary: The American Water Works Association questioned why the EPA's toxicological analysis resulted in substantially lower criteria than those of other authoritative bodies and suggested re-examination of the data and better alignment with methodology used by those other organizations.

Response:

In the derivation of the recreational criteria and swimming advisories for microcystins and cylindrospermopsin, the EPA used the oral RfD values that were previously derived in its HESDs for microcystins and cylindrospermopsin (U.S. EPA 2015c, 2015d). The peer review of the EPA's HESDs included charge questions requesting comment on whether there was sufficient data to derive reference doses for microcystins and cylindrospermopsin. The peer reviewers supported the development of reference values for these cyanotoxins. See Recreational AWQC/SA Table 2-2 for a list of international recreational water guideline or action levels for cyanobacteria and microcystins. Microcystin thresholds in other countries range between four and 25 µg/L and the EPA's AWQC are also within that range.

Comments Summary: The State of Wisconsin Department of Natural Resources suggested that the EPA explore criteria derived using the 80th percentile values. This commenter requested the EPA conduct a sensitivity analysis to understand which exposure factors are the most sensitive.

Response:

The EPA followed its 2000 AWQC guidance (U.S. EPA 2000), which recommends using 90th percentile values. The Effects Characterization (section 7.3.1) of the Recreational AWQC/SA provides an evaluation of multiple lifestages.

Comments Summary: The Mississippi River Collaborative recommended that the EPA revise its draft guidelines to be more conservative in protecting human health and suggested alternative calculated criteria values. They calculated alternate draft guidelines for microcystins (1.23 µg/L) and cylindrospermopsin (2.31 µg/L) and stated that they should be considered by the EPA to replace the present draft guidelines. They suggested that these values could be rounded to two µg/L and 2.5 µg/L, respectively. They noted that, at present, the lowest state recreational guidelines for microcystins and cylindrospermopsin are 0.8 µg/L and four µg/L, respectively.

Response:

The EPA appreciates the commenter's offer of alternative values and reminds states and tribes that the Recreational AWQC/SA are recommendations; states and authorized tribes have the flexibility to adopt other values into state standards if those values are scientifically defensible and protective of the designated use.

Comments Summary: The Texas Commission on Environmental Quality recommended that the EPA incorporate the results of the 2012 National Lakes Assessment (NLA) into the draft recommendations

rather than relying solely on the 2007 NLA report. This would ensure that the recommendations would reflect the most recent data.

Response:

The 2012 NLA results were not published in time to incorporate those results in the draft document before it was released for public comment. The EPA has revised the current document to include the 2012 NLA results.

Category 8 – Implementation

Category 8.1 - Implementation – Recommend/provide information on methods for cyanotoxins

Comments Summary: Many commenters (State of Wyoming Department of Environmental Quality, Iowa Department of Natural Resources et al., Georgia Department of Natural Resources Georgia Environmental Protection Division, Hall and Associates, Iowa Farm Bureau Federation, Lake Erie Foundation, State of Wisconsin Department of Natural Resources, Florida Department of Environmental Protection, Kentucky Division of Water, Texas Commission on Environmental Quality, Massachusetts Department of Public Health and Massachusetts Department of Environmental Protection, New Jersey Department of Environmental Protection, North Carolina Upper Neuse River Basin Association, Washington DC American Water Works Association, Association of Clean Water Administrators, National Association of Clean Water Agencies, Clean Ocean Water Act, Great Lakes Environmental Law Center), regardless of whether they support using the document as an AWQC or swimming advisory, requested recommendations/information on monitoring methods (and sample protocols). They stated that there are many methods available and it is not clear which is best for recreational water bodies. They noted that the EPA has not approved a cyanotoxin method in 40 CFR Part 136. Several commenters also raised concerns over the variability of available methods based on the 2007– 2008 Florida round-robin study. Hall and Associates and the Iowa Farm Bureau Federation also expressed concern over differentiating between naturally occurring blooms and those due to the discharge of pollutants.

Response:

The EPA agrees that information on the use of analytical methods and associated sampling techniques would be helpful to implement the AWQC/SA. The Agency recently released technical materials to aid in the development of cyanobacteria and cyanotoxin monitoring programs, including information on available methods (U.S. EPA 2017a, 2017b). Specifically, these materials include: a decision tree on monitoring and notifying the public on the risk from cyanotoxins; information on available analytical methods and technologies; and examples of and links to state HABs program resources.

For the EPA's response to differentiating between naturally occurring blooms and blooms due to pollutants please refer to comment category 1.5.

Related information:

- There is no single cyanotoxin method the EPA recommends at this time for ambient waters; however, the Recreational AWQC/SA magnitude values are at least an order of magnitude above the limit of detection for nearly all available methods. A recent study by Gaget et al. (2017)

compared several assays for cyanotoxins and supports the EPA's conclusion that there is no "gold standard" technique for the detection of cyanotoxins in recreational waters; however, current methods are good at confirming presence of cyanotoxins. The paper recommends considering cost, practicality, reliability and comparability of results before choosing a method.

- Analytical methods and remote technology for measuring/predicting cyanotoxins is rapidly evolving through research by the EPA's Office of Research and Development, other federal and state agencies, as well as by companies selling the various kits and supplies associated with cyanotoxin tests. For example, the methods used in the 2007–2008 round-robin study in Florida as well as the method used in the EPA's 2012 National Aquatic Resource Surveys have been updated or refined.
- The EPA recently released an ambient-water method for quantifying specific microcystins (and nodularin) using Adda-ELISA technology (EPA Method 546). The EPA made available in 2018, two draft ambient-water methods based on liquid chromatography-tandem mass spectrometry (LC/MS/MS) technology: one for thirteen microcystin congeners and nodularin, and another for cylindrospermopsin and anatoxin-a.
- Sample preparation/processing and analytic standards are very much tied to individual methods and therefore questions on these issues can be answered by the protocol or vendor of the method materials. Sampling issues related to where and when to sample are tied to the location and environmental conditions and what question is being asked (e.g., is it safe to swim, or is this water in attainment with WQS?). Local or state managers can best address those issues on a site-specific basis. The EPA intends to continue to develop information on sampling issues as additional research and data becomes available.

Category 8.2 - Implementation – Use of non-toxin endpoints

Comments Summary: A few commenters (Iowa Department of Natural Resources et al., New Jersey Department of Environmental Protection, North Carolina Lower Neuse River basin Association, Washington DC American Water Works Association, Iowa Farm Bureau Federation, Lake Erie Foundation Clean Water Action/Clean Water Fund, State of Wisconsin Department of Natural Resources) requested information on issuing advisories or prioritizing analytical testing based on phycocyanin, chlorophyll *a*, cell counts, or other (non-toxin) information. Some commenters already have a HAB program based on a non-toxin endpoint.

Response:

The EPA agrees that information on the use of analytical methods and associated sampling techniques would be helpful, and includes information on cyanobacterial cells in the Effects Characterization section of the Recreational AWQC/SA document. In addition, the Agency has recently released technical materials to aid in the development of cyanobacteria and cyanotoxin monitoring programs (U.S. EPA 2017b). Specifically, in addition to information on analytical methods for cyanotoxins, these materials include: a discussion on prioritizing recreational waters for monitoring; a discussion of, and links to, non-toxin methods (e.g., identification of cyanobacteria species); use of non-toxin endpoints (e.g., the WHO and certain state programs); and remote sensing tools for use in issuing advisories. The cyanotoxin implementation materials include three key references for cyanobacteria identification (U.S. Geological Survey), cell counts (the WHO), and cell biomass (*International Guidance Manual for the Management of Toxic Cyanobacteria* referred to as the 'Australian Report'). The EPA's Office of Research and Development and the National Oceanic and Atmospheric Administration continue to make

progress toward providing remote sensing data on chlorophyll *a* concentrations in large water bodies nationwide.

Category 8.3 - Implementation – Criteria support materials

Comments Summary: Several commenters (State of Wisconsin Department of Natural Resources, State of Wyoming Department of Environmental Quality, Kentucky Division of Water, Texas Commission on Environmental Quality, California State Water Resources Control Board, Vermont Department of Environmental Conservation, State of Utah Department of Environmental Quality Division of Water Quality, Ohio Environmental Protection Agency, Washington DC American Water Works association, Association of Clean Water Administrators, Agricultural Retailers Association et al., Oregon Department of Environmental Quality, Surfrider Foundation, Great Lakes Law Center), urged the EPA to address how to assess waterbodies for impairment, calculate cyanotoxin Total Maximum Daily Loads (TMDLs), and collect samples for CWA 303(d) listing decisions and issue permits. Some commenters (Texas Commission on Environmental Quality, Washington DC American Water Works Association, Agricultural Retailers Association et al., Great Lakes Environmental Law Center) would like the EPA to address how to develop and implement management strategies. The New York State Department of Environmental Conservation and Department of Health, Association of Clean Water Administrators suggested conveying qualitative information to the public, such as public notices or general recommendations to avoid recreational exposure in areas with suspected or confirmed cyanobacterial blooms.

Response:

The EPA agrees that information on implementation of microcystins and cylindrospermopsin criteria would be helpful. The Agency's goal is to release criteria technical support materials following the final Recreational AWQC/SA that provide information on implementation of these criteria, including information on assessment and CWA section 303(d) listing, TMDL development, and CWA section 402 NPDES permitting. In a separate effort, the EPA is working to develop nutrient criteria tools that take this recreational criteria endpoint into account.

Related information:

- The EPA is working to ensure implementation-related questions and comments are addressed through separate implementation materials.
- The EPA has published Recreational Water Communication Toolbox for Cyanobacterial Blooms that provides resources for beach managers to use in communicating risk to the public about cyanotoxins in lakes, rivers, or other recreational water bodies (U.S. EPA 2017a).

Category 8.4 - Implementation – Impacts of implementation

Comments Summary: A few commenters (Iowa Department of Natural Resources, Texas Commission on Environmental Quality, American Water Works Association) expressed concern over the impact of implementing the Recreational AWQC/SA on existing water quality management programs and the public's perception of water safety. They suggest that the EPA remain flexible in their implementation of these criteria and seek to prepare state and local authorities for potential issues. Some of the commenters suggested investigating the cause of the conditions causing the blooms (Oregon Department of Environmental Quality, Georgia Department of Natural Resources Georgia Environmental Protection

Division) or increasing public education (Agricultural Retailers Association et al., Clean Water Action/Clean Water Fund, North Carolina Lower Neuse River Basin Association) instead of focusing on the quantitative measure of cyanotoxin levels. Some commenters (Iowa Department of Natural Resources et al., Georgia Department of Natural Resources Georgia Environmental Protection Division, American Water Works Association, Association of Clean Water Administrators, Iowa Farm Bureau Federation, Ohio Environmental Protection Agency, Georgia Department of Natural Resources Georgia Environmental Protection Division) are concerned that they will not be able to afford comprehensive cyanotoxin testing of all water bodies. The City and County of Honolulu Department of Environmental Services Division of Environmental Quality, Honolulu, Hawaii noted that HABs rarely occur in their region and implementing monitoring and analysis is not justifiable in that region. The American Water Works Association suggests the EPA wait for the revised the WHO drinking water guidelines (currently under review) before finalizing its assessment.

Response: The EPA intends to remain flexible in guidance on how states might implement these criteria. The implementation materials that the EPA plans to release should help states and local authorities identify potential issues and suitable local solutions. The EPA agrees that investigation of the cause of conditions that cause blooms and further public education are important components of protecting public health. These efforts can be supported by quantitative measures of cyanotoxin levels. CWA 304(a) human health criteria do not take financial or technological constraints into consideration. The EPA is working with the WHO in the update of their drinking water guidelines. However, these AWQC/SA are for recreational waters, not for drinking water.

Category 9 – Other General Comments

Comments Summary: Twelve commenters (State of Wyoming Department of Environmental Quality, Florida Department of Environmental Protection, Texas Commission on Environmental Quality, California State Water Resources Control Board, Connecticut Department of Energy and Environmental Protection, Georgia Department of Natural Resources, Georgia Environmental Protection Division, State of Utah Department of Environmental Quality Division of Water Quality, Massachusetts Department of Public Health and Massachusetts Department of Environmental Protection, Ohio Environmental Protection Agency, Water and Environmental Testing, Inc. and South Valley Water Reclamation Facility, National Association of Clean Water Agencies, The North Carolina, Upper Neuse River Basin Association, Mississippi River Collaborative) provided editorial comments for the EPA to consider, including updated or corrected information, and requests for clarification.

Response:

The EPA made the following requested editorial updates:

- The EPA clarified in the opening summary that the values are based on children's oral exposure due to their findings that this group experiences the highest exposure.
- The EPA updated the document with the cylindrospermopsin study sample sizes.
- The EPA added information to the citation for the Humpage and Falconer (2002) reference, including the URL link to Water Research Australia website where the report can be accessed.
- The EPA added clarification to the document that the values refer to total microcystins.

- The EPA double-checked and verified the accuracy of the microcystins concentration in surfaces waters values.
- The EPA corrected the status of state recreational water guidelines for cyanotoxins and cyanobacteria in Texas.
- The EPA updated the document to reflect information provided regarding California's guidelines or action levels for microcystins, cylindrospermopsin, and cyanobacterial cells to include the recent work of the California Cyanobacteria and Harmful Algal Bloom (CCHAB) Network.
- The EPA updated the document to accurately reflect the Connecticut Department of Energy and Environmental Protection program guidelines for cyanotoxins and cyanobacteria.
- The EPA updated the document to provide scientifically accurate information regarding distribution of microcystins through the water column.
- The EPA checked and updated information regarding cyanobacteria identified during the 2016 bloom in Utah Lake.
- The EPA updated the document to accurately report MDPH guidelines for cyanobacteria in freshwater recreational water bodies in Massachusetts.
- The EPA updated the document to accurately report Ohio state action levels for microcystins.
- The EPA corrected section cross references.
- The EPA clarified the cylindrospermopsin no-observed-adverse-effect-level.

The EPA did not change the title of the document as suggested by The North Carolina, Upper Neuse River Basin Association because the title as drafted is an accurate reflection of the contents and intention of the document.

The EPA also reviewed over 60 articles and attachments that the commenters cited or included in their comment submission. Citations were added to the Recreational AWQC/SA document where appropriate.

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