Brief Update to Cyanotoxin Draft Criteria – NC SAC

EPA-ACWA Hosted a webinar on September 10, 2018 announcing a revision to the draft they issued in December 2016. (close of public comment period March 2017)

EPA revised the document to:

- Incorporate new children's ingestion rate data
- Reexamined the Relative Source Contribution parameter in line with US EPA Guidance
- Revised the duration and frequency recommendations
- Revised the toxigenic cell density based upon updated values for microcystins
- Other additional details on toxicological studies

1. **Ingestion rate:**
   a. comments criticized the draft document's conservative assumption (**0.33 L /day**) derived from a study with limited participants at the 97th %tile
   b. US EPA response used incidental ingestions volumes from more recent (2017) publications with greater participants combined with revised exposure durations at the 90th %tile consistent with the US EPA HH Methodology (EPA, 2000)
   c. **RESULT**: Ingestion Rate for children reduced to **0.21 L/day**
2. **Relative Source Contribution (RSC):**
   a. The draft used an RSC of 0.8. Commenters argued that recreational criteria have not previously considered other sources
   b. **RESULT:** US EPA revised draft **does not include an RSC** – consistent with the derivation of other recreational criteria. Other sources are acknowledged in the document. This choice is consistent with health effects based on a short-term exposue.
3. **Duration and Frequency**
   a. For the draft, criteria were **not to be exceeded more than 10 % of days/recreational season** – up to one year
   b. **RESULT:** EPA has revised and aligned the duration component with the EPA 10-day Health Advisory for drinking water, and to additionally recognize the seasonal HAB occurrence
   c. Additionally, EPA recommends examination of the pattern of HABs in a body of water and establishing a "number of years" as a risk management/impairment decision
4. **Cyanobacterial Cells**
   a. The draft had a summary of health effects – but, no criteria. Toxigenic cell density of 20,000 cells/ml was suggested for microcystins
   b. **RESULT:** Toxigenic cell density was revised to 40,000 cells/ml to reflect the changes to the updated AWQC for microcystins.

UPDATED Values to be used as AWQC or Swimming Advisory (attached)

Document in its entirety is still in review by the US EPA. Date of release – anticipated as late fall 2018.

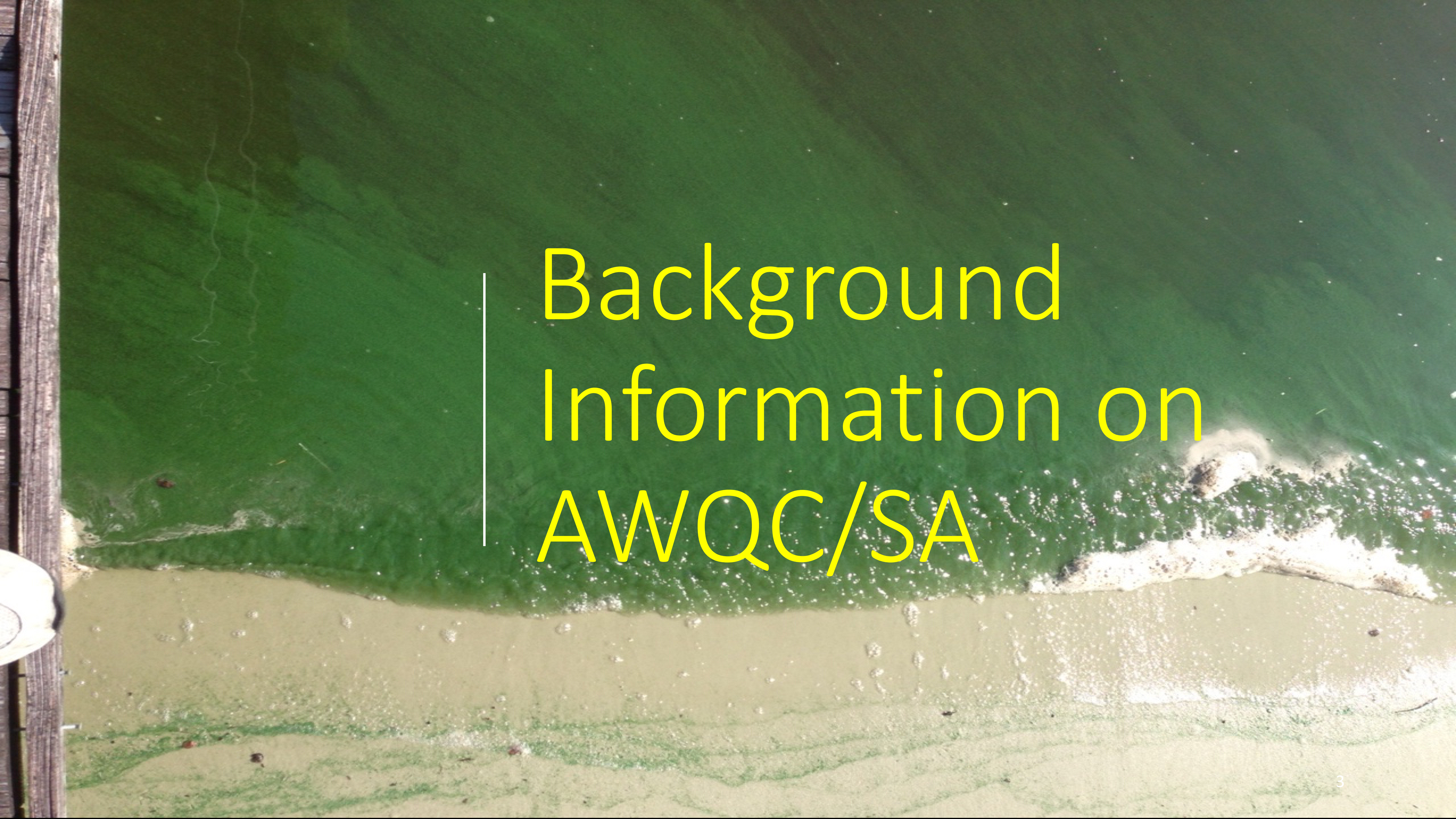
Revised Recreational Ambient Water Quality Criteria and/or Swimming Advisories (AWQC/SA) for Cyanotoxins

EPA – ACWA Meeting
September 10, 2018

John Ravenscroft
Office of Water, Office of Science and Technology, Health and Ecological Criteria Division

Presentation Outline

- Background information on AWQC/SA
- Revising the Recreational AWQC/SA in response to public comment
- Implementation Tools for AWQC/SA



Background Information on AWQC/SA

Genesis of the Recreational AWQC/SA for Cyanotoxins

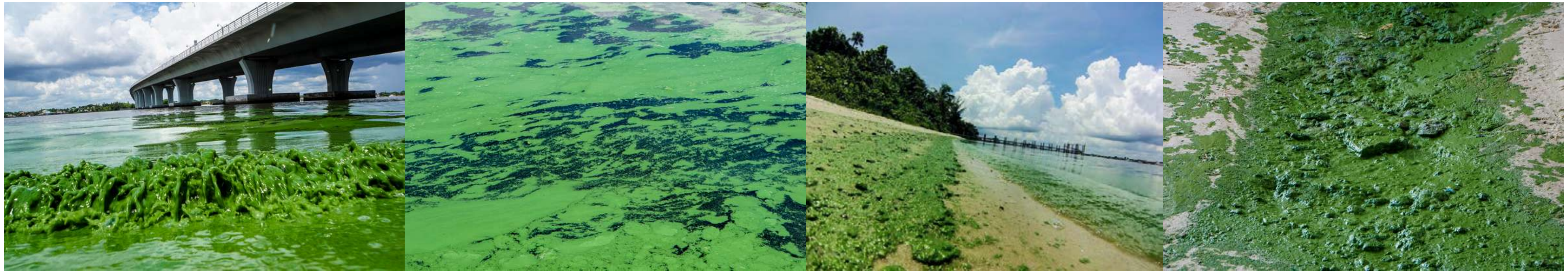
- In 2015, EPA published Health Effects Support Documents that describe the human health effects from exposure to the cyanotoxins microcystins, cylindrospermopsin and anatoxin-A.
- Two Drinking Water Health Advisories (2015) were developed for microcystin and cylindrospermopsin.
- Upon publication, EPA received questions about effects from exposure during swimming and fish consumption.

Development of AWQC/SA and Stakeholder Engagement

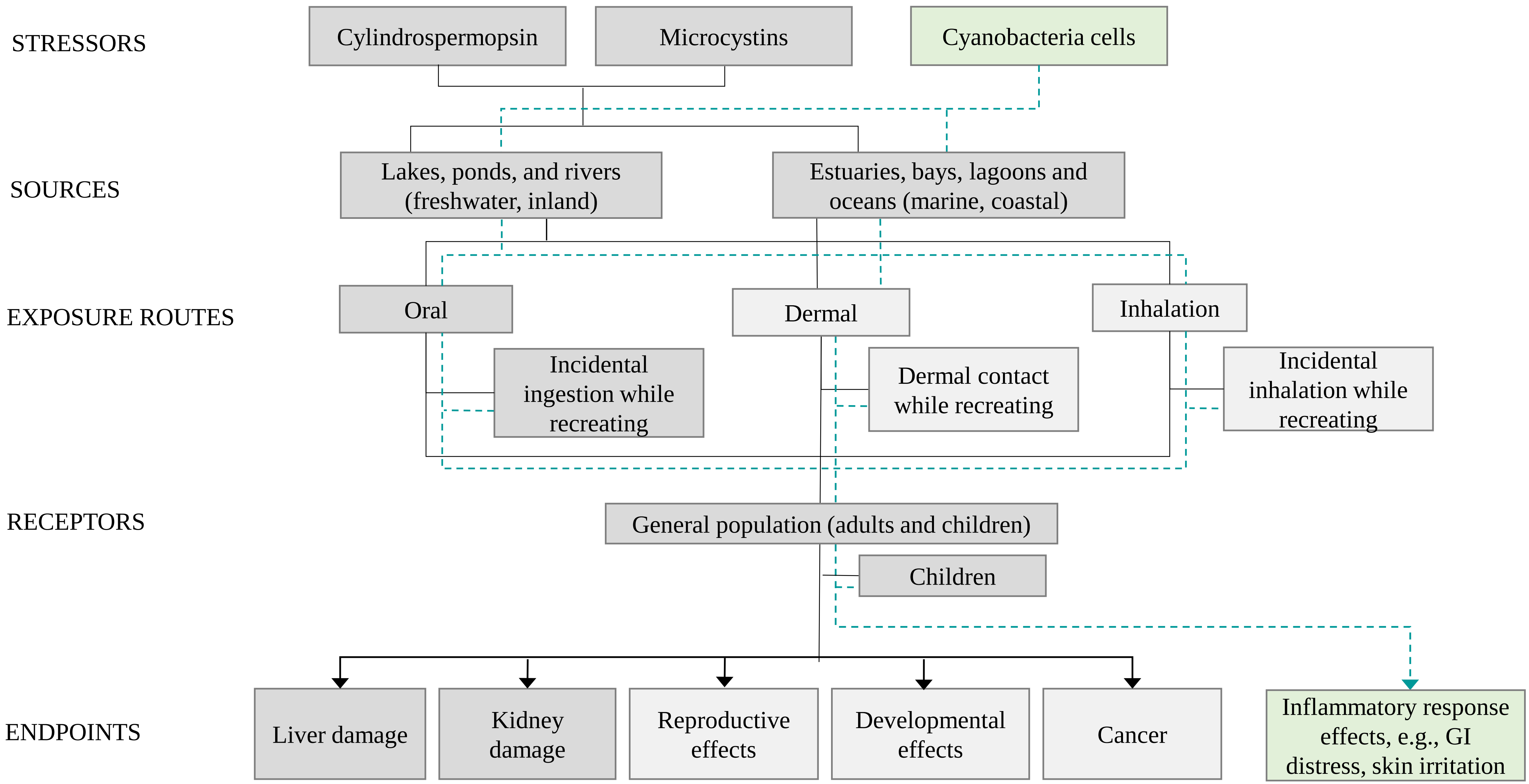
- EPA initiated development of values that reflect the latest science to protect the primary contact recreational use.
- EPA worked with ACWA. Outreach to a variety of other stakeholders over the last several years.
- Arrived at recommendations for values that states can use either as §304(a) recreational criteria or as swimming advisories, or both.
  - Adopted as WQS and used for CWA purposes.
  - Use as basis for swimming advisories for notification purposes.

Development Approach

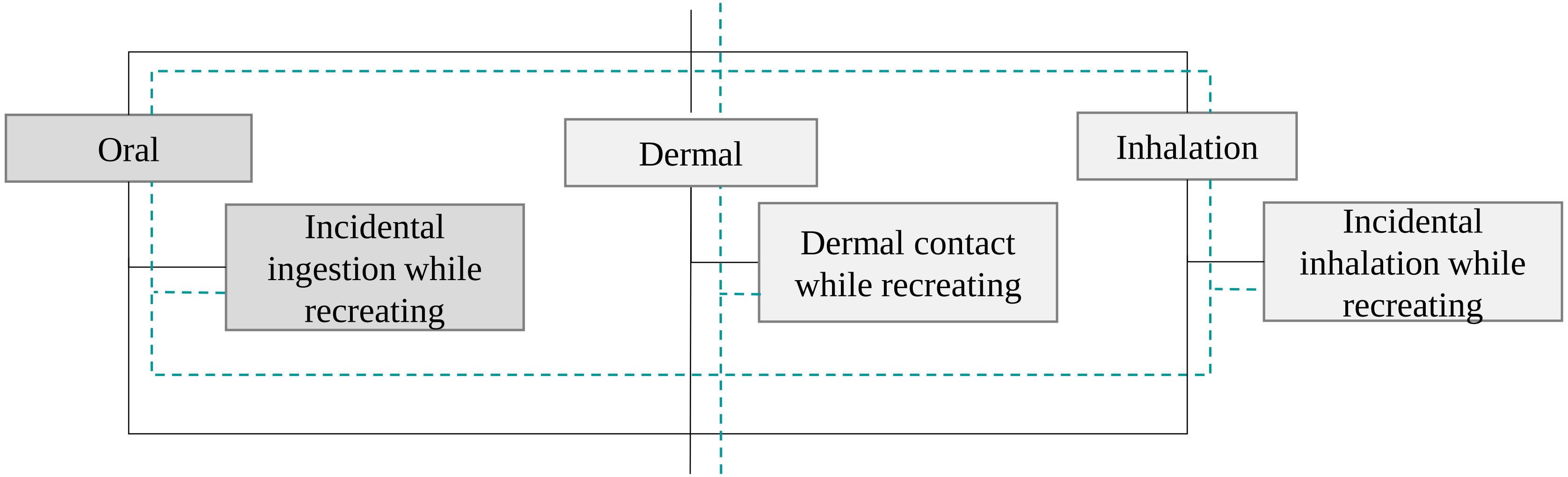
- Use peer-reviewed science to develop recommended values for microcystins and cylindrospermopsin to protect the recreational use.
- Use Agency-recommended recreational exposure values in a scenario which includes immersion and incidental ingestion of ambient water consistent with primary contact recreation.
- Evaluate the latest science describing health effects from exposure to cyanobacteria cells.



Conceptual Model of Cyanotoxin and Cyanobacteria Exposure Pathways While Recreating



Exposure Routes: How are recreators exposed?

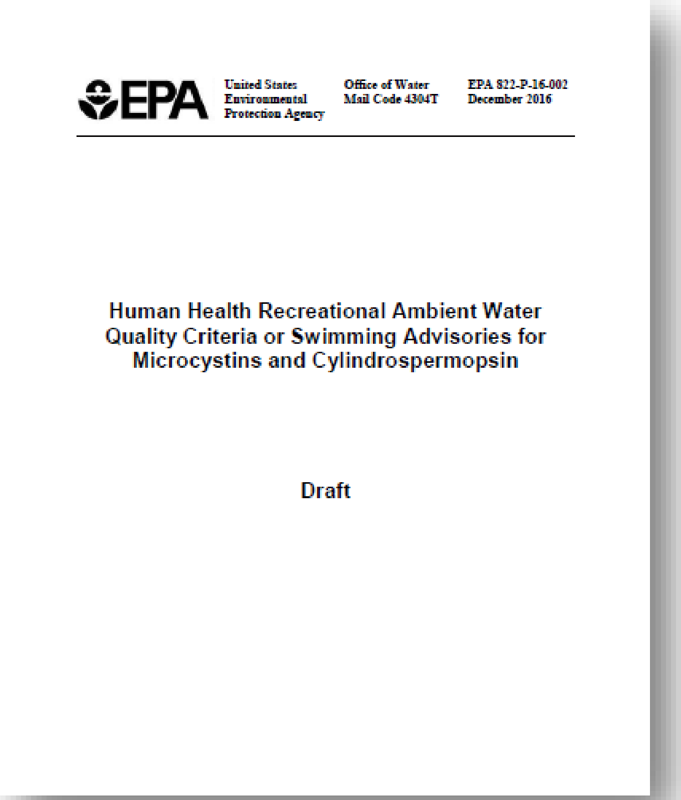


- Evaluated the scientific literature for information on three exposure routes.
- Incidental ingestion of water while swimming is a primary pathway for exposure compared to other recreational water activities.
- Although inhalation and dermal toxicity data were not available, analyses were conducted to compare exposure relative to ingestion.
- HAB-related illness outbreaks in recreational waters reported by CDC suggests dermal and inhalation pathways can be important to consider for recreational exposure to cyanobacterial cells. This is described in the effects characterization of the criteria.

Finding: Children's Exposure and Health

- Children share a disproportionate share of the incidents during HAB-associated outbreaks (Hilborn et al. 2014; Weirich and Miller 2014).
  - 66% of the outbreaks in 2009-2010 were <19 yr.
  - 35% were <9 yr
  - 80% of all confirmed illness reports due to fresh water cyanotoxin exposure involved children.
- Children have greater potential exposure compared to others when recreating.
  - Incidentally ingest a larger volume of water.
  - Spend more time in the water compared to other age groups.
- Evidence shows younger children can be more highly exposed (DeFlorio-Barker et al. 2017; Dufour et al. 2017; Schets et al. 2011).

EPA's DRAFT Recreational AWQC/SA Recommendations



EPA United States Environmental Protection Agency | Office of Water Mail Code 4304T | EPA 822-P-16-002 December 2016

Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin

Draft

Application	Draft Recommended AWQC/SA	
	Microcystins	Cylindrospermopsin
	4 µg/L	8 µg/L
Swimming Advisory	Not to be exceeded on any day.	
Recreational Water Criteria	Not to be exceeded more than 10 percent of days per recreational season up to one calendar year.	

https://www.epa.gov/sites/production/files/2016-12/documents/draft-hh-rec-ambient-water-swimming-document.pdf

Cyanobacterial Cells Characterization

- Document describes available data on effects related to total cyanobacterial cell exposure.
- Elevated cell densities associated with inflammatory health endpoints
  - Health studies demonstrate a linkage between exposure to total cyanobacteria and health effects
  - Available data were insufficient to suggest a nationally-applicable value.
    - Significant density range: 5,000—100,000 total cyanobacterial cells/mL (freshwater)
    - Differences in health endpoints between studies.

Draft AWQC/SA Public Comments

- Draft AWQC/SA posted for public comment in December 2016.
- Public comment period closed March 2017.
- Received comments from 52 entities: states and one tribe, industry representatives and consultants, and environmental organizations.

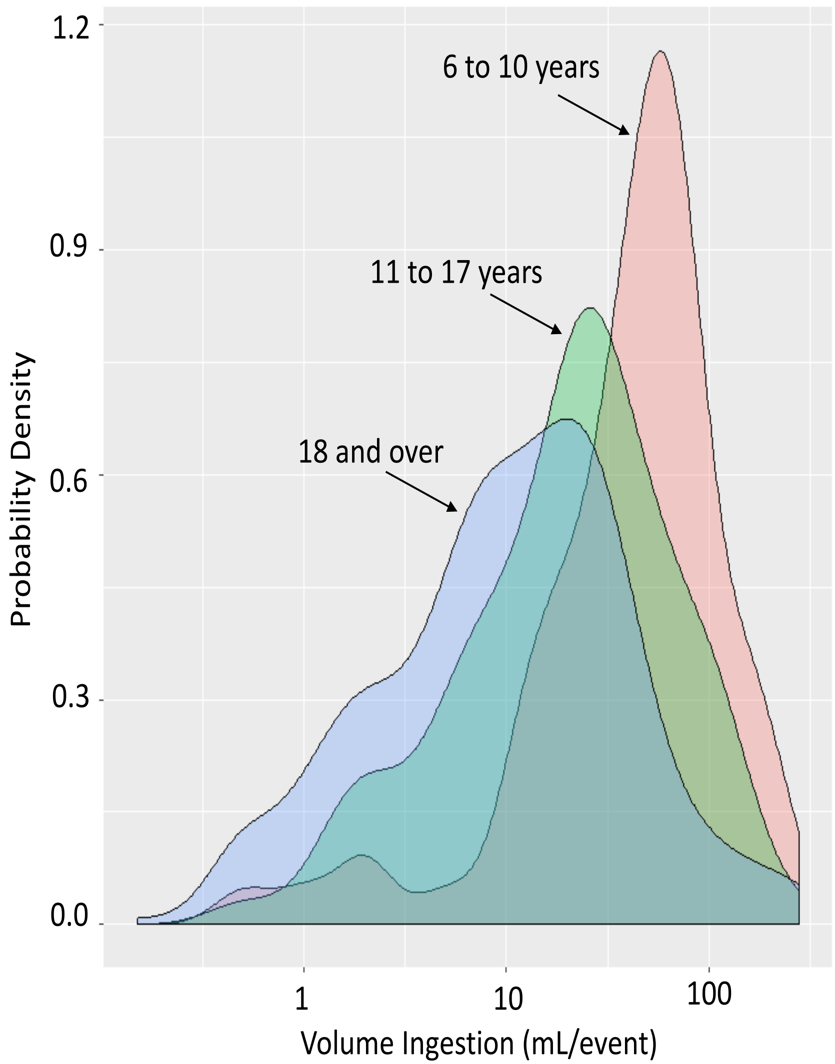
Revising the Recreational AWQC/SA for Cyanotoxins

Revision Highlights

- Major comments addressed the calculation of children's ingestion rate, and duration and frequency components.
- The document was revised to:
  - Incorporate new, more scientifically robust, children's ingestion data published in 2017. Provide additional detail on the science underpinning daily ingestion rate (L/d)
  - Revisited application of relative source contribution parameter, consistent with Guidance.
  - Revised duration and frequency recommendations.
  - Revised estimated toxigenic cell density based on updated values for microcystins.
- We added additional information and detail on toxicological studies in response to comments.

Incidental Ingestion for Age Groups

- For the draft, EPA based estimates of ingestion volume on Dufour et al, 2006, which included 53 participants. The daily ingestion rate (0.33 L/day) was the product of the 97th percentile children's incidental ingestion rate and mean exposure duration for children ages 5 to 11 years.
- Comments criticized the conservatism of the incidental ingestion rate and the limited number of people that participated in the Dufour et al., 2006 study.
- Dufour et al., 2017 was published after the release of the draft and is a more scientifically robust study, including 548 participants, breaking them into additional age groups, and recording the duration of exposure.
- In the revised, EPA combined two distributions: incidental ingestion volumes based on Dufour et al. (2017) and exposure durations from EPA's (1997) *Exposure Factors Handbook*. The 90th percentile of the *combined* distribution is the basis for the exposure parameter, consistent with EPA's Human Health Methodology (EPA, 2000). The revised ingestion rate for children 6 to 10 is reduced to 0.21 L/d.



Relative Source Contribution (RSC)

- For the draft, EPA used an RSC of 0.8. In deriving this value, EPA estimated that incidentally ingested water was the dominant source of exposure to cyanotoxins resulting from primary contact recreation.
- While many agreed with EPA’s selection of this parameter, others pointed out that recreational criteria developed by EPA previously have not considered other sources of toxins, such as drinking water or fish consumption.
- EPA decided to not include an RSC in the derivation of the recommended magnitude in this revision, consistent with derivation of other recreational criteria. However, other sources are acknowledged.
- Not including an RSC is also consistent with the health effects based on short-term exposure.

Duration and Frequency of the AWQC

- For the draft, EPA recommended that criteria not be exceeded more than 10 percent of days per recreational season up to one calendar year. This recommendation was consistent with the 2012 recreational criteria developed for enterococci and *E. coli.*
- Commenters requested EPA provide additional scientific rationale and health relevancy for the recommendation
- EPA reconsidered the frequency and duration components of the criteria and agreed to align the duration component with the 10-day Health Advisory, and to take into consideration seasonal HAB occurrence characteristics such as length of event and severity of occurrence.
  - EPA recommends that the number of years that a pattern of HAB formation occurs that results in impairment of the recreational use is a risk management decision that EPA expects states to define in their water quality standards.

Cyanobacterial Cells Characterization

- The draft provided a summary of available information on health effects associated with cyanobacterial cells, but did not derive criteria associated with cell density due to data uncertainties. It includes:
  - tables of cell density guidelines used by states, countries and international organizations,
  - information available demonstrating a link between total cyanobacterial cell exposure and inflammatory illness,
  - toxigenic cell density of 20,000 cells/mL based on the Draft recommended AWQC/SA for microcystins
- In comments many states indicated they use cell density to manage water quality. Commenters, emphasized the importance of characterizing the inflammatory effects resulting from exposure to cells. They also indicated the importance of having information about adverse effects related to cell density in this document.
- In the revised document the estimate of toxigenic cell density was revised to reflect the updated recommended AWQC/SA for microcystins. As a result, the concentration of cells associated with toxigenic *Microcystis sp* increased to 40,000 cells/mL.

EPA's REVISED Recreational AWQC/SA Recommendations

Application of Recommended Values	Microcystins			Cylindrospermopsin		
	Magnitude (µg/L)	Duration	Frequency	Magnitude (µg/L)	Duration	Frequency
Swimming Advisory	8	One day	Not to be exceeded	15	One day	Not to be exceeded
Recreational Ambient Water Quality Criteria	8	1 in 10-day assessment period across a recreational season	More than 3 excursions in a recreational season, not to be exceeded in more than one year[b]	15	1 in 10-day assessment period across a recreational season	More than 3 excursions in a recreational season, not to be exceeded in more than one year[b]

[a] These recommendations can apply independently within an advisory program or in WQS. States can choose to apply either or both toxin recommendations when evaluating excursions within and across recreational seasons.

[b] An excursion is defined as a 10-day assessment period with any toxin concentration higher than the criteria magnitude. When more than three excursions occur within a recreational season and that pattern reoccurs in more than one year, it is an indication the water quality has been or is becoming degraded and is not supporting its recreational use. As a risk management decision, states should include in their water quality standards an upper-bound frequency stating the number of years that pattern can occur.

Implementation Tools for Cyanotoxins in Recreational Waters

Implementation Tools - Phase 1

EPA posted suite of materials on July 7, 2017:

- Help states and communities protect public health during harmful blooms
- Assist in developing cyanobacteria monitoring programs
- Communicate health risks to the public
- Address harmful bloom outbreaks

Development Process

- Cooperative EPA/State Effort
  - Workgroup with Association of Clean Water Administrators (ACWA) members:
    - 6 states (NC, WI, IN, UT, IA, CA)
  - Solicited implementation issues related to cyanotoxin criteria and/or numeric nutrient criteria for lakes.
  - Used webinars and face-to-face meetings to discuss and work through implementation issues.
- Also worked with: EPA -Drinking Water, Monitoring, Wastewater Permitting, ORD; ASTHO, CDC.

Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters

A compilation of web materials, useful documents and links-

- Main Page:
  - Basic info on cyanotoxins and cyanobacteria
  - Many links to state/local government documents, NOAA, CDC, WHO sites
- Monitoring Document:
  - Information on setting up a monitoring program and prioritizing waters, recommendations for notifying the public, considerations for methods
- Communication Toolbox:
  - FAQs, social media template and press release templates, Cyanobacteria Bloom Response Contact List and notification signage examples

Implementation Tools – Phase 2

- In conjunction with finalization of the cyanotoxin criteria/advisory document, provide additional implementation support materials
  - FAQs for assessment/listing/TMDLs/NPDES permits in recreational waters
  - Adoption and implementation flexibilities for criteria
- Expected summer 2018

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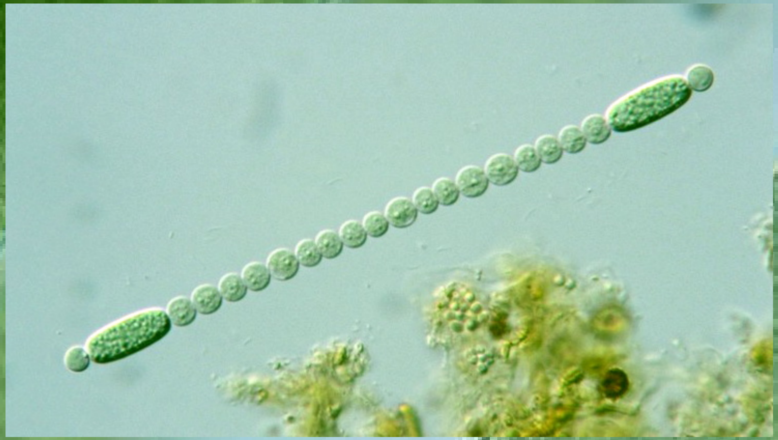

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EPA's CyanoHABs Website

www.epa.gov/cyanohabs

Brown AND Caldwell

North Carolina Nutrient Science Advisory Council

Recommendations for Defining CHLa Assessment Units in Reservoirs

Clifton F. Bell | September 24, 2018

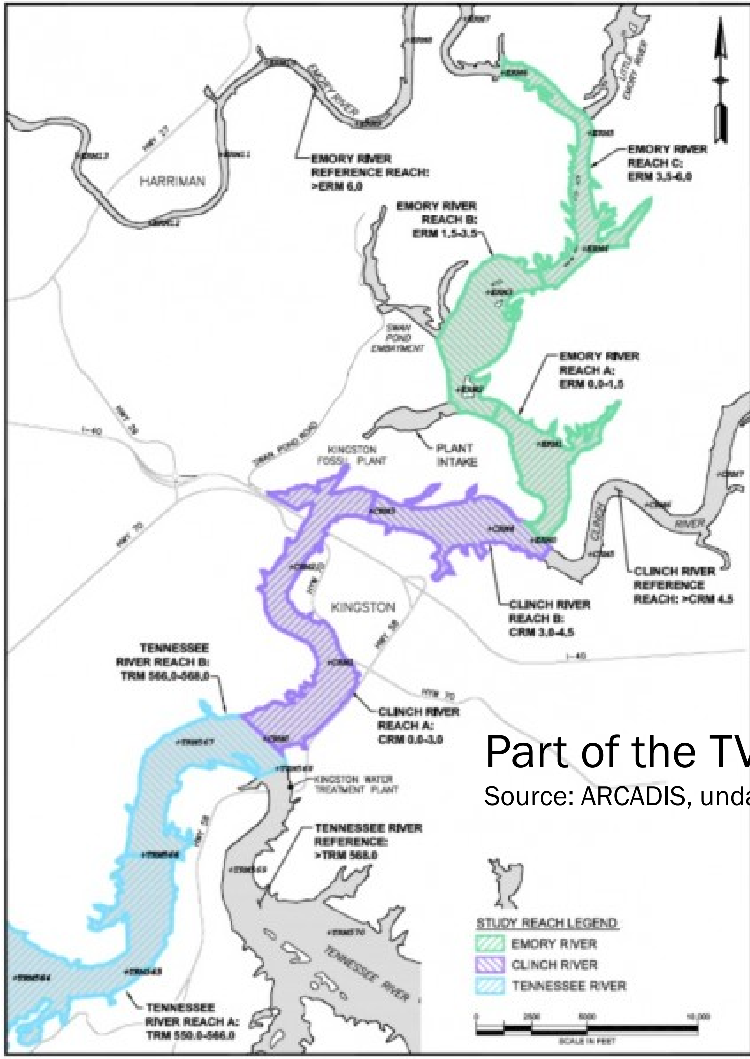
Some Guiding Principles

- Segmentation should drive monitoring design, not the other way around.
- For CHLa assessment, lakes and reservoirs should be segmented into logical assessment/management units based on:
  - Recognizable morphological features
  - Limnological principles
  - Relatively homogenous (not uniform) CHLa conditions
- Segmentation should strike a reasonable balance between lumping and splitting along a CHLa gradient.

USEPA Guidance (2005) on Segmentation

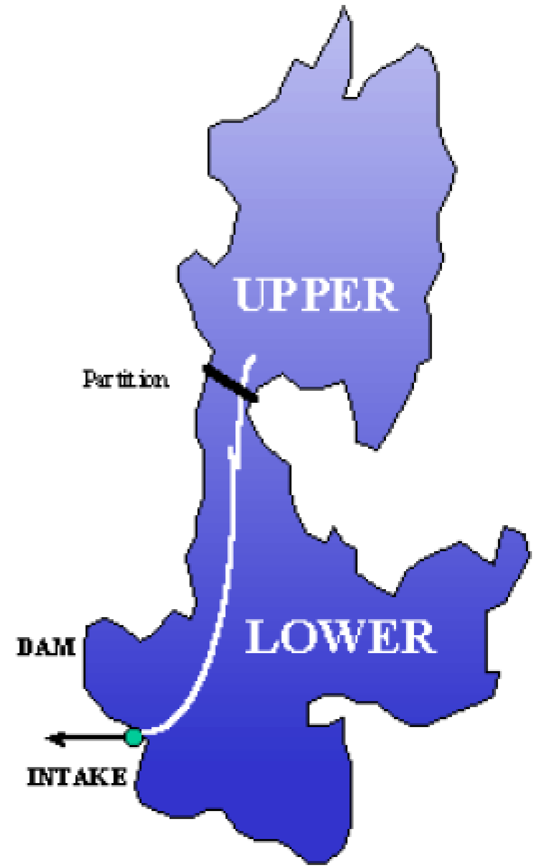
- "Segments should…be larger than a sampling station but small enough to represent a relatively homogenous parcel of water with regard to hydrology, land use influences, point and nonpoint source loadings, etc."
- "Segmentation may reflect an *a priori* knowledge of factors such as flow, channel morphology, substrate, riparian conditions, adjoining land uses, confluence with other water bodies, and potential sources of pollutant loadings…"

Use of Morphology: Recognizable Junctions, Constrictions, and Embayments



Part of the TVA System

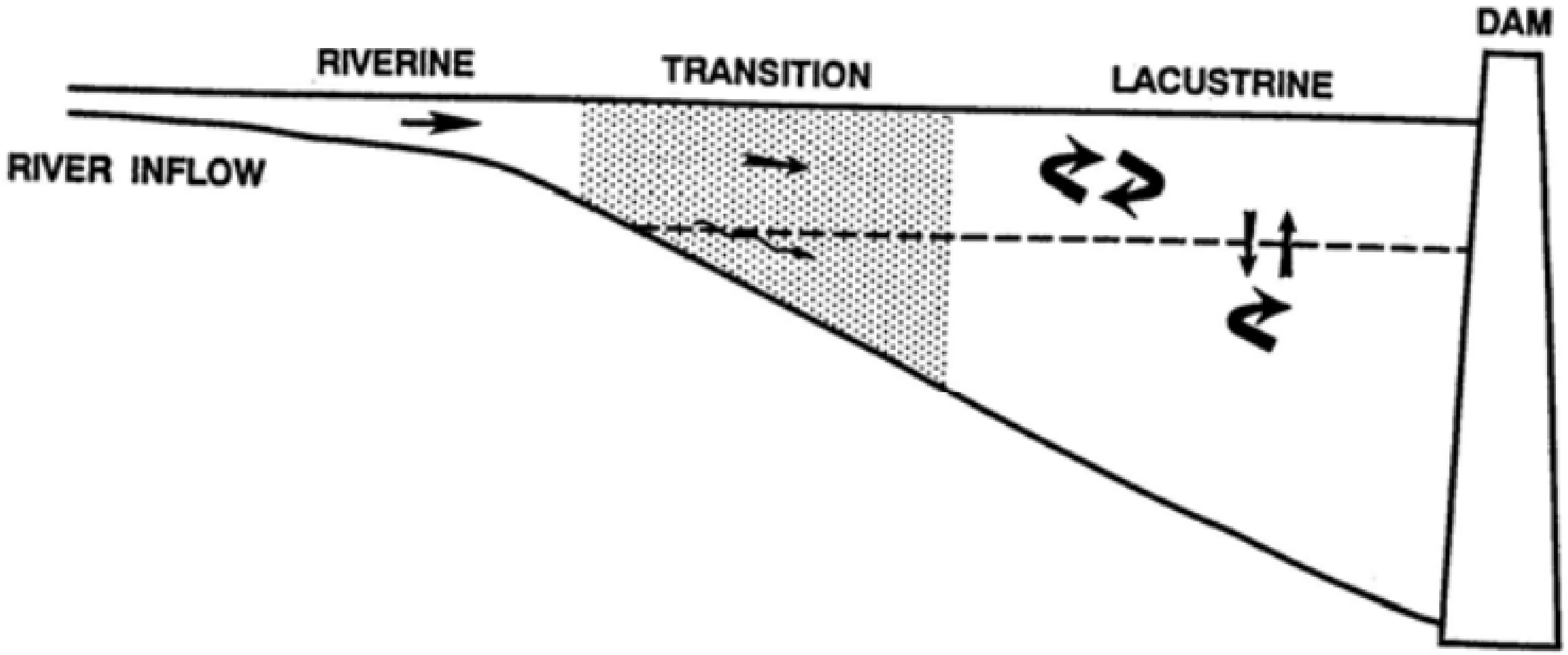
Source: ARCADIS, undated



Stafford Reservoir No. 2, CT

Source: Kortmann, undated

Use of Limnology: Riverine, Transitional, and Lacustrine Zones



Source; Wetzel, 2001

Use of Limnology: Riverine, Transitional, and Lacustrine Zones

Source; Kimmel and Groeger, 1984

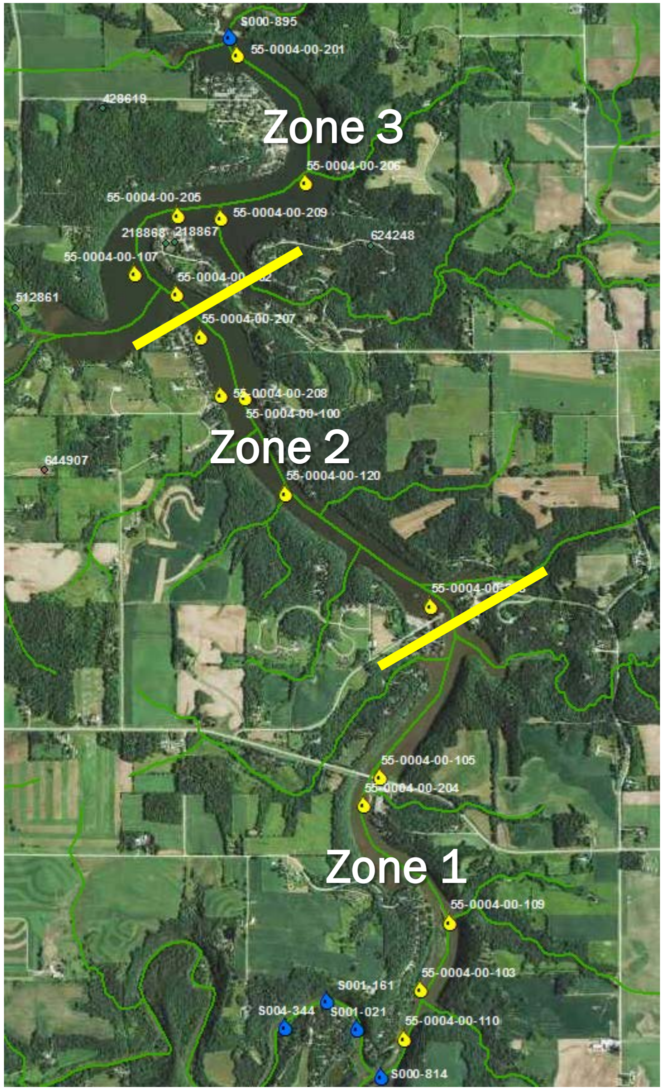
RIVERINE ZONE
- Narrow basin
- High flow
- High suspended solids, low light
- High nutrients, advective supply
- Light limited photosynthesis
- Algal cell loss by sedimentation
- Organic matter supply allochthonous
- More "eutrophic"

TRANSITIONAL ZONE
- Broader, deeper basin
- Reduced flow
- Lower suspended solids, more light
- Advective nutrient supply reduced
- High photosynthesis
- Algal cell loss by sedimentation, grazing
- Intermediate
- Intermediate

LACUSTRINE ZONE
- Broad, deep lake-like
- Little flow
- Clearer
- Internal nutrient recycling, low nutrients
- Nutrient limited photosynthesis
- Algal cell loss by grazing
- Organic matter supply autochthonous
- More "oligotrophic"

CHLa Procedures from Other States

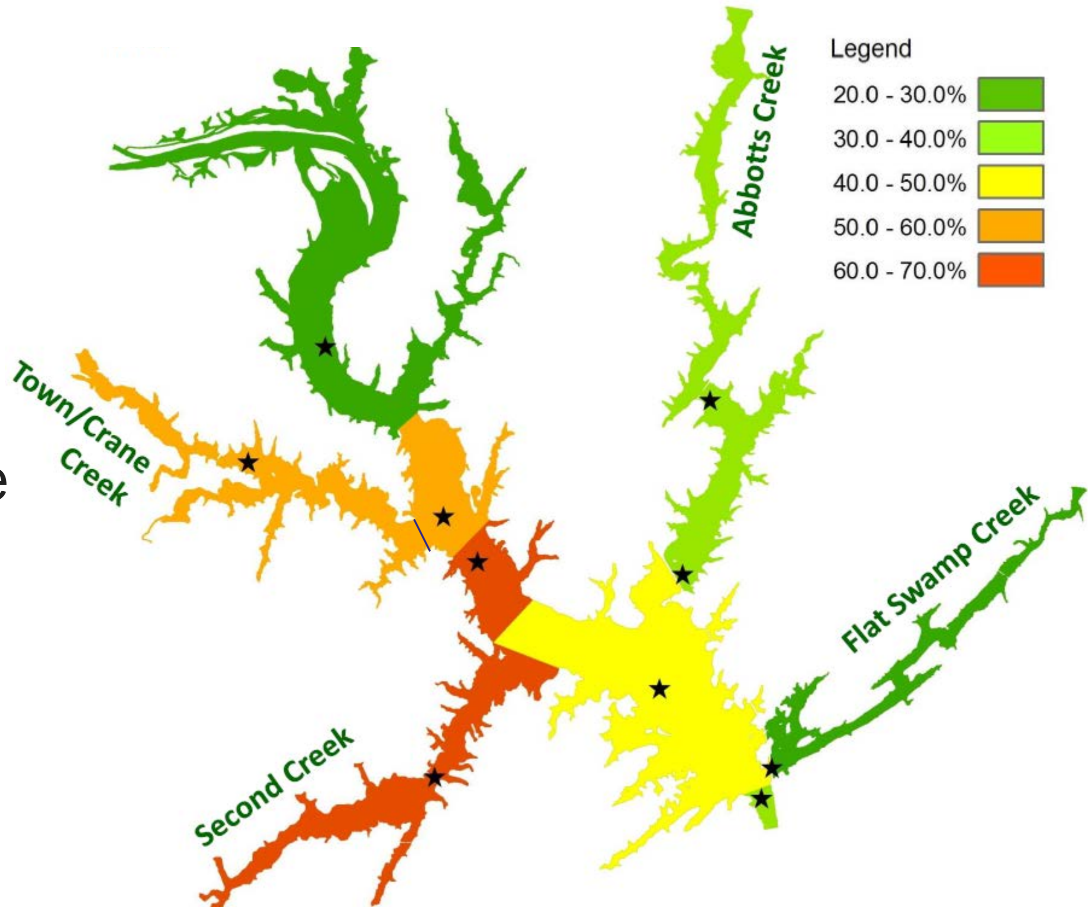
- <u>Most common</u>:
  - Define assessment units *a priori* and stick with them.
  - HUC8s
  - Often little documentation.
  - Often use limnological zones & major junctions
- <u>Some states/reservoirs</u>: Only assess CHLa in lacustrine zone or near dam (e.g., VA, AL)



Lake Zumbro, MN

NC's Current Procedure

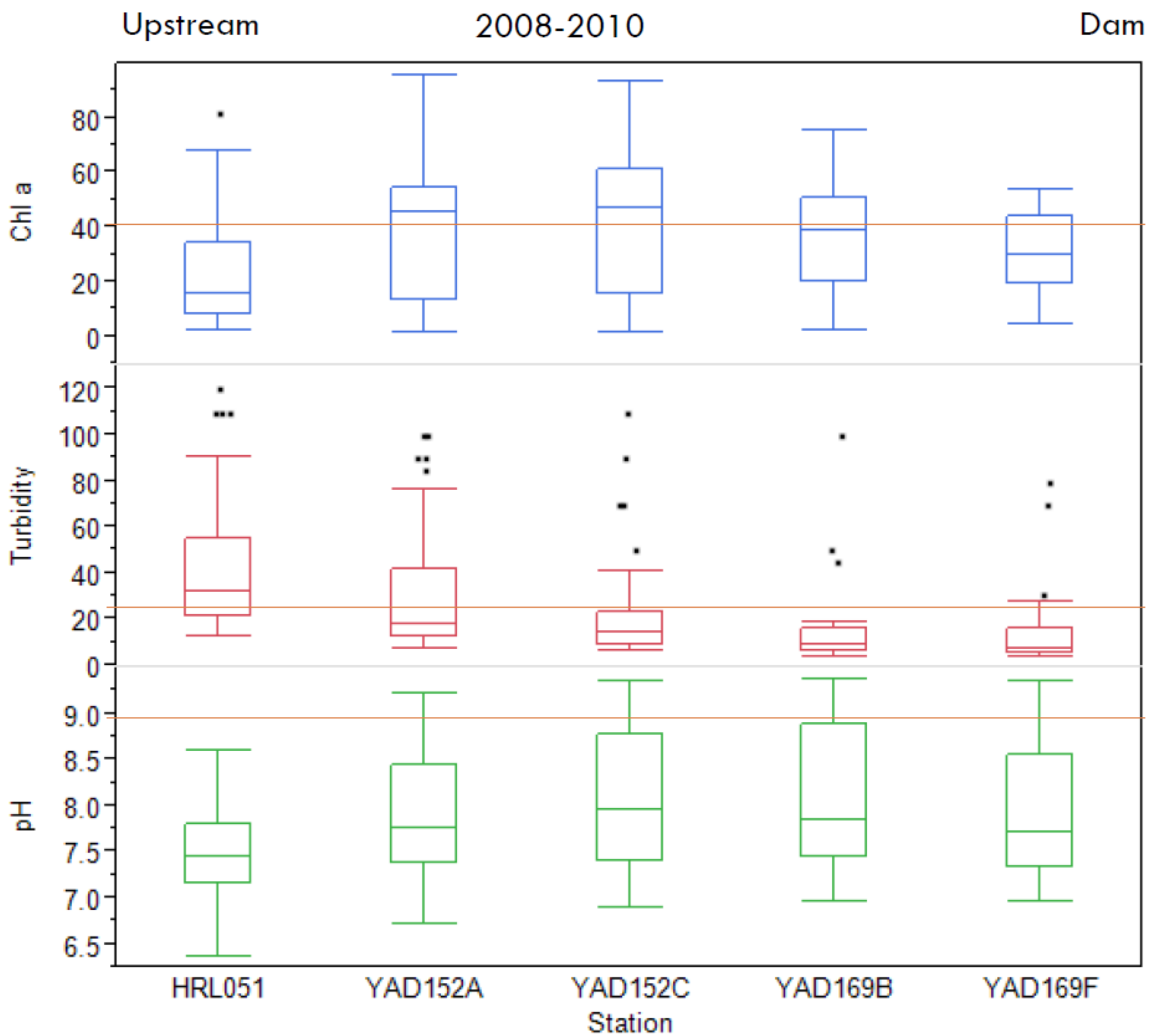
- If two stations in an assessment unit show different attainment results, split into two segments.
- Can chop water bodies into small segments based on station locations.
- Station locations determine assessment units, not the other way around
- Leads to unstable assessments
- Increases implementation costs because "worst" station controls.

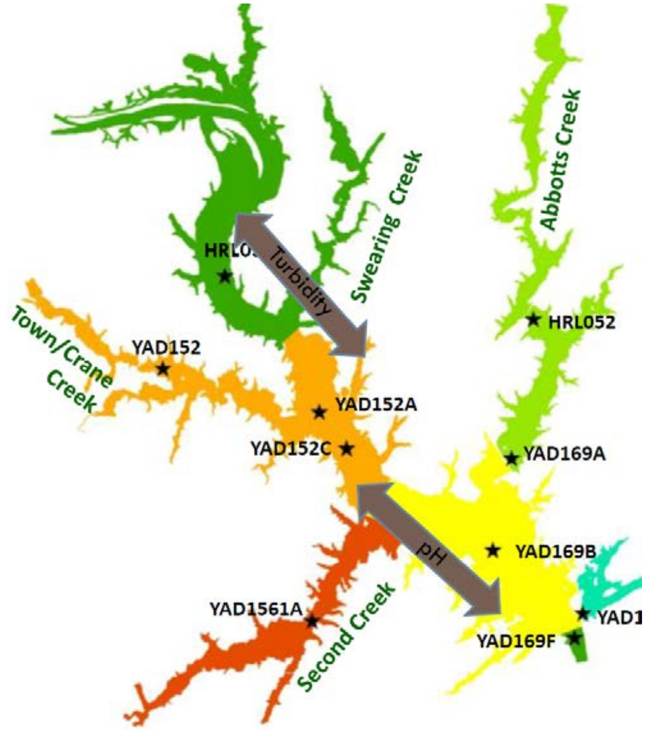


A priori definition of assessment units is especially appropriate for CHLa

- CHLa is a “master” variable for managing the overall trophic state of lakes and reservoirs.
- CHLa criteria are usually expressed as seasonal averages rather than instantaneous values.
- Generally not directly set based on acute toxicity to a swimming or drifting organism, aka toxic metal or organic.
- Points to need for balance between lumping and splitting.

Stations YAD152A and YAD152C Are "Relatively Homogenous" wrt CHLa





Recap of Recommendation

- For the purposes of CHLA assessment, reservoirs should be segmented into logical management units based on *a priori* knowledge of:
  - Morphology
  - Limnological zones
  - Relatively homogenous (not uniform) CHLa conditions
- Segments should not be subdivided for CHLa assessment simply because one station attains and another fails for some parameter.
- Strike a reasonable balance between splitting and lumping along a CHLa gradient

Options discussed for calculating Chl a criteria

~

Geometric Mean (Geomean)

vs

Arithmetic Mean (Average)

vs

Percent Exceedance of a Standard

NCDP Meeting

9/24/2018

Nora Deamer – Basin Planner

Option 1:

What is Geometric Mean

- Central number in a geometric progression (e.g., *9* in *3, 9, 27*), also calculable as the *n* th root of a product of *n* numbers.
  - Also a measure of central tendency
  - Often used when comparing different items—finding a single "figure of merit" for these items—when each item has multiple properties that have different numeric ranges
  - Geomean ≤ Average <u>ALWAYS</u>

Geometric Mean

$$GM = \sqrt[n]{a_1 a_2 a_3 \ldots a_n}$$

Geomean Example

Example:

DATASET = 3, 9, 27

Geomean = $(3*9*27)^{1/3} = (729)^{1/3} = 9$

Notes about Geomean

- Geometric mean is often used to evaluate data covering several orders of magnitude (e.g. fecal coliform 0-6,000)
- If your data covers a narrow range (e.g. max value at least 3x the smallest value), or if the data is normally distributed around high values (i.e. skew to the left), geometric means (log transformations) may not be appropriate
- Do not use geometric mean on data that is already log transformed such as pH or decibels (dB)
- Physical meaning? What does it mean to multiply concentration by concentration?

Option 2:

What is Arithmetic Mean?

- Sum of all values (n) divided by n
  - Measure of central tendency
  - Useful when evaluating independent values (i.e. test scores)
  - Greatly influenced by outliers

Arithmetic Mean(average)

$$AM = \frac{a_1 + a_2 + a_3 + \ldots + a_n}{n}$$

Arithmetic Mean (Average) Example

Example:

DATASET = 3, 9, 27

Average = (3+9+27)/3 = (39)/3 = 13

Option 3:

What is % Exceedance of the WQ Standard?

- Number of all values exceeding a critical values (n>40 µ/L) divided by the total number (n) of samples collected for the time period of interest multiplied by 100.
  - The percent of times (in a certain period) that a random process exceeds some critical value.
  - Intended to allow for excursions of the standard (~10%).
  - Useful when evaluating critical values “not to exceed” in order to protect a specific use.

Example

DATASET = 45, 20, 50, 12, 12, 50, 12, 50, 25, 35

Total n = 10

n>40 = 4

Percent Exceedance = 40 % (with 99% confidence)

Average = 31.1

Geomean = 26.50

Option 3:

Percent Exceedance of the WQ Standard

*Benefits of this method from a basin planning perspective:

- ❖Transparent assessment.
- ❖Easily understood by the general public.
- ❖Easy to explain how a bloom event relates to the standard.

Geomean and Arithmatic Mean provide a "Central Tendency" calculation

- A central tendency value might be an optimal environmental number, is it protective when you get the extreme responses in the environment? (The extreme concentrations are when you are more likely to have a negative ecosystem responses, i.e., toxin production, fish kills, low DO, high pH)

- Does the Central Tendency protects all designated uses?

- Does the Central Tendency protects downstream uses?

High Rock Lake – 2016 Ambient Monitoring Summary
May – October

		chlorophyll-a (photic zone composite)				
	# of samples	# exceed 40 µg/L	% > 40 µg/L	average (µg/L)	geomean (µg/L)	range (µg/L)
Mainstem						
HRL051	10	2	20	26	19	6.5 - 64
YAD152A	10	8	80	55	52	20 - 80
YAD152C	11	9	81.8	59	57	33 - 74
YAD169B	10	8	80	46	44	24 - 57
YAD169F	10	4	40	38	36	19 - 55
Arms						
YAD156A	10	8	80	53	51	34 - 72
YAD169A	11	3	27.3	39	39	31 - 52
YAD169E	10	2	20	32	31	20 - 48

Table 4-2. 2014-2017 Chlorophyll-a (µg/L) summary metrics for each Falls Lake monitoring location.

Location	Year	n	n (%) > 40 µg/L	Mean (Annual)	Mean (Growing Season)	Geometric Mean (Annual)	Geometric Mean (Growing Season)
	2015	12	2 (17%)	31	35	30	33
	2016	12	2 (17%)	28	36	25	34
	2017	12	5 (42%)	42	49	39	47
CAAE - FL10C	2015	12	4 (33%)	33	36	31	34
	2016	12	1 (8%)	28	32	24	32
	2017	11	9 (82%)	44	49	42	49
DWR - NEU0171B	2014	12	3 (25%)	34	33	31	32
	2015	12	2 (17%)	33	35	32	34
	2016	12	2 (17%)	28	35	25	34
	2017	12	5 (42%)	40	45	38	44
DWR - LC01	2014	12	1 (8%)	32	29	31	28
	2015	12	0 (0%)	25	28	24	27
	2016	12	0 (0%)	24	26	22	25
	2017	12	3 (25%)	37	40	35	39
CAAE - FL9C	2015	12	2 (17%)	31	34	29	31
	2016	12	2 (17%)	25	26	22	26
	2017	11	8 (73%)	44	50	41	46
DWR - NEU018C	2015	12	1 (8%)	26	31	22	29
	2016	12	0 (0%)	24	28	22	27
	2017	12	4 (33%)	42	47	38	43
DWR - NEU018E	2014	12	3 (25%)	34	31	31	28
	2015	12	1 (8%)	27	29	25	25
	2016	12	1 (8%)	28	34	25	31
	2017	12	4 (33%)	42	46	38	42
DWR - LI01	2014	12	2 (17%)	36	30	33	29
	2015	12	2 (17%)	29	30	28	29
	2016	12	2 (17%)	29	31	27	30
	2017	12	4 (33%)	42	42	40	40

Upper Neuse River Basin Association Monitoring Program Annual Report. May 2018

https://unrba.org/sites/default/files/UNRBA%202018%20Annual%20Report%20-%20Final.pdf

Other issues to consider -

- Seasonality – Summer vs Year Round
- Sampling protocol – Depth Integrated vs Grab (should this depend on the type of bloom/algal community type?
- Toxic vs Nontoxic