TO: California Urban Water Agencies Central Valley Drinking Water Program Work Group
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SUBJECT: Final Technical Memorandum No. 1 –Review Procedures, Policies, and Guidance Used by Other California Agencies

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The objective of this task is to gain an understanding of the procedures used by the California Office of Environmental Health Hazard Assessment (OEHHA) and the California Department of Health Services (CDHS) to protect drinking water quality, as well as summarize the basis for the targets established by CALFED for total organic carbon and bromide.

CALIFORNIA OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

OEHHA, specifically the Water Toxicology Unit, is responsible for establishing Public Health Goals (PHGs) in California. A PHG is the level of a contaminant in drinking water that does not pose a significant risk to public health. This is not a regulatory standard, rather a guidance level for CDHS to consider when setting a drinking water Maximum Contaminant Level (MCL) for a constituent. A PHG should not be interpreted as a boundary between a safe and dangerous level of a contaminant, since exceeding these limits is still considered safe for public consumption as long as it is below the MCL set by CDHS. PHGs are different from Maximum Contaminant Level Goals (MCLGs) which are set by the U.S. Environmental Protection Agency (USEPA). MCLGs are the level of a contaminant in drinking water below which there is no known or expected risk to health, including a margin of safety.

PHGs may be either lower or higher than MCLs because they are set based on best available, updated, toxicity data, not regulatory considerations. When they are set at a higher level than the MCL (or the previous PHG), it should not be expected that CDHS would correspondingly increase the MCL, because there is no regulatory incentive to do so (municipal water suppliers are already meeting the lower standard).

PHGs are defined in the law as non-regulatory values, so they are exempt from review by the Office of Administrative Law. PHGs may be used as appropriate starting points for remediation decisions by other programs and agencies, but such uses are not explicitly promoted or supported by OEHHA because no authorization or funding is provided to OEHHA for such activities.

A review of the OEHHA website (www.oehha.ca.gov/water), and communication with its staff, were the basis for developing this summary of the OEHHA methodology for establishing PHGs.

There is a formal process that OEHHA implements when setting a PHG, which includes several steps. These are summarized below.

- OEHHA first announces the initiation of a risk assessment for a specific constituent, on both the OEHHA website and through the California Regulatory Notice Register (CRNR).
- OEHHA then compiles all relevant scientific information available. There are no formal guidelines for selection of studies for use in risk assessment for development of PHGs. OEHHA does reject some studies as being of little use for risk assessment, and may give a lot of weight to others based on their high quality, compared to other acceptable studies. OEHHA assesses study quality based on the data reported as well as OEHHA's knowledge of the techniques used. These include:
    - Studies of chemical effects on lab animals.
    - Studies of humans who have been exposed to the constituent.
    - Supporting studies such as basic chemistry, exposure modeling, in vitro assays, and structure-activity relationships.
- OEHHA then performs a Health Risk Assessment. The assessment is typically conducted by OEHHA staff, but can be performed by a contractor. This includes:
    - Evaluating data on carcinogenic and non-carcinogenic endpoints to determine critical endpoints and the corresponding effect levels, assuming potential lifetime exposures.
        - Cancer potency factors used by OEHHA (and posted on the OEHHA cancer potency factor database) for developing a PHG may be based on metabolized dose of a chemical rather than administered dose, so they should be used with caution by other agencies in calculating acceptable exposure levels.
    - Considering health effects on sensitive population groups, such as pregnant women, fetuses, children, and elderly.
    - Considering cumulative effects and possible interactions with other environmental chemicals.
- OEHHA staff then calculates a draft PHG using the information derived from the Health Risk Assessment. The process is different depending on the health endpoint, meaning carcinogenic or non-carcinogenic. The PHG is set based on the lowest estimated protective value. In a very few cases, the health-protective level for non-cancer effects is lower than that for cancer (at the 10^{-6} risk level), when the chemical can cause either type health endpoint. In these cases, the PHG is based on the non-cancer effect (cadmium, lead, and uranium, for example). In others, although it is clear that the chemical can cause cancer under certain conditions, oral cancer potency cannot be calculated, so the PHG is based on a non-cancer effect. Depending on OEHHA's judgment of the relevance of cancer from the oral exposure route, an extra uncertainty factor may be added for concern about cancer, despite the lack of adequate info on cancer by oral exposure.

- For cancer causing constituents, OEHHA will set the health-protective level (PHG) at the one in a million lifetime (70-year) extra cancer risk level. This is accepted as a negligible risk standard.
- For non-cancer effects, OEHHA considers uncertainties in the available data to estimate the level of the constituent in drinking water that would not cause significant health effects in people who drink that water every day for a lifetime.
  - This commonly includes uncertainty factors from 10 to 3,000.
  - This includes assumptions about drinking water consumption rate, body weight, and relative source contribution from water.

- OEHHA then develops a formal draft PHG document for review.
  - First the draft PHG document is circulated for internal review at OEHHA and comments are incorporated.
  - Next OEHHA provides the draft PHG document to other agencies and independent peer reviewers for external peer review.
    - The intensity of the peer review process depends on the significance of the constituent.
    - External peer review is not required by law, unless requested and funded by an interested party.
  - After peer review is completed, OEHAA will post the draft PHG document on the OEHHA website and in the CRNR to solicit public input with a 45-day comment period.
  - OEHHA also provides a public workshop to solicit comments on the draft PHG document.
  - If requested by an external party, OEHHA will arrange for additional external peer review, but they must agree to pay for all related costs.
  - Upon review of comments received on the draft PHG document, OEHHA will make any necessary changes and repost the document on the OEHHA website for an additional 30-day comment period.
- OEHHA then determines the final PHG and publishes the final PHG document.
  - OEHHA will make any final changes based on last comments received, considering all relevant input.
  - OEHHA will post the final document and responses to comments on the OEHHA website.

The Safe Drinking Water Act (HSC 116365) mandates that OEHHA must review and revise (if appropriate) existing PHGs at least every five years, based on availability of new data or improved methods. Currently the OEHHA reviews of existing PHGs are taking longer than five years for most constituents due to funding limitations. The process for review is the same as the above specified for a new constituent. PHGs for constituents for which there is no relevant new data are updated by a brief memorandum, posted on the OEHHA website.

The CDHS is mandated to set a drinking water MCL "as close as feasible" to the PHG, also considering cost and feasibility in standard development. Several California MCLs for non-federally regulated chemicals have been set on the basis of the PHG, including methyl tert-butyl ether, molinate, and thiobencarb. Six other MCLs have been revised (downward) in response to the PHG since the inception of the program in 1996, including cyanide, ethylbenzene, 1,2,4-trichlorobenzene, atrazine, methoxychlor, and oxamyl. CDHS can also request development of a PHG for an unregulated constituent as needed, such as N-nitrosodimethylamine and perchlorate.

CALIFORNIA DEPARTMENT OF HEALTH SERVICES

The CDHS is responsible for protecting drinking water quality in California. In order to achieve that goal, CDHS adopts federal drinking water standards as well as develops state specific standards and criteria. The state version of the adopted federal regulations must be at least as stringent as the federal standards, but can be more stringent.

Surface Water Treatment Rule

The US Environmental Protection Agency (EPA) promulgated the Surface Water Treatment Rule (SWTR) in June 1989. CDHS adopted its version of the SWTR in 1991. This rule specified that surface water supplies must be treated with filtration and disinfection to reduce microbial contaminants. The SWTR does allow some systems to provide unfiltered surface water supplies. There are strict source water quality levels that must be met, including 90 percent of source water fecal coliform concentrations less than 20 most probable number per 100 milliliters (MPN/100mL) or total coliform levels less than 100 MPN/100mL (based on 5 samples per week for a six-month period). These triggers were set based upon the previous public health standards set in “The Green Book” in the 1960’s for pristine water supplies.

For those systems implementing filtration, the rule specifically requires 3-log reduction of *Giardia* and 4-log reduction of viruses, unless the source is subjected to significant sewage, agricultural, or recreational hazards where higher levels of reduction may be appropriate. When determining reduction requirements, the location and type of potential contaminating activities needs to be considered in addition to the source water quality. EPA provided criteria for higher levels of reduction using *Giardia* cyst concentrations, see **Table 1** below.

Table 1
Reduction Requirements for the SWTR From EPA

***Giardia* Inactivation**	3-log	4-log	5-log
Daily Average Cyst Concentration (#/100L)	≤ 1	>1 - 10	>10 – 100

The triggers are based on assuring less than one case of microbiologically–caused illness per year per 10,000 people, based on consumption of two liters of water daily. These numbers were derived from a survey of water sources to characterize the level of *Giardia* occurrence (Rose, 1988), and use older, outdated, analytical methods. These methods are generally considered qualitative indicating more presence/absence than a quantitative concentration. The current analytical methods for *Giardia* are significantly better in terms of separation, recovery, and identification. Therefore, it is uncertain how valid the levels in **Table 1** are today.

Since analytical methods for *Giardia* in 1989 were not well developed, CDHS determined that it was not feasible for water systems to use direct measurements for determining level of treatment. Therefore, CDHS determined that there was a direct relationship between coliform and *Giardia* and viruses and allowed the use of coliform as a surrogate. The relationship was developed informally by a committee comprised of CDHS staff. The CDHS staff discussed available data for coliform and pathogens at the time for various surface water supplies around the State, as well as the relative dischargers and risks associated with the various supplies. The group determined that a trigger level of 1000 MPN/100mL would be an appropriate number, using analytical methods of the day, to determine if additional reduction requirements were appropriate. CDHS adopted these surrogates and **Table 2** provides a summary of the recommended levels of total coliform triggering increased treatment at the time of rule rollout.

Table 2
Guidance for Increased Reduction Requirements From CDHS

Median Monthly Total Coliform Concentration (MPN/100 mL)	≤1000	>1000 – 10,000	>10,000 – 100,000
***Giardia* Cyst Reduction**	3-log	4-log	5-log
Virus Reduction	4-log	5-log	6-log

Based on the coliform methods in use in the 1980's it was common knowledge that surface water supplies generally resulted in a 1:5 ratio of fecal to total coliform, therefore CDHS allowed systems to use fecal coliform data in lieu of total coliform, with the proportionately lower trigger levels.

"The Blue Book" identified Water Quality Criteria in 1972 including bacteria. Data was presented which showed that the presence of pathogens, specifically *Salmonella*, in freshwater streams significantly increased when fecal coliform levels went above 200 densities per 100mL.

It should be noted that the analytical methods for total coliform analysis have changed substantially since the 1980's, specifically increasing the number of bacteria strains that are detected with the method. Generally, this has resulted in a significant increase in the reported value of total coliform in most water sources. This is not so notable for fecal coliform and *E.Coli*. Therefore, the numbers in the table above are probably not valid today, as well as the 1:5 ratio of fecal to total coliform.

Recycled Water Laws

CDHS also established coliform densities for various uses of recycled water. Division 4, Chapter 3 of Title 22 clearly identifies the water recycling criteria for California. The quality of the recycled water is variable, depending on the ultimate use of the water. These were developed by correlating health risk assessment studies on coliform in drinking water to the level of public health threat of the proposed activity. There are four major categories; surface irrigation, impoundment, cooling, and other purposes. **Table 3** provides a brief summary of the level of treatment required for the various types of recycled water uses.

Table 3
Recycled Water Use Requirements Summary

Undisinfected Secondary[1]	Disinfected Secondary-23[3]	Disinfected Secondary-2.2[2]	Disinfected Tertiary[4]
Surface irrigation of orchards, vineyards, non food-bearing trees, crops and pasture for non-milk producing animals, crops not eaten by humans, and food crops that undergo commercial processing prior to human consumption.	**Surface irrigation** of cemeteries, freeway landscaping, restricted access golf courses, ornamental nursery stock, sod farms, pasture for milk animals for human consumption, nonedible vegetation with controlled access.	**Surface irrigation** of food crops where edible portion is not in contact with recycled water.	**Surface irrigation** of food crops, parks and playgrounds, school yards, residential landscaping, and unrestricted access golf courses.
-	**Impoundment** used for landscape purposes and do not utilize decorate fountains.	**Impoundment** for restricted recreational use and publicly accessible fish hatcheries.	**Impoundment** for non-restricted recreational use.
-	**Cooling** that does not create a mist.	-	**Cooling** that uses a cooling tower, evaporative condenser, spraying, or mist mechanism.
Other purposes such as flushing sanitary sewers.	**Other purposes** such as boiler feed, nonstructural fire fighting, soil compaction, mixing concrete, dust control, clearing roads, and industrial processes not in contact with humans.	-	**Other purposes** such as toilets/urinals, priming drain taps, structural fire fighting, decorative fountains, commercial laundries, artificial snow making, and commercial car washes.

[1]Recycled water that is oxidized
[2]Recycled water that is oxidized and disinfected so that the median concentration of total coliform is <23MPN/100mL over seven days, and <240 MPN/100mL in all but one sample over 30 days
[3]Recycled water that is oxidized and disinfected so that the median concentration of total coliform is <2.2MPN/100mL over seven days, and <23 MPN/100mL in all but one sample over 30 days
[4]Recycled water that is filtered and disinfected so that the median concentration of total coliform is <2.2MPN/100mL over seven days, and <23 MPN/100mL in all but one sample over 30 days and no samples shall exceed 240 MPN/100mL

In addition to the specified treatment requirements, there are also use area requirements, such as limiting impoundments within 100 feet of a domestic water supply well, and limited application of recycled water near a domestic water supply well.

Groundwater Recharge Reuse

CDHS is in the process of developing Groundwater Recharge Reuse regulation for the recharge of groundwater with recycled water. This involves treating wastewater to a level of disinfected tertiary recycled water, including filtration and disinfection as noted in the footnote above. The water can then be used to recharge groundwater for future domestic water supply. The water can be recharged either by spreading or injection. Upon initiation of the program the recharge water must be limited to 20 percent recycled water for spreading projects and 50 percent recycled water for injection projects. That percent may be increased over time, up to 100 percent, if the on-going performance testing and assessment shows there is no degradation of the groundwater aquifer.

The draft rule requires that water that is spread must be retained in the aquifer for at least six months and must be extracted at least 500 feet from the spreading area. This accounts for the expected soil/aquifer treatment resulting in die-off of pathogens. Water that is injected must be retained in the aquifer for at least 12 months and must be extracted at least 2000 feet from the injection site.

The draft rule also requires that the recycled water quality must meet all Title 22 primary MCLs for inorganic (except nitrogen compounds), organic, radiological, and disinfection by-product (DBP) compounds, action levels for lead and copper, and secondary MCLs. Since nitrogen can be present in many forms, the draft rule presents three methods for ensuring that the overall nitrogen compounds are controlled, by keeping total nitrogen levels less than 10 milligrams per liter (mg/L), regardless of transformation in the recharge environment.

In addition, CDHS specifies limits for Total Organic Carbon (TOC) in the recharge water. All recycled water must have TOC less than 16 mg/L prior to mixing with the diluent water for recharge. However, the TOC of the recharge water is also limited based on the percent of recycled water in the recharge. The equation to determine the maximum TOC allowed in the recharge water is:

$$TOC_{max} = \frac{0.5\text{ mg/L}}{\text{Recycled Water Contribution}}$$

This is based on the 20-week running average, over the previous year, of all TOC results. At the initial limit of 20 percent recycled water this results in a TOC concentration of 2.5 mg/L in the recharge water. When the recycled contribution is increased to 100 percent, the recharge water (and therefore the recycled water) is limited to 0.5 mg/L. This equation was developed assuming that groundwater typically has TOC less than 0.5 mg/L, therefore this would be protective of the source water quality and prevent significant degradation for beneficial uses, including municipal drinking water.

CALFED TARGETS

The CALFED Bay-Delta Program established a target for providing safe, reliable, and affordable drinking water in a cost-effective way, which is to achieve either average concentrations at Delta drinking water intakes of 3 mg/L TOC and 50 micrograms per liter (µg/L) bromide, or an equivalent level of public health protection using a cost-effective combination of alternative source waters, source control, and treatment technologies (CALFED Record of Decision for the Programmatic Environmental Impact Statement/Environmental Impact Report [EIS/EIR], 2000). These numerical targets for TOC and bromide were based on a study conducted for the California Urban Water Agencies (CUWA) by a panel of nationally recognized drinking water quality experts (Expert Panel).

Background

CUWA convened the Expert Panel to determine the required concentrations of TOC and bromide in Delta source water that would allow utilities treating Delta water to comply with current and probable future drinking water regulations using available advanced water treatment technology. The purpose of the Expert Panel report was to recommend Delta drinking water quality targets that CALFED staff could use to evaluate alternatives being considered in the CALFED EIS/EIR. Specifically, the Expert Panel was charged with:

- Developing potential future regulatory scenarios.
- Defining appropriate process criteria for coagulation, ozonation, granular activated carbon, and membrane treatment processes.
- Estimating source water quality concentrations (TOC and bromide) for Delta water supplies that would allow users implementing the defined treatment technologies to comply with the regulatory scenario.

Predicted Regulatory Scenarios

The Expert Panel conducted this study in 1997 and 1998, before several important regulations were promulgated by the EPA. These regulations include; the Stage 1 Disinfectants and Disinfection Byproducts (D/DBP) Rule, the Stage 2 D/DBP Rule, the Interim Enhanced Surface Water Treatment Rule (IESWTR) and the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). CUWA asked the Expert Panel to use their best professional judgment to predict the future outcome of these regulations and to consider that the CALFED Program was tasked with developing a long-term solution for the Delta.

TOC and bromide are DBP precursors that lead to the formation of DBPs such as total trihalomethanes (TTHM), haloacetic acids (HAA5), and bromate. The DBPs are directly regulated by the Stage 1 and Stage 2 D/DBP rules. Water treatment operators must control the formation of DBPs in treated water while providing adequate disinfection to control pathogenic microorganisms. Control of microorganisms is measured by the degree to which viruses, *Giardia*, and *Cryptosporidium* are removed and inactivated. Microorganism control is regulated by the two surface water treatment rules. The Expert Panel focused on the protozoa, *Giardia* and *Cryptosporidium*, because viruses are easily inactivated at the disinfectant levels required for protozoan inactivation.

Table 4 compares the Expert Panel's predicted long-term scenario with the current regulatory scenario. **Table 4** shows that current regulations are less stringent in some cases (*Giardia* and bromate) than the predicted long-term scenario used by the Expert Panel in its evaluation of source water requirements for TOC and bromide.

Table 4
Comparison of the Expert Panel's
Predicted Long-Term Regulatory Scenario and Current Regulations

Parameter	Treatment Requirement or MCL	
	Expert Panel Scenario	Adopted Regulations
Giardia	Additional 1- or 2-log inactivation by disinfection after treatment removal credit	No direct regulation, more stringent treated water turbidity limits.
Cryptosporidium	Additional 1-log inactivation by disinfection after treatment removal credit	Additional log action triggered by source water levels of *Cryptosporidium* (bin classification) and type of treatment utilized. Action varies from nothing for low source water concentrations (Bin 1) and up to 5.5-log removal and inactivation for high source water concentrations (Bin 4).
TTHMs	40 µg/L, based on running annual average (an annual average of quarterly averages of all distribution system monitoring sites)	80 µg/L, based on locational running annual average (an annual average for each individual distribution system monitoring site)
HAA5	30 µg/L, based on running annual average (an annual average of quarterly averages of all distribution system monitoring sites)	60 µg/L, based on locational running annual average (an annual average for each individual distribution system monitoring site)
Bromate	5 µg/L	10 µg/L

The Expert Panel did not take into account the effect of having to comply with the TTHM and HAA5 MCLs based on locational running annual averages at all points in the distribution system. However, a system-wide running annual average will generally be lower than the peak locational running annual averages within a system, so there may be some ability to compare the predicted and actual outcomes.

The Expert Panel predicted that an additional 1-log inactivation of *Cryptosporidium* would be required in the future for all systems and sources. The LT2ESWTR requires various levels of action, based on the level of *Cryptosporidium* in the source waters, which may be more or less than 1-log. It appears, based on monitoring that has been conducted in the last few years, that the water purveyors treating Delta water will not be required to achieve additional action for *Cryptosporidium*. The LT2ESWTR requires follow-up monitoring and reassessment of source water *Cryptosporidium* levels every six years.

There is considerable potential for these regulations to become even more stringent in the future. Additional DBPs may be regulated, including iodinated DBPs; individual species of TTHM or HAA5 may be regulated due to the potentially more severe health effects associated with the brominated compounds; the MCLs for TTHM and HAA5 may be reduced; the bromate MCL may be reduced because the current 10 µg/L MCL does not even provide protection at the 10^{-4} cancer risk level (5 µg/L is the 10^{-4} risk level); or the compliance determination calculations may be amended to represent more site-specific or acute health considerations.

Treatment Processes Required to Meet Predicted Future Regulations

The Expert Panel evaluated the ability of several treatment processes to meet the predicted long-term regulatory scenario. They determined that either ozone disinfection or enhanced coagulation followed by chlorine disinfection with a chloramine residual were the two processes that were most suitable and cost-effective for Delta water. Enhanced coagulation removes TOC from the water prior to disinfection, thereby reducing the formation of TTHM and HAA5. If ozone is used as a disinfectant, rather than chlorine, the formation of TTHM and HAA5 is greatly reduced but bromate is produced with Delta water that contains high levels of bromide. These two processes can be added to the conventional filtration facilities that treat Delta water. The Expert Panel noted that enhanced coagulation with chlorine and chloramine disinfection could meet the predicted long-term regulatory scenario for DBPs and *Giardia* inactivation; however, ozone disinfection would be required to meet the additional 1-log inactivation of *Cryptosporidium*. The Expert Panel also evaluated granular activated carbon and membrane filtration. They concluded that neither of these processes was feasible for the large-scale water treatment plants that treat Delta water (up to 750 million gallons per day) and could potentially cost an order of magnitude more than implementing enhanced coagulation or ozone.

Source Water Quality

The Expert Panel used data submitted by CUWA members, available literature, on-going research, and their own experience and best professional judgment to arrive at potential source water quality requirements. Available models for DBP formation were used to support the initial conclusions reached by the Expert Panel.

The Expert Panel reviewed source water and treated water data from plants that treat Delta water and determined that TTHM were formed more readily than HAA5 and would control the amount of TOC allowed in Delta source waters. They applied a safety factor of 20 percent and, using the predicted future MCL of 40 µg/L, set a treated water goal of 32 µg/L for TTHM. Then they evaluated the ability to meet the treated water TTHM goal in conjunction with the various microbiological regulatory scenarios and concluded that Delta water should contain less than 3 mg/L of TOC and less than 50 µg/L of bromide to allow users the flexibility to incorporate either enhanced coagulation or ozone disinfection to meet the predicted long-term regulatory scenario. The TOC concentration is constrained by the formation of TTHM when using enhanced coagulation for TOC removal and free chlorine to inactivate *Giardia*. The bromide concentration is constrained by the formation of bromate when using ozone to inactivate *Cryptosporidium*.

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