Table 1 and Table 2 extracted from the Cyanobacteria Information Gaps document

Table 1. The areas of agreement for cyanoHAB impairment in the Delta were developed by the Science Work Group after review and discussion of the white paper.

Issue #	Topic	Agreement
1	Cyanoblooms	*Microcystis* is the most comment cyanoHAB genus in the Delta although cyanoblooms of *Aphanizomenon* and *Anabaena* have also been documented.
2	Toxicity	CyanoHAB blooms can cause adverse impacts for people, livestock and aquatic wildlife because the metabolic byproducts are liver and nerve toxins. Humans and livestock concerns include degradation of drinking water and contact recreation. Impacts to aquatic wildlife include acute and chronic toxicity and bioconcentration of toxins in the food chain.
3	Toxins	Microcystin is the primary toxic cyanoHAB byproduct detected in the Delta. There are numerous types of microcystins. Microcystin LR is believed to be the most toxic of these byproducts and is consistently measured in the Delta.
4	Risk	The risk of microcystin exposure to people and wildlife has not been well quantified in the Delta although potentially toxic concentrations to both people and wildlife have been detected. Additional monitoring will be needed to ascertain the extent, magnitude, duration and frequency of these episodes.
5	Toxicological guidelines	The California Office of Health Hazard Assessment, World Health Organization and the U.S. EPA have published human and some domesticated animal health guidelines for some microcystins. These congeners have been measured in water and organisms in the estuary. No toxicological guidelines are available for wildlife, making a robust aquatic life risk assessment difficult without additional toxicological studies to establish no effect and low effect levels.
6	Hot Spots	The San Joaquin River in the Central Delta has experienced reoccurring cyanoHAB blooms. High concentrations may also have occurred in other unmonitored locations in the Delta.
7	Trends	Visible *Microcystis* blooms were first observed in the late 1990s and are now common in the Delta during the summer and fall.
8	Drivers	Seven water quality drivers have been identified that likely control the production of *Microcystis* blooms in the Delta. These are temperature, high irradiance, water clarity, flushing time, a stratified water column, salinity, and nutrients.
9	Delta Heterogeneity	The absolute magnitude of the drivers may change independently of each other in different areas of the delta resulting in changes in their relative importance and in the probability of *Microcystis* blooms.
10	Bloom initiation	Present bloom initiation may be triggered by higher water temperatures, increased residence time and/or increased water clarity in the Central Delta. There is no evidence that nutrient concentrations, forms or ratios trigger bloom initiation.

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Table 1 Continued…

11	Bloom size	It is uncertain which driver limits maximum *Microcystis* bloom biomass and toxin concentration in the Central Delta.
12	Maximum potential bloom size	If other drivers do not limit production, *Microcystis* growth will continue until the available nutrient pool is exhausted.
13	Nutrient Limitation	Further research is necessary to evaluate whether *Microcystis* bloom growth reduces ambient nutrient concentrations and whether final biomass is constrained by the available nutrient pool.

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Table 2. Summary of information gaps identified by the Cyanobacteria Science Work Group for the Delta after review and discussion of the cyanobacteria white paper. Topics 1 through 6 may best be addressed by a combination of monitoring and special studies. The two efforts should be closely coordinated to simultaneously inform multiple issues at the same time.

Topic	Management Question	Knowledge gap	Recommendation
1	Have the major hotspots where cyanoHAB blooms occur and/or where people & wildlife are at greatest risk from exposure been identified?	Uncertainty exists whether the location & magnitude of hotspots in the Delta have been identified because of a lack of a comprehensive surveillance program.	Develop a comprehensive multi-year monitoring program
2	What risk do cyanoHAB toxin levels pose for human drinking water & contact recreation?	The risk of exposure has not been adequately characterized because there is no monitoring program in the Delta measuring bloom formation and toxin levels in a manner appropriate for determining human health impacts and because relevant exposures thresholds such as Maximum Contaminant Level Goals for cyanotoxins in drinking water have not been developed.	The expanded monitoring program should include surface scum monitoring to evaluate potential human health impacts.
3	What risk do cyanoHAB toxin levels pose for aquatic wildlife in the Delta?	The risk to wildlife has not been adequately characterized because of the absence of a Delta-wide monitoring program. In addition, there are no accepted aquatic life benchmarks for comparing toxin levels against.	Develop a monitoring program to measure dissolved & particulate cyanoHAB toxin concentrations. Develop appropriate suite of wildlife biometrics including tissue concentrations. Let others determine appropriate toxicological endpoints.
4	Chlorophyll is the most common measurement of algal abundance in the Delta. Relationships have been observed elsewhere between chlorophyll & toxin levels. Do similar relationships exist in the Delta which would allow a preliminary assessment of the risk to humans and wildlife?	Is there a consistent relationship between chlorophyll and cell abundance/toxin levels in different seasons and locations in the Delta? Does the relationship change during bloom development and senescence? Could these relationships be used to predict human and wildlife health impacts?	See recommendations for topic #1 above.

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Table 2. Continued…

5	What factor(s) limit the growth rate and ultimate maximum size of a bloom & its toxin level? Are these factor(s) controllable?	No information exists on which factor(s) control cyanoHAB growth rates and limit final bloom biomass in the Delta. It is also not known whether these factors differ by season and location.	Monitor multiple blooms at different stages of development and at different locations in the Delta to determine what controls growth rate, maximum biomass & toxin level. Evaluate the importance of other factors in addition to those identified in the white paper.
6	Can nutrient management reduce the magnitude & frequency of blooms and the risk of elevated toxin levels anywhere in the Delta?	Do nutrient concentrations decline as blooms develop? Does a lack of nutrients arrest bloom growth & determine final bloom biomass? What nutrient levels are predicted to constrain bloom biomass below a level that poses a risk to people & wildlife? Do these concentrations change in different areas of the Delta? How would low nutrient concentrations affect the growth of other beneficial phytoplankton species?	Conduct high frequency temporal monitoring in combination with special studies to determine whether nutrients affect maximum bloom biomass & toxin level. Research should be closely coordinated with topic #5 above.
7	Can models help evaluate the relative importance of different cyanoHAB drivers, test management scenarios & evaluate additional ecological effects of nutrient management?	Algal and cyanoHAB ecosystem models are not available for the Delta although a Modeling Science Work Group is being formed to make recommendations on model development.	Develop an ecosystem model that includes a cyanoHAB component. All cyanoHAB monitoring and special studies should be coordinated with model development to inform model calibration and validation.

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