

State Water Resources Control Board
1,2,3-Trichloropropane (1,2,3-TCP) Maximum Contaminant Level (MCL)
Regulations
Response To External Scientific Peer Review

The State Water Resources Control Board (State Water Board) is in the process of adopting regulations to establish a Maximum Contaminant Level (MCL) for 1,2,3-Trichloropropane (1,2,3-TCP). In accordance with Section 57004 of the California Health and Safety Code (HSC), the State Water Board submitted a request and supporting documents for an external scientific peer review of the scientific portions of the draft regulations on July 1, 2016.

The reviewers were asked to evaluate five elements representing assumptions, findings and conclusions that constitute the scientific basis of the proposed regulations:

- 1) The appropriateness of the Cost Estimation Method/Approach.
- 2) Whether a Detection Limit for the Purposes of Reporting (DLR) of 0.000005 milligrams per liter (mg/l), equivalent to 5 nanograms per liter (ng/L), equivalent to 5 parts per trillion (ppt), is the most appropriate DLR with respect to available analytical methods and statutory requirements.
- 3) Whether the Method used to estimate the reduction in annual theoretical cancer cases for each drinking water source that is contaminated with 1,2,3-TCP is appropriate.
- 4) Whether Granular activated carbon (GAC) is the best available technology (BAT) for the treatment of 1,2,3-TCP.
- 5) Whether the preliminary staff recommendation of a Maximum Contaminant Level of 0.000005 mg/l or 5 ng/L would be protective of public health.

Reviewers were also invited to comment on whether taken as a whole, the scientific portion of the proposed MCL is based on upon sound scientific knowledge, methods, and practices. The following individuals provided scientific peer review comments:

Ralph L. Kodell, Ph.D.
Professor Emeritus
Department of Biostatistics
Fay W. Boozman College of Public Health
University of Arkansas for Medical Sciences

Shane A. Snyder, Ph.D. BCES
Professor and Co-Director
Department of Chemical & Environmental Engineering
University of Arizona

Helmut Zarbl, Ph.D.
Professor, Environmental and Occupational Medicine
Robert Wood Johnson Medical School
Rutgers University

Responses to the request were received and published to the State Water Board's website: http://www.swrcb.ca.gov/water_issues/programs/peer_review/. This document contains a compilation of comments received from the scientific peer reviewers on the five elements identified as the scientific basis for the proposed regulations. Comments from peer reviewers were copied verbatim from their submittals and any errors, typographical or otherwise, have not been corrected.

REVIEW ITEM 1: COST ESTIMATION METHOD/APPROACH IS APPROPRIATE

(Kodell): For a given candidate MCL, the steps followed in the cost estimation approach diagrammed in Attachment 1A and illustrated in Attachment 2A appear to be appropriate, although I did not examine these steps in minute detail. However, it is not clear why, in the present case, six incremental potential MCLs for 1,2,3-Trichloropropane (1,2,3-TCP), from 5 ng/L to 150 ng/L, were evaluated. It is stated that California Health and Safety Code Section 116365 requires that the State Water Board adopt MCLs as close to the public health goal (PHG) as is technically and economically feasible at the time of the MCL adoption. Given that the PHG is 0.7 ng/L, and that, while levels lower than 5 ng/L may be detectable by certain select methods, 5 ng/L is the lowest level considered reliably detectable by analytical methods that are commonly available, it seems that consideration of DLRs and MCLs much greater than 5 ng/L is not warranted (certainly, not as high as 150 ng/L).

Response: The reviewer asked why the State Water Board evaluated multiple MCLs, up to and including concentrations of 150 ng/L, when 5 ng/L is the proposed MCL. When the State Water Board began developing an MCL for 1,2,3-TCP, the economic feasibility of 5 ng/L had not yet been determined. Developing costs for multiple MCLs should provide the State Water Board with sufficient data regarding economic feasibility such that, if 5 ng/L was determined to be economically infeasible, an economically feasible alternative MCL could be identified.

Changes to Proposed Regulations: None

(Snyder): Cost-estimations provided based on existing systems in California appear to be accurate; however, additional data would be helpful to better optimize 1,2,3-TCP attenuation and minimize operational costs.

Cost-estimation data provided for GAC seems reasonable considering the limited data available. Assumptions of bed volume lifespans should be viewed as preliminary estimates. Cost estimations were relatively thorough for GAC; however, comparisons to costs for other viable technologies are sparse at best. A discussion of alternative technologies for 1,2,3-TCP is provided in Opinion 3 of this report. For GAC, only a few water qualities have been considered and only a few carbon types are considered. Ideally, additional information would be provided that demonstrates the efficacy of differing carbon types, differing empty-bed contact times (EBCTs), and under a range of water qualities. While full-scale testing of these variables is not always feasible, preliminary testing using rapid small-scale column tests (RSSCTs) is highly advisable. Using RSSCTs, water agencies can more quickly gauge the performance of various carbons and EBCTs before moving into pilot or full-scale designs (Crittenden et al., 1991; Redding et al., 2009; Anumol et al., 2015). Overall, I believe that the cost-

estimation provided by SWRCB in relation to GAC is reasonable and reliable within the constraints of the very limited data available; however, cost-estimations for other technological solution is largely absent within the documents provided by SWRCB.

Response: The reviewer commented that the cost estimation for GAC did not explore a wide range of factors including carbon types, empty bed contact times, and water quality characteristics. Cost estimates for GAC were developed using a U.S. Environmental Protection Agency (EPA) cost model and data from water systems currently treating for 1,2,3-TCP. The State Water Board did not analyze the full range of potential design and operational choices that a public water system (PWS) may choose for each specific application. Typically, a PWS will explore site-specific design and operational choices at each well site to determine whether costs can be reduced and/or performance can be improved. The costs associated with these types of variations are beyond the scope of the estimates necessary for the purposes of developing this regulation, but would be appropriate considerations when a PWS begins considering possible treatment options.

The reviewer also commented that the State Water Board did not evaluate other alternative technologies besides GAC when performing the cost evaluation. The State Water Board is required to designate at least one BAT during the development of an MCL. The designation of GAC as the BAT does not preclude a water system from instead installing and receiving a permit for an alternative technology such as powdered activated carbon or ultraviolet-advanced oxidation processes. HSC 116370 requires the State Water Board to consider “the costs and benefits of best available treatment technology that has been proven effective under full-scale field applications”. The State Water Board did not propose other technologies as BAT candidates because insufficient cost and benefit data exists for those technologies and no California PWS known to the State Water Board are using those technologies for treatment of 1,2,3-TCP at full-scale.

Changes to Proposed Regulations: None.

(Zarbl): The proposal provides a thorough and detailed analysis of the cost associated with the installation and operation of Granular Activated Charcoal filtration that could reduce 1,2,3-TCP levels in drinking water below the proposed MCL and DLR. As required, the cost estimates were done over a range of different MCLs. The estimated cost associated with each MCL is then compared to the predicted reduction in excess cancers in the exposed populations (Appendix 2A). The method used to calculate costs was estimated assuming wells with a source concentration of 150 nanograms/liter.

The comparison of cost analyses across a variety of MCLs in relation to possible reduction in cancer risk is presented in in the graph form (*note: a detailed Figure legend*

should be provided in the final version of the proposal). The results of the cost comparison indicates an almost linear increase in costs as the proposed MCL decreases, with a possible increase slope as the proposed MCL is reduced to 15 ng/l or lower. The estimates of annual cancer avoided decrease less dramatically as the MCL decreases, and appears to become asymptotic as the proposed MCL drops below 15 ng/l. These estimates would tend to indicate that below an MCL of 15 ng/l, the cost benefit ratio increases significantly, with little additional decrease in cancer risk while cost rise significantly. This observation is, however based on the data as presented in the proposal. Since there was no statistical analysis of the estimates (no error bars or confidence limits presented on the graph), it is difficult to assess whether changes in the slope of the line are real or perceived. It would be helpful to estimate the confidence intervals for both the cost estimates and the annual cancer avoided calculations. Nonetheless, the data presented indicated that decreasing the MCL from 15 to 5 ng/l increases costs significantly. The proposal indicates that based on an abundance of caution and sensitivity of currently availability, accredited technologies to accurately determine the level of contamination, the state should mandate a MCL of 5 ng/l. Although fairly conservative, the proposed MCL is not unreasonable and is in line with those set by other states (e.g., New Jersey).

It is important note to that the cost estimates presented are an underestimate of the costs that would be incurred if sampling and analysis were to be performed using approaches standard in analytical chemistry. The reports and cost estimated all indicate that when water samples are taken, they comprise a single one liter aliquot of the drinking water. Repeated samples are only done of there is a level of 1,2,3-TCP above the MCL. This is problematic for several reasons. While the commercial certified laboratories no doubt perform the analysis in triplicate, these represent technical replicates. The standard practice in analytical chemistry is to also perform sampling in triplicate. This not only allows for statistical analysis of the variance, but controls for difference in levels due to sampling and handling of the samples. This is particularly important when the level of contamination is close to the MCL or DLR. As will be discussed in Review Item #2 below, the proposed MCL and DLR of 5 ng/l are at the limit of quantitation by the approved methods (EPA 504.1). In this case the variance around the detection limit is crucial, as a single value could be below the DLR due to experimental parameter including but not limited to, actual variations in samples taken, sample extraction efficiency, sample handling, sampling errors, laboratory contamination.

Moreover, it is possible that contaminant levels could vary across the day as water flow changes. It might therefore also be useful to take the samples at different times of the day. The net effect of performing cost analyses using a single sample is a three-fold

underestimate in the cost of performing the chemical analysis. A justification for performing single sample analyses should therefore be provided.

Responses: The reviewer noted that statewide costs of compliance appeared to increase significantly as the evaluated MCL decreased from 15 to 5 ng/L. The State Water Board does not perform a cost-benefit analysis when evaluating economic feasibility for MCLs and is required to select an MCL that is as close to the Public Health Goal (PHG) as is feasible. Additionally, when populations are exposed to 1,2,3-TCP concentrations in drinking water, it is of public health benefit to reduce the concentration of the contaminant to one that is as low as is feasible, in order to minimize the resultant cancer risk.

The figure the reviewer noted was intended as a visual guide and a more detailed version is not part of the regulatory package. Upon re-review of the figure, the presentation of the data in the chart should have been in a format that does not imply a linear correlation between each MCL (e.g., bar chart presentation). The figure, in any format, was not used as part of the cost estimation process and did not have any bearing on any of the State Water Board's conclusions or proposed regulations. The figure probably should not have been included in the materials for peer review.

The reviewer commented that monitoring costs are underestimated because commercial laboratories may perform more than one analysis when determining the concentration of 1,2,3-TCP in a water system's source. Average sample analysis costs were obtained by an informal laboratory survey of commercial laboratories throughout the state and are intended to represent the cost that a water system would expect when performing the required monitoring. None of the laboratories expressed a need to perform multiple sample analyses for source monitoring to meet regulatory requirements. Any possible additional elective sampling performed by a PWS was not considered in the cost estimation.

The reviewer commented that single-sample analysis for compliance purposes may result in false positives or negatives due to variance in results. Existing drinking water regulations do not mandate additional sampling beyond the existing monitoring frequencies. While the regulations could be modified to require additional sampling to ensure that a given sampling event is more likely to be accurate, a change of that type would likely be a significant regulatory undertaking given the large number of contaminants currently regulated. The State Water Board believes that the required four quarters of initial sampling, the optional confirmation sampling following a detection of 1,2,3-TCP, and the additional monthly or quarterly sampling following confirmation of the presence of 1,2,3-TCP should be sufficient to determine whether or not a source has 1,2,3-TCP contamination above the proposed MCL.

Changes to Proposed Regulations: None

REVIEW ITEM 2: A DLR OF 5 NG/L IS THE MOST APPROPRIATE DLR WITH RESPECT TO AVAILABLE ANALYTICAL METHODS AND STATUTORY REQUIREMENTS.

(Kodell): The DLR of 5 ng/L appears to be appropriate in the sense that several commonly available analytical methods at ELAP (Environmental Laboratory Accreditation Program)-certified commercial laboratories have been identified as being capable of achieving a minimum reporting level of 5 ng/L for 1,2,3-TCP. It is stated that ELAP certification for methods that may be capable of detecting 1,2,3-TCP at levels below 5 ng/L is not widespread in California. Thus, it is argued that a lower level than 5 ng/L for a DLR is not economically or technically feasible. This conclusion appears to be justified.

Response: None.

Changes to Proposed Regulations: None

(Snyder): Analytical methods are currently available from laboratories that are certified by the Environmental Laboratory Accreditation Program (ELAP) are capable achieving a Detection Limit for the Purposes of Reporting (DLR) of 5 ng 1,2,3-TCP/Liter of water; however, some questions remain as to the reliability of these methods in natural aqueous matrices.

Several analytical methods have been utilized in order to identify and quantify trace levels of 1,2,3-TCP in water. Generally, gas chromatography (GC) is used to separate mixtures of volatile and semi-volatile organic substances, including 1,2,3-TCP, isolated from environmental samples. The US Environmental Protection Agency (EPA) has developed and published methods that include 1,2,3-TCP among other constituents. Methods promulgated by the EPA include various revisions of method 504.1, method 524.2, and method 524.3. The State of California Department of Public Health has developed methods specifically optimized for 1,2,3-TCP, including SRL 524M-TCP, SRL 525M-TCP, and a recently published method. These methods will be discussed in detail in the following sections.

US Environmental Protection Agency Methods:

Using liquid-liquid extraction (LLE) using hexane, followed by GC with electron capture detection (ECD), method 504.1 (revision 1.1) claims a method detection limit (MDL) of 0.02 ug/L (parts per billion) (EPA, 1995a). However, because of the relatively nonselective nature of ECD, method 504.1 also states that “Confirmatory evidence should be obtained for all positive results.” Confirmation under method 504.1 requires the use of either a second GC analytical column of dissimilar phases or (when

concentrations are great enough) GC coupled to mass spectrometry (GC-MS). Within method 504.1 revision 1.1, the EPA demonstrates that with seven replicate samples fortified to 100 ng/L with 1,2,3-TCP, a mean recovery of 91.9% with a relative standard deviation (RSD) of 13.88% may be achieved (EPA, 1995a).

Method 524.2 relies on a purge and trap interface (PTI), which sweeps organic substances from water samples using an inert gas then trapping the volatilized organics on a stationary phase (EPA, 1995b). The stationary phase (trap) is then rapidly heating to re-volatilize and introduce the focused organics into the GC instrument. The EPA demonstrates this method using a fortification level of 100 ng/L, which results in a mean accuracy of 96% with a %RSD of 6.5 which was used to calculate an MDL of 30 ng/L for 1,2,3-TCP. In August of 2009, EPA published Method 524.3, which as a newer method that targets 76 volatile organic compounds (VOCs), including 1,2,3-TCP. This method increases the number of internal standards from 1 to 3, and the number of surrogate standards from 2 to 3. Instead of preservation by pH suppression, method 524.3 uses maleic and ascorbic acid. The QA/QC requirements of method 524.3 also changed, particularly in how the calibration curve is evaluated and the requirement of Minimum Reporting Level confirmation criteria. Method 524.3 was specified in the US EPA's Unregulated Contaminant Monitoring Rule 3 (UCMR3) with an MRL of 0.03 ug/L (30 ng/L) {EPA, 2016 #5351}. As of July 2016, the EPA reported that only 253 of 36,532 results received were above the MRL and only 65 public water systems (PWS) of 4,905 tested at 1,2,3-TCP concentrations above the MRL of 30 ng/L.

California Department of Public Health Methods:

The State of California Department of Public Health (DPH) developed at least three analytical methods capable of report limits for 1,2,3-TCP at, or below, 5 ng/L. Unlike the aforementioned EPA methods, the California DPH methods are specific to 1,2,3-TCP and do not include other analytes. The methods employed are purge and trap GC-MS (PTI-GCMS) (Okamoto et al., 2002b), continuous LLE GC-MS (Okamoto et al., 2002a), and a combined solid-phase extraction (SPE) PTI-GC-MS (Liao et al., 2016). Of these, according to my review of available literature, only the PTI-GC-MS (SRL 524M-TCP) and LLE-GC-MS (SRL 525M-TCP) are used under the Environmental Laboratory Accreditation Program (ELAP) required for regulatory purposes.

The PTC-GC-MS (SRL 524M-TCP) method uses a linear calibration range from 5 to at least 500 ng/L and is not recommended for higher concentrations (Okamoto et al., 2002b). Both single quadrupole and ion-trap mass spectrometers were used in the development of the method; however, the authors note that those using ion-trap mass spectrometers "are cautioned that quantifying TCP at the 5 ng/L level may not be achievable." Yet, the authors note that ion-trap mass spectrometers have superior

selectivity for compound identification. It seems that triple-quadrupole (QQQ) mass spectrometers were not evaluated, which may have provided both superior sensitivity and selectivity. A deuterium labeled internal standard, 1,2,3-trichloropropane-D5 (TCP-D5), is added at the same concentration to all samples and standards. It should be noted that many laboratories, including some EPA methods, would consider the addition of an isotopically-labeled standard to the sample as a surrogate standard (as opposed to an internal standard). Regardless, the recovery of TCP-D5 is used to normalize the recovery of 1,2,3-TCP in samples. The authors note that, depending on the analytical column used, some substances can interfere with 1,2,3-TCP quantification if present (for instance, in environmental samples and/or leaching from analytical equipment). The method requires laboratory fortified blanks (LFBs) containing 1,2,3-TCP at 20-50 ng/L be replicated seven times to achieve a mean recovery between 80-120% and an RSD of 20%. The method further requires an MDL study “preparing and analyzing a minimum of seven replicates of a 5.0 ng/L TCP standard over a period of three days, or more.” It is not entirely clear, though implied, that the MDL study is performed in laboratory (purified) water. The reporting limit should be no less than 3x the MDL. The method provides detailed quality assurance and quality control (QA/QC) measures, including ions used for mass spectrometry and guidance regarding observations of skewed ion abundances. The method calls for “taking appropriate action”, in needed, to correct for interfering compounds; however, it is unclear what appropriate action is specifically recommended. The authors claim demonstrated MDLs of 0.9 and 2.3 ng/L for quadrupole and ion-trap mass spectrometers, respectively. These data would suggest that ion-trap was not successful in achieving a reporting limit of 5 ng/L using a 3x the MDL reporting limit calculation. In my professional opinion, this method using a quadrupole mass spectrometer is barely adequate to obtain a DLR of 5 ng/L. It is concerning that the lowest calibration point is at the desired DLR. Moreover, MDLs are calculated from statistical methods where replication is more important than sensitivity. That said, the verification of the MDL with 5 ng/L standards is promising; however, specific details on whether this would be successful in a true environmental matrix is absent and risks of interferences are known. Another consideration is that while reproducibility is good, the recovery of an isotopically-labeled surrogate is used to normalize for 1,2,3-TCP recovery. Since the lowest point in the calibration curve is 5 ng/L, any variation in recovery could result in a false negative (or positive) which may have implications for regulatory compliance.

The other method used by the State of California, and used in ELAP laboratories, uses continuous LLE with GC-MS detection (SRL 525M-TCP). This method also is specific to 1,2,3-TCP and also uses a linear calibration range of 5 to at least 500 ng/L (Okamoto et al., 2002a). In general, the analytical method is similar to that of SRL 524M-TCP with the significant exception of the sample extraction and introduction methodology.

Continuous LLE is achieved with SRL 525M-TCP by extraction a 1L water sample for approximately 16 hours (overnight) with dichloromethane (DCM). The resulting DCM extract is dried (to remove residual water), then evaporated to 1 mL using nitrogen gas. Analysis is performed by injecting 2 μ L of the final extract into a GC-MS system. As described previously, TCP-D5 is added to both samples and standards for isotope-dilution quantification. The method was demonstrated using reagent grade (purified) water fortified to 5 ng/L of 1,2,3-TCP and replicated eight times, resulting in an MDL of 0.8 ng/L with a mean recovery of 111% and RSD of 4.8%. The authors estimate a reporting limit of 5 ng/L for 1,2,3-TCP. It is unclear if natural/environmental waters fortified at the estimated MRL to evaluate the potential impact of a background matrix. However, six groundwater samples were tested by both the LLE and the PTI methods with resulting 1,2,3-TCP concentrations ranging from 8 to 77 ng/L with good comparability. Yet, it seems that no natural waters with less than 8 ng/L were evaluated nor is any mention of potential interferences discussed. In my professional opinion, SRL 525M-TCP also is barely adequate for the desired DLR of 5 ng/L of 1,2,3-TCP in environmental waters. The method description speaks to an MDL study “by preparing and analyzing a minimum of seven replicates of a 5.0 ng/L TCP standard over a period of three days, or more.” It is unclear to me if the method requires fortification of a reagent water samples to 5 ng/L or if this is simply analysis of an analytical standard. If the latter, it must be erroneous as analytical standards specified in this method are in μ g/L concentrations. Regardless, in my opinion, an MRL (or DLR) for an analytical method to be used for environmental compliance should be higher than the lowest point in the calibration curve (equated to water assuming 100% recovery). Since the lowest point in the calibration curve is 5 ng/L, any variation in recovery could result in a false negative (or positive) which may have implications for regulatory compliance.

More recently, the State of California Department of Public Health, Drinking Water and Radiation Laboratory Branch, has published in peer-reviewed literature a more sensitive method for 1,2,3-TCP using a combination of SPE and PTI to achieve an MRL of 0.30 ng/L (Liao et al., 2016). This is a highly unique method, which the authors’ claim “the two sample preparation methods have never been used in combination.” This unlikely coupling seems to have quite promising results; however, seems very labor intensive and time consuming as currently applied. The method also relies on isotope-dilution quantification using TCP-D5 as a surrogate/internal standard. The published manuscript does provide results of a single matrix spike at 1 ng/L with a recovery of 87% and shows good replication for two environmental samples. Considering that this method is not likely to have ELAP “approval” at this point in time, further critique will not be provided. However, the method, though seemingly labor intensive, does show good promise for 1,2,3-TCP identification and quantification, as demonstrated by a water treatment process sampling where “raw” water is reported at 5.8 ng/L and “finished”

water was less than detection. From my review, this published method has not been recommended for regulatory application; however, I believe it shows promise in achieving a desired MRL of 5 ng/L, or lower, based on the data available.

Response: The reviewer noted that while analytical methods are currently available from laboratories that are certified by the Environmental Laboratory Accreditation Program (ELAP) and are capable of achieving a Detection Limit for the Purposes of Reporting (DLR) of 5 ng 1,2,3-TCP/Liter of water, some questions remain as to the reliability of these methods in natural aqueous matrices. There is substantial experience with the use of these methods by accredited laboratories in natural aqueous matrices in California. The State Water Board's ELAP provides regulatory oversight and accreditation to commercial and utility-owned laboratories that provide regulatory compliance monitoring for PWS in California. There are currently 23 commercial laboratories certified by California ELAP to analyze for 1,2,3-TCP using SRL524M-TCP to support the notification level of 5 ng/L for 1,2,3-TCP. SRL524M-TCP has been used by commercial and utility-owned laboratories in California for over ten years in the monitoring and reporting of 1,2,3-TCP in California drinking water systems. Those laboratories have produced over 8,000 drinking water analyses for 1,2,3-TCP at the 5 ng/L reporting limit. This experience has served to identify potential interference issues and establish confidence in the method.

The State Water Board conducted a review of the monitoring data for the approximately 44 wells that have monitoring results showing a 1,2,3-TCP concentration near the method reporting level of 5 ng/l. The review focused on wells with average 1,2,3-TCP concentrations between 5 and 7 ng/l. The purpose of the review was to screen the data for readily-apparent patterns or anomalies that might be an indication of inconsistent analytical data at these low levels. Though not conclusive, the review did not identify any unusual patterns of significant short or medium term fluctuations in the level of contamination with 1,2,3-TCP that might be evidence of inconsistent analytical results.

The reviewer provided a detailed discussion of the analytical methods and raised some concerns including the statement that in his “professional opinion, SRL 525M-TCP also is barely adequate for the desired DLR of 5 ng/L of 1,2,3-TCP in environmental waters”.

The discussion of analytical methods provided by the peer reviewers is helpful and will be useful in implementation of the regulations. It should be noted that Method SRL 524M-TCP is used for the vast majority of analyses in the State Water Board water quality database. Additionally, there are no laboratories currently certified by the ELAP for Method SRL 525M-TCP. Promulgation of an MCL will necessitate that laboratories are certified for analytical methods with a DLR of 5 ng/l.

The peer reviewer stated that in his opinion, "... an MRL (or DLR) for an analytical method to be used for environmental compliance should be higher than the lowest point in the calibration curve (equated to water assuming 100% recovery). Since the lowest point in the calibration curve is 5 ng/L, any variation in recovery could result in a false negative (or positive) which may have implications for regulatory compliance."

Water quality monitoring regulations (Title 22, Section 64445.1 et seq of the California Code of Regulations) in California include several standard provisions designed to ensure that compliance determinations are not based on any one sample. When an organic chemical is detected, a water system is allowed to collect up to two additional samples to confirm the initial finding. If the two additional samples do not show the presence of the organic chemical, the initial positive finding is disregarded. Additional monthly or quarterly monitoring is required if one or both of the additional samples show the presence of the organic chemical, and the combined data is used to determine compliance with an MCL. In addition, compliance with the MCL is not based on one positive sample result, but rather a running annual average. These standard provisions will be applicable to the compliance monitoring for 1,2,3-TCP and will help ensure that setting MCL at DLR will not result in a PWS being out of compliance because of false detections.

At the time of development, SRL524M-TCP was evaluated in an inter-laboratory method evaluation process by the State Department of Health Services' Sanitation and Radiation Laboratories (SRL). This evaluation confirmed that the method could be performed as described and laboratories could meet the Quality Control criteria set forth in the method.

The State Water Board understands concerns about reliability of the data when the MCL is established at the level of the DLR. It should be noted that the ample experience by ELAP-accredited laboratories with the testing for 1,2,3-TCP in California in a range of natural aqueous matrices provides a high degree of confidence with the analytical methods, the DLR and the results of the analyses.

It should also be noted that other MCLs that have been established at levels that are at or near their respective DLRs. For example, the MCL for perchlorate is 6 micrograms per liter ($\mu\text{g/l}$), while the DLR is 4 $\mu\text{g/l}$. In that case, obtaining reliable data for the purposes of determining compliance has not been problematic.

In regards to the potential for false negative or positive results using SRL524M-TCP, **the Peer Reviewer acknowledged that "The method provides detailed quality assurance and quality control (QA/QC) measures, including ions used for mass spectrometry and guidance regarding observations of skewed ion abundances."**

There are also other factors that may contribute to false negative (or positive) results, such as a failure to follow sample collection, handling, storage, and analysis according to the method.

In specific regard to false positive results, precautions exist concerning sample collection, handling, storage, and analysis to ensure the validity of the analytical result. Samples are also collected in duplicate. If the validity of the result from the first sample is in question, the second sample may be analyzed and the results used to either corroborate the first sample or provide further information regarding potential sampling errors.

Changes to Proposed Regulations: None

(Zarbl): 1,2,3-TCP, a probable human carcinogen (IARC), has been detected in numerous drinking water wells in California and is therefore a health concern. Although both the EPA and the State are in the process of developing regulations, there is currently no Federal standard for acceptable levels in drinking water. The USEPA considers 1,2,3-TCP to be a carcinogenic VOC and is therefore included in the included in the unregulated included in the unregulated carcinogenic volatile organic compound rule (UCMR3). The current reporting level at the national level is set at 30 ng/l. However, the State is required to use the public health goal of 0.7 ng/l set by the California Office of Environmental Health and Standards Assessment in establishing a MCL and DLR for 1,2,3-TCP. The state is mandated to set the MCL and DLR at levels as close as possible to the level set by the COEHSA as possible, given prevailing quantitation limits available using approved methods available from ELAP-certified commercial laboratories.

Given that 1,2,3-TCP is a probable carcinogen, it is appropriate to reduce the amount present in drinking water. At the present time, the limit of quantitation using EPA approved methods in ELAP certified commercial analytical laboratories is 5 ng/l. It is therefore logical to use this as the DLR for reporting to the State, so that appropriate actions can be taken to mitigate levels in drinking water. However, it is important that an adequate number of replicate water samples are analyzed to ensure that the levels detected are reproducible and are subjected to appropriate statistical analysis. This would eliminate the possibility of samples that are at or exceed the DLR from being classified as acceptable.

There is also a problem inherent in setting the DLR at the limit of quantitation. Any levels that are even marginally below the limit of quantitation are assumed to be outside the range where measurements are accurate. If levels close to the DLR are detected, it might be useful to repeat the analysis on a larger sample volume. At a minimum, the reproducibility of the result should be verified by statistical analysis of levels detected in

multiple samples. It might also be useful to sample the water at different times of the day when usage is significantly different. Alternatively, facilities might voluntarily report and replace GAC when 1,2,3-TCP levels approach the DLR at the 75% sampling port in the GAC column. This approach was in fact used by one of the facilities for which operating reports were provided in the proposal.

It should also be noted that more sensitive assays are currently available for measuring 1,2,3-TCP in drinking water, some of which can quantify 1,2,3-TCP at the PHG recommended level. Since these are currently not available in commercial ELAP-certified laboratories, the current proposal is not to accept data from these analyses. This seems counterproductive. As long as the laboratories performing the analyses follow accepted procedures for Quality Control and Quality Assurance, the results generated should be considered, at least for the purposes of triggering further evaluation in certified laboratories.

Grandfathering of test results performed prior to the establishment of the state MCL and DLR is appropriate, as long as the results were obtained in an accredited laboratory using approved methods.

Response: The peer reviewer stated that “...it is important that an adequate number of replicate water samples are analyzed to ensure that the levels detected are reproducible and are subjected to appropriate statistical analysis. This would eliminate the possibility of samples that are at or exceed the DLR from being classified as acceptable.” The State Water Board believes that standard sampling and analyses protocols and procedures are sufficient to adequately address this concern. The concern with samples being erroneously classified as acceptable (i.e., false negatives) is further discussed below.

The peer reviewer suggested that the State Water Board consider the results of sampling using methods that provide data at levels below the DLR. The peer reviewer suggested that such results should be considered for the purpose of triggering further investigation.

The State Water Board agrees with the peer reviewer’s suggestion that the results of all samples collected (even those with reported levels below the DLR) should be considered for investigative purposes and for “the purposes of triggering further evaluation in certified laboratories”.

California regulations require that sample results submitted to the State Water Board for regulatory purposes come from laboratories which are ELAP-certified for the method used to obtain the result. If a sample is analyzed using more sensitive methods from an uncertified laboratory and if those results indicate the presence of 1,2,3-TCP in drinking

water, then State Water Board staff may, at their discretion, require a water system to perform additional analysis using ELAP-certified methods and laboratories.

Regarding the “Grandfathering” of test results performed prior to the establishment of the State MCL, the State Water Board agrees with the peer reviewer’s suggestion that such results must be obtained from an accredited laboratory using approved methods. Such provisions will be established in the regulation.

Regarding the concerns with the Detection Level for Reporting (DLR) at a level that is just 3 times the Method Detection Level (MDL), the State Water Board agrees that this necessitates extra diligence in ensuring the reliability and accuracy of data. The State Water Board believes that there are multiple safeguards in place to help ensure that compliance determinations are based on the most accurate and complete data available. These safeguards include the requirement for confirmation samples to confirm initial analytical results.

In addition, PWS are allowed (and self-motivated) to perform additional investigative work in the event of any positive sample result. Such investigative work might include sending split samples to multiple laboratories for additional confirmation, sampling of nearby wells to identify the extent of the contamination, and investigation of the likely sources of the contamination (i.e., review of information on past application of soil fumigants in the area).

The additional investigative work may include some of the suggestions provided by the peer reviewers such as collecting larger sample volumes, collecting time-series samples through an entire well-pumping cycle and even collecting samples from multiples geological strata within the well casing (where possible).

Changes to Proposed Regulations: None

REVIEW ITEM 3: METHOD USED TO ESTIMATE REDUCTION IN ANNUAL THEORETICAL CANCER CASES FOR EACH DRINKING WATER SOURCE THAT IS CONTAMINATED WITH 1,2,3-TCP IS APPROPRIATE.

(Kodell): The modified definition of the reduction in annual theoretical cancer cases for each contaminated source is given in Attachment 2 as:

$$\text{Reduction} = \frac{[(\text{average of source monitoring results}) \times (\text{population exposed}) \times (\text{risk})]}{70 \text{ years}}$$

In an earlier version of Attachment 2 that was sent to potential reviewers prior to their selection as reviewers, the definition was given as:

$$\text{Reduction} = \frac{[(\text{average of source monitoring results} - \text{evaluated MCL}) \times (\text{population exposed}) \times (\text{risk})]}{70 \text{ years}}$$

I believe the latter expression (the original one) is correct, in that it represents a *reduction* in cases, i.e., the difference between the number of cases estimated based on current exposure levels and the number estimated if the MCL were put into effect (assuming the MCL would be lower than the current average exposure level). To me, the revised definition would actually give only the theoretical annual number of cases occurring under current exposure levels, i.e., it would *not* give the *reduced* number of cases.

Using the average of source monitoring results from all acceptable samples from a given source as a representative contamination level of 1,2,3-TCP for that source seems justified. Approximating the population served by a source within a water system using the average over all sources in the system inherently assumes that all sources serve the same number of people. Apparently, population-served-per-source data are not available. However, wording used under Step 4 of Review Item 1, “the number of people served by each source,” indicates that such data are available. If these data are available, they ought to be used so that the per-source calculation will be more accurate. However, once all reductions are summed, as outlined in Step 6 of Review Item 1, it shouldn’t make any difference.

The public health goal (PHG) value of 0.7 ng/L that is used here to calculate the “risk” (actually, the *slope*: see next paragraph) is based on having linearity at least up to an excess risk level of 0.1 (Public Health Goal for 1,2,3-Trichloropropane in Drinking

Water, OEHHA 2009, <http://oehha.ca.gov/water/public-health-goal/final-public-health-goal-123-trichloropropane-drinkingwater>), so the assumed linearity would easily apply up to the proposed MCL of 5 ng/L, and would apply to average source monitoring results above 5 ng/L as long as those results would not greatly exceed 5 ng/L.

As mentioned I believe the “risk” that appears in the formula is actually meant to represent the *slope* of a line used for linear extrapolation instead of actual *risk*, where risk is defined as the probability of occurrence of an event (cancer, in this case). The ratio of excess cancer risk at the PHG to the PHG itself is really the *cancer potency factor* based on low-dose, linear extrapolation from a 0.1 excess risk level (OEHHA, 2009). The PHG of 0.7 ng/L established by OEHHA in 2009 for drinking water (after making appropriate conversions) corresponds to a lifetime excess individual cancer risk of 1 in 1 million (equivalently, 1 excess cancer case per million people each of whom lives 70 years). So, 1 lifetime excess cancer case per million people is the *risk* (10^{-6}), and the *potency factor* is the *slope*, i.e., the excess risk divided by the PHG (in this case, $10^{-6}/0.7$ ng/L). Thus, I would use either *potency factor* or *slope* in the reduction formula in place of the word *risk*. Perhaps, more importantly, I calculate a different value for the potency factor from the value of 0.00142857 given in Attachment 2. If I am correct in dividing 10^{-6} by 0.7 to get the potency factor, then the potency factor for 1,2,3-TCP expressed in ng/L units should be 0.00000142857, not 0.00142857. So, either my calculation is too low by a factor of 1000 or the proposed value in Attachment 2 is too high by a factor of 1000.

Responses: The reviewer noted that the risk, or potency factor, may be incorrect by a factor of 1,000. The risk factor is calculated by dividing the cancer risk (1 in 1 million people over 70 years) by the public health goal of 0.0007 micrograms per liter ($\mu\text{g/L}$), not 0.7 ng/L. Using micrograms instead of nanograms should result in the risk factor provided to peer reviewers.

The reviewer recommended using the numbers of people served by each source in the cost estimate, if those numbers are available. The numbers of people served by each source are not known unless a water system only has one active source. The method of estimating population served as described in Attachment 2, Review Item 3 is the same method used in Attachment 2, Review Item 1. We agree that to avoid confusion the description provided to the peer reviewers in Attachment 2, Review Item 1 regarding what data was available to the State Water Board could have been made clearer.

The reviewer recommended that the terms “potency factor” or “slope” should be used instead of “risk”. The State Water Board has historically used the term “risk”

when describing the linear extrapolation, but will ensure that definitions in supporting documents make clear that the word “risk” is defined as the potency factor.

The reviewer commented that the health benefits equation used in calculations should be revised to use the difference between the average of source monitoring results and any proposed MCL, rather than simply using the average of results. Using the difference between the results and a proposed MCL will represent the reduction in cancer cases at that MCL, instead of the number of cases occurring at current exposure levels by simply using the results. The State Water Board agrees with the comment that the health benefits equation should be revised to use the difference between the average of source monitoring results and any proposed MCL and has made revisions to the calculations and documents provided with the regulation to reflect this agreement. Upon recalculation using the revised equation, the resulting change in cancer reduction did not result in a change to the proposed MCL.

Changes to Proposed Regulations: None.

(Zarbl): The method used for estimating the reduction in cancer risk for each drinking water source contaminated with 1,2,3-TCP is driven by the PHG level of 0.7 ng/l. The PHG takes into account exposures from other sources including inhalation during showers and other household water uses. The calculation averages all source monitoring results for each well. While this is a reasonable approach the data indicated that the levels in some wells have actually been increasing. Using the average of past contamination levels, without modeling the effects of increasing trends may actually underestimate to reduction in cancer risk for those wells moving forward.

Since the calculations exclude wells whose levels of the contaminant are below the MCL, the total number of exposed individuals could be significantly underestimated. Including wells with lower levels would increase the size of the exposed population. Including individuals exposed to lower levels would be appropriate, since the PHG guidance suggests that the goal is approximately 7-fold below the MCL (small attributable risk in large population). By contrast, the focus on wells above the MCL could overestimate the reduction in the population receiving the highest doses. While this would seem to be a laudable goal, the affected population size above the MCL actually very small relative to the desired reduction in caners per million persons exposed for 70 years (large attributable risk in a small population). It is therefore unclear if estimating reduction in cancer risk using only those exposed to levels above the MCL provides an accurate estimate of the population risk across all wells. However, given the dearth of certified data at levels below the DLR, the method used may be the only method using simple calculations. Nonetheless, it might be useful to model the reductions in the entire fraction of the populations that receives the bulk of their drinking

water from wells assuming different levels of contamination at the source, beginning at the PHG.

The calculated reduction also fails to take into account any population or exposure specific variables such as the age of those exposed and actual amounts consumed in specific communities. Given the relatively small number of individuals served by any specific well, failure to consider these variables could skew the results for individual wells.

The risk parameter was calculated using the PHG-derived potency factor of one excess cancer per million persons per 70 years divided by the PHG (0.00142857). This is reasonable.

Responses: The reviewer commented that the evaluation did not attempt to model apparently increasing trends in 1,2,3-TCP contamination in some wells and may have underestimated the extent of cancer risk reduction. The State Water Board's estimate of cancer risk reduction was a summation of averages of known contaminated sources. While some sources may see an increase in 1,2,3-TCP concentration over time, other sources may see a reduction, and the State Water Board does not have a way to accurately extrapolate cancer risk reduction based on those changes.

The reviewer commented that the numbers of people served by each source, if known, should be used in cost estimations. The numbers of people served by each source are not known unless a water system only has one active source. The method of estimating population served as described in Attachment 2, Review Item 3 is the same method used in Attachment 2, Review Item 1. We agree that the description provided to the peer reviewers in Attachment 2, Review Item 1 could have been made clearer in what data is available to the State Water Board to avoid confusion.

The reviewer commented that the number of exposed individuals could be significantly underestimated, and wondered if estimating reduction in cancer risk using only those exposed to levels above the MCL provides an accurate estimate of the population risk across all wells. Due to the lack of 1,2,3-TCP monitoring data below the proposed DLR of 5 ng/L, the State Water Board does not have a way to meaningfully estimate cancer risk in populations exposed to 1,2,3-TCP at levels below 5 ng/L.

The reviewer suggested that it might be useful to model the reductions in the entire fraction of population that receives the bulk of their drinking water from wells assuming different levels of contamination at the source, beginning at the PHG. In addition, the reviewer thought that the State Water Board should take into

account the population or exposure specific variables, such as age of those exposed and the actual amounts consumed in specific communities. The State Water Board developed the cancer risk avoidance estimates using the PHG as a baseline. The PHG was developed without any accounting for population groups. From the OEHHA PHG report, page 32, risk characterization: “No sensitive populations were identified”. OEHHA concludes that pregnant women and their fetuses, the elderly, and other potentially sensitive populations will be adequately protected by this PHG.

Changes to Proposed Regulation: None.

REVIEW ITEM 4: GRANULATED ACTIVATED CARBON (GAC) IS THE BEST AVAILABLE TECHNOLOGY (BAT) FOR THE TREATMENT OF 1,2,3-TCP.

(Kodell): The selection of GAC as the BAT relies in part on the 2015 Corona Environmental Consulting report for the Winton Water and Sanitary District, *Winton Water and Sanitary District: Treatment Technologies and Costs to Treat 1,2,3-Trichloropropane*, pages 9-11 (Attachment 6). Relative to UV Based processes, Ozone Based Oxidation, and Aeration, GAC Adsorption was argued to be more reliable and more cost effective in achieving levels below the DLR of 5 ng/L.

It is stated that GAC was identified as the BAT after reviewing engineering reports from multiple water systems in California with permitted GAC treatment for 1,2,3-TCP removal and monitoring data. Attachments 7a-7g have been provided as reports and excerpts on the effectiveness of GAC as treatment for 1,2,3-TCP.

Attachment 7b for the Lante Plant shows that there was only a single mild excursion above 5 ng/L (actually, 5.2) during the period sampled. Attachment 7e for the City of Shafter indicated no detections at or above 5 ng/L. Attachment 7g for the City of Burbank indicated that after GAC treatment, all sampled values were below 0.005 µg/L = 5 ng/L. However, even though Attachment 7c for the City of Glendale indicates a reporting limit of 50 ppt, Attachment 7d appears to show many values of 1,2,3-TCP at 0.5 µg/L. Perhaps I am reading the table wrong in Attachment 7d, or the concentration units are incorrectly reported.

Response: The reviewer commented that the performance data for the City of Glendale (included as Attachment 7d) contained some results reported at a reporting limit of 0.5 µg/L when the reporting limit described in Attachment 7c was less than 0.05 µg/L. The performance data included with Attachment 7d with reporting limits higher than 0.05 µg/L or 0.005 µg/L may have been mistakenly reported with an inappropriate DLR, been analyzed by a laboratory incapable of achieving lower reporting limits, or have been analyzed when analytical methods capable of achieving lower reporting limits were not commonly available. The intent of Attachment 7d is to highlight that granular activated carbon (GAC) is capable of removing 1,2,3-TCP to concentrations below the proposed detection limit for reporting (DLR) of 0.005 µg/L; the additional data is for historical perspective and completeness.

Changes to Proposed Regulations: None

(Snyder): Granular activated carbon (GAC) is likely to be the best available technology (BAT) for reducing 1,2,3-TCP concentrations in water to less than 5 ng/L; however,

other technologies should have been considered and not all scenarios for advanced oxidation processes (AOPs) were evaluated.

The primary means of removing organic chemicals from water are oxidation, physical removal, and biological degradation. The review of technologies considered granular activated carbon (GAC), which is a means of physical removal and relocation of 1,2,3-TCP, as the BAT for treatment. There was meager consideration of advanced oxidation processes (AOPs) and aeration (another form of physical removal). In fact, relatively few published manuscripts regarding the treatment of water for 1,2,3-TCP could be located using Web of Science literature searching conducted in late September, 2016. Based on my review of the documents provided by the SWRCB, review of published literature, and review of grey literature using Google search engine, I am in agreement that GAC is the BAT for removing 1,2,3-TCP in groundwater to less than 5 ng/L; however, other technologies are likely to also be successful if optimized. However, only GAC appears to have been proven successful for field applied treatment using DLR of 5 ng/L or less.

While data available do support that GAC is appropriately considered as BAT for 1,2,3-TCP removal to 5 ng/L, or less, other technologies could likely achieve this level of efficacy as well. For instance, powdered activated carbon (PAC) is not considered in the materials provided by SWRCB and quite likely would be highly successful for 1,2,3-TCP. PAC has been successfully used for a diversity of organic contaminant removal from water and offers the advantage of continuously fresh carbon surfaces and can be used when needed and turned off if not needed (Yoon et al., 2003; Ziska et al., 2016). However, for the groundwater scenarios described by the SWRCB, it is unlikely that occurrence of 1,2,3-TCP will be highly variable and PAC is generally more appropriate for surface water systems. Nevertheless, there may be situations where PAC is more appealing for 1,2,3-TCP depending on the particular water quality and existing treatment train.

Generally, 1,2,3-TCP is not amenable to biodegradation. However, some laboratory studies have shown promise using genetically engineered or naturally optimized bacterial strains (Bowman et al., 2013; Dvorak et al., 2014; Samin et al., 2014). At current, biological systems do not appear to be BAT for 1,2,3-TCP. Additional work would be necessary to determine if larger scale biological systems could be optimized for required efficacy.

Because 1,2,3-TCP is a halogenated aliphatic organic molecule, the quantum yield from direct photolysis is expected to be low and a hydroxyl radical promoter (such as hydrogen peroxide) would be needed for efficient oxidation in a UV system. While one

report provided by SWRCB suggested that 1,2,3-TCP had been evaluated at bench-scale using UV-advanced oxidation process (UV-AOP), details are extremely sparse. The report does not provide information on what hydroxyl radical promotor was used nor is any information regarding concentration of the promotor provided. This cursory discussion regarding UV-AOP efficacy is not sufficient alone to dismiss UV-AOP as a BAT. In California, UV-AOP is used in at least two full-scale potable water reuse systems for oxidation of post-RO water, particularly for relatively resilient constituents like 1,4-dioxane. More recently, the use of chlorine in UV-AOP also has shown great promise for oxidation of resilient contaminants (Pisarenko et al., 2013). From my own experience in evaluation UV-AOP technologies, I believe this technology could be successful for 1,2,3-TCP remediation to <5 ng/L; however, I have been unable to locate any literature to demonstrate successful in-field application for 1,2,3-TCP nor am I aware of any cost estimates specific for 1,2,3-TCP.

Other oxidative techniques such as ozone-peroxide and Fenton-based processes also show promise for 1,2,3-TCP removal (Hunter, 1997; Khan et al., 2009; EPA, 2014). Again, the lack of detailed application data would limit cost-estimation and appropriate consideration as BAT.

Zero-valent iron and zero-valent zinc have also shown promise for 1,2,3-TCP attenuation (Salter-Blanc et al., 2012; Noubactep, 2013). These types of reductive processes show excellent potential for 1,2,3-TCP attenuation and field trials have been performed for zerovalent zinc demonstrated feasibility (Salter-Blanc et al., 2012). Regardless, data are relatively sparse as compared to GAC processes, thus cost estimations would be far more challenging and applications to more diverse water qualities would be advised.

Air-stripping processes would be expected to have moderate efficacy for 1,2,3-TCP attenuation; however, full-scale data provided by the SWRCB suggest that as currently operated, air-stripping will not be sufficient to reach the 5 ng/L DLR. Further work would be required to fully understand the feasibility of air-stripping technologies, but considering the available data, I do not believe air-stripping should be considered as BAT for the purposes of a draft MCL for 1,2,3-TCP.

From the data I have reviewed, and in consideration of SWRCB policy that requires listing of a BAT with promulgation of an MCL, I agree that GAC should be considered the BAT for the purposes of a draft MCL for 1,2,3-TCP. The SWRCB has provided sufficient full-scale data to indicate that GAC can be successful for attenuating 1,2,3-TCP to the DLR of 5 ng/L. However, it should be noted that there are a limited number of groundwater facilities and it is possible that other water qualities could be more

challenging, especially if a surface water was found to contain 1,2,3-TCP above the MCL, yet this is unexpected.

Response: The reviewer made various comments on the feasibility of using alternative treatment technologies to GAC to treat 1,2,3-TCP. The State Water Board is required to designate at least one BAT during the development of an MCL. The designation of GAC as the BAT does not preclude a water system from instead installing and receiving a permit for an alternative technology such as powdered activated carbon or ultraviolet-advanced oxidation processes. HSC 116370 requires the State Water Board to consider “the costs and benefits of best available treatment technology that has been proven effective under full-scale field applications”. The State Water Board did not propose other technologies as BAT candidates because insufficient cost and benefit data exists for other technologies and no California PWS known to the State Water Board are using other technologies for treatment of 1,2,3-TCP at full-scale. Please also refer to the Response to Comment on Review Item 1.

Changes to Proposed Regulations: None.

(Zarbl): The report evaluated three methods that can be used to reduce the level of 1,2,3-TCP in water from contaminated wells. These include the use of blending water supplies to reduce levels below the DRL, use of air strippers and filtration through GAC columns. Based on the characteristics and limitations of each (see below), it was concluded that GAC was the only viable method for drinking water treatment. The proposed use of Granular Activated Charcoal for treatment of 1,2,3-TCP contaminations in well water is appropriate, with certain limitations and caveats.

- Blending. The use of water supply blending to reduce 1,2,3-TCP levels below the DLR is not a viable method of mitigating contamination. While blending can reduce levels in drinking water to approach to meet regulatory requirements and reduce individual exposures, it does not address the issue of contamination. Hence, blending should only be used in special cases, and then only as a short-term measure. The problem is that there is a potentially false sense of security in reducing the levels of the contaminant below the DLR. Regulatory standards such as MCLs or DLRs are not a magic number below which there is no risk. The standards are based on risk assessments using estimates of hazard and exposures derived from the best data available at the time. They are designed to limit the incidence of a particular disease endpoint to a designated level, in this case, no more than one additional cancer per million people exposed. Blending to meet regulatory requirements would only distribute the risk over a larger population. Moreover, the most of the contaminant would presumably be returned to the environment.

As an example, the 2010 Performance Report for the Lante Plant in Baldwin, CA, indicated that 1,2,3-TCP uses a combination of air stripping, GAC and blending to ensure that the levels of 1,2,3-TCP are below the DLR of 5.0 ng/l. In 2010, 1,2,3-TCP was detected at a level of 5.2 nanograms/liter. This prompted a report to the State Water Board, precipitating a shutdown and remediation of the GAC facility. However, if the level had for example been 4.8 ng/l, there would have been no requirement for reporting to the State. This is problematic because in reality the 4.8 and 5.2 are probably within the error of the assays used to measure the 1,2,3-TCP levels (this issue is addressed in greater detail in the response to Review Item #2 below). A recent calculation at a water facility estimated that reaching the DLR by blending would have required a 17-fold dilution, which was not feasible. In summary, while blending is in general acceptable, its sole purpose should not be to reduce 1,2,3-TCP to levels below the DLR.

- **Air Stripper.** Air strippers are an efficient method for removal of volatile organic compounds. The basic principle is the differential solubility of the compound in water versus air. As water moves down a column with a countercurrent of air, volatile compounds exchange from water into the gas phase, reducing the levels in water. Disadvantages of this method include the need to then remove contaminants from the air before release into the environment, particularly in the case of carcinogens, and the differential efficiency in removal of volatile organic based on Henry's Law. Compounds with low solubility in water are removed efficiently while those with relatively higher solubility are poorly removed. A typical stripper removes approximately 50% of 1,2,3-TCP dissolved in water. Thus, even ten air stripper columns were used in series would only reduce the 1,2,3-TCP to 0.01% of the original levels. This level of reduction would be inadequate if 1,2,3-TCP were present at the levels detected in the wells evaluated in the proposal.
- **Granular Activated Charcoal.** GAC columns, especially those derived from coconut shells, are a highly effective and efficient method for removal of 1,2,3-TCP from drinking water. Real world studies of functioning wells evaluated in the proposal clearly demonstrated the ability of a single column (30 feet tall and 10 feet in diameter) to reduce 1,2,3-TCP levels in well water that are significantly above the DLR, down to levels that are not detectable using approved analytical methods. Moreover, the GAC method can be combined in series with other methods including air strippers, ion exchange columns and LEUV systems to remove other contaminants. Although the GAC is clearly the best available

method for removal of 1,2,3-TCP, it does have operational limitations and potential problems, all of which were addressed in the addressed in the proposal and were, for the most part, included in the cost estimates. These include the following:

1. GAC has the ability to concentrate nitrates, which will elute during the first 90 minutes of restarting the system. These contaminants must be monitored, captured and mitigated before allowing filtered water to enter the drinking water supply. This requires capture basins and the costs they incur.
2. Charcoal beds are prone to microbial contaminations that must be monitored, and appropriate disinfection applied when microbes are present at specified levels.
3. GAC will also remove other organic contaminants with high efficiency. Many will have higher binding affinities than 1,2,3-TCP, leading to saturation of charcoal beds and necessitating their frequent replacement. Studies presented in the proposal indicated that use of air strippers up front greatly reduces the presence of VOCs and extends the bed life of GAC columns. This combination is highly recommended for other sites with multiple organic contaminants.
4. The level of contamination in the well water may vary over time depending on the season, water use and drought conditions. It is therefore useful to monitor the GAC bed for saturation, so that replacement occurs prior to contaminant breakthrough.

Response: The reviewer recognized GAC as appropriate treatment for 1,2,3-TCP, with certain limitations and caveats. These limitations and caveats may be addressed as part of the permitting of the system. The State Water Board's District Offices are responsible for reviewing any proposal for treatment from a PWS, including repurposing existing treatment, prior to issuing a permit for that treatment. Permits issued by the State Water Board typically contain site-specific operating requirements which could address the concerns raised.

Changes to Proposed Regulations: None

REVIEW ITEM 5: THE PRELIMINARY STAFF RECOMMENDATION OF A MAXIMUM CONTAMINANT LEVEL OF 0.000005 MG/L (OR 5 NANOGRAMS PER LITER) WOULD BE PROTECTIVE OF PUBLIC HEALTH.

(Kodell): Because the PHG of 0.7 ng/L corresponds to an excess cancer risk of 10^{-6} , i.e., one expected additional cancer case per million 70-year lifetimes, the assumption that risk is linearly related to exposure at the 1,2,3-TCP levels of concern implies that the lifetime cancer risk at 5 ng/L would be about 7×10^{-6} . The PHG is presumed, to the extent possible, to account for differential sensitivities among subgroups of the population. Thus, significant risk to public health would appear to be avoided by achieving an MCL of 5 ng/L.

Response: Thank you for your comment.

Changes to Proposed Regulations: None

(Snyder): The preliminary staff recommendation of an MCL of 5 ng/L for 1,2,3-TCP would be protective of public health, but implementation of an MCL of 5 ng/L may be challenging using currently approved analytical methods.

The production of absolutely pure water is not only impractical; it is virtually impossible. Moreover, “pure” water is actually corrosive and not healthy for consumption. Considering the ubiquity of anthropogenic chemicals in the environment and the propensity for these chemicals to contaminate drinking water, rigorous regulations have been imposed to protect consumers from excessive health risks through ingestion of contaminants in drinking water. I did not review in any detail the toxicological data that became the foundation of the Public Health Goal (PHG) used in part as the basis for the suggested MCL for 1,2,3-TCP. My review was focused on BAT and DLR aspects of the proposed regulation. With the assumption that the PHG and risk assessment calculations are correct, I have no reason to believe that an MCL of 5 ng/L would not be protective of public health. I also believe that the BAT of GAC was appropriately selected based on full-scale operations in the State of California and considering the regulatory framework of the state. My only concern from the review of materials provided to me, and my own review of available literature, is the establishment of a reliable DLR of 5 ng/L. While it appears that laboratories are able to provide calculated MRLs at or below 5 ng/L, questions remain as to potential interferences, intrinsic method variability, and method performance within the diversity of water qualities that would be regulated by the proposed MCL. In my professional opinion, it would be far preferable to have MRLs well below the MCL. Essentially, a DLR at the MCL means that any positive result is a potential violation of the MCL. Considering that analytical

methods employed often have variability of up to 20%, it is concerning to me that the MCL and DLR would be the same. Moreover, remediation performance modeling of 1,2,3-TCP to be compliant with an MCL of 5 ng/L will be challenged by analytical data of insufficient sensitivity. In summary, I see no overt issues with the establishment of an MCL of 5 ng/L for 1,2,3-TCP aside from previously discussed issues surrounding the accuracy and precision of the analytical methods suggested.

Response: The reviewer reiterated concerns regarding the proposed DLR of 5 ng/L. Please refer to the Response to Comment No. 2 on Review Item 2.

Changes to Proposed Regulations: None

(Zarbl): The International Agency of Cancer Research has classified 1,2,3-TCP as a probable human carcinogen (type 2A) based largely on animal data. Although there is inadequate human data, there is a large body of evidence for carcinogenicity at multiple sites and in multiple species of experimental animals. It is therefore reasonable to assume that this man-made genotoxic chemical will also be carcinogenic in humans. An abundance of caution should therefore be used in setting guidelines that minimize human exposures. 1,2,3-TCP has been detected in numerous wells in the state of California. After evaluating recently data, the California OEHSA has determined that minimizing cancer risk due to 1,2,3-TCP in drinking water requires reduction of this carcinogen to levels below 0.7 ng/l. This PHG is expected to reduce to number of additional tumors due to 1,2,3-TCP in drinking water to less than one per million persons exposed over 70 years. This is a very stringent requirement that should adequately protect the populations using contaminated wells for drinking water.

While analytical methods for detection of 1,2,3-TCP at and below the PHG are currently available, they are primarily used in research setting. In setting an MCL and DLR for a chemical, regulators must take into account the sensitivity of the assays currently available in commercial ELAP-certified testing laboratories. Using EPA-approved protocols, the limit of quantitation is currently set at 5 ng/l. This level of 1,2,3-TCP was proposed as the MCL and DLR for drinking water from underground wells in California. The same MCL is being used in other states other states including New Jersey. By contrast the United States EPA has proposed a DLR of 30 ng/l. Thus, the proposed MCL and DLR are 6-fold below the USEPA reporting level and 7-fold higher than the PHG for California. The question is whether this intermediate MCL provides any additional reduction in cancer risk relative to the USEPA target. According the graph showing calculated number of cancer avoided as a function of the MCL (presented in Attachment 2A), there would appear to be a slight reduction in excess cancer by reducing the MCL from 30 to 5 ng/l), albeit at almost twice the cost. As already indicated in the Review Items above, these calculations are probably underestimating the costs of

testing, while possibly overestimating the health benefit by only considering the populations with the highest potential exposures. The calculations presented do not include any confidence limits, making it difficult to discern potential variability in the cost and potential benefits.

The report also proposed Granular Activated Charcoal as the only viable method for removing 1,2,3-TCP from contaminated well water. This conclusion is strongly supported by engineering and technical performance reports from individual wells. Although no specific data were presented, it is likely that well water treated with GAC with no detected 1,2,3-TCP (ND) may actually have levels below the MCL and the PHG level. Assuming this is the case, it is valid to ask how many additional cancers would be prevented if GAC actually reduced levels well below the MCL. Based on a simple extrapolation of the graph provided in Attachment #2, the effect would not appear to be large due to the asymptotic shape of the curve. If this is indeed the case, then setting the MCL at 5ng/l would be almost as effective as attaining the PHG.

The findings on the whole support the conclusion that the use of BAC to reduce 1,2,3-TCP levels in drinking water to a MCL of 5ng/l, with a DRL of 5 ng/l would provide adequate protection of populations who obtain drinking water from contaminated wells. A caveat of this interpretation is again the lack of confidence limits in the calculated values used to estimate costs and reduction of excess cancers. In addition, BAC may have the additional benefit of reducing levels of other organic compounds that have adverse health effects.

Response: The reviewer reiterated concerns regarding monitoring costs and cost-benefit at lower evaluated MCLs. Please refer to the Response to Comment No. 3 on Review Item 1 for information regarding monitoring costs and why the State Water Board does not perform a cost-benefit analysis.

The reviewer inquired about estimating the number of avoided cancers for populations who receive treated water that contains 1,2,3-TCP well below the proposed DLR. The State Water Board did not extrapolate cancer avoidance to the population of California – the cancer avoidance value presented to peer reviewers is an estimated value solely based on the populations known to be exposed to contaminated sources, and represents cancer avoidance for only those same populations. Similarly, the State Water Board did not attempt to extrapolate the risk of cancer to populations exposed to 1,2,3-TCP at concentrations below the proposed DLR of 5 ng/L because the State Water Board has almost no data regarding contamination below 5 ng/L.

Changes to Proposed Regulations: None