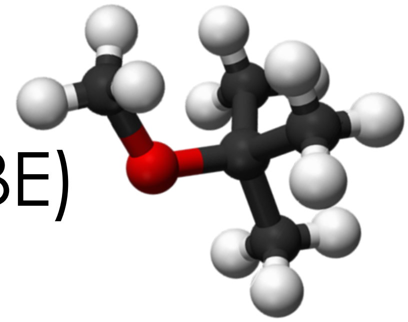
Groundwater Fact Sheet
Methyl tertiary-butyl ether (MTBE)



Constituent of Concern
Methyl tertiary-butyl ether

Synonym
MTBE, Methyl tert-butyl ether, 2-Methoxy-2-Methyl propane, Methyl 1,1-Dimethylethyl Ether

Chemical Formula
$C_5H_{12}O$ or $(CH_3)_3COCH_3$

CAS Number
1634-04-4

Storet Number
46491

Summary
Methyl tert-butyl ether (MTBE) is a regulated drinking water contaminant with an established Maximum Contaminant Level for drinking water at 13 µg/L (MCL) and a secondary (SMCL) level at 5 µg/L. The SMCL was established for water quality esthetic properties such as taste and odor. The most prevalent use of MTBE was as a gasoline additive, designed for more efficient fuel combustion thus to improve overall air quality. California has prohibited the use of MTBE in gasoline as of January 1, 2004. MTBE is a chemical compound that is manufactured by the chemical reaction of methanol and isobutylene. At room temperature, MTBE is a volatile, flammable, and colorless liquid that dissolves rather easily in water.

Based on State Water Resources Control Board (SWRCB) data from 2007 to 2017, seven active and standby public water wells (of 9,050 sampled, 728 detections) had at least one detection of MTBE above the primary MCL, and eight public water wells with MTBE concentrations above the secondary MCL (but not above the primary MCL). The counties with the greatest number of detections above the primary MCL are San Bernardino County with two wells over the MCL, and one detection above the MCL each in Lake, Los Angeles, Monterey, and Shasta counties.

REGULATORY WATER QUALITY LEVELS[1]

METHYL TERTIARY-BUTYL ETHER (MTBE)

Type	Agency	Concentration
Federal MCL	EPA[2]	NA
State MCL (primary)	SWRCB[3]	13 µg/L
State SMCL (secondary)	SWRCB[3]	5 µg/L
Detection Limit for Purposes of Reporting (DLR)	SWRCB[3]	3 µg/L
Public Health Goal (PHG)	OEHHA[4]	13 µg/L

[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

MTBE DETECTIONS IN PUBLIC WATER WELL SOURCES[5]	
Number of active and standby public water wells with MTBE concentrations [6] > 13 µg/L (MCL) and > 5 µg/L (SMCL)	7 of 9,050 wells tested and 8 of 9,050 wells tested, with 728 detections
Top counties with MTBE detection in public wells above the MCL	San Bernardino (2), Monterey (1), Lake (1), Shasta (1) and Los Angeles (1)

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

ANALYTICAL INFORMATION		
Approved EPA methods	524.2	8260
Detection Limit (µg/L)	0.09	0.5
Notes	Gas chromatography with mass spectrometer detector	Additional fuel oxygenates are included in this method and lower detection limit
Known Limitations to Analytical Methods	The ability of Method 8260 to analyze samples for the full suite of gasoline range petroleum hydrocarbons, the inability of Method 8020 to analyze some of the other required fuel oxygenates and decreasing costs have led Method 8260 to become the "standard" for fuel oxygenate analysis for groundwater samples.	
Public Drinking Water Testing Requirements	In accordance with federal regulations, California requires public water systems to sample their sources (wells) and have the samples analyzed for known contaminants, including MTBE, to determine compliance with drinking water standards (MCL). Primary MCL are based on health protection, technical feasibility, and costs. Secondary MCL are based on consumer acceptance, including parameters such as odor, taste, and appearance. The water suppliers must notify the SWRCB-DDW and the public when a primary MCL (13 µg/L) or secondary MCL (5 µg/L) has been exceeded and take appropriate action.	

MTBE Occurrence

Anthropogenic Sources

The most prevalent use of MTBE is as a gasoline additive to either raise the octane level or make gasoline burn cleaner. MTBE in unleaded gasoline is typically 11 to 15 percent of the total volume. By the mid-1990s, the demand for MTBE was over 200,000 barrels (approximately 8.4 million gallons) a day. However, around the same time, MTBE was identified as a significant groundwater contaminant and several states began to restrict the use of the compound. California established a MCL for MTBE in 2000, and prohibited MTBE use in gasoline sold in California as of January 1, 2004. At least 15 additional states have regulations prohibiting or restricting the use of MTBE in gasoline. MTBE production has significantly fallen since the early 2000s.

MTBE can be released to groundwater by leaking underground storage tanks and piping, atmospheric deposition, spills during transportation, and leaks at refineries. Underground storage tank or piping releases make up most of the releases that have impacted groundwater. Studies have shown that atmospheric deposition of MTBE usually only results in trace concentrations (few µg/L). In contrast, point sources of MTBE contamination (i.e., underground storage tank sites) are readily evident by much higher concentrations.

Natural Sources

MTBE is a manufactured chemical that does not occur naturally in the environment.

History of Occurrence

MTBE has been used as a gasoline additive in the United States since 1979, when it was originally introduced as an octane-enhancing replacement for lead. In August 1995, the City of Santa Monica discovered MTBE in drinking water supply wells at its Charnock Wellfield. By 1996, persistent and increasing levels of MTBE at concentrations as high as 610 µg/L caused all of the Charnock Wellfield supply wells to be shut down. Several public supply wells in South Lake Tahoe were found to be impacted by MTBE. In 2001, the South Tahoe Public Utility District took 12 of the District's 34 drinking water wells off-line due to the detection or nearby presence of MTBE. In Glennville, California, MTBE was detected in drinking water at some of the highest levels of MTBE ever recorded. One well tested at 20,000 µg/L. After banning MTBE as a gasoline additive, the number of detections in public wells has been steadily declining.

Contaminant Transport Characteristics

MTBE is a threat to groundwater due to its high solubility, mobility and high resistance to biological degradation. MTBE can move rapidly through the unsaturated zone to groundwater. Poor sorption to sediments and organic material results in MTBE velocities near or even faster than that of groundwater itself.

Research has suggested that MTBE can be degraded by certain bacterial strains under strongly oxic conditions, particularly at the aerobic fringes of petroleum hydrocarbon plumes which may explain why large MTBE groundwater plumes are generally not observed. Bacteria will preferentially degrade other more easily metabolized hydrocarbons first. In cases where biologic degradation does occur, toxic degradation products such as tertiary-butyl alcohol (TBA) and tertiary-butyl formate (TBF) can be formed.

Remediation and Treatment Technologies

There are several effective remediation technologies that remove MTBE from soil and groundwater. These include:

Soil Vapor Extraction (SVE)

SVE is effective on MTBE in the unsaturated zone due to the high vapor pressure of MTBE. SVE is often used together with low temperature thermal desorption (LTTD). MTBE is more difficult to remove when in the dissolved phase.

Air Sparging

MTBE can be removed from groundwater by air sparging. Due to the high solubility of MTBE, it may take a large volume of sparged air to volatize the MTBE from the groundwater. The air may also oxygenate the groundwater and stimulate biodegradation of dissolved contaminants. Air sparging must be used in conjunction with soil vapor extraction.

In-situ Oxidation

In-situ oxidation relies on the capacity of certain chemicals (e.g., hydrogen peroxide combined with iron) to rapidly oxidize organic molecules in water.

Bioremediation

MTBE is generally slower to biodegrade under natural conditions than other gasoline constituents. However, recent field studies have shown that under enhanced conditions (e.g., addition of oxygen, microbes, and/or nutrients to the soil and groundwater), MTBE can biodegrade more rapidly.

Flushing (Pump and Treat)

This technology consists of pumping contaminated groundwater to the surface and treating it using air stripping, activated carbon, or advanced oxidation. The high solubility and low soil adsorption of MTBE allows MTBE to be readily flushed from the aquifer. For treatment of drinking water, the most commonly used treatment techniques are air stripping, carbon adsorption, and advanced oxidation (oxidation of contaminants using appropriate combinations of ultraviolet light, chemical oxidants, and catalysts).

In addition to the established technologies discussed above, there are many other emerging technologies for the remediation and treatment of MTBE, including bioaugmentation, synthetic resin adsorbents, electron beam oxidation, and fluidized bed bioreactors. Phytoremediation has been used at sites with shallow groundwater conditions.

Health Effect Information

Breathing small amounts of MTBE for short periods may cause nose and throat irritation. There are no data available on the effects in humans of ingesting MTBE. Studies with rats and mice suggest that ingesting MTBE may cause gastrointestinal irritation, liver and kidney damage, and nervous system impacts.

There is no evidence that MTBE causes cancer in humans, although animal studies have found that breathing high levels of MTBE for long periods may cause kidney or liver cancer.

Low concentrations of MTBE may cause unpleasant taste and odor effects (similar to turpentine) in drinking water.

Key Resources

1. California State Water Resources Control Board-Drinking Water Division. *MTBE: Regulation and Drinking Water Monitoring Results, 2014.* *https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MTBE.html*
2. California State Water Resources Control Board. *A Compilation of Water Quality Goals, 17th Edition, (SWRCB, 2016)*. http://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/index.shtml
3. California Office of Environmental Health Hazard Assessment (OEHHA). 1999. March 1999. *Public Health Goal for Methyl Tertiary Butyl Ether (MTBE) in Drinking Water.* http://oehha.ca.gov/media/downloads/water/chemicals/phg/mtbef_0.pdf
4. National Environmental Methods Index (NEMI), *MTBE.* https://www.nemi.gov/methods/analyte_results/?media_name=&source=&instrumentation=&analyte_name=mtbe&category
5. US Environmental Protection Agency, 2016, Contaminated Site Clean-up Information MTBE – Overview: https://archive.epa.gov/mtbe/web/html/clean.html
6. US Environmental Protection Agency, 2016, Contaminants of Concern (COC) at Underground Storage Tank (UST) Sites. https://www.epa.gov/ust/contaminants-concern-coc-underground-storage-tank-ust-sites

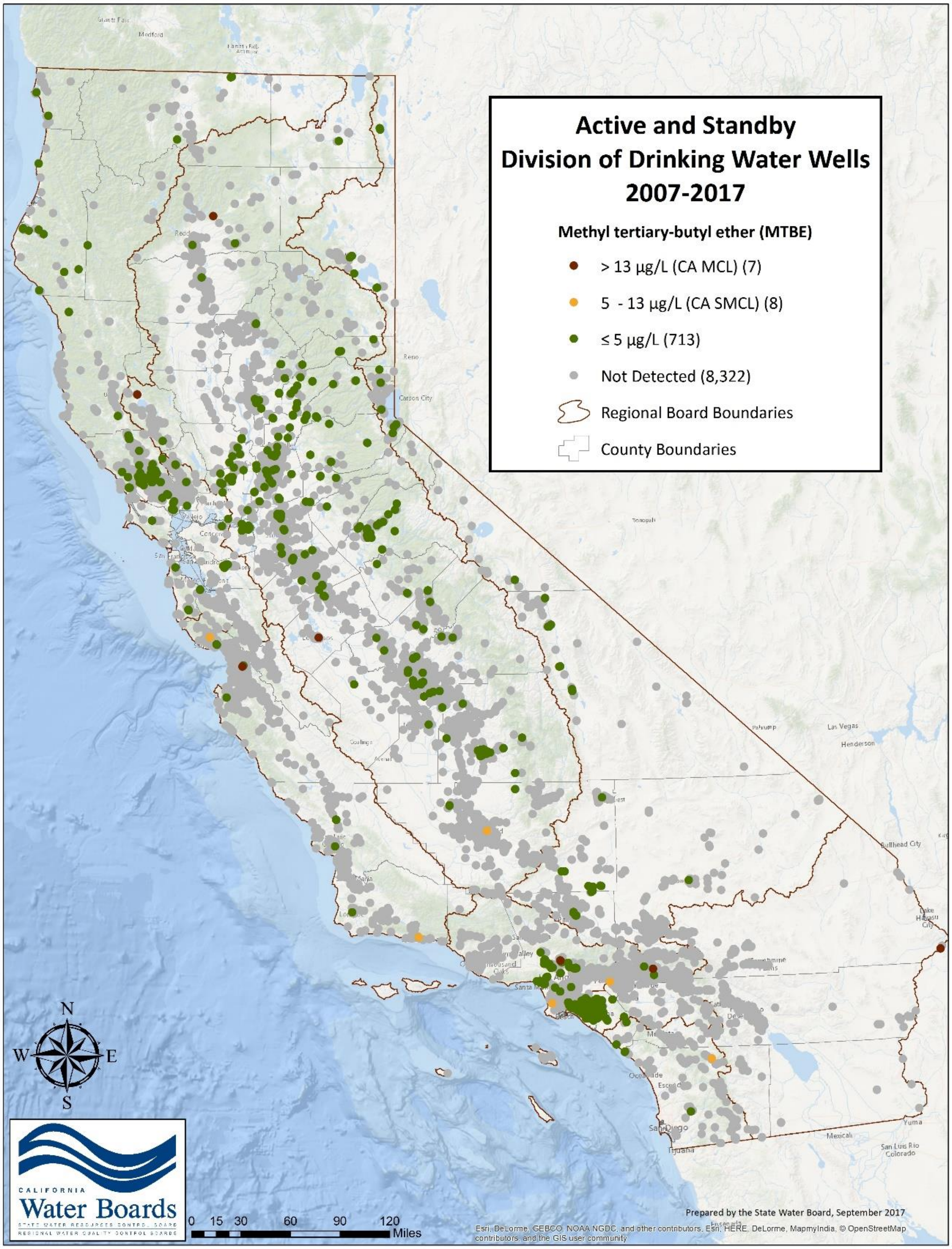


Figure 1. Active and standby public drinking water wells that had at least one detection of MTBE above the MCL, 7 wells, above the SMCL, 8 wells, and below the SMCL, 713 wells, for the period 2007-2017. (*Source: Public supply well data in* GAMA GIS*).*