Reductions of Perchlorate in Drinking Water

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LEVELS OF PERCHLORATE IN DRINKING WATER HAVE DECLINED

Perchlorate is commonly used in solid rocket propellants, munitions, fireworks, airbag initiators for vehicles, matches, and signal flares. Perchlorate may occur naturally, particularly in arid regions such as the southwestern U.S. and can be found as a byproduct in hypochlorite solutions used for treating drinking water and nitrate salts used to produce fertilizers, explosives, and other products.

At certain levels, perchlorate can prevent the thyroid gland from getting enough iodine, which can affect thyroid hormone production. For pregnant women with low iodine levels, sufficient changes in thyroid hormone levels may cause changes in the child's brain development. For infants, changes to thyroid hormone function can also impact brain development.

The EPA finds that perchlorate levels in drinking water supplies have declined since the EPA published a final determination to regulate perchlorate in 2011. The 2011 determination was based on occurrence data collected between 2001 and 2005 under the 1st Unregulated Contaminant Monitoring Rule (UCMR1). At that time, the Agency found that over 4% of water systems tested detected perchlorate and that between 5.2-16 million people may be exposed to perchlorate in drinking water.

In the June 2019 National Primary Drinking Water Regulation for Perchlorate proposal, EPA presented an updated occurrence analysis that demonstrates that the levels of perchlorate in drinking water and sources of drinking water have decreased since the UCMR1 data collection. This document summarizes the main factors contributing to the decrease in perchlorate levels which include: 1) the promulgation of a drinking water regulation for perchlorate in California and Massachusetts; and 2) the ongoing remediation efforts in the state of Nevada to address perchlorate contamination in groundwater adjacent to the lower Colorado River upstream of Lake Mead. This document also summarizes the status of the 15 water systems that reported elevated levels of perchlorate under the UCMR 1. Finally, this document summarizes actions to reduce levels of perchlorate through remediation activities at perchlorate contaminated sites and through proper storage and handling of hypochlorite solutions.

California & Massachusetts Drinking Water Regulations

Perchlorate occurrence in drinking water systems in the state of California accounted for approximately 60% of all perchlorate detections reported under UCMR1. In 2007, California promulgated a drinking water regulation for perchlorate of 6 ppb. At the time UCMR1 data collection was completed in 2005, there were 30 systems with perchlorate occurrence above 6 ppb in California. The EPA compared entry point data collected under UCMR1 to current entry point monitoring data for water systems in California. As of 2019, only one system in California is in violation of the state standard of 6 ppb, and no systems had perchlorate concentrations above 18 ppb (the lowest level proposed by EPA in June 2019).

In addition, Massachusetts adopted a drinking water standard for perchlorate of 2 ppb in 2006. One water system in Massachusetts had a perchlorate detection in UCMR1. Based on a review of current publicly available information, there are no systems in Massachusetts in violation of the state standard.

Reduction of Perchlorate Levels in the Southwest

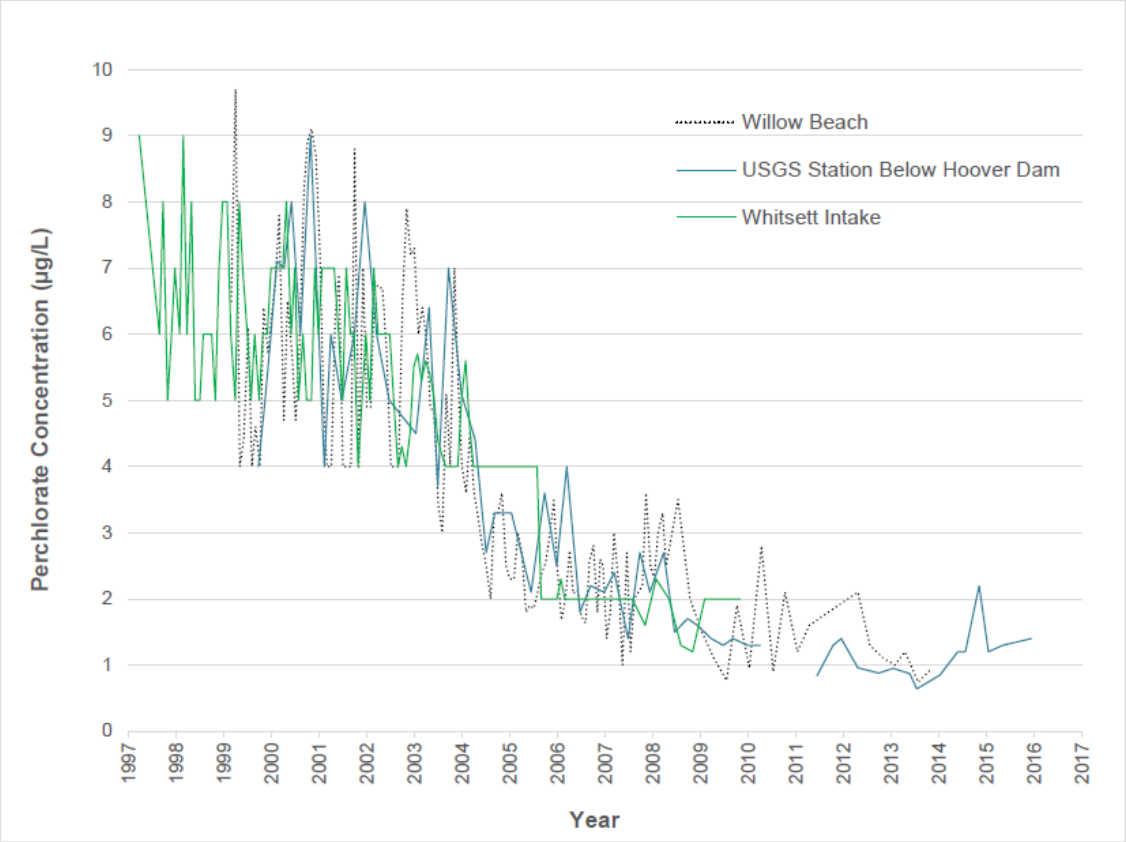
Lower Colorado River Case Study

The Lower Colorado serves as the primary source of water for the Metropolitan Water District (MWD) of Southern California and as a source for several public water systems in Arizona and Nevada. The primary source of perchlorate along the Lower Colorado is manufacturing facilities near Henderson, Nevada. Contaminated groundwater had seeped into the Las Vegas Wash, which drains into Lake Mead and then the Colorado River. Full remediation was active at two industrial sites in the Las Vegas Valley between 2002 and 2006.

The data provided by the Nevada Division of Environmental Protection (NDEP) and the Southern Nevada Water Authority show a decreasing trend in perchlorate concentrations over the last decade, especially after point-source remediation efforts began in 2002. Perchlorate samples were collected at a USGS site just below the Hoover Dam; Willow Beach, Arizona; and Whitsett, California. Whitsett is an MWD source water intake point. Perchlorate raw water sample results from 1997 to 2016 from the USGS station, Willow Beach, and Whitsett sites are shown in Exhibit A.

For the USGS site, perchlorate concentrations ranged between 4 to 9 ppb prior to 2002. After 2009, most concentrations were between 1 and 2 ppb. Willow Beach perchlorate concentrations were 4 to 10 ppb prior to 2002 and were 1 to 3 ppb after 2009. Whitsett perchlorate concentrations were between 4 and 9 ppb from 1997 until 2005. After 2006, the majority of perchlorate concentrations were below 2 ppb. Thus, at all monitoring locations, there was a downward trend in perchlorate levels in the Lower Colorado River. Note that perchlorate analytical methods and their respective detection limits changed over the monitoring period (i.e., perchlorate could be measured at lower levels).

Exhibit A. Perchlorate Raw Water Sample Results from the Willow Beach, USGS Station, and Whitsett Sampling Sites, 1997 – 2016



Arizona Department of Environmental Quality (ADEQ) Case Study

In 1999, the ADEQ conducted a perchlorate occurrence study of Arizona water resources. Samples were collected from the Colorado River, Central Arizona Project (CAP) Canal, and various groundwater sources in the Phoenix area. Perchlorate concentrations of 480 ppb were found in Lake Mead and along the Colorado River main stem and the CAP Canal the results were between 11 ppb and non-detection (at that time defined by Arizona as less than 4 ppb).

In 2000 and 2001, the City of Phoenix conducted a second round of perchlorate monitoring at the same sample locations used in the 1999 ADEQ study, and monitoring results showed decreased perchlorate levels along the Colorado River main stem and in the CAP Canal.

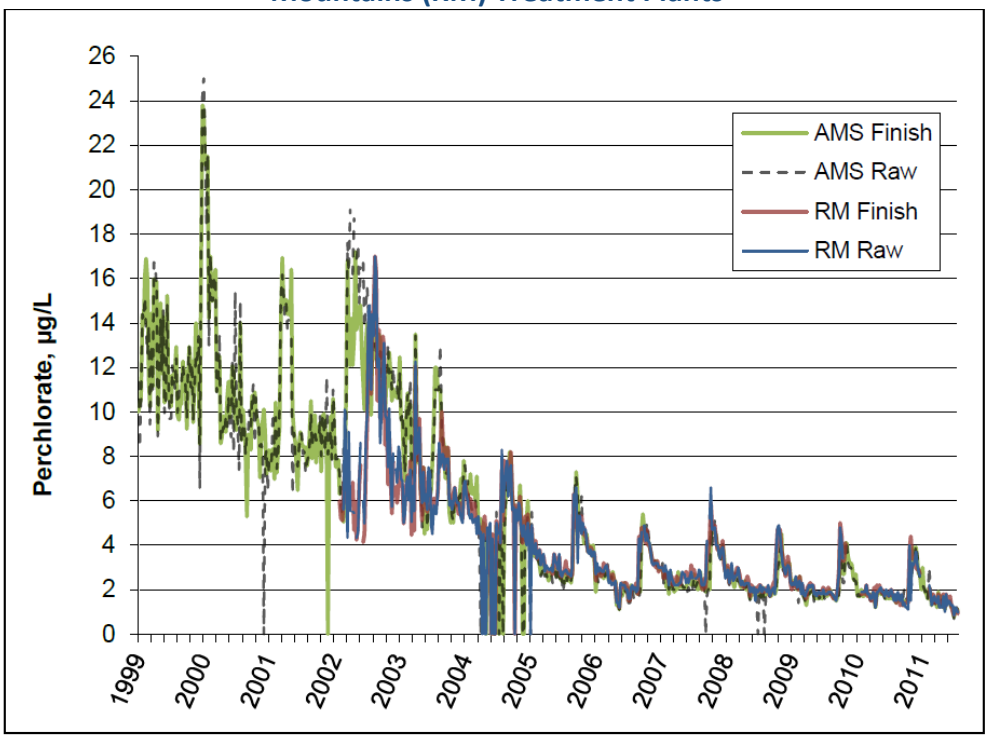
In 2004, the City of Phoenix collected 392 finished water samples and found 39 perchlorate detections ranging from 2 ppb (the Arizona specified reporting limit) and 5.4 ppb. Raw water samples were also collected at 67 sites that included Colorado River water, man-made recreational impoundments, canals, wells, agricultural areas and ground water recharge projects. Perchlorate was detected in 24 samples from 24 different sites and perchlorate concentrations ranged from non-detection to 7.4 ppb.

Nevada Division of Environmental Protection (NDEP) Case Study

The NDEP evaluated data from two water treatment plants: Alfred Merritt Smith Water Treatment Facility and River Mountains Water Treatment Facility. The plants are part of the Southern Nevada Water System, which sources water from the Lower Colorado River.

Perchlorate levels found in both raw and finished water decreased in a relatively consistent and an overall significant amount over the 13-year sampling period, as shown in Exhibit B (1999 – 2011).

Exhibit B. Perchlorate Raw and Finished Water Data from Alfred Merritt Smith (AMS) and River Mountains (RM) Treatment Plants



Although the laboratory analytical methods changed over the period of sampling i.e., perchlorate could be measured at lower levels, the time period and range of decreases mirror those identified in the Lower Colorado River case study.

STATUS OF WATER SYSTEMS WITH UCMR1 RESULTS > 18 PPB

In its 2011 final regulatory determination for perchlorate, the EPA relied upon the UCMR1 data as the best available data on the frequency and level of perchlorate in drinking water. In the June 2019 National Primary Drinking Water Regulation for Perchlorate proposal, EPA presented updated occurrence analysis that demonstrates that the levels of perchlorate in drinking water and sources of drinking water have decreased since the UCMR1 data collection.

Using the updated UCMR1 data presented in the June 2019 proposal, the EPA identified 15 water systems located across 12 states with at least one reported result that was greater than 18ppb[1]. Although systems are not required to take actions to reduce perchlorate in drinking water, the EPA found that perchlorate levels have been reduced in many of the systems. The status of each of these systems is described in Table 1 below.

To obtain updated data and/or information regarding perchlorate levels, the EPA reviewed Consumer Confidence Reports and other publicly available data, as well as published studies. In addition, the EPA contacted some water systems for information about current perchlorate levels.

Table 1: Update on Systems with Perchlorate levels above 18 ppb in the UCMR 1 (2001-2005)

State	System Name	Range of UCMR 1 Results (ppb)[2]	Update on Mitigation and Levels of Perchlorate
Florida	Sebring Water	ND-70	EPA contacted the Sebring system in January 2020. Operations personnel indicated that no follow-up/updated monitoring data for perchlorate is available.
Florida	Manatee County Utilities Dept	ND-30	Researchers contacted the system to identify the source of perchlorate. System personnel attributed the sole perchlorate detection under UCMR1 to analytical error. System personnel indicated that three other quarterly samples collected under UCMR1 as well as other subsequent perchlorate sampling efforts were non-detect. Source: AWWA (2008)
Georgia	Oconee Co.-Watkinsville	38 (single sample)	Researchers contacted the system and found that a perchlorate contaminated well was removed from service in 2003. The system indicates that perchlorate is no longer detected. Source: Luis et al. (2019)
Louisiana	St. Charles Water District 1 East Bank	ND-24	EPA was not able to identify updated data on perchlorate levels for this system.

[1] Eighteen (18) ppb is the lowest alternative maximum contaminant level goal the Agency considered in the June 2019 proposal.
[2] Values have been rounded. ND describes a sampling event where perchlorate was not detected at or above the UCMR 1 minimum reporting level of 4 ppb.

State	System Name	Range of UCMR 1 Results (ppb)[2]	Update on Mitigation and Levels of Perchlorate
Maryland	City of Aberdeen	ND-19	The system's 2018 Consumer Confidence Report (CCR) indicates that perchlorate was not detected. According to the Maryland Department of Environment, perchlorate was not detected in this system in 2019. In addition, researchers contacted the system and found that there has been no detection of perchlorate since treatment was installed in 2009. Source: Luis et al. (2019)
Maryland	Chapel Hill - Aberdeen Proving Grounds	ND-20	EPA contacted the Chapel Hill System in January 2020. Water system personnel indicate that the Chapel Hill WTP was taken off-line and was replaced with a new treatment plant and five new production wells. The new treatment plant started operations on January 27, 2020. System personnel also indicate that monitoring was conducted in November 2019 and perchlorate was not detected in either the source well water or the finished water. In addition, according to the Maryland Department of Environment, perchlorate was not detected in this system in 2019.
Mississippi	Hilldale Water District	ND-20	EPA contacted the Hilldale System in January 2020. Water system personnel indicated that no follow-up/updated monitoring data for perchlorate is available.
New Mexico	Deming Municipal Water System	15-20	Data from EPA's SDWIS/FED indicates that the entry point that reported detections in UCMR1 (Well #3) is now inactive (i.e., the contaminated source is no longer in use). Source: SDWIS/FED (2016).
Nevada	City of Henderson	6-23	Researchers report that the perchlorate levels described in the system's CCR ranged from non-detect to 9.7 ppb. Source AWWA (2008).
Ohio	Fairfield City PWS	6-27	EPA contacted the Fairfield City System in January 2020. Water system personnel indicated that follow-up monitoring was

State	System Name	Range of UCMR 1 Results (ppb)[2]	Update on Mitigation and Levels of Perchlorate
			conducted after UCMR1, between 2002 and 2004. The Ohio EPA provided copies of the follow-up monitoring results which indicate that results at the entry point ranged from non-detect to 13 ppb.
Ohio	Hecla Water Association-Plant PWS	ND-32	EPA contacted the Hecla Water Association System in January 2020. Water system personnel indicated that that no follow-up/updated monitoring data for perchlorate is available.
Oklahoma	Enid	ND-30	EPA reviewed Oklahoma's monitoring data and did not find any monitoring results reported for perchlorate.
Pennsylvania	Meadville Area Water Authority	ND-33	EPA contacted the Meadville System in January 2020. Water system personnel indicated that no follow-up/updated monitoring data for perchlorate is available.
Puerto Rico	Utuado Urbano	ND-420	EPA contacted the Puerto Rico Aqueduct and Sewer Authority (PRASA) in January 2019. PRASA personnel indicated that no updated monitoring data for perchlorate is available. *NOTE: The PRASA personnel stated that the Utuado water system was significantly impacted by hurricane Maria and monitoring records from years prior to 2017 were lost.*
Texas	City of Levelland	ND-32	Researchers found that a water storage tank was the source of perchlorate contamination, the wells feeding the tank were tested by the state and perchlorate was not detected. The water tank was shut off from service. Source: Luis et al. (2019).

ACTIONS TO REDUCE PERCHLORATE IN THE ENVIRONMENT AND DRINKING WATER

Perchlorate Contamination in the Environment

The EPA addresses perchlorate contamination in the environment through its authorities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), known also as Superfund. There are around 60 Superfund sites conducting remediation activities for perchlorate. These sites are located in the states of Alabama, Arizona, California, Massachusetts, Maryland, North Carolina, Oregon, Texas and West Virginia. The status of these sites is provided in Table 2 below.

Table 2: CERCLA Sites Addressing Perchlorate

State	Site Name	Federal Facility?	NPL list?	Media Type	Status*
AL	USARMY/NASA Redstone Arsenal[+]	Y	Y	Groundwater	Construction underway
AZ	Apache Powder Co.[+]	N	Y	Groundwater, Soil	Construction complete
AZ	Gila River Indian Community Toxaphene Site	N	N	Soil	Early action
AZ	Pacific Waste Disposal Services	N	N	Liquid Waste	Early action
AZ	Phoenix-Goodyear Airport Area	N	Y	Groundwater	Construction underway
CA	Aerojet General Corp.[+]	N	Y	Groundwater, Soil	Construction underway
CA	Edwards Air Force Base[+]	Y	Y	Soil, Groundwater, Debris	Construction underway
CA	El Toro Marine Corps Air Station	Y	Y	Groundwater	Construction underway
CA	Jet Propulsion Laboratory (NASA)[+]	Y	Y	Groundwater	Construction underway
CA	Lawrence Livermore Natl Lab (Site 300) (USDOE)[+]	Y	Y	Groundwater	Construction underway
CA	Mcclellan Air Force Base (Ground Water Contamination)	Y	Y	Groundwater	Construction underway
CA	Mojave River Pyrotechnics Site	-	-	Soil	Early action
CA	Rockets, Fireworks, And Flares Site[+]	N	Y	Groundwater	Construction underway
CA	San Fernando Valley (Area 1)	N	Y	Groundwater	Construction underway
CA	San Gabriel Valley (Area 1)[+]	N	Y	Groundwater	Construction underway
CA	San Gabriel Valley (Area 4)	N	Y	Groundwater	Construction underway

State	Site Name	Federal Facility?	NPL list?	Media Type	Status*
MA	Otis Air National Guard Base/Camp Edwards+	Y	-	Groundwater	Construction complete
MD	Indian Head Naval Surface Warfare Center	Y	-	Soil	Construction underway
MD	Ordnance Products, Inc.+	N	Y	Groundwater	Construction complete
MD	USN Naval Surface Warfare Ctr-White Oak+	Y	-	Groundwater	Construction underway
NC	Chemtronics, Inc.	N	Y	Groundwater	Construction complete
OR	Portland Harbor+	N	Y	Groundwater, Sediment, Fish Tissue, Surface Water	Design underway
TX	Longhorn Army Ammunition Plant+	Y	Y	Soil, Groundwater, Surface Water, Soil	Construction underway
TX	Pantex Plant (USDOE)	Y	Y	Groundwater	Construction complete
WV	Allegany Ballistics Laboratory (USNAVY)+	Y	Y	Soil	Construction underway

* Design underway – refers to a stage before there is a Record of Decision on a final remedy. Early action – indicates that efforts are underway to address contaminated media before the final Record of Decision is in place. Construction underway – indicates that efforts to implement a remedy to address the contaminated media (groundwater or soil), are ongoing. Construction complete – indicates that a remedy has been implemented, but it may be ongoing for some time (in many cases for years).

+ Describes a site with multiple operable units which often are parcels of land with distinct cleanup plans.

Federal and state agencies have developed best management practices that have contributed to the identification of and reductions to perchlorate levels in the environment. For example, in 2006, the Department of Defense (DOD) issued a handbook to assist DoD facilities in complying with DoD policy governing perchlorate sampling and testing activities for both environmental restoration/cleanup and compliance monitoring programs. The handbook is online at: https://www.denix.osd.mil/cmrmp/ecmr/perchlorate/policy/unassigned/dod-perchlorate-handbook/.

Additionally, the California Department of Toxic Substances Control (DTSC) Best Management Practices Regulations for disposal of perchlorate wastes to prevent release of wastes into the environment became operative on July 1, 2006. More information on the types of perchlorate-containing products

that may be subject to these requirements and the perchlorate best management practices is available at: https://dtsc.ca.gov/wp-content/uploads/sites/31/2015/08/HWM_FS_Perchlorate_7-061.pdf.

Perchlorate in Drinking Water due to Use of Sodium Hypochlorite

EPA Actions

Sodium hypochlorite is used for water disinfection and, due to degradation, perchlorate has been detected in hypochlorite solutions. A 2009 study by the American Water Works Association (AWWA) and Water Research Foundation found that perchlorate can be present in hypochlorite solutions and can continue to form with a rate of formation that depends on storage conditions. The study found that to minimize perchlorate formation, hypochlorite solutions should be stored in dark and cool conditions, diluted if possible and used within a few weeks of manufacture.

In response to concerns raised by stakeholders and pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the EPA published an Interim Decision for Calcium, Sodium and Potassium Hypochlorite in March 2018. The Agency requires that advisory best management practices be added to hypochlorite drinking water disinfection product labels to minimize the potential for chlorate and perchlorate formation during storage. These best management practices can be used individually and in combination, and include limited storage time, adequate solution pH range, sunlight exposure avoidance, controlled storage temperature, and dilution.

EPA label amendments for drinking water disinfection products

Summary of Labeling Changes for Hypochlorites in Drinking Water Disinfection End Use Products		
Description	**Labeling Language for Hypochlorites**	**Placement on Label**
For drinking water uses	"The following practices help to minimize degradant formation in drinking water disinfection: • It is recommended to minimize storage time. • It is recommended that the pH solution be in the range of 11-13. • It is recommended to minimize sunlight exposure by storing in opaque containers and / or in a covered area. Solutions should be stored at lower temperatures. Every 5°C reduction in storage temperature will reduce degradant formation by a factor of two.	Precautionary Statements, on applicable labels

	• Dilution significantly reduces degradant formation. For products with higher concentrations, it is recommended to dilute hypochlorite solutions with cool, softened water upon delivery, if practical for the application."	

Industry Actions

Research by the AWWA and the Water Research Foundation found that hypochlorite concentration, pH, ionic strength, and temperature were major factors impacting perchlorate and chlorate formation in stored hypochlorite solutions at drinking water utilities.

In response, AWWA developed standards and guidance which provide several recommendations to minimize perchlorate formation as a result of hypochlorite decomposition. These recommendations are contained in AWWA's Hypochlorite standard (B300) and include:

1. Dilute stored hypochlorite solutions on delivery.
2. Store hypochlorite solution at lower temperatures (every 5°C reduction reduces perchlorate formation rate by about 2).
3. Control hypochlorite solution within the pH range of 11 to 13.
4. Avoid extended storage times (hypochlorite degrades over time into oxygen, chlorate, and perchlorate; earlier use reduces perchlorate addition because of lower perchlorate concentration and lower disinfectant dosage to satisfy the target chlorine residual).
5. In most U.S. states, chemicals added to drinking water must meet third-party certification for NSF/ANSI/CAN 60: Drinking Water Treatment Chemicals – Health Effects (NSF, 2019). As part of this standard, certification listing, and manufacturer's use instructions or documentation supplied with the product "shall reference the recommended handling and storage practices contained in AWWA B300-Hypochlorites." (NSF/ANS, 2016, Standard 60, Section 6.3.3.1)
6. In combination, these new EPA labeling requirements, state certification requirements, and industry guidelines recommending best management practices on hypochlorite solutions will minimize the potential for perchlorate formation in systems utilizing hypochlorite products for drinking water disinfection purposes.

CONCLUSION

The EPA re-evaluated the available data on the frequency and level of perchlorate occurrence in public water systems. The EPA has compared this information to the lowest potential Maximum Contaminant

Level Goal under consideration by the Agency in the June 19, 2019 proposal. The EPA concludes that there is infrequent occurrence of perchlorate at the levels of public health concern. In addition, studies show that perchlorate occurrence in the environment has decreased over time, due to several mitigation actions taken by the EPA and others.

REFERENCES

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