

GROUNDWATER INFORMATION SHEET

Chromium VI

Revised: February 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	<p>The California Department of Public Health (CDPH) adopted a regulation in 2001 that included Cr⁶ as an unregulated chemical requiring monitoring. While “unregulated” usually refers to a contaminant that lacks a Maximum Contaminant Level (MCL), Cr⁶ is regulated under the CDPH’s MCL of 50 micrograms per liter (µg/L) for Total Chromium. CDPH must adopt a Public Health Goal (PHG) for Cr⁶ before adopting any MCL. OEHHA proposed a draft PHG of 0.2 µg/L for Cr⁶. Because the final PHG is not yet available, CDPH has not proceeded with the MCL process for Cr⁶. The detection limit for purposes of reporting (DLR) for Cr⁶ is 1 µg/L. Based on CDPH data collected through 2006, 3,229 of 6,536 active and standby status public drinking water wells tested have had concentrations of Cr⁶ greater than the DLR of 1 µg/L. Of 1,108 active and standby status public wells tested, 33 have had concentrations of Total Chromium greater than CDPH’s MCL for Total Chromium of 50µg/L. Most detections have occurred in Los Angeles, San Bernardino and Fresno Counties.</p>

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REGULATORY AND WATER QUALITY LEVELS¹		
Type	Agency	Concentration
Federal MCL (Cr ⁶)	US EPA, Region 9	N/A
State MCL (Cr ⁶)	CDPH	In process
DLR (Cr ⁶)	CDPH	1 µg/L
PHG (Cr ⁶)	OEHHA	0.2 µg/L (in review)
Others:		
Preliminary Remediation Goal (PRG) (Cr ⁶)	US EPA, Region 9	100 µg/L
IRIS (non-cancer health effect) (Cr ⁶)	US EPA, Region 9	21 µg/L
Federal MCL (Total Chromium)	US EPA, Region 9	100 µg/L
State MCL (Total Chromium)	CDPH	50 µg/L
DLR (Total Chromium)	CDPH	10 µg/L

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

SUMMARY OF DETECTIONS IN PUBLIC DRINKING WATER WELLS²	
Detection Type	Number of Groundwater Sources
Number of active and standby public water wells with Cr ⁶ concentrations > 1 µg/L.	3,229 of 6,536 public wells tested
Top 3 counties having public water wells with Cr ⁶ concentrations > 1 µg/L.	Los Angeles, San Bernardino, Fresno
Number of active and standby public water wells ³ with Total Chromium concentrations > 50 µg/L.	33 of approximately 1,108 public wells tested
Top 3 Counties having public water wells with total chromium concentration > 50 µg/L.	Los Angeles, Yolo and Kern

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

³Drinking 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.

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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 adopted a regulation identifying Cr ⁶ as an unregulated chemical requiring monitoring. As a result, public water systems began collecting data on the presence of 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 soils and plants. Most 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. Naturally occurring Cr ⁶ may be associated with serpentinized peridotite (serpentinite) of the Franciscan formation (Presidio of San Francisco). It is expected to occur in chromium containing formations such as peridotite or serpentinite under oxidizing conditions (Coast Ranges of California). The mineral chromate is found in northern California (Klamath Mountains).

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<p>History of Occurrence</p>	<p>Cr⁶ has been found in groundwater at several industrial sites where wood treatment or metal plating solutions have leaked or spilled. Cr⁶ 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. Cr⁶ was used to reduce corrosion in a natural gas compressing station. Contaminated water was suspected of causing cancer and tumors in Hinkley residents. Since then, Cr⁶ was found at elevated concentrations in groundwater at several locations in California; City Of Glendale in San Fernando Valley, Topock and Kettleman City. Cr⁶ occurs naturally in groundwater at the Presidio of San Francisco, Lawrence Livermore National Laboratory, Paradise Valley in Arizona and Atacama Desert in Chile. Recent sampling of drinking water throughout California suggests that Cr⁶ may occur naturally in many locations. As of December 2006, (CDPH data base), Cr⁶ has been reported at concentrations above 1 µg/L in 260 out of 3,229 sampled wells. Concentrations up to 54µg/L were found in Los Angeles County. High concentrations of Cr⁶ were also found in Merced County (33 µg/L), San Bernardino County (32 µg/L), Santa Barbara County (45 µg/L) Santa Cruz County (38 µg/L) and Yolo County (42 µg/L).</p>
<p>Transport Characteristics</p>	<p>Cr⁶ is readily soluble in water. Under high Eh (oxidizing) and alkaline (pH above 7) conditions, Cr⁶ can be predominant in groundwater. However, in presence of organic matter, such as ferrous iron (Fe II) and sulfide, Cr⁶ can be readily reduced to Cr³ and immobilized. Adsorption of Cr⁶ by clays, soils, and natural aquifer materials is low to moderate under near-neutral pH ranges commonly encountered in groundwater.</p>

REMEDIATION & TREATMENT TECHNOLOGIES

In-situ Treatment:

Reducing Cr^6 to the more immobile form of Cr^3 is effective in soil or groundwater. 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 on-line treatment 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 *Bacillus* sp. within packed bed reactors has also been reported.

Natural Attenuation

Cr^6 can be attenuated naturally under certain aquifer and soil conditions. 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 from the 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 can be toxic. When inhaled, it can damage the lining of the nose and throat and irritate the lungs. Cr^6 is known to cause cancer in humans when inhaled. The hazards of airborne Cr^6 in the workplace environment have been extensively documented. 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, it can upset the gastrointestinal tract and damage the liver and kidneys, however evidence suggests Cr^6 does not cause cancer when ingested, most likely because it is rapidly converted to the trivalent form after entering the stomach.

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KEY REFERENCES

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4. Montgomery Watson; Technical Memorandum-Hexavalent Chromium in Groundwater, Presidio of San Francisco, prepared for US COE, April 1998
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6. U S Environmental Protection Agency; National Primary Drinking Water Regulations- consumer Fact Sheet on: Chromium,
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9. U S Environmental Protection Agency-Technology Innovation Program- Contaminant Focus-Chromium VI (August 15, 2007).
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10. Yi-Tin Wang; Hexavalent Chromium Reduction by Bacillus sp. in a Packed-Bed Bioreactor, Environmental Science & Technology; 31(5); 1446-1451. (Article)

FOR MORE INFORMATION, CONTACT: Jan Stepek, SWRCB (916) 341-5777

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**Active and Standby CDPH Wells with at Least
One Detection of Chromium (Total) > 50 µg/L MCL (33 wells)**

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

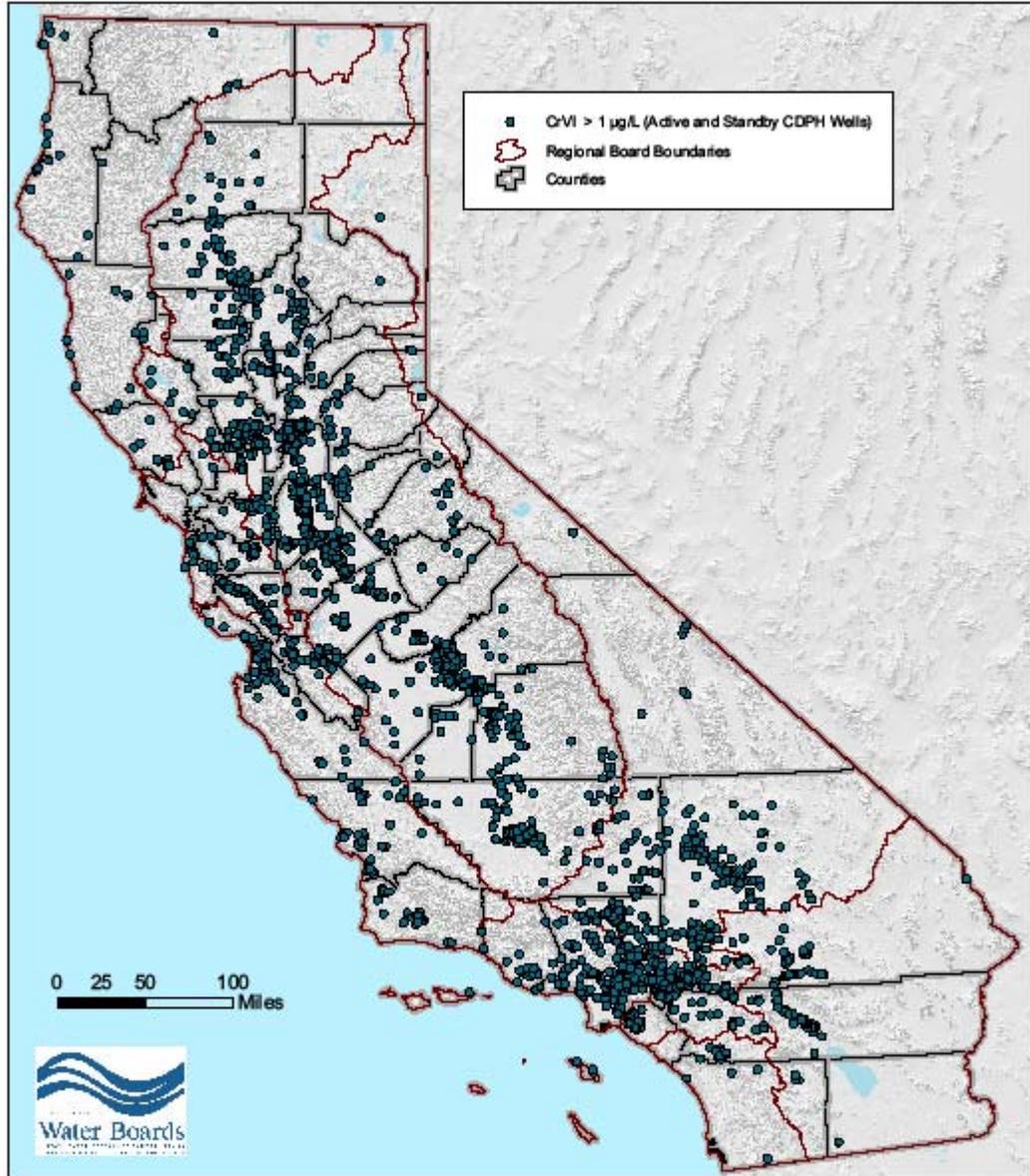
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Abandoned, Destroyed, Inactive CDPH Wells with at Least One Detection of Chromium (Total) > 50 µg/L MCL (8 wells)

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

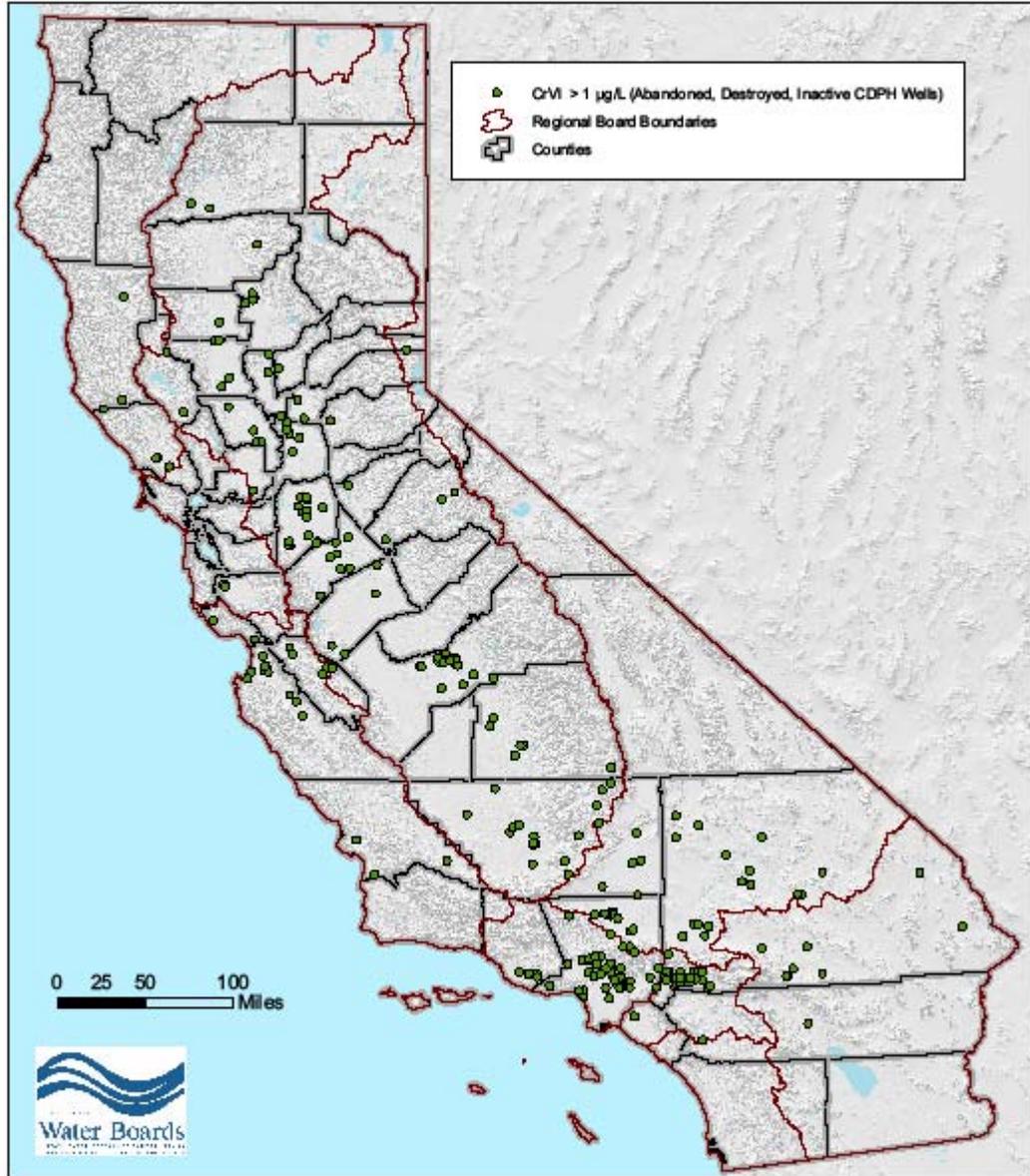
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**Active and Standby CDPH Wells with at Least
One Detection of Chromium VI > 1 µg/L MCL (3229 wells)**

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

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

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