

Hexavalent Chromium Maximum Contaminant Level (MCL) Best Available Technologies (BAT)

External Peer Review Summary and Response

The State Water Resources Control Board (State Water Board) is developing regulations to establish a maximum contaminant level (MCL) for hexavalent chromium. Health and Safety Code section 116370 requires the State Water Board to adopt a finding of the best available technology (BAT) for achieving compliance when adopting a primary drinking water standard, “tak[ing] into consideration the costs and benefits of best available treatment technology that has been proven effective under full-scale field applications.” Health and Safety Code section 57004 requires agencies to submit the scientific portions of proposed regulations for external peer review prior to adoption, “along with a statement of the scientific findings, conclusions, and assumptions on which the scientific portions of the proposed rule are based and the supporting scientific data, studies, and other appropriate materials”; if the reviewers find that the agency has failed to demonstrate that the scientific portions of any proposed regulation is based on “sound scientific knowledge, methods, and practices,” the agency must either revise the scientific portions of the proposed regulation or explain why they have a sound scientific basis.

The State Water Board submitted a request and supporting documents for an external scientific peer review of the BAT identified draft hexavalent chromium regulations on August 10, 2021. The reviewers were asked to evaluate the assumptions, findings, and conclusions underlying the following determinations: 1) Ion exchange, reduction/coagulation/filtration (RCF), and reverse osmosis (RO) should, consistent with HSC section 116370, be designated as best available technologies (BAT) for the treatment of hexavalent chromium; and 2) additional information is needed to designate stannous chloride as BAT for the treatment of hexavalent chromium. Reviewers were also invited to comment on whether the scientific portion of the proposed MCL is based on upon sound scientific knowledge, methods, and practices when taken as a whole. The following individuals provided scientific peer review comments:

Graham A. Gagnon, Ph.D., P.Eng.
Professor & Director, Centre for Water Resources Studies
Dalhousie University
Halifax, Nova Scotia

Daniel Giammar, Ph.D., P.E.
Walter E. Browne Professor of Environmental Engineering
Department of Energy, Environmental, and Chemical Engineering
Washington University in St. Louis
St. Louis, Missouri

David Sedlak, Plato Malozemoff Professor, Ph.D.
Director, Berkeley Water Center
Department of Civil & Environmental Engineering
University of California at Berkeley
Berkeley, California

The following consists of summaries of each of the reviewer's comments and the State Water Board's response to those comments. The full peer review, including the original peer review request and all peer reviewer comments, is available on the [State Water Board hexavalent chromium webpage](#).

Reviewer 1 – Graham Gagnon

Summary: The reviewer agreed that the findings, assumptions, and conclusions underlying the State Water Board's determinations are reasonable and based upon sound scientific knowledge, methods, and practices. This reviewer observed that the studies relied upon by the State Water Board were conducted by highly qualified researchers, peer-reviewed or cited by other studies, and independently arrived at consistent conclusions. He also noted that the studies evaluated distribution system water quality for stannous chloride and RO, but not for ion exchange and RCF (even though these technologies are well-applied, and it is assumed distribution system water would not be adversely affected).

Response: Thank you for your review. We did not evaluate the distribution system water quality for the removal technologies because hexavalent chromium is not expected to be in the distribution system. However, the fate of hexavalent chromium when stannous chloride treatment (without filtration) is used is not well understood; we intend to request additional evaluation of the distribution system water quality should this technology be proposed for use by a public water system.

Reviewer 2 – Daniel Giammar

Summary: The reviewer stated that the cited references were appropriate and that given the information available, ion exchange, RCF, and RO should be designated BAT. He highlights that the RCF literature sources did not discuss controlled dosing of chlorine (which has the potential to reoxidize Cr³ back to Cr⁶) or treatment with high dissolved organic carbon in source water, which may require membrane filtration instead of granular media filtration as the last step. In addition, this reviewer points out that nanofiltration may also be used to achieve 70-90% removal of hexavalent chromium, which may be appropriate depending on the source water and the final MCL. The reviewer stated that stannous chloride should not be made a BAT based on the issues described (does not remove contaminant, may be reoxidized in distribution system, and stannous chloride may exceed maximum use level).

State Water Board Question: Does the reviewer have any suggested sources to document nanofiltration removal of hexavalent chromium?

Reviewer Question Response: “Regarding nanofiltration, I have not done a recent literature search on nanofiltration for Cr(VI) removal. The paper that I thought of first is in Journal AWWA (<https://awwa.onlinelibrary.wiley.com/doi/epdf/10.1002/awwa.1051>). It is focused on using NF to regenerate brine from anion exchange treatment for Cr(VI) and not for direct treatment of potable water source, but it has good information regarding the high rejection of Cr(VI) by NF membranes. Often RO and NF are lumped together, and indeed the process is very similar and the actual membranes chosen are different.”

Response: Thank you for your review. While the discussion and sources provided for RCF did not delve into some issues you bring up (controlled dosing of chlorine and treatment with high dissolved organic carbon), the additional source and explanations below clarify those points. Hazen and Sawyer (2015) evaluated the reoxidation of trivalent chromium to hexavalent chromium in the presence of chlorine and found that the chlorine needed to oxidize the excess ferrous prior to filtration did not reoxidize a significant amount of trivalent chromium back into hexavalent chromium. It is agreed that the chlorine dose should be controlled for both the oxidation process and post-treatment distribution chlorine residual. Raw water with high organic carbon may interfere with the coagulation process and result in poor floc formation, in which case a microfiltration membrane-based filtration may be more effective. Overall, we have provided the evidence to support that RCF can adequately treat hexavalent chromium and should be classified as a BAT. Thank you for the information on the ability of nanofiltration to treat hexavalent chromium.

Hazen and Sawyer. 2015. Enhanced Reduction/Coagulation/Filtration Testing for Removing Hexavalent Chromium. City of Glendale Water & Power. Retrieved from: <https://www.glendaleca.gov/home/showpublisheddocument/28326/6358994175897000>.

Reviewer 3 – David Sedlak

Summary: The reviewer concludes that the cited sources support ion exchange as a BAT. The reviewer also concludes that the cited sources also support RCF as a BAT; he questions whether 100 gallons-per-minute should be considered a full-scale field operation, but concedes this is a policy issue rather than a scientific one. Though the reviewer notes that he was unable to access the data for the Chino Desalter, he states that it seems reasonable to conclude that RO treatment is capable of producing water with low Cr6 concentrations under full-scale conditions and that there are hundreds of full-scale RO plants operating in the US from which costs can be estimated with reasonable certainty. In response to stannous chloride, the reviewer is not convinced that the given evidence is a basis for denying the BAT classification, stating that any technology listed here could fail under the wrong conditions. The limitations of the

technology are valid, but there may still be conditions under which the treatment technology is viable.

Response: Thank you for your review. We regret that you were unable to access the information we provided on the Chino Desalter, which showed an incidental treatment of hexavalent chromium from about 5 ug/L to less than 1 ug/L. We appreciate your comments on the definition of full-scale, which we agree is a policy issue. The State Water Board agrees that there are conditions under which stannous chloride treatment technology is viable, and lack of a BAT designation does not preclude any appropriate technology from being used.