State Water Resources Control Board
Division of Water Quality
GAMA Program

GROUNDWATER INFORMATION SHEET

Chromium VI

Revised: April 2008

The purpose of this fact sheet is to provide general information regarding a specific constituent of concern (COC). The following information, compiled by staff of the Groundwater Ambient Monitoring and Assessment (GAMA) Program, is pulled from a variety of sources and relates mainly to drinking water. For additional information, the reader is encouraged to consult the references cited at the end of this information sheet.

GENERAL INFORMATION	
Constituent of Concern	Chromium VI (Cr^6)
Aliases	Hexavalent Chromium
Chemical Formula	Cr^6
CAS No.	185440-29-9
Storet No.	01032
Summary	The California Department of Public Health (CDPH) included Cr^6 as an unregulated chemical requiring monitoring in 2001. OEHHA proposed a draft Public Health Goal (PHG) of 0.2 µg/L for Cr^6 in 2005. Based on testing data from the CDPH, 3229 of 6536 active and standby public water wells have detected concentrations of Cr^6 greater than the detection limit for purposes of reporting (DLR) of 1 µg/L. Most detections of Cr^6 have occurred in Los Angeles, San Bernardino and Fresno Counties.

Cr^6 REGULATORY AND WATER QUALITY LEVLES[1]		
Type	Agency	Concentration
Federal MCL	US EPA, Region 9	N/A
State MCL	CDPH	In process
DLR	CDPH	1 μg/L
Public Health Goal (PHG)	OEHHA	0.2 μg/L (in review)
Preliminary Remediation Goal (PRG) IRIS (non-cancer health effect)	US EPA, Region 9 US EPA, Region 9	100 μg/L 21 μg/L

[1]These levels generally relate to drinking water, other water quality levels may exist. For further information, see *Water Quality Goals* (Marshack, 2007).

SUMMARY OF Cr^6 DETECTIONS IN PUBLIC DRINKING WATER WELLS[2]	
Detection Type	**Number of Groundwater Sources**
Number of active and standby public water wells with Cr^6 concentrations > 1 μg/L.	3229 of 6536 public wells tested
Top 3 counties having public water wells with Cr^6 concentrations > 1 μg/L.	Los Angeles, San Bernardino, Fresno

[2]Based on CDPH data collected from 1994-2006 (Geotracker).

[3]Drinking water supplied from active and standby public water wells is typically treated and/or blended. Individual wells and wells for small water systems not regulated by CDPH are not included.

ANALYTICAL INFORMATION		
Method	**Detection Limit**	**Note**
GFAAS and ICP-MS (screening methods)	1 μg/L	CDPH approved for public drinking water systems
US EPA 218.6	0.2 μg/L	CDPH approved
USGS by GFAAS	0.05 μg/L	Cr^6 separation in the field, not time sensitive
Known limitations to Analytical Methods	Water sample pH must be adjusted to 9.0-9.5, stored at 4° C and analyzed within 24 hours. The USGS cation exchange sampling method is not time sensitive and separation of Cr^6 is done in the field.	
Public Drinking Water Testing Requirements	In January 2001, CDPH identified Cr^6 as an unregulated chemical requiring monitoring. As a result, public water systems began to test for Cr^6 in their drinking water supplies.	

OCCURRENCE	
Anthropogenic Sources	Chromium is a metallic chemical that originates as a contaminant in the environment from the discharges of dye and paint pigments, wood preservatives, chrome-plating liquid wastes, and leaching from hazardous waste sites. The greatest use of chromium is in metal alloys such as stainless steel; protective coatings on metal; magnetic tapes; and pigments for paints, cement, paper, rubber, composition floor covering, etc. The two largest sources of chromium emission in the atmosphere are from the chemical manufacturing and combustion of natural gas, oil and coal.
Natural Sources	Chromium is a metal found in natural deposits of ores containing other elements, mostly as chrome-iron ore. It is also widely present in soil and plants. Under most conditions, natural chromium in the environment occurs as Cr^3. Under highly oxidizing conditions (pH >7) and with presence of minerals containing chromium, part of it may occur as Cr^6 dissolved in groundwater. Recent sampling of drinking water throughout California suggests that Cr^6 may occur naturally in groundwater at many locations. Naturally occurring Cr^6 may be associated with serpentinized peridodite (serpentinite) of the Franciscan Formation (Presidio of San Francisco). It may occur in chromium containing formations such as peridotite or sepentinite under oxidizing conditions (Klamath Mountains and Coast Ranges).

History of Occurrence	Cr^6 has been found in groundwater at several industrial sites where wood treatment or metal plating solutions were used. Cr^6 contaminating groundwater became well known after Pacific Gas & Electric (PG&E) was accused by residents of contaminating groundwater in the Hinkley community, west of Barstow. Cr^6 was used to reduce corrosion in a natural gas compressor plant. Contaminated water was suspected of causing cancer and tumors in Hinkley residents. Since then, Cr^6 has been found at elevated concentrations in groundwater at several locations in California; Glendale, Topock and Kettleman City. Cr^6 occurs naturally in groundwater at the Presidio of San Francisco and Lawrence Livermore National Laboratory. As of December 2006, Cr^6 has been reported at concentrations above 1 μg/L in 3229 out of 6536 sampled active and standby public water wells. Elevated concentrations of Cr^6 have been found in Los Angeles (54μg/L), Merced (33 μg/L), San Bernardino (32 μg/L), Santa Barbara (45 μg/L), Santa Cruz (38 μg/L) and Yolo (42 μg/L) counties.
Transport Characteristics	Cr^6 is readily soluble in water. Under high Eh (oxidizing) and alkaline (pH above 7) conditions, Cr^6 can be predominant in groundwater. However, in the presence of organic matter, such as ferrous iron (Fe II) and sulfide, Cr^6 can be readily reduced to Cr^3 and immobilized. Adsorption of Cr^6 by clayey soil and natural aquifer materials is low to moderate under near-neutral pH ranges commonly encountered in groundwater.

REMEDIATION & TREATMENT TECHNOLOGIES

In-situ Treatment:
In several laboratory and field pilot tests, and full-scale remediation systems, Cr^6 has been removed using a permeable reactive barrier filled with zero-valent iron granules, surfactant-modified zeolite or by injection of sodium dithionite. Other methods include geochemical fixation, soil flushing and extraction, and electrokinetics. Also, the use of tin is being proposed to reduce Cr^6 to Cr^3 in the San Gabriel basin as part of a process for the production of potable water.

Above-Ground Treatment
Drinking water can be treated by different pump and treat remediation systems. Cr^3 and Cr^6 can be removed by an activated carbon filter, reverse osmosis or ion exchange resin. The ion exchange method should be used with caution, as presence of other metals may interact with the process and decrease system effectiveness. Removal of Cr^6 by seaweed biosorbent and bacteria (Bacillus sp.) within packed bed reactors has also been used.

Natural Attenuation
Natural attenuation of Cr^6 may occur in the subsurface environment through reduction by organic matter, iron hydroxides or sulfides. Prior to selection of natural attenuation as an option for remediation, the following conditions need to be demonstrated: 1) there are natural reducers present within the aquifer, 2) the amount of Cr^6 and other reactive constituents do not exceed the capacity of the aquifer to reduce them, 3) the rate of Cr^6 reduction is greater than the rate of transport of the aqueous Cr^6 off the impacted site, 4) the Cr^6 remains immobile, and 5) there is no net oxidation of Cr^3 to Cr^6.

HEALTH EFFECT INFORMATION

Cr^6 is known to cause cancer in humans when inhaled. Cr^6 can also damage the lining of the nose and throat and irritate the lungs. A number of scientific studies have found elevated rates of lung cancer in workers with occupational exposure to Cr^6 by inhalation. A few studies of workers exposed to Cr^6 by inhalation have shown an increase in cancers of the gastrointestinal tract. When swallowed, Cr^6 can upset the gastrointestinal tract and damage the liver and kidneys. Scientific evidence suggests Cr^6 does not cause cancer when ingested since it is rapidly converted to Cr^3 after entering the stomach.

KEY REFERENCES

1. Bohumil Voleski; Removal of Trivalent and Hexavalent Chromium by Seaweed Biosorbent, environmental Science & technology; 1998; 32(18); 2693-2698. (Article)

2. California Department of Public Health; Chromium 6 (Hexavalent Chromium) in Drinking Water: Sampling and Analysis http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6.aspx

3. Dorota Z. Haman, Del b. Bottcher; Home Water Quality and Safety University of Florida, Cooperative Extension Service, Institute of Food and Agricultural Science, http://edis.ifas.ufl.edu/BODY_AE009

4. Montgomery Watson; Technical Memorandum-Hexavalent Chromium in Groundwater, Presidio of San Francisco, prepared for US COE, April 1998

5. U S Environmental Protection Agency; Field Applications of In-Situ Remediation Technologies: Permeable Reactive Barriers, EPA 542-R-99-002, April 1999

6. U S Environmental Protection Agency; National Primary Drinking Water Regulations- consumer Fact Sheet on: Chromium, http://www.epa.gov/safewater/dwh/c-ioc/chromium.html

7. U S Environmental Protection Agency; Groundwater Issue; Natural attenuation of Hexavalent Chromium in Groundwater & Soils; by Robert Puls, 1994, EPA/540/S-94/505

8. U S Environmental Protection Agency; Groundwater Issue- Behavior of Metals in Soils, EPA/540/S-92/018, by Joan McLean and Bert E. Bledsoe

9. U S Environmental Protection Agency-Technology Innovation Program-Contaminant Focus-Chromium VI (August 15, 2007). http://www.clu-in.org/contaminantfocus/default.focus/sec/chromium_VI/cat/Overview/

10. Yi-Tin Wang; Hexavalent Chromium Reduction by Bacillus sp. in a Packed-Bed Bioreactor, Environmental Science & Technology; 31(5); 1446-1451. (Article)

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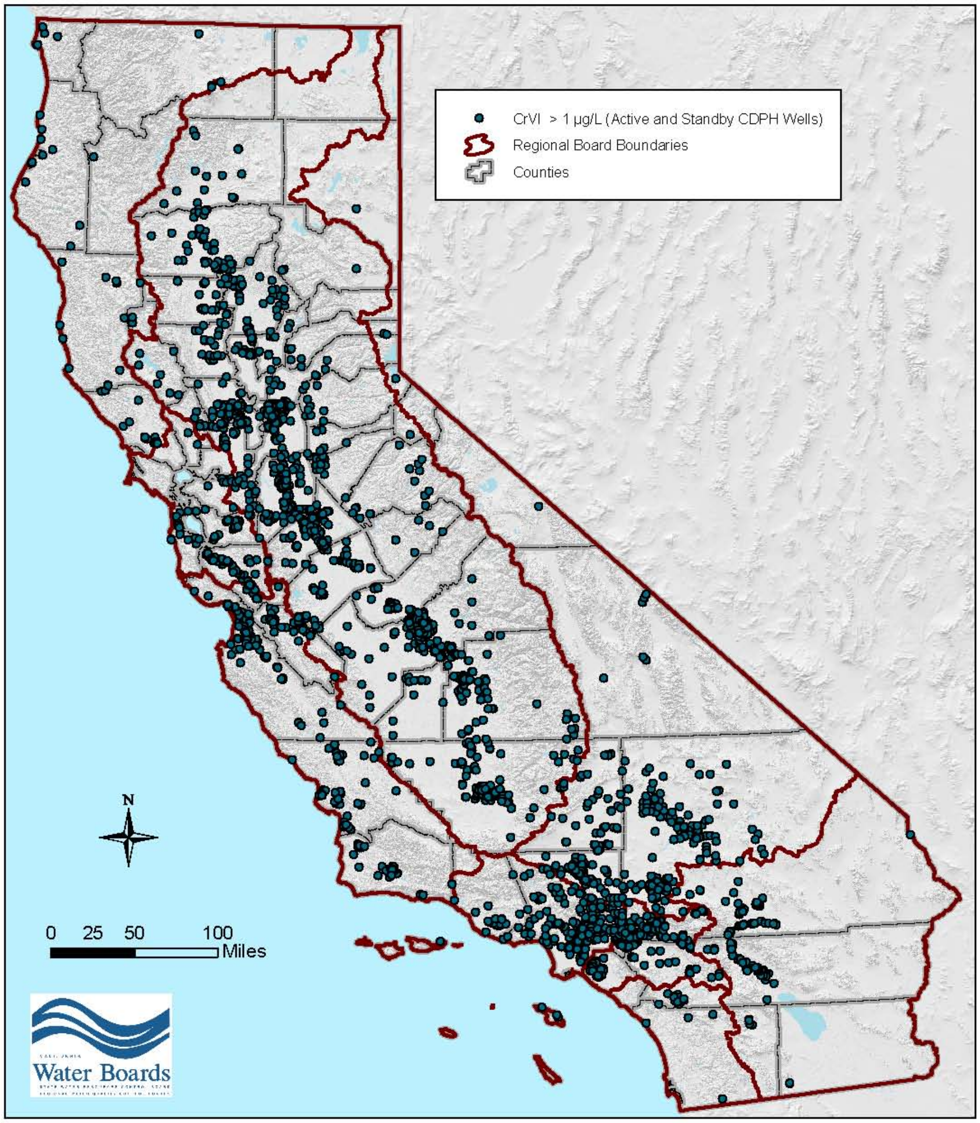
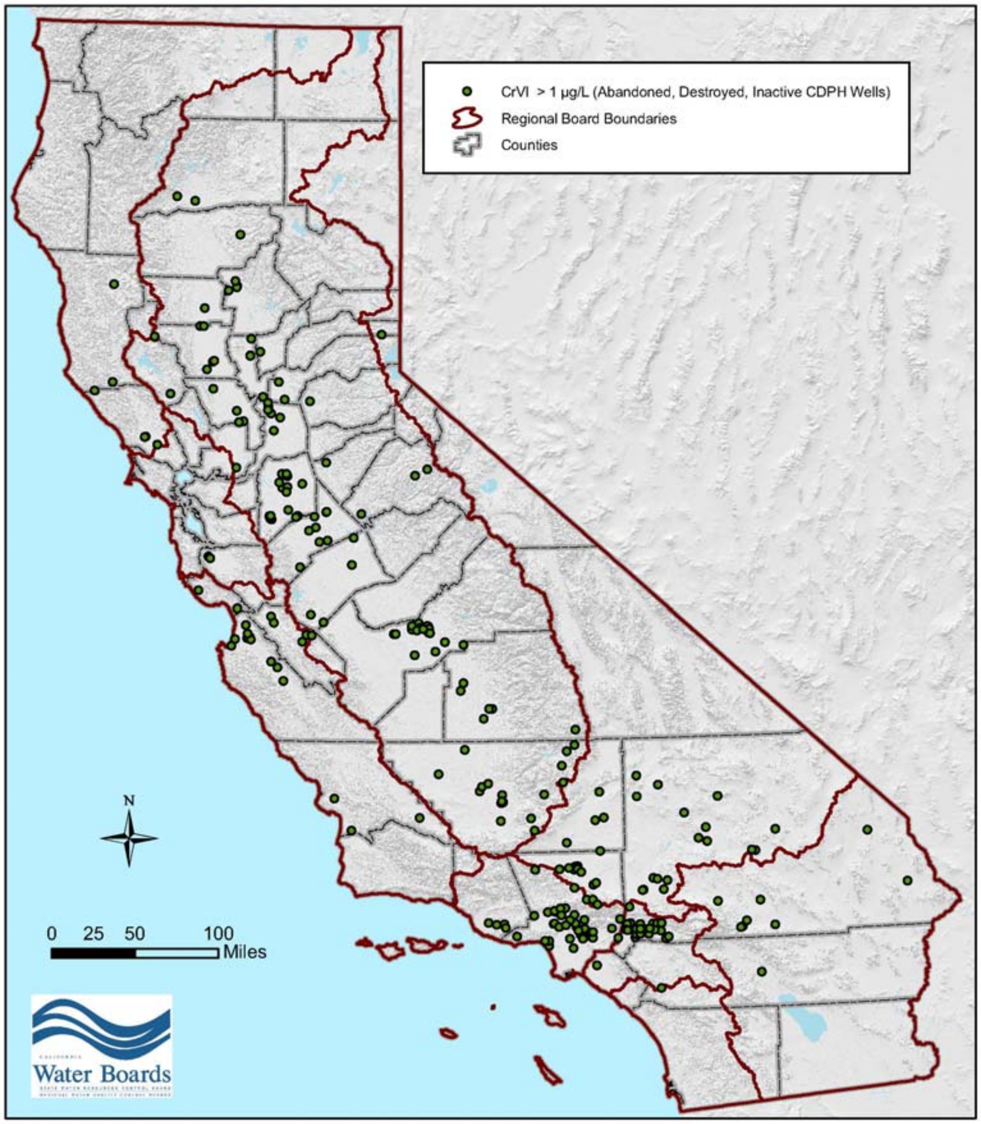


Active and Standby CDPH Wells with at Least One Detection of Chromium VI Above the DLR of 1 µg/L (3229 wells)

Source 1994 - November 2006 CDPH Data
(Map revised October 25, 2007)



Abandoned, Destroyed, Inactive CDPH Wells with at Least One Detection of Chromium VI Above the DLR of 1 µg/L MCL (260 wells)

Source 1994 - November 2006 CDPH Data
(Map revised October 25, 2007)