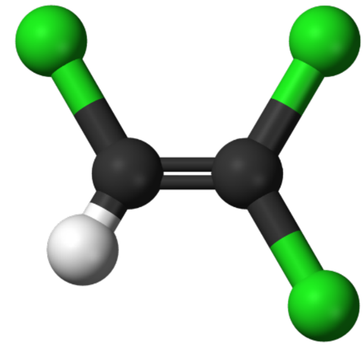
Groundwater Fact Sheet
Trichloroethylene (TCE)



Constituent of Concern
Trichloroethylene (TCE)

Synonym
1,1,2-Trichloroethylene, Ethylene trichloride, Acetylene trichloride, Trilene, Trichloroethene, Anamenth, Blancosolv

Chemical Formula
C_2HCl_3 or $ClCH{=}CCl_2$

CAS Number
79-01-6

Storet Number
39180

Summary
The current State Maximum Contaminant Level (MCL) for trichloroethylene (TCE) is 5 micrograms per liter (µg/L). TCE is a chlorinated solvent that may occur in groundwater in dissolved form and/or as a free product that sinks below the water table in the form of a dense non-aqueous phase liquid (DNAPL). It is more volatile than PCE, a chlorinated solvent that degrades into TCE under certain conditions. As a result, TCE can form vapors that can migrate upward from the water table and infiltrate into basements. TCE is used as an intermediate in the manufacture of a hydrofluorocarbon employed as a refrigerant (HFC-134a) and as a solvent to remove grease from metal parts. The US Environmental Protection Agency (EPA) determined TCE to be carcinogenic to humans by all routes of exposure. Reductive dechlorination processes in groundwater can slowly degrade TCE to vinyl chloride (VC), which is also considered a human carcinogen, and eventually to ethene, a subproduct that also naturally occurs in the environment.

Based on State Water Resources Control Board (SWRCB) data from 2007 to 2017, there were 186 active and standby public wells (of 8,994 wells tested, 470 detections) that had at least one detection of TCE above the MCL. Most detections of TCE occurred in three counties; Los Angeles (153), San Bernardino (14) and Fresno (6).

REGULATORY WATER QUALITY LEVELS[1]

TRICHLOROETHYLENE (TCE)

Type	Agency	Concentration
Federal MCL	EPA[2]	5 µg/L
State MCL	SWRCB[3]	5 µg/L
Detection Limit for Purposes of Reporting (DLR)	SWRCB[3]	0.5 µg/L
Public Health Goal (PHG)	OEHHA[4]	1.7 µg/L[5]

[1]These levels are generally related to drinking water. Other water quality levels may exist. For further information, see "A Compilation of Water Quality Goals", 17th Edition (SWRCB 2016).
[2]EPA – United States Environmental Protection Agency
[3]SWRCB - State Water Resources Control Board.
[4]OEHHA – Office of Environmental Health Hazard Assessment
[5]After the EPA reclassified TCE as a human carcinogen, OEHHA initiated a review of the PHG for TCE in September 2012.

TCE DETECTIONS IN PUBLIC WATER WELL SOURCES[6]	
Number of active and standby public water wells with TCE concentrations > 5 µg/L [7]	186 of 8,994 wells tested with 470 detections
Top 3 counties with TCE detection in public wells above the MCL.	Los Angeles (153), San Bernardino (14), Fresno (6)

[6]Based on 2007-2017 public standby and active well (groundwater sources) data collected by the SWRCB.
[7]Water from public active and standby public groundwater sources is typically treated to prevent exposure to chemical concentrations above MCL. Data from private domestic wells and wells with less than 15 service connections are not available.

ANALYTICAL INFORMATION			
Approved EPA methods	502.2	524.2	8260B
Detection Limit (µg/L)	0.01	0.2	0.02
Known Limitations to Analytical Methods	Sample must be cooled to 4 °C upon collection, analyzed within 14 days and free of air bubbles.		
Public Drinking Water Testing Requirements	TCE is a regulated contaminant for which monitoring is required (Title 22, Section 64431, et seq.).		

TCE Occurrence

Anthropogenic Sources

TCE is primarily used as a an intermediate in the manufacture of a hydrofluorocarbon employed as a refrigerant (HFC-134a). TCE is also used as a solvent to remove grease from metal parts, particularly in the automotive and metal machining industry. As a general solvent or as a component of solvent blends, TCE is used with adhesives, lubricants, paints, varnishes, paint strippers, pesticides, and cold metal cleaners. It can be found in many household products, including paint removers, adhesives, spot removers, and rug-cleaning fluids. It is also used in various chemical manufacturing processes. Historically, TCE was also used in foods, beverages (decaffeination of coffee), pet foods, medicine, pharmaceuticals, and cosmetics.

Natural Sources

TCE does not occur naturally in the environment.

History of Occurrence

TCE has been in use for almost a century. The largest sources of TCE in groundwater are releases from chemical waste sites, improper disposal practices, and leaking storage tanks and pipelines. The major sources of TCE to the environment are landfills and air emissions.

Historically, TCE at concentrations above the MCL (5 µg/L) was found in over 200 public wells in California, with the majority of occurrence in the Los Angeles, San Bernardino, and Fresno counties.

Contaminant Transport Characteristics

TCE is moderately soluble in water and soil. TCE is denser than water and free phase TCE will sink to the bottom of an aquifer as a dense non-aqueous phase liquid (DNAPL). TCE can destroy the structure of clayey minerals, making them more permeable to dissolved contaminants. TCE is not readily degraded in groundwater, although some TCE may naturally degrade under anaerobic conditions. However, TCE may degrade into compounds that are toxic and more difficult to degrade than TCE, such as dichloroethylene (DCE) and vinyl chloride (VC).

Remediation and Treatment Technologies

Groundwater remediation

Air Stripping, Ultraviolet (UV) Light, and Activated Carbon:

TCE is typically removed from groundwater using a traditional pump and treat system where water is treated above ground by air-stripping and activated carbon filtration and/or UV treatment.

Permeable Reactive Barriers (PRB):

PRB are filled with zero-valent iron granules and/or organic matter has been used to remediate and contain TCE plumes in-situ.

Innovative Methods:

Oxidation, using potassium permanganate, thermal remediation using electrodes, and steam or enhanced biodegradation are currently being tested. An increasing variety of nanoscale materials with environmental applications has been developed over the past several years. For example, nanoscale materials have been used to remediate contaminated soil and groundwater at hazardous waste sites, such as sites contaminated by chlorinated solvents or oil spills.

Drinking Water and Wastewater Treatment

Drinking water may be treated using various in-line processes. Traditionally, air stripping and activated carbon filters are used to remove TCE and other volatile organic carbons (VOCs) from water. Ultraviolet radiation with the addition of hydrogen peroxide is also used for low-flow systems. Wastewater treatment plants use chemical oxidizers (such as potassium permanganate) and biodegradation processes to remove VOCs from water.

Health Effect Information

Acute

overexposure to TCE vapor can affect the central nervous system, e.g., light-headedness, drowsiness, and headache. Acute exposure may lead to unconsciousness or in extreme circumstances to death. TCE may irritate the respiratory tract at high vapor concentrations. Prolonged contact with the chemical in liquid form can cause irritation of the skin and eyes.

Chronic

Repeated exposure in excess of recommended occupational limits has been associated with damage to the liver, kidneys, and nervous system.

Carcinogen

TCE is considered carcinogenic in the State of California and was added to the list of carcinogens in 1988. EPA determined TCE to be carcinogenic to humans by all routes of exposure.

Key Resources

1. California Environmental Protection Agency. Office of Environmental Health Hazard Assessment. Public Health Goal for Trichloroethylene in Drinking Water. July, 2009 http://www.oehha.ca.gov/water/phg/tce070909.html
2. California Environmental Protection Agency. Office of Environmental Health Hazard Assessment, Initiation of Process to Update Public Health Goals for Three Chemicals in Drinking Water, September 2012. http://www.oehha.ca.gov/water/phg/pdf/2012InitiationReport.pdf
3. California State Water Resources Control Board. GAMA GIS online tools. https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/
4. Fetter, C. W., Applied Hydrogeology. 1988. Merrill Publishing Company.
5. Howard, H. Philip, et al., Environmental Degradation Rates. 1991. Lewis Publisher.
6. Montgomery H. J., Groundwater Chemicals-Desk Reference. 2000. Lewis Publisher.
7. Nanotechnology: Applications for Environmental Remediation Overview, http://www.clu-in.org/techfocus/default.focus/sec/Nanotechnology%3A_Applications_for_Environmental_Remediation/cat/Overview/
8. National Environmental Methods Index (NEMI), Trichloroethylene. https://www.nemi.gov/methods/keyword/?keyword_search_field=trichloroethylene
9. State Water Resources Control Board. January 2016. *A Compilation of Water Quality Goals, 17th Edition, (SWRCB, 2016)*. http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/index.shtml
10. U.S. Environmental Protection Agency, Technologies- Permeable Reactive Barriers. https://cluin.org/techfocus/default.focus/sec/Permeable_Reactive_Barriers%2C_Permeable_Treatment_Zones%2C_and_Application_of_Zero-Valent_Iron/cat/Overview/
11. U.S. Environmental Protection Agency, Contaminated Site Clean-Up Information. Bioremediation Overview.
12. http://www.clu-in.org/techfocus/default.focus/sec/Bioremediation/cat/Overview/
13. US Environmental Protection Agency, Contaminated Site Clean-Up Information, Contaminant focus - Trichloroethylene.
14. https://clu-in.org/contaminantfocus/default.focus/sec/Trichloroethylene_(TCE)/cat/Overview/
15. US Environmental Protection Agency, Preliminary Information on Manufacturing, Processing, Distribution, Use, and Disposal: Trichloroethylene.
16. https://www.regulations.gov/document/EPA-HQ-OPPT-2016-0737-0003

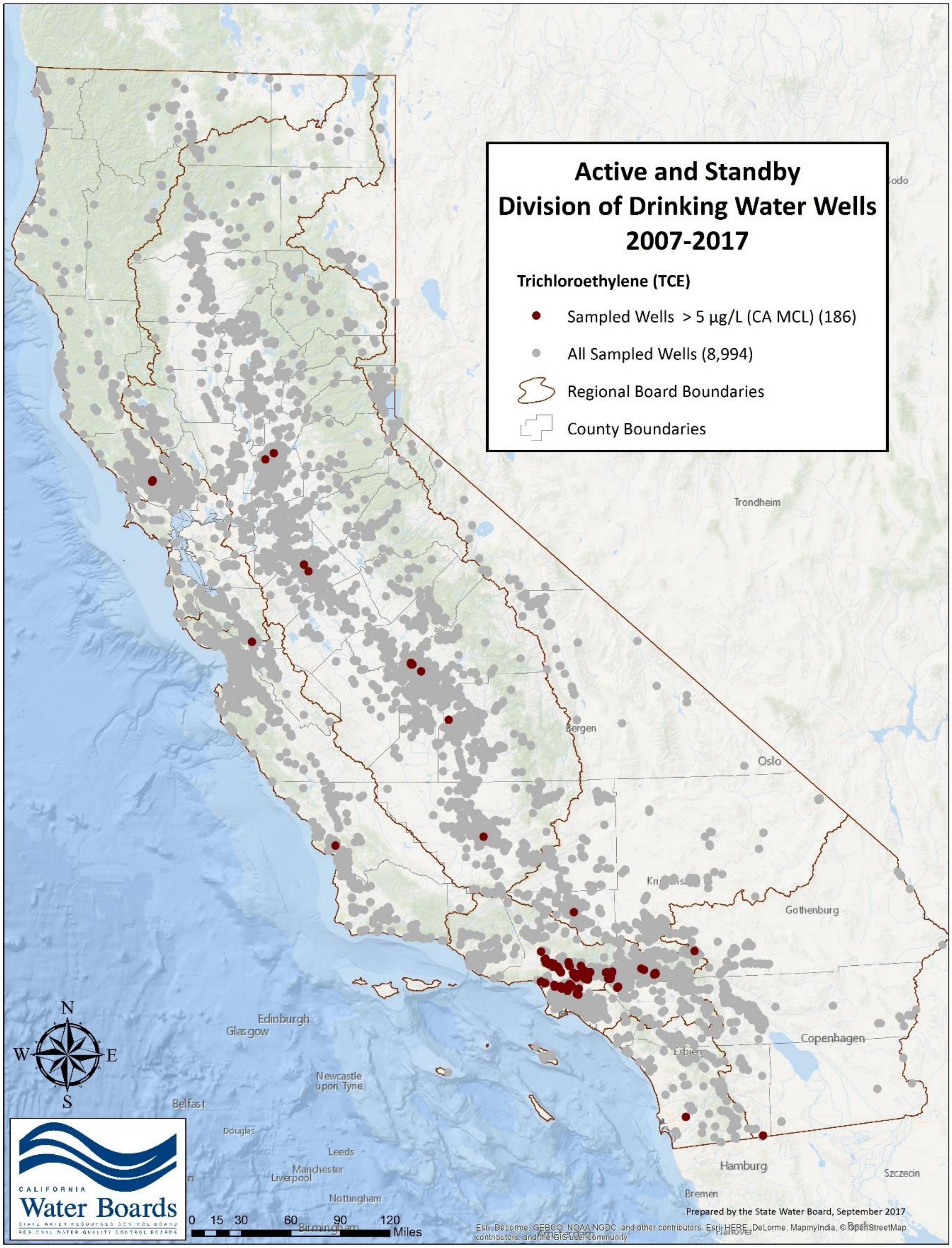


Figure 1. Active and standby public drinking water wells that had at least one detection of TCE above the MCL, 2007-2017, 186 wells. (*Source: Public supply well data in [GAMA GIS]*).