State of California
STATE WATER RESOURCES CONTROL BOARD

Hexavalent Chromium Maximum Contaminant Level (MCL) Standardized Regulatory Impact Assessment (SRIA)

December 13, 2022

State Water Resources Control Board
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ABBREVIATIONS

BAT – Best Available Technology

BEA – Bureau of Economic Analysis

BAU – Business as Usual

CCR – California Code of Regulations

CDPH – California Department of Public Health

CEM – Cost Estimating Methodology

CER – Cost-Effectiveness Ratio

CPI – Consumer Price Index

CWS – Community Water System

DDW – Division of Drinking Water

DLR – Detection Limit for Purposes of Reporting

U.S. EPA – United States Environmental Protection Agency

GPM – Gallons per Minute

HSC – California Health and Safety Code

MCL – Maximum Contaminant Level

MCER – Marginal Cost-Effectiveness Ratio

NAICS – North American Industry Classification System

NTNCWS – Non-transient Non-community Water System

O&M – Operations and maintenance

OEHHA – Office of Environmental Health Hazard Assessment

PHG – Public Health Goal

POU – Point-of-Use

PWS - Public Water System

RIMS – Regional Input-Output Modeling System

SRIA – Standardized Regulatory Impact Assessment

State Water Board – State Water Resources Control Board

TNCWS – Transient Non-community Water System

A. INTRODUCTION

The Division of Drinking Water (DDW) of the State Water Resources Control Board (State Water Board) is responsible for adopting drinking water standards. Primary drinking water standards, as defined in section 116275 of the California Safe Drinking Water Act (Health & Safety Code (HSC), div. 104, pt. 12, ch. 4, section 116270 et seq.), must be set in accordance with the requirements of HSC 116365. The purpose of the proposed regulation addressed in this Standardized Regulatory Impact Assessment (SRIA) is to adopt a primary drinking water standard for hexavalent chromium in drinking water consisting of a maximum contaminant level (MCL) and pertinent monitoring and reporting requirements. Consistent with Title 1 of the California Code of Regulations (CCR), section 2003(a), the economic impact method used for the assessment was the Regional Input-Output Modeling System (RIMS II) developed by the U.S. Bureau of Economic Analysis (BEA).

A.1 Regulatory History

Hexavalent chromium is currently regulated under the 0.05 milligrams per liter (mg/L) MCL for total chromium. California's MCL for total chromium was established in 1977, when what was then a "National Interim Drinking Water Standard" for total chromium was adopted. The total chromium MCL was established to address exposures to hexavalent chromium, which is the more toxic form of chromium. The U.S. Environmental Protection Agency (U.S. EPA) adopted the same standard for total chromium in 1986 but raised the federal MCL to 0.1 mg/L in 1991. California retained its 0.05 mg/L MCL for total chromium.

In 1999, the California Department of Public Health's (CDPH's) precursor, the California Department of Health Services, sought to determine whether an MCL that is specific for hexavalent chromium would be appropriate. Subsequently, concerns about hexavalent chromium's potential carcinogenicity when ingested resulted in the adoption of Health and Safety Code section 166365.5, which required CDPH to adopt a new MCL specific for hexavalent chromium.

In July of 2011, OEHHA established a hexavalent chromium Public Health Goal (PHG) of 0.02 micrograms per liter (ug/L). This enabled CDPH to proceed with setting a primary drinking water standard specific to the hexavalent form of chromium. As part of that rulemaking process, in August 2013 CDPH proposed a hexavalent chromium MCL of 0.010 mg/L (10 ug/L).

On May 28, 2014, the Office of Administrative Law (OAL) approved the regulations submitted by CDPH, and the MCL became effective on July 1, 2014. On September 4, 2015, Senate Bill 385 was signed by the Governor to provide public water systems (PWS) time to come into compliance without being deemed in violation of the MCL.

On May 31, 2017, the Superior Court of Sacramento County issued a judgement invalidating the hexavalent chromium MCL for drinking water. The court ordered the State Water Board to take the necessary actions to delete the hexavalent chromium MCL from the California Code of Regulations. The deletion became effective on September 11, 2017, and since that date, no MCL specifically for hexavalent chromium has been in effect. The court's reason for finding the MCL invalid was that CDPH failed to determine whether the MCL was economically feasible. The court also ordered the adoption of a new hexavalent chromium MCL, which is the purpose of the current rulemaking.

A.2 Proposed Regulatory Action

Amend Section 64415 (Laboratory and Personnel): A new subsection (b) will be added, and the previous subsection (b) will become subsection (c). The new subsection (b) will specify that U.S. EPA methods 218.6 and 218.7 must be used to monitor for hexavalent chromium.

Amend Section 64431 (Maximum Contaminant Levels – Inorganic Chemicals): Table 64431-A would be revised to add a hexavalent chromium MCL of 10 ug/L. There is currently no MCL for hexavalent chromium, and the State Water Board is required—both by state law and court order—to create one. This MCL will provide public health benefits by reducing the amount of hexavalent chromium in drinking water, which will reduce the number of people who develop cancer and other health conditions from this contaminant.

Amend Section 64432 (Monitoring and Compliance – Inorganic Chemicals): Table 64432-A would be changed to adopt a hexavalent chromium detection limit for purposes of reporting (DLR) of 0.05 ug/L. A DLR will be beneficial by ensuring a consistent standard of reporting for hexavalent chromium data statewide, which will increase the data quality of hexavalent chromium sampling results, provide for improved determination of hexavalent chromium in drinking water sources, and allow future determination of technological feasibility of treating to concentrations as low as 0.05 ug/L.

Subsection (p) will be added to include requirements for a compliance plan, which will be required for any system that exceeds the MCL before the applicable date in Table 64432-B. The compliance plan must be submitted within 90 days of the MCL exceedance, and must include:

- The proposed method for complying with the hexavalent chromium MCL;
- If the proposed compliance method requires construction, the date by which the system will submit to the State Board final plans and specifications for the proposed compliance method;
- If the proposed compliance method requires construction, the anticipated dates for commencing construction and completing 100% of construction;
- The anticipated date by which a treatment plant operations plan will be completed. The operations plan must include:
    - Performance monitoring program;
    - Unit process equipment maintenance program;
    - How and when each unit process is operated;
    - Procedures used to determine chemical dose rates;
    - Reliability features; and

- Treatment media inspection program.

The compliance plans are required to ensure compliance with the hexavalent chromium MCL no later than the applicable date in Table 64432-B, and systems may submit amendments to their compliance plan. All compliance plans will need to be reviewed and approved by the State Water Board.

Table 64432-B would be added to provide compliance dates for different system sizes. For systems with 10,000 or more service connections, the compliance date would be two years after the regulation takes effect. For systems with 1,000 to 9,999 service connections, the compliance date would be three years after the regulation takes effect. For systems with fewer than 1,000 service connections, the compliance date would be four years after the regulation takes effect. These compliance dates provide extra time for all systems (instead of requiring compliance when the regulation takes effect) and allow smaller systems to benefit from any technological advancements or cost savings discovered by larger systems, which generally have more resources with which to implement treatment.

<u>Amend Section 64447.2</u> (Best Available Technologies (BAT) – Inorganic Chemicals): Table 64447.2-A would be revised to adopt best available technologies (BAT) for hexavalent chromium. The best available technologies are capable of reducing hexavalent chromium below the MCL of 10 ug/L. However, other technologies exist that may also be capable of reducing hexavalent chromium to concentrations below the MCL. The State Water Board is not prescribing that any particular treatment(s) be used, and water systems may use any form of treatment that they demonstrate is capable of reducing hexavalent chromium concentrations below the MCL. The benefits of this section are that water systems know which standard treatments are successfully used to treat hexavalent chromium without the need to invest in newer or untested technology.

<u>Amend Section 64465</u> (Public Notice Content and Format): Appendix 64465-D would be revised to adopt health effects language for public notifications for a hexavalent chromium MCL violation. The U.S. EPA initiated this specific language requirement in regulations for primary MCLs in 1991, and, for consistency, language for this state mandated MCL has been adopted as well. The benefit of this provision is that it will provide consistency in informing the public of the possible health effects related to hexavalent chromium if a MCL violation occurs, consistent with HSC 116450.

<u>Amend Section 64481</u> (Content of Consumer Confidence Report): Appendix 64481-A would be revised to adopt Consumer Confidence Report language (typical origins of contaminants with primary MCLs) for hexavalent chromium. The language proposed is in conformance with the language for other chemicals with primary MCLs, a specific language requirement initiated in 1998 by the U.S. EPA. The purpose of this section is to establish the primary content and format requirements of the Consumer Confidence Report, including the language to be communicated to the public when a contaminant has been detected. This benefits the public by providing the Consumer Confidence Report health concerns description required by HSC 116470.

Subsection (p) would be added to require that specific language be added to a system’s Consumer Confidence Report if the system exceeds the hexavalent chromium MCL before the applicable date in Table 64432-B. Table 64481-F would be added to provide the specific language required to explain that although hexavalent chromium was detected at levels above the MCL, the system is not considered in violation of the MCL until the applicable date in Table 64432-B. The system must also include in the Consumer Confidence Report the actions it is taking or plan to take to ensure compliance by the applicable compliance date.

A.3 Major Regulation Determination

The Proposed Regulations have been determined to be a major regulation under 1 CCR section 2000, requiring a SRIA because the economic impact of the regulation is projected to exceed $50 million in a 12-month period. The determination of costs includes required monitoring and treatment costs for all PWS[1] in California.[2] Monitoring costs are expected to start in the year the regulation is adopted (year 1), and treatment costs are expected to start two years after the regulation is adopted (year 3). However, smaller systems will be given additional time to install treatment and come into compliance: systems with 1,000 to 10,000 service connections must begin treatment by year 4, and systems with less than 1,000 service connections must begin treatment by year 5. Costs are expected to exceed $50 million two years after the regulation is adopted (year 3).

In addition, HSC 57005 requires that before adopting any regulation with impacts to the state's business enterprises in excess of $10 million, the State Water Board must evaluate whether there are less costly alternatives to the proposed regulation that would be equally as effective in achieving environmental protection and achieve full compliance with statutory mandates. That evaluation is found in section F of this document.

A.4 Baseline Information

California requires PWS to sample their drinking water sources and have the samples analyzed for inorganic chemicals to determine compliance with MCLs, also referred to as drinking water standards. PWS can be community water systems (CWS), non-transient non-community water systems (NTNCWS), transient non-community water systems (TNCWS), or wholesalers. Each of PWS can have any number of sources and serve any number of people. The proposed regulation directly affects the 233 PWS with hexavalent chromium concentrations of more than 10 ug/L, out of a total of 7,355 PWS in California.[3] Of the 233 affected PWS, 160 are CWS, 62 are NTNCWS, 7 are TNCWS, and 4 are wholesalers. Of the 233 PWS, 146 are privately-owned systems and 82 are public water

[1] Most TNCWS are not required to monitor their sources.

[2] Although there may be other, less expensive ways to comply with the MCL (such as blending, drilling new wells, or purchasing water from another system), costs are estimated based on the assumption that all systems in exceedance of the MCL will treat.

[3] Not all sources have tested for hexavalent chromium. 95% of CWS sources, 80% of NTNCWS sources, and 54% of wholesaler sources were tested for hexavalent chromium between January 1, 2010, and June 21, 2021. Only 8% of TNCWS sources have sampled (these systems are usually not required to test for hexavalent chromium). Therefore, the number of affected sources may increase as more systems complete testing.

agencies. Of the privately owned PWS, 13 are small businesses, as detailed in section C.3. These 13 are either NTNCWS or TNCWS.

Out of the 10,131 PWS sources that sampled for hexavalent chromium between January 1, 2010, and June 21, 2021, 501 sources (in the 233 systems) have annual concentrations above the proposed MCL of 10 ug/L. Combined, these contaminated systems serve 5,542,798 people statewide, who are expected to experience health benefits from lower concentrations of hexavalent chromium in their drinking water, as detailed in section B.3, but also indirect costs, as discussed in section C.5. The vast majority of the population affected is served by CWS (5,328,938 people) and 94% are in urban areas.

The economic impact of the proposed regulation is evaluated against a baseline of current business as usual (BAU) practices in which hexavalent chromium is not regulated except as a part of the total chromium MCL of 50 ug/L. In this baseline, water systems are not required to sample for or treat hexavalent chromium specifically. However, 9 systems have already installed treatment for hexavalent chromium, even though source concentrations do not exceed 50 ug/L. However, because the baseline does not include a requirement to treat for hexavalent chromium below 50 ug/L, the estimated treatment costs for these 9 systems are included in the cost estimates below.

A.5 Public Outreach and Input

There have been six pre-regulation workshops held for the hexavalent chromium MCL. The first workshop, held on April 27, 2020, focused on economic feasibility and included a white paper titled "Economic Feasibility Analysis in Consideration of a Hexavalent Chromium MCL" published in February 2020. The second and third workshops were held on December 8 and 9, 2020, and covered treatment costs assumptions, equations, data, and results. The fourth and fifth workshops were held on April 5 and 7, 2022, and covered an administrative draft of the MCL with a focus on updated cost estimates. A CEQA scoping meeting was held between the two sets of workshops, on November 29, 2021. Comments, suggestions, and alternatives were solicited at each workshop and meeting, and during the following comment periods:

- Notice released on March 6, 2020 (revised April 9, 2020), with written comments due May 15, 2020;
- Notice released on November 25, 2020, with written comments due December 31, 2020;
- Notice released on November 5, 2021, with written comments due December 6, 2021;
- Notice released on March 21, 2022, with written comments due April 29, 2022.

B. BENEFITS

Section 2003, subdivision (a)(3) requires that the SRIA use an economic impact method and approach that can produce, to the extent possible, qualitative estimates of economic variables that address or facilitate the quantitative or qualitative estimation of the benefits of the regulations, including the benefits to health, safety and welfare of California residents, worker safety and state's environment and quality of life. Although it is possible to calculate an estimated reduction in cancer rates from the proposed regulations, only a qualitative estimation of benefits is provided given the lack of an established and approved methodology for the Water Board to use to monetized benefits.

Subsection (c) of that regulation requires that costs and benefits be separately identified for different groups of agencies, businesses, and individuals, if the impact of the regulations will differ significantly among groups. Here, the benefits of the regulations were considered for the typical business, small businesses, and individuals.

The primary benefits of the proposed regulation are improved public health through the improvement of drinking water quality. The main beneficiaries would be those served by PWS whose current concentration of hexavalent chromium is greater than the proposed MCL. Hexavalent chromium, even at low levels, can cause both cancer and noncancer health effects. The health benefits are the reduction in adverse health effects from hexavalent chromium in drinking water, as discussed below. While the reduction in cancer cases can be estimated, the reduction in noncancer cases (mainly liver toxicity) cannot be estimated due to limits in the science of noncancer effects.

Additional benefits are the increased public confidence in the safety of California's public drinking water from hexavalent chromium concentrations above the MCL and public assurance that exposure to hexavalent chromium in drinking water is at the lowest level technologically and economically feasible.

B.1 Benefits to Typical Businesses

The typical business will benefit from having cleaner drinking water, which may translate to health benefits and healthcare cost savings for customers or employees, as well as savings on bottled water, to the degree people are avoiding or treating tap water due to hexavalent chromium. This could lead to increased spending on goods and services for things other than healthcare or bottled water. These effects cannot currently be quantified.

B.2 Benefits to Small Businesses

Small businesses will experience the benefits listed above for typical businesses.

B.3 Benefits to Individuals

There are two categories of health benefits to individuals: cancer and noncancer. The cancer-related health benefits are calculated using the hexavalent chromium PHG (0.02 ug/L), the highest annual hexavalent chromium concentration (ug/L) of each PWS source, the population served by each PWS, and the number of sources in each PWS. The number of cancer cases avoided by reducing the hexavalent chromium concentration in each source to the MCL are estimated for each source with this equation:

$$Cases = \left(\frac{PWS\ Population}{no.\ of\ sources\ in\ PWS}\right) * \left(\frac{Cr6\ source\ concentration - MCL}{1{,}000{,}000 * PHG}\right)$$

where the hexavalent chromium concentration, the MCL, and the PHG all have the same units. This equation multiplies the source's proportional population by the reduced risk of drinking water at the MCL. Because the PHG represents a one in one million cancer risk (OEHHA, 2011), the equation is divided by one million to calculate the number of cases expected at a given concentration for a given population.

For an MCL of 10 ug/L, approximately 898 cancer cases will be avoided over 70 years statewide. There is currently no established and approved methodology for the Water Board to use to quantify a monetized benefit for reducing cancer risk. Therefore, while staff calculated avoided cancer cases based on OEHHA's PHG report (OEHHA, 2011), there is no methodology to monetize these benefits. This document therefore does not include an assessment of the monetary benefit of these reductions.

Additional nonquantifiable health benefits are expected in the form of reduced cases of liver toxicity and a reduction in adverse effects in the liver and blood forming tissues (OEHHA, 2011). Concentrations of hexavalent chromium below 2 ug/L protect against these noncancer effects. However, because the noncancer effects of hexavalent chromium are nonlinear, the number of cases caused by any particular concentration above 2 ug/L cannot be quantified.

The treatment for hexavalent chromium may in some cases provide a secondary benefit by removing other contaminants in drinking water. For example, treatment through ion exchange may remove trace levels of other inorganic contaminants, such as uranium and arsenic, that may be present in some public water system wells. The health concerns associated with such contaminants would be reduced. The magnitude of this secondary benefit is likely to be relatively low and cannot be estimated based on currently available data.

As noted above, another benefit of adopting an MCL is that it may improve public perception of the safety of the drinking water supply, potentially resulting in a lower demand for home water treatment systems and a decreased rate of consumption of bottled water.[4] The purchase of bottled water, which costs $52 to $107 per month for a 3-person household (calculated in the Cost Estimating Methodology (CEM), section I.7), is a burden, especially for those with lower incomes. In addition, increased confidence in the tap water may reduce consumption of sweetened beverages in place of water.

Individuals also benefit from the Consumer Confidence Report language, which is intended to inform the public of the major origins or sources of the contaminant and the health effects of that contaminant. Because the language makes sure that the public are all aware of the sources of hexavalent chromium and the health effects, it provides consistent statewide quality of information between PWS and their customers, which is essential to communities trusting the water they are served.

[4] Bottled water is not specifically tested for hexavalent chromium and may not be safer to drink than tap water. However, some people prefer drinking bottled water when they are concerned about the safety of tap water.

C. COST IMPACTS

The proposed regulation will result in direct costs to PWS, which will likely have spillover effects to individuals and businesses that purchase water from impacted PWS. Individuals and businesses that are not PWS are not expected to face any direct costs due to this regulation. Instead, they will experience water cost increases to the degree that PWS pass on the costs of monitoring and treating for hexavalent chromium to them as customers. The direct costs to PWS and higher water bills result in indirect and induced costs to the economy statewide, which are discussed in the macroeconomic analysis (section E).

Costs include monitoring, capital costs of treatment, operation and maintenance of treatment, and preparation of compliance plans. The analysis of specific categories of individual and business enterprises affected includes typical businesses (privately owned PWS), small businesses (privately owned NTNCWS and TNCWS); Native American tribes; individuals served by PWS; and businesses that purchase water from PWS. Costs are expected to start at the beginning of 2024, when all PWS required to monitor must do so within 6 months of the regulation's effective date if they have not sampled in the past 2 years. PWS will have different dates for complying with the MCL based on the compliance schedule in Table 1, which assumes the regulation will become effective in the last quarter of 2023.

Table 1. Compliance Schedule

System Size	Compliance Schedule	Estimated Date of Compliance with MCL
10,000 service connections or more	2 years from regulation's effective date	January 1, 2026
1,000 to 9,999 service connections	3 years from regulation's effective date	January 1, 2027
Less than 1,000 service connections	4 years from regulation's effective date	January 1, 2028

C.1 Direct Cost Inputs

The State Water Board used the hexavalent chromium detections for active sources from its Water Quality Information Replacement (WQIR) database for the period January 1, 2010, through June 21, 2021 (SWRCB, 2021b) and data from the Safe Drinking Water Information System (SDWIS) (SWRCB, 2021a). The source monitoring results were evaluated to obtain the highest running annual average concentration for each active source. Sources with an annual average concentration above the proposed MCL (10 ug/L) were assumed to use the least expensive treatment between Reduction-Coagulation-Filtration (RCF), strong base anion exchange (SBA), and weak base anion exchange (WBA) treatment, the details of which are in the CEM (section I). At the proposed MCL of 10 ug/L, RCF is calculated to be the least expensive treatment for all but 11 sources. WBA treatment was chosen for the remaining 11 sources, and SBA treatment was never the least expensive option for any source at the proposed MCL.

Because the costs of each treatment type were calculated for each source, it is possible to compare costs across treatment types and sources to identify cost trends. For example, the higher a source's hexavalent chromium concentration, the higher the calculated WBA resin and disposal costs were, which was likely due to the assumption that WBA resins were not regenerated, so their use would be directly proportional to the amount of hexavalent chromium removed from the source water. Comparatively, SBA resins may or may not be regenerated, and resin use also depended on the amount of sulfate and nitrate in the source water, so the same resin and disposal cost trends were not observed. Following the WBA trend, the 11 sources for which WBA treatment was calculated to be the least expensive are some of the least contaminated sources (the highest influent concentration among them was 11.3 ug/L). When comparing to the selected WBA annualized costs, the alternative RCF costs were calculated between $917 and $33,815 higher and the alternative SBA costs were calculated between $88,577 and $271,816 higher. Across all sources, SBA was generally the most expensive treatment option, accounting for 70% of the highest calculated costs. Disposal costs were often a driver for high SBA costs, and resin and disposal costs were often a driver for high WBA costs. In comparison, high RCF costs were driven by capital costs and chemical costs.

C.1.a Monitoring Costs

Source monitoring is required for CWS, NTNCWS, and wholesalers. TNCWS are only required to monitor sources for inorganic chemicals (including hexavalent chromium) if they are using surface water sources to serve an average daily population greater than 1,000 people or if they are subject to potential contamination based on a sanitary survey. Source monitoring can be at either routine or increased frequencies, depending on the contamination of the source and the type of water being monitored (groundwater or surface water). Routine monitoring, which occurs when a source has hexavalent chromium concentrations below the MCL, is required once every three years for groundwater sources and once per year for surface water sources. Increased monitoring, which is triggered by hexavalent chromium concentrations above the MCL, is required quarterly (four times per year) for both groundwater and surface water sources. Treatment monitoring will be required if a source treats for hexavalent chromium. The treated effluent must be monitored monthly to ensure compliance with the MCL.

Monitoring is estimated to cost $78.63 per sample based on a survey of California laboratories (more details are available in the CEM, section I.3.a.1). All monitoring (routine, increased, and treated) costs are summarized in Table 2 by year and by system type.

Table 2. Monitoring Costs (in 2022 dollars)

Year	CWS	NTNCWS	TNCWS	Wholesalers	Total
2024	402,324	83,243	24,375	23,353	533,295
2025	402,324	83,243	24,375	23,353	533,295
2026	567,447	83,243	24,375	23,353	698,418
2027	679,730	83,243	24,375	32,789	820,137
2028	791,070	151,179	30,980	32,789	1,006,018
2029	791,070	151,179	30,980	32,789	1,006,018

C.1.b Capital Costs (Annualized)

Capital costs are the upfront treatment costs, which consist of equipment, infrastructure, construction activities, and professional services. A detailed breakdown of the capital costs is available in the CEM (section I.3.a.2). Capital costs were calculated for each source installing treatment. The statewide capital costs are shown in Table 3 by year and by system type. Capital costs are assumed to be amortized over 20 years and will be fully amortized by 2047.

Table 3. Annual Amortization of Capital Costs (in 2022 dollars)

Year	CWS	NTNCWS	TNCWS	Wholesalers	Total
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	57,472,321	0	0	615,890	58,088,212
2027	86,977,729	0	0	615,890	87,593,620
2028	91,883,698	2,509,505	217,530	615,890	95,226,624
2029	91,883,698	2,509,505	217,530	615,890	95,226,624

C.1.c Annual Operations and Maintenance (O&M) Costs

Operations and Maintenance (O&M) costs consist of disposal of wastes, chemicals, labor, energy, and maintenance costs. A detailed breakdown of O&M costs is available in the CEM (section I.3.a.2). O&M costs were calculated for each source installing treatment. The statewide annual O&M costs are shown in Table 4 by year and by system type. The O&M costs are then further broken down for the macroeconomic analysis into disposal and chemicals costs, shown in Table 5 andTable 6, respectively, by year and system type. However, the chemical and disposal costs for very small systems could not be separated from other O&M costs, so they are included in the remaining O&M costs (O&M costs minus disposal and chemical costs), which are shown in Table 6 by year and by system type.

Table 4. Total Operations and Maintenance Costs (in 2022 dollars)

Year	CWS	NTNCWS	TNCWS	Wholesalers	Total
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	48,783,806	0	0	575,617	49,359,423
2027	75,056,607	0	0	575,617	75,632,224
2028	79,991,261	2,533,727	234,935	575,617	83,335,540
2029	79,991,261	2,533,727	234,935	575,617	83,335,540

C.1.c.1 Disposal Costs

Disposal costs, which are a component of the total annual O&M costs, were calculated for each source installing treatment, as described in the CEM (section I.3.a.2). As previously discussed, some disposal costs could not be separated from other O&M costs and, therefore, were not included in this section. The statewide disposal costs are shown in Table 5 by year and by system type.

Table 5. Disposal Costs (O&M Component) (in 2022 dollars)

Year	CWS	NTNCWS	TNCWS	Wholesalers	Total
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	4,683,914	0	0	15,007	4,698,921
2027	6,604,789	0	0	15,007	6,619,795
2028	6,712,784	17,471	0	15,007	6,745,262
2029	6,712,784	17,471	0	15,007	6,745,262

C.1.c.2 Chemical Costs

Chemical costs, which are a component of the total O&M costs, were calculated for each source installing treatment, as described in the CEM (section I.3.a.2). As previously discussed, some chemical costs could not be separated from other O&M costs and, therefore, were not included in this section. The statewide chemical costs are shown in Table 6 by year and by system type.

Table 6. Chemical Costs (O&M Component) (in 2022 dollars)

Year	CWS	NTNCWS	TNCWS	Wholesalers	Total
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	12,933,558	0	0	42,854	12,976,412
2027	18,236,654	0	0	42,854	18,279,508
2028	18,470,530	49,847	0	42,854	18,563,231
2029	18,470,530	49,847	0	42,854	18,563,231

C.1.c.3 Remaining Operations & Maintenance Costs

The remaining O&M costs[5] for each source requiring treatment are shown in Table 7, by year and by system type. The remaining O&M costs equal the total O&M costs minus disposal and chemical costs.

Table 7. Remaining O&M Costs (O&M Component) (in 2022 dollars)

Year	CWS	NTNCWS	TNCWS	Wholesalers	Total
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	31,166,334	0	0	517,756	31,684,091
2027	50,215,164	0	0	517,756	50,732,921
2028	54,807,947	2,466,409	234,935	517,756	58,027,047
2029	54,807,947	2,466,409	234,935	517,756	58,027,047

C.1.d Costs to Prepare Compliance Plans

All PWS with sources that exceed the MCL would be required to submit a compliance plan by the end of 2024. An average of 100 hours of an engineer's time will be needed to prepare each compliance plan.[6] Based on the average California engineer's salary of $113,200, the hourly cost to employ a qualified water quality engineer (including overhead) is $76 per hour, the calculations for which are detailed in the CEM (section I.3.a.3). The estimated cost to prepare a compliance plan is $7,619 per system. Table 8 shows the total statewide costs to prepare compliance plans, by system type. Because compliance plans are a one-time cost, they are only expected to occur in one year.

Table 8. Total Costs to Prepare Compliance Plans (in 2022 dollars)

Year	CWS	NTNCWS	TNCWS	Wholesalers	Total
2024	1,219,077	472,392	53,335	30,477	1,775,281

C.1.e Total Direct Costs

The costs shown in Table 2,Table 3, Table 4, and Table 8 are combined in Table 9 below, showing the total costs to all PWS by year. The costs in Table 5,Table 6, and Table 7 are also not combined because they are already included in the total O&M costs in Table 4.

[5] The remaining O&M costs consist mostly of labor, energy, and maintenance costs. However, for very small systems, disposal and chemical costs could not be separated from the remaining costs, so those costs are also included here.

[6] A range of 80 to 120 hours (average 100 hours) was determined based on staff experience with reviewing other technical reports of a similar nature, including tracking submittals, receipts, reviews, and compliance statuses; reviewing for completeness and compliance; and conducting any necessary follow-up with water system personnel or their representatives.

Table 9. Annual Direct Costs (in 2022 dollars)

Year	Monitoring Costs	Amortized Capital Costs	Operations & Maintenance Costs	Compliance Plan Costs	Total Costs
2024	533,295	0	0	1,775,281	2,308,576
2025	533,295	0	0	0	533,295
2026	698,418	58,088,212	49,359,423	0	108,146,053
2027	820,137	87,593,620	75,632,224	0	164,045,981
2028	1,006,018	95,226,624	83,335,540	0	179,568,183
2029	1,006,018	95,226,624	83,335,540	0	179,568,183

C.2 Direct Costs on Typical Businesses (PWS)

All businesses that experience direct costs due to this regulation are PWS.[7] For each PWS category, a typical business is assumed, defined as a hypothetical average privately owned PWS with the average sizes and average characteristics that reflect the privately owned systems in that category. The annual costs to the typical privately owned PWS for each water system category are shown in Table 10. However, these are only the average costs for PWS not already in compliance with the MCL. PWS already in compliance will only experience monitoring costs, which annually average $70, $38, $36, and $291 for privately owned CWS, NTNCWS, TNCWS, and wholesalers, respectively. Wholesalers are not included in the table because there are no privately owned wholesalers that are expected to exceed the proposed MCL of 10 ug/L. As noted above, each system that exceeds the MCL will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619 per system. Because this is a one-time cost, it is not included in the annual costs below.

Table 10. Annual Costs to the Typical Privately Owned PWS for Each System Type (in 2022 dollars)

PWS Type	Number of Systems	Average Number of People Served	Average Number of Service Connections	Monitoring Costs	Amortized Capital Costs	Operations & Maintenance Costs	Total Costs
CWS	91	3,737	1,071	1,825	133,224	118,101	253,151
NTNCWS	48	168	5	1,468	36,460	37,345	75,273
TNCWS	7	156	41	1,258	31,076	33,562	65,896

[7] However, most businesses that are impacted by this regulation will only experience indirect costs when they buy drinking water from a PWS. Those indirect costs are discussed in section C.6.

C.3 Direct Costs on Small Businesses (NTNCWS and TNCWS)

CWS and wholesalers are water companies (utilities) providing drinking water to the public and, pursuant to Government Code section 11342.610, are exempt from the definition of a small business in the Administrative Procedure Act. However, NTNCWS and TNCWS may be considered small businesses if they are independently owned and operated, not dominant in their field of operation, and have less than 100 employees (Gov. Code section 11346.3). While some NTNCWS and TNCWS may be small business, the State Water Board does not currently have the data to evaluate which systems meet the criteria. Therefore, the impacts for a typical small business were estimated as the average impacts of privately owned NTNCWS and TNCWS systems. Table 11 shows the annual costs to a typical small business. As noted above, in addition to the costs in Table 11, each system that exceeds the MCL will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619 per system. Because this is a one-time cost, it is not included in the annual costs below.

Table 11. Annual Costs to the Typical Small Business (in 2022 dollars)

PWS Type	Monitoring Costs	Amortized Capital Costs	Operations & Maintenance Costs	Total Costs
Typical Small Business	1,441	23,689	17,996	43,126

C.4 Direct Costs on Native American Tribes

Current monitoring data indicates that only one impacted PWS is owned by a Native American Tribe (a medical facility in Yolo County), and the costs associated with treating the water in that system are shown in Table 12. In addition to the costs in Table 12, the system will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619. Because this is a one-time cost, it is not included in the annual costs below.

Table 12. Statewide Annual Costs to Native American Tribes (in 2022 dollars)

PWS Type	Number of Systems	Monitoring Costs	Amortized Capital Costs	Operations & Maintenance Costs	Total Costs
NTNCWS	1	1,258	23,119	29,243	53,621

C.5 Cost Impact on Individuals Served by Affected PWS

The proposed regulation does not impose any direct costs on individuals served by the affected PWS or on any other individual in California.[8] However, the affected PWS may choose to pass on some or all of their increased costs to the households that they serve,

[8] This regulation only applies to PWS, not private wells.

likely in the form of higher monthly water bills. Thus, based on current monitoring data, it is expected that 5,327,349 individuals – approximately 14% of California's population – would experience water cost increases. Table 13 presents the distribution of the affected population across quartile ranges of additional monthly water costs. The table includes the population in affected CWS only (approximately 5.3 million individuals out of the 5.5 million affected). The population served by the other types of water systems could not be calculated due to data limitations. As shown in the table, approximately 4.5 million individuals might incur additional water costs no greater than $20.46 per month, 743,632 individuals might incur additional water costs ranging from $20.46 to $57.92 per month, 93,616 individuals might incur additional water costs ranging from $57.92 to $121.02 per month, and 5,047 individuals might incur additional water costs ranging from $121.02 to $463.21 per month. These estimates are conservative because they assume that the affected PWS choose to pass on all of their increased costs to households.[9]

Table 13. Population with Potential Additional Monthly Water Costs per Household (in 2022 dollars)

Quartiles of additional monthly water costs	Population served by affected CWS	Percent of state population
1st quartile ($0.10 to $20.46)	4,485,054	11.45%
2nd quartile ($20.46 to $57.92)	743,632	1.9%
3rd quartile ($57.92 to $121.02)	93,616	0.24%
4th quartile ($121.02 to $463.21)	5,047	0.01%
Total	5,327,349[10]	13.60%

The potential economic impact of higher household water bills on the state economy is discussed in the Macroeconomic Modeling section (section E). Potential health benefits to individuals served by the affected PWS are discussed in the Benefits section (section B).

C.6 Cost Impact on Businesses that Purchase Water from Affected PWS

The proposed regulation does not impose any direct costs on businesses other than PWS. However, as with households, the affected PWS may choose to pass on some or all of their increased costs to the businesses that they serve, likely in the form of higher monthly water bills. These businesses would incur additional water costs similar to those

[9] PWS may be eligible for grant funding. PWS may also be able to use other, non-treatment methods to comply with the MCL.

[10] This population total does not add up to the total population served by CWS because two CWS (a resort and a detention center) do not charge households for water, and so were not included in this table.

incurred by households, as described in the prior section. The number and types of businesses affected cannot be assessed due to data limitations.[11]

D. FISCAL IMPACTS

In addition to impacts to the PWS, businesses, and individuals identified above, the proposed regulation would also have impacts on local, state, and federal governments, which are referred to as "Fiscal Impacts."

D.1 Local Government

The State Water Board's most recent data about hexavalent chromium contamination indicates that there are 82 PWS that have sources contaminated with hexavalent chromium above 10 ug/L that are operated by local governments, usually a city, county, or district. As noted above, in addition to the costs in Table 14, each system that exceeds the MCL will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619 per system. Because this is a one-time cost, it is not included in the annual costs table below. This workload is expected to be absorbed by existing local government personnel and resources (so no additional personnel costs are assumed), and the costs are expected to be passed on to ratepayers.

Table 14. Statewide Annual Costs to Local Government (in 2022 dollars)

PWS Type	Number of Systems	Monitoring Costs	Amortized Capital Costs	Operations & Maintenance Costs	Total Costs
CWS	67	339,682	77,948,350	67,646,690	145,934,722
NTNCWS	11	16,355	647,465	644,006	1,307,826
TNCWS	0	0	0	0	0
Wholesaler	4	12,581	615,890	575,617	1,204,089
Total	82	368,618	79,211,704	68,866,314	148,446,636

D.2 State Government

D.2.a State Water Resources Control Board

The initial impact of the proposed regulation on the State Water Board would be a relatively small impact on staffing resources, which could potentially be accommodated through redistribution of existing staff at the district office level. However, additional personnel may be needed for effective implementation and enforcement of the adopted MCL, including for tasks such as evaluating submitted compliance plans. Every system with at least one source above the proposed MCL will be required to submit a compliance plan. It is estimated that an average of 35 hours of DDW staff time will be needed to review and respond to each compliance plan, and the hourly cost to employ a Water

[11] Note that some businesses that use water in their business (e.g., cement plant), may be able to use other nontreated source of water for their production needs.

Resource Control Engineer (including overhead) is $90.69 per hour, the calculations for which are detailed in the CEM (section I). The total costs to the State Water Resources Control Board are detailed by PWS type in Table 15.

Table 15. Total Costs to State Water Resources Control Board (in 2022 dollars)

PWS Type	Number of Systems	Total Number of Hours to Review Compliance Plans	Total Costs to Review Compliance Plans
CWS	160	5,600	507,864
NTNCWS	62	2,170	196,797
TNCWS	7	245	22,219
Wholesaler	4	140	12,697
Total[12]	233	8,155	739,577

D.2.b Other State Agencies

Table 16 shows the breakdown of annual costs to state agencies. Only one PWS that is expected to exceed the MCL is owned by a state agency (the University of California), and the agency will incur costs if treatment is necessary to comply with the MCL. As noted above, in addition to the costs in Table 16, each system that exceeds the MCL will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619 per system. Because this is a one-time cost, it is not included in the annual costs below. No other significant direct or indirect impacts on other state agencies associated with the adoption of this MCL have been identified.

Table 16. Annual Costs to Other State Agencies (in 2022 dollars)

PWS Type	Number of Systems	Number of Sources Affected	Monitoring Costs	Amortized Capital Costs	Operations & Maintenance Costs	Total Costs
CWS	1	2	2,516	42,480	50,423	95,419

D.3 Federal Government

The State Water Board's most recent data about hexavalent chromium contamination indicate that there are 3 PWS that have sources contaminated with hexavalent chromium above 10 ug/L that are owned by the federal government. These systems are a Marine Corps air combat center, an Army heliport, and a defense distribution depot. As noted above, in addition to the costs in Table 17, each system that exceeds the MCL will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619 per system. Because this is a one-time cost, it is not included in the annual costs table below. This workload is expected to be fully absorbed by existing federal government personnel and resources (so no additional personnel costs are assumed). Hence, the

[12] Due to rounding errors, the values may not add up to the total.

proposed regulation is assumed to not significantly impact federal government costs or tax revenue.

Table 17. Annual Statewide Costs to the Federal Government (in 2022 dollars)

PWS Type	Number of Systems	Number of Affected Sources	Monitoring Costs	Amortized Capital Costs	Operations & Maintenance Costs	Total Costs
CWS	1	8	10,065	1,769,460	1,546,934	3,326,459
NTNCWS	2	2	2,516	88,834	67,911	159,260

E. MACROECONOMIC IMPACTS

E.1 Methods for Determining Economic Impacts

Direct costs were used as inputs of an economic model to assess the macroeconomic, indirect, and induced effects of the regulation. The State Water Board used the regional economic model developed by the U.S. Bureau of Economic Analysis (BEA): the Regional Input-Output Modeling System (RIMS II), to estimate the effects of the regulation, and used RIMS II multipliers from 2017 for California's economy.

E.2 Inputs of the Assessment

The analysis begins with the cost data in Table 9 above, the sectors impacted by compliance-related spending, and the assumption that increased charges PWS impose on their customers to cover all compliance costs can be treated as a reduction in earnings. Each type of cost in Table 9 was assigned the most appropriate RIMS II code and multipliers, based on North American Industry Classification System (NAICS) descriptions. (NAICS categories are more specific than RIMS II categories; RIMS II categories at a higher level of aggregation are used when needed.) NAICS is the standard used by federal statistical agencies to classify business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. Table 18 lists the industries that are directly related to the monitoring and treatment of hexavalent chromium.

Table 18. NAICS Categories Selected

Direct Cost Category	NAICS Category Description
Monitoring	Architectural, engineering, and related services
Amortized Capital Costs	Water, sewage, and other systems
Chemicals (O&M Component)	Other basic inorganic chemical manufacturing
Disposal (O&M Component)	Waste management and remediation services
Remaining O&M Costs	Water, sewage, and other systems

Preparing Compliance Plans	Architectural, engineering, and related services

The next step is to identify the RIMS II multipliers for each sector for gross outputs, earnings, employment, and value added. See Table 19.

Table 19. RIMS II Multipliers (Type II)

Direct Cost Category	RIMS II multipliers Gross Output (per dollar)	Earnings (per dollar)	Jobs (per million dollars)	Value Added (per dollar)
Monitoring	2.1742	0.831	12.8366	1.3008
Amortized Capital Costs	1.6436	0.3696	5.5647	1.0221
Chemicals (O&M Component)	1.7513	0.3656	5.2517	0.8368
Disposal (O&M Component)	1.9711	0.5465	9.4293	1.0634
Remaining O&M Costs	1.6436	0.3696	5.5647	1.0221
Preparing Compliance Plans	2.1742	0.831	12.8366	1.3008
Households	1.2177	0.366	7.9523	0.7091

E.3 Main Assumptions and Limitations of the Model

The RIMS II model, and the use of it here for this assessment, depend on assumptions and are subject to limitations that the reader must keep in mind. Below, the major assumptions and limitations are listed and discussed.

Assumptions and limitations specific to this analysis.

1. Potentially significant benefits to households or other water customers are not modeled.

   As noted, these benefits will include fewer adverse health issues, including cancer and liver toxicity. That could have been modeled as a lower demand for healthcare and related services, but these substantial benefits are hard to quantify. In addition, the model does not reflect lower demand for bottled water and home water treatment systems that may result from the regulation, to the degree people increase their use of tap water or decrease purchases they may make to mitigate poor water quality due to hexavalent chromium.

   Meaning: Benefits of the regulation, including the public health considerations that motivate this regulation, are not reflected in the modeling. If these were accounted for, all the results would change (because the monetary benefits would change the model output).

2. Total California household spending is assumed to drop by an amount equal to the total direct costs of compliance, and this change will have indirect economic effects.

   This reflects that households are major water users and systems will likely increase charges to customers to cover any increased costs. However, the model does not account for potential funding that likely would be available to assist systems in coming into compliance.

   The assumption that household spending statewide will drop by an amount equal to the total direct costs of compliance was made to keep the modeling simple because the data needed for a more precise analysis does not exist. (These include the sectors for which final demand for goods and services will be affected by water charges, the degree of those effects, and the degree to which affected PWS will increase water charges faced by businesses or governments.)

   Assumptions embedded in this approach include that the increased water charges are equivalent to decreased earnings as defined in RIMS II -- wages, salaries, and proprietors' income. Thus, the model may not fully reflect the economic behavior of those people whose earnings are not as defined in RIMS II. Assumptions also include that people outside of California won't experience higher water charges due to this regulation.

   Several considerations are therefore not reflected in the modeling:

   - PWS may not ever be able to pass all of their increased costs on to their customers, for a variety of reasons. For example, NTNCWS and TNCWS (e.g., packing plants, farms, and restaurants) will need to comply with the regulation but may be less able than some other systems to pass their compliance costs to their customers.

     <u>Meaning: all else equal, the impacts of payment changes modeled as a reduction in household income may be overestimated.</u>

   - System's customers are businesses and government entities, not just households.

     <u>Meaning: impacts modeled as a reduction in household income are overestimated and water cost increases for other entities are ignored. Other entities or sectors for which water costs are a major element of their production and that get water from PWS that must comply with the regulation may be impacted (some of these businesses may be able to rely on untreated water for their needs, such as for irrigation or other non-potable needs).</u>

   - The regulation will increase costs for a subset of systems in California and so the impacts on households will be concentrated in those systems' service areas, rather than spread equally across all water customers in California (13.6% of California's population is expected to experience water cost increases). Under the conservative assumption of costs being fully passed on to residential ratepayers, analysis suggests households will be affected to different degrees. See Table 13.

Meaning: the aggregate, statewide results mask a distribution of impacts. However, some PWS offer discounted rates to those who qualify, and other funding opportunities are available to PWS to help pay for coming into compliance with the MCL, such as programs administered by the State Water Board that provide grants and low-interest loans.

- Some people, such as those living in apartments, may not be billed directly for their individual water use, so the impact on their budgets may be less than assumed (though all else equal, their rents may be increased to reflect higher water costs).

  Meaning: all else equal, impacts on household spending may be less than the modeling suggests.

- Some households, businesses, and government entities have their own private wells or are served by water sources that do not exceed the proposed MCL and are otherwise not getting water from an affected PWS.

  Meaning: the aggregate, statewide results mask a distribution of impacts.

3. PWS' capital investments are assumed to be amortized over 20 years.

   See the comments under item 6 in this section.

4. PWS may find ways to comply with the regulation other than treatment, such as obtaining new water supplies or blending multiple water sources. These other compliance activities are expected to cost less than centralized treatment.

   Meaning: The costs and economic impacts in this analysis represent the upper limits of costs and economic impacts for this regulation.

General RIMS II assumptions and limitations.

5. RIMS II multipliers only estimate the impact from changes in final demand on one or more regional industries (in this SRIA, industries that are directly related to the monitoring and treatment of hexavalent chromium).

6. RIMS II results describe what the state of the economy may be like after all sectors make assumed economic adjustments.

   As there is no timeline in the RIMS II model, results listed for any year should be interpreted as the outcomes in the new economic equilibrium due to the costs of the proposed regulation in that year. (Keep in mind the model amortizes capital investments over 20 years and that amortization will not be done until 2048.) For example, Table 21 shows results for years 2024 to 2029. The results in each row reflect only the compliance costs for that year—which increase over time as shown in Table 9—and assume that all economic adjustments, including changes to water charges, occur instantaneously.

Meaning: The reader may want to focus on the figures for 2028 (the first full implementation year), since some adjustments will take time. The reader should note that after the transition period is over and all capital costs are fully amortized, which is assumed to be in 2048, the ongoing annual results will be smaller in magnitude than shown in the tables for the years listed.

7. Businesses in the affected industries have no permanent supply constraints.

   Supply constraints will not be a problem in the long run, as markets will adjust to provide the goods and services needed for compliance.

   See the discussion under item 6 in this section.

8. Businesses in the affected industries can satisfy additional demand with an increase in inputs and labor from within the State.

   This is not fully realistic: some portion of goods and services needed for compliance will come from out of state. However, the majority share of the changes in final demand due to the regulation are for services that are generally provided to systems by California firms. Any non-bottled drinking water imported by PWS from out of state would also be required to meet the MCL.

   Meaning: To the degree this assumption is violated, the economic impacts of the regulation in California are likely to be smaller in magnitude than the modeling suggests because they will impact economies inside and outside of California.

9. Businesses have fixed patterns of purchases, and there will be no technological changes that shift what inputs are needed to create outputs, and the RIMS II data used for 2017 is appropriate.

   These are not fully realistic, but these are common assumptions when using models such as RIMS II. While the economy has changed since 2017, that is the most recent set of RIMS II multipliers the Water Board has. Note that PWS and providers of goods and services are likely to find more cost-effective solutions to satisfy the requirements of the proposed regulation over time. For example, the technologies for monitoring and treatment have become more efficient over time and this trend is likely to continue.

   Meaning: to the degree these assumptions are violated, the economic impacts of the regulation may be different from what the modeling suggests.

E.4 RIMS II Assessment Results

The resultant macroeconomic impacts are shown in Table 20 for gross output, earnings, jobs, and value added.

Gross output represents the total value of goods or services produced in a region within a given period. It is used as a measure for the overall size of the economy. The model combines the effects of higher demand for the goods and services needed for compliance and the effects of higher charges for water lowering household income.

Table 20 contains the main results.

Gross Output. The total impact on gross output is +$81 million in 2028, in 2022 dollars. The impact is small compared to the size of the California economy, which was about $3 trillion in 2020 (U.S. Bureau of Economic Analysis, 2022).

Earnings (personal income). The total impact on aggregate earnings is +$2 million in 2028, in 2022 dollars.

Jobs (part time and full-time). The total impact on jobs is -401 in 2028. As a fraction of California civilian employment in 2028, projected by the Department of Finance, this drop is not significant.

Value added. Value added is the additional value contributed by the use of factors of production, consisting of payments to labor, payments to government, and returns on investment. It excludes the values of direct inputs and intermediate inputs, either domestically produced or imported. The total impact on value added is +$53 million in 2028, in 2022 dollars. This is tiny, compared to the California economy.

Table 20. Macroeconomic Impacts in 2028

Direct Impact Category	Gross Output (2022 dollars)	Earnings (2022 dollars)	Jobs (number of part- and full-time jobs	Value Added (2022 dollars)
Monitoring	2,187,284	836,001	13	1,308,628
Amortized Capital Costs	156,514,479	35,195,760	530	97,331,132
Chemicals (O&M Component)	32,509,786	6,786,717	97	15,533,712
Disposal (O&M Component)	13,295,586	3,686,286	64	7,172,912
Remaining O&M Costs	95,373,254	21,446,797	323	59,309,445
Households	(218,660,175)	(65,721,955)	(1,428)	(127,331,798)
Total	81,220,215	2,229,606	(401)	53,324,031

Note: Compliance plans are required to be completed by 2024 so there are no impacts from preparing compliance plans in 2028.

As noted, the RIMS II model does not describe the transition path from BAU to the time when all economic adjustments have been made. With that major caveat, to show a transition path, Table 21 presents results for the years 2024 through 2029, assuming the economy fully adjusts each year to the costs PWS will pay in those years.

Table 21. Macroeconomic Impacts by Year

Year	Gross Output (2022 dollars)	Earnings (2022 dollars)	Jobs (number of part- and full-time jobs)	Value Added (2022 dollars)
2024	2,208,153	1,073,488	11	1,365,984
2025	510,097	247,982	3	315,551
2026	49,366,441	1,490,909	(239)	31,833,900
2027	74,439,034	2,066,900	(366)	48,461,169
2028	81,220,215	2,229,606	(401)	53,324,031
2029	81,220,215	2,229,606	(401)	53,324,031

E.4.a California Employment Impacts

The modeled net effect on employment is negative and small relative to the California economy. See Table 22.

Table 22. Changes in Employment Relative to Statewide Civilian Employment

Year	Change in Jobs (number of part- and full-time jobs)	Projection for Statewide Civilian Employment (number of jobs)	Change in Jobs Relative to Statewide Civilian Employment (%)
2024	11	20,012,100	0.0001%
2025	3	20,161,176	0.0000%
2026	(239)	20,161,176	-0.0012%
2027	(366)	20,161,176	-0.0018%
2028	(401)	20,161,176	-0.0020%
2029	(401)	20,161,176	-0.0020%

Note: Employment projections from the Department of Finance were used for 2024 and 2025, and the later years were assumed to stay at 2025 levels.

E.4.b California Business Impacts

The proposed regulation directly affects the 233 PWS with hexavalent chromium concentrations of more than 10 ug/L, out of a total of 7,355 PWS in California. Of the 233 PWS, 146 are privately-owned systems and 82 are public water agencies. Of the privately owned PWS, 13 are small businesses, as detailed in section C.3.

As shown in the analysis above, testing service providers (e.g., analytical laboratories) and services related to hexavalent chromium water treatment will experience an increased demand from PWS. Laboratories will likely experience an increased demand because of the additional analysis required for hexavalent chromium. Consulting firms, construction firms, and the material and labor industries may also experience an increased demand. The demand for any service related to hexavalent chromium treatment of any kind is also likely to increase. If the installation of treatment increases classification ratings for PWS, there may also be an increased demand for operators with high-level certifications (See Cal. Code Regs., tit. 22, section 64413.1(b)(5) and (7)).

PWS costs are paid for by household water bills and, in some cases, through grants, bonds or loans. As such, it is not expected that any PWS would shut down as a result of the regulation.

As noted, the set of entities that buy water from affected PWS may face higher charges for water and, depending on their situations, will be able to pass on those higher costs to their customers. This may impact some entities but is unlikely to have macroeconomic impacts.

E.4.c Impacts on Investments in California

Table 3 shows that, once adjustments are made, but while the one-time capital costs are still being amortized, the impact on investment (capital costs) per year will be an increase of approximately $95 million, in 2022 dollars. Table 20 shows that will lead to an increase in gross output of $157 million and an increase in value added of $97 million, both in 2022 dollars. These impacts are insubstantial compared to California's roughly $3 trillion annual economy.

E.4.d Impacts on Individuals in California

As noted, the modeling assumes aggregate personal income will be affected when systems pass compliance costs on to people as customers. Table 23 shows the assumed annual changes to aggregate personal income statewide. It also shows annual projections for California personal income obtained from the Department of Finance. As shown, the impact of the proposed regulation on personal income statewide is not substantial.

Table 23. Changes in Personal Income

Year	Change in Personal Income (2022 dollars)	Projection for California Personal Income (billions of 2022 dollars)	Change in Personal Income as Portion of California Total Personal Income (%)
2024	(2,308,576)	3,175	-0.00007%
2025	(533,295)	3,279	-0.00002%
2026	(108,146,054)	3,212	-0.00336%
2027	(164,045,981)	3,143	-0.00522%
2028	(179,568,182)	3,069	-0.00585%
2029	(179,568,182)	2,997	-0.00599%

Note: The United States Department of Food and Agriculture's Economic Research Service's consumer price index projections, from January 2022, were used to convert income projections, in current dollars, from the Department of Finance, to 2022 dollars.[13] The Department of Finance's

[13] USDA ERS - International Macroeconomic Data Set.

projections for California Personal Income for 2024 and 2025 were used, and the 2025 level was used for the later years. These values were converted from current dollars to 2022 dollars.

However, those living in the service areas affected by the proposed regulation comprise a fraction of the state's population (approximately 14%), and in some cases their monthly water bills could increase significantly, assuming that all costs are passed on to them and distributed equally among connections in their service areas. This impact is discussed in detail in section C.5.

E.4.e Creation or Elimination of Businesses

Businesses providing the goods and services needed for monitoring and treatment of hexavalent chromium are likely to expand in size or number. (The model does not distinguish between more firms entering the market or existing firms producing more output.)

The potential changes in water costs will be distributed among many sectors and so are not expected to lead to the creation or elimination of businesses.

E.4.f Incentives for Innovation

Establishing an MCL for hexavalent chromium will lead to systems installing treatment technologies capable of removing hexavalent chromium from their water. As more hexavalent chromium treatment systems are implemented, more data will be available on the effectiveness of different types of treatment under different circumstances (including differing water quality types). Systems will look for both effective technologies and inexpensive technologies, which will drive innovation for hexavalent chromium water treatment technologies.

E.4.g Competitive Advantage or Disadvantage

PWS are generally not in competition with other systems; they are utilities that can pass costs onto their consumers. (As noted, most NTNCWS and TNCWS businesses are wineries, packing plants, farms, restaurants, etc., with a primary business other than supplying water. These companies, and others facing higher water charges from their PWS, may be able to pass any increased costs on to their customers, depending on their market environment.)

Non-California water providers are unlikely to increase sales into California because non-bottled drinking water originating from outside of California is also subject to the requirements in the proposed regulation.

E.4.h Summary and Interpretation of the Assessment Results

In summary, the potentially most important limitation of this analysis, as noted in section E.3, is that benefits of the regulation, including the public health considerations that motivate this regulation, are not reflected in the modeling. If these monetary benefits were accounted for in the modeling, the net results would reflect those benefits. One of the most important assumptions underlying this analysis is that systems will eventually increase charges to customers to cover all compliance costs. With all the assumptions and limitations in mind, the modeled economic impacts—positive and negative—ramp up over time until 2028, are small relative to the California economy, and will largely be passed on from systems to others. Ongoing impacts will be smaller in magnitude after capital costs are fully amortized.

F. ALTERNATIVES

The State Water Board has evaluated alternatives or modifications to the proposed regulation as mandated by Government Code section 11346.2. To solicit alternatives from stakeholders, the State Water Board conducted three public workshops in April and December 2020, and in April 2022. Alternative regulatory proposals were received during those meetings and workshops for MCLs of 1 and 50 ug/L. During the pre-rulemaking stage of this regulation, the State Water Board developed costs for a total of 21 potential MCLs (1 through 15, 20, 25, 30, 35, 40, and 45 ug/L). All 21 potential MCLs were included in the cost-effectiveness analysis (section F.4), but only three alternatives (1, 8, and 12 ug/L) were individually analyzed. The alternative at 1 ug/L was analyzed because it was received by the public as a proposal. The alternatives at 8 and 12 ug/L were chosen by the State Water Board as high and low alternatives to the proposed MCL of 10 ug/L. The public proposal for an MCL at 50 ug/L is not being evaluated separately because it is not as stringent as the current baseline, where PWS must comply with the total chromium (trivalent chromium plus hexavalent chromium) MCL of 50 ug/L.

F.1 Alternative 1

The first alternative proposes using a less stringent MCL of 12 ug/L. Under this alternative, a total of 181 PWS have sources with hexavalent chromium concentrations higher than 12 ug/L, compared to 233 PWS under the proposed regulation. These 181 PWS have 385 sources with hexavalent chromium concentrations above 12 ug/L and serve 4,099,760 people.

F.1.a Costs

The annual direct costs under this alternative are shown in Table 24, broken down by year and cost category. In addition, Table 25 shows the breakdown of annual O&M costs for each category of PWS during full implementation (all years after 2027), which is needed for the macroeconomic analysis.

Table 24. Annual Direct Costs for Alternative 1 (in 2022 dollars)

Year	Monitoring Costs	Amortized Capital Costs	O&M Costs	Compliance Plan Costs	Total Costs
2024	500,061	0	0	1,379,081	1,879,141
2025	500,061	0	0	0	500,061
2026	629,328	42,147,578	35,370,581	0	78,147,487
2027	718,023	66,036,526	56,009,758	0	122,764,307
2028	863,331	71,847,519	61,644,642	0	134,355,492

Year	Monitoring Costs	Amortized Capital Costs	O&M Costs	Compliance Plan Costs	Total Costs
2029	863,331	71,847,519	61,644,642	0	134,355,492

Table 25. Breakdown of Annual O&M Costs for Alternative 1 at Full Implementation (in 2022 dollars)

PWS Type	Chemical Costs	Disposal Costs	Remaining O&M Costs	Total Costs
CWS	13,092,707	4,774,469	41,243,208	59,110,384
NTNCWS	42,022	14,740	2,028,233	2,084,995
TNCWS	0	0	123,826	123,826
Wholesalers	7,177	2,529	315,731	325,437

Table 26 shows the annual costs at full implementation for the typical privately owned PWS (business) of each system type. Wholesalers are not included because there are no privately owned wholesalers with sources exceeding 12 ug/L. Annual costs are compared to the proposed regulation as a percent. In addition to the annual costs presented in Table 26, each system that exceeds the MCL will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619 per system. Because this is a one-time cost, it is not included in the annual costs below.

Table 26. Annual Costs to the Typical Privately Owned PWS for Each System Type for Alternative 1 (in 2022 dollars)

PWS Type	Number of Systems	Average Number of People Served	Average Number of Service Connections	Annual Cost for a Typical System	Comparing to Proposed Regulation (%)
CWS	70	2,501	753	222,149	-12.25
NTNCWS	40	184	5	75,679	+0.54
TNCWS	3	257	94	81,361	+23.47

F.1.b Benefits

The benefits of Alternative 1 include avoided cancer and noncancer cases (liver toxicity and adverse effects in the liver and blood forming tissues), healthcare cost savings, and cost savings on municipal water alternatives (such as home treatment systems or bottled water). Although data limitations prevent a quantitative estimation for most of these benefits, it is estimated that up to 713 cancer cases will be avoided over 70 years. The total magnitude of these benefits is expected to be smaller than from the proposed regulation.

F.1.c Economic Impacts

As in the main analysis, the RIMS II model is applied to direct costs under the Alternative 1 scenario in 2028, the first full implementation year. The costs, reported in Table 24, have been separated into the same NAICS categories used for the proposed MCL, which are shown in Table 18. Results of the macroeconomic impact analysis are presented in Table 27. Compared to the proposed regulation, the impact of Alternative 1 on gross output, earnings, and value added is approximately 25% smaller. However, there are 25% fewer job losses relative to job losses under the proposed regulation. This is consistent with lower direct costs under Alternative 1.

Table 27. Macroeconomic Impacts in 2028 under Alternative 1

Direct Impact Category	Gross Output (2022 dollars)	Earnings (2022 dollars)	Jobs (number of part- and full-time jobs)	Value Added (2022 dollars)
Monitoring	1,877,054	717,428	11	1,123,021
Amortized Capital Costs	118,088,582	26,554,843	400	73,435,349
Chemicals (O&M Component)	23,015,420	4,804,681	69	10,997,147
Disposal (O&M Component)	9,444,995	2,618,685	45	5,095,534
Remaining O&M Costs	71,843,396	16,155,585	243	44,677,011
Households	(163,604,683)	(49,174,110)	(1,068)	(95,271,479)
Total	60,664,765	1,677,112	(300)	40,056,583

F.1.d Cost-Effectiveness

Under Alternative 1, it is expected that about 10.2 annual cancer cases will be avoided at an annual cost of about $134 million at full implementation, equivalent to about $13.2 million per cancer case avoided. Under the proposed regulation, about 12.8 annual cancer cases will be avoided at an annual cost of about $180 million at full implementation, equivalent to about $14 million per cancer case avoided. The cost-effectiveness difference between 12 ug/L and the proposed 10 ug/L is relatively small (less than $1 million). Going by this limited standard, this means that similar cost effectiveness is achieved at 12 ug/L as at 10 ug/L even though the lower MCL is more health protective. For an alternate cost-effectiveness analysis of a wider range of potential MCLs, see section F.4.

F.1.e Reason for Rejecting

Alternative 1 does not sufficiently address the requirement in the HSC 116365 of setting the MCL as close to the PHG as is technologically and economically feasible, placing primary emphasis on the protection of public health. Alternative 1 is slightly more cost-effective than the proposed regulation, but it provides fewer benefits. Because the proposed regulation provides more health benefits than Alternative 1 at similar cost-effectiveness, Alternative 1 was rejected.

F.2 Alternative 2

The second alternative proposes a more stringent MCL of 8 ug/L. Under this alternative, a total of 336 PWS have sources with hexavalent chromium concentrations higher than 8 ug/L, compared to 233 PWS under the proposed regulation. These 336 PWS have 745 sources with hexavalent chromium concentrations above 8 ug/L and serve 8,522,968 people.

F.2.a Costs

The annual direct costs under this alternative are shown in Table 28, broken down by year and cost category. In addition, Table 29 shows the breakdown of annual O&M costs for each category of PWS during full implementation (all years after 2027), which is needed for the macroeconomic analysis.

Table 28. Annual Direct Costs for Alternative 2 (in 2022 dollars)

Year	Monitoring Costs	Amortized Capital Costs	O&M Costs	Compliance Plan Costs	Total Costs
2024	603,223	0	0	2,560,061	3,163,284
2025	603,223	0	0	0	603,223
2026	879,686	93,882,692	82,511,384	0	177,273,762
2027	1,037,261	133,191,810	120,963,592	0	255,192,663
2028	1,306,175	144,812,842	132,617,515	0	278,736,533
2029	1,306,175	144,812,842	132,617,515	0	278,736,533

Table 29. Breakdown of Annual O&M Costs at Full Implementation for Alternative 2 (in 2022 dollars)

PWS Type	Chemical Costs	Disposal Costs	Remaining O&M Costs	Total Costs
CWS	31,315,258	11,659,465	83,325,251	126,299,974
NTNCWS	174,748	73,102	4,333,553	4,581,403
TNCWS	0	0	411,240	411,240
Wholesalers	204,832	99,243	1,020,824	1,324,898

Table 30 shows the annual costs at full implementation for the typical privately-owned PWS (business) of each system type. Wholesalers are not included in Table 30 because there are no privately owned wholesalers with sources exceeding 8 ug/L. Annual costs are compared to the proposed regulation as a percent. In addition to the annual costs presented in Table 30, each system that exceeds the MCL will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619 per system. Because this is a one-time cost, it is not included in the annual costs below.

Table 30. Annual Costs to the Typical Privately Owned PWS for Each System Type for Alternative 2 (in 2022 dollars)

PWS Type	Number of Systems	Average Number of People Served	Average Number of Service Connections	Annual Cost for a Typical System	Comparing to Proposed Regulation (%)
CWS	125	10,308	2,526	429,499	+69.66
NTNCWS	69	229	5	77,869	+3.45
TNCWS	13	183	30	65,756	-0.21

F.2.b Benefits

The benefits of Alternative 2 include avoided cancer and noncancer cases (liver toxicity and adverse effects in the liver and blood forming tissues), healthcare cost savings, and cost savings on municipal water alternatives (such as home treatment systems or bottled water). While data limitations prevent a quantitative estimation for most of these benefits, it is estimated that up to 1,136 cancer cases will be avoided over 70 years. The total magnitude of these benefits is expected to be greater than from the proposed regulation.

F.2.c Economic Impacts

As in the main analysis, the RIMS II model is applied to direct costs under the Alternative 2 scenario in 2028, the first full implementation year. The costs, reported in Table 28, have been separated into the same NAICS categories used for the proposed MCL, which are shown in Table 18. Results of the macroeconomic impact analysis are presented in Table 31. Compared to the proposed regulation, the impact of Alternative 2 on gross output and value added is approximately 55% greater, and the impact on earnings is about 60% greater. However, job losses are about 55% higher relative to job losses under the proposed regulation. This is consistent with higher direct costs under Alternative 2.

Table 31. Macroeconomic Impacts in 2028 under Alternative 2

Direct Impact Category	Gross Output (2022 dollars)	Earnings (2022 dollars)	Jobs (number of part- and full-time jobs)	Value Added (2022 dollars)
Monitoring	2,839,886	1,085,431	17	1,699,072
Amortized Capital Costs	238,014,387	53,522,826	806	148,013,206
Chemicals (O&M Component)	55,507,170	11,587,633	166	26,522,240

Disposal (O&M Component)	23,321,681	6,466,084	112	12,581,947
Remaining O&M Costs	146,429,751	32,927,985	496	91,059,776
Households	(339,417,476)	(102,017,571)	(2,217)	(197,652,076)
Total	126,695,398	3,572,389	(620)	82,224,166

F.2.d Cost-Effectiveness

While it is not possible to quantify all the benefits of regulating hexavalent chromium, it is expected that it will cost more to prevent each cancer case under Alternative 2. Under Alternative 2, it is expected that about 16.2 annual cancer cases will be avoided at an annual cost of about $279 million at full implementation, equivalent to about $17.2 million per cancer case avoided. Under the proposed regulation, about 12.8 annual cancer cases will be avoided at an annual cost of about $180 million at full implementation, equivalent to about $14 million per cancer case avoided. Going by this limited standard, Alternative 2 is a much less cost-effective alternative compared to the proposed regulation. For an alternate cost-effectiveness analysis of a wider range of potential MCLs, see section F.4.

F.2.e Reason for Rejecting

Although Alternative 2 is expected to provide more health benefits in terms of avoided cancer and noncancer cases, healthcare costs, bottled water, etc., the measure of cost-effectiveness in this analysis is based solely on dollar per cancer case avoided. Under this measure, Alternative 2 is much less cost-effective than the proposed regulation and is thereby rejected.

F.3 Alternative 3

The third alternative proposes a more stringent MCL of 1 ug/L. Under this alternative, a total of 1,568 PWS have sources with hexavalent chromium concentrations higher than 1 ug/L, compared to 233 PWS under the proposed regulation. These 1,568 PWS have 4,182 sources with hexavalent chromium concentrations above 1 ug/L and serve 25,317,312 people.

This alternative was proposed by the public. While costs were developed for this alternative, treating to this level may not be technologically feasible for all systems. Some systems will have water quality or other constraints that prevent them from being able to consistently treat to below 1 ug/L. Reverse osmosis, which has the ability to treat below 1 ug/L, may also not be feasible for some systems due to the large amount of reject water[14] (water scarce areas may not have enough water supply without the reject water).

[14] Reject water can constitute 40% or more of the water volume treated by reverse osmosis. Also called concentrate or wastewater, reject water is a byproduct of the treatment process and may contain chemicals, such as antiscalant and washing solutions, as well as heavy metals and organic and inorganic compounds. Up to one third of the total reverse osmosis treatment costs could be to dispose of the reject water (Mohamed et al., 2005).

However, the analysis in this alternatives section will only evaluate the cost-effectiveness of treating to this level.

F.3.a Costs

The annual direct costs under this alternative are shown in Table 32, broken down by year and cost category. Table 33 shows the breakdown of annual O&M costs for each category of PWS during full implementation (all years after 2027), which is needed for the macroeconomic analysis.

Table 32. Annual Direct Costs for Alternative 3 (in 2022 dollars)

Year	Monitoring Costs	Amortized Capital Costs	O&M Costs	Compliance Plan Costs	Total Costs
2024	1,589,479	0	0	11,946,953	13,536,432
2025	1,589,479	0	0	0	1,589,479
2026	3,320,912	669,973,531	778,100,077	0	1,451,394,520
2027	4,031,413	862,283,642	989,163,355	0	1,855,478,409
2028	5,535,447	934,256,858	1,080,801,166	0	2,020,593,471
2029	5,535,447	934,256,858	1,080,801,166	0	2,020,593,471

Table 33. Breakdown of Annual O&M Costs at Full Implementation for Alternative 3 (in 2022 dollars)

PWS Type	Chemical Costs	Disposal Costs	Remaining O&M	Total Costs
CWS	340,879,293	122,101,626	484,566,567	947,547,486
NTNCWS	2,611,252	912,516	31,264,361	34,788,128
TNCWS	797,744	278,559	3,125,085	4,201,388
Wholesalers	35,137,817	16,580,127	42,546,219	94,264,163

Table 34 shows the annual costs at full implementation for the typical privately-owned PWS (business) of each system type. Annual costs are compared to the proposed regulation as a percent. In addition to the annual costs presented in Table 34, each system that exceeds the MCL will also be required to prepare a compliance plan, which is a one-time cost estimated at $7,619 per system. Because this is a one-time cost, it is not included in the annual costs below. In Table 34, the average number of service connections is not included for wholesalers because wholesalers do not directly serve residents, and the comparison to the proposed regulation cannot be made for wholesalers because there were no privately owned wholesalers identified as having to comply with the proposed regulation.

Table 34. Annual Costs to the Typical Privately Owned PWS for Each System Type for Alternative 3 (in 2022 dollars)

PWS Type	Number of Systems	Average Number of People Served	Average Number of Service Connections	Annual Cost for a Typical System	Comparing to Proposed Regulation, Statewide (%)
CWS	552	8,857	2,191	945,156	+273.36
NTNCWS	377	207	8	93,107	+23.69
TNCWS	65	498	13	116,243	+76.4
Wholesalers	5	67,501	-	7,559,552	-

F.3.b Benefits
The benefits of Alternative 3 include avoided cancer and noncancer cases (liver toxicity and adverse effects in the liver and blood forming tissues), healthcare cost savings, and cost savings on municipal water alternatives (such as home treatment systems or bottled water). While data limitations prevent a quantitative estimation for most of these benefits, it is estimated that up to 3,536 cancer cases will be avoided over 70 years. The total magnitude of these benefits is expected to be greater than from the proposed regulation.

F.3.c Economic Impacts
As in the main analysis, the RIMS II model is applied to direct costs under the Alternative 3 scenario in 2028, the first full implementation year. The costs, reported in Table 32, have been separated into the same NAICS categories used for the proposed MCL, which are shown in Table 18. Results of the macroeconomic impact analysis are presented in Table 35. Compared to the proposed regulation, the impact of Alternative 3 on gross output, earnings, and value added is approximately an order of magnitude greater (between 967% and 1,383% greater). However, job losses are about 987% higher relative to job losses under the proposed regulation. This result is in line with the much greater magnitude of direct costs under Alternative 3.

Table 35. Macroeconomic Impacts in 2028 under Alternative 3

Direct Impact Category	Gross Output (2022 dollars)	Earnings (2022 dollars)	Jobs (number of part- and full-time jobs)	Value Added (2022 dollars)
Monitoring	12,035,169	4,599,956	71	7,200,509
Amortized Capital Costs	1,535,544,572	345,301,335	5,199	954,903,935
Chemicals (O&M Component)	664,488,939	138,718,184	1,993	317,503,766

Disposal (O&M Component)	275,703,331	76,440,501	1,319	148,740,765
Remaining O&M Costs	922,885,069	207,531,225	3,125	573,911,431
Households	(2,460,476,670)	(739,537,210)	(16,068)	(1,432,802,830)
Total	950,180,410	33,053,991	(4,362)	569,457,576

F.3.d Cost-Effectiveness

While it is not possible to quantify all the benefits of regulating hexavalent chromium, it is expected that it will cost more to prevent each cancer case under Alternative 3. Under Alternative 3, it is expected that about 50.5 annual cancer cases will be avoided at an annual cost of about $2 billion at full implementation, equivalent to about $40 million per cancer case avoided. Under the proposed regulation, about 12.8 annual cancer cases will be avoided at an annual cost of about $180 million at full implementation, equivalent to about $14 million per cancer case avoided. Going by this limited standard, Alternative 3 is a much less cost-effective alternative compared to the proposed regulation. For an alternate cost-effectiveness analysis of a wider range of potential MCLs, see section F.4.

F.3.e Reason for Rejecting

While Alternative 3 provides more health benefits, it is much less cost-effective than the proposed regulation. In addition, no POU/POE devices registered in California treat hexavalent chromium to this level, which means that systems with less than 200 service connection would have no alternative to centralized treatment. As already discussed, technological feasibility may also be an issue for some systems at this treatment level. Therefore, Alternative 3 is not a viable alternative to the proposed regulation.

F.4 Additional Cost-Effectiveness Analysis for All Alternatives

While there is currently no established and approved methodology for the State Water Board to quantify a monetized health benefit for reducing cancer risk, monetized health benefits are expected to be proportional to the theoretical excess cancer cases avoided. Therefore, the ratios in this section have units of dollars per unit of health benefits, where one unit of health benefits represents the monetized health benefits (whatever those may be) of avoiding one cancer case. Table 36 shows the cost-effectiveness ratio (CER) and marginal cost-effectiveness ratio (MCER) for all PWS for each potential MCL. The CER was calculated by dividing the annual costs (at full implementation) by the annual theoretical cancer cases avoided, and the MCER was calculated by dividing the change in costs by the change in annual theoretical cancer cases avoided. While the CER shows the cost estimated per each cancer case avoided, the MCER shows how much extra it will cost to provide an additional unit of health benefits at each treatment level. The MCER is important because it can show at which levels the cost of an additional health benefit may jump, indicating decreasing cost-effectiveness. The change in the MCER will indicate whether is it more expensive (positive values) or less expensive (negative values) to provide additional health benefits compared to the previously evaluated MCL level. The percent change in the MCER can help put the magnitude of the changes into perspective, where negative changes indicate higher cost effectiveness and positive changes indicate lower cost-effectiveness.

Table 36. Cost-Effectiveness Analysis

MCL (ug/L)	Cost-Effectiveness Ratio	Marginal Cost-Effectiveness Ratio	Change in Marginal Cost-Effectiveness Ratio	Percent Change in Marginal Cost-Effectiveness Ratio (%)
45	31,237,840	-	-	-
40	19,335,524	11,777,990	-	-
35	15,188,801	9,609,622	-2,168,368	-18.4
30	11,885,880	5,496,124	-4,113,499	-42.8
25	11,602,979	10,917,620	5,421,497	98.6
20	12,531,263	13,747,857	2,830,237	25.9
15	12,928,386	13,314,970	-432,887	-3.1
14	12,832,853	12,145,707	-1,169,263	-8.8
13	12,935,765	13,686,639	1,540,932	12.7
12	13,194,643	15,184,415	1,497,776	10.9
11	13,542,933	16,368,382	1,183,967	7.8
10	14,002,455	17,793,849	1,425,467	8.7
9	15,625,111	29,091,521	11,297,672	63.5
8	17,176,369	29,169,510	77,989	0.3
7	18,174,742	25,460,683	-3,708,827	-12.7
6	19,543,647	28,963,919	3,503,236	13.8
5	21,420,579	33,651,631	4,687,711	16.2
4	24,918,467	45,977,391	12,325,761	36.6
3	28,460,725	47,815,821	1,838,430	4.0
2	32,321,838	51,203,577	3,387,756	7.1
1	39,997,660	71,041,474	19,837,897	38.7

As shown in Table 36, the CER is not linear across potential MCLs. However, it starts out high at $31 million for 45 ug/L, drops to $11.6 million for 25 ug/L, and climbs to $40 million for 1 ug/L. The high CERs at lower and higher potential MCLs suggest the MCL should be placed higher than 7 ug/L and lower than 40 ug/L to avoid the least cost-effective MCLs.

The change to the MCER is also not linear. Large positive changes in the MCER mean a large drop in cost-effectiveness for some potential MCLs (9, 4, and 1 ug/L all have positive MCER changes of more than $11 million). A moderate increase in the MCER occurs for the potential MCL of 25 ug/L ($5.4 million) and appears to be, in part, due to the large drop in the two preceding MCLs, especially since both the MCER and CER at 25 ug/L are lower than their counterparts at 40 ug/L (and the CER at 25 ug/L is the lowest in the table, indicating the highest overall cost-effectiveness). The percent change at 25 ug/L (99%) is the highest percent increase in Table 36; however, this percentage is based on the lowest MCER ($5.5 million), and the total increase is only $5.4 million. The large increases in the MCER are $11 million (9 ug/L), $12 million (4 ug/L), and $20 million (1 ug/L). These three potential MCLs also have three of the largest percent increases in the table, indicating large drops in cost effectiveness at these potential MCLs.

A cost effective MCL is chosen using Table 36 by starting with the highest potential MCL (45 ug/L) and determining whether higher or similar cost effectiveness can be achieved at successively lower MCLs. From 45 ug/L, it makes sense to drop to 40, to 35, and then to 30 ug/L because the CER is lower at each successive MCL and the change in the MCER is indicating higher cost effectiveness as the MCL is lowered. Although there is a jump in the MCER for 25 ug/L (discussed in the previous paragraph), this MCL has the highest cost effectiveness overall, so it makes sense to move the MCL from 30 to 25 ug/L. The jump in the MCER from 25 to 20 ug/L is moderate and largely offset by the next two MCLs (15 and 14 ug/L), which make the jump from 25 to 14 ug/L quite small (only $1.2 million). This means that similar cost effectiveness is achieved at 14 ug/L as at 25 ug/L even though the lower MCL is much more health protective. Therefore, it makes sense to move the MCL down to 14 ug/L. From 14 ug/L, only small increases in the MCER occur until the large increase at 9 ug/L, so it makes sense to place the MCL as low as 10 ug/L. The increase in the MCER is very large at 9 ug/L, and successive MCLs do little to offset it. In addition, a large jump in the CER occurs at 9 ug/L. For these reasons, it would not be cost-effective to place the MCL at 9 ug/L or lower, compared to the MCL at 10 ug/L.

Based on this cost-effectiveness analysis, it is cost-effective to place the MCL down to 10 ug/L, but not lower.

G. CONCLUSION

The proposed hexavalent chromium MCL of 10 ug/L would have the following macroeconomic impacts on California based on the RIMS II model: an increase in gross output of $81 million, an increase in aggregate earnings of $2 million, and $53 million in value added, but a decrease of approximately 401 jobs (all compared to the baseline of not implementing a hexavalent chromium MCL). Potential MCLs at 1, 8, and 12 ug/L were evaluated as alternatives to the current proposal. While some alternatives were slightly more cost-effective than the proposed MCL of 10 ug /L, they did not provide as many health benefits. Because HSC 116365 requires that the MCL be set as close to the PHG as is technologically and economically feasible, placing primary emphasis on the protection of public health, alternatives with similar cost-effectiveness but fewer health benefits must be rejected. An additional cost-effectiveness analysis that compared the proposed MCL to 20 alternatives also showed that 10 ug/L is the lowest the MCL can be set while avoiding large decreases in cost-effectiveness.

While many benefits of this regulation are difficult to quantify, improved public health is the primary benefit, which may be experienced as a reduction in the number of cancer cases (up to 12.8 per year) and noncancer cases (liver toxicity). Increased public confidence in the state’s drinking water may also have monetary benefits for families that choose to no longer purchase bottled water or home treatment systems.

H. REFERENCES

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I. APPENDIX A: COST ESTIMATING METHODOLOGY (CEM)

The State Administrative Manual, section 6607 contains the standard methodology developed for use in estimating costs in regulations. The main components of that methodology are (I) Statement of the Mandate, (II) Background or Introductory Material, (III) Working Data, Assumptions, and Calculations, and (IV) Conclusions.

This section presents the cost estimating methodology (CEM) for the proposed rulemaking – Hexavalent Chromium Maximum Contaminant Level (MCL) Regulations. This rulemaking has been identified as a potential Major Regulation as defined by Government Code section 11342.548, and this section has been developed within a SRIA.

In summary, there are costs to the regulated community associated with the adoption of this regulation. The evaluation of potential costs incurred by applicable California public water systems (PWS) is based on the requirements for hexavalent chromium set forth in the proposed regulation. The proposed regulation establishes an MCL for hexavalent chromium, establishes a detection limit for purposes of reporting (DLR) for hexavalent chromium, specifies the analytical methods for monitoring, specifies the associated health effects and contaminant origin language, identifies best available technologies (BAT), and requires PWS to submit a compliance plan. The potential costs associated with the proposed regulation are incurred primarily from the treatment of drinking water in order to meet the MCL for hexavalent chromium. A more detailed discussion on the topic of costs is provided below.

I.1 Statement of the Mandate

The proposed regulation would not impose on local agencies or school districts a mandate that requires state reimbursement because the requirement to provide drinking water that meets the MCL for hexavalent chromium will not be a requirement unique to local government and will apply equally to public and private water systems.

Local agencies or school districts currently incur costs in their operation of PWS and although the regulations may result in a “higher level of service,” no reimbursement is required pursuant to Article XIIIB, section 6 of the California Constitution because they apply generally to all individuals and entities that operate PWS in California and do not impose unique requirements on local governments. Similarly, PWS can pass on the cost of implementation of the regulation through increasing service fees. Therefore, no state reimbursement of these costs is required.

Local regulatory agencies also may currently incur costs for their responsibility to enforce state regulations related to small PWS that they regulate. However, local agencies are authorized to assess fees to pay reasonable expenses incurred in enforcing statutes and regulations related to small PWS (Health & Saf. section 101325). Therefore, no reimbursement of any incidental costs to local agencies in enforcing this regulation would be required (Gov. Code section 17556, subd. (d)).

I.2 Background or Introductory Material

All suppliers of domestic water to the public are subject to regulations adopted by the United States Environmental Protection Agency (U.S. EPA) under the Safe Drinking Water Act of 1974, as amended (42 U.S.C. section 300f et seq.), as well as regulations adopted by the State Water Resources Control Board (State Water Board) under the California Safe Drinking Water Act (Health & Saf. Code, div. 104, pt. 12, ch. 4, section 116270 et seq.).

Currently, U.S. EPA has a drinking water standard for total chromium, which includes hexavalent chromium as one part of the total chromium standard, but has no standard specifically for hexavalent chromium. The State Water Board has the responsibility and authority to adopt the subject regulations.

California requires PWS to sample their drinking water sources and have the samples analyzed for inorganic chemicals to determine compliance with MCLs, also referred to as drinking water standards. The PWS must notify the State Water Board and the public when drinking water supplied to the public is noncompliant with a primary MCL and take appropriate action, which may include taking the source out of use, blending it with another source, or treating the water.

HSC section 116365 imposes requirements on the State Water Board for adoption of primary drinking water standards for the protection of public health. One of these requirements is that the State Water Board set primary drinking water standards at a level that is as close as feasible to the corresponding public health goal (PHG), placing primary emphasis on the protection of public health, and that, to the extent technologically and economically feasible, avoids any significant risk to public health.

Public health goals are established by the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA). In July 2011, OEHHA established the PHG for hexavalent chromium at 0.02 micrograms per liter (ug/L) or parts per billion (ppb). The State Water Board proposes an MCL for hexavalent chromium of 10 ug/L.

Monitoring and treating for hexavalent chromium to meet the MCL will have fiscal and economic impacts, and those impacts were analyzed.

Furthermore, there are additions to existing regulations to identify the BAT to treat hexavalent chromium, set the DLR, identify analytical methods for use by the laboratories, and identify language to describe potential health effects and the typical origins of hexavalent chromium. However, these activities will not have significant economic impacts to PWS as most costs will be related to monitoring and treating hexavalent chromium. The cost of adopting the hexavalent chromium DLR was included in the monitoring estimates. Based on a survey of laboratories, the cost of performing a single hexavalent chromium analysis appears to be independent of the DLR considered down to 0.05 ug/L.

I.3 Working Data, Assumptions, and Calculations

The proposed regulations would primarily apply to community water systems (CWS), non-transient non-community water systems (NTNCWS), and wholesalers. Transient non-community water systems (TNCWS) contaminated above the proposed MCL will also be required to comply with the MCL, but they are not subject to monitoring requirements unless they use surface water and have large daily populations or have been determined subject to potential contamination. Because daily population and potential contamination determinations are not available, any TNCWS with a surface water source that has sampled for hexavalent chromium in the past is assumed to be required to meet CWS monitoring requirements for hexavalent chromium. This conservative assumption ensures that monitoring costs for TNCWS will not be underestimated.

The two primary types of costs to PWS for the proposed regulations are for monitoring and treatment. To estimate these costs, the State Water Board used the working data, tools, assumptions, and calculations described below. The estimated costs were rounded to the nearest dollar for ease in review.

I.3.a Working Data and Tools

The State Water Board used the hexavalent chromium detections for active sources from its Water Quality Information Replacement (WQIR) database for the period January 1, 2010, through June 21, 2021 (SWRCB, 2021a). The source monitoring results in the downloaded WQIR data were evaluated to obtain running annual averages for each affected active source, and the highest annual average for each source was used to estimate compliance costs. Using the historical worst-case scenario for each source means that the enclosed costs do not leave out any known, contaminated sources from consideration and that, overall, costs will be conservative, especially since treating higher hexavalent chromium concentrations costs more.

To calculate costs, these annual averages were compared to the proposed MCL (10 ug/L), and the alternate MCLs (1 to 15, 20, 25, 30, 35, 40, and 45 ug/L), to estimate the number of sources that would be in violation of each potential MCL. The number of affected water systems was also estimated for each potential MCL.

The population served by each source was estimated using information (number of sources in each system and population served by each system) obtained from the State Water Board's Safe Drinking Water Information System (SDWIS) database (SWRCB, 2021b). The number of water sources used, by water system size, was also obtained from the SDWIS database.

I.3.a.1 Monitoring Costs

To obtain sample analysis costs, the State Water Board identified and surveyed 40 laboratories that had submitted water quality data for hexavalent chromium between December 2014 and December 2020 to assess both capacity and capability for sample analysis. A total of 21 laboratories (12 commercial and 9 municipal PWS) responded, providing sample analysis costs, minimum reporting levels, and lowest calibration points for EPA Methods 218.6 and 218.7. Through the survey and follow-up communication with responding laboratories, the State Water Board determined that 0.05 ug/L was the lowest concentration to which California laboratories could reliably quantify hexavalent chromium in drinking water while still attaining the target spike recovery range (70 to 130 percent). For a hexavalent chromium test with a minimum reporting level of 0.05 ug/L, the average cost per sample was $78.63, with the sample costs ranging from $30 to $140 per sample. The average value of $78.63 per sample was used to estimate hexavalent chromium monitoring costs.

I.3.a.2 Treatment Costs

A water system with a drinking water source in violation of the hexavalent chromium MCL would be required to either remove the source from service or treat the source to come into compliance and would incur both capital and operations and maintenance (O&M) costs if the source was treated. Other compliance options, such as blending, may be available to water systems. However, the data needed to evaluate the feasibility of other options on a system-by-system basis is not available, so for purposes for estimating costs, the State Water Board assumed that all sources in violation of the potential hexavalent chromium MCLs would require treatment. Three types of treatment are identified in the regulations as BAT for treatment of hexavalent chromium: Reduction-Coagulation-Filtration (RCF); Ion Exchange; and Reverse Osmosis (RO).

RCF, Ion exchange, and RO treatment are all capable of treating water down to at least 1 ug/L for hexavalent chromium. Two types of ion exchange technology can be used to treat hexavalent chromium: strong base anion exchange (SBA) and weak base anion exchange (WBA). SBA was chosen as one of the technologies to calculate treatment costs because it was the most common treatment installed in the nine California PWS to treat hexavalent chromium contamination at the time of this rulemaking (seven systems installed SBA, one system installed WBA, and one system installed point-of-entry (POE) reverse osmosis). However, some systems may have water quality constraints (such as high sulfate concentrations) that would make using SBA very expensive. Therefore, cost estimates for RCF and WBA treatment were also developed as alternatives.

Centralized treatment cost estimates for SBA ion exchange, WBA ion exchange, and RCF were calculated for each CWS, NTNCWS, TNCWS, and wholesaler source with an annual hexavalent chromium concentration above the considered MCL. After the costs for all treatment types were calculated, the least expensive option was selected (on an annual basis after amortizing capital costs as described below) for each source. In addition, costs for alternatives to centralized treatment (POU devices) were also calculated for CWS with less than 200 service connections (though these costs are only available for informational purposes and are not used to estimate compliance costs). The monitoring, capital, and O&M costs for POU devices are discussed separately in section I.3.c.3, but these costs will not be considered for compliance purposes; they are included only for informational purposes.

All costs were calculated in Python[15] for each treated source as described here, using the highest annual average as the influent concentration of the source and 80% of the potential MCL as the treatment goal. In addition, influent concentrations were capped at

[15] Python is a computer programming language often used for data analysis.

50 ug/L because PWS are already required to treat hexavalent chromium to 50 ug/L under the total chromium MCL.

In the sources used to estimate costs, ion exchange technology and RCF technology were both able to treat finished water to below 1 ug/L. To calculate the costs of achieving different target effluents, a by-pass equation was used to calculate how much of the water should be treated to achieve the desired effluent concentration (Najm et al., 2014):

$$Q_{treated} = Q_{total} \times \frac{(C_{influent} - C_{target})}{(C_{influent} - C_{treated})}$$ (*Equation A1*)

In the above equation, C_{target} is 80% of the MCL and $C_{treated}$ is 0.8 ug/L for both ion exchange and RCF treatment. $Q_{treated}$ becomes the flow used to calculate treatment costs. This new treated flow is only used for O&M calculations. Capital equipment sizing and the associated capital costs are determined using the design flow, which is equal to 1.5 times the average flow (the peaking factor is 1.5), without reductions that occur when a by-pass is installed. This means that even though O&M costs are calculated to reflect effluents at 80% of the MCL, all systems would be capable of treating to less than 1 ug/L with the selected capital equipment.

The use of a by-pass equation is an idealized methodology to estimate O&M costs for different effluent levels and it does not indicate that a by-pass should be used with treatment; the by-pass equation is used solely for cost estimating purposes.

Maintenance and labor costs were calculated the same way for each treatment technology (except for RCF treating less than 100 gpm because those O&M costs already include maintenance costs). Annual maintenance costs were 3% of the corresponding capital costs (Najm et al., 2014). Labor costs were calculated from the 2020 Occupational Employment and Wage Statistics from the Bureau of Labor Statistics, which states that Water and Wastewater Treatment Plant Operators in California have a median annual salary of $75,570 (U.S. Bureau of Labor Statistics, 2020a). However, the median salary of a new employee does not fully represent the costs to employers. Therefore, a multiplier of 1.4 was applied to the salary to account for the costs of benefits and employment taxes (U.S. Small Business Administration). To hire a full-time operator at a median annual salary of $75,570 would cost the employer $105,798 annually, and a half-time operator would cost the employer $52,899 annually. In the following sections, either a full-time or half-time operator was specified for each treatment type.

I.3.a.2.A Ion Exchange Costs: Strong Base Anion

Costs for SBA treatment were developed for two groups of PWS sources: those that treat at least 100 gpm and those that treat less than 100 gpm. The costs for sources that treat at least 100 gpm were derived from Najm et al. (2014), which included costs for two variations of SBA treatment: either disposal to a local sewer without treatment or treatment to remove chromium from the waste brine followed by hauling of the clarified brine off-site for disposal. Because not all PWS have access to a sewer to discharge waste, the option to haul clarified waste brine off site was used for these cost estimates.

Any PWS with access to a sewer will have lower disposal costs than those described below.

The sources that treat at least 100 gpm were assumed to regenerate their spent resin, clarify waste brine, and dewater sludge. The sources that treat less than 100 gpm were assumed to dispose of spent resin as hazardous waste and buy new resin. Because sources that regenerate spent resin, clarify waste brine, and dewater sludge need different equipment than sources that just dispose of spent resin and buy more, the cost estimates were developed separately for these two size categories. While the O&M costs for sources that treat less than 100 gpm were derived from Najm et al. (2014), the capital costs were estimated using the U.S. EPA Work Breakdown Structure (WBS) Model for Anion Exchange Treatment (U.S. EPA, 2021).

Capital costs for SBA ion exchange treatment for sources with flows of at least 100 gpm were derived from Najm et al. (2014) with the following cost categories and details:

- Equipment
    - Includes strainer, ion exchange vessels, salt brine system, waste regeneration water tank, clarifier, ferrous sulfate feed system, clarified regeneration brine tank, fast rinse water recycle tank, backwash pumps, and filter press.
    - Ancillary equipment (15% of equipment costs).
    - Installation (30% of equipment costs).
    - Equipment costs were converted to June 2022 dollars using the ENR 20-Cities Construction Cost Index (ENR, 2014; ENR, 2022).
- Building and Slab
    - Indoor equipment footprint is based on the space needed for the strainer, clarifier, ferrous sulfate feed system, and dewatering equipment, which is 255 square feet for treatment at 100 gpm and 751 square feet at 10,000 gpm.
    - Indoor working space is equal to the indoor equipment footprint, such that the total building area is double the indoor equipment footprint.
    - Outdoor footprint is based on the space needed for the ion exchange vessels, salt system, waste brine tanks, rinse tanks, and ferrous sulfate feed system.
    - Indoor building costs and slab costs were converted to June 2022 dollars using the ENR 20-Cities Building Cost Index, which were $216.45 and $72.15 per square foot, respectively (ENR, 2014; ENR, 2022).
- Construction activities
    - Includes mobilization, site work and yard piping, electrical and HVAC equipment and installation, instrumentation components, installation, and programming (45% of the equipment, building, and slab costs above).
    - Construction contingency (25% of the construction activities above).
    - Contractor overhead and profit (15% of the construction activities above).
    - Initial resin load, estimated based on updated strong base resin cost of $243.66 per cubic foot with a 7.5% sales tax and 5% installation cost.

- The average of strong base ion exchange resin costs provided in U.S. EPA (2021) was $218 per cubic foot, which was updated to $243.66 (June 2022 dollars) using the water treatment compounds cost index (U.S. Bureau of Labor Statistics, 2022b).

- Professional services
  - Engineering design, pilot testing, environmental permitting, construction management, start-up support services, administrative and legal services (includes pilot costs).
  - Professional services contingency (25% of the above professional services costs).

The costs described above are shown in **Error! Not a valid bookmark self-reference.**. SBA capital costs for each individual source with flows at least 100 gpm were calculated by linearly interpolating between the values in Error! Not a valid bookmark **self-reference.**.

Table A1. SBA capital cost estimates by design flow for sources with flows of 100 gpm or greater (Najm et a., 2014).

Design Flow (gpm)	Capital Cost (2022 dollars)
100	1,638,586
250	2,674,049
500	3,586,621
1,000	4,553,303
2,000	7,150,157
5,000	10,498,018
7,500	14,897,759
10,000	18,005,247

SBA capital costs for sources with flows less than 100 gpm were developed using the following inputs and changes to the U.S. EPA (2021) model:

- An empty bed contact time of 3 minutes.
- A sales tax of 7.25% was added to the equipment costs.
- Land costs were excluded.

The following upgrades to better quality equipment were made in the model to reflect current industry practices:

- Pressure vessels: fiberglass tanks were switched to stainless steel tanks.

- Brine and other storage tanks: plastic and cross-linked polyethylene (XLPE) tanks were switched to stainless steel tanks. If stainless steel tanks were unavailable, fiberglass was chosen.
- Residuals holding tanks/basins: plastic/HDPE tanks were switched to steel tanks.
- Piping: PVC piping was switched to stainless steel piping.
- Valves and fittings: polypropylene/PVC valves and fittings were switched to stainless steel valves and fittings.
- Brine eductors: plastic eductors were switched to stainless steel eductors.

In addition, costs were included for a pilot study, site work, yard piping, electrical work (includes yard wiring; 10% of equipment costs), contingency (25% of equipment costs), process engineering (20% of equipment costs), miscellaneous allowance (10% of equipment costs), legal, fiscal, and administrative costs (2% of equipment costs), and construction management and general contractor overhead.

Because these costs were developed with national average costs, they were increased by 10% to account for higher construction costs in California, which was based on the San Francisco and Los Angeles ENR construction cost indexes compared to the 20-cities average (ENR, 2022).

The inputs and changes above to the U.S. EPA WBS model produced the capital costs per design flow in gpm shown in **Error! Not a valid bookmark self-reference.**. SBA capital costs for each individual source with flows less than 100 gpm were calculated by linearly interpolating between the values in **Error! Not a valid bookmark self-reference.**. These costs were converted to June 2022 dollars using the ENR 20-cities construction cost index (ENR 2021; ENR, 2022).

Table A2. SBA capital cost estimates by design flow for sources with flows less than 100 gpm (US EPA, 2021)

Design Flow (gpm)	Capital Cost (2022 dollars)
10	233,786
20	255,185
40	343,870
60	350,418
80	356,744
100	373,611

The lowest flow available in the cost model is 10 gpm, so any flow less than 10 gpm was assigned the capital costs of a 10-gpm system.

The O&M costs for SBA had two options for brine disposal: clarified waste brine hauled off site, and waste brine discharged to a sewer (no clarifier needed). For PWS sources that treat at least 100 gpm with SBA, costs were derived from Najm et al. (2014), with the updates and changes described below. The SBA O&M costs for PWS sources that treat less than 100 gpm were also derived from Najm et al. (2014), except that instead of assuming regeneration of spent resin, it was assumed that spent resin was disposed of as non-RCRA hazardous waste and new resin was purchased as a replacement.

Therefore, SBA O&M costs for sources that treat flows of at least 100 gpm are composed of salt, ferrous sulfate, new resin, energy, brine disposal, sludge disposal, labor, and maintenance costs. The SBA O&M costs for sources that treat flows less than 100 gpm are composed of new resin, disposal of spent resin, energy, labor, and maintenance costs.

The O&M costs detailed in Appendix A of Naim et al. (2014) provide costs for 60% utilization, so the estimates were scaled up to represent 100% utilization for each system size. For SBA treatment, the annual amounts needed of salt, ferrous sulfate (to clarify waste brine), resin, and energy were multiplied by their respective unit costs, which were updated as follows:

- Salt: $160 per ton updated to $193 per ton in 2022 dollars using the rock salt cost index (U.S. Bureau of Labor Statistics, 2022a).
- Ferrous sulfate: $2.20 per gallon updated to $2.79 per gallon in 2022 dollars using the water treatment compounds cost index (U.S. Bureau of Labor Statistics, 2022b).
- SBA Resin: The average of strong base ion exchange resin costs provided in U.S. EPA (2021) was $218 per cubic foot, which was updated to $243.66 per cubic foot in 2022 dollars using the water treatment compounds cost index (U.S. Bureau of Labor Statistics, 2022b).
- Energy: $0.193 per kWh, based on current commercial energy costs (U.S. Energy Information Administration, 2022).

Waste brine is the primary waste product of the SBA process when resin is regenerated. In specific cases, waste brine can be discharged to the local sewer. However, not all PWS have access to this option, and some wastewater systems will not accept waste brines with high concentrations of metals, which is likely with SBA waste brine used to treat hexavalent chromium. A clarifier can be used to reduce and precipitate metals (especially hexavalent chromium) into a sludge, which is dewatered and disposed of separately. Dewatered sludge is expected to be classified as non-RCRA hazardous waste in California.

While the standard approach in SBA treatment is to use each batch of brine once and dispose of it, several studies have shown that the salt brine can be reused twice without an impact (Najm et al., 2017). Even reusing the brine up to 20 times only had minor impacts on regeneration efficiency, and those impacts could be mitigated by extending the contact time between the brine and resin or increasing the temperature during brine regeneration (Najm et al., 2014), which could represent substantial cost savings for PWS. Clarified waste brine volume was halved to represent the case where brine is used twice.

SBA disposal costs depend on the volume of clarified waste brine and sludge produced, as previously described. Those volumes are multiplied by their respective updated unit costs below:

- Liquid waste disposal (brine): $230 per kgal updated to $297 per kgal in 2022 dollars based on the waste collection and remediation services cost index (U.S. Bureau of Labor Statistics, 2022d).
- Dewatered sludge and spent resin disposal (non-RCRA hazardous waste): $2,000 per ton updated to $2,583 per ton in 2022 dollars based on the waste collection and remediation services cost index (U.S. Bureau of Labor Statistics, 2022d).

The SBA cost estimates in Najm et al. (2014) assumed 6,400 bed volumes treated before regeneration of the resin was needed. However, the following equation was included to determine bed volumes before breakthrough for any individual source, based on water quality:

$$Bed\ Volumes = 6{,}541 - 8{,}307.5 \times log\left\{\left(\frac{[SO_4]}{48}\right) + \left(\frac{[NO_3]}{62}\right)\right\}$$ (*Equation A2*)

To use the above equation for each source, the average sulfate and nitrate concentrations were calculated from more than 10 years of data (January 1, 2010, through June 21, 2021). If either sulfate or nitrate concentrations were unavailable for a particular source, 6,400 bed volumes to breakthrough were assumed to represent moderate conditions. While Najm et al. (2014) found that the above equation matched well with experimental results, in high-sulfate conditions (such as sulfate concentrations above 300 mg/L) the equation can produce a negative result. To represent challenging water quality, a minimum of 500 bed volumes was assumed as a conservative estimate (a minimum of 2,000 bed volumes were observed in the study)[16].

Clarified waste brine, sludge volumes, and spent resin volumes were modified to account for water-quality-specific bed volumes by increasing or decreasing the volumes proportionally (initial volumes assumed 6,400 bed volumes), with more bed volumes corresponding to smaller volumes of brine and sludge.

SBA treatment plants that regenerate resin were assumed to need a full-time operator ($105,798 annually), and treatment plants without regeneration were assumed to need a part-time operator ($52,899 annually). Much more staff time will be needed to operate a treatment system with a regeneration facility than a single-use resin system. In addition, smaller treatment facilities will take less time to operate. These assumptions were derived from U.S. EPA (2021), which details the estimated operator hours per year needed for SBA treatment, broken down by treatment process.

[16] Fewer bed volumes means that the resin is able to treat less water before it needs to be replaced or regenerated, which will be more expensive than resin able to treat more bed volumes.

I.3.a.2.B Ion Exchange Costs: Weak Base Anion

WBA costs were only developed for PWS sources that treat at least 100 gpm. WBA costs were not estimated for PWS sources that treat less than 100 gpm because reliable costs for this flow range could not be found.

The costs for sources that treat at least 100 gpm were derived from Najm et al. (2014), which included costs for two variations of WBA treatment: adjusting pH with carbon dioxide and then air stripping and adjusting pH with hydrochloric acid and sodium hydroxide. The latter option was selected because the equipment footprint was much smaller, which means it is more likely to be an option for PWS that are space constrained. Capital costs for WBA treatment have the following cost categories and details:

- Equipment
  - Includes strainer, HCl storage and feed system, vessels, waste backwash water tank, and caustic storage and feed system.
  - Ancillary equipment (15% of equipment costs).
  - Installation (30% of equipment costs).
  - Equipment costs were converted to June 2022 dollars using the ENR 20-Cities Construction Cost Index (ENR, 2014; ENR, 2022).
- Building and Slab
  - Indoor equipment footprint is based on the space needed for the strainer, HCl equipment, and NaOH system, which is 36 square feet for treatment at 100 gpm and 530 square feet at 10,000 gpm.
  - Indoor working space is equal to the indoor equipment footprint, such that the total building area is double the indoor equipment footprint.
  - Outdoor footprint is based on the space needed for the ion exchange vessels, HCl system, NaOH system, and backwash water tank.
  - Indoor building costs and slab costs were converted to June 2022 dollars using the ENR 20-Cities Building Cost Index, which were $216.45 and $72.15 per square foot, respectively (ENR, 2014; ENR, 2022).
- Construction activities
  - Includes mobilization, site work and yard piping, electrical and HVAC equipment and installation, and instrumentation and control components (45% of the equipment, building, and slab costs above).
  - Construction contingency (25% of the construction activities above).
  - Contractor overhead and profit (15% of the construction activities above).
  - Initial resin load, estimated based on updated strong base resin cost of $243.66 per cubic foot with a 7.5% sales tax and 5% installation cost.
    - The average of strong base ion exchange resin costs provided in U.S. EPA (2021) was $218 per cubic foot, which was updated to $243.66 (June 2022 dollars) using the water treatment compounds cost index (U.S. Bureau of Labor Statistics, 2022b).
- Professional services
  - Engineering design, pilot testing, environmental permitting, construction management, start-up support services, administrative and legal services (includes pilot costs).

- Professional services contingency (25% of the above professional services costs).

The costs described above are shown in Table A3. Capital costs for each individual source with flows at least 100 gpm were calculated by linearly interpolating between the values in Table A3.

Table A3. WBA capital cost estimates by design flow for sources with flows of 100 gpm or greater (Najm et a., 2014).

Design Flow (gpm)	Capital Cost (2022 dollars)
100	1,073,296
250	1,554,311
500	2,082,033
1,000	3,759,558
2,000	6,520,844
5,000	9,662,353
7,500	13,324,763
10,000	17,276,495

Because the costs provided were for 60% utilization, the O&M costs were scaled up to represent 100% utilization. The annual amounts needed of hydrochloric acid, sodium hydroxide, resin, and energy were multiplied by their respective unit costs, which were updated as follows:

- Hydrochloric acid: $2,200 per ton from Najm et al. (2014) was updated to $2,791.84 per ton using the water treatment compounds cost index (U.S. Bureau of Labor Statistics, 2022b).
- Sodium hydroxide: $1,000 per ton from Najm et al. (2014) was updated to $1,269.02 per ton using the water treatment compounds cost index (U.S. Bureau of Labor Statistics, 2022b).
- WBA Resin: the average of four sources[17] of current WBA resin costs, $600 per cubic foot in 2022 dollars.
- Energy: $0.193 per kWh, based on current commercial energy costs (U.S. Energy Information Administration, 2022).

[17] The WBA resin cost from Najm et al. (2014) was converted to 2022 dollars using the using the water treatment compounds cost index (U.S. Bureau of Labor Statistics, 2022b); current pricing was also obtained from online resin retailers (APS Water, 2022; Crystal Quest, 2022; Servapure, 2022).

Labor costs for WBA treatment have been updated to account for a full-time operator at an annual cost of $105,798, as derived above. Disposal costs for WBA treatment were determined by multiplying the amount of resin replaced annually by the unit cost for the disposal of non-RCRA hazardous waste, which was updated from $2,000 to $2,583 per ton in 2022 dollars based on the waste collection and remediation services cost index (U.S. Bureau of Labor Statistics, 2022d).

I.3.a.2.C Reduction/Coagulation/Filtration Costs

The capital costs for RCF treatment were derived for two groups of PWS sources: those that treat at least 100 gpm and those that treat less than 100 gpm. The sources that treat at least 100 gpm were assumed to use ferrous sulfate as a reductant and construct a treatment plant similar to that described in Najm et al. (2014). Sources that treat less than 100 gpm were assumed to use a treatment process designed for small systems that uses electrolytic stannous as the reductant (Aqua Metrology Systems, 2022).

The RCF capital costs for sources that treat flows of at least 100 gpm were based on the methodology of Najm et al. (2014), outlined below. The costs were updated using ENR cost indexes specific to the type of cost, as shown in the capital cost categories below:

- Equipment
  - Includes RCF filtration vessels, reduction contactor vessels, ferrous sulfate feed system, backwash system, and backwash return.
  - Ancillary equipment (15% of total equipment costs).
  - Installation (30% of total equipment costs).
  - Equipment costs were converted to June 2022 dollars using the ENR 20-Cities Construction Cost Index (ENR, 2014; ENR, 2022).
- Building and Slab
  - Indoor equipment footprint, based on the space needed for the ferrous sulfate system, which is 20 square feet for treatment up to 2,000 gpm and 40 square feet for larger treatment flows.
  - Indoor working space is equal to the indoor equipment footprint, such that the total building area is double the indoor equipment footprint.
  - Outdoor footprint is based on the equipment floor area needed for RCF filtration vessels, reduction contactor vessels, and the backwash system.
  - Indoor building costs and slab costs were converted to $216.45 and $72.15 per square foot, respectively, in June 2022 dollars using the ENR 20-Cities Building Cost Index (ENR, 2014; ENR, 2022).
- Construction activities
  - Mobilization, site work and yard piping, electrical and HVAC equipment and installation, instrumentation components, installation, and programming (45% of the equipment, building, and slab costs above).
  - Construction contingency (25% of the construction activities above).
  - Contractor overhead and profit (15% of the construction activities above).
  - Initial filtration media load, estimated based on updated sand/anthracite media cost of $29.84 (in 2022 dollars) per cubic foot with a 7.5% sales tax and 5% media installation cost.

        - Sand/anthracite based on unit cost of $20 per cubic foot updated to June 2022 dollars using a cost index for sand (U.S. Bureau of Labor Statistics, 2022c).
- Professional services
    - Engineering design, verification testing, environmental permitting, construction management, start-up support services, administrative and legal services.
    - Professional services contingency (25% of the above professional services costs).
- Initial Filtration Media Load, estimated based on updated sand/anthracite media cost with a 7.5% tax and 5% media installation cost.

The capital costs described above are shown in Table A4. Capital costs for each individual source with flows of at least 100 gpm were calculated by linearly interpolating between the values in Table A4.

Table A4. RCF capital cost estimates by design flow for sources with flows of at least 100 gpm (Najm et al., 2014)

Design Flow (gpm)	Capital Cost (2022 dollars)
100	1,384,549
250	2,146,283
500	3,529,632
1,000	4,446,482
2,000	5,739,023
5,000	11,141,943
7,500	16,370,813
10,000	20,462,410

Because the Najm et al. (2014) costs assumed a 60% utilization rate, the O&M estimates were scaled up to represent 100% utilization. The changes and updates made to the O&M costs are detailed below:

- Ferrous sulfate was used as the reductant, and the cost of $2.20 per gallon was updated to $2.79 per gallon in 2022 dollars using the water treatment compounds cost index (U.S. Bureau of Labor Statistics, 2022b).
- The unit energy cost has been updated to the average electricity price for commercial end users in California, $0.193 per kWh (U.S Energy Information Administration, 2022).

- Disposal costs for dewatered solids were updated from $2,000 to $2,583 per ton using the waste collection and remediation services cost index (U.S. Bureau of Labor Statistics, 2022d).
- Labor costs were updated to account for a full-time operator at a cost of $105,798, as derived above.

RCF capital costs for sources with flows less than 100 gpm were based on industry quotes from Aqua Metrology Systems for a stannous-based (rather than ferrous-based) RCF treatment system (Aqua Metrology Systems, 2022). These costs include a generator, contactor, filters, pipework, a skid/trailer, and an online duo efficient analyzer for hexavalent chromium and total chromium. While the analyzer is not necessary for the treatment system, it allows for operation without constant oversight (called unattended mode) and for the system to be monitored remotely. Table A5 shows capital costs for the stannous-based RCF treatment system, including an added contingency cost of 25% (to stay consistent with all other capital costs, which include the 25% contingency from Najm et al. (2014)). Capital costs for each individual source with flows less than 100 gpm were calculated by linearly interpolating between the values in Table A5. Any source with flows less than 5 gpm was assigned the costs of a 5-gpm treatment system.

Table A5. RCF capital cost estimates by design flow for sources treating flows less than 100 gpm (Aqua Metrology Systems, 2022)

Design Flow (gpm)	Capital Cost (2022 dollars)
5	225,000
10	237,500
20	250,000
50	606,250
100	731,250

The RCF O&M costs include the stannous consumables, the remote system condition monitoring, system maintenance, a 10-year warranty, and sludge removal. Because the analyzer was included in the capital costs and system maintenance (including labor) is already included in O&M costs, additional labor costs are only for a half-time operator ($52,899 annually). The RCF O&M costs for sources with flows less than 100 gpm are shown in Table A6. RCF O&M costs for each individual source that treats less than 100 gpm are estimated by linearly interpolating between the costs in Table A6. A source with flows less than 5 gpm was assigned the costs of a 5-gpm treatment system.

Table A6. RCF annual O&M cost estimates by design flow for sources treating less than 100 gpm (Aqua Metrology Systems, 2022)

Design Flow (gpm)	O&M Cost (2022 dollars)
5	25,000
10	30,000
20	40,000
50	95,000
100	155,000

In addition to the costs in Table A6, energy costs were calculated based on energy consumption of about 2,190 kWh per year for a 10-gpm system (Aqua Metrology Systems, 2021). These energy costs were calculated by multiplying the consumed energy by the average electricity price for commercial end users in California, $0.193 per kWh (U.S Energy Information Administration, 2022).

I.3.a.2.D Centralized Treatment Alternatives

For smaller systems, a lower cost alternative to centralized treatment is point-of-use (POU) or point-of-entry (POE) devices. Systems with less than 200 service connections may be permitted to use POU or POE treatment in lieu of centralized treatment for the purpose of reducing contaminants to achieve compliance with one or more MCLs. POU capital and O&M costs were estimated for systems with less than 200 service connections using the U.S. EPA POU and POE cost estimating tool (EPA tool) (US EPA, 2007). The POU capital cost includes the cost for treatment device purchase, installation, educational materials, and water quality monitoring. Indirect capital costs, such as permitting, pilot studies, engineering design, and contingency are also included. The O&M costs include the labor to maintain the POU equipment, prepare and distribute education program updates, and monitor water quality. The State Water Board did not estimate the cost of POE treatment due the lack of POE devices certified for hexavalent chromium treatment and registered for sale in California.

The EPA tool assumes that a PWS treating for hexavalent chromium uses a POU RO device for treatment. While non-RO POU devices may exist for hexavalent chromium treatment, there are a greater number and wider selection of POU RO devices currently registered for sale in California. As of June 17, 2021, California has registered 93 RO devices under the State Water Board Residential Water Treatment Device Program that are certified under NSF International and American National Standards Institute (NSF/ANSI) 58 to remove hexavalent chromium (SWRCB, 2021). Of the currently registered devices, 24 are certified to treat hexavalent chromium from an average influent concentration of 300 ug/L to levels below 10 ug/L, while 13 devices are certified to treat hexavalent chromium to levels below 5 ug/L. Average costs were collected from device manufacturer or retail websites and are summarized in Subappendix B (section I.7), Tables SB1 and SB2. The POU devices are capable of removing both trivalent and hexavalent chromium. Costs for replacement RO membrane cartridges, sediment pre-filters, and pre- and post-membrane filters were averaged.

RO systems treating hexavalent chromium to levels below 5 ug/L are, on average, more expensive than devices that treat to levels below 10 ug/L. POU device cost estimates are conservative since costs are based on purchasing individual units rather than in bulk.

For systems requiring treatment and that opt to use a POU treatment strategy, the primary assumptions and parameters are documented in both the U.S. EPA Tool User Guide and the Cost Estimating Methodology attachment for Point-of-Use and Point-of-Entry regulations (SWRCB, 2017; US EPA, 2007). The following list of assumptions summarizes the adjustments made to the EPA tool:

- Household service connections are used for system size input in the EPA tool;
- The average per capita consumption of water using a POU device is 0.63 gallons per person per day. The consumption rate is based on the ninety-fifth percentile estimation for ingestion of both direct and indirect community water (i.e., tap water from the community water supply) for all ages (Kahn & Stralka, 2009). Direct water refers to plain water ingested directly as a beverage, while indirect water refers to water added to foods and beverages before consumption;
- The average California household size is approximately three persons (U.S. Census Bureau, 2019);
- The average sample analysis cost from surveyed commercial laboratories accredited by ELAP for analyzing hexavalent chromium in drinking water (using a detection limit for purposes of reporting at 0.05 ug/L) was used ($78.63 per sample);
- The EPA tool uses an average loaded wage rate based for plumbers and electricians with a fringe benefits multiplier of 1.48 for POU installation labor rates. The May 2020 California median hourly wage for plumbers is $29.58 per hour and for electricians is $32.95 per hour (U.S. Bureau of Labor Statistics, 2020b, 2020c);
- Cost for system technical and clerical labor hours were based on a study on labor costs for national drinking water rules prepared for U.S. EPA by the Science Applications International Corporations (SAIC) in 2003. The hourly wages plus benefits are $26.06 (2003 dollars) and $18.54 (2003 dollars) for technical and clerical staff in the water supply industry, adjusted to 2021 dollars (USEPA, 2007); and
- Hourly labor rates were adjusted using March 2021 Economic Cost Index of 155.7 and March 2021 Consumer Price Index of 267.054 (U.S. Bureau of Labor Statistics, 2021a, 2021b).

I.3.a.3 Compliance Plan Costs

PWS will be required to submit a compliance plan if they exceed the MCL before their applicable compliance date. It is estimated that it would take a system between 80 and 120 hours (100 hours average) to prepare the plan, and 30 to 40 hours (35 hours average) for DDW engineers to review and respond to the plan.

The annual mean salary for a civil engineer in California is $113,200 (U.S. Bureau of Labor Statistics, 2021c). However, the salary of a new employee does not fully represent the costs to employers. Therefore, a multiplier of 1.4 was applied to the salary to account for the costs of benefits and employment taxes (U.S. Small Business Administration). The mean salary of $113,200 times 1.4 is $76.19 per hour, times 100 hours brings the total cost to prepare a compliance plan to $7,619.

The cost to the SWRCB is needed for the SRIA and form STD 399. The annual salary for water resource control engineers at the SWRCB ranges from $70,188 to $131,472 (California Department of Human Resources, 2022). The high end of this range ($131,472) will be used to estimate the costs to review each compliance plan. Overhead costs are an additional 43.21% of the salary, which means the hourly cost to review a plan is $90.69. Since plan review is expected to take an average of 35 hours, the average cost to the SWRCB to review a plan is $3,174.

I.3.b Additional Assumptions

The assumptions used by Najm et al. (2014) to develop estimated treatment costs are documented in their report. The U.S. EPA (2021) also included their assumptions in the documentation for their model. The State Water Board's assumptions used to estimate treatment costs (consisting of both capital and O&M costs) are also provided in section I.3.a.2 of this document, above. Additional assumptions the State Water Board relied upon in developing estimated costs are as follows:

- Water quality data from the State Water Board's WQIR database provides a sufficient basis for cost analysis for the proposed regulations (the Districts have reviewed this data and submitted corrections, which are detailed in Subappendix A);
- Any source exceeding a proposed MCL will treat the source to come into compliance;
- Each affected source requiring treatment will have its own treatment plant and will incur capital, O&M, and monitoring costs;
- The average demand is calculated using 150 gallons/person/day for CWS and wholesalers, and 120 gallons/person/day for NTNCWS and TNCWS, which is discussed in further detail below;
- The peaking factor used to determine maximum day demand is 1.5, which is consistent with the peaking factor used to determine source capacity in California Code of Regulations, title 22, division 4, chapter 16, section 64554;
- The hexavalent chromium concentration in the treated water is at a level equal to 80% of the MCL;
- The water provided by each source is equal to the total system water produced divided by the total number of active sources for that system;

- The population exposed to a source is equal to the total PWS population divided by the total number of active sources for that PWS;
- Water systems that need to install treatment to comply with the proposed hexavalent chromium MCL will use RCF, SBA, or WBA treatment, selecting the least expensive treatment for each source;
- Operator costs adjustments specifically due to changes in water treatment facility class were not considered as a specific cost. However, part-time or full-time operator salaries were included in these costs, depending on the complexity of treatment;
- Land costs were not included;
- Hexavalent chromium influent concentration for each source is assumed to be the highest annual average of the running annual averages of the previous 10 years of source concentration in ug/L. However, for purposes of estimating costs, influent concentrations do not exceed 50 ug/L because hexavalent chromium is already regulated through the total chromium MCL (50 ug/L) in the baseline; and
- Specific state, county, and city building ordinance requirements are not accounted for in cost estimates.

The daily per capita water demand of 150 gallons was originally a rounded value based on water usage data provided to the State Water Board by 386 California urban water suppliers during June 2014 and increased by 10 percent (SWRCB, 2017). To check the validity of this assumption, the 2019 EAR water production data was used to calculate the average per capita daily demand for CWS and NTNCWS: 152 and 119 gallons/capita/day, respectively. While 150 gpcd was found to be an appropriate estimate of demand for community systems, NTNCWS systems use much less water on a per person basis. The rounded value of 120 gpcd was used as the demand estimate for NTNCWS systems.

I.3.c Cost Calculations

The calculations for monitoring and treatment costs are discussed below.

I.3.c.1 Monitoring Costs

There are three types of monitoring costs under the existing inorganic chemical regulations. The number of water systems needing to conduct each type will differ.

- *Routine:* A water system with drinking water sources previously not monitored or with sources showing hexavalent chromium equal to or below the proposed MCL would be required to monitor those sources once every three years (groundwater) and once every year (surface water) [22 CCR 64432(c)].
- *Increased:* A water system with one or more drinking water sources showing hexavalent chromium above the proposed MCL would be required to monitor those sources quarterly. A reduction in monitoring frequency may be requested from the

State Water Board after systems have completed two (for groundwater) or four (for surface water) consecutive quarters of monitoring showing results below the proposed MCL [22 CCR 64432(h)(1)].

- *Treated:* A water system treating a drinking water source for hexavalent chromium to comply with the proposed MCL would be required to monitor the treated water monthly [22 CCR 64432(e), 22 CCR 64432.8(a)].

If the data does not specify a source type (surface water or groundwater), it was conservatively assumed to be surface water because the monitoring requirements for surface water are more stringent. Any cost occurring less frequently than once per year was annualized.

I.3.c.2 Treatment Costs (Capital and O&M)

Capital costs were calculated for each source and evaluated treatment type by using the design flow of the source and interpolating between the appropriate capital cost values from the above sections. The capital costs were then annualized using the capital recovery method with an interest rate (i in decimal format) of 7% (i.e., 0.07) and an amortization period (n) of 20 years. The equations used for this amortization are:

$$Annualized\ Capital\ Cost = Initial\ Capital\ Cost * Amortization\ Factor$$

(*Equation A3*)

$$Amortization\ Factor = \frac{i \times (1+i)^n}{(1+i)^n - 1} = 0.0944$$

(*Equation A4*)

The O&M costs were calculated for each source and evaluated treatment type using the categories and costs detailed in their respective sections and the new treated flow (Equation A1).

Table A7. Number of sources in each design flow range (in gpm)

Design Flow Range (gpm)	Number of CWS Sources	Number of NTNCWS Sources	Number of TNCWS Sources	Number of Wholesaler Sources	Total Number of Sources
< 5	19	13	1	6	39
5 to 10	32	12	2	2	48
10 to 20	28	16	1	-	45
20 to 50	32	23	2	-	57
50 to 100	20	5	1	-	26
100 to 250	40	3	-	1	44
250 to 500	114	-	-	1	115
500 to 1,000	100	-	-	-	100

1,000 to 2,000	17	-	-	-	17
2,000 to 5,000	10	-	-	-	10
5,000 to 7,500	-	-	-	-	-
7,500 to 10,000	-	-	-	-	-

The Python code used to calculate the costs is available online.[18] The code utilizes engineering and cost information pertaining to treatment, flow rates, resins, chemicals, power, labor, and potential MCL level to calculate individual monitoring, capital, and O&M costs for each source with an annual hexavalent chromium concentration above the MCL.

All costs were converted into June 2022 dollars using the indexes detailed in their respective sections.

I.3.c.3 Point-of-Use Treatment Costs (Capital and O&M)

The U.S. EPA POU cost estimating tool was used to calculate POU annualized capital and annual O&M costs for systems with fewer than 200 service connections (U.S. EPA, 2007) (

[18] The Hexavalent Chromium MCL Github Repository is available at https://github.com/CAWaterBoardDataCenter/Hexavalent-Chromium-MCL.

Table A7). Linear equations were fit to the costs (r-squared value of 1) to create total annualized cost equations (sum of annualized capital and annual O&M costs) based on POU device treatment capability and the number of service connections (Figure A1). The linear equations differ by MCL because the POU devices registered under the California Water Treatment Device Program have varying costs depending on the devices' ability to treat hexavalent chromium (ISOR Attachment 3, Table 2). The devices' overall percent reduction of hexavalent chromium was multiplied by the influent NSF challenge concentration to determine the devices' treatment ability. The linear equations were then applied to each water system impacted by the different potential MCLs. Costs were summed for each water system size category: less than 100 service connections and from 100 to 200 service connections. To determine the POU monthly cost per connection for each water system size category, the total annualized cost ($/year) was divided by the total number of service connections in each size category and 12 months, as shown below:

$$POU\ monthly\ cost\ per\ connection = Total\ annualized\ cost\ [\$/year] \div Total\ number\ of\ connections \div 12\ [months/year]$$

(*Equation A5*)

Table A7. Total Annualized POU Costs

Service Connections (sc)	MCL of 4 or 5 ug/L	MCL of 6 or 7 ug/L	MCL of 8 ug/L	MCL of 9 ug/L	MCL of 10 to 25 ug/L
25	$16,016	$15,142	$14,051	$12,636	$11,861
50	$31,146	$29,400	$27,218	$24,388	$22,838
100	$61,202	$58,429	$53,345	$47,685	$44,585
150	$91,373	$86,134	$79,588	$71,098	$66,447
200	$121,428	$114,443	$105,715	$94,394	$88,194

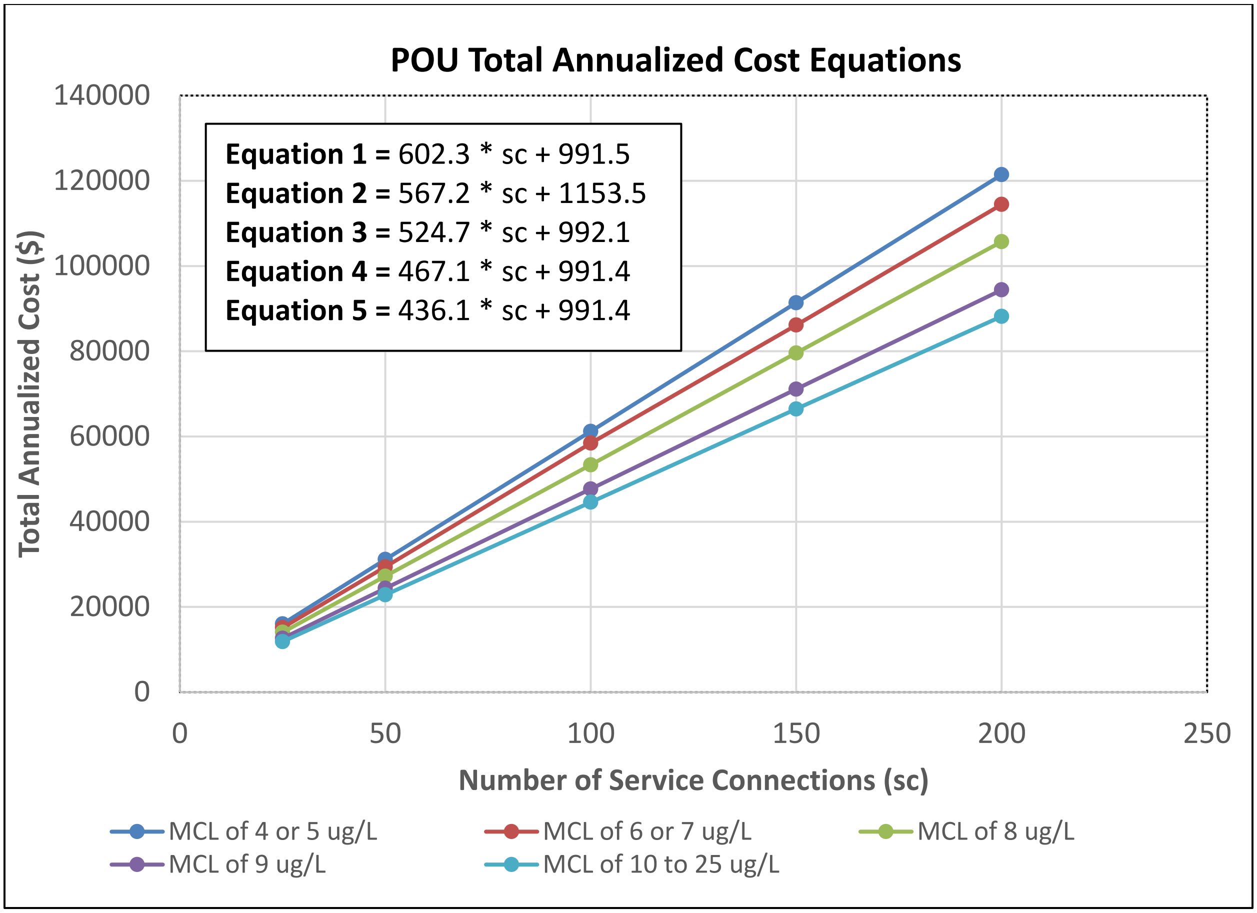

Figure A1. Total Annualized Linear Cost Equations for POU Costs

To compare costs to centralized treatment, the POU and centralized treatment should have the same life cycle cost over a similar period of time. The useful life of a POU device was assumed to be 10 years, based on case studies in U.S. EPA POU tool guidance and vendor information (U.S. EPA, 2007). This period reflects the expected time the devices will remain installed and operating given regular maintenance (e.g., filter replacement). After 10 years, the POU device is assumed to be replaced with a new, but similar POU device that uses RO technology. While prices for the POU device may increase or decrease in 10 years (e.g., due to inflation or improved POU or POE treatment technologies), the POU calculation used for this analysis assumes the price of the POU devices are bought at the same present value prices.

These costs are expressed as monthly costs per connection in Table A8.

Table A8. Estimated monthly costs per connection of POU treatment for small water systems

MCL (ug/L)	SC less than 100	SC greater than or equal to 100 or less than 200
4, 5	$52	$51
6, 7	$47	$47
8	$46	$44
9	$41	$40
10 to 25	$38	$37

I.4 Conclusion

The State Water Board is promulgating regulations for hexavalent chromium. Adopting a drinking water MCL for hexavalent chromium is consistent with statutory requirements and provides increased public health protection by reducing the potential risk of adverse health effects associated with hexavalent chromium. The primary costs to the regulated community are related to treatment necessary to comply with the hexavalent chromium MCL.

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I.6 Subappendix A

Table SA1 shows manual changes made to the data after it was pulled from the system and before costs were estimated. These changes were recommended by the engineer(s) of each relevant DDW district. Each system number is listed followed by the change that was made and other relevant information.

Table SA1. Manual changes to source data

Water System	Change	Notes
CA0110003	Population to 23,600 from 59,000	Pop impacted of 2,950 per source
CA0110010	Population to 42,480 from 40	Wholesaler; Pop impacted of 3,540
CA0710002	Population to 3,360 from 22,295	Pop impacted of 1,120
CA1910048	Volume of GW sources reduced to 5.4%	2020 EAR used to determine GW/SW proportion
CA1910067	Volume of GW sources reduced to 8.7%	2020 EAR used to determine GW proportion
CA1910097	Population of Facility 11 changed to 550 from 5,220	Pop impacted of 110
CA3410017	Population of non-SW sources to 64,000 from 48,738	Pop impacted of 4,000
CA3410020	Population of non-SW sources to 116,000 from 510,931	Wholesaler; Pop impacted of 4,000
CA3410029	Population of non-SW sources to 132,000 from 168,686	Pop impacted of 4,000
CA3610018	Population halved for GW sources to 101,175 to reduce customers served by 50%	
CA3610029	Population halved to 28,839 to reduce customers served by 50%	
CA3610036	GW source not used	According to EARs, well has not been used to produce water since 2017
CA3610037	Population halved for GW sources to 38,912 to reduce customers served by 50%	
CA3610041	Population halved for GW sources to 118,500 to reduce customers served by 50%	
CA3610055	Population halved for GW sources to 27,146 to reduce customers served by 50%	

Water System	Change	Notes
CA3810001	GW sources adjusted to 0.02% of total production	2020 EAR used to determine GW proportion
CA3810011	Population to 4,000 from 884,363	Pop impacted of 1,000
CA3910001	Population of non-SW sources to 32,825 from 173,272	Pop impacted of 1,313
CA3910011	Population of non-SW sources to 4,000 from 92,800	Pop impacted of 400
CA3910012	Population of non-SW sources to 28,238 from 163,538	Population impacted of 2,017
CA5010005	Population to 6,996 from 14,530	Pop impacted of 1,166
CA5010010	Population to 86,220 from 441,629	Pop impacted of 1,437
CA5710001	Population of non-SW sources to 36,000 from 70,963	Pop impacted of 4,000
CA5710006	Population of non-SW sources to 32,000 from 60,978	Pop impacted of 4,000
CA5710009	Population of non-SW sources to 24,000 from 48,828	Pop impacted of 4,000

I.7 Subappendix B: Point-of-Use Residential Water Treatment Devices Costs for Hexavalent Chromium

As of June 17, 2021, California has registered 93 reverse osmosis (RO) devices that are NSF International and American National Standards Institute (NSF/ANSI) certified under NSF/ANSI 58 to remove hexavalent chromium. Of the registered devices, 24 are certified to treat hexavalent chromium from an average influent concentration of 300 µg/L to levels below 10 ug/L, while 13 devices are certified to treat hexavalent chromium to levels below 5 ug/L. No point-of-use (POU) RO device is currently certified and registered to treat hexavalent chromium below 3 ug/L. Cost data for 13 devices are summarized in Table SB1 and Table SB2. Bottled water costs were also calculated for comparison with POU treatment costs.

Table SB1. Costs of POU RO Treatment Device and Replacement Cartridges for Residential Water Devices Treating Hexavalent Chromium

Manufacturer	Model Name	Average Effluent Concentration (ug/L)	Filtration System ($)	Replacement Membrane ($)	Sediment Pre-filter ($)	Carbon Pre-filter ($)	Carbon Post-filter ($)	References
A. O. Smith Corporation	AO-US-RO-4000	9	175 to 210	90 to 133	NA	30 to 43	30 to 43	1, 2, and 3
Brondell, Inc.	RC100	8	350	80	23	23	23	4, 5
North Star Water Treatment System	NorthStar NSRO42C4	3	600	62	NA	22	22	6
3M Purification Inc.	3MRO401	5	431 to 811	135 to 382	26 to 60	30 to 58	31 to 466	7,8, 9, 10, and 11
EcoPure Systems Inc.	EcoPure ECOP30	8	159	40	NA	20	20	12
EcoWater Systems, LLC	GNRQ18NBN	9	200	65	NA	30	30	13, 14, and 15

Kohler Company	K-22155	7	458 to 665	152 to 245	48 to 66	54 to 76	57 to 82	16, 17, 18, 19, and 20
Puronics Water Systems, Inc.	Micromax 6500 TFC	3	995	250	56	56	56	21

Table SB2. RO System Replacement Membrane and Filter Cartridge Costs Used in U.S. EPA POU Cost Tool

MCL	RO System	RO Replacement	Sediment Pre-filter	Carbon Pre-filter	Carbon Post-filter
4, 5	648	131	56	34	34
6, 7	516	99	44	37	40
8	497	116	28	35	37
9	400	93	33	30	31
10 to 25	296	89	36	31	32

The average monthly cost of bottled water was calculated using the same assumptions for POU treatment costs:

- Average per capital daily indirect and direct consumption of drinking water is 0.63 gallons per day; and
- Average household size is 3 people.

An online Google search was performed to collect a range of costs for bottled water packaged either in a case or as a single unit (Table SB3). The minimum, average, and maximum costs per gallon of bottled water are $0.92, $1.15, and $1.89, respectively. The average monthly household cost of bottled water is calculated as 3 persons per household * 0.63 gallons of drinking water consumed per person per day * $1.30 per gallon of bottled water * 30 days per month, which equals $96.48. The minimum monthly household cost of drinking water is $52.16, and the maximum monthly cost of bottled water is $107.16.

Table SB3. Bottled Water Costs

Bottle Brand	Case or Unit	Case or Unit Cost	Cost per Gallon	References
Arrowhead	24 pack, each bottle 16.9 ounces	$3.89 to $4.79	$1.23 to $1.51	22
Arrowhead	2.5-gallon unit	$1.79 to $2.56	$1.02 to $1.39	22
Crystal Geyser	1-gallon unit	$1.01 to 1.24	$1.01 to 1.24	23
Great Value Drinking Water	24 pack, each bottle 16.9 ounces	$2.92	$0.92	24
Dasani	24 pack, each bottle 16.9 ounces	$4.99 to $5.99	$1.57 to $1.89	25

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