FINAL REPORT

Summary of Review Panel Comments for

CALFED Water Quality Program, Stage 1 Final Assessment

Summary Prepared by:

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Based upon Reviews by:

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Executive Summary

Background

The CALFED Bay-Delta Program (CALFED) is a joint state-federal effort with four goals: to improve water supply reliability, water quality, and levee reliability, and to restore the largest estuary on the West Coast. The CALFED Water Quality Program (WQP) focuses on drinking water quality and indirectly on agricultural water quality. Ecosystem water quality is implemented under the Ecosystem Restoration Program. The WQP is jointly implemented by the U.S. Environmental Protection Agency, the California Department of Health Services, the State Water Resources Control Board, and the Regional Water Quality Control Boards, in coordination with the California Department of Water Resources, U.S. Bureau of Reclamation, and the U.S. Geological Survey. The CALFED Bay-Delta Public Advisory Committee (Water Quality Subcommittee) closely coordinates with and provides advice to the WQP agencies on CALFED actions.

The guiding documentation for CALFED is the Record of Decision (ROD) for the Programmatic Environmental Impact Statement and Report (PEIS/EIR). The ROD lays out a 30-year plan to meet program objectives for the four program goals. The Preferred Program Alternative chosen in the ROD employs a through-Delta approach to conveyance. CALFED agencies agreed in the ROD that this conveyance approach would be monitored and then assessed at the end of seven years (defined herein as Stage 1) to determine whether it is meeting the Program's goals and objectives.

The ROD outlines a general water quality goal of "continuously improving Delta water quality for all uses, including in-Delta environmental and agricultural use," and contains specific water quality milestones and implementation actions for water quality improvement. The primary purpose of the CALFED Water Quality Program Stage 1 Final Assessment Report (Final Assessment) is to assess the progress made by the WQP towards meeting CALFED water quality targets and alternative treatment technologies. The Final Assessment builds on previous CALFED water quality reports for the ROD (initial assessment, treatment, and technical assessment) and also addresses water quality issues identified through more recent Delta planning efforts (Delta Vision).

The Final Assessment also provides:

- Drinking water quality context for the End of Stage 1 conveyance alternatives.
- Integration and synthesis of scientific information on Delta drinking water quality from the source to the tap.
- Priorities for water quality actions for the next stage (herein referred to as Stage 2).
- Initial WQP performance measures to move the program to a performance-based program in Stage 2.
- Documentation for past and future drinking water decision-making.

<u>Peer Review Charge</u>

The overall goal of this peer review is to assist the CALFED WQP and the CALFED Water Quality Subcommittee in evaluating the overall adequacy of the findings, conclusions and recommendations in the Final Assessment and the information used to support them. The peer review panel (RP) provides here a written review that focuses on the strengths and weaknesses of the Final Assessment Report and Appendices. The RP was directed to focus on the following subject/topic areas and specific questions:

1. **Information Gathering:** Has the most appropriate scientific information been used in developing all technical areas? Are the methods of collecting information (existing or new) understandable, scientifically defensible, fully documented and the best available? What information (e.g. data, conceptual models, etc.) was not considered that should have been presented or addressed?

2. **Information Analysis and Results:** Have processes and methodologies (e.g. analyses of data) been used that are understandable, scientifically defensible, fully documented and appropriate? What results are missing that could reasonably be obtained? Are the modeling and risk analysis approaches employed defensible and consistent with other large scale projects elsewhere in the nation and internationally?

3. **Findings and Recommendations:** How well are the key findings and recommendations supported by the stated data, methodologies or conceptual models, and analysis results? Do the findings and recommendations sufficiently address the level of progress made by the WQP for Stage 1?

4. **Conveyance:** Are the findings and recommendations regarding the role of conveyance in meeting the water quality objective valid?

5. **Stage 2 Priorities:** Do the identified priorities follow logically from the findings and recommendations. Are there additional critical knowledge gaps?

6. **Approach for "equivalent level of public health protection":** In the CALFED Bay-Delta Program Record of Decision (2000) the goal of the WQP is to provide "safe, reliable, and affordable drinking water in a cost-effective way," with a target to "achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies." Is the approach taken to determining if an "equivalent level of public health protection" has been achieved appropriate? Are there other ways to evaluate progress towards this goal?

7. **Treated water quality:** Are the conclusions about linkage between source water quality and treated water quality valid? Are additional treated water quality data and analysis of needed?

8. **Performance Measures:** Are the identified performance measures sufficient and appropriate for the stated goals of the program?

Water Quality Review Panel Members & Report Preparation

The RP consists of 4 nationally renowned water quality scientists and engineers who together cover the breadth of relevant issues needed to ensure a thorough evaluation of the Stage 1 Final Assessment. The RP were:

- Phillippe Daniel - Vice President of CDM Inc. (Walnut Creek, CA)
- David Reckhow – Professor of Civil and Environmental Engineering at University of Massachusetts (Amherst, MA)
- Philip Singer – Professor of Environmental Sciences and Engineering at University of North Carolina at Chapel Hill (Chapel Hill, NC)
- Paul Westerhoff - Professor and Chair of Civil and Environmental Engineering at Arizona State University (Tempe, AZ)

One RP member (Westerhoff) served as the lead reviewer. The lead reviewer was requested to conduct the same review as the other RP members, facilitate and coordinate completion of the reviews, and integrate the reviewers' comments into a cohesive report. On July 10, 2008, the lead reviewer traveled to Sacramento and presented a summary of the RP comments to CALFED staff and the CALFED Water Quality Subcommittee.

Independent reviews were prepared by each RP member; these are provided in appendices to the committee report. An integrated set of comments responding to the eight subject/topic areas and questions was prepared by the lead reviewer, and serves as the body of this RP document. This integrated text was, in most cases, taken verbatim from individual RP comments. A short introductory section with general summary comments was prepared by the entire RP.

Summary of Key RP Responses to Eight Subject/Topic Areas

This section highlights the more critical responses in the eight subject/topic areas in which the RP was charged to comment. The main document provides more in-depth analysis and discussion, and additional issues in response to the specific questions in each subject/topic area.

1. **Information Gathering:** *Has the most appropriate scientific information been used in developing all technical areas? Are the methods of collecting information (existing or new) understandable, scientifically defensible, fully documented and the best available? What information (e.g. data, conceptual models, etc.) was not considered that should have been presented or addressed?*

   - Data on many relevant water quality parameters exist, many of which could impact human health, but either have not been reported or have been inadequately reported:
     - Inorganics: arsenic, iodide, nitrate
     - Organics: UVA254, Dissolved Organic Nitrogen (DON), pesticides, algal toxins
     - Pathogens: Giardia, Cryptosporidium
     - Emerging Disinfection By-Products (DBPs): NDMA & other N-DBPs, iodinated DBPs
     - Aesthetics: Threshold odor number, MIB, Geosmin
   - Reviews indicate such data exists
   - Total organic carbon (TOC) is a regulatory framework tool for Enhanced Coagulation, but dissolved organic carbon (DOC) and ultraviolet absorbance at 254 nm (UV254) really drive DBP formation. DOC should be emphasized as a more important metric.
   - There was no apparent attempt to validate data from multiple labs, use on-line sensors, or obtain data from other sources.

- Too much emphasis is placed on DBP data at the point of entry to the distribution system; DBP data "at the tap" is the key point of important potential health impact, yet no tap water data are presented.
- Better land-use delineation and tracking of water quality parameters over time is needed (satellite imaging perhaps).
- WQP would benefit greatly from developing an integrated data management system (GIS-based).
- Report requires more information on validation of "fingerprinting" model (DSM2).

2. **Information Analysis and Results:** *Have processes and methodologies (e.g. analyses of data) been used that are understandable, scientifically defensible, fully documented and appropriate? What results are missing that could reasonably be obtained?*

   - More information on individual DBPs, rather than DBP classes, would facilitate assessment of ELPH.
   - Box and whiskers plots or averages to correlate TOC or DBP concentrations are mis-used; how did this evolve from the ROD?
   - Analysis should consider TOC and Br as they occur *together*, and not as separate statistical parameters. Their combination affects DBP formation.
   - Source water quality is only ONE determinant of finished water quality; the other is treatment
   - Analysis and discussion of treatment factors (Chapter 6) was poorly executed

   Are the modeling and risk analysis approaches employed defensible and consistent with other large scale projects elsewhere in the nation and internationally?

   - The RP did <u>*not*</u> think the Stage 1 document contained any meaningful health risk analysis.
   - Risk analysis is a function of both exposure to a chemical and the potency of the chemical. The linkage between THM & HAA5 and ELPH was never established; while THM and HAA5 are regulated contaminants (assumed by the Federal Advisory Committee for this regulation to serve as a surrogate for other halogenated DBP), significant evidence of the presence of more potent (emerging) DBPs exists. Just because these "emerging" DBPs are not regulated nationally does mean they should be precluded from a risk analysis. National regulations are based upon *national* exposure assessments, potency of the chemicals, and an economic analysis of the cost of treatment.
   - Greater use of models could have been employed. This includes not only watershed models, but also conveyance models and, more importantly, models for water treatment plant performance (e.g., WTP.exe is a readily available and widely accepted USEPA model).

3. **Findings and Recommendations:** *How well are the key findings and recommendations supported by the stated data, methodologies or conceptual models, and analysis results? Do the findings and recommendations sufficiently address the level of progress made by the WQP for Stage 1?*

- *ELPH* was operationally defined as 40 ug/L TTHM, 30 ug/L HAA5, and 5 ug/L bromate. Page 7-3 states that more fitting measures should be identified; a more robust development of ELPH should be performed.
- Recommendations were based upon a series of performance metrics that were developed. The performance metrics suggested, however, are not really measures of performance. Some alternative performance measures might be:
  - How much have DBPs been reduced as a result of various actions?
  - How much has the DOC and bromide concentration been reduced at Delta intakes by various actions?
  - How many plants are exceeding the levels of 40 ug/L TTHM, 30 ug/L HAA5, and 5 ug/L bromate?
- The report is heavily weighted on watershed processes rather than on treatment or distribution which equally impact exposure and consequently human health risk.

4. **Conveyance:** *Are the findings and recommendations regarding the role of conveyance in meeting the water quality objective valid?*

- The Delta by-pass option may reduce health risk, depending on what is included (or excluded) in the risk analysis.
- Inadequate validation of Delta model makes it difficult to assess related recommendations
- Decisions are being made based upon a maximum of 17 years of data. Uncertainty into the future should be a concern. Consider secondary, longer-term data sources, and associated correlations (streamflow, snowpack, temperature, etc).
- CALFED should be concerned and responsible for changes in water quality during conveyance; the report currently implies this is up to municipalities. If ELPH is applied in the ROD, then CALFED must take more ownership of what happens during conveyance. Nutrients from the Delta may be impacting water quality during conveyance, or selective timing of Delta water diversions may improve water quality
- More in-situ monitors are needed

5. **Stage 2 Priorities:** *Do the identified priorities follow logically from the findings and recommendations. Are there additional critical knowledge gaps?*

- Most priorities were viewed as valid
- Defining ELPH assessment method is a high priority
- Better understanding of organic carbon characteristics relative to treatment and DBP formation is important; DBP formation potential testing is not necessary (surrogates and models could be used)
- Top priority should include on-line DOC, UVA and electrical conductivity monitoring at 8 sampling locations using real-time sensor systems. Monthly sampling is simply inappropriate and too infrequent given the scope and importance of the CALFED program. Dedicated funds must be sought for monitoring purposes.
- Multiple barriers are essential.
- A compartment model that includes Delta water factors, conveyance and treatment modules should be developed. This would greatly enhance the ability to predict, *a priori*, the potential improvements in water quality by different implementation projects.
- A specific goal should be “reducing TOC”

- Demonstrating alternative technologies is under-emphasized as a Stage 2 goal. These could include mobile pilot plants, novel technologies, and novel management options (e.g. bank filtration)
- CALFED must consider the potential regulation of N-DBPs in the future. Many are being monitored as part of the Unregulated Contaminant Monitoring Rule/ (USEPA) program and data should be available from several of the water entities. Synthesis of this emerging DBP data is important because of their increased concern and potential for regulation. California now has an action level for NDMA and this must be considered as well.
- Stage 2 should define the target balance between science, implementation activities, and effort needed to comply with legal decisions
- Dedicated funding for research (not only implementation) is needed to collect critical monitoring and scientific data

6. **Approach for "equivalent level of public health protection":** *In the CALFED Bay-Delta Program Record of Decision (2000) the goal of the WQP is to provide "safe, reliable, and affordable drinking water in a cost-effective way," with a target to "achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies." Is the approach taken to determining if an "equivalent level of public health protection" has been achieved appropriate? Are there other ways to evaluate progress towards this goal?*

   - Same comments as for Question 2 (above) apply:
     - The RP did ***not*** think the approach taken to determine if ELPH protection has been achieved is appropriate.
     - Risk analysis is a function of both exposure to a chemical and the potency of the chemical. The linkage between THM & HAA5 and ELPH was never established; whileTHM and HAA5 are regulated contaminants, significant evidence exists for the occurrence of more potent DBPs. Just because these "emerging" DBPs are not regulated nationally does mean they should be precluded from a risk analysis. National regulations are based upon *national* exposure assessments, potency of the chemicals, and an economic analysis of the cost of treatment.
   - Many other chemicals, other than DBPs, may actually drive risk assessment (e.g., arsenic). Just because such chemicals are below the USEPA Maximum Contaminant Level (MCL) does not mean they do not pose a health risk. For example, the MCL for arsenic is 10 µg/L, but even at a concentration of 1 µg/L, arsenic is more carcinogenic than chloroform at a concentration of 80 ug/L. Simply using USEPA regulations as the basis for a risk assessment of ELPH was found to be unsatisfactory by the RP.
   - Use of HAA5 is not defensible in terms of "best science." While HAA5 is a regulatory parameter with an MCL, there are actually nine chlorinated and brominated HAAs (HAA9),. This regulatory decision was driven by analytical method limitations at the time the initial regulation was developed. The HAA species missing from HAA5 contain bromine, and it is believed that the brominated species may be more harmful than their fully chlorinated counterparts. These brominated species are of high relevance in Delta waters because of their relatively high bromide concentrations.

7. **Treated water quality:** *Are the conclusions about linkage between source water quality and treated water quality valid? Are additional treated water quality data and analysis of needed?*

   - All reviewers agreed this was the weakest part of the report and the chapter covering this topic (Chapter 6) should be revised and reviewed again by an expert in the field of drinking water treatment. Specifics are detailed in the main text and are too lengthy to summarize here.
   - Treatment is as important a determinant for DBP exposure as source water quality, and this was not sufficiently addressed or highlighted in the report. The report emphasized source water quality in the Delta far more than the types of treatment implemented to control DBP formation.

8. **Performance Measures:** *Are the identified performance measures sufficient and appropriate for the stated goals of the program?*

   - All reviewers had concerns regarding the performance measures. In their current forms, the performance measures are not really metrics but recommendations. Examples are on page 7-12 & Appendix C in the Stage 1 report. The final Stage 1 report should develop appropriate metrics, justify their selection, and prioritize them.
   - Aesthetics probably have the most significant impact on customer satisfaction. It is a leading factor contributing to customers seeking alternative sources (i.e., point of use devices, bottled water, etc.) and also serves as a surrogate for the consumers' sense of safety. The use of consumer complaints, however, has some limitations. First, it does not capture the subset of the customer base that has already stopped drinking tap water due to poor taste and odor. Second, people tend to adapt to a baseline (even if it is non-optimal) and then react more to deviations from the baseline (as measured by complaints). Specific measures for taste and odor should be tracked (e.g., threshold odor numbers); synthesis of MIB and geosmin data is specifically recommended.
   - Simply looking at periods when Br is > a value OR TOC > a value is not appropriate. One must really look at the combination of Br & TOC simultaneously.
   - Data obtained from WTPs on DBPs should include companion data on TOC, Br and treatment processes employed, especially disinfection scheme/dosages. DBPs leaving the plant are inappropriate measures of consumer exposure to DBPs. Actual distribution system measurements, or simulated distribution samples should be used in future efforts.

Recommendations from the RP

The reviewers found the research conducted and summarized in the Stage 1 document to be a major effort that has been worthwhile and productive. The report would be strengthened by a more comprehensive introduction of how the Equivalent Level of Public Health Protection (ELPH) was interpreted as applied in the Stage 1 document, and a better introduction on the basics of disinfection (DBP) formation, including the specific role of organic matter and bromide in the formation of regulated and non-regulated DBPs.

Total and dissolved organic carbon and salinity & bromide occurrence throughout the Delta is presented comprehensively in the document. The Stage 1 draft document does require some targeted revision and clarifications before it can serve as a sound and stand alone document. Specifically, these revisions should address the following key points:

1. Improve the risk assessment approach and introduction of the basic *Equivalent Level of Public Health Protection (ELPH)* interpretation
2. Chapter 6 dealing with water treatment operations requires significant revision, and the use of treatment plant water quality models should be considered (e.g., WTP.exe developed by the USEPA)
3. Inconsistencies exist between the main text and the numerous appendices; the report is difficult to read and follow, given the formatting of the appendices
4. Recommendations for Stage 2 should be revised to address the RP comments that will help achieve the CALFED Water Quality Program objectives
5. A CALFED representative should be charged with responding to each RP member comment and decide how to address these in the Stage 1 final report.
6. Stage 2 should define the target balance between science, implementation activities, and effort needed to comply with legal decisions, and it would be helpful to develop a comprehensive and linked model that tracks organics and bromide within the Delta, through conveyance, to water treatment plants, and into the distribution systems in order to assess the impact or benefit of implementation plans. Such a model could be continuously improved while still providing decision-makers with a framework on how to assess real performance measures, including answers to basic questions such as “How much have DBPs been reduced as a result of various actions?”

ELPH, as it was operationally defined by numerical targets, was not deemed to be a suitable risk assessment approach. Methods for a more robust quantitative, risk analysis are available and should be developed for CALFED.. Instead, a regulatory framework involving specific values for THM4, HAA5 and bromate were selected based upon previously proposed USEPA regulations that are no longer relevant. The use of regulated DBPs only was viewed as an unsatisfactory risk assessment approach as the national regulatory process lags behind knowledge of DBP species toxicity and must balance economics and DBP nationwide occurrence. In addition, consideration of DBPs alone may exclude significant human risk from other contaminants in drinking water (e.g., arsenic).

Introductory materials on regulations and contaminants seem to focus on DBPs. It seems that this comes from the 1998 panel report. Since the resulting ELPH targets are used to focus the WQP, it seems that more explanation and justification for these targets is needed. Either there needs to be a more comprehensive assessment of risks from drinking water contaminants (chemical and biological) or, if this has already been done, it needs to be highlighted. This analysis and discussion needs to be presented early in the report, and if it leads to the conclusion that DBPs are the major risk, so be it, but the case for focusing almost exclusively on DBPs has to be made.

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Report Preparation

This report was prepared by organizing comments from four reviewers (Phillippe Daniel / CDM Inc.; David Reckhow / University of Massachusetts at Amherst, Philip Singer / University of North Carolina at Chapel Hill, and Paul Westerhoff / Arizona State University). Complete comments from each reviewer are included as Appendices A to D. In most cases, text was taken verbatim from the reviewers. In some cases, similar comments from multiple reviewers were combined and reported together.

A summary presentation of the review panel feedback was presented to CALFED on July 10, 2008 in Sacramento, CA by Dr. Paul Westerhoff (Appendix E). The presentation summarized key points raised by all four reviewers.

General Comments and Overall Recommendations by the Review Panel

The charge to the reviewers was to review the document (CALFED Water Quality Program, Stage 1 Final Assessment) and respond to eight topics and related questions. The reviewers found the research conducted and summarized in the Stage 1 document to be a major effort that has been worthwhile and productive. The total and dissolved organic carbon and salinity & bromide occurrence throughout the delta is presented comprehensively in the document. The Stage 1 draft document does require some targeted revision and clarifications before it can serve as a sound and stand alone document. Specifically, these revisions should address the following key points (details are provided in the main document & attached Powerpoint™ presentation in the appendix):

1. Improve the risk assessment approach and introduction of the basic *Equivalent Level of Public Health Protection (ELPH)* interpretation
2. Chapter 6 requires significant revisions
3. Inconsistencies exist between main text and numerous appendices; report is difficult to read and follow given the formatting of the appendices
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ELPH was not viewed as a risk assessment approach. Instead, a regulatory framework involving specific values for THM4, HAA5 and bromate were selected based upon old, proposed USEPA regulations. This was not viewed as a risk assessment approach to use regulatory DBPs only, as the national regulatory process lags behind knowledge of specific DBP specie toxicity and must balance economics and DBP occurrence nationwide. In addition, consideration of DBPs may exclude significant human risk from other contaminants in drinking water (e.g., arsenic).

Introductory materials on regulations and contaminants seem to focus on disinfection byproducts (DBPs). It seems that this comes from the 1998 panel report. Since the resulting ELPH targets are used to focus the WQP, it seems that more explanation and justification for these targets is needed. Either there needs to be a more comprehensive assessment of risks from drinking water contaminants (chemical and biological) or, if this has already been done, it needs to be highlighted. This analysis and discussion needs to be presented early in the report, and if it leads to the conclusion that DBPs are the major risk, so be it, but the case for focusing almost exclusively on DBPs has to be made.

Responses to Peer Review Charge Questions

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to "achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies." Is the approach taken to determining if an "equivalent level of public health protection" has been achieved appropriate? Are there other ways to evaluate progress towards this goal?

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8. **Performance Measures:** Are the identified performance measures sufficient and appropriate for the stated goals of the program?

This section provides integrated Review Panel responses to each of these eight subject/topic areas.

1. Information Gathering:

Has the most appropriate scientific information been used in developing all technical areas? Are the methods of collecting information (existing or new) understandable, scientifically defensible, fully documented and the best available? What information (e.g. data, conceptual models, etc.) was not considered that should have been presented or addressed?

1. The authors of the report have collected extensive information on TOC/DOC and bromide/salinity/TDS concentrations throughout the Delta; most of the data have been gathered from reports generated by CalFed and other California agencies. Additionally, data on finished water quality, notably THMs, HAAs, and bromate, have been collected for a large number of water utilities treating Delta water. Again, these data were obtained from a number of CalFed and DHS reports. The data should prove useful in guiding the CalFed Water Quality Program.

2. Water quality parameters not collected/analyzed at the intake – A number of parameters with potential public health and regulatory significance did not appear to be analyzed as part of this assessment:

    a. Arsenic - Classified as a human carcinogen, there is strong epidemiological data linking drinking water exposures in other countries to cancer. In terms of health effects information, the data for arsenic is quite solid in comparison to other drinking water constituents. It should be reported in a comparison of upstream-downstream of Delta diversion points.

    b. Dissolved organic nitrogen (DON) – Nitrogen is noted for algal nutrients, but DON is not noted as an important precursor to nitrogenous disinfection by-products, important for reasons presented below. Upstream wastewater or agricultural sources of DON are important to consider with respect to drinking water quality alongside the current focus on TOC. TKN data is reported on page 5-62 yet no connection is made relative to nitrogenous DBPs. Select studies of DON (a different method than for TKN) exist on Delta water and could be mined for this purpose.

c. Threshold odor number – A frequently measured parameter at water treatment plants, it is one indicator of aesthetic water quality.

d. Likewise, there is a paucity of data related to taste and odor-causing organics, such as MIB and geosmin, as they relate to nutrient levels and algal activity in the various Delta waters. Data is presented to indicate that Delta waters have elevated nutrient levels and it is stated that algal blooms occur and that undesirable levels of MIB and geosmin have been reported at several of the intakes, but no supporting data on algae, MIB, or geosmin are provided.

e. In Chapter 6, the odor threshold for MIB is reported as 10 ug/L. This is incorrect – the units are nanogram (not microgram) per liter for this threshold.

f. BOM/AOC –Organic carbon peaks are noted in conjunction with first significant run-off events (page 5-54), focusing on TOC. The potential for differences in organic loading of biodegradable fractions of TOC/DOC (BOM/AOC) may be one of the only aspects that *might* impact distribution system water quality that would differ between above and below Delta diversion points.

g. Algal toxins - These have been a significant area of research for the drinking water community since the early 1990s. Recent incidents involving algal toxins have served to increase public awareness of algal toxin occurrence among water utility managers, media, and the general public. In 1998, when the first Contaminant Candidate List (CCL) was published after the 1996 Safe Drinking Water Act Amendments, algal toxins were included. There is international regulatory interest in anatoxin, microcystin, and cylindrospermopsin. Are these toxins a potential concern in the Delta?

h. Nitrate is discussed in the context of its concern as a nutrient for algal growth but no mention is made about the fact that nitrate is regulated on its own at a level of 10 mg/L as N. Nitrate is regulated because it causes methemoglobinemia. The elevated levels approaching 8 mg/L are a cause of concern beyond algal growth concerns.

i. Primary productivity is potentially quite important here. There is mention of this at several points, especially in Chapter 7. I'm guessing there are lots of data on algal counts, productivity, biomass, and chemical indicators (diurnal DO swings, pH swings, etc.). It is well accepted that algae can be major sources of DBP precursors, especially nitrogenous ones.

j. Polyacrylamide use in agriculture was noted as an agricultural BMP, yet there was no discussion of its fate and transport, and its degradation products. Perhaps this is explored elsewhere. There are some indications in the literature that acrylamide and acrylate are degradation products.

3. Water quality parameters not collected/analyzed for the treated water (in addition to the above) – A number of parameters in treated water with potential public health and regulatory significance did not appear to be analyzed as part of this assessment:

    a. Incomplete-conflicting data. Some results seem incorrect (e.g., results for bromate noted in Chapter 4 and Chapter 6 for ozone plants on the South Bay Aqueduct conflict).

    b. DBPs – Running annual averages are discussed with the possibility of locational values being used for regulatory compliance in the future (page 6-32). Yet, it appears that only instantaneous values are plotted in figures from the CDPH database.

    c. Brominated organic compounds – These are noted in passing, and speciation was presented for trihalomethanes and haloacetic acids (in Appendix D). No haloacetontrile, haloketone or halopicrin concentrations are noted. Some of this data is available as part of EPA's Information Collection Rule database and some from individual utilities.

    d. Nitrosamines – NDMA and other nitrosamines have been known carcinogens since the 1960s when concern arose over the use of nitrite salts in food preservation. Their quantification in drinking water is relatively recent. A group of six nitrosamines is currently on the Unregulated Contaminant Monitoring List so that USEPA can determine their prevalence and see if regulation is warranted. The simplest and most prevalent nitrosamine is NDMA. The EPA IRIS classification of NDMA is B2, making it a probable human carcinogen. There is currently no MCL for NDMA, though an action level of 10 ng/L was set in 2002, based in part on the discovery of NDMA as a disinfection byproduct. In 2006, OEHHA set a draft public health goal of 3 ng/L for NDMA. There is some plausibility that nitrogenous DBPs like NDMA account for the bladder cancer results observed in epidemiology studies of chlorinated drinking water (Bull, 2003).

    e. Other nitrogenous DBPs – While NDMA has been a focus, other nitrogenous DBPs are of potential health and regulatory concern (e.g., haloacetonitriles, halonitromethanes, cyanogen halides).

    f. Hydrazine - Hydrazine is a compound typically used in chemical synthesis which was recently found as a chloramine disinfection by-product in a 2006 study by Najm et al. Hydrazine is classified as a probable human carcinogen.

    g. Iodinated products – Iodo-acids and iodo-THMs. Most of the iodo-acids are genotoxic or cytotoxic with IAA more toxic than currently regulated HAAs. Consideration should be given to a preliminary Delta survey.

    h. Another information gap is that there is no mention of the literature related to short-term acute health risks associated with DBPs, e.g. reproductive and developmental health risks. One of the most widely publicized studies (Waller and Swan) on this subject was done in a community using Delta water. The preamble to the Stage 2 D/DBP Rule speaks extensively to this concern.

i. There is a paucity of data (in fact none) related to microorganisms and the potential occurrence of pathogens in the various Delta waters. Mention is made in a few places that Delta waters are relatively free of fecal coliform, Giardia, Crypto, and viruses, but no supporting data are provided. In fact, almost the entire report is devoted to bromide/salinity and DOC/TOC; microbial issues should be of high priority as well. In Chapter 2, there is extensive discussion of the D/DBP Rules but almost no discussion of the various rules aimed at pathogenic microorganisms, e.g. SWTR and LT1 and LT2 ESWTR. This is a significant omission.

j. Again, almost the entire report is devoted to bromide/salinity and DOC/TOC, but there are other water quality concerns that should be addressed, or at least mentioned. Examples include the fact that, because many of the utilities using Delta water have resorted to use of combined chlorine (monochloramine) as a terminal disinfectant to comply with DBP regulations (this is discussed further below), water quality issues such as nitrification and NDMA formation are important consequences of this action. Because DOC and bromide levels are as high as they are, compliance with the regulations has forced many systems to use combined chlorine. NDMA occurrence is greater in chloraminated waters than in waters using free chlorine as a terminal disinfectant.

k. The subjects of emerging chemical and microbial contaminants, the various contaminant candidate lists (CCLs) developed by the USEPA, and pesticides, pharmaceutically active compounds, personal care products, and endocrine disruptors, are barely mentioned in the report.

l. Could one use agricultural chemicals or wastewater indicators as surrogates for DOC sources moving forward? Select conservative trace-level organic or inorganic surrogates.

m. The Stage I report relies upon extensive data from multiple sources for TOC/DOC, bromide, conductance, chloride. There is no validation methods described for inclusion/exclusion of data from perhaps >20 different laboratories and on-line stations. This makes the data useful, but perhaps less than scientifically defensible. If all the data came from certified laboratories, that should be stated. Even so – validation of outliers is very critical. Are on-line data (not from certified labs) labeled differently?

n. The report eludes to the potential role of iodide in forming unregulated DBPs. It is highly likely that iodide may correlate with bromide and chloride and predominantly be of seawater origin. However, other sources also exist. At a minimum CALFED should attempt to determine iodide concentrations in various Delta waters and then correlate iodide concentrations to bromide and chloride to determine if a relationship exists.

4. Organic Carbon related issues

a. Throughout the report TOC and DOC data are presented. DOC is far more important in controlling DBPs. TOC is more of a regulatory framework tool related to

Enhanced Coagulation. TOC is important if a disinfectant is applied to untreated water. Within the Delta, DOC is more important than TOC as a metric.

b. The relative levels of DOC and bromide at the various locations throughout the Delta, including the Delta intakes, are interesting as they relate to the targeted levels of 3.0 and 0.05 mg/L, respectively. But, as noted, the averages are of limited value. The historical trends shown are of greater interest, but it would have been useful if the trends were related to hydrological events and patterns, and Delta operations such as changes in pumping and storage practices. Hydrology and water resources management impact DOC and bromide levels. Hence it would be useful to superimpose hydrologic patterns and changes in management practices on figures such as Figure 5.20 and others in much the same way as it was done for bromide in Figure 5.17.

c. The statement is made repeatedly throughout the report (e.g. pages 5-22, 6-1) that more information needs to be developed relating DOC concentrations and the nature of the DOC to its DBP formation potential. This has been a continuous subject of study over the past 20 years, and much is known about the relationship between DOC properties and DBP formation potential, yet no reference to these studies appear in this report. Authors of key papers on this subject include Croue, Reckhow, Amy, Westerhoff, and Singer, to name a few. There is general agreement that THM and HAA formation potential increase as the hydrophobic organic content of the DOC in the water increases. It has also been shown that DBP formation potential strongly correlates with ultraviolet absorbance (e.g. at 254 nm) of the water and that specific UV absorbance (SUVA) is a good measure of the reactivity of the DOC with respect to DBP formation, yet these key items of information are not addressed in this report. If the information is not available, then a recommendation should be made that such information be collected. In any case, the literature on this subject should be incorporated into this report.

5. Disinfection by-product related issues:

   a. It is well known that bromide impacts the extent of DBP formation and DBP speciation. This is one of the reasons for having a 50 ug/L target for bromide. However, DBP speciation patterns and their linkage to bromide levels are not presented or discussed to any appreciable degree. In Appendix D, the figures on page D33 and D34 show how the THM formation and speciation patterns shift across Delta-impacted water utilities; this is important because brominated DBPs are generally of greater health concern than their fully chlorinated counterparts. The whole subject of speciation is in need of greater discussion in the main report.

   b. Related to (6a), there is no mention of the fact that measurement and regulation of HAA5 underestimates HAA occurrence, especially in waters containing high levels of bromide such as Delta water. It has been shown, for many waters including a number of Delta-impacted waters (Singer and co-workers), that bromochloroacetic acid, bromodichloroacetic acid, and dibromochloroacetic acid tend to be present at concentrations greater than dichloroacetic acid and trichloroacetic acid, and that if all of the bromine- and chlorine-containing HAAs (there are 9 of them, e.g. HAA9) are measured, total HAA concentrations tend to be approximately twice the HAA5 concentrations in Delta-impacted waters. The point here is that the non-regulated HAA species are never mentioned in this report even though they are present at significant levels in Delta-impacted waters. The bromine-containing species tend to be more harmful than their chlorine-containing counterparts, and this subject has been reported in the literature for the past 12 years.

c. The linkage between raw water quality and DBP production has been captured by a variety of models such as the USEPA's Water Treatment Plant Simulation Model that was used in the FACA process for the Stage 1 and Stage 2 D/DBP Rules. My recollection is that Malcolm Pirnie and MWD also developed a variant of this model using simulated (or actual) Delta water and that this model was used by CalFed in setting the 3.0 and 0.05 mg/L targets for DOC and bromide, respectively. In any case, no mention is made of these models or of their applicability in linking DOC and bromide to DBP production, and the impact of changes in DOC and/or bromide levels in the Delta to ultimate DBP formation.

d. Mention is made repeatedly about water quality "from source to tap," but no consideration is given to variations in DBP levels in the distribution system. Changes in DBP levels in the system may be beyond the scope of this Stage 1 report, yet it is an important issue. It is not evident where the THM, HAA5, and bromate data in Chapter 5 come from; are they point of entry (POE) values, values in the distribution system as close to the POE as possible, or system-wide average values. If they are values in the distribution system as close to the POE as possible, it is not clear what this means in terms of distribution system residence time. If all of the systems are on combined chlorine, there may not be much of a difference between POE values and system-wide averages but, in any case, the notion of source to tap is an incorrect inference because a comprehensive assessment of tap water values is not presented.

e. A critical flaw potentially in the data gathering is related to the selection of TTHM and HAA5 information obtained from water utilities. It appears from the appendices that values are reported from a location within the water treatment plants; labeled as "plant tap", "plant effluent", "lab tap", etc). These samples represent the THM and HAA levels <u>leaving</u> the WTP and <u>not</u> water the public is actually drinking or bathing with. According to the ROD, it states that an "…equivalent level of public protection…" THM and HAA levels will continue to increase as water travels from a WTP through the distribution system to public water taps. This idea is captured by the adoption of a locational average of THM or HAA concentrations in distribution systems in the Stage 2 D/DBP Rule. When free chlorine is used as a final residual disinfectant, THM and HAA levels may increase by 50% to 300% over the levels leaving the WTP, thereby making comparison to the stated ROD goals much worse. When chloramines are used instead of free chlorine in distribution systems, THM and HAA levels throughout the system are comparable with levels exiting the WTP. Plants that use free chlorine should be separated from those that use chloramines in their distribution systems. At a minimum, it would be more defensible to use EPA distribution system running annual average numbers, instead of plant effluent data, for the DBP evaluations. This data is available at the State Department of Environment Quality, and does not necessitate consulting each individual WTP. Looking forward, It would be better to consider multiple reporting locations in each distribution system.

f. The report is based upon TTHM and HAA5. As reported here TTHM equals the sum of chloroform, dichlorobromethane, chlorodibromomethane and bromoform. However, iodinated THM species also exist. Therefore it would be more appropriate to label the sum of these four THM species as THM4. Likewise, there are at least 9 HAA species. The USEPA only regulated the sum of 5 species because, at the time, there was a lack of occurrence data on the remaining four HAA species. The four species that comprise HAA9, but not HAA5, are all brominated HAAs. Therefore, because TOC and bromide are both important targets, HAA9 should be analyzed to the extent possible rather than HAA5. Water utilities often have this data, but do not report it. Requesting the additional information should be part of any future DBP assessments.

g. All THM and HAA data are presented and analyzed relative to TOC or bromide based upon microgram per liter levels of THM and HAA. This is acceptable from a regulator framework. However, it is less scientifically defensible because proper statistical data analysis should be based upon molar THM or HAA concentrations. These are simple conversions, but quite important. For example, 0.1 m of CHCl3 or CHBr3 equates to 12 versus 25 g/L, respectively. Both species contain the same amount of carbon (C), reflecting the scientific/chemical fact that a certain type of site in the DBP precursor molecule can form any of the individual THM species based upon the ratio of bromide to TOC present in the water. This becomes very important as one attempts to relate two very important DBP precursors (TOC, bromide) to DBP formation across a large spatial system where both parameters (TOC, bromide) are changing.

h. The relatively high levels of nitrate in portions of the Delta (e.g., Figure 5.74) and intense sunlight will undoubtedly result in some photo-nitration. It would be good to keep this in mind and watch the halonitromethane levels in treated drinking waters. This would be of special concern if nitrate levels were to increase.

6. Improved understanding of data collection locations and improved reporting of flowrates would be helpful:

a. The report states that some flowrates are known and others are not. It would seem appropriate to include a map showing all known flow gauge locations (USGS, stormwater, etc) within the drainage basins.
b. The report shows only a few geographic land use maps in parts of the Delta. It would seem advantageous to move to a data management system that is spatially explicit and based upon GIS mapping coordinates. In the short and long-run, this will allow greater integration of new data sources as they come on-line (e.g., DOC monitors), allow correlations with land use, allow easy integration over time (e.g., merging of data from counties, etc), facilitate numerical modeling, etc. GIS mapping is not only a data management system, but can be used in a variety of fate and transport modeling activities to investigate “scenarios” or “hypotheses”. Even in its current form, the data seems to be in too many different locations, spreadsheets, etc. and not well integrated.
c. Several sections in the report state that drinking water is a relatively small percentage of water exported from the Delta into the canals. What is the actual

percentage that is treated by water treatment plants relative to agriculture, industry or other uses? This would seem to be quite important to understand. The report alludes to changing populations, so presumably this percentage of water treatment "water" in the canals would also increase as agriculture and other uses decline? Or would flowrates in the canals be increased?

7. Improved development of hydraulic and chemical models would benefit in understanding options to meet DOC and DBP goals:

    a. The "fingerprinting" model (DSM2) is used to make conclusions about sources of organic carbon (pg 5-38). However, without more information and some comparison of model predictions vs. actual measurements, it's very hard to assess its accuracy.

    b. There is quite a bit of discussion on the movement of water and conservative substances (e.g., bromide, salinity), as there should be. However, as a reader who is unfamiliar with prior hydrological studies of the Delta, I had trouble discerning the current state of water quality modeling in this system. For example, Figure 3.4 seems to be based on actual data, but I can't rule out the possibility that this was from some hydrologic model. On page 4-5 the authors mention the "network of monitoring stations throughout the Delta that continuously record data on flow, EC, and other constituents." This sounds promising, but, from this point on, almost all data presented are either bromide concentrations or TOC. Also, almost all data are from one of the half-dozen major pumping stations or from one location on each of the two major rivers. What are the "other constituents", and where are all of the other monitoring stations? The data that are presented show a nice continuous record from about 1990 to the present. The authors present these data in time series and box plots. Drivers are referred to in qualitative terms, but there's no clear demonstration that a reliable quantitative model exists. Figure 4.11 shows a simple graph of bromide vs. time at one location. How about a line predicting bromide based on a physical model rather than a simple straight line through the data? I would be surprised if a good, calibrated hydraulic model didn't exist for the Delta (on page 5-1, the report indicates that salinity "is well monitored, modeled and managed"; on page 5-3 is a reference to the "Delta Simulation Model 2"). So why not say so, and show how reliable it is (i.e., show predicted vs. measured concentrations under a variety of climate & management conditions)? It's possible that Figure 5.3 or 5.4 was included for this reason, but there are no data shown, and it's almost impossible to understand this figure from the text. Without this type of background, it's hard to assess or even accept the later claims made for impacts of conveyance alternatives on bromide levels.

8. There are some organizational problems that make the report difficult to read and follow. Some pertain to the patchwork nature of the appendices. For example, in trying to understand better the data in Figure 6.7 (pg 6-9) of the main report, I looked for the symbol key. After some searching, I found that this figure was the same as Figure 64 in Appendix D. On page 9 of Appendix E to Appendix D (not the same as the principal Appendix E), I found a listing of codes for Figure 64. Unfortunately, these were not the same as those shown in the figure that they refer to. There are still some errors (e.g.,

Figure 5.3 and 5.4 are reversed), and references are often not sufficiently complete to allow one to locate them from primary sources. I found some of the box plots odd and difficult to understand (e.g., Figure 5.11 to 5.14), where “month” or “water year type” were the continuous variables being characterized.

2. Information Analysis and Results:

Have processes and methodologies (e.g. analyses of data) been used that are understandable, scientifically defensible, fully documented and appropriate? What results are missing that could reasonably be obtained? Are the modeling and risk analysis approaches employed defensible and consistent with other large scale projects elsewhere in the nation and internationally?

1. Comments on risk assessment methodology:

    a. There was no risk analysis conducted in this report.

    b. There are no modeling and risk assessment approaches using the available data. In fact, the whole concept of ELPH is never defined, other than 40, 30, 5 ug/L for TTHM, HAA5, and bromate, respectively, and the linkage between the 3 mg/L TOC and the 0.05 mg/L bromide raw water targets and these ELPH goals is not defined. Furthermore, these TTHM, HAA5, and bromate levels hardly constitute equivalent levels of public health protection without also addressing other water quality concerns. For example, one could achieve these levels without adding any disinfectant.

    c. The risk analysis approach seemed to be a comparison against regulatory benchmarks and source water targets. A more analytical approach would be beneficial (described later)

    d. Two databases were used for assessing the degree to which “ELPH targets” (defined as THM, HAA and bromate on page 4-13) are being met: the Consumer Confidence Reports for 2005 and 2006, and the CDPH database for 2004-2006. No discussion is presented on the differences in results between the databases. No examination of actual detection limits and reporting on bromate was done. No data was furnished from the CCRs, and the data plotted from the CDPH database implied detection limits of 1 ug/l in one case. Figure 4.17 indicates data from 1985 to 2006 and Figure 4.18 indicates data from 2004 to 2006. The data for SBA are inconsistent between these two figures, and are both in error. In addition, using the same CDPH database, Figure 6.21 appears to capture the occurrence of bromate.

    e. Individual DBP species – Some were shown, but there was no analysis of their significance, a critical issue for ELPH. No segregation of analysis of water quality outcomes for different seasonal and hydrological conditions is presented.

    f. Bromate assessment – In Chapter 6, treated water quality is evaluated for several different locations. The bromate data is presented from the CDPH database, but apparently as instantaneous values, not running annual averages. On this basis the conclusion is made that ELPH targets are not being met. No discussion is provided as to detection limits (are 5 ug/L entries Non Detects or actual measured concentrations?). Since bromate is of such great importance, it seems a more robust discussion is merited.

2. Relationship of analysis to ELPH targets:

   a. Manner in which the treatment information has been presented. Meeting the treated water DBP targets for TTHM, HAA5, and bromate of 40, 30, and 5 ug/L depends on source water quality and the type of treatment employed. THMs and HAAs depend upon the amount of chlorine applied and the contact time of the water with free chlorine. If a utility disinfects with ozone or UV and then uses combined chlorine, their THM and HAA levels will be relatively low, regardless of the source water DOC or bromide. The same is true if they use micro/ultrafiltration and combined chlorine. If a utility coagulates, settles, and filters before applying chlorine for disinfection, their DBP levels will depend not on the source water DOC but on the filtered water DOC. In the case of bromate, if a utility uses ozone for disinfection but does so at a low pH, their bromate levels will be low regardless of the raw water bromide concentration. Information on chlorine doses, point of chlorination, use of chloramines, application point of ammonia, pH of ozonation is not presented anywhere in the report, yet these factors are major determinants of DBPs produced in the finished water.

   b. The manner of data presentation leads to much confusion and many erroneous conclusions. For example, Figure 6.7 suggests no correlation between TTHM and TOC. I suspect that the squares are for a water that has a very short free chlorine contact time and disinfects with ozone, UV, or membranes and uses combined chlorine. If the squares are omitted, there is a strong pattern relating TTHM to TOC, although there are some outliers that might be explainable because of temperature or some other consideration such as those mentioned above. Similarly, Figure 6.15 is misleading as are the other figures like it (e.g. Figure 6.19). I suspect that the plants with TTHM levels less than 10 ug/L all use combined chlorine, perhaps ozone and combined chlorine, with little free chlorine contact time. Likewise, for bromate, the plants with no bromate probably do not use ozone. This is not apparent from the figures when all of the results from all of the plants in the region are combined in this manner. It would make much more sense to present the data plant by plant so that one can see what individual plants have done in the way of treatment to keep DBPs low regardless of the source water DOC and bromide. The fact of the matter is that source water quality is only one determinant of finished water quality. The type of treatment is another, and there are numerous treatment options that a utility can use, depending upon the progressiveness of its leadership, local economics, etc., to achieve low DBP levels. This is not reflected in any of the discussion.

   c. In fact, I would argue that the regional conceptual models, such as Figure 6.18, are incorrect. The drivers shown in the second row, i.e. raw water quality, alternative supplies, regulations, and socioeconomic considerations, are actually drivers for the type of treatment employed. The type of treatment is not a driver but is driven by these other factors. It is then the type of treatment used on these raw water qualities that determine treated water quality, i.e. TTHMs, HAAs, bromate, as well as finished water DOC, bromide, taste and odor, etc. In that sense, the type of treatment is the linkage, and this conceptual model is valid for all regions. It is then the treated water quality plus distribution system considerations (e.g. terminal disinfectant, storage, distribution system operations) that control tap water DBP levels. When viewed in this manner, there is no need for individual regional conceptual models. All the models are the same, but it is raw water quality in the region that drives the different treatment options, i.e. simpler treatment for the watershed plants to meet the ELPH targets while more advanced technologies for the NBA, Delta/SBA plants, etc.

3. Analysis of water treatment conditions & related models:

   a. Figure 6.10 is poor. Giving overall chemical doses for treatment makes no sense. You cannot logically add mg/L alum, caustic, chlorine, ammonia, corrosion inhibitor. It would make much more sense to give chlorine doses, ozone doses, etc. I would suspect that the same argument could be made if chlorine dose was plotted.

   b. A variety of conceptual models are presented. These are quite useful. The only missing piece appears to be the "distribution system" that would belong after the "water treatment plant" to represent travel time of water, where TOC, bromide and a disinfectant are in contact and potentially still forming DBPs.

   c. It would be quite easy to include a mathematical model of water treatment plant performance and DBP formation. The USEPA and consultants have developed a model (WTP.exe) that is very robust and has been previously used in USEPA regulatory decision-making for THM and HAA MCLs. It would make sense to use three "representative" water treatment plants in the model: 1) a conventional WTP with free chlorine, 2) a conventional WTP with chloramines, and 3) a plant that uses ozone. The models predict TOC removal and DBP formation through the plant, and DBP formation into a distribution system. The model could be customized to individual facilities as desired, but would not be needed for broader scale assessments. The models have already been validated and published in peer review journals, and are suitable for use based upon the water quality outlined in the documents provided to this reviewer. Such a model would allow relationship between the primary ROD parameters (TOC and Br) to an effect on the public (THM, HAA). No discussion of the availability of these models is provided in the report.

   d. The report mentions the significance of alkalinity and SUVA in achieving TOC treatment goals. All the plants being served with Delta water should be binned according to the USEPA Enhanced Coagulation guidelines, which is based upon TOC and alkalinity and has exceptions for low SUVA waters. This would be very helpful to know which utilities must meet these guidelines. This is directly related to "chemical usage" as reported in the document. Figure 6.10 and associated discussion is very misleading and inappropriate. This figure was developed based upon tables in Appendix D (Table 3.2). The total mg/L of chemicals used is not relevant. Table 3.2 (Appendix D) should be used in the main document.

   e. This reviewer feels like Chapter 6 was written by a group less familiar with water treatment practices than would be appropriate for such an important report. In contrast, Appendix D is technically well written. Chapter 6 lacks the critical insights presented in Appendix D.

4. Relationship to hydrologic and salt flux models:
    a. A mathematical model for salinity was developed and relied upon heavily in the report. Insufficient information was made available to evaluate the accuracy of this model.

    b. I would have liked to have seen more mass balance data on organic carbon and bromide in a simple visual format. It would have been helpful to see fluxes represented on a map of the Delta, with mass balances at junctions and estimates of losses/gains. It seems that a substantial amount of flow or velocity data is available for many of the rivers and channels. This could have been combined with chemical concentration data to get mass fluxes.

    c. I applaud the WQP's efforts to attend to bromide levels. However, given the strong correlation between bromide and chloride (e.g., Figure 5.1) and the potential importance of iodide, which probably also correlates well with chloride, I'm thinking that it might be more effective to just consider salinity or conductivity. Presumably these data are far more numerous and possibly more precise.

5. Use of statistics and their representation:

    a. The report uses box and whisker plots and running annual averages to represent most of the data. This is useful if done properly. However, it is **<u>not</u>** useful for the prediction of DBP formation or the correlation of raw water quality and DBP formation. As seen in many plots of "actual data" (e.g., Figure 3.4 in the Stage I water quality study – in the Appendix), TOC values may remain high for several months (i.e., in the 15 to 20 mg/L range) while the running annual average only increases from 6 to 7 mg/L. For those 6 months of high TOC, there will be high levels of DBPs formed. Thus, while annual average TOC data are easier to tabulate and represent for comparing different sites relative to the ROD target of 3 mg/L, it does not reflect the reality of the water quality that the water treatment plants are receiving, and thus does not reflect the quality of water the public receives. The ROD sets a target of 3 mg/L, and somewhere along the path it was decided to use a running annual average for this purpose. I believe this decision may be flawed. A better approach may be the use of different statistical analysis procedures. For example, binning the data into the number of days that TOC values are in certain ranges. This approach was used in some parts of the report, but not the entire report. Another approach would be to develop and present frequency distributions of the data. CALFED should reconsider the adequacy of using a running annual average for either TOC or bromide.

    b. Different statistical representations of data are used throughout the report (box and whisker plots, running annual averages, binning, etc). This is useful for discussion, but makes it difficult to determine which is more important: average/medians, or bins, or ….

6. The presentation and discussion of TOC/DOC and salinity/bromide occurrence throughout the Delta has been presented and analyzed relatively comprehensively.

3. Findings and Recommendations:

How well are the key findings and recommendations supported by the stated data, methodologies or conceptual models, and analysis results? Do the findings and recommendations sufficiently address the level of progress made by the WQP for Stage 1?

1. The report presents a significant amount of data collected from diverse sources. The key findings and recommendations are largely supported by the information provided and sufficiently address the level of progress made for Stage 1. Several locations in the report state that "…spending constraints that restrict the program's ability to implement its highest priority [programs]". However it is not clear as to what these high priority programs are. The report alludes to real time monitoring as a high priority (I think), but otherwise states mainly where funding has gone and that mostly demonstration or on-the-ground projects are fundable. If such a list of other high priority projects exist, they should be explicitly stated in the report's conclusions along with estimates for conducting such research. Such a list may attract funding from other, as yet untapped, sources.

2. Issues related to DBP assessments and implications of ELPH goal:

    a. Recommendation for refining the ELPH goal has the greatest merit. Operationalizing it simply as THMs of 40 ug/l, HAAs of 30 ug/l and bromate of 5 ug/l has significant limitations. Without a better evaluation tool, all the other program elements are of diminished value. I concur with the statement: "a more fitting measure should be identified" (page 7-3) though I think that multiple measures may be needed.

    b. The data presented support the fact that the numeric average TOC and bromide concentrations at the Delta intakes exceed the drinking water quality targets of 3 and 0.05 mg/L, respectively. A primary concern is that ELPH has never been defined, other than 40, 30, 5 ug/L for TTHM, HAA5, and bromate, respectively. These levels hardly constitute equivalent levels of public health protection. Furthermore, there are statements in the report that "the ELPH approach is the backbone of the WQP" (page 4-1, para 2), but it is unfortunate that we have to wait until the Conclusions in Chapter 7 to be told that there is still not an acceptable definition of ELPH protection.

    c. One of the objectives was to develop an initial comprehensive set of WQP performance measures. I saw a lot of recommendations that were labeled performance metrics but they were not really measures of performance but recommendations as to what needed to be done. Examples of true performance measures might be "how much have DBPs been reduced as a result of various actions?" or "how much has the TOC and bromide concentration been reduced at the Delta intakes?" or "how many plants are exceeding the ELPH targets of 40, 30, 5 ug/L?" Similarly, for taste and odor, performance measures might be "how many taste and odor complaints have been reported for utilities using Delta water?" or "to what extent have taste and odor complaints been reduced?"

3. Assessment of water treatment plants and distribution systems:

a. In my opinion, while there has been a good assessment of DOC and bromide concentrations across the Delta, there has not been an integrated assessment of treatment. Such an assessment needs to be made.

b. Another objective was to address drinking water quality from “source to tap,” but only finished/treated water quality at the POE is presented. Tap water quality would require knowledge of distribution system design and operations, but this appears to be beyond the scope of this study/assessment. It might be an important consideration for Stage 2.

c. It would be desirable to present a parallel table to Table 7.1 summarizing treated water quality across the utilities included in the analysis. It would be helpful to include information on chlorine doses, point of chlorine application, free chlorine contact time, use of combined chlorine which, as noted above, are the determinants of THM and HAA compliance.

4. Conveyance:

Are the findings and recommendations regarding the role of conveyance in meeting the water quality objective valid?

1. If we accept the validity of the Delta model, the findings and recommendations regarding conveyance seem valid. This is especially true for bromide. The report is at times too qualitative to be completely convincing. From the information provided it is difficult to determine if the conveyance model is based on a real physical hydraulic model. It would be good to have this explained a bit more clearly. I would also reiterate that some model validation with real data should be presented.

2. Delta by-pass option comments:
    a. Short of a complete Delta by-pass, the notion of regional specific alternatives makes sense (e.g., NBA intake relocation). These of course depend on the interplay with water treatment technology and cost-effectiveness considerations.

    b. The potential to relocate all the diversion canal intakes to the Sacramento River appears technically feasible and is being considered. This would definitely meet the TOC and Br goals and is well developed as a technically feasible recommendation.

3. There are 8 recommendations concerning the subject of conveyance. Comments include the following

    a. As indicated in the second, there has been too much emphasis on salinity and not enough on other constituents of pubic health concern.

    b. The fourth recommendation, while noble in nature, will be difficult to address, i.e. how to deal with “drinking water” that is not used for actual consumption but is used instead for irrigation, landscaping, etc. This issue seems to be beyond the scope of this assessment.

    c. The proposed solution related to uncertainty is important. The longest data record presented may have gone back 17 years to 1990. It would be highly advantageous to look at a longer period of record, even if it exists for only a flow or other parameters. The USGS has lots of historical flow and water quality data I suspect, based upon my experience in other watersheds. I believe it should be possible to go back to the 1940s or so. Additional data, such as average snowpack coverage should also be collected from archives. This information is critical when trying to understand the relationship between precipitation and runoff patterns in future climate change scenarios.

    d. Solution #8 in the report related to “restricting intakes” is unclear what the solution actual is, and probably needs to be restated.

4. Limitations of the recommendations:

    a. The report concludes that water quality (TOC, Br, T&O) changes once water exits the Delta into the conveyance systems (canals, reservoirs, etc) because of a wide range of factors. This is well described. However, the conclusion appears to be that this is no longer CALFEDs mission and that regional WTPs have to manage and deal with this themselves. On one level that is acceptable because it limits the scope of the challenge to the Delta region itself. However, on a broader level it may not truly lead to the intent of the ROD to protect the public. In these regards the report does not adequately address recommendations for dealing with the conveyance system. Developing an approach for this second point is critical to part of the "conveyance solution" regarding the need for a "multiple barrier approach".

b. Expanding water quality monitoring to focus on TOC, in addition to salinity is appropriate. Monthly sampling is inadequate and in-situ TOC and EC conductors should be located at 10 to 20 locations. In the longer run, including N and P concentrations are relevant, but in the short-term do not seem to control TOC or bromide levels in the Delta. Here it would be very useful to start monitoring seasonal variations in trace level organics and TOC simultaneously. For example, primidone is a prescribed pharmaceutical that is in all wastewater effluents and quite persistent in the environment. It would be useful to monitor a wastewater effluent probe (e.g., primidone) to understand the percentage of wastewater at various locations in the Delta during different seasons / flow conditions of the year. Higher primidone levels mean more TOC of wastewater origin. Likewise, selecting 1 or 2 herbicide/pesticide tracers would be useful (e.g., atrazine which is already regulated in drinking water). These could be used to determine how much TOC is coming from agricultural origins. If different pesticides are used on different crops, or in different parts of the Delta then monitoring these may also allow differentiation between different crop uses and TOC sources.

c. The NOM conceptual model should also consider loss and generation processes that occur during conveyance. There seems to be a lack of recognition that NOM concentrations are subject to various loss and generation processes. On page 5-36, the authors state that *"organic carbon that is bioavailable, which is generally the particulate form of organic carbon, suggesting that there may be minimal conflict between supporting the Delta food web and reducing DBPs".* This has a footnote to reference #23 (organic carbon conceptual model report), which was not readily available to me. My experience is that most dissolved NOM is both bioavailable and reactive to some extent. Perhaps there's something in reference #23 that shows this not to be the case in the Delta, but I remain skeptical.

d. On page 5-13, it is stated that "controlling the flow of water at strategic locations in the Delta can have a major effect on salinity." However, the short-term conveyance alternative based on changing bathymetry (Franks tract project, through delta facility and delta cross channel) seem to offer only modest improvements (2-17% reductions in bromide). It seems that the peripheral canal, as a long-term option, is the only one that has any hope of bringing bromide levels down to the target. It would be helpful to know if there is any other alternative (e.g., active barrier system) that might be less ambitious than the peripheral canal but still reduce bromide levels substantially.

5. Stage 2 Priorities:

Do the identified priorities follow logically from the findings and recommendations. Are there additional critical knowledge gaps?

1. Interpretation of targets, objectives and goals remains one of the more daunting aspects of this program. There is a significant need to develop alternatives means for assessing "an equivalent level of public health protection." This is necessary to streamline further monitoring and analysis efforts.

    a. Which constituents should be reduced ties both the refinement of ELPH and an assessment as to whether certain measures would concurrently reduce multiple constituents of concern (e.g., would measures for reducing organic carbon also reduce organic nitrogen loading?). In addition, it might not be only "the presence of algae in drinking water conveyances" that should be prioritized, but the potential for episodic growth of algae giving rise to customer dissatisfaction that should be assessed. If this is not feasible, then it would favor a treatment-based solution instead of a source control one.

    b. Refinements to performance measures should continue, especially with regard to customer satisfaction.

    c. In addition to the water quality parameters indicated in response to question 1, the refinement of ELPH should not be restricted either to disinfection by-products that are currently regulated, but address other constituents, including those for which little health effects data is currently available. It is possible to do a more robust risk analysis as detailed below.

    d. The ELPH protection goal requires major re-evaluation as to what it means and how it is to be defined and quantified.

    e. I would focus more on public health and strive for adoption of quantitative goals. This means that the full set of risks should be explicitly considered. The current focus is almost entirely on DBPs and seems to ignore other contaminants and risks.

    f. I would also argue for a more comprehensive physical-based transport model coupled to a set of water treatment plant models. These could be developed using the existing generic WTP models as a starting point.

    g. Performance measures – The write-up/plan is vague. I would recommend including predicted DBPs (using WTP.exe as described above).

2. Stage 2 should include more comprehensive and integrated models. Multiple barrier models should be developed that can a priori be used to predict the likely benefits in TOC or Bromide and public health protection. Such models would include existing models for water quality in the Delta, but would then be augmented with conveyance and water treatment plant (including potable water distribution systems) models. One good model for simulating TOC, bromide and DBPs in water treatment plants was developed by the USEPA and has been used in establishing national MCLs for DBPs; its name is WTP.exe.

3. Stage 2 recommendations related to organic carbon balanced against other water quality issues:

    a. Some of the Stage 2 priorities address information that is already known, e.g. a better understanding of the role of organic carbon quality in DBP production (see papers by Croue, Reckhow, Amy, Westerhoff, Singer). While this is indeed a priority, it should have been included in the Stage 1 assessment. Better definition of DOC and Br levels beyond those achieved with monthly grab samples is a legitimate criticism and deserving of priority ranking.

    b. The multiple barrier approach to drinking water protection is appropriate, and this includes source water protection as an important first barrier. But attention needs to be placed not only on bromide and DOC, but also on nitrate, whose levels are perilously close to the primary MCL, pathogens, pesticides, nutrients and algal growth, dissolved organic nitrogen, and emerging microbial and chemical contaminants.

4. Related to Stage 2 recommendations:
    a. General Strategy is appropriate.

    b. Interpretation of targets, objectives and goals – see comments for items 1 through 3 above related to running annual averages and a move towards understanding peaking and variability is needed. Also, ELPH must address DBP levels the public are exposed to and ***not*** THM or HAA levels leaving the water treatment plants (see items 1-3 above).

    c. Reducing bromide concentration in Delta intakes – these activities would appropriate control bromide levels

    d. Reducing constituents of concern – there should be a specific stage 2 goal of "reducing TOC" Focusing on the Sacramento river makes sense. It is clear that pathogens are not a major issue, and the study should stay focused on TOC and Bromide, and not include too broad of spectrum of water quality constituents as suggested in the report. Numerical models would be useful, as well as spatially explicit models (see GIS discussion in items 1-3 above). Algae does cause problems to drinking water, but it seemed clear in the report that most of the algae problems were in canals or conveyance systems and not within the Delta. Because of resources, I would suggest not focusing on ecosystem food chains in the Delta. This opinion would change in the USGS report on isotope analysis of organic carbon found algae to be responsible for >20% of the TOC at the Delta intakes of concern. Staying focused on quantifying the benefits of implementation activities will be the key to success. In chapter 7 there is some mention of NOM assessment and characterization. I would encourage this, but warn that a careful decision must be made as to the appropriate measurement to make. There are many types of NOM characterization techniques, and some will be helpful, whereas others will not.

    e. Improving water quality "downpipe" – "Downpipe" is not an appropriate term and is introduced only here at the end of the report. The necessity exists to control TOC (and potentially dilute Br) in sub watersheds. These should be encouraged, as outlined.

f. Demonstrating alternative treatment technologies – this is under emphasized as a Stage 2 goal. It appears that 2 regional demonstration plants will be established – this is an excellent idea. Would it be better to make these “mobile pilot plants” such that multiple utilities would ultimately benefit? This reviewer believes that other novel treatment technologies should be explored that push the idea of “treatment”. This could include varies takes on “bank filtration” which has been shown to reduce TOC by >50% in many locations. Could sand be placed in the bottom of the canals to effectively form a 2-foot deep slow sand filter that contains perforated pipes that collect and deliver water to treatment plants? Could a short section of canal be widened, unlined and lateral recovery wells installed?

6. Approach for "equivalent level of public health protection":

In the CALFED Bay-Delta Program Record of Decision (2000) the goal of the WQP is to provide "safe, reliable, and affordable drinking water in a cost-effective way," with a target to "achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies." Is the approach taken to determining if an "equivalent level of public health protection" has been achieved appropriate? Are there other ways to evaluate progress towards this goal?

1. One review answered this question as "No" – the approach taken to assess ELHS is currently inappropriate as I read it in the report. The report draws its conclusions based upon THM4 and HAA5 levels leaving the WTP instead of within the distribution system. See above.

2. Another review answered this question "I think this is a worthwhile approach". In particular, the use of TOC as a surrogate for DBP formation is a good idea given the current state of understanding of DBPs and human health. TOC and TON are probably better target parameters than THM and HAA formation. For example, use of chloramines without pre chlorination is cited on page 6-31 as very effective for controlling THMs and HAAs.

    a. However, our current knowledge suggests that some nitrogen-containing DBPs, probably compounds enhanced by pure chloramination, are more likely to have adverse human health effects than those that are currently regulated.

    b. I also think that the discussion regarding "future conditions" (page 6-32) is too centered on regulations. Although regulations are intended to help provide a minimum uniform level of protection to the public, they do take decades to develop as noted. In a world where new information on drinking water contaminants and public health impacts is constantly emerging, the regulatory imperatives do not always agree with the current understanding of best public health practice. For this reason, I'd recommend discussion of public health impacts as separate from regulatory requirements.

    c. It may even be possible to develop and calibrate water treatment plant models for at least some of these alternative criteria. Again these could be built upon the foundation of the existing WTP model developed under EPA contact. Any such model should probably include a sub-model for DBP changes in distribution systems.

3. Evaluation of ELPH:

    a. As noted above, major consideration needs to be given to defining and quantifying a true measure of ELPH protection. The present goals of 40, 30, and 5 ug/L for THMs, HAA5, and bromate are a starting point, but are too limited. As indicated above, one can achieve these goals without disinfecting water.

b. There are other ways of examining “Equivalent Level of Public Health Protection” and such means should be explored. This would be an important priority for CALFED.

c. Drinking water is a complex mixture of various microbes and inorganic and organic chemicals. To assess water against a series of benchmarks without considering the overall mixture seems less than optimal. It is understandable since regulations are often promulgated independently and sequentially. Yet, there are calls to do more.

d. The selection of quantitative criteria for “equivalent protection” is not an easy task. Better treatment can certainly mitigate any lack of achievement with the base stage 1 objectives. One approach would be to adopt a set of finished WQ criteria based on some key bulk parameters. The classical criteria for THMs, HAAs and DOC could be retained as a guideline for controlling a broad range of byproducts. However, other (often more targeted) bulk parameters would add focus based on current toxicological understanding. One possibility for these would be:
   - Total organic bromine (TOBr) and total organic iodine (TOI) criteria for finished waters when the raw water bromide criteria can’t be achieved
   - Criteria on dissolve organic nitrogen (DON), halogen (TOX), total nitrosamines, and total organic chloramines for finished waters when the raw water TOC criteria can’t be achieved.

4. Future needs to characterize dissolved organic matter:
   a. A stated knowledge gap in the report is “One high priority for Stage 2 is to improve our understanding of organic carbon quality within the watersheds and its role in DBP formation.” This is a true knowledge gap, yet no clear approach is proposed on how this would be addressed. State of the art research suggests that all types of organics contribute towards DBP formation, in terms of yields (DBP formed per mg DOC). Since a carbon mass balance seems infeasible because of insufficient flow gauges from all sources, one approach is outlined above in item #4 – where trace organics of distinctive origins are used as tracers of bulk DOC. Recent studies suggest that organic colloids comprise a significant fraction of DOC (20% and more), yet little information is available on its sources and ability to be removed, although it does have considerable DBP formation potential. With years of experience, the easiest parameter to measure in conjunction with DOC to understand organic carbon quality is UV absorbance at 254 nm. UVA254 is already measured by WTPs, it relates to the USEPA Enhanced Coagulation guidelines, it is highly correlated with the ability to remove DOC during water treatment, it correlates with ozone demand (and therefore relates to bromate formation), it correlates well in finished water to THM and HAA formation, and it is easy to measure with low-cost instrumentations (including some that are now on-line). Finally, building organic carbon quality into a numerical model for organic carbon concentrations would not be difficult to do.

5. An alternative approach to assist ELPH implementation is described below:

   The EPA Science Advisory Board released a report *Integrated Environmental Decision Making in the 21st Century* calling EPA to focus on the reduction of total risks resulting from risk management decisions rather than focusing on the reduction of any particular risk

(EPASAB, 2000). EPA is authorized to incorporate such considerations by the 1996 SDWA Amendments:

> *"...the level or levels or treatment techniques shall minimize the overall risk of adverse health effects by balancing the risk from the contaminant and the risk from other contaminants the concentrations of which may be affected by the use of a treatment technique or process that would be employed to attain the maximum contaminant level or levels"*

A major limitation of such efforts is the lack of and controversial interpretation of health effects information. Much controversy surrounds the method by which the risks of chemicals are assessed. To illustrate, after three years of litigation (and over 10 years of research), the issue of setting a safe level for chloroform, a DBP, had to be decided in a United States Court of Appeals (March 31, 2000). Furthermore, the President's Commission Report on Risk Management (1997) cautions that the typical numerical risk estimates for individual chemical compounds (termed "bright lines") are problematic:

> *"The all-or-nothing nature of use of a bright line could be misunderstood and construed to imply that there is an exact boundary between safety and risk, even though risk-based bright lines are burdened by all the uncertainty, variability, and assumptions inherent in cancer risk estimation."*

How does one assess the overall public health risk associated with what is acknowledged to be a "soup" of constituents? The risk posed by a given compound can be expressed as the potency (or the strength of its particular adverse health effect response) multiplied by the concentration at which this constituent occurs:

Risk = Potency x Concentration

Cumulative risks from exposures to carcinogens have been widely assumed to be additive (EPA, 1998)[1]. This assumption is probably conservative at the low levels of exposure that are encountered in drinking water. A numeric index can be developed to compare different waters containing varying levels of constituents. A similar analysis can be done non-cancer endpoints (a Hazard Index based on reference doses).

A major limitation of such efforts is the lack of and controversial interpretation of health effects information. Much controversy surrounds the method by which the risks of chemicals are assessed. In addition, it is important to include as many constituents of some health significance found in water as possible, to be comprehensive in such an exercise.

Such limitations acknowledged, such an analysis can be performed. For example, consider the potency factors given in the table below.

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[1] EPA 1998. Technical Support Document on Risk Assessment of Chemical Mixtures. EPA/600/8-90/064.

Chemical	*Cancer Potency Factor*
Arsenic (As)	250
Atrazine	7
Benzene	7
Benzo[a]pyrene	250
Beryllium	1
Bromate	20
Bromodichloromethane	0.5
Bromoform	0.1
Chloroform	0.01
Chromium (Cr+6)	0.02
Dibromoacetonitrile	0.01
Dibromochloromethane	0.5
Dichloroacetic acid	0.3
Dichloroacetonitrile	0.03
Methyl tertiary butyl ether (MTBE)	0.1
N-Nitrosodimethylamine (NDMA)	500

The relative potency (if we assume that the compounds are acting on the same target) would imply that:

- Bromoform at 1 ug/l would make an equivalent contribution as 10 ug/l of chloroform (of course, chloroform is believed to have a threshold and has the only EPA-published non-zero MCLG).
- Bromate at 1 ug/l would have an equivalent contribution as 40 ug/l as bromodichloromethane.
- Arsenic at 1 ug/l would have an equivalent contribution as 12.5 ug/l of bromate.

Any such analysis needs to consider the plausibility of the health effects data. But what is particularly important is arsenic. Small variations in arsenic concentrations could drive the overall cancer risk dramatically. A water that had 4 ug/l of arsenic (well within drinking water standards) with 10 ug/l of bromate, could have a much higher risk than a water with 3 ug/l of arsenic and 2 ug/l bromate (likely the limit of detection).

This has not yet been considered in CALFED’s notion of ELPH. It is all the more significant since the health effects database for arsenic is arguably stronger than most other water contaminants.

6. Role and consideration of arsenic

EPA has recently concluded that inorganic arsenic (As) causes human cancer most likely by many different modes of action.[2] This is based on the observed findings that As undergoes successive methylation steps in humans and results in the production of a number of intermediate metabolic products and that each has its own toxicity. EPA asked the Science Advisory Board to comment on the soundness of its conclusion.

The Panel report (2007) concluded that:

a. "Multiple modes of action may operate in carcinogenesis induced by inorganic As because there is simultaneous exposure to multiple metabolic products as well as multiple target organs and the composition of metabolites can differ in different organs.
b. Each arsenic metabolite has its own cytotoxic and genotoxic capability.
c. Inorganic arsenic (As^{III}) and its metabolites are not direct genotoxicants because these compounds do not directly react with DNA. However, AS^{III} and some of its metabolites can exhibit indirect genotoxicity, induce aneuploidy, cause changes in DNA methylation, and alter signaling and hormone action. In addition, As can act as a transplacental carcinogen and a cocarcinogen.
d. Studies of indirect genotoxicity strongly suggest the possibility of a threshold for arsenic carcinogenicity. However, the studies discussed herein do not show where such a threshold might be, nor do they show the shape of the dose-response curve at these low levels. In addition, a threshold has not been confirmed by epidemiological studies. This issue is an extremely important area for research attention, and it is an issue that should be evaluated in EPA's continuing risk assessment for As.
e. Arsenic essentiality and the possibility of hormetic effects are in need of additional research to determine how they would influence the determination of a threshold for specific arsenic-associated health endpoints."

Arsenic is also known to have other non-cancer adverse health and developmental effects including, but are not limited to, hypertension, neurotoxicity, respiratory disease, and skin disease.

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2 EPA-SAB-07-008 Advisory on EPA's Assessments of Carcinogenic Effects of Organic and Inorganic Arsenic: A Report of the US EPA Science Advisory Board

7. Treated water quality

Are the conclusions about linkage between source water quality and treated water quality valid? Are additional treated water quality data and analysis of needed?

1. All reviewers agreed this was the weakest portion of the report. Some reasons are provided in response to questions 1 & 2 and others are described below.

    a. Treated water quality is addressed in Chapter 6 though not with clear questions being posed. Does source water quality impact treated water quality? It depends on the treatment process. Are there treatment technologies that can produce water that meets ELPH for various Delta water quality scenarios? Undoubtedly, though the costs would vary. Is it possible to improve source water quality short of TOC of 3.0 mg/l and bromide of 50 ug/l such that ELPH can be met without significant changes to water treatment processes? It depends on how ELPH is defined.

    b. Most WTPs gauge the ability to meet DBP goals based upon DOC of finished water, in addition to other factors (Br, temperature, pH, type of disinfectant, contact time with disinfectant, etc). Therefore, it would be useful to have not only raw water DOC/TOC but also finished water levels. This is very useful because it can simplify the level of complexity of all the differences in treatment processes used at each of the 50+ WTPs in the service area. I suspect you will then see a clear relationship between finished water DOC and DBP levels. This approach will help guide treatment plants towards certain types of treatment in the long run.

    c. Comments in question#1 regarding WTP.exe modeling should also be pursued to address this comment.

2. Additional comments on Chapter 6 findings:

    a. The overview performance graphic (Figure 6.8) presents THM and HAA data but not bromate. This would be helpful to include.

    b. In the overview of the ten treatment plants, a tangential observation is made on treatment cost differences between Sacramento River and Delta sources. Those inferences about cost differences are questionable based on the dataset. Figure 6.10 shows very small bars for Redding and City of Sacramento, and higher bars for Delta plants except one.
        i. No explanation is given for the outlier, the CLWA Earl Schmidt Filtration Plant (it has an enhanced coagulation exemption since it uses ozone and, like Sacramento, treats lower turbidity water).
        ii. The data presented in Appendix E are different than shown. For example, it indicates that the Sacramento doses are higher than shown in Figure 6.10 (alum doses of 11 to 28 mg/l) yet appears the same as the CLWA plant (though it use ferric chloride at a dose of 1 mg/l).
        iii. ACWD TP#2 has the same dose range as Sacramento in Appendix E, Table 3.2 (albeit ferric rather than alum). Drawing cost conclusions from

this database seems unwarranted (see section 5.1.2 and 6.1.4 of Appendix E).

c. Watershed plants are discussed with the conclusion that they meet the ELPH operationalized targets of 40/30 for THMs and HAAs. It is silent on the significance of the bromate data presented in Figure 6.13 which shows three data points above 10 ug/l.

d. For the Delta/South Bay Aqueduct region, two items are telling. First, the bromate levels are above 5 ug/l without much discussion as to what is being done on treatment optimization to reduce bromate (projects have been completed as indicated in Appendix A). Second, the fact of CCWD's "TTHM (6 ug/L) and HAA5 (2 ug/L)…well below ELPH targets, but also poses challenges in managing bromate formation" begs the question as to what is ELPH? Is it 40/30/5? Or is it an aggregate measure that combines the various water quality constituents resulting from the interplay of source water quality and treatment technology?

e. Other specific comments include:
   i. Page 6-1, last para. The statement that "scientific understanding of DBP formation is relatively young" seems odd since the subject has been studied intensely for more than 30 years. Further, as noted above, linkages between ELPH targets and source water quality have indeed been developed in the form of EPA's Water Treatment Plant simulation model and were used extensively as part of the FACA negotiations for the Stage 1 and Stage 2 D/DBP Rules. I believe they were also used by CalFed in establishing the raw water quality goals for TOC and bromide in order to keep TTHMs and HAA5 below 40 and 40 ug/l, respectively. The report is silent on these linkages and the EPA models.

   ii. Page 6-4, para 3 and 4. As noted earlier, key considerations that affect the linkage between source water quality and DBPs in the treated water are (1) where the utilities add their free chlorine for primary disinfection, (2) whether or not they use alternative primary disinfectants in place of free chlorine (e.g. ozone, ClO2, UV, membranes), and (3) whether or not they add ammonia to produce combined chlorine and, if so, where. The information provided here does not get at these important drivers of DBP formation. Such information is available in plant records, and should also be available from DHS. The information presented in Figures 6.4 and 6.5 is not especially useful.

   iii. Figure 6.6. I still believe this conceptual model of treated drinking water quality is not quite correct. Raw water quality, regulations, leadership, and economics determine the nature of the treatment plants in place. Coupled with these factors (drivers) and raw water quality, the type of treatment determines the finished water quality entering the distribution system. In that sense, the treatment plant is the linkage between raw water quality and finished water quality. This is consistent with the brief example at the bottom of page 6-7 that source water quality in terms of Crypto will determine the additional treatment required.

iv. Page 6-7 figure 6.6 What the public is exposed to in drinking water very much depends upon conveyance IN THE water distribution system after water treatment and can not be overlooked in significance.

v. Page 6-8 conducting many THMFP tests will NOT be useful. Use wtp.exe along with water quality.

vi. Page 6-8, top. It is good to know that the SWP Sanitary Survey monitoring results indicate that no additional log removal credits would be required for Crypto. Because of the importance of pathogens and the LT2 Rule, it would be good to present the findings to support this statement.

vii. Page 6-8, para 2. It needs to be recognized that in order to keep DBPs below the ELPH levels of 40, 30, 5 using a source water containing 3 mg/L DOC and 50 ug/L Br, utilities will have to use combined chlorine as a terminal disinfectant or more expensive technologies such as ozonation, UV disinfection, or membrane filtration. This point is not well recognized or brought out in this report.

viii. Page 6-8, para 3. The role of bromide in this analysis is missing. Correlations between DBPs and DOC will not be successful if bromide is not considered in the equation. Further, it is important that attention be given to the individual THM and HAA species as the brominated species tend to be more harmful than their fully chlorinated counterparts. Para 4 makes this point, but it requires much more emphasis. Additionally, it needs to be recognized that measurement of only HAA5 in bromide-rich waters does not capture the four other bromine-containing HAAs that are present at significant concentrations. The report is silent on HAA9 despite more than 10 years of research n this subject.

ix. Page 6-8, last para. There is a fundamental error in allowing the ELPH to be applied to treated water at the point of entry (POE) to the distribution system. Unless utilities are using combined chlorine as a terminal disinfectant, in which case THMs and HAAs in the system and at the customers' taps are essentially the same as at the POE, THM and HAA levels will continue to increase in the distribution system and consumers exposed to water with a high residence time in the distribution system will not be getting an equivalent level of public health protection. Comparisons between DBP levels in the distribution system need to be compared with DBP levels at the POE to ascertain the importance of the distribution system in making an ELPH assessment.

x. Furthermore, use of the distribution system location closest to the treatment plant may prove to be misleading, depending on how far this point is from the POE and depending whether the utility uses free or combined chlorine in their system. Also, this difference will be different from utility to utility.

xi. Figure 6.7 is somewhat misleading. It is important to know what the plants in the lower right quadrant are doing to have such low THMs with such high TOC's. I suspect they are using ozone or membranes and use very little free

Cl2. This is probably also true for utility N1 (open squares), with THMs less than 10 ug/L regardless of TOC.

xii. Page 6-9, para 3. Last sentence downplays what we already know about DBP formation. It is not surprising that plants treating a high Br, high DOC water will have high levels of BOTH brominated and chlorinated DBPs. Furthermore, it is well known that waters dominated by hydrophobic/humic carbon with high SUVA values have a high DBP formation potential.

xiii. Page 6-10 figure 6.9 the level of bromide influence is high in THM speciation – same for unregulated Br-HAA. Measure HAA9 going forward in all studies.

xiv. Figure 6.10 is terrible. It is irrational to sum doses of different chemicals.

xv. Page 6-13 Based upon SUVA, TOC and alkalinity which WTPs require enhanced coagulation?

xvi. Figure 6.11 to 6.13. What accounts for the high levels of THMs and bromate in some cases? This suggests that even the Watershed plants that start with good source water occasionally have problems meeting the ELPH targets. What were the bromide and DOC levels associated with these episodic high values?

xvii. Figures 6.15 to 6.17. Again, what accounts for these episodic high THMs and bromate levels? What were the Br and DOC levels? The very low THM levels (squares) are probably for an ozonation/NH2Cl treatment scenario, a plant that went from free chlorine in the 1990's to ozone after the year 2000.

xviii. Page 6-17, para 2. This is the first time that grazing is mentioned. If there are cattle in the watershed, shouldn't there be more attention paid to potential pathogens?

xix. Page 6-17, last para. Again, the performance metrics are really recommendations. For item 2, CDPH should track treatment operations data as well as treated water data. For item 4, how does distribution system monitoring provide any information about the relationship between source water quality and treatment? Changes occur in the distribution system. The DBP values in the system are a function not only of source water quality and treatment and the DBP values at the POE, but also continued formation of DBPs in the distribution system.

xx. Figures 6.19 to 6.21. There is a wealth of useful information buried in these figures. All of the systems use water with common source water characteristics, yet they produce very different levels of DBPs. Why? The answer can be ascertained and demonstrated if the data are disaggregated. First, pull out the plants using ozone or membranes for primary disinfection and little use of free chlorine; examples are D2 and D6. Then pull out plants using combined chlorine. Then look at plants using only free chlorine. There should be some useful information here that is lost when all of the records are combined. The same comments hold for the CA Aqueduct plants in Figures 6.23-6.25.

xxi. Page 6-21, para 2. Omitted in this discussion is the use of combined chlorine after primary disinfection, with little use of free chlorine. Same is true in subsequent paragraphs for other utilities on this page.

xxii. Page 6-22. It would be very useful to see the speciation of THMs and HAAs for these facilities treating bromide-rich water. Speciation of DBPs is important in view of their differing health effects.

xxiii. Page 6-27. The entire discussion here is on variations in source water quality, but there is no discussion of variations in treatment among the different systems. I expect that the differences observed for different utilities are due to variations in BOTH water quality and type of treatment utilized.

xxiv. Page 6-28, para 2. It would be useful to see some nutrient and taste and odor data.

xxv. Page 6-30, para 3. I agree that it is important to examine and understand infrastructure actions that can lower precursor levels of Br and DOC at the water treatment plant intakes. But it also important to understand how water treatment plants can attenuate these high precursor levels by adopting treatment strategies that minimize DBP formation.

xxvi. Page 6-31, para 4, line 5. The short free chlorine contact time is for viruses, not Giardia.

xxvii. Page 6-31, para 4. First mention of NDMA and microbial regrowth in the distribution system. These are important water quality issues that heretofore have not been mentioned.

xxviii. Page 6-32, regulatory changes and the future. NDMA should be specifically noted here as more utilities change to combined chlorine for terminal disinfection in order to "stabilize" DBP levels in the system. Likewise, we see the first mention of nitrogen-containing DBPs. The latter have been a growing research activity in the drinking water arena for the past 7 years. Furthermore, reference should be made to growing concern about water quality deterioration in the distribution system and the potential for microbial intrusion into the system due to low pressure and negative pressure spikes. Can combined chlorine attenuate these challenges?

xxix. Page 6-32. Climate change and population growth are addressed, appropriately so. A suggestion for mathematical modeling is made, also appropriate.

8. Performance Measures:

Are the identified performance measures sufficient and appropriate for the stated goals of the program?

1. All reviewers had concerns over the performance measures: Here are how each reviewer answered the question:
   a. These seem to lack a quantitative component. See prior comments.

   b. As noted above, the performance measures are not really metrics but recommendations. True performance metrics need to be developed. Some examples are given above, and later in the comments for Chapters 4-6.

   c. Performance measures for Stage 2 are mentioned on page 7-12 and reference Appendix C. This makes it difficult to really understand any level of prioritization of the parameters, which will be important given "limited ability to fund monitoring projects".

   d. Aesthetics are an important issue that was not well addressed.

2. What are some additional priority issues suggested by the reviewers:

   a. Top priority should include DOC, UVA and electrical conductivity on-line at 8 sampling locations using real time sensor systems. Monthly sampling is simply inappropriate and too infrequent given the scope of this CALFED program, dedicated funds must be sought for monitoring. CALFED must consider the future, potential regulations of N-DBPs. Many are being collected as part of the Unregulated Contaminant Monitoring / USEAP program and should be available from several of the water entities. Synthesis of these emerging DBPs is important moving forward because of their increased concern and potential for regulation. California now has an action level for NDMA and this must be included moving forward. Organic nitrogen should be included, as a N-DBP precursor, moving forward. Understanding the shift from free chlorine to chloramines must be studied in CALFED WTPs as it will influence DBPs exposed to the public. Most WTPs will collect daily or weekly TOC samples and write them into logs – synthesis of this data would be critical to understand effects of conveyance.

   b. Aesthetics probably have the most significant impact on customer satisfaction. It is a leading factor contributing to customers seeking alternative sources (i.e., point of use devices, bottled water, etc.) and also serves as surrogate for consumer sense of safety. As noted by Jardine et al. (1997), customers may sometimes be right in reasoning that tastes and odors indicate a potential hazard since many potential water contaminants can pose a health concern at levels below those that can be detected by odor. They conclude:

      The absence of offensive tastes or odors in drinking is a necessary, but not a sufficient condition for consumers to be assured of the safety of their drinking water. Unless very *specific and reliable evidence can be provided, consumers will have rational grounds to question the security of their water supply.*

The aesthetic issues are recognized in the report as “Objective 2” on page 4-17 and page C-7, and measured by consumer complaints. The use of consumer complaints, however, has some limitations. First, it does not recognize the subset of the customer base that has already stopped drinking tap water due to poor taste. Second, people tend to adapt to a baseline (even if it is non-optimal) and then react more to deviations from the baseline (as measured by complaints). My sense is that these two factors cause consumer complaints to be a performance measure that underestimates aesthetic differences upstream and downstream of Delta diversion points.

An alternative or complementary performance measure is the Threshold Odor Number or TON, a frequently measured parameter at water treatment plants.

Specific measures for taste and odor should be tracked; recommend synthesis MIB and geosmin data specifically.

c. Furthermore, Target 2a focuses on reducing the frequency or algae blooms. This target, however, may or may not indicate the presence of tastes and odors – this depends on the algal species. Perhaps this is why Target 2b is offered. In any case, use of TON could be a useful metric.

d. Simply looking at periods when Br is > a value OR TOC > a value is not appropriate. One must really look at the combination of Br & TOC simultaneously.

e. Data obtained from WTPs on DBPs MUST include the following: 1) companion data on TOC, Br and treatment processes including disinfection scheme/dosages, 2) DBPs leaving the plant are alone inappropriate measures. Actual distribution systems, or simulated distribution samples MUST be used moving forward.

Additional comments and questions related to information in the report text

Report needs to be carefully edited. There are a number of grammatical errors throughout. Among these are the following, but many more occur:

- Page 3-9, para 2. required requirements.
- Page 3-9, para 2. by lower the pH
- Page 5-1, para 3, there is a phrase missing on line 6.
- Page 5-3, para 2. Figures 5-3 and 5-4 are reversed.
- Figure 5-2. Bottom. Salinity, not salintv.
- Page 5-13, para 4. $140 million?
- Page 5-17, para 1, line 3. be…..be
- Page 5-18, 3rd line from bottom. …are will…
- Page 5-53, para 1. p=0.0000?
- Page 6-17, item 4. Monitor….monitoring…

Report is overly repetitive. Some subjects and material are discussed multiple times throughout. As a result, the report does not flow very well.

Reference citations at end of each chapter are incomplete.

Chapter 1.

This report deals with Stage 1 of a CalFed assessment and preparation for a subsequent Stage 2. This is very confusing language because the major focus is on TOC/DOC, bromide, and DBPs which are regulated via the Stage 1 and Stage 2 Disinfectants/ Disinfection By-products Rules? The terms Stage 1 and Stage 2 are first mentioned on Pages1-2 and 1-3, but they are not defined and readers familiar with the two stages of the D/DBP Rule will be confused, as I was. A statement should be made at the beginning of the report distinguishing between Stage 1 and Stage 2 of the Assessment and Stage 1 and Stage 2 of the D/DBP Rules.

The objectives of the report are not obvious. Page 1-3 lists 4 'multiple purposes' of the Stage 1 Final Assessment. If these are the objectives underlying this document, they need to be clearly labeled as objectives.

There is no mention of DBPs in the 'multiple purposes' (objectives?) on Page 1-3 or anywhere else in Chapter 1, yet this is a primary point of concern with respect to Delta water quality and this report. The only related reference is to 50 ug/L bromide and 3 mg/L total organic carbon on Page 1-1, but the fact that these targets are related to DBPs is not mentioned. In contrast, Chapter 2 opens with reference to DBP precursors in the first paragraph and the remainder of Chapter 2 focuses on DBPs. If DBPs are a major focus of this report, and they are, shouldn't they be highlighted/emphasized in the objectives and in this first Chapter?

Chapter 2.

There are a number of incorrect statements in this chapter. Examples:
Page 1-1, para 2. Chlorination alone is not responsible for essentially eliminating waterborne disease as stated. Filtration was a major contributor. Also, pathogens are microbes.

Page 2-1, para 3. Microbes such as protozoan cysts, as well as bacteria and viruses, can cause acute health effects. If you start with Milwaukee, you have to mention cysts.
Page 2-1, para 4. DBPs do not form when nutrients are exposed to oxidants.
Same paragraph. Those containing bromine, not bromate, are the most potent.
Same paragraph. THMs and HAAs are regulated at levels that are presumed to be within the 10^{-4} to 10^{-6} cancer risk. Only bromate is regulated outside this range, at 10 ug/L.
Page 2-2, para 1. Reference this recent study.
Page 2-3, last para. Stage 1 not I. Also, the rule is the D/DBP Rule not the DBP Rule. Same for Stage 2 on page 2-4.
Page 2-4, para 2. EPA's MCLs are 0.08 and 0.06 mg/L, not 80 and 60 ug/L. Likewise, 0.10 mg/L not 100 ug/L. Bromate is 0.01 mg/L, not 10 ug/L.
Page 2-4, para 3. Last sentence, new locations for LRAA should be chosen for 'maximum' THM and HAA levels, not simply 'higher' levels.
Page 2-8, last para. Stage 2 D/DBRR not Stage 2 LTSWTR.
Page 2-9, para 1. Same mistake.
Figure 2.3, Page 2-9, shows 50 ppb for Br and 3.0 ppm for TOC. Units should be consistent, e.g. ug/L, mg/L in text (page 2.8).

DBP regulations are summarized on Pages 2-3 to 2-4, but no summary of the microbial regulations is provided. In that sense, the report is not balanced. As a water quality report, shouldn't it be? Aren't microbial issues important?

The target of the Water Quality Plan to achieve 50 ug/L bromide and 3.0 mg/L TOC (page 2-8, para 2) is not related to DBPs and DBP regulations until Section 2.8 on Page 2-8. Because the long-term scenario described in this section is actually the driver for the bromide and TOC targets, this material should be moved to the beginning of this chapter as it sets the stage for what follows, i.e. tying the discussion of DBPs on Pages 2-3 to 2-4 more explicitly to bromide and TOC and providing the rationale for the Br and TOC targets.

Page 10, last para. Again, the question of pathogens seems to be an add-on, rather than a theme of significant importance to water quality. The focus of this report seems to be on DBPs, TOC and Br, but pathogens are of equal concern yet are covered to a very limited degree?

Figure 2-4 shows the Source to Tap paradigm but, as will be noted below, no attention is given to distribution. Treatment is discussed, but not the distribution system. Hence, the focus of the WQP is really Source to Point of Entry or Treated Water Quality, not Tap Water Quality.

Chapter 3.

Page 3-3, para 3. Mixing of seawater and fresh water is the result of the tides AND rainfall, runoff, and snow melt.

Figure 3.4. Can Banks and Tracy be located on this very informative figure? Other intakes? The cause of the high EC in the lower right (San Juaquin River) should be explained. Is there a parallel map available for bromide? This would be more to the point.

Page 3-6 Why is southwestern region high in salinity?

The first 7 pages of this chapter deal with salinity/bromide. Section 3.2 deals with Salinity and then we jump to Treatment in Section 2.3. What about TOC/DOC? There ought to be a section here, after Salinity, addressing organic carbon in the Delta. I realize that it comes later in the report, but some mention should be made of it here before discussing treatment.

Page 3-8. Top paragraph refers to coagulation, flocculation, and clarification as pre-treatment. Better to call this conventional treatment; it is more than merely "pre-treatment."

Page 3-8. End of para 4 gives log removals for microbes. This is critical information related to removal of pathogens, yet this is the first and only time anywhere in this report that this subject of log removals is addressed. LT2ESWTR and associated requirements for pathogen inactivation/removal should have been discussed in Chapter 2, as noted above.

Table 3.1. TDS should precede nutrients. Also, nitrate is not simply a nutrient. There is a primary MCL for nitrate (10 mg/L) because of its health effects (methemoglobinemia), not because it is a nutrient. Also, the statements about pathogen monitoring in the 3rd column for bromide and TOC are out of place. Also, what about pesticides and other synthetic organic chemicals? These ought to be of concern in agriculturally-impacted waters.

Page 3-11 What about NDMA and potential trace-level precursors?

Page 3-11, end para 2. It is not pH buffering that helps limit bromate formation; it is reduced pH. Same paragraph – rain water has NO alkalinity, not low alkalinity.

Page 3-11. No discussion of microbes/pathogens. Turbidity is discussed briefly, but no reference is made to the fact that it is used as a surrogate for potential pathogens.

Page 3-11, para 4. No reference to the fact that HAA5 does not capture many of the HAAs found in bromide-dominated waters.

Page 3-12. Para 2 opens with chronic health risks. What about acute health risks? Acute risks from microbes ought to come first. Also, no mention of acute risks associated with DBPs, e.g. developmental and reproductive risks.

Page 3-12, para 3. Nitrosamines are associated more with chloramination than with chlorination. This is a concern (discussed below) because many systems using Delta water use combined chlorine as a terminal disinfectant. Also, same paragraph, bladder cancer, not carcinogenesis. And no DBP studied to date appears capable of producing bladder cancer, IN TOXOCOLOGICAL studies.

Page 3.12, last para. Given the concern of brominated DBPs, why is there no mention of HAA9? References on this subject have been in the literature for more than 10 years, and Delta-impacted waters are prime candidates for bromine-containing HAAs that are not regulated.

Page 13, para 6. Add "quality" to the first sentence.

Figure 3.5. Under drivers, change Sources and Fate of Pollutants to Sources of Impurities. They are not all "pollutants." Also, I would argue that raw water quality, regulations and socioeconomics are drivers of treatment plant characterstics. Treatment is not a driver of the linkage between raw water quality and finished water quality. It IS the linkage. Also, the outcome labeled Disinfection level/type is strange. Why not microbial safety or microbial

quality? Also, there should be a distribution system linkage between treatment plant outcomes and water quality at the tap.

Chapter 4.

Figure 4-3. Given the emphasis on DBPs in this report, it is surprising that there are so few studies addressing DBPs. This seems out of balance and inconsistent with the Stage 1 assessment.

Page 4-6, para 1. Bromide is NOT regulated at treatment plants. Also, the DBPs are not regulated as 3-month averages but as annual averages. Also brominated DBPs are not regulated; TTHMs, HAA5 consist of non-brominated DBPs, too.

Page 4-6, para 2. Total organic carbon is NOT regulated at treatment plants. Further, it is incorrect to say that TOC must be reduced to improve disinfection efficiencies. It must be reduced because it forms regulated DBPs, as indicated, but it must also be reduced because it forms other as-yet unidentified DBPs that may have adverse health impacts. That is the objective of the enhanced coagulation matrix.

Page 4-6, para 3. The report says that source water data is much more publicly available than treated water quality data. I do not believe this to be the case. Finished water quality is a matter of pubic record and should be readily obtainable form DHS as well as the utilities directly.

Figure 4-7, 4-8. It would be useful to compare these historic patterns in TOC and bromide with rainfall, runoff, snowmelt information or to Delta storage/pumping operations to understand and demonstrate the drivers for these observations. A sentence to this effect is given at the bottom of page 9, but it needs greater emphasis.

Table 4.1 is a critical finding; it is good to see it repeated and discussed in the Conclusions chapter (7).

The trend analyses given in Figures 4-10 to 4-12 are a good idea, but I suspect that the lines shown are simple regression lines with relatively small correlation coefficients. Is it possible to conduct a more statistically sophisticated analysis on these data?

Page 4-12. The treated water quality assessment is poorly done. It is not sufficient to simply indicate what chemicals or processes were used (Table 4.3), but details as to how they were used. Examples include chlorine and ozone doses, approximate free chlorine contact times, where the chlorine and/or ozone was applied, and most importantly, if combined chlorine was used and where the ammonia was applied. DBP formation depends on the DOC and bromide concentration at the point of chlorine addition, and how long the water was in contact with free chlorine before ammonia was added to convert the free chlorine to combined chlorine which essentially stops further THM and HAA production.

Page 4-13, para 1. The report states that Watershed, NBA, and Delta plants have been meeting the TTHM ELPH targets. The data in Table 4.4 do not support this statement as Delta and NBA plants show some means in excess of 40 (and even 80 ug/L).

The key point associated with treatment and the ELPH goals is "what have the plants done with waters in excess of 3 mg/L TOC and 50 ug/L bromide to allow them to meet the 40, 30, 5 ug/L ELPH targets, and what is the cost of these treatments?" Some plants implemented ozone, some membrane filtration, many chloramination. This is the essence of DBP compliance in waters with excess TOC and bromide, and this needs to be analyzed in greater detail than it has been.

Performance Measures on Page 4-17. I don't consider these items "performance measures." We have a good objective "to provide safe and reliable drinking water by reducing DBP formation." The so-called "performance measure" is "to reduce production of DBPs….." I consider this a "recommendation," not a performance measure. A performance measure would be "how much have DBPs been reduced as a result of various actions?" or "how much has the TOC and bromide concentration been reduced at the Delta intakes?" or "how many plants are exceeding the ELPH targets of 40,30,5?" Similarly, for taste and odor in objective 2, the so-called performance measure is again an objective or recommendation. A performance measure would be "how many taste and odor complaints have been reported for utilities using Delta water?" or "to what extent have taste and odor complaints been reduced?" Objective 3 requires a definition of "cost-effective action" before a performance measure can be developed, but an example might be "how has the cost of treatment increased as a result of treatment modifications made for purposes of compliance with ELPH goals, and how do these costs compare to national trends?"

Page 4-18, para 2. The Conclusions state that "WQP projects have achieved measurable water quality improvements in some Delta locations, helped improve tap water quality with advanced treatment technology, and have advanced our understanding….." This may be true, but it has not been shown explicitly by the material presented in this chapter. If these are indeed the conclusions to be reached, then the material in this chapter needs to be presented in a manner that explicitly demonstrates these findings.

Page 4-18 The idea of clearly defining equivalent level of protection is critical moving forward.

Chapter 5.

40-50% of this chapter on water quality constituents of concern deals with bromide/salinity; 35-40% deals with TOC/DOC. Surely there are other constituents of concern that are worthy of mention, e.g. microbes, pesticides and other synthetic organic compounds, nitrate, emerging contaminants.

Figure 5-3. In outcomes, what is meant by "timing of bromide"

Page 5-12 what will be the effect of changing flows in canals on algae blooms in the future?

Page 5-13, last paragraph. The question becomes one of balancing costs. What is the cost of the various diversions to lower bromide and TOC vs the cost of additional treatment to comply with regulated DBP levels.

Page 5-17, para 2. These are not performance metrics. Not sure what they are. Same applies for other Performance Metrics, e.g. top of page 5-19. Metric at bottom of page 5-19 is a recommendation.

Page 5-18, para 1. This description is not very helpful without reference to a map that shows the Delta Mendota Canal and Newman Wasteway. This is a recurring concern throughout the report, i.e reference to locations but no map to identify locations.

Page 5-21. Only 1 page in this whole section is devoted to pathogens. It is also the last entry in the Introduction in para 2, line 1. Disturbing that pathogens are of such a low apparent priority.

Page 5-21, line 1, para 3. primary function is to remove and/or inactivate pathogens. Removal (filtration) is first line of defense.

Page 5-21. No data on pathogen occurrence is provided. What kind of monitoring is done? What has (or has not been) measured? This is a serious omission. The performance metric on page 5-22 is a recommendation.

Page 5-22. While there is extensive information presented on the amount of overall TOC/DOC, there is little to no information provided about the characteristics of this organic carbon, e.g. molecular weight, humic/non-humic nature, hydrophobic/hydrophilic nature, etc. Many studies have been conducted relating the nature of DOC to its amenability to removal by various water treatment processes and its propensity to react with chlorine and other oxidants and disinfectants. Many of these studies have been conducted using Delta water. Paragraph 1 of Section 5.2.2 makes mention of UV absorbance and SUVA, but that is the last we see of it.

Page 5-22, Section 5.2.2, para 1 and 2. Some mis-statements. Last line of para 2 – analysis of its carbon content by its absorbance, not reflectivity, of UV light. Para 3 – It is incorrect to imply that water treatment plants do not measure DOC and only measure TOC. Many do measure DOC. The statement at the end of this paragraph is absolutely incorrect. Many studies have been conducted on the characteristics of DOC responsible for DBP production; these studies have been done for the past 20 years, and include Delta water.

Page 5-22, para 6. The section on turbidity is out of place here. It relates to pathogen removal and belongs in the previous section on pathogens. Turbidity is a surrogate for the potential presence of pathogens.

Page 5-23 figure 5.19 It seems a little odd that at the highest TOC levels that DOC/TOC is so close to unity. It would be expected to be lower.

Page 5-25. Modeling is an important tool. My understanding is that the DWR model for EC and bromide has been calibrated and validated and is therefore useful for predictive purposes. Is this also true for DOC? I doubt it. The use and validity of models is an important subject that is worthy of a separate discussion.

Page 5-28, para 1, line 3. This is a strange statement. It is odd to suggest that Delta island contributions increase at higher intake concentrations. It would be more appropriate to state that “increased intake DOC concentrations occur when the Delta island contribution is greater.” Cause and effect?

Page 5-28, para 4, line 2. I disagree with use of the word “slightly.” I think the differences are more than slight.

Page 5-36, para 2. Same comment as above. Linkage between nature of DOC and DBP formation has been well studied. Elsewhere in the same paragraph, EPA’s Water Treatment Plant simulation model, which was used in FACA negotiations for the Stage 1/2 D/DBP Rules, was used (and can be used) to predict DBP formation when settled water is chlorinated. Also, many researchers have looked at DBP formation after precursors have been removed by coagulation and clarification, and the ICR database contains many such examples.

Page 5-36 It is really unclear what percentage of water comes from sewage treatment plants into the various canals. This should be a focus moving forward because of concern of EDC/PPCPs to water treatment plants.

Page 5-42. This is not a performance metric but a recommendation.

Page 5-61, para 2. The 10 mg/L nitrate value is not a nutrient goal but a primary MCL. Of concern is that some of the waters in Table 5.3 and Figures 5.72 and 5.74 are perilously close to (and even one exceeds) this primary MCL.

Page 5-61, para 2. Mention of the CCL at the end of this paragraph is the first time the CCL is mentioned. Discussion of (or at least reference to) emerging contaminants, both chemical and microbial, is missing from this report on water quality issues.

Page 5-62 table 5.3 What are the DON levels? Some of these would appear to have very high DON levels which are N-DBP precursors.

Page 5-65. The relatively high TKN values in Figure 5.76 are cause for concern given their chlorine demand. High TKN levels lead to higher chlorine doses for disinfection with free chlorine at the water treatment plants; 0.5 mg/L TKN would have a chlorine demand of 4-5 mg/L. Also, this raises the question of dissolved organic nitrogen and the formation of nitrogenous DBPs when the waters are chlorinated. N-DBPs are a growing area of concern and have been so for the past 7 years, yet the report is silent on this issue.

Page 5-67 it would be extremely helpful to somehow improve estimates of pumpage from agricultural areas back into the delta.

Page 5-69, bottom, and 5-73. There ought to be performance metrics and recommendations that can be developed on this subject. Possible metrics are: Reduction of nitrate levels to XX mg/L, or extent of reduction of nitrate levels. Same for phosphate. Same for chlorophyll a. Also, reduction in occurrence of taste- and odor-causing compounds at the intakes, e.g. MIB and geosmin. Possible recommendations are monitoring and modeling of nutrient levels and algal growth in the Delta and at the Delta intakes. This is a high priority subject, given the statement on Page 5-73 that nutrients and algae will increasingly challenge treatment plant operations. They will.

Page 5-75. It is disturbing that only 2 paragraphs are devoted to pesticides and emerging contaminants. This report is overly concerned with bromide, DOC, and DBPs, almost at the expense of all other potential water quality contaminants. This is an example. There must be some data on pesticides to show that it is “below levels of concern.” What kind of monitoring has been done? Where and at what frequency? What detection limits? Without some information of this type, we cannot agree that pesticides are not a concern.

The same comment applies to pharmaceuticals, personal care products, endocrine disruptors, algal toxins, and other emerging contaminants. What kind of monitoring has been done? Where and at what frequency?

Page 5-75. Good to see climate change addressed. Impact of sea level rise on bromide levels should be easy to model. Impact on DOC, nutrients, and algal growth will be more difficult.

Appendix A – Review comments by Phillippe Daniel

Peer Review of CALFED Water Quality Program, Stage 1 Final Assessment

Comments of Phillippe Daniel, Vice President, Camp Dresser & McKee, Inc.

The responses to the questions contained in the charge are presented below, first noting the question, then providing responses. Overall, a wide array of issues have been addressed, spanning source controls, project operations, source water quality variations, and treatment. All of these are presented in this Stage 1 document in an effort guide further refinement of CALFED's efforts.

The most significant comments focus on opportunities to develop "an equivalent level of public health protection" (aka ELPH) in some ways that CALFED has not apparently explored but could be informative and complementary to the current approach.

1. Information Gathering: *Has the most appropriate scientific information been used in developing all technical areas? Are the methods of collecting information (existing or new) understandable, scientifically defensible, fully documented and the best available? What information (e.g. data, conceptual models, etc.) was not considered that should have been presented or addressed?*

1. Water quality parameters not collected-analyzed at the intake – A number of parameters with potential public health and regulatory significance did not appear to be analyzed:

    a. Arsenic - Classified as a human carcinogen, there is strong epidemiological data linking drinking water exposures in other countries to cancer. In terms of health effects information, the data for arsenic is quite solid in comparison to other drinking water constituents. It should be reported in a comparison of upstream-downstream of Delta diversion points.
    b. Dissolved organic nitrogen (DON) – Nitrogen is noted for algae nutrients, but DON is not noted as an important precursor to nitrogenous disinfection by-products, important for reasons presented below. Upstream wastewater or agricultural sources are important to consider for drinking water supplies alongside the current focus on TOC. TKN data is reported on page 5-62 yet no connection is made relative to nitrogenous DBP. Select studies of DON (a different method than for TKN) exist on Delta water and could be mined.
    c. Threshold odor number – A frequently measured parameter at water treatment plants, it is one indicator of aesthetics.
    d. BOM/AOC –Organic carbon peaks are noted in conjunction with first significant run-off events (page 5-54), focusing on TOC. The potential for differences in organic loading of biodegradable fraction (BOM/AOC) may be one of the only aspects that *might* impact distribution system water quality that would differ between above and below Delta diversion points.
    e. Algal toxins - These have been a significant area of research for the drinking water research community since the early 1990s. Recent incidents involving algal toxins have served to increase public awareness of algal toxin occurrence among the utility water quality managers, media, and general public. In 1998, when the first Contaminant Candidate List (CCL) was published after the 1996 Safe Drinking Water Act Amendments, algal toxins were included. There is international regulatory interest in anatoxin, microcystin, and cylindrospermopsin.

2. Water quality parameters not collected-analyzed for the treated water (in addition to the above) – A number of parameters with potential public health and regulatory significance did not appear to be analyzed:

    a. DBPs – Running annual averages are discussed with the possibility of locational values being used for regulatory compliance in the future (page 6-32). Yet, it appears that instantaneous values are plotted up in figures from the CDPH database.
    b. Brominated organic compounds – These are noted in passing, and speciation was presented for trihalomethanes and haloacetic acids (in Appendix D). No concentrations for halacetontriles, haloketones or halopicrin concentrations noted. Some of this data is available as part of EPA's Information Collection Rule database and some from individual utilities.
    c. Nitrosoamines – NDMA and other nitrosoamines have been a known carcinogens since the 1960s when concern arose over the use of nitrite salts in food preservation. Their quantification in drinking water is relatively recent. A group of six nitrosoamines is currently of on the Unregulated Contaminant Monitoring List so that USEPA can determine their prevalence and see if regulation is warranted. The simplest and most prevalent nitrosoamine is NDMA. The EPA IRIS classification of NDMA is B2, making it a probable human carcinogen. There is currently no MCL for NDMA, though an action level of 10 ng/L was set in 2002, based in part on the discovery of NDMA as a disinfection byproduct. In 2006, OEHHA set a draft public health goal of 3 ng/L for NDMA. There is some plausibility that nitrogenous DBPs like NDMA account for the bladder cancer results observed in epidemiology studies of chlorinated drinking water (Bull, 2003).
    d. Other nitrogenous DBP – While NDMA has been a focus, other nitrogenous DBPs of health and regulatory concern (e.g., haloacetonitriles, halonitromethanes, cyanogen halides).
    e. Hydrazine - Hydrazine is a chemical compound typically used in chemical synthesis which was recently found as a chloramine disinfection by-product in a 2006 study by Najm et al. Hydrazine is classified as a probable human carcinogen.
    f. Iodinated products – Iodo-acids and iodo-THMs. Most of the iodo-acids are genotoxic or cytotoxic with IAA more toxic than currently regulated HAAs. Consideration should be given to a preliminary Delta survey.

3. Incomplete-conflicting data Some results seem incorrect (e.g., results for bromate noted in Chapter 4 and Chapter 6 for ozone plants on the South Bay Aqueduct conflict).

4. Polyacrylamide use in agriculture was noted as a agricultural BMP, yet there was no discussion of its fate and transport, and its degradation products. Perhaps this is explored elsewhere. There are some indications suggestions in the literature that acrylamide and acrylate are degradation products.

2. Information Analysis and Results: *Have processes and methodologies (e.g. analyses of data) been used that are understandable, scientifically defensible, fully documented and appropriate? What results are missing that could reasonably be obtained? Are the modeling and risk analysis approaches employed defensible and consistent with other large scale projects elsewhere in the nation and internationally?*

1. The risk analysis approach seemed to be a comparison against regulatory benchmarks and source water targets. A more analytical approach would be beneficial (described later).

2. Two databases were used for assessing the degree to which “ELPH targets” (defined as THM, HAA and bromate on page 4-13): the Consumer Confidence Reports for 2005 and 2006, and the CDPH database for 2004-2006. No discussion was made on the differences in results between the databases. No examination of actual detection limits and reporting on bromate was done. No data was furnished from the CCRs and the data plotted from the CDPH database implied detection limits of 1 ug/l in one case. Figure 4.17 indicates data from 1985 to 2006 and Figure 4.18 indicates data from 2004 to 2006. The data for SBA are inconsistent between these two figures, and are both in error. In addition, using the same CDPH database, Figure 6.21 appears to the capture the plausible occurrence of bromate.

3. Individual DBP species – Some were shown, but there was no analysis of their significance, a critical issue for ELPH. No segregation of analysis of water quality outcomes for different seasonal and hydrological conditions.

4. Bromate assessment – In Chapter 6, treated water quality is evaluated for several different locations. The bromate data is presented from CDPH database but as apparently instantaneous values, not running annual averages. On this basis the conclusion is made that ELPH targets are not met. No discussion is made as to detection limits (are 5 ug/l entries Non Detects or actual measured concentrations?). Since bromate has such importance, it seems a more robust discussion is merited.

3. Findings and Recommendations: *How well are the key findings and recommendations supported by the stated data, methodologies or conceptual models, and analysis results? Do the findings and recommendations sufficiently address the level of progress made by the WQP for Stage 1?*

Recommendation for refining the ELPH goal has the greatest merit. Operationalizing it simply as THMs of 40 ug/l, HAAs of 30 ug/l and bromate of 5 ug/l has significant limitations. Without a better evaluation tool, all the other program elements are of diminished value. I concur with the statement: “a more fitting measure should be identified” (page 7-3) though think that it may be multiple measures.

4. Conveyance: *Are the findings and recommendations regarding the role of conveyance in meeting the water quality objective valid?*

Short of a complete Delta by-pass, the notion of regional specific alternatives makes sense (e.g., NBA intake relocation). These of course depend on the interplay with water treatment technology and cost-effectiveness considerations.

5. Stage 2 Priorities: *Do the identified priorities follow logically from the findings and recommendations. Are there additional critical knowledge gaps?*

Interpretation of targets, objectives and goals remains one of the more daunting aspects of this program. There is a significant need to develop alternatives means for assessing “an equivalent level of public health protection.” This is necessary to streamline further monitoring and analysis efforts.

Which constituents should be reduced ties both the refinement of ELPH and an assessment as to whether certain measures would concurrently reduce multiple constituents of concern (e.g., would measures for reducing organic carbon also reduce organic nitrogen loading?). In addition, it might not be only "the presence of algae in drinking water conveyances" that should be prioritized, but the potential for episodic growth of algae giving rise to customer dissatisfaction that should be assessed. If this is not feasible, then it would favor a treatment-based solution instead of a source control one.

Refinements to performance measures should continue, especially with regard to customer satisfaction.

In addition to the water quality parameters indicated in response to question 1, the refinement of ELPH should not be restricted either to disinfection by-products that are currently regulated, but address other constituents, including those for which little health effects data is currently available. It is possible to do a more robust risk analysis as detailed below.

6. Approach for "equivalent level of public health protection": *In the CALFED Bay-Delta Program Record of Decision (2000) the goal of the WQP is to provide "safe, reliable, and affordable drinking water in a cost-effective way," with a target to "achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies." Is the approach taken to determining if an "equivalent level of public health protection" has been achieved appropriate? Are there other ways to evaluate progress towards this goal?*

There are other ways of examining "Equivalent Level of Public Health Protection" and such means should be explored. This would be an important priority for CALFED.
Drinking water is a complex mixture of various microbes and inorganic and organic chemicals. To assess water against a series of benchmarks without considering the overall mixture seems less than optimal. It is understandable since regulations are often promulgated independently and sequentially. Yet, there are calls to do more.

The EPA Science Advisory Board released a report *Integrated Environmental Decision Making in the 21st Century* calling EPA to focus on the reduction of total risks resulting from risk management decisions rather than focusing on the reduction of any particular risk (EPASAB, 2000). EPA is authorized to incorporate such considerations by the 1996 SDWA Amendments:

> *"...the level or levels or treatment techniques shall minimize the overall risk of adverse health effects by balancing the risk from the contaminant and the risk from other contaminants the concentrations of which may be affected by the use of a treatment technique or process that would be employed to attain the maximum contaminant level or levels"*

A major limitation of such efforts is the lack of and controversial interpretation of health effects information. Much controversy surrounds the method by which the risks of chemicals are assessed. To illustrate, after three years of litigation (and over 10 years of research), the issue of setting a safe level for chloroform, a DBP, had to be decided in a United States Court of Appeals (March 31, 2000). Furthermore, the President's Commission Report on Risk Management (1997) cautions that the typical numerical risk estimates for individual chemical compounds (termed "bright lines") are problematic:

"The all-or-nothing nature of use of a bright line could be misunderstood and construed to imply that there is an exact boundary between safety and risk, even though risk-based bright lines are burdened by all the uncertainty, variability, and assumptions inherent in cancer risk estimation."

How does one assess the overall public health risk associated with what is acknowledged to be a "soup" of constituents? The risk posed by a given compound can be expressed as the potency (or the strength of its particular adverse health effect response) multiplied by the concentration at which this constituent occurs:

Risk = Potency x Concentration

Cumulative risks from exposures to carcinogens have been widely assumed to be additive (EPA, 1998)[3]. This assumption is probably conservative at the low levels of exposure that are encountered in drinking water. A numeric index can be developed to compare different waters containing varying levels of constituents. A similar analysis can be done non-cancer endpoints (a Hazard Index based on reference doses).

A major limitation of such efforts is the lack of and controversial interpretation of health effects information. Much controversy surrounds the method by which the risks of chemicals are assessed. In addition, it is important to include as many constituents of some health significance found in water as possible, to be comprehensive in such an exercise.

Such limitations acknowledged, such an analysis can be performed. For example, consider the potency factors given in the table below.

Chemical	***Cancer Potency Factor***
Arsenic (As)	250
Atrazine	7
Benzene	7
Benzo[a]pyrene	250
Beryllium	1
Bromate	20
Bromodichloromethane	0.5
Bromoform	0.1
Chloroform	0.01
Chromium (Cr+6)	0.02
Dibromoacetonitrile	0.01
Dibromochloromethane	0.5
Dichloroacetic acid	0.3

3 EPA 1998. Technical Support Document on Risk Assessment of Chemical Mixtures. EPA/600/8-90/064.

Chemical	Cancer Potency Factor
Dichloroacetonitrile	0.03
Methyl tertiary butyl ether (MTBE)	0.1
N-Nitrosodimethylamine (NDMA)	500

The relative potency (if we assume that the compounds are acting on the same target) would imply that:

1. Bromoform at 1 ug/l would make an equivalent contribution as 10 ug/l of chloroform (of course, chloroform is believed to have a threshold and has the only EPA-published non-zero MCLG).
2. Bromate at 1 ug/l would have an equivalent contribution as 40 ug/l as bromodichloromethane.
3. Arsenic at 1 ug/l would have an equivalent contribution as 12.5 ug/l of bromate.

Any such analysis needs to consider the plausibility of the health effects data. But what is particularly important is arsenic. Small variations in arsenic concentrations could drive the overall cancer risk dramatically. A water that had 4 ug/l of arsenic (well within drinking water standards) with 10 ug/l of bromate, could have a much higher risk than a water with 3 ug/l of arsenic and 2 ug/l bromate (likely the limit of detection).

This has not yet been considered in CALFED's notion of ELPH. It is all the more significant since the health effects database for arsenic is arguably stronger than most other water contaminants.

> EPA has recently concluded that inorganic arsenic (iAs) causes human cancer most likely by many different modes of action.[4] This is based on the observed findings that iAs undergoes successive methylation steps in humans and results in the production of a number of intermediate metabolic products and that each has its own toxicity. EPA asked the Science Advisory Board to comment on the soundness of its conclusion.
>
> The Panel report (2007) concluded that:
>
> "i) Multiple modes of action may operate in carcinogenesis induced by i[norganic]As because there is simultaneous exposure to multiple metabolic products as well as multiple target organs and the composition of metabolites can differ in different organs.
>
> ii) Each arsenic metabolite has its own cytotoxic and genotoxic capability.
>
> iii) Inorganic arsenic (iAs^{III}) and its metabolites are not direct genotoxicants because these compounds do not directly react with DNA. However, iAS^{III} and some of its metabolites can exhibit indirect genotoxicity, induce aneuploidy, cause changes in DNA methylation, and alter signaling and hormone action. In addition, iAs can act as a transplacental carcinogen and a cocarcinogen.

[4] EPA-SAB-07-008 Advisory on EPA's Assessments of Carcinogenic Effects of Organic and Inorganic Arsenic: A Report of the US EPA Science Advisory Board

iv) Studies of indirect genotoxicity strongly suggest the possibility of a threshold for arsenic carcinogenicity. However, the studies discussed herein do not show where such a threshold might be, nor do they show the shape of the dose-response curve at these low levels. In addition, a threshold has not been confirmed by epidemiological studies. This issue is an extremely important area for research attention, and it is an issue that should be evaluated in EPA's continuing risk assessment for iAs.

v) Arsenic essentiality and the possibility of hormetic effects are in need of additional research to determine how they would influence the determination of a threshold for specific arsenic-associated health endpoints."

Arsenic is also known to have other non-cancer adverse health and developmental effects including, but are not limited to, hypertension, neurotoxicity, respiratory disease, and skin disease.

7. Treated water quality: *Are the conclusions about linkage between source water quality and treated water quality valid? Are additional treated water quality data and analysis of needed?*

Treated water quality is addressed in Chapter 6 though not with clear questions being posed. Does source water quality impact treated water quality? It depends on the treatment process. Are there treatment technologies that can produce water that meets ELPH for various Delta water quality scenarios? Undoubtedly, though the costs would vary. Is it possible to improve source water quality short of TOC of 3.0 mg/l and bromide of 50 ug/l such that ELPH can be met without significant changes to water treatment processes? It depends on how ELPH is defined.

Some thoughts on Chapter 6 findings:

1. The overview performance graphic (Figure 6.8) presents THM and HAA data but not bromate. This would be helpful to include.

2. In the overview of the ten treatment plants, a tangential observation is made on treatment cost differences between Sacramento River and Delta sources. Those inferences about cost differences are questionable based on the dataset. Figure 6.10 shows very small bars for Redding and City of Sacramento, and higher bars for Delta plants except one.
    a. No explanation is given for the outlier, the CLWA Earl Schmidt Filtration Plant (it has an enhanced coagulation exemption since it uses ozone and, like Sacramento, treats lower turbidity water).
    b. The data presented in Appendix E are different than shown. For example, it indicates that the Sacramento doses are higher than shown in Figure 6.10 (alum doses of 11 to 28 mg/l) yet appears the same as the CLWA plant (though it use ferric chloride at a dose of 1 mg/l).
    c. ACWD TP#2 has the same dose range as Sacramento in Appendix E, Table 3.2 (albeit ferric rather than alum). Drawing cost conclusions from this database seems unwarranted (see section 5.1.2 and 6.1.4 of Appendix E).

3. Watershed plants are discussed with the conclusion that they meet the ELPH operationalized targets of 40/30 for THMs and HAAs. It is silent on the significance of the bromate data presented in Figure 6.13 which shows three data points above 10 ug/l.

4. For the Delta/South Bay Aqueduct region, two items are telling. First, the bromate levels are above 5 ug/l without much discussion as to what is being done on treatment optimization to reduce bromate (projects have been completed as indicated in Appendix A). Second, the fact of CCWD's "TTHM (6 ug/L) and HAA5 (2 ug/L)…well below ELPH targets, but also poses challenges in managing bromate formation" begs the question as to what is ELPH? Is it 40/30/5? Or is it an aggregate measure that combines the various water quality constituents resulting from the interplay of source water quality and treatment technology?

8. Performance Measures: *Are the identified performance measures sufficient and appropriate for the stated goals of the program?*

Aesthetics probably have the most significant impact on customer satisfaction. It is a leading factor contributing to customers seeking alternative sources (i.e., point of use devices, bottled water, etc.) and also serves as surrogate for consumer sense of safety. As noted by Jardine et al. (1997), customers may sometimes be right in reasoning that tastes and odors indicate a potential hazard since many potential water contaminants can pose a health concern at levels below those that can be detected by odor. They conclude:

> *The absence of offensive tastes or odors in drinking is a necessary, but not a sufficient condition for consumers to be assured of the safety of their drinking water. Unless very specific and reliable evidence can be provided, consumers will have rational grounds to question the security of their water supply.*

The aesthetic issues are recognized in the report as "Objective 2" on page 4-17 and page C-7, and measured by consumer complaints. The use of consumer complaints, however, has some limitations. First, it does not recognize the subset of the customer base that has already stopped drinking tap water due to poor taste. Second, people tend to adapt to a baseline (even if it is non-optimal) and then react more to deviations from the baseline (as measured by complaints). My sense is that these two factors cause consumer complaints to be a performance measure that underestimates aesthetic differences upstream and downstream of Delta diversion points.

An alternative or complementary performance measure is the Threshold Odor Number or TON, a frequently measured parameter at water treatment plants.

Furthermore, Target 2a focuses on reducing the frequency or algae blooms. This target, however, may or may not indicate the presence of tastes and odors – this depends on the algal species. Perhaps this is why Target 2b is offered. In any case, use of TON could be a useful metric.

Appendix B – Review comments by Dr. David Reckhow

Critical Review of the CALFED WQP Stage 1 Final Assessment

Dave Reckhow
25 May 08

The Stage 1 Final Assessment document represents a very ambitious undertaking, and in general the report and its appendices are well written. Also, I'd like to say that the authors have done an admirable job of presenting much of the complex information that is needed. There are several areas where I believe it could be improved.

Introductory material on regulations and contaminants seems to focus on disinfection byproducts (DBPs). It seems that this comes from the 1998 panel. Since the resulting ELPH targets are used to focus the WQP, it seems that more explanation and justification is needed. Either there needs to be a more comprehensive assessment of risks from drinking water contaminants (chemical and biological), or if this has already been done it needs to be highlighted. This analysis and discussion needs to be presented early in the report, and if it leads to the conclusion that DBPs are the major risk, so be it, but the case has to be made.

There are some organizational problems that make the report difficult to read and follow. Some pertain to the patchwork nature of the appendices. For example, in trying to understand better the data in Figure 6.7 (pg 6-9) of the main report, I looked for the symbol key. After some searching, I found that this figure was the same as figure 64 in Appendix D. On page 9 of appendix E to appendix D (not the same as the principle appendix E), I found a listing of codes for figure 64. Unfortunately, these were not the same as those shown in the figure that they refer to. There are still some errors (e.g., Figure 5.3 and 5.4 are reversed), and references are often not sufficiently complete to allow one to locate them from primary sources. I found some of the box plots odd and difficult to understand (e.g., Figure 5.11 to 5.14), where "month" or "water year type" were the continuous variables being characterized.

1. Information Gathering

This is quite a bit of discussion on the movement of water and conservative substances (e.g., bromide, salinity), as there should be. However, as a reader who is unfamiliar with prior hydrological studies of the Delta, I had trouble discerning the current state of water modeling in this system. For example, Figure 3.4 seems to be based on actual data, but I can't rule out the possibility that this was from some hydrologic model. On page 4-5 the authors mention the "network of monitoring stations throughout the Delta that continuously record data on flow, EC, and other constituents." This sounds promising, but from this point on almost all data presented are either bromide concentrations or TOC. Also, almost all data are from one of the half-dozen major pumping stations or from one location on each of the two major rivers. What are the "other constituents", and where are all of the other monitoring stations? The data that are presented show a nice continuous record from about 1990 to the present. The authors present these data in time series and box plots. Drivers are referred to in qualitative terms, but there's no clear demonstration that a reliable quantitative model exists. Figure 4.11 shows a simple graph of bromide vs time at one location. How about a line predicting bromide based on a physical model rather than a simple straight line through the data? I would be surprised if a good, calibrated hydraulic model didn't exist for the Delta (on page 5-1, the report indicates that salinity "is well monitored, modeled and managed"; on page 5-3 is a reference to the "Delta Simulation Model 2"). So why not say so, and show how reliable it is (i.e., show predicted vs measured concentrations under a variety of climate & management conditions)? It's possible that Figure 5.3 or 5.4 was included for this reason, but there are no data shown, and it's almost impossible to understand this figure from the text. Without this type of background, it's hard to assess or even accept the later claims made for impacts of conveyance alternatives on bromide levels.

The "fingerprinting" model (DSM2) is also used to make conclusions about sources of organic carbon (pg 5-38). However, without more information and some comparison of model predictions vs actual measurements, it's very hard to assess its accuracy.

Qualitative data on the organic precursors are generally lacking. While DOC and UV absorbance are useful, there are many other measurements that could have been helpful. This could include more specific information on DBP precursor levels, NOM characterization data, organic nitrogen concentrations, etc. For example, I have seen information on specific DBP precursor levels NOM characteristics in the delta island drains in other publications. This could help in assessing the importance of that particular source of NOM and tell us a bit about its chemical nature.

Primary productivity is potentially quite important here. There is mention of this at several points, especially in chapter 7. I'm guessing there are lots of data on algal counts, productivity, biomass, and chemical indicators (diurnal DO swing, pH swing, etc.). It is well accepted that algae can be major sources of DBP precursors, especially nitrogenous ones.

The relatively high levels of nitrate in portions of the delta (e.g., figure 5.74), and intense sunlight will undoubtedly result in some photonitration. It would be good to keep this in mind and watch the halonitromethane levels in treated drinking waters. This would be of special concern if nitrate levels were to increase.

2. Information Analysis and Results

As previously mentioned, I would have liked to have seen more mass balance data on organic carbon and bromide in a simple visual format. It would have been helpful to see fluxes represented on a map of the delta, with mass balances at junctions and estimates of losses/gains. It seems that a substantial amount of flow or velocity data is available for many of the rivers and channels. This could have been combined with chemical concentration data to get mass fluxes.

I applaud the WQP's efforts to attend to bromide levels. However, given the strong correlation between bromide and chloride (e.g., figure 5.1) and the potential importance of iodide, which probably also correlates well with chloride, I'm thinking that it might be more effective to just consider salinity or conductivity. Presumably these data are far more numerous and possibly more precise.

3. Findings and Recommendations

See appropriate sections below.

4. Conveyance

Yes, if we accept the validity of the Delta model, the findings and recommendations regarding conveyance seem valid. This is especially true for bromide. The report is at times too qualitative to be completely convincing. I can't quite tell from the information provided if the conveyance model is based on a real physical hydraulic model. It would be good to have this explained a bit more clearly. I would also reiterate that some model validation with real data should be presented.

The NOM conceptual model should also consider loss and generation processes that occur during conveyance. There seems to be a lack of recognition that NOM concentrations are subject to various loss and generation processes. On page 5-36, the authors state that *"organic carbon that is bioavailable, which is generally the particulate form of organic carbon, suggesting that there may be minimal conflict between supporting the Delta food web and reducing DBPs".* This has a footnote to reference #23 (organic carbon conceptual model report), which was not readily available to me. My experience is that most dissolved NOM is both bioavailable and reactive to some extent. Perhaps there's something in reference #23 that shows this not to be the case in the Delta, but I remain skeptical.

On page 5-13, it is stated that "controlling the flow of water at strategic locations in the Delta can have a major effect on salinity." However, the short-term conveyance alternative based on changing bathymetry (Franks tract project, through delta facility and delta cross channel) seem to offer only modest improvements (2-17% reductions in bromide). It seems that the peripheral canal, as a long-term option, is the only one that has any hope of bringing bromide levels down to the target. It would be helpful to know if there is any other alternative (e.g., active barrier system) that might be less ambitious than the peripheral canal but still reduce bromide levels substantially.

5. Stage 2 Priorities

I would focus more on public health and strive for adoption of quantitative goals. This means that the full set of risks should be explicitly considered. The current focus is almost entirely on DBPs and seems to ignore other contaminants and risks.

I would also argue for a more comprehensive physical-based transport model coupled to a set of water treatment plant models. These could be developed using the existing generic WTP models as a starting point.

In chapter 7 there is some mention of NOM assessment and characterization. I would encourage this, but warn that a careful decision must be made as to the appropriate measurement to make. There are many types of NOM characterization techniques, and some will be helpful, whereas others will not.

6. Approach for "equivalent level of public health protection"

I think this is a worthwhile approach. In particular, the use of TOC as a surrogate for DBP formation is a good idea given the current state of understanding of DBPs and human health. TOC and TON are probably better target parameters than THM and HAA formation. For example, use of chloramines without pre chlorination is cited on page 6-31 as very effective for controlling THMs and HAAs. However, our current knowledge suggests that some nitrogen-containing DBPs, probably compounds enhanced by pure chloramination, are more likely to have adverse human health effects than those that are currently regulated.

I also think that the discussion regarding "future conditions" (page 6-32) is too centered on regulations. Although regulations are intended to help provide a minimum uniform level of protection to the public, they do take decades to develop as noted. In a world where new information on drinking water contaminants and public health impacts is constantly emerging, the regulatory imperatives do not always agree with the current understanding of best public health practice. For this reason, I'd recommend discussion of public health impacts as separate from regulatory requirements.

The selection of quantitative criteria for "equivalent protection" is not an easy task. Better treatment can certainly mitigate any lack of achievement with the base stage 1 objectives. One approach would be to adopt a set of finished WQ criteria based on some key bulk parameters. The classical criteria for THMs, HAAs and DOC could be retained as a guideline for controlling a broad range of byproducts. However, other (often more targeted) bulk parameters would add focus based on current toxicological understanding. One possibility for these would be:

- Total organic bromine (TOBr) and total organic iodine (TOI) criteria for finished waters when the raw water bromide criteria can't be achieved
- Criteria on dissolve organic nitrogen (DON), halogen (TOX), total nitrosamines, and total organic chloramines for finished waters when the raw water TOC criteria can't be achieved.

Precise numerical criteria would probably come from parallel monitoring of a set of plants in a control group that is not adversely impacted by poor raw water quality (e.g., low DOC, low bromide).

It may even be possible to develop and calibrate water treatment plant models for at least some of these alternative criteria. Again these could be built upon the foundation of the existing WTP model developed under EPA contact. Any such model should probably include a sub-model for DBP changes in distribution systems.

7. Treated water quality

See comments under #6

8. Performance measures

These seem to lack a quantitative component. See prior comments.

Appendix C – Review comments by Dr. Phil Singer

CalFed Water Quality Program Stage 1 Final Assessment Draft Report (October 2007)

Review Comments by Philip C. Singer

Responses to Peer Review Charge Questions:

1. Information Gathering

The authors of the report have collected extensive information on TOC/DOC and bromide/salinity/TDS concentrations throughout the Delta; most of the data have been gathered from reports generated by CalFed and other California agencies. Additionally, data on finished water quality, notably THMs, HAAs, and bromate, have been collected for a large number of water utilities treating Delta water. Again, these data were obtained from a number of CalFed and DHS reports. The data should prove useful in guiding the CalFed Water Quality Program.

However, in response to the questions concerning information gathering, there are a number of limitations and shortcomings associated with the information gathered.

d. The relative levels of DOC and bromide at the various locations throughout the Delta, including the Delta intakes, are interesting as they relate to the targeted levels of 3.0 and 0.05 mg/L, respectively. But, as noted, the averages are of limited value. The historical trends shown are of greater interest, but it would have been useful if the trends were related to hydrological events and patterns, and Delta operations such as changes in pumping and storage practices. Hydrology and water resources management impact DOC and bromide levels. Hence it would be useful to superimpose hydrologic patterns and changes in management practices on figures such as Figure 5.20 and others in much the same way as it was done for bromide in Figure 5.17.

e. The statement is made repeatedly throughout the report (e.g. pages 5-22, 6-1) that more information needs to be developed relating DOC concentrations and the nature of the DOC to its DBP formation potential. This has been a continuous subject of study over the past 20 years, and much is known about the relationship between DOC properties and DBP formation potential, yet no reference to these studies appear in this report. Authors of key papers on this subject include Croue, Reckhow, Amy, Westerhoff, and Singer, to name a few. There is general agreement that THM and HAA formation potential increase as the hydrophobic organic content of the DOC in the water increases. It has also been shown that DBP formation potential strongly correlates with ultraviolet absorbance (e.g. at 254 nm) of the water and that specific UV absorbance (SUVA) is a good measure of the reactivity of the DOC with respect to DBP formation, yet these key items of information are not addressed in this report. If the information is not available, then a recommendation should be made that such information be collected. In any case, the literature on this subject should be incorporated into this report.

f. It is well known that bromide impacts the extent of DBP formation and DBP speciation. This is one of the reasons for having a 50 ug/L target for bromide. However, DBP speciation patterns and their linkage to bromide levels are not presented or discussed to any appreciable degree. In Appendix D, the figures on page D33 and D34 show how the THM formation and speciation patterns shift across Delta-impacted water utilities; this is important because brominated DBPs are generally of greater health concern than their fully chlorinated counterparts. The whole subject of speciation is in need of greater discussion in the main report.

g. Related to (c), there is no mention of the fact that measurement and regulation of HAA5 underestimates HAA occurrence, especially in waters containing high levels of bromide such as Delta water. It has been shown, for many waters including a number of Delta-impacted waters (Singer and co-workers), that bromochloroacetic acid, bromodichloroacetic acid, and dibromochloroacetic acid tend to be present at concentrations greater than dichloroacetic acid and trichloroacetic acid, and that if all of the bromine- and chlorine-containing HAAs (there are 9 of them, e.g. HAA9) are measured, total HAA concentrations tend to be approximately twice the HAA5 concentrations. The point here is that the non-regulated HAA species are never mentioned in this report even though they are present at significant levels in Delta-impacted waters. The bromine-containing species tend to be more harmful than their chlorine-containing counterparts, and this subject has been reported in the literature for the past 12 years.

h. The linkage between raw water quality and DBP production has been captured by a variety of models such as the USEPA's Water Treatment Plant Simulation Model that was used in the FACA process for the Stage 1 and Stage 2 D/DBP Rules. My recollection is that Malcolm Pirnie and MWD also developed a variant of this model using simulated (or actual) Delta water and that this model was used by CalFed in setting the 3.0 and 0.05 mg/L targets for DOC and bromide, respectively. In any case, no mention is made of these models or of their applicability in linking DOC and bromide to DBP production, and the impact of changes in DOC and/or bromide levels in the Delta to ultimate DBP formation.

i. Another information gap is that there is no mention of the literature related to short-term acute health risks associated with DBPs, e.g. reproductive and developmental health risks. One of the most widely publicized studies (Waller and Swan) on this subject was done in a community using Delta water. The preamble to the Stage 2 D/DBP Rule speaks extensively to this concern.

j. There is a paucity of data (in fact none) related to microorganisms and the potential occurrence of pathogens in the various Delta waters. Mention is made in a few places that Delta waters are relatively free of fecal coliform, Giardia, Crypto, and viruses, but no supporting data are provided. In fact, almost the entire report is devoted to bromide/salinity and DOC/TOC; microbial issues should be of high priority as well. In Chapter 2, there is extensive discussion of the D/DBP Rules but almost no discussion of the various rules aimed at pathogenic microorganisms, e.g. SWTR and LT1 and LT2 ESWTR. This is a significant omission

k. Likewise, there is a paucity of data related to taste and odor-causing organics, such as MIB and geosmin, as they relate to nutrient levels and algal activity in the various Delta waters. Data is presented to indicate that Delta waters have elevated nutrient levels and it is stated that algal blooms occur and that undesirable levels of MIB and geosmin have been reported at several of the intakes, but no supporting data on algae, MIB, or geosmin are provided.

l. Nitrate is discussed in the context of its concern as a nutrient for algal growth but no mention is made about the fact that nitrate is regulated on its own at a level of 10 mg/L as N. Nitrate is regulated because it causes methemoglobinemia. The elevated levels approaching 8 mg/L are a cause of concern beyond algal growth concerns.

m. Again, almost the entire report is devoted to bromide/salinity and DOC/TOC, but there are other water quality concerns that should be addressed, or at least mentioned. Examples include the fact that, because many of the utilities using Delta water have resorted to use of combined chlorine (monochloramine) as a terminal disinfectant to comply with DBP regulations (this is discussed further below), water quality issues such as nitrification and NDMA formation are important consequences of this action. Because DOC and bromide levels are as high as they are, compliance with the regulations has forced many systems to use combined chlorine. NDMA occurrence is greater in chloraminated waters than in waters using free chlorine as a terminal disinfectant.

n. The subjects of emerging chemical and microbial contaminants, the various candidate contaminants lists (CCLs) developed by the USEPA, and pesticides, pharmaceutically active compounds, personal care products, and endocrine disruptors, are barely mentioned in the report,

o. Mention is made repeatedly about water quality "from source to tap," but no consideration is given to variations in DBP levels in the distribution system. Changes in DBP levels in the system is an important issue, but may be beyond the scope of this Stage 1 report, yet it is am important issue. It is not evident where the THM, HAA5, and bromate data in Chapter 5 come from; are they point of entry (POE) values, values in the distribution system as close to the POE as possible, or system-wide average values. If they are values in the distribution system as close to the POE as possible, it is not clear what this means in terms of distribution system residence time. If all of the systems are on combined chlorine, there may not be much of a difference between POE values and system-wide averages but, in any case, the notion of source to tap is an incorrect inference because a comprehensive assessment of tap water values is not presented.

2. Information Analysis and Results.

The presentation and discussion of TOC/DOC and salinity/bromide occurrence throughout the Delta has been presented and analyzed relatively comprehensively.

d. My biggest criticism is the manner in which the treatment information has been presented. Meeting the treated water DBP targets for TTHM, HAA5, and bromate of 40, 30, and 5 ug/L depends on source water quality and the type of treatment employed. THMs and HAAs depend upon the amount of chlorine applied and the contact time of the water with free chlorine. If a utility disinfects with ozone or UV and then uses combined chlorine, their THM and HAA levels will be relatively low, regardless of the source water DOC or bromide. The same is true if they use micro/ultrafiltration and combined chlorine. If a utility coagulates, settles, and filters before applying chlorine for disinfection, their DBP levels will depend not on the source water DOC but on the filtered water DOC. In the case of bromate, if a utility uses ozone for disinfection but does so at a low pH, their bromate levels will be low regardless of the raw water bromide concentration. Information on chlorine doses, point of chlorination, use of chloramines, application point of ammonia, pH of ozonation is not presented anywhere in the report yet these factors are major determinants of DBPs produced in the finished water.

e. The manner of data presentation leads to much confusion and many erroneous conclusions. For example, Figure 6.7 suggests no correlation between TTHM and TOC. I suspect that the squares are for a water that has a very short free chlorine contact time and disinfects with ozone, UV, or membranes and uses combined chlorine. If the squares are omitted, there is a strong pattern relating TTHM to TOC, although there are some outliers that might be explainable because of temperature or some other consideration such as those mentioned above. Similarly, Figure 6.15 is misleading as are the other figures like it (e.g. Figure 6.19). I suspect that the plants with TTHM levels less than 10 ug/L all use combined chlorine, perhaps ozone and combined chlorine, with little free chlorine contact time. Likewise, for bromate, the plants with no bromate probably do not use ozone. This is not apparent from the figures when all of the results from all of the plants in the region are combined in this manner. It would make much more sense to present the data plant by plant so that one can see what individual plants have done in the way of treatment to keep DBPs low regardless of the source water DOC and bromide. The fact of the matter is that source water quality is only one determinant of finished water quality. The type of treatment is another, and there are numerous treatment options that a utility can use, depending upon the progressiveness of its leadership, local economics, etc., to achieve low DBP levels. This is not reflected in any of the discussion.

f. In fact, I would argue that the regional conceptual models, such as Figure 6.18, are incorrect. The drivers shown in the second row, i.e. raw water quality, alternative supplies, regulations, and socioeconomic considerations, are actually drivers for the type of treatment employed. The type of treatment is not a driver but is driven by these other factors. It is then the type of treatment used on these raw water qualities that determine treated water quality, i.e. TTHMs, HAAs, bromate, as well as finished water DOC, bromide, taste and odor, etc. In that sense, the type of treatment is the linkage, and this conceptual model is valid for all regions. It is then the treated water quality plus distribution system considerations (e.g. terminal disinfectant, storage, distribution system operations) that control tap water DBP levels. When viewed in this manner, there is no need for individual regional conceptual models. All the models are the same, but it is raw water quality in the region that drives the different treatment options, i.e. simpler treatment for the watershed plants to meet the ELPH targets while more advanced technologies for the NBA, Delta/SBA plants, etc.

g. Figure 6.10 is awful. Giving overall chemical doses for treatment makes no sense. You cannot logically add mg/L alum, caustic, chlorine, ammonia, corrosion inhibitor. It would make much more sense to give chlorine doses, ozone doses, etc. I would suspect that the same argument could be made if chlorine dose was plotted.

h. There are no modeling and risk assessment approaches using the available data. In fact, the whole concept of ELPH is never defined, other than 40, 30, 5 ug/L for TTHM, HAA5, and bromate, respectively, and the linkage between the 3 mg/L TOC and the 0.05 mg/L bromide raw water targets and these ELPH goals is not defined. Furthermore, these TTHM, HAA5, and bromate levels hardly constitute equivalent levels of public health protection without also addressing other water quality concerns. For example, one could achieve these levels without adding any disinfectant.

3. Findings and Recommendations

d. The data presented support the fact that the numeric average TOC and bromide concentrations at the Delta intakes exceed the drinking water quality targets of 3 and 0.05 mg/L, respectively. A primary concern is that ELPH has never been defined, other than 40, 30, 5 ug/L for TTHM, HAA5, and bromate, respectively. These levels hardly constitute equivalent levels of public health protection. Furthermore, there are statements in the report that "the ELPH approach is the backbone of the WQP" (page 4-1, para 2), but it is unfortunate that we have to wait until the Conclusions in Chapter 7 to be told that there is still not an acceptable definition of ELPH protection.

e. One of the objectives was to develop an initial comprehensive set of WQP performance measures. I saw a lot of recommendations that were labeled performance metrics but they were not really measures of performance but recommendations as to what needed to be done. Examples of true performance measures might be "how much have DBPs been reduced as a result of various actions?" or "how much has the TOC and bromide concentration been reduced at the Delta intakes?" or "how many plants are exceeding the ELPH targets of 40, 30, 5 ug/L?" Similarly, for taste and odor, performance measures might be "how many taste and odor complaints have been reported for utilities using Delta water?" or "to what extent have taste and odor complaints been reduced?"

f. Another objective was to address drinking water quality from "source to tap," but only finished/treated water quality at the POE is presented. Tap water quality would require knowledge of distribution system design and operations, but this appears to be beyond the scope of this study/assessment. It might be an important consideration for Stage 2.

g. It would be desirable to present a parallel table to Table 7.1 summarizing treated water quality across the utilities included in the analysis. It would be helpful to include information on chlorine doses, point of chlorine application, free chlorine contact time, use of combined chlorine which, as noted above, are the determinants of THM and HAA compliance.

h. In my opinion, while there has been a good assessment of DOC and bromide concentrations across the Delta, there has not been an integrated assessment of treatment. Such an assessment needs to be made.

4. Conveyance

a. There are 8 recommendations concerning the subject of conveyance. All are legitimate, but as indicated in the second, there has been too much emphasis on salinity and not enough on other constituents of pubic health concern.

b. The fourth recommendation, while noble in nature, will be difficult to address, i.e. how to deal with "drinking water" that is not used for actual consumption but is used instead for irrigation, landscaping, etc. This issue seems to be beyond the scope of this assessment.

5. Stage 2 Priorities

a. Some of the Stage 2 priorities address information that is already known, e.g. a better understanding of the role of organic carbon quality in DBP production (see papers by Croue, Reckhow, Amy, Westerhoff, Singer). While this is indeed a priority, it should have been included in the Stage 1 assessment. Better definition of DOC and Br levels beyond those achieved with monthly grab samples is a legitimate criticism and deserving of priority ranking.

b. The multiple barrier approach to drinking water protection is appropriate, and this includes source water protection as an important first barrier. But attention needs to be placed not only on bromide and DOC, but also on nitrate, whose levels are perilously close to the primary MCL, pathogens, pesticides, nutrients and algal growth, dissolved organic nitrogen, and emerging microbial and chemical contaminants.

c. The ELPH protection goal requires major re-evaluation as to what it means and how it is to be defined and quantified.

6. Approach for ELPH Protection

a. As noted above, major consideration needs to be given to defining and quantifying a true measure of ELPH protection. The present goals of 40, 30, and 5 ug/L for THMs, HAA5, and bromate are a starting point, but are too limited. As indicated above, one can achieve these goals without disinfecting water.

7. Treated Water Quality

a. This is one of the weakest portions of the report. See comments on Chapter 6 below and answers to questions 1 and 2 above.

8. Performance Measures

a. As noted above, the performance measures are not really metrics but recommendations. True performance metrics need to be developed. Some examples are given above, and later in the comments for Chapters 4-6.

<u>Other General Comments About the Report.</u>

Report needs to be carefully edited. There are a number of grammatical errors throughout. For example:
Page 3-9, para 2. required requirements.
Page 3-9, para 2. by lower the pH
Page 5-1, para 3, there is a phrase missing on line 6.
Page 5-3, para 2. Figures 5-3 and 5-4 are reversed.
Figure 5-2. Bottom. Salinity, not salintv.
Page 5-13, para 4. $140 million?
Page 5-17, para 1, line 3. be…..be
Page 5-18, 3rd line from bottom. …are will…
Page 5-53, para 1. p=0.0000?
Page 6-17, item 4. Monitor….monitoring…
Many more.

Report is overly repetitive. Some subjects and material are discussed multiple times throughout. As a result, the report does not flow very well.

Reference citations at end of each chapter are incomplete.

Chapter by Chapter Comments.

Chapter 1.

This report deals with Stage 1 of a CalFed assessment and preparation for a subsequent Stage 2. This is very confusing language because the major focus is on TOC/DOC, bromide, and DBPs which are regulated via the Stage 1 and Stage 2 Disinfectants/ Disinfection By-products Rules? The terms Stage 1 and Stage 2 are first mentioned on Pages1-2 and 1-3, but they are not defined and readers familiar with the two stages of the D/DBP Rule will be confused, as I was. A statement should be made at the beginning of the report distinguishing between Stage 1 and Stage 2 of the Assessment and Stage 1 and Stage 2 of the D/DBP Rules.

The objectives of the report are not obvious. Page 1-3 lists 4 'multiple purposes' of the Stage 1 Final Assessment. If these are the objectives underlying this document, they need to be clearly labeled as objectives.

There is no mention of DBPs in the 'multiple purposes' (objectives?) on Page 1-3 or anywhere else in Chapter 1, yet this is a primary point of concern with respect to Delta water quality and this report. The only related reference is to 50 ug/L bromide and 3 mg/L total organic carbon on Page 1-1, but the fact that these targets are related to DBPs is not mentioned. In contrast, Chapter 2 opens with reference to DBP precursors in the first paragraph and the remainder of Chapter 2 focuses on DBPs. If DBPs are a major focus of this report, and they are, shouldn't they be highlighted/emphasized in the objectives and in this first Chapter?

Chapter 2.

There are a number of incorrect statements in this chapter. Examples:
Page 1-1, para 2. Chlorination alone is not responsible for essentially eliminating waterborne disease as stated. Filtration was a major contributor. Also, pathogens are microbes.
Page 2-1, para 3. Microbes such as protozoan cysts, as well as bacteria and viruses, can cause acute health effects. If you start with Milwaukee, you have to mention cysts.
Page 2-1, para 4. DBPs do not form when nutrients are exposed to oxidants.
Same paragraph. Those containing bromine, not bromate, are the most potent.
Same paragraph. THMs and HAAs are regulated at levels that are presumed to be within the 10^{-4} to 10^{-6} cancer risk. Only bromate is regulated outside this range, at 10 ug/L.
Page 2-2, para 1. Reference this recent study.
Page 2-3, last para. Stage 1 not I. Also, the rule is the D/DBP Rule not the DBP Rule. Same for Stage 2 on page 2-4.
Page 2-4, para 2. EPA's MCLs are 0.08 and 0.06 mg/L, not 80 and 60 ug/L. Likewise, 0.10 mg/L not 100 ug/L. Bromate is 0.01 mg/L, not 10 ug/L.
Page 2-4, para 3. Last sentence, new locations for LRAA should be chosen for 'maximum' THM and HAA levels, not simply 'higher' levels.
Page 2-8, last para. Stage 2 D/DBRR not Stage 2 LTSWTR.
Page 2-9, para 1. Same mistake.
Figure 2.3, Page 2-9, shows 50 ppb for Br and 3.0 ppm for TOC. Units should be consistent, e.g. ug/L, mg/L in text (page 2.8).

DBP regulations are summarized on Pages 2-3 to 2-4, but no summary of the microbial regulations is provided. In that sense, the report is not balanced. As a water quality report, shouldn't it be? Aren't microbial issues important?

The target of the Water Quality Plan to achieve 50 ug/L bromide and 3.0 mg/L TOC (page 2-8, para 2) is not related to DBPs and DBP regulations until Section 2.8 on Page 2-8. Because the long-term scenario described in this section is actually the driver for the bromide and TOC targets, this material should be moved to the beginning of this chapter as it sets the stage for what follows, i.e. tying the discussion of DBPs on Pages 2-3 to 2-4 more explicitly to bromide and TOC and providing the rationale for the Br and TOC targets.

Page 10, last para. Again, the question of pathogens seems to be an add-on, rather than a theme of significant importance to water quality. The focus of this report seems to be on DBPs, TOC and Br, but pathogens are of equal concern yet are covered to a very limited degree?

Figure 2-4 shows the Source to Tap paradigm but, as will be noted below, no attention is given to distribution. Treatment is discussed, but not the distribution system. Hence, the focus of the WQP is really Source to Point of Entry or Treated Water Quality, not Tap Water Quality.

Chapter 3.

Page 3-3, para 3. Mixing of seawater and fresh water is the result of the tides AND rainfall, runoff, and snow melt.

Figure 3.4. Can Banks and Tracy be located on this very informative figure? Other intakes? The cause of the high EC in the lower right (San Juaquin River) should be explained. Is there a parallel map available for bromide? This would be more to the point.

The first 7 pages of this chapter deal with salinity/bromide. Section 3.2 deals with Salinity and then we jump to Treatment in Section 2.3. What about TOC/DOC? There ought to be a section here, after Salinity, addressing organic carbon in the Delta. I realize that it comes later in the report, but some mention should be made of it here before discussing treatment.

Page 3-8. Top paragraph refers to coagulation, flocculation, and clarification as pre-treatment. Better to call this conventional treatment; it is more than merely "pre-treatment."

Page 3-8. End of para 4 gives log removals for microbes. This is critical information related to removal of pathogens, yet this is the first and only time anywhere in this report that this subject of log removals is addressed. LT2ESWTR and associated requirements for pathogen inactivation/removal should have been discussed in Chapter 2, as noted above.

Table 3.1. TDS should precede nutrients. Also, nitrate is not simply a nutrient. There is a primary MCL for nitrate (10 mg/L) because of its health effects (methemoglobinemia), not because it is a nutrient. Also, the statements about pathogen monitoring in the 3^{rd} column for bromide and TOC are out of place. Also, what about pesticides and other synthetic organic chemicals? These ought to be of concern in agriculturally-impacted waters.

Page 3-11, end para 2. It is not pH buffering that helps limit bromate formation; it is reduced pH. Same paragraph – rain water has NO alkalinity, not low alkalinity.

Page 3-11. No discussion of microbes/pathogens. Turbidity is discussed briefly, but no reference is made to the fact that it is used as a surrogate for potential pathogens.

Page 3-11, para 4. No reference to the fact that HAA5 does not capture many of the HAAs found in bromide-dominated waters.

Page 3-12. Para 2 opens with chronic health risks. What about acute health risks? Acute risks from microbes ought to come first. Also, no mention of acute risks associated with DBPs, e.g. developmental and reproductive risks.

Page 3-12, para 3. Nitrosamines are associated more with chloramination than with chlorination. This is a concern (discussed below) because many systems using Delta water use combined chlorine as a terminal disinfectant. Also, same paragraph, bladder cancer, not carcinogenesis. And no DBP studied to date appears capable of producing bladder cancer, IN TOXOCOLOGICAL studies.

Page 3.12, last para. Given the concern of brominated DBPs, why is there no mention of HAA9? References on this subject have been in the literature for more than 10 years, and Delta-impacted waters are prime candidates for bromine-containing HAAs that are not regulated.

Page 13, para 6. Add "quality" to the first sentence.

Figure 3.5. Under drivers, change Sources and Fate of Pollutants to Sources of Impurities. They are not all "pollutants." Also, I would argue that raw water quality, regulations and socioeconomics are drivers of treatment plant characterstics. Treatment is not a driver of the linkage between raw water quality and finished water quality. It IS the linkage. Also, the outcome labeled Disinfection level/type is strange. Why not microbial safety or microbial quality? Also, there should be a distribution system linkage between treatment plant outcomes and water quality at the tap.

Chapter 4.

Figure 4-3. Given the emphasis on DBPs in this report, it is surprising that there are so few studies addressing DBPs. This seems out of balance and inconsistent with the Stage 1 assessment.

Page 4-6, para 1. Bromide is NOT regulated at treatment plants. Also, the DBPs are not regulated as 3-month averages but as annual averages. Also brominated DBPs are not regulated; TTHMs, HAA5 consist of non-brominated DBPs, too.

Page 4-6, para 2. Total organic carbon is NOT regulated at treatment plants. Further, it is incorrect to say that TOC must be reduced to improve disinfection efficiencies. It must be reduced because it forms regulated DBPs, as indicated, but it must also be reduced because it forms other as-yet unidentified DBPs that may have adverse health impacts. That is the objective of the enhanced coagulation matrix.

Page 4-6, para 3. The report says that source water data is much more publicly available than treated water quality data. I do not believe this to be the case. Finished water quality is a matter of pubic record and should be readily obtainable form DHS as well as the utilities directly.

Figure 4-7, 4-8. It would be useful to compare these historic patterns in TOC and bromide with rainfall, runoff, snowmelt information or to Delta storage/pumping operations to understand and demonstrate the drivers for these observations. A sentence to this effect is given at the bottom of page 9, but it needs greater emphasis.

Table 4.1 is a critical finding; it is good to see it repeated and discussed in the Conclusions chapter (7).

The trend analyses given in Figures 4-10 to 4-12 are a good idea, but I suspect that the lines shown are simple regression lines with relatively small correlation coefficients. Is it possible to conduct a more statistically sophisticated analysis on these data?

Page 4-12. The treated water quality assessment is poorly done. It is not sufficient to simply indicate what chemicals or processes were used (Table 4.3), but details as to how they were used. Examples include chlorine and ozone doses, approximate free chlorine contact times, where the chlorine and/or ozone was applied, and most importantly, if combined chlorine was used and where the ammonia was applied. DBP formation depends on the DOC and bromide concentration at the point of chlorine addition, and how long the water was in contact with free chlorine before ammonia was added to convert the free chlorine to combined chlorine which essentially stops further THM and HAA production.

Page 4-13, para 1. The report states that Watershed, NBA, and Delta plants have been meeting the TTHM ELPH targets. The data in Table 4.4 do not support this statement as Delta and NBA plants show some means in excess of 40 (and even 80 ug/L).

The key point associated with treatment and the ELPH goals is "what have the plants done with waters in excess of 3 mg/L TOC and 50 ug/L bromide to allow them to meet the 40, 30, 5 ug/L ELPH targets, and what is the cost of these treatments?" Some plants implemented ozone, some membrane filtration, many chloramination. This is the essence of DBP compliance in waters with excess TOC and bromide, and this needs to be analyzed in greater detail than it has been.

Performance Measures on Page 4-17. I don't consider these items "performance measures." We have a good objective "to provide safe and reliable drinking water by reducing DBP formation." The so-called "performance measure" is "to reduce production of DBPs….." I consider this a "recommendation," not a performance measure. A performance measure would be "how much have DBPs been reduced as a result of various actions?" or "how much has the TOC and bromide concentration been reduced at the Delta intakes?" or "how many plants are exceeding the ELPH targets of 40,30,5?" Similarly, for taste and odor in objective 2, the so-called performance measure is again an objective or recommendation. A performance measure would be "how many taste and odor complaints have been reported for utilities using Delta water?" or "to what extent have taste and odor complaints been reduced?" Objective 3 requires a definition of "cost-effective action" before a performance measure can be developed, but an example might be "how has the cost of treatment increased as a result of treatment modifications made for purposes of compliance with ELPH goals, and how do these costs compare to national trends?"

Page 4-18, para 2. The Conclusions state that "WQP projects have achieved measurable water quality improvements in some Delta locations, helped improve tap water quality with advanced treatment technology, and have advanced our understanding….." This may be true, but it has not been shown explicitly by the material presented in this chapter. If these are indeed the conclusions to be reached, then the material in this chapter needs to be presented in a manner that explicitly demonstrates these findings.

Chapter 5.

40-50% of this chapter on water quality constituents of concern deals with bromide/salinity; 35-40% deals with TOC/DOC. Surely there are other constituents of concern that are worthy of mention, e.g. microbes, pesticides and other synthetic organic compounds, nitrate, emerging contaminants.

Figure 5-3. In outcomes, what is meant by “timing of bromide”

Page 5-13, last paragraph. The question becomes one of balancing costs. What is the cost of the various diversions to lower bromide and TOC vs the cost of additional treatment to comply with regulated DBP levels.

Page 5-17, para 2. These are not performance metrics. Not sure what they are. Same applies for other Performance Metrics, e.g. top of page 5-19. Metric at bottom of page 5-19 is a recommendation.

Page 5-18, para 1. This description is not very helpful without reference to a map that shows the Delta Mendota Canal and Newman Wasteway. This is a recurring concern throughout the report, i.e reference to locations but no map to identify locations.

Page 5-21. Only 1 page in this whole section is devoted to pathogens. It is also the last entry in the Introduction in para 2, line 1. Disturbing that pathogens are of such a low apparent priority.

Page 5-21, line 1, para 3. primary function is to remove and/or inactivate pathogens. Removal (filtration) is first line of defense.

Page 5-21. No data on pathogen occurrence is provided. What kind of monitoring is done? What has (or has not been) measured? This is a serious omission. The performance metric on page 5-22 is a recommendation.

Page 5-22. While there is extensive information presented on the amount of overall TOC/DOC, there is little to no information provided about the characteristics of this organic carbon, e.g. molecular weight, humic/non-humic nature, hydrophobic/hydrophilic nature, etc. Many studies have been conducted relating the nature of DOC to its amenability to removal by various water treatment processes and its propensity to react with chlorine and other oxidants and disinfectants. Many of these studies have been conducted using Delta water. Paragraph 1 of Section 5.2.2 makes mention of UV absorbance and SUVA, but that is the last we see of it.

Page 5-22, Section 5.2.2, para 1 and 2. Some mis-statements. Last line of para 2 – analysis of its carbon content by its absorbance, not reflectivity, of UV light. Para 3 – It is incorrect to imply that water treatment plants do not measure DOC and only measure TOC. Many do measure DOC. The statement at the end of this paragraph is absolutely incorrect. Many studies have been conducted on the characteristics of DOC responsible for DBP production; these studies have been done for the past 20 years, and include Delta water.

Page 5-22, para 6. The section on turbidity is out of place here. It relates to pathogen removal and belongs in the previous section on pathogens. Turbidity is a surrogate for the potential presence of pathogens.

Page 5-25. Modeling is an important tool. My understanding is that the DWR model for EC and bromide has been calibrated and validated and is therefore useful for predictive purposes. Is this also true for DOC? I doubt it. The use and validity of models is an important subject that is worthy of a separate discussion.

Page 5-28, para 1, line 3. This is a strange statement. It is odd to suggest that Delta island contributions increase at higher intake concentrations. It would be more appropriate to state that "increased intake DOC concentrations occur when the Delta island contribution is greater." Cause and effect?

Page 5-28, para 4, line 2. I disagree with use of the word "slightly." I think the differences are more than slight.

Page 5-36, para 2. Same comment as above. Linkage between nature of DOC and DBP formation has been well studied. Elsewhere in the same paragraph, EPA's Water Treatment Plant simulation model, which was used in FACA negotiations for the Stage 1/2 D/DBP Rules, was used (and can be used) to predict DBP formation when settled water is chlorinated. Also, many researchers have looked at DBP formation after precursors have been removed by coagulation and clarification, and the ICR database contains many such examples.

Page 5-42. This is not a performance metric but a recommendation.

Page 5-61, para 2. The 10 mg/L nitrate value is not a nutrient goal but a primary MCL. Of concern is that some of the waters in Table 5.3 and Figures 5.72 and 5.74 are perilously close to (and even one exceeds) this primary MCL.

Page 5-61, para 2. Mention of the CCL at the end of this paragraph is the first time the CCL is mentioned. Discussion of (or at least reference to) emerging contaminants, both chemical and microbial, is missing from this report on water quality issues.

Page 5-65. The relatively high TKN values in Figure 5.76 are cause for concern given their chlorine demand. High TKN levels lead to higher chlorine doses for disinfection with free chlorine at the water treatment plants; 0.5 mg/L TKN would have a chlorine demand of 4-5 mg/L. Also, this raises the question of dissolved organic nitrogen and the formation of nitrogenous DBPs when the waters are chlorinated. N-DBPs are a growing area of concern and have been so for the past 7 years, yet the report is silent on this issue.

Page 5-69, bottom, and 5-73. There ought to be performance metrics and recommendations that can be developed on this subject. Possible metrics are: Reduction of nitrate levels to XX mg/L, or extent of reduction of nitrate levels. Same for phosphate. Same for chlorophyll a. Also, reduction in occurrence of taste- and odor-causing compounds at the intakes, e.g. MIB and geosmin. Possible recommendations are monitoring and modeling of nutrient levels and algal growth in the Delta and at the Delta intakes. This is a high priority subject, given the statement on Page 5-73 that nutrients and algae will increasingly challenge treatment plant operations. They will.

Page 5-75. It is disturbing that only 2 paragraphs are devoted to pesticides and emerging contaminants. This report is overly concerned with bromide, DOC, and DBPs, almost at the expense of all other potential water quality contaminants. This is an example. There must be some data on pesticides to show that it is "below levels of concern." What kind of monitoring has been done? Where and at what frequency? What detection limits? Without some information of this type, we cannot agree that pesticides are not a concern.

The same comment applies to pharmaceuticals, personal care products, endocrine disruptors, algal toxins, and other emerging contaminants. What kind of monitoring has been done? Where and at what frequency?

Page 5-75. Good to see climate change addressed. Impact of sea level rise on bromide levels should be easy to model. Impact on DOC, nutrients, and algal growth will be more difficult.

Chapter 6

Page 6-1, last para. The statement that "scientific understanding of DBP formation is relatively young" seems odd since the subject has been studied intensely for more than 30 years. Further, as noted above, linkages between ELPH targets and source water quality have indeed been developed in the form of EPA's Water Treatment Plant simulation model and were used extensively as part of the FACA negotiations for the Stage 1 and Stage 2 D/DBP Rules. I believe they were also used by CalFed in establishing the raw water quality goals for TOC and bromide in order to keep TTHMs and HAA5 below 40 and 40 ug/l, respectively. The report is silent on these linkages and the EPA models.

Page 6-4, para 3 and 4. As noted earlier, key considerations that affect the linkage between source water quality and DBPs in the treated water are (1) where the utilities add their free chlorine for primary disinfection, (2) whether or not they use alternative primary disinfectants in place of free chlorine (e.g. ozone, ClO2, UV, membranes), and (3) whether or not they add ammonia to produce combined chlorine and, if so, where. The information provided here does not get at these important drivers of DBP formation. Such information is available in plant records, and should also be available from DHS. The information presented in Figures 6.4 and 6.5 is not especially useful.

Figure 6.6. I still believe this conceptual model of treated drinking water quality is not quite correct. Raw water quality, regulations, leadership, and economics determine the nature of the treatment plants in place. Coupled with these factors (drivers) and raw water quality, the type of treatment determines the finished water quality entering the distribution system. In that sense, the treatment plant is the linkage between raw water quality and finished water quality. This is consistent with the brief example at the bottom of page 6-7 that source water quality in terms of Crypto will determine the additional treatment required.

Page 6-8, top. It is good to know that the SWP Sanitary Survey monitoring results indicate that no additional log removal credits would be required for Crypto. Because of the importance of pathogens and the LT2 Rule, it would be good to present the findings to support this statement.

Page 6-8, para 2. It needs to be recognized that in order to keep DBPs below the ELPH levels of 40, 30, 5 using a source water containing 3 mg/L DOC and 50 ug/L Br, utilities will have to use combined chlorine as a terminal disinfectant or more expensive technologies such as ozonation, UV disinfection, or membrane filtration. This point is not well recognized or brought out in this report.

Page 6-8, para 3. The role of bromide in this analysis is missing. Correlations between DBPs and DOC will not be successful if bromide is not considered in the equation. Further, it is important that attention be given to the individual THM and HAA species as the brominated species tend to be more harmful than their fully chlorinated counterparts. Para 4 makes this point, but it requires much more emphasis. Additionally, it needs to be recognized that measurement of only HAA5 in bromide-rich waters does not capture the four other bromine-containing HAAs that are present at significant concentrations. The report is silent on HAA9 despite more than 10 years of research n this subject.

Page 6-8, last para. There is a fundamental error in allowing the ELPH to be applied to treated water at the point of entry (POE) to the distribution system. Unless utilities are using combined chlorine as a terminal disinfectant, in which case THMs and HAAs in the system and at the customers' taps are essentially the same as at the POE, THM and HAA levels will continue to increase in the distribution system and consumers exposed to water with a high residence time in the distribution system will not be getting an equivalent level of public health protection. Comparisons between DBP levels in the distribution system need to be compared with DBP levels at the POE to ascertain the importance of the distribution system in making an ELPH assessment.

Furthermore, use of the distribution system location closest to the treatment plant may prove to be misleading, depending on how far this point is from the POE and depending whether the utility uses free or combined chlorine in their system. Also, this difference will be different from utility to utility.

Figure 6.7 is somewhat misleading. It is important to know what the plants in the lower right quadrant are doing to have such low THMs with such high TOC's. I suspect they are using ozone or membranes and use very little free Cl2. This is probably also true for utility N1 (open squares), with THMs less than 10 ug/L regardless of TOC.

Page 6-9, para 3. Last sentence downplays what we already know about DBP formation. It is not surprising that plants treating a high Br, high DOC water will have high levels of BOTH brominated and chlorinated DBPs. Furthermore, it is well known that waters dominated by hydrophobic/humic carbon with high SUVA values have a high DBP formation potential.

Figure 6.10 is terrible. It is irrational to sum doses of different chemicals.

Figure 6.11 to 6.13. What accounts for the high levels of THMs and bromate in some cases? This suggests that even the Watershed plants that start with good source water occasionally have problems meeting the ELPH targets. What were the bromide and DOC levels associated with these episodic high values?

Figures 6.15 to 6.17. Again, what accounts for these episodic high THMs and bromate levels? What were the Br and DOC levels? The very low THM levels (squares) are probably for an ozonation/NH2Cl treatment scenario, a plant that went from free chlorine in the 1990's to ozone after the year 2000.

Page 6-17, para 2. This is the first time that grazing is mentioned. If there are cattle in the watershed, shouldn't there be more attention paid to potential pathogens?

Page 6-17, last para. Again, the performance metrics are really recommendations. For item 2, CDPH should track treatment operations data as well as treated water data. For item 4, how does distribution system monitoring provide any information about the relationship between source water quality and treatment? Changes occur in the distribution system. The DBP values in the system are a function not only of source water quality and treatment and the DBP values at the POE, but also continued formation of DBPs in the distribution system.

Figures 6.19 to 6.21. There is a wealth of useful information buried in these figures. All of the systems use water with common source water characteristics, yet they produce very different levels of DBPs. Why? The answer can be ascertained and demonstrated if the data are disaggregated. First, pull out the plants using ozone or membranes for primary disinfection and little use of free chlorine; examples are D2 and D6. Then pull out plants using combined chlorine. Then look at plants using only free chlorine. There should be some useful information here that is lost when all of the records are combined. The same comments hold for the CA Aqueduct plants in Figures 6.23-6.25.

Page 6-21, para 2. Omitted in this discussion is the use of combined chlorine after primary disinfection, with little use of free chlorine. Same is true in subsequent paragraphs for other utilities on this page.

Page 6-22. It would be very useful to see the speciation of THMs and HAAs for these facilities treating bromide-rich water. Speciation of DBPs is important in view of their differing health effects.

Page 6-27. The entire discussion here is on variations in source water quality, but there is no discussion of variations in treatment among the different systems. I expect that the differences observed for different utilities are due to variations in BOTH water quality and type of treatment utilized.

Page 6-28, para 2. It would be useful to see some nutrient and taste and odor data.

Page 6-30, para 3. I agree that it is important to examine and understand infrastructure actions that can lower precursor levels of Br and DOC at the water treatment plant intakes. But it also important to understand how water treatment plants can attenuate these high precursor levels by adopting treatment strategies that minimize DBP formation.

Page 6-31, para 4, line 5. The short free chlorine contact time is for viruses, not Giardia.

Page 6-31, para 4. First mention of NDMA and microbial regrowth in the distribution system. These are important water quality issues that heretofore have not been mentioned.

Page 6-32, regulatory changes and the future. NDMA should be specifically noted here as more utilities change to combined chlorine for terminal disinfection in order to "stabilize" DBP levels in the system. Likewise, we see the first mention of nitrogen-containing DBPs. The latter have been a growing research activity in the drinking water arena for the past 7 years. Furthermore, reference should be made to growing concern about water quality deterioration in the distribution system and the potential for microbial intrusion into the system due to low pressure and negative pressure spikes. Can combined chlorine attenuate these challenges?

Page 6-32. Climate change and population growth are addressed, appropriately so. A suggestion for mathematical modeling is made, also appropriate.

Appendix D – Review comments by Dr. Paul Westerhoff

Review Panel Comments by Paul Westerhoff, PhD, PE

The overall goal of this peer review is to assist the CALFED WQP and the CALFED Water Quality Subcommittee in evaluating the overall adequacy of the findings, conclusions and recommendations in the Final Assessment and the information used to support them. The peer review panel (RP) will provide a written review that focuses on the strengths and weaknesses of the Final Assessment Report and Appendices.

The RP will focus on the following subject areas and questions:

1. Information Gathering: *Has the most appropriate scientific information been used in developing all technical areas? Are the methods of collecting information (existing or new) understandable, scientifically defensible, fully documented and the best available? What information (e.g. data, conceptual models, etc.) was not considered that should have been presented or addressed?*

The Stage I report relies upon extensive data from multiple sources for TOC/DOC, bromide, conductance, chloride. There is no validation methods described for inclusion/exclusion of data from perhaps >20 different laboratories and on-line stations. This makes the data useful, but perhaps less than scientifically defensible. If all the data came from certified laboratories, that should be stated. Even so – validation of outliers is very critical. Are on-line data (not from certified labs) labeled differently?

The report states that some flowrates are known and others are not. It would seem appropriate to include a map showing all known flow gauges (USGS, stormwater, etc) within the drainage basins.

The report does show only a few geographic land use maps, related to land use in part of the delta. It would seem advantageous to move to a data management system that is spatially explicit and based upon GIS mapping coordinates. In the short and long-run this will allow greater integration of new data sources as them come on-line (e.g., DOC sensors), allow correlations to land use, allow easy integration over time (e.g., merging of data from counties, etc), facilitate numerical modeling, etc. GIS mapping is not only a data management system, but can be used in a variety of fate and transport modeling activities to investigate "scenarios" or "hypotheses". Even in its current form, the data seems to be in too many different locations, spreadsheets, etc and not well integrated.

A critical flaw potentially in the data gathering is related to the selection of TTHM and HAA5 information obtained from water utilities. It appears from the appendices that values are reported from a location within the water treatment plants; labeled as "plant tap", "plant effluent", "lab tap", etc). These samples represent the THM and HAA levels <u>leaving</u> the WTP and <u>not</u> water the public actually drinking. According to the ROD, it states that an "…equivalent level of public protection…" THM and HAA levels will continue to increase as water travels from a WTP through the distribution system to public water taps. This idea is captured in the review of a changing DBP regulatory framework to a locational average of THM or HAA in distribution systems. When free chlorine is used as a final residual disinfectant, THM and HAA levels may increased by 50% to 300% over the levels leaving the WTP. Thus making comparison to the stated ROD goals much worse. When chloramines are used, instead of free chlorine, in distribution systems THM and HAA levels are comparable with levels exiting the WTP. Plants that use free chlorine should be separated from those that use chloramines in their distribution systems. At a minimum it would be more defensible to use EPA distribution system running annual average numbers, instead of plant effluent data, for the DBP evaluations. This data is available at the State Department of Environment Quality, and does not necessitate asking each individual WTP. It would be better looking forward to consider multiple reporting locations in each distribution system. I believe it is important for CALFED to define the **location** that best represents the intent of the protecting the public, and I do not believe that is plant effluent water quality but instead some point(s) in the distribution system.

The report is based upon TTHM and HAA5. As reported here TTHM equals the sum of chloroform, dichlorobromethane, chlorodibromomethane and bromoform. However, iodinated THM species also exist. Therefore it would be more appropriate to label the sum of these four THM species as THM4. Likewise, there are at least 9 HAA species. The USEPA only regulated the sum of 5 species because, at the time, a lack of analytical standards and data on the remaining four HAA species. The four species that comprise HAA9, but not HAA5, are all brominated HAAs. Therefore, because TOC and bromide are both important targets, to the extent possible HAA9 should be analyzed rather than HAA5. Water utilities often have this data, but do not report it. Requesting the additional information should be made in the future.

All THM and HAA data are presented and analyzed relative to TOC or bromide based upon microgram per liter levels of THM and HAA. This is acceptable from a regulator framework. However, it is less scientifically defendable which would do statistical analysis based upon molar THM or HAA concentrations. These are simple conversions, but quite important. For example, 0.1 μm of CHCl3 or CHBr3 equates to 12 versus 25 μg/L, respectively. Both species contain the same amount of carbon (C), reflecting the scientific/chemical fact that a certain type of organic site in the TOC can form any of the individual THM species based upon the ratio of bromide to TOC present in the water. This becomes very important as one attempts to relate two very important DBP precursors (TOC, bromide) to DBP formation across a large spatial system where both parameters (TOC, bromide) are changing.

The report eludes to the potential role of iodide in forming unregulated DBPs. It is highly likely that iodide may correlate with bromide and chloride and predominantly be of seawater origin. However, other sources also exist. At a minimum CALFED should attempt to correlate iodide concentrations to bromide and chloride to determine if a relationship exists.

The report eludes to taste and odor concerns and the role of MIB and geosmin, algae metabolites, in causing these problems. There are no MIB or geosmin values in the report. In chapter 6, the odor threshold for MIB is reported as 10 μg/L. This is incorrect – the units are nanogram (not microgram) per liter for this threshold.

Several locations in the report state that drinking water is a relatively small percentage of water exported from the Delta into the canals. What is the actual percentage that is treated by water treatment plants relative to agriculture, industry or other uses? This would seem to be quite important to understand. The report eludes to changing populations, so presumably this percentage of water treatment "water" in the canal would also increase as agriculture and other uses decline? Or would flowrates in the canals be increased?

2. Information Analysis and Results: *Have processes and methodologies (e.g. analyses of data) been used that are understandable, scientifically defensible, fully documented and appropriate? What results are missing that could reasonably be obtained? Are the modeling and risk analysis approaches employed defensible and consistent with other large scale projects elsewhere in the nation and internationally?*

There was no risk analysis conducted in this report.

The report uses bar and whisker diagrams and running annual averages to represent most of the data. This is useful and done properly. However, it does **not** become useful in the prediction or correlation to DBP formation. As seen in many plots of "actual data" (e.g., Figure 3.4 in the Stage I water quality study – in the appendix), TOC values may remain high for several months (i.e., in the 15 to 20 mg/L range) while the running annual average only increases from 6 to 7 mg/L. For those 6 months of high TOC there will be high levels of DBPs formed. Thus, while annual average TOC data are easier to tabulate and statistically represent for different sites relative to the ROD target of 3 mg/L, it does not reflect the reality of the water quality that the water treatment plants are receiving, and thus reflect the water the public receives. The ROD sets a target of 3 mg/L, and somewhere along the path it was decided to use a running annual average. I believe this decision may be flawed. A better approach I believe may be different statistical analysis approaches. For example, binning into the number of days that TOC are in certain TOC ranges. This approach was used in some parts, but not the entire report. Another approach would be frequency distributions of the data. CALFED should reconsider the adequacy of using a running annual average for either TOC or bromide.

Different statistical representations of data are used throughout the report (bar and whisker plots, running annual averages, binning, etc). This is useful for discussion, but makes it difficult to determine which is more important: average/medians, or bins, or ….

A variety of conceptual models are presented. These are quite useful. The only missing piece appears to be a "distribution system" that would belong after a water treatment plant, to represent travel time of water where TOC, bromide and a disinfectant are in contact and potentially forming DBPs.

A mathematical model for salts was developed and relied upon heavily in the report. Insufficient information was made available to evaluate the accuracy of this model.

It would be quite easy to include a mathematical model of water treatment plant performance and DBP formation. The USEPA and consultants have developed a model (WTP.exe) that is very robust and has been previously used in USEPA regulatory decision making for THM and HAA MCLs. It would make sense to use three "representative" water treatment plants in the model: 1) a conventional WTP with free chlorine, 2) a conventional WTP with chloramines, 3) a plant that uses ozone. The models predict TOC removal and DBP formation through the plant, and DBP formation into a distribution system. The model could be customized to individual facilities as desired, but would not be needed for broader scale assessments. The models have already been validated and published in peer review journals, and are suitable for use based upon the water quality outlined in the documents provided to this reviewer. Such a model would allow relationship between the primary ROD parameters (TOC and Br) to an effect on the public (THM, HAA).

The report mentions the significance of alkalinity and SUVA in achieving TOC treatment goals. All the plants being served with Delta water should be binned according to the USEPA Enhanced Coagulation guidelines, which is based upon TOC and alkalinity and has exceptions for low SUVA waters. This would be very helpful to know which utilities must meet these guidelines. This is directly related to "chemical usage" as reported in the document. Figure 6.10 and associated discussion is very misleading and appropriate/defendable. This figure was developed based upon tables in Appendix D (Table 3.2). The total mg/L of chemicals used is not relevant. Table 3.2 (Appendix D) should be used in the main document.

This reviewer feels like Chapter 6 was written by a group less familiar with water treatment practices than would be appropriate for this level of a report. In contrast, Appendix D is technically well written. Chapter 6 lacks critical insights present in Appendix D.

3. Findings and Recommendations: *How well are the key findings and recommendations supported by the stated data, methodologies or conceptual models, and analysis results? Do the findings and recommendations sufficiently address the level of progress made by the WQP for Stage 1?*

Yes – the report is of quite high quality and clarity. The key findings and recommendations are largely supported by the information provided and sufficiently address the level of progress made for Stage 1.

Several locations in the report state that "…spending constraints that restrict the programs ability to implement its highest priority [programs]" . However it is not clear what these high priority programs exactly are. The report eludes to real time monitoring as a high priority (I think), but otherwise states mainly where funding has gone and that mostly demonstration or on-the-ground projects are fundable. If such a list of other high priority projects exist, they should be explicitly stated in the reports conclusions along with estimates for conducting such research. In doing so, such a list may attract funding from other, as of yet untapped, sources.

4. Conveyance: *Are the findings and recommendations regarding the role of conveyance in meeting the water quality objective valid?*

The basic conclusions appear to be two fold. First, the potential to relocate all the diversion canal intakes to the Sacramento River appears technically feasible and is being considered. This would definitely meet the TOC and Br goals and is well developed as a technically feasible recommendation. Second, the report concludes that water quality (TOC, Br, T&O) changes once water exits the Delta into the conveyance systems (canals, reservoirs, etc) because of a wide range of factors. This is well described. However, the conclusion appears to be that this is no longer CALFEDs mission and that regional WTPs have to manage and deal with this themselves. On one level that is acceptable because it limits the scope of the challenge to the Delta region itself. However, on a broader level it may not truly lead to the intent of the ROD to protect the public. In these regards the report does not adequately address recommendations for dealing with the conveyance system. Developing an approach for this second point is critical to part of the "conveyance solution" regarding the need for a "multiple barrier approach".

Expanding water quality monitoring to focus on TOC, in addition to salinity is appropriate. Monthly sampling is inadequate and in-situ TOC and EC conductors should be located at 10 to 20 locations. In the longer run, including N and P concentrations are relevant, but in the short-term do not seem to control TOC or bromide levels in the Delta. Here it would be very useful to start monitoring seasonal variations in trace level organics and TOC simultaneously. For example, primidone is a prescribed pharmaceutical that is in all wastewater effluents and quite persistent in the environment. It would be useful to monitor a wastewater effluent probe (e.g., primidone) to understand the percentage of wastewater at various locations in the Delta during different seasons / flow conditions of the year. Higher primidone levels mean more TOC of wastewater origin. Likewise, selecting 1 or 2 herbicide/pesticide tracers would be useful (e.g., atrazine which is already regulated in drinking water). These could be used to determine how much TOC is coming from agricultural origins. If different pesticides are used on different crops, or in different parts of the Delta then monitoring these may also allow differentiation between different crop uses and TOC sources.

The proposed solution related to uncertainty is important. The longest data record presented may have gone back 17 years to 1990. It would be highly advantageous to look at a longer period of record, even if it exists for only a flow or other parameters. The USGS has lots of historical flow and water quality data I suspect, based upon my experience in other watersheds. I believe it should be possible to go back to the 1940s or so. Additional data, such as average snowpack coverage should also be collected from archives. This information is critical when trying to understand the relationship between precipitation and runoff patterns in future climate change scenarios.

Solution #8 in the report related to “restricting intakes” is unclear what the solution actual is, and probably needs to be restated.

5. Stage 2 Priorities: *Do the identified priorities follow logically from the findings and recommendations. Are there additional critical knowledge gaps?*

Stage 2 includes six recommendations – each of which are described here:
1. General Strategy is appropriate.
2. Interpretation of targets, objectives and goals – see comments for items 1 through 3 above related to running annual averages and a move towards understanding peaking and variability is needed. Also, ELPH must address DBP levels the public are exposed to and ***not*** THM or HAA levels leaving the water treatment plants (see items 1-3 above).
3. Reducing bromide concentration in Delta intakes – these activities would appropriate control bromide levels
4. reducing constituents of concern – there should be a specific stage 2 goal of “reducing TOC” Focusing on the Sacramento river makes sense. It is clear that pathogens are not a major issue, and the study should stay focused on TOC and Bromide, and not include too broad of spectrum of water quality constituents as suggested in the report. Numerical models would be useful, as well as spatially explicit models (see GIS discussion in items 1-3 above). Algae does cause problems to drinking water, but it seemed clear in the report that most of the algae problems were in canals or conveyance systems and not within the Delta. Because of resources, I would suggest not focusing on ecosystem food chains in the Delta. This opinion would change in the USGS report on isotope analysis of organic carbon found algae to be responsible for >20% of the TOC at the Delta intakes of concern. Staying focused on quantifying the benefits of implementation activities will be the key to success.
5. Improving water quality “downpipe” – “Downpipe” is not an appropriate term and is introduced only here at the end of the report. The necessity exists to control TOC (and potentially dilute Br) in sub watersheds. These should be encouraged, as outlined.
6. Demonstrating alternative treatment technologies – this is under emphasized as a Stage 2 goal. It appears that 2 regional demonstration plants will be established – this is an excellent idea. Would it be better to make these “mobile pilot plants” such that multiple utilities would ultimately benefit? This reviewer believes that other novel treatment technologies should be explored that push the idea of “treatment”. This could include varies takes on “bank filtration”

which has been shown to reduce TOC by >50% in many locations. Could sand be placed in the bottom of the canals to effectively form a 2-foot deep slow sand filter that contains perforated pipes that collect and deliver water to treatment plants? Could a short section of canal be widened, unlined and lateral recovery wells installed?

Performance measures – The write-up/plan is vague. I would recommend including predicted DBPs (using WTP.exe as described above).

6. Approach for "equivalent level of public health protection": *In the CALFED Bay-Delta Program Record of Decision (2000) the goal of the WQP is to provide "safe, reliable, and affordable drinking water in a cost-effective way," with a target to "achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies." Is the approach taken to determining if an "equivalent level of public health protection" has been achieved appropriate? Are there other ways to evaluate progress towards this goal?*

No – the approach taken to assess ELHS is currently inappropriate as I read it in the report. The report draws its conclusions based upon THM4 and HAA5 levels leaving the WTP instead of within the distribution system. See discussion in item # 1 above.

A stated knowledge gap in the report is "One high priority for Stage 2 is to improve our understanding of organic carbon quality within the watersheds and its role in DBP formation." This is a true knowledge gap, yet no clear approach is proposed on how this would be addressed. State of the art research suggests that all types of organics contribute towards DBP formation, in terms of yields (DBP formed per mg DOC). Since a carbon mass balance seems infeasible because of insufficient flow gauges from all sources, one approach is outlined above in item #4 – where trace organics of distinctive origins are used as tracers of bulk DOC. Recent studies suggest that organic colloids comprise a significant fraction of DOC (20% and more), yet little information is available on its sources and ability to be removed, although it does have considerable DBP formation potential. With years of experience, the easiest parameter to measure in conjunction with DOC to understand organic carbon quality is UV absorbance at 254 nm. UVA254 is already measured by WTPs, it relates to the USEPA Enhanced Coagulation guidelines, it is highly correlated with the ability to remove DOC during water treatment, it correlates with ozone demand (and therefore relates to bromate formation), it correlates well in finished water to THM and HAA formation, and it is easy to measure with low-cost instrumentations (including some that are now on-line). Finally, building organic carbon quality into a numerical model for organic carbon concentrations would not be difficult to do.

7. Treated water quality: *Are the conclusions about linkage between source water quality and treated water quality valid? Are additional treated water quality data and analysis of needed?*

No – linkages between source water quality and treated water quality are not adequate in the report.

Most WTPs gauge the ability to meet DBP goals based upon DOC of finished water, in addition to other factors (Br, temperature, pH, type of disinfectant, contact time with disinfectant, etc). Therefore, it would be useful to have not only raw water DOC/TOC but also finished water levels. This is very useful because it can simplify the level of complexity of all the differences in treatment processes used at each of the 50+ WTPs in the service area. I suspect you will then see a clear relationship between finished water DOC and DBP levels. This approach will help guide treatment plants towards certain types of treatment in the long run.

Comments in item #1 regarding WTP.exe modeling should also be pursued to address this comment.

8. Performance Measures: *Are the identified performance measures sufficient and appropriate for the stated goals of the program?*

Performance measures for Stage 2 are mentioned on page 7-12 and reference Appendix C. This makes it difficult to really understand any level of prioritization of the parameters, which will be important given "limited ability to fund monitoring projects". To this end a few comments will be made. Top priority should include DOC, UVA and electrical conductivity on-line at 8 sampling locations using real time sensor systems. Monthly sampling is simply inappropriate and too infrequent given the scope of this CALFED program, dedicated funds must be sought for monitoring. CALFED must consider the future, potential regulations of N-DBPs. Many are being collected as part of the Unregulated Contaminant Monitoring / USEAP program and should be available from several of the water entities. Synthesis of these emerging DBPs is important moving forward because of their increased concern and potential for regulation. California now has an action level for NDMA and this must be included moving forward. Organic nitrogen should be included, as a N-DBP precursor, moving forward. Understanding the shift from free chlorine to chloramines must be studied in CALFED WTPs as it will influence DBPs exposed to the public. Most WTPs will collect daily or weekly TOC samples and write them into logs – synthesis of this data would be critical to understand effects of conveyance.

Simply looking at periods when Br is > a value OR TOC > a value is not appropriate. One must really look at the combination of Br & TOC simultaneously.

Data obtained from WTPs on DBPs MUST include the following: 1) companion data on TOC, Br and treatment processes including disinfection scheme/dosages, 2) DBPs leaving the plant are alone inappropriate measures. Actual distribution systems, or simulated distribution samples MUST be used moving forward.

Specific measures for taste and odor should be tracked; recommend synthesis MIB and geosmin data specifically.

Additional comments and questions

Page 3-6 Why is southwestern region high in salinity?
Page 3-11 What about NDMA and potential trace-level precursors?
Page 4-18 The idea of clearly defining equivalent level of protection is critical moving forward.
Page 5-12 what will be the effect of changing flows in canals on algae blooms in the future?
Page 5-23 figure 5.19 It seems a little odd that at the highest TOC levels that DOC/TOC is so close to unity. It would be expected to be lower.
Page 5-36 It is really unclear what percentage of water comes from sewage treatment plants into the various canals. This should be a focus moving forward because of concern of EDC/PPCPs to water treatment plants.
Page 5-62 table 5.3 What are the DON levels? Some of these would appear to have very high DON levels which are N-DBP precursors.
Page 5-67 it would be extremely helpful to somehow improve estimates of pumpage from agricultural areas back into the delta.
Page 6-7 figure 6.6 What the public is exposed to in drinking water very much depends upon conveyance IN THE water distribution system after water treatment and can not be overlooked in significance.
Page 6-8 conducting many THMFP tests will NOT be useful. Use wtp.exe along with water quality.
Page 6-10 figure 6.9 the level of bromide influence is high in THM speciation – same for unregulated Br-HAA. Measure HAA9 going forward in all studies.
Page 6-13 Based upon SUVA, TOC and alkalinity which WTPs require enhanced coagulation?

Throughout – DOC is far more important than TOC moving forward
Throughout- Could one use agricultural chemicals or wastewater indicators as surrogates for DOC sources moving forward? Select conservative trace-level organic or inorganic surrogates

Appendix E – Copy of presentation delivered by Dr. Paul Westerhoff on July 15, 2008 to CALFED in Sacramento, CA

Summary of Review Panel Comments for CALFED Water Quality Program, Stage 1 Final Assessment

July 10, 2008

Summary Prepared by: Dr. Paul Westerhoff

Based upon Reviews by:
Phillippe Daniel
Dr. David Reckhow
Dr. Philip Singer
Dr. Paul Westerhoff

Charge to review committee

1. Review CALFED Water Quality Program Stage 1 Final Assessment (Final Draft, October 2007) document

2. Provide feedback around 8 targeted topics and associated questions

- Presentation today attempts to focus on most significant deficiencies identified by the review panel

1

Overall Comments – I

- Stage 1 represents a major effort that has been worthwhile and productive
- TOC/DOC and salinity/bromide occurrence throughout the Delta is presented comprehensively
- Stage 1 Final Assessment document does require some targeted revisions & clarifications to serve as a stand alone document. These include:

Overall Comments – II

1. Improve the risk assessment approach and basic *Equivalent Level of Public Health Protection (ELPH)* interpretation
2. Chapter 6 requires significant revisions
3. Inconsistencies exist between main text and numerous appendices; report is difficult to read and follow given the formatting of the appendices
4. Recommendation for Stage 2 should be revised to address reviewers' comments that will help achieve the CALFED Water Quality Program objectives
5. Stage 2 should define the target balance between science, implementation activities and effort needed to comply with legal decisions

Equivalent Level of Public Health Protection (ELPH) – I

- *In the CALFED Bay-Delta Program Record of Decision (2000) the goal of the WQP is to provide "safe, reliable, and affordable drinking water in a cost-effective way," with a target to "achieve either: (a) average concentrations at Clifton Court Forebay and other southern and central Delta drinking water intakes of 50 µg/L bromide and 3.0 mg/L total organic carbon, or (b) an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies."*
- It seems plausible that ELPH would encompass a risk assessment from multiple water contaminants.
- Introductory material should discuss why DBP's, rather than pathogens, arsenic or other pollutants, are the driver for risk reduction.

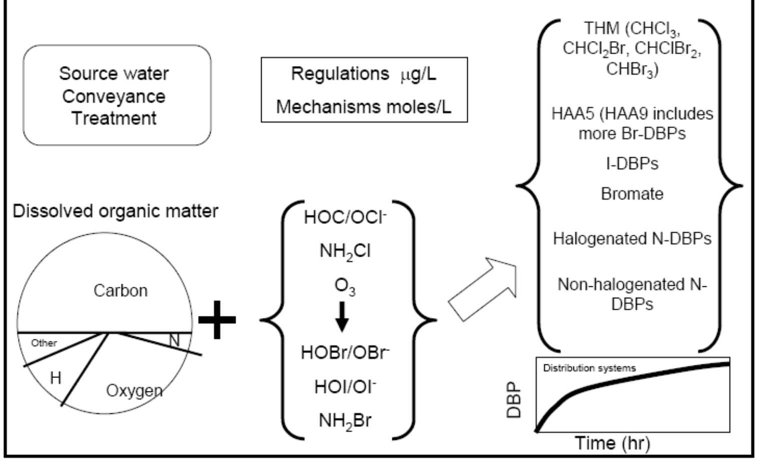
Equivalent Level of Public Health Protection (ELPH) – II

- Consideration should be given to development of risk indices based on simple additivity for cancer and a hazard index for non-cancer endpoints. This would be more comprehensive and include non-THM and HAA constituents.
- Tracking THM4 and HAA5 levels alone were not seen as providing an ELPH
- Inadequate attention / data collection focused on DBP levels "at the tap" where public is exposed to the water

1. Information Gathering

- Data on many relevant water quality parameters exist, but have not been reported or reporting is inadequate:
  - Inorganics: arsenic, iodide, nitrate
  - Organics: UVA254, DON, pesticides, algal toxins
  - Pathogens: Giardia, Cryptosporidium
  - Emerging DBPs: NDMA & other N-DBPs, iodinated DBPs
  - Aesthetics: Threshold odor number, MIB, Geosmin
  - Reviews indicate such data exists
- TOC is a regulatory framework tool for Enhanced Coagulation, but DOC (and UV254) really drives DBP formation. DOC should be emphasized as a more important metric since POC is easily removed.
- There was no attempt to validate data from multiple labs, on-line sensors or other sources
- Insufficient DBP data "at the tap"; too much emphasis on DBP data at the point of entry to the distribution system
- Better land-use delineation and tracking over time is needed (satellite imaging perhaps)
- WQP would benefit greatly from developing an integrated data management system (GIS-based)
- *Report requires more information on validation of "fingerprinting" model (DSM2)*

DBP Basics Should be Included



4

Models exist to predict DBP formation in water treatment plants

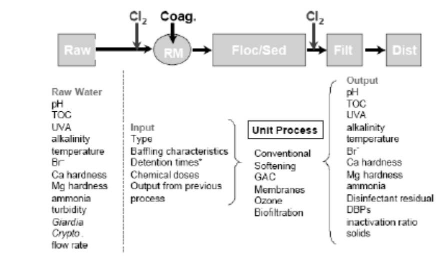
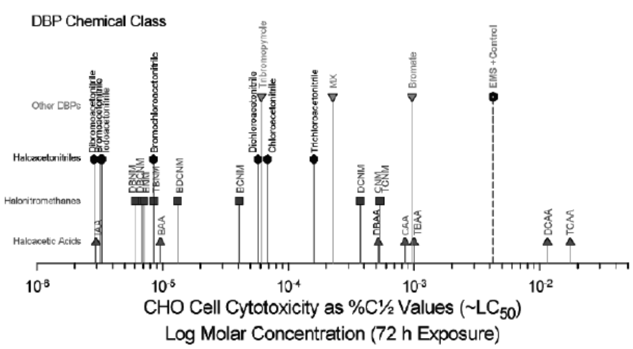


Figure 1-1 Water Treatment Plant Model Schematic

USEPA Model: WTP.exe

Potential significance of Br-DBPs & N-DBPs are crucial



Br-DBPs & I-DBPs more toxic than Cl-DBPs; should consider DBP species instead of sum of DBP class

Some N-DBPs more toxic than C-DBPs

Source: M. Plewa

5

2. Information Analysis and Results

- *Have processes and methodologies (e.g. analyses of data) been used that are understandable, scientifically defensible, fully documented and appropriate?*
  - More information on individual DBPs, rather than DBP classes, is required
  - Use of box and whisker plots or running averages to correlate TOC or DBP concentrations is mis-used; how did this evolve from the ROD?
  - Analysis should consider TOC & Br co-occurring *together*, and not as separate statistical parameters. Their combination affects DBP formation.
  - Source water quality is only ONE determinant of finished water quality; the other is treatment
  - Analysis of treatment factors (chapter 6) was poorly executed

- *Are the modeling and risk analysis approaches employed defensible and consistent with other large scale projects elsewhere in the nation and internationally? NO*
- *The reviewers did not think the report contained adequate, if any, actual risk assessment*
- *The linkage between THM & HAA5 and ELPH was never established*

6

3. Findings and Recommendations

- *ELPH* must be operationally defined and stated. Here it appears to be 40 ug/L TTHM, 30 ug/L HAA5 and 5 ug/L bromate. Page 7-3 states more fitting measures should be identified; this should be done.
- Recommendations were based upon a series of performance metrics developed. The performance metrics suggested are not really performance metrics. Some alternative performance measures might be:
  - How much have DBPs been reduced as a result of various actions?
  - How much has the DOC and bromide concentration been reduced at Delta intakes by various actions?
  - How many plants are exceeding the ELPH conditions of 40 ug/L TTHM, 30 ug/L HAA5 and 5 ug/L bromate?
- The report is heavily weighted on watershed processes rather than treatment or distribution which equally impact exposure and consequently human health risk

An Alternative Approach to the ELPH Conundrum

- How does one assess the overall public health risk associated with what is acknowledged to be a "soup" of constituents?
- The risk posed by a given compound can be expressed as the potency multiplied by the concentration at which this constituent occurs:

Risk = Potency x Concentration

- Cumulative risks from exposures to carcinogens have been widely assumed to be additive.
- A numeric index can be developed to compare different waters containing varying levels of constituents. A similar analysis can be done non-cancer endpoints (a Hazard Index based on reference doses).

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4. Conveyance

- *Are the findings and recommendations regarding the role of conveyance in meeting the water quality objective valid?*
- The Delta by-pass option would dramatically reduce health risk
- Inadequate validation of Delta model makes it difficult to assess related recommendations
- Decisions are being made based upon a maximum of 17 years of data. Uncertainty into the future should be a concern. Consider secondary, longer-term data sources and associated correlations (streamflow, snowpack, temperature, etc).
- CALFED should be concerned & responsible for changes in water quality during conveyance – report currently implies this is up to municipalities. If ELPH is applied in the ROD, then CALFED must take more ownership of what happens during conveyance. Nutrients from the Delta may be impacting water quality during conveyance, or selective timing of Delta water diversions may improve water quality
- More in-situ monitors are needed

5. Stage 2 Priorities

- Most priorities were viewed as valid
- Defining ELPH targets must be done
- Better understanding of organic carbon quality relative to treatment and DBP formation is important, but DBP FP testing is not necessary (use surrogates & models)
- Multiple barriers are good, and should *all* be modeled (including conveyance, WTP and distribution systems)
- A specific goal should be "reducing TOC"
- Demonstrating alternative technologies is under emphasized as a Stage 2 goal. These could include mobile pilot plants, novel technologies, and novel management options (bank filtration)
- Stage 2 should define the target balance between science, implementation activities and effort needed to comply with legal decisions
- Dedicated funding for research (not only implementation) is needed to collect critical monitoring and scientific data

6. Approach for "equivalent level of public health protection"

- *Is the approach taken to determining if an "equivalent level of public health protection" has been achieved appropriate? Are there other ways to evaluate progress towards this goal? NO*
- *See previous slides*

7. Treated water quality

- *Are the conclusions about linkage between source water quality and treated water quality valid? Are additional treated water quality data and analysis needed?*
- All reviewers agreed this was the <u>weakest</u> chapter and must be revised.
- Specifics are in the detailed comments
- Treatment is as important a determinant for DBP exposure as source water quality

8. Performance Measures

- *Are the identified performance measures sufficient and appropriate for the stated goals of the program?*
- All reviewers had concerns regarding the performance measures
  - *As stated, the performance measures are not really metrics but recommendations*
  - *These are listed on page 7-12 & Appendix C. The final Stage 1 report must develop appropriate metrics, justify their selection, and prioritize them.*

Questions

- Reviewers:
  - Phillippe Daniel / CDM (Walnut Creek, CA)
  - David Reckhow / Univ. of Massachusetts at Amherst
  - Philip Singer / Univ. of North Carolina at Chapel Hill
  - Paul Westerhoff / Arizona State University