



San Francisco
Water Power Sewer
Services of the San Francisco Public Utilities Commission

Screening and Recommended Actions for Contaminants of Emerging Concern (CECs) in SFPUC Drinking Water: 2016 Update

FINAL

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Foreword

In 2008, per the Mayor's direction, the San Francisco Public Utilities Commission (SFPUC) developed a San Francisco Water Quality Protection Plan. An action item from the plan is to "clarify and revise the monitoring framework for emerging contaminants." In 2011, the proposed SFPUC approach for screening and prioritizing contaminants of emerging concern (CECs) in drinking water was presented in a November 1, 2011 memorandum to the Commission.

Specifically, the CEC approach for the SFPUC drinking water system:

- Helps the SFPUC manage contaminants that are not being covered by existing regulations,
- Helps prioritize limited resources on CECs of concern to SFPUC, and
- Provides a framework for involving the Commission, stakeholders and the public in CEC decisions.

A 2013 report entitled "Screening and Recommended Actions for Contaminants of Emerging Concern (CECs) in SFPUC Drinking Water System" (2013 CEC Report) represented the first implementation of SFPUC's CEC approach and the first evaluation of CECs by the SFPUC Water Quality Division. The 2013 CEC Report included:

- Background information on CECs,
- The development process and basic steps of SFPUC's approach to CECs,
- CEC group descriptions and examples,
- CEC group screening evaluations for the SFPUC system,
- CEC group priorities, and
- Recommended actions.

Greater detail on specific SFPUC protocols and plans related to CECs were provided in the appendices of the 2013 CEC Report.

The purpose of this 2016 report is to incorporate new data and new findings with regard to CECs and to update CEC screening evaluations and priorities as appropriate.

In the future, stakeholders will be updated every three years with regards to high and medium priority CECs and any emerging issues. Every six years, the SFPUC will review and update all CEC group screening evaluations, priorities and recommendations.

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List of Supporting Information

Supporting Information A	Summary of Findings for Recent CEC Literature and Regulatory Trends
Supporting Information B	SFPUC CEC Screening Evaluations for Drinking Water
Supporting Information C	2013-2016 CEC Monitoring in SFPUC Water Data Summary
Supporting Information D	2013 – 2016 Priorities and Recommended Actions for CECs in SFPUC Drinking Water System and Status as of April 2016
Supporting Information E	Water Research Foundation Project #4242 Report “Fate of Non-regulated Disinfection By-Products in Distribution Systems” Excerpts

Acronyms and Abbreviations

ADIs	Acceptable Daily Intakes
AWWA	American Water Works Association
CAC	Citizens Advisory Committee
CCL	Candidate Contaminant List
CDC	Center for Disease Control and Prevention
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulations
CECs	Contaminants of Emerging Concern
cells/mL	cells per milliliter
DBPs	Disinfection byproducts
DDW	Division of Drinking Water
DWEL	Drinking Water Equivalent Level
EDC	Endocrine Disrupting Compounds
EPA	Environmental Protection Agency
EU	European Union
HAAs	Haloacetic acids
HAL	Health Advisory Level
HOS	Hypolimnion Oxygenation System
HPC	Heterotrophic Plate Count
HRL	Health Reference Level
HTWTP	Harry Tracy Water Treatment Plant
LIMS	Laboratory Information Management System
LRAA	Locational Running Annual Average
MCL	Maximum Contaminant Level
MRL	Method Reporting Limit
ND	Non-detect
NDMA	<i>N</i> -nitrosodimethylamine
ng/L	nanograms per liter (parts per trillion)
NL	Notification Level
NOM	Natural Organic Matter
NSF 61	National Sanitation Foundation Standard 61
NWRI	National Water Research Institute
OPPPs	Opportunistic Premise Plumbing Pathogens
PAHs	Polyaromatic hydrocarbons
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated Biphenyls
pCi/L	picocuries per liter
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonate
PHG	Public Health Goal

PPCPs	Pharmaceuticals and Personal Care Products
PSW	Partnership for Safe Water
PWS	Public Water System
RWQCB	Regional Water Quality Control Board
SDWA	Safe Drinking Water Act
SFDPH	San Francisco Department of Public Health
SFPUC	San Francisco Public Utilities Commission
SFPUC-NRD	San Francisco Public Utilities Commission Natural Resources Division
SOCs	Semi-volatile Organic Chemicals
SOP	Standard Operating Procedure
SVWTP	Sunol Valley Water Treatment Plant
SWRCB	State Water Resources Control Board
TCP	1,2,3-trichloropropane
TCR	Total Coliform Rule
THMs	Trihalomethanes
TOC	Total Organic Carbon
TTHMs	Total trihalomethanes
UCMR	Unregulated Contaminant Monitoring Rule
ug/L	micrograms per liter (parts per billion)
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
VOCs	Volatile Organic Chemicals
WHO	World Health Organization
WQD	Water Quality Division
WRF	Water Research Foundation

Executive Summary

This report presents an evaluation of contaminants of emerging concern (CECs) in the San Francisco Public Utilities Commission (SFPUC) drinking water system. CECs are unregulated contaminants that may be detected in water and for which little may be known about their sources, occurrence, removal during treatment, fate in drinking water distribution systems, and potential risk to human health and the environment. SFPUC Water Quality Division (WQD) has developed an approach for grouping, screening, and prioritizing these unregulated contaminants to determine the need, if any, for further action such as water quality monitoring. Background on CECs and the SFPUC CECs approach for drinking water was presented in a November 1, 2011 memorandum to the Commission (SFPUC, 2011).

A 2013 report entitled “Screening and Recommended Actions for Contaminants of Emerging Concern (CECs) in SFPUC Drinking Water System” (2013 CEC Report) (SFPUC, 2013) represented the first implementation of SFPUC’s CEC approach. Understanding that knowledge in this area would continue to develop, planned updates to the 2013 CEC Report were designated to be provided periodically. The purpose of this 2016 report is to incorporate new data and new findings with regard to CECs and to update CEC screening evaluations as appropriate.

The stakeholders will be updated about the progress of CEC investigations every three years with regards to high and medium priorities and any emerging new issues. Every six years, the SFPUC will review and update all CEC group screening evaluations, priorities and recommendations.

Recent CEC Regulatory Developments

A review of domestic and international regulatory trends related to SFPUC’s choice of CECs or ranking was performed (Supporting Information A). Significant regulatory developments since 2013 include:

- Unregulated Contaminant Monitoring Rule 3 (UCMR3) monitoring was completed by SFPUC in 2013. The UCMR3 contains 2 microbial pathogens, 7 naturally-occurring hormones, 5 inorganics (and total chromium- a regulated contaminant), 1 pesticide, 13 industrial chemicals (including 6 perfluorochemicals), and 1 disinfection by-product. All constituents were not detected in the SFPUC system except for the following: chlorate, total chromium, chromium-6, strontium and vanadium. For those constituents detected in one or more samples, all detections were far below the respective health reference levels (HRLs), i.e., notification levels, public health goals and/or drinking water equivalent levels. SFPUC will voluntarily continue monitoring of some detected constituents in 2016.
- A proposed UCMR4 was announced in 2015, for monitoring to be performed in 2018 to 2020. The proposed UCMR4 contains 10 algal toxins (plus 2 indicators), 2 inorganics, 9 pesticides and/or pesticide manufacturing products, 9 haloacetic acid disinfection byproducts (plus 2 indicators), and 6 industrial and commercial chemicals (Supporting Information A). The USEPA is currently receiving stakeholder input on the proposed UCMR4, therefore changes to constituents and/or monitoring locations between the proposed and final UCMR4 are possible.

- A draft Candidate Contaminant List 4 (CCL4) was released by the USEPA in 2015 (Supporting Information A). Based on the USEPA's review of the best available health effects and occurrence data since release of the CCL3, USEPA made these changes to the list:
 - Two new contaminants were added (manganese and nonylphenol).
 - Perchlorate was removed because the agency made a positive regulatory determination in 2011.
 - Five contaminants with preliminary regulatory determinations were removed. In October 2014, the USEPA made preliminary determinations to not regulate four contaminants (1,3-dinitrobenzene; dimethoate; terbufos and terbufos sulfone) and to regulate one contaminant (strontium) listed on CCL3. In 2014, the California State Water Resources Control Board (SWRCB) established a maximum contaminant level (MCL) for chromium-VI. This chemical is therefore no longer classified as a CEC.

The UCMR and draft CCL4 compounds are listed by SFPUC CEC group in Supporting Information A.

Recent Relevant CEC Literature

A review of relevant new literature that has bearing on SFPUC's CEC approach, choice of CECs, or ranking was performed (Supporting Information A). The review was focused on, but not limited to: peer-reviewed sources, published since 2013, with an emphasis on review or survey articles. Literature searches were conducted using the following databases: Water Research Foundation, Journal of the American Water Works Association and Google Scholar. Numerous abstracts, papers and reports were evaluated, only a selection of which were chosen for inclusion in the updated CEC Screening Evaluations.

Numerous papers, reports and workshops have been devoted to the topic of water utility management strategies for CECs. The majority stress that the current chemical-specific risk assessment approach is not feasible for prioritizing the majority of CECs. A flexible multi-element prioritization framework is typically recommended to identify compounds of highest concern, with a stress on the need for adaptive management. The approach taken by SFPUC (see below) is consistent with current recommendations for CEC evaluation and management. No changes to the overall approach and structure of the program have been identified as needed at this time.

With regard to individual CECs and their relative importance, the peer-reviewed literature surveyed indicated the refinement of existing knowledge since 2013, rather than the discovery of new, priority-changing information. Numerous national occurrence surveys of different CEC groups have been released, as have review papers discussing the occurrence, health impacts and behavior during water treatment of different CECs.

While concern about many CEC categories remains relatively unchanged since 2013, several categories have received increased or decreased attention by the water industry and/or general public.

Microbial contaminants remain a high priority due to health significance in general. Microbial pathogens are the most pervasive contaminants and definitely the most certain to cause

disease if they are allowed to breach water treatment processes (Hrudey and Hrudey, 2014) or distribution systems.

One CEC topic has garnered increased national focus since 2013 and is described below along with the SFPUC WQD priority:

Algal Toxins:

- Algal toxins are of increased interest due to ongoing regulatory review and awareness of the potential for the presence of these toxins in algal blooms in reservoirs. There has been nation-wide media coverage about algal toxins in drinking water systems, including a 2014 emergency shut down of drinking water supplies in Toledo, Ohio. In 2015, the USEPA issued Drinking Water Health Advisories for two algal toxins and 10 algal toxins were included in the proposed UCMR4. Based on monitoring conducted by SFPUC, it appears that the vulnerability of SFPUC water supplies to algal toxins is low; however, algal toxins could occur in some SFPUC source waters and therefore the priority of this CEC category was maintained at “medium”. SFPUC has performed several algal toxin investigations in its source waters and prepared an Algae Monitoring and Mitigation Plan. SFPUC is currently conducting 12 months of algal toxins monitoring at its most susceptible East Bay Reservoir (August 2015 to August 2016) to assess toxin occurrence and treatability at Sunol Valley Water Treatment Plant (SVWTP). A response plan to algal toxin occurrence will be completed in 2016.

Three CEC topics have decreased in prominence since 2013 and are discussed below along with their SFPUC WQD priorities:

Chromium-VI:

- Effective as of July 1, 2014, the California SWRCB released a maximum contaminant level (MCL) for chromium-VI of 10 ug/L. This chemical is therefore no longer classified as a CEC and has been removed from this report; however, as a regulated drinking water constituent, SFPUC continues to monitor for this constituent in source and finished waters.

Pharmaceuticals and Personal Care Products (PPCPs):

- Numerous recently published studies have concluded that at the very low concentrations typically observed in drinking water sources, the majority of PPCPs do not pose a significant risk to human health. Correspondingly, there has been a decrease in media coverage of this issue in recent years. While PPCPs remain a CEC for drinking water, recent concern has focused more on wastewater impacts on water supplies and environmental impacts of these contaminants. PPCPs were classified as a low priority in the 2013 CEC Report because participation in an occurrence study indicated no detection of PPCPs in SFPUC source and treated waters (with the exception of two naturally occurring hormones in raw source water, which can be considered PPCPs). Studies conducted over the past decade have thus far indicated no appreciable risk to human health from low-level exposure to PPCPs in drinking water. SFPUC has protected watersheds and source waters are not impacted by significant wastewater discharges. Therefore, this CEC category remains a “low” priority. Due to potential interest from customers and improving analytical methodologies, SFPUC plans on

sampling for PPCPs in source and treated waters on a periodic basis; i.e., every 6 years to ensure no change in water quality with respect to this group of contaminants.

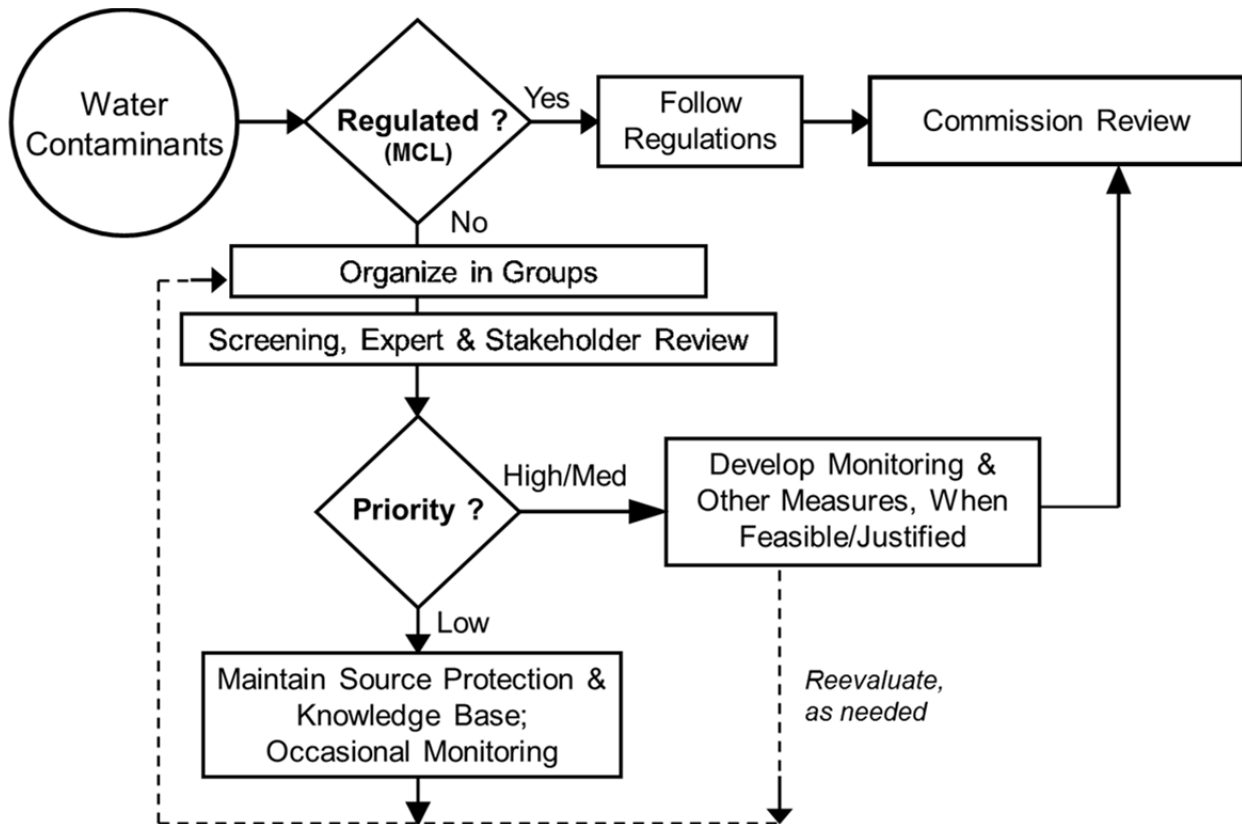
Nitrosamines:

- Priority for nitrosamines was reduced from high to medium due to consistent and low levels (mostly non-detect) observed in the SFPUC voluntary quarterly monitoring program. Based on this sampling, nitrosamines control is considered optimized. The monitoring program will be reduced to semi-annual to ascertain that polymer formulation does not change nitrosamine levels and that control remains optimized.

Approach for CECs in SFPUC Drinking Water

The SFPUC WQD has developed an approach for grouping, screening, and prioritizing unregulated CECs groups to determine the need, if any, for further action such as water quality monitoring. The approach is summarized in Figure ES-1. Due to the large number of CECs and lack of specific information, the CEC approach utilizes grouping and indicators and is more qualitative compared to regulated contaminants that have numeric water quality criteria. The SFPUC Commission endorsed this approach in November 2011 (<http://www.sfwater.org/index.aspx?page=647>).

Figure ES-1. Flowchart of SFPUC CEC Approach for Drinking Water



This evaluation represents the implementation of the approach. The approach is intended to (1) provide a consistent, proactive, and flexible means of organizing and prioritizing CECs work, and (2) enhance stakeholder engagement on CEC issues. The approach includes the use of

Screening Evaluations for each CEC group, expert and stakeholder reviews, and public communication to evaluate the significance and prioritization of various CEC groups or individual CECs for the SFPUC drinking water system.

CEC Groups and Screening Evaluations for SFPUC Drinking Water

San Francisco’s water system has very high quality sources of supply, yet trace detections of some CECs are possible. The SFPUC CEC approach groups CECs with similar properties and/or common routes of entry into the water system to structure the evaluation process and make the large number of CECs manageable. Each group is screened to determine its priority for SFPUC drinking water. The twelve (12) SFPUC CEC groups are listed in Table ES-1.

The Screening Evaluations are attached to this report (Supporting Information B) and include general information, context of the CEC investigation at SFPUC, and diagnostic questions on health, occurrence, and treatment. This information was obtained through literature review, web searches, occurrence data if available, and professional experience. The final section of each Screening Evaluation prioritizes the CEC group and states recommended actions. Expert and stakeholder review of the Screening Evaluations was conducted for all groups.

The CEC groups listed in Table ES-1 remain unchanged from those included in the 2013 CEC Report. Updated 2016 Screening Evaluations for each CEC group have been prepared to include CEC and other relevant water quality data collected since 2013 as well as relevant recent peer-reviewed literature and regulatory developments (Supporting Information B).

Table ES-1. SFPUC Drinking Water CEC Categories and Groups

General Categories	CEC Group
Naturally-Occurring Contaminants	Microbial Waterborne Pathogens Algal Toxins Inorganics Naturally-Occurring Hormones
Treatment/Distribution Byproducts	Disinfection Byproducts (DBPs) (nitrosamines) DBPs (other than nitrosamines) Leachate from Materials (liners, gaskets, etc.)
Manmade Contaminants	Halogenated Flame Retardants Industrial and Commercial Chemicals Nanomaterials Pesticides Pharmaceuticals & Personal Care Products (PPCPs)

Drinking Water CEC Prioritization and Recommended Actions

The CEC Screening Evaluations determine the priority and recommended actions for each group. Prioritization is based on health risks (i.e., contaminant level in drinking water that poses health concern), occurrence in source and treated waters, and expected removal during treatment. This information is derived from research papers, government agencies, professional associations and research foundations, and SFPUC studies (i.e., SFPUC monitoring or treatment studies).

CEC contamination of SFPUC surface water sources is relatively unlikely because the reservoirs are in protected watersheds. There are no significant municipal or industrial wastewater discharges to SFPUC water sources, which is generally recognized as the principal source of many CECs to drinking water and can occur in other communities via treated discharges upstream of drinking water intakes.

The SFPUC CEC group priorities are summarized in Table ES-2 with the justification and recommended actions. One group is considered a high priority for SFPUC drinking water: Microbial Waterborne Pathogens. Three groups are considered a medium priority: Disinfection Byproducts (Nitrosamines), Disinfection Byproducts (Other than Nitrosamines), and Algal Toxins. The remaining CEC groups have “low” priorities because of a low likelihood of occurrence in SFPUC drinking water at levels of possible health significance. These priorities are unchanged from the 2013 report with the exceptions of DBPs (nitrosamines) and Inorganics (chromium-VI only). Nitrosamines has been changed from a high priority to a medium priority based on monitoring data showing optimized conditions. Chromium-VI is now a regulated constituent in California and is therefore no longer classified as a CEC. Inorganics other than chromium-VI were previously classified as “low” priority therefore the entire Inorganics group is now considered to be “low” priority.

For all CEC groups, maintaining source water protection and optimized water treatment and distribution operations, as well as the continual tracking of new information and any regulatory developments, are recommended. Additional recommendations specific to each CEC group can be found in Table ES-2. CEC group priorities and recommended actions from the previous 2013 CEC Report as well as the implementation status of all 2013 recommended actions as of April 2016 are available in Supplemental Information D.

Groundwater will be a relatively minor, future water source for SFPUC. For both surface water sources and groundwater sources, natural sources of select CECs may lead to trace detections (e.g., microbial waterborne pathogens in surface water due to wildlife in the watershed; trace metals in groundwater due to natural mineral dissolution). Although surface water and ground water sources will differ slightly in quality and protection, SFPUC’s CEC approach applies to both sources equally.

Cases of contamination reviewed by Hrudey and Hrudey (2014) have demonstrated how an apparently very small degree of contamination can seriously endanger a drinking water supply. Preventing source water from being contaminated is almost universally more cost-effective than allowing water quality degradation and implementation of additional treatment. Further, “multiple barrier approach” is only as good as our ability to keep the barriers functioning at their individual peak efficiency (Hrudey and Hrudey, 2014).

Some of the recommended actions presented here include monitoring of CECs between 2016 and 2022. These actions are presented in Table ES-3 Monitoring Plan. Monitoring recommendations, as well as sampling locations and frequency are included in the table.

Table ES-2. Priorities and Recommended Actions for CECs in SFPUC Drinking Water System for 2016 – 2022

CEC Group	Priority	Justification	Recommended Actions ^(a)
Microbial Waterborne Pathogens	High	<p>Microbial CECs have been linked elsewhere (though not for SFPUC) to waterborne disease outbreaks and therefore can impact public health and customer satisfaction.</p> <p>The potential for occurrence in SFPUC drinking water is low due to the use of multiple barriers: watershed protection, filtration of local supplies, multiple disinfectants, cross-connection and backflow control, sanitary practices during main breaks and construction, etc. However, microbial CECs are a high priority due to the health significance in general and discovery of new pathogens.</p>	<ul style="list-style-type: none"> • Benchmark through national or state surveys when appropriate. • Continue participation in Partnership for Safe Water (PSW) for SFPUC water treatment plants to meet turbidity removal standards. • Consider joining the PSW for the SFPUC distribution system or consider informally adopting some components of PSW for distribution system. • Continue distribution system programs to prevent entry of microbial contaminants and maintain disinfectant residual. • Follow Revised Total Coliform Rule compliance and investigation requirements. • When feasible, support beyond-the-meter activities, such as, survey of <i>Legionella</i> and other opportunistic pathogens in premise plumbing. • Provide educational materials on large building water quality issues related to water age due to conservation.
Disinfection By-Products (DBPs) Nitrosamines	Medium	<p>Nitrosamines are a medium priority because they are occasionally detected at trace levels in SFPUC treated drinking water (NDMA occasionally greater than PHG of 3 ng/L), California Notification Levels (NL) exist for three nitrosamines, and a future Maximum Contaminant Level (MCL) is likely.</p> <p>Based on monitoring conducted to date for six nitrosamines, SFPUC control of nitrosamines is optimized.</p>	<ul style="list-style-type: none"> • Maintain optimized treatment: avoid polymer overfeed, provide free chlorine contact time before chloramination, and minimize detention time in the distribution system. • Continue voluntary semi-annual nitrosamine monitoring.
DBPs Other than nitrosamines	Medium	<p>Unregulated DBPs are formed at trace levels during disinfection and occur in SFPUC drinking water. The occurrence and fate of these CECs are a focus of ongoing research; much less is known about health significance.</p> <p>It is not likely that these CECs, other than chlorate, will be regulated in the near future. Chlorate and formaldehyde have CA NLs. Chlorate is also on EPA's UCMR3 and hence an EPA priority. Chlorate and formaldehyde are</p>	<ul style="list-style-type: none"> • Continue to minimize detention time in the distribution system; e.g., take redundant reservoirs out of service when possible, deeper reservoir cycling, and main pipeline flushing. • Develop operational monitoring plan for HAA5, HAA9 and THMs to support DBP optimization strategy.

CEC Group	Priority	Justification	Recommended Actions ^(a)
		<p>detected in SFPUC treated drinking waters but at levels below CA NLs.</p>	<ul style="list-style-type: none"> • Continue the Chemical Quality Control Program at water treatment plants to minimize impurities in treatment chemicals (e.g., chlorate). • Continue or – where needed – initiate monthly treated water monitoring for chlorate at Alameda East, SVWTP and HTWTP Effluents. • Perform UCMR4 mandatory monitoring for 3 haloacetic acid groups, 2018-2020.
Algal Toxins	Medium	<p>Though rare, adverse health impacts to humans from algal toxins in drinking water associated with severe algal blooms have been reported elsewhere (though not for SFPUC). Algae types and levels and algal toxin concentrations could change over time due to climate change or other environmental factors.</p> <p>Based on monitoring conducted from 2007 to 2016, it appears that the vulnerability of the majority of SFPUC water supplies to algal toxins is low. However, algal toxins could occur in some of SFPUC source waters at levels of possible health significance during significant algal blooms.</p> <p>No algal toxins were detected in any drinking water samples.</p>	<ul style="list-style-type: none"> • Continue addressing recommendations identified in 2015 sanitary surveys for Alameda Watershed and Peninsula Watershed. • Continue coordination with the SFPUC Natural Resources Division (SFPUC-NRD) on limnology profiles and algae species characterization, maintain hypolimnetic oxygenation systems, and conduct algae treatment as needed. • Complete year-long algal toxin monitoring (8/2015 to 8/2016) at Calaveras Reservoir (and other source waters, as needed) with SFPUC-NRD. Based on the data, develop an overall program for monitoring and evaluating algal toxins. • Develop response plan for algal toxin occurrence (e.g. source water change, treatment optimization, blending, notification). • Perform UCMR4 mandatory monitoring for 10 algal toxins and 2 indicator parameters (see Monitoring Plan), 2018-2020.
Inorganics	Low	<p>Significant levels of inorganic contaminants are generally not expected due to SFPUC's protected watersheds.</p>	<ul style="list-style-type: none"> • Continue the Chemical Quality Control Program at water treatment plants to minimize impurities in treatment chemicals (e.g., metals). • Investigate multi-utility/industry opportunity to improve treatment chemical purchasing specifications. • Follow-up UCMR3 sampling for strontium and vanadium in raw and treated waters in 2016. • Perform UCMR4 mandatory monitoring for germanium and manganese, 2018-2020.

CEC Group	Priority	Justification	Recommended Actions^(a)
Halogenated Flame Retardants	Low	Halogenated flame retardants do not occur and are not expected to occur in SFPUC source waters or distribution system, based on available monitoring data and the fact that SFPUC watersheds and source waters are not impacted by significant wastewater and industrial discharges or urban runoff.	<ul style="list-style-type: none"> For forest fires retardants, monitor types of retardants in use and application areas. If application is in watersheds, conduct post-fire water quality monitoring.
Industrial and Commercial Chemicals	Low	Industrial CECs are of low concern due to SFPUC's protected watersheds and source waters, which are not impacted by significant wastewater and industrial discharges or urban runoff. Air deposition may cause trace levels of industrial chemicals within the watersheds (e.g., polyaromatic hydrocarbons, PAHs). SFPUC monitoring for select, unregulated industrial chemicals has indicated no detections, and together with SFPUC monitoring of regulated industrial chemicals, has confirmed the effectiveness of source water protection.	<ul style="list-style-type: none"> Perform UCMR4 mandatory monitoring for 6 industrial chemicals, 2018-2020. As more information becomes available, or to further focus this review process, select subgroups of industrial/commercial chemicals could be considered in a new, separate Screening Evaluation. Candidates include unregulated perfluorochemicals, plasticizers, and PAHs.
Leachate from Materials	Low	<p>Leachates from liners and other treatment/distribution system materials are unlikely to occur at levels of health significance. All materials must be NSF 61 approved, which provides assurance that materials are appropriate for water systems.</p> <p>Soak tests are an additional, proactive step that SFPUC implements in order to ensure that new linings and other materials are properly installed. Past soak tests have shown that detections of regulated contaminants, which potentially could serve as indicators of non-regulated leachates, are very low (typically about 1% of MCLs). Generally, soak tests are worst-case conditions and any leaching should decrease significantly over time.</p>	<ul style="list-style-type: none"> Continue to require contract specifications to specify NSF 61 materials for the interiors of tanks, pipelines, and other facilities. Continue to ensure that only NSF 61 materials are used in construction projects. Conduct soak tests as needed.
Nanomaterials	Low	Nanomaterials are unlikely to occur in SFPUC treated drinking water (from surface water or groundwaters) because the watersheds and source waters are not impacted by significant industrial or wastewater discharges or urban runoff. Very little is known about nanomaterial occurrence in US drinking waters, health significance, and treatment effectiveness. These CECs are the subject of preliminary research.	<ul style="list-style-type: none"> Benchmark through national or state surveys when appropriate.

CEC Group	Priority	Justification	Recommended Actions ^(a)
Naturally-Occurring Hormones	Low	Naturally-occurring hormones are unlikely to occur in SFPUC treated drinking water at levels of possible health significance because: (1) detections in raw water have been very low, (2) hormones are generally well removed by the type of drinking water treatment systems used by SFPUC, (3) there have been no detections in treated water, and (4) studies and reviews conducted in the U.S. and internationally over the past decade have thus far indicated no appreciable risk to human health from low-level exposure to natural hormones in drinking water.	<ul style="list-style-type: none"> Conduct voluntary periodic surveys of hormones in source and treated waters every 6 years, similar to PPCPs. If available, participate in a national survey.
Pesticides	Low	Pesticides (regulated or unregulated) are not expected to occur in SFPUC treated drinking water at levels of possible health significance because SFPUC watersheds are not impacted by significant agricultural or urban runoff. If present, many pesticides would be oxidized by chlorine or ozone during SFPUC drinking water treatment. SFPUC monitoring since 2006 has not detected pesticides in source waters.	<ul style="list-style-type: none"> Continue to minimize and track pesticide use in the watersheds. Pesticide application programs (e.g. SFPUC Integrated Pest Management Program), pesticide users, and types of pesticides (e.g., glyphosate) are identified in the sanitary surveys for Hetch Hetchy, Alameda, and Peninsula Watersheds. Perform UCMR4 mandatory monitoring for 9 pesticides, 2018-2020.
Pharmaceuticals & Personal Care Products	Low	SFPUC monitored its source and treated drinking waters for PPCPs in 2006, 2012 and 2013. PPCPs are a low priority because: (1) SFPUC monitoring has shown non-detects or very low-level (low confidence) detections, (2) SFPUC has protected watersheds and source waters that are not impacted by significant wastewater discharges, and (3) studies and reviews conducted in the U.S. and internationally over the past decade have thus far indicated no appreciable risk to human health from low-level exposure to PPCPs in drinking water.	<ul style="list-style-type: none"> Conduct voluntary periodic survey of PPCPs in source and treated waters every 6 years; if available, participate in a national survey.

(a) In addition to the recommended actions listed for each CEC group, **the following recommended actions apply to all CEC groups:**

- Maintain source water protection and optimized multibarrier water treatment and distribution system operation
- Track information, peer-reviewed publications, and any federal and state regulatory developments

Acronyms

CECs = contaminants of emerging concern

CA NLs = California Notification Levels (non-regulatory)

DBPs = disinfection byproducts

MCL = maximum contaminant level

NDMA = *N*-nitrosodimethylamine

ng/L = nanogram per liter (parts per trillion)

NSF 61 = National Sanitation Foundation Standard 61

PAHs = polyaromatic hydrocarbons

PHG = Public Health Goal, California (non-regulatory)

PPCPs = pharmaceuticals and personal care products

UCMR4 = USEPA Unregulated Contaminant Monitoring Rule 4

ug/L = microgram per liter (parts per billion)

Table ES-3. Monitoring Plan for CECs, 2016 – 2022, San Francisco Regional Water System and San Francisco Water System

CEC Group [Priority]	Monitoring Recommendations^(a), Contaminant (MRL)	Locations*	Frequency
Microbial Waterborne Pathogens [High]	<p>Follow rTCR monitoring (no change in monitoring from current TCR).</p> <p>Continue nitrification monitoring to maintain disinfectant residual in distribution system.</p> <p>Benchmark microbial CECs through national and state surveys, when appropriate.</p> <p>When feasible, survey <i>Legionella</i> and other opportunistic pathogens in premise plumbing.</p>	NA	NA
DBPs Nitrosamines [Medium]	<p>Continue semi-annual nitrosamines monitoring.</p> <p>Collect total chlorine, free ammonia, pH, temperature and conductivity along with nitrosamine samples.</p> <p><u>Nitrosamines:</u> <i>N</i>-Nitrosodimethylamine, NDMA (2 ng/L) <i>N</i>-Nitrosodiethylamine, NDEA (2 ng/L) <i>N</i>-Nitrosodi-n-butylamine, NDBA (2 ng/L) <i>N</i>-Nitrosodi-n-propylamine, NDPA (2 ng/L) <i>N</i>-Nitrosomethylethylamine, NMEA (2 ng/L) <i>N</i>-Nitrosopyrrolidine, NPYR (2 ng/L)</p>	Plant Effluents Distribution System	Semi-annual monitoring
DBPs Other than nitrosamines [Medium]	<p>Continue monitoring of select UCMR3 compound:</p> <p>Chlorate (20 ug/L)</p> <p>Monitor for the following UCMR4 compounds and indicators, 2018-2020:</p> <p>HAA5^(e) HAA6Br^(f) HAA9^(g) Total Organic Carbon (TOC)^(h) Bromide^(h)</p>	Plant Effluents UCMR4 locations – see notes ^(b)	Monthly and Annual (with Title 22 monitoring) UCMR4 frequency – see notes ^(c)

CEC Group [Priority]	Monitoring Recommendations ^(a) , Contaminant (MRL)	Locations*	Frequency
Algal Toxins [Medium]	August 2015 to August 2016 Calaveras Reservoir Study (follow-up as necessary): Total Microcystin (0.15 ug/L) Cylindrospermopsin (0.05 ug/L) Saxitoxin (0.02 ug/L) Anatoxin-a (0.15 ug/L)	Calaveras Reservoir, SVWTP influent and effluent, (other reservoirs as needed)	Every two weeks
	Monitor for the following UCMR4 compounds and indicators, 2018-2020: Total Microcystin (0.3 ug/L) Microcystin-LA (0.008 ug/L) Microcystin-LF (0.006 ug/L) Microcystin-LR (0.02 ug/L) Microcystin-LY (0.009 ug/L) Microcystin-RR (0.006 ug/L) Microcystin-YR (0.02 ug/L) Nodularin (0.005 ug/L) Anatoxin-a (0.03 ug/L) Cylindrospermopsin (0.09 ug/L) Temperature ^(d) pH ^(d)	UCMR4 locations – see notes ^(b)	UCMR4 frequency – see notes ^(c)
Inorganics [Low]	Continue 2016 monitoring of select UCMR3 compounds (2 metals): Strontium (0.3 ug/L) Vanadium (0.2 ug/L)	All source water reservoirs and treated waters	Summer of 2016 only (part of 2016 Title 22 monitoring)
	Monitor for the following UCMR4 compounds (2 metals), 2018-2020: Germanium (0.3 ug/L) Manganese (0.4 ug/L)	UCMR4 locations – see notes ^(b)	UCMR4 frequency – see notes ^(c)
Halogenated Flame Retardants [Low]	Benchmark through national and state surveys, when appropriate	NA	NA
Industrial and Commercial Chemicals [Low]	Monitor for the following UCMR4 compounds (6 industrial/commercial chemicals), 2018-2020: 1-butanol (2.0 ug/L) 2-methoxyethanol (0.4 ug/L) 2-propen-1-ol (0.5 ug/L) butylated hydroxyanisole (0.03 ug/L) o-toluidine (0.007 ug/L) Quinoline (0.02 ug/L)	UCMR4 locations – see notes ^(b)	UCMR4 frequency – see notes ^(c)

CEC Group [Priority]	Monitoring Recommendations^(a), Contaminant (MRL)	Locations*	Frequency
Leachate from Materials [Low]	Monitor for VOCs and SOCs per EPA Methods 524 and 525, respectively, and other contaminants when warranted. For as-needed sampling, see SFPUC Manual of Procedures, Disinfection/Dechlorination and Related Tasks (2011).	As needed to confirm new or significant construction practices	As needed to confirm new or significant construction practices
Nanomaterials [Low]	Benchmark through national and state surveys, when appropriate.	NA	NA
Pesticides [Low]	Monitor for the following UCMR4 compounds (9 pesticides), 2018-2020: alpha-hexachlorocyclohexane (0.01 ug/L) Chlorpyrifos (0.03 ug/L) Dimethipin (0.2 ug/L) Ethoprop (0.03 ug/L) Oxyfluorfen (0.05 ug/L) Profenofos (0.3 ug/L) Tebuconazole (0.2 ug/L) Total permethrin (cis- & trans-) (0.04 ug/L) Tribufos (0.07 ug/L)	UCMR4 locations – see notes ^(b)	UCMR4 frequency – see notes ^(c)
Pharmaceuticals & Personal Care Products (PPCPs) [Low] and Naturally- Occurring Hormones [Low]	Consider benchmarking through national and state surveys, when appropriate. Monitor every 6 years if not covered by national/state surveys	TBD Source Waters and Treated Waters	TBD Every 6 years

Notes

*Detailed location can be found in the report, where applicable.

Proposed UCMR4 monitoring consists of one year of quarterly monitoring for 30 contaminants (or indicators) to be conducted between March 2018 and November 2020. “Low” priority CEC groups do not require monitoring per SFPUC CEC approach but monitoring may be indicated in above table if required by UCMR4.

(a) In addition to above monitoring plan, participate in national and state CEC surveys and conduct special monitoring for any breaking CEC issue (new research study findings, etc.), when appropriate.

(b) UCMR4 locations: TBD – Sampling Locations include: 1) Entry points to the distribution system (EPTDS), 2) Source Water Intake Locations (SR), 3) Stage 2 Disinfectants and Disinfection

Byproduct Rule Sampling Locations (Stage 2 DBPR), and 4) Distribution system maximum residence time (DSMRT).

- (c) UCMR4 frequency: Quarterly for one year
- (d) Temperature and pH are indicator parameters and must be measured at the same time as cyanotoxin sample collection.
- (e) HAA5 includes: dibromoacetic acid, dichloroacetic acid, monobromoacetic acid, monochloroacetic acid, trichloroacetic acid.
- (f) HAA6Br includes: bromochloroacetic acid, bromodichloroacetic acid, dibromoacetic acid, dibromochloroacetic acid, monobromoacetic acid, tribromoacetic acid.
- (g) HAA9 includes: bromochloroacetic acid, bromodichloroacetic acid, chlorodibromoacetic acid, dibromoacetic acid, dichloroacetic acid, monobromoacetic acid, monochloroacetic acid, tribromoacetic acid, trichloroacetic acid.
- (h) TOC and Bromide are indicator compounds and must be sampled with HAA samples.

MRL = Minimum Reporting Level

DBPs = disinfection by-products

CEC = contaminant of emerging concern

NA = not applicable

SFRWS = San Francisco Regional Water System

SFWS = San Francisco Water System

TC = Total Coliform

UCMR4 = Proposed Unregulated Contaminant Monitoring Rule 4

WRF = Water Research Foundation

References

Hrudey, S.E. and Hrudey. E.J. 2014. Ensuring Safe Drinking Water. Learning from Frontline Experience with Contamination. AWWA, Denver, CO.

SFPUC. 2011. Proposed Approach for Contaminants of Emerging Concern (CECs) in SFPUC's Drinking Water System. San Francisco Public Utilities Commission, November 1, 2011.

SFPUC. 2013. Screening and Recommended Actions for Contaminants of Emerging Concern (CECs) SFPUC Drinking Water System. San Francisco Public Utilities Commission, December 17, 2013.

Supporting Information

Supporting Information A	Summary of Findings for Recent CEC Literature and Regulatory Trends
Supporting Information B	SFPUC CEC Screening Evaluations for Drinking Water
Supporting Information C	2013-2016 CEC Monitoring in SFPUC Water Data Summary
Supporting Information D	Water Research Foundation Project #4242 Report “Fate of Non-regulated Disinfection By-Products in Distribution Systems”
Supporting Information E	2013 – 2016 Priorities and Recommended Actions for CECs in SFPUC Drinking Water System and Status as of April 2016