

**Peer Review**  
**Scientific Basis of Proposed Hexavalent Chromium Maximum Contaminant Level**  
**Best Available Technologies**

**Reviewer:** Graham Gagnon, PhD, P.Eng.  
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**Date:** November 11, 2021

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Based on my expertise and experience, I am reviewing the findings, assumptions, or conclusions I agreed I could review with confidence:

1. Ion exchange, RCF, and RO should be designated BAT for the treatment of hexavalent chromium.
2. Additional information is needed to designate Stannous Chloride a BAT for the treatment of hexavalent chromium.

Based on my review of materials, I conclude that the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices, as described herein.

**Findings, Assumptions and Conclusions**

Ion exchange, RCF, and RO should be designated BAT for the treatment of hexavalent chromium.

1. Ion exchange should be designated BAT for the treatment of hexavalent chromium
  - a. The scientific material has provided evidence for ion exchange as a viable technology capable of removing hexavalent chromium to below 1 µg/L.
  - b. The scientific material demonstrated that previous work conducted with weak-base and strong-base anion (WBA and SBA, respectively) exchange resins have demonstrated the efficacy of using anion exchange technology to remove hexavalent chromium.
  - c. The scientific analysis relied on a mix of design-based studies (e.g., Hazen and Sawyer, 2013) and peer reviewed studies (e.g., Seidel et al., 2014). These studies were conducted independently and reached a similar conclusion in terms of feasibility. These studies were also conducted by highly qualified individuals with appropriate qualifications to conduct the work.
  - d. The reviewer assumed that pilot work conducted date has reported evidence with a high degree of quality assurance. Given that independent studies resulted in the same outcomes this assumption would pose minimal risk to the conclusions

- e. Based on the pilot work conducted to date, the scientific material concluded that ion exchange technology should be considered as BAT for the treatment of hexavalent chromium.
  - f. The reviewer finds these findings, assumptions and conclusions for ion exchange to be reasonable and based on scientific evidence.
2. Reduction, coagulation, and filtration (RCF) should be designated BAT for the treatment of hexavalent chromium
- a. The scientific material has provided evidence for reduction, coagulation, and filtration (RCF) as a viable technology capable of removing hexavalent chromium to below 1 µg/L.
  - b. The scientific material cited Gumerman et al. (1979), who recognized that the combination of ferrous sulfate and filtration could be used to remove hexavalent chromium from drinking water. The Gumerman et al. (1979) report has been cited 9 times (according to Google Scholar) by scientific studies in drinking water.
  - c. The scientific material demonstrated that Hazen and Sawyer (2013) demonstrated that RCF could achieve hexavalent chromium of less than 5 µg/L. Hazen and Sawyer (2013) confirmed Gumerman et al (1979) assessment independently.
  - d. The scientific material cited Blute et al. (2015b), who noted that RCF is not appropriate for “very small” water systems. The scientific material provided does not restrict RCF technology by flow rate or population size; in doing so, the scientific material assumes that design engineers would be in the best position to determine additional constraints on water technology. The reviewer views this assumption is reasonable and consistent with a standard of care in the drinking water industry.
  - e. Based on the pilot work conducted to date, the scientific material concluded that reduction, coagulation, and filtration (RCF) should be considered as BAT for the treatment of hexavalent chromium.
  - f. The reviewer finds these findings, assumptions and conclusions for reduction, coagulation, and filtration (RCF) to be reasonable and based on scientific evidence.
  - g. Reverse Osmosis (RO) should be designated as BAT for the treatment of hexavalent chromium
  - h. The scientific material has provided evidence for RO as a viable technology capable of removing hexavalent chromium to below 1 µg/L.
  - i. The scientific material demonstrated that two full-scale RO treatment plants in California (CA3610075 and CA3310083) in 2021 used primarily for desalting show incidental treatment of hexavalent chromium from about 5 µg/L to <1 µg/L. This analysis is particularly compelling, as these full-scale water plants have multi-water quality objectives and hexavalent chromium is also removed.
  - j. The scientific material provides evidence (Brandhuber et al., 2004) for previously conducted research that demonstrated the feasibility of RO for removing hexavalent chromium to concentrations less than 2 µg/L.
  - k. Based on the pilot work conducted to date, the scientific material concluded that RO should be considered for BAT for the treatment of hexavalent chromium.

- I. The reviewer finds these findings, assumptions and conclusions for RO to be reasonable and based on scientific evidence.
3. Additional information is needed to designate Stannous Chloride as a BAT for the treatment of hexavalent chromium
  - a. The scientific material has provided sound evidence for recommending that additional information is required to designate stannous chloride as a BAT for the treatment hexavalent chromium.
  - b. The scientific material cites a study by Henrie et al. (2019) that evaluated stannous chloride as a viable technology for hexavalent chromium removal. T Henrie et al. (2019) was published in a peer reviewed journal and is assumed to be of high quality.
  - c. Henrie et al. (2019) study demonstrated several limitations of stannous chloride presently that would restrict its viability as a water technology for hexavalent chromium removal
  - d. Based on the pilot work conducted to date, the scientific material concluded that additional information is required for stannous chloride for the treatment of hexavalent chromium.
  - e. The reviewer finds these findings, assumptions and conclusions for stannous chloride to be reasonable and based on scientific evidence.

### **Assessment of Additional Questions**

Are there any scientific subjects that are part of the scientific basis of the proposal that are not described below?

- The information provided for stannous chloride included an assessment of water quality during treatment and distribution. The RO review cited results from a full-scale plants which presumably have not had adverse water quality results in the distribution system for hexavalent chromium. However, for ion exchange and RCF the studies presented did not report or speculate on any unintended consequences to distribution system water quality. As both ion exchange and RCF are well-applied water technologies in the drinking water industry, it is assumed that distribution system water quality will not be adversely affected. Nevertheless, distribution system water quality was assessed for stannous chloride and not directly assessed for ion exchange and RCF.

Taken as a whole, is the proposal based upon sound scientific knowledge, methods, and practices?

- Overall, the scientific material presented for the best available technologies for treatment hexavalent chromium is reasonable and based upon sound scientific knowledge, methods, and practices.