Chapter 13:
MTBE

A chapter from:

Regulatory Determinations Support Document for Selected Contaminants from the Second Drinking Water Contaminant Candidate List (CCL 2)

EPA Report 815-R-08-012

Contents

Exhibits

Abbreviations

ADHS	Arizona Department of Health Services
AST	Above-Ground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
AWS	American Water System
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
BUST	Bureau of Underground Storage Tanks
CAA	Clean Air Act
California DHS	California Department of Health Services
CAS	Chemical Abstracts Service
CBG	Clean-Burning Gasoline
CCL 2	Second Contaminant Candidate List
Connecticut DPH	Connecticut Department of Public Health
CWS	Community Water System
CWSS	Community Water System Survey
DIPE	Di-isopropyl Ether
ETBE	Ethyl Tertiary Butyl Ether
EWG	Environmental Working Group
Florida DEP	Florida Environmental Protection
GIS	Geographic Information System
GW	Ground Water
Hawaii DOH	Hawaii Department of Health
HRL	Health Reference Level
Iowa DNR	Iowa Department of Natural Resources
LARWQCB	Los Angeles Regional Water Quality Control Board
LUST	Leaking Underground Storage Tank
Maine DEP	Maine Department of Environmental Protection
MCL	Maximum Contaminant Level
MDA	Michigan Department of Agriculture
MDE	Maryland Department of the Environment
MDEQ	Michigan Department of Environmental Quality
MRL	Minimum Reporting Level
MTBE	Methyl Tertiary Butyl Ether
NAWQA	National Water Quality Assessment
NDEP	Nevada Department of Environmental Protection
NEIWPCC	New England Interstate Water Pollution Control Commission
NESCAUM	Northeast States for Coordinated Air Use Management
New Jersey DEP	New Jersey Department of Environmental Protection
NHDES	New Hampshire Department of Environmental Services
NPDES	National Pollutant Discharge Elimination System
NTNCWS	Non-Transient Non-Community Water System

PHG	Public Health Goal
PWS	Public Water System
RFG	Reformulated Gasoline
RL	Reporting Limit
SCWC	Southern California Water Company
SRA	Sabine River Authority
STPUD	South Tahoe Public Utility District
SW	Surface Water
TAME	Tertiary Amyl Methyl Ether
TBA	Tertiary Butyl Alcohol
TRI	Toxics Release Inventory
UCMR 1	First Unregulated Contaminant Monitoring Regulation
USDOE	United States Department of Energy
USGS	United States Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
Washington DOE	Washington Department of Ecology

13 MTBE

13.1 Definition

Methyl tertiary butyl ether (MTBE) is a volatile organic compound (VOC) commonly used as a gasoline additive. MTBE is also known as methyl *t*-butyl ether, methyl tert butyl ether, and 2-methoxy-2-methylpropane. The Chemical Abstracts Service (CAS) registry number for MTBE is 1634-04-4. It does not have any common trade names.

13.1.1 Properties and Sources

MTBE is a colorless, flammable liquid with a strong, unpalatable odor similar to turpentine. It does not occur naturally in the environment. MTBE is synthesized from methanol, a compound derived from natural gas, and isobutylene or other petroleum refinery products (ATSDR, 1996). Chemically, it is very similar to other ethers such as ethyl tertiary butyl ether (ETBE) and tertiary amyl methyl ether (TAME) (USEPA, 2003a). However, because of its low production cost and good blending characteristics, MTBE is the most commonly used oxygenate added to gasoline to improve air quality (Squillace *et al.*, 1997). Like benzene, toluene, ethylbenzene, and xylenes (BTEX), MTBE is also used to increase octane in gasoline (Deeb *et al.*, 2000). Exhibit 14-1 lists some of MTBE's physical and chemical properties and provides a comparison to some of benzene's characteristics.

Exhibit 13-1: Physical and Chemical Properties of MTBE (and Comparison with Benzene)

Identification		
CAS number	1634-04-4	
Molecular Formula	CH_3-O-C(CH_3)$_3$	
Physical and Chemical Properties		
Boiling Point	55.2 °C [1]	
Melting Point	-109 °C [1]	
Molecular Weight	88.15 g/mol [1]	**Benzene**
Log K_{oc}	1.05 (estimated) [2] 2.89 (calculated) [3] 1.04-1.09[4]	1.8-1.99 [4] 1.5-2.16 [4]
Density	0.7405 g/cm^3 at 20 °C [1]	0.8787 g/cm^3 at 15 °C [10]
Log K_{ow}	1.24 [2] 1.20 [4]	2.13 [4] 1.56-2.15 [4]
Water Solubility	51,000 mg/L at 25 °C [5] 43,000 - 54,3000 mg/L [4]	1,780 mg/L [4]
Vapor Pressure	245 mm Hg at 25 °C [6] 245 - 256 mm Hg at 20 °C [4]	76 mm Hg at 25 °C [4] 95.19 mm Hg at 25 °C [4]
Henry's Law Constant	5.87×10^{-4} atm-m^3/mol at 25 °C [7] 0.018 (dimensionless) at 20 °C [4] 0.024 (dimensionless), predicted [8] 0.055 (dimensionless), from literature [8]	5.5×10^{-3} atm-m^3/mol at 25 °C [11] 0.22 (dimensionless) [4]
Freundlich Isotherm Constant (K)	218 (µg/g)(L/µg)$^{1/n}$ [9]	

[1] *Lide, 1994 (as cited in ATSDR, 1996)*

[2] *Gilbert and Calabrese, 1992 (as cited in ATSDR, 1996)*

[3] *USEPA, 1995a (as cited in ATSDR, 1996)*

[4] *Zogorski et al., 1997*

[5] *Bennett and Philip, 1928 (as cited in HSDB, 2004)*

[6] *Merck, 1989 (as cited in ATSDR, 1996)*

[7] *Hine and Mookerjee, 1975 (as cited in ATSDR, 1996)*

[8] *Speth et al., 2001*

[9] *Speth and Miltner, 1990 (as cited in Speth et al., 2001)*

[10] *Merck, 1989 (as cited in ATSDR, 1997)*

[11] *Mackay and Leinonen, 1975 (as cited in ATSDR, 1997)*

13.1.2 Environmental Fate and Behavior

MTBE has several properties that increase its persistence and mobility in the environment once released. Its Henry's Law constant and high vapor pressure predict volatilization from moist and dry soil surfaces (HSDB, 2004). However, its high water solubility and low Henry's Law dimensionless constant means it dissolves in water more readily rather than it volatilizes (Fiorenza and Rifai, 2003). MTBE is very mobile in soil, only sorbing weakly to soil particles. Benzene's K_{oc} is almost an order of magnitude higher than MTBE's, which indicates that MTBE adsorbs to soil less than benzene.

MTBE primarily reaches ground water via infiltration of gasoline into water, although contamination also occurs via vapor-phase diffusion (Dakhel *et al.*, 2003). Once dissolved in ground water, it generally resists degradation and moves at nearly the same velocity as ground water. Because of its properties, with enough time and distance MTBE would be expected at the leading edge of a gasoline plume, or completely separated from the rest of the plume if the contaminant source were eliminated (Happel *et al.*, 1998).

In 2003 the New England Interstate Water Pollution Control Commission (NEIWPCC) surveyed the 50 States about MTBE contamination at leaking underground storage tank (LUST) sites. Twelve States estimate average MTBE plume lengths of up to 250 feet; 10 States estimate average plumes of 250 to 500 feet, and 2 States (Maine and New York) estimate average MTBE plumes greater than 500 feet. Twenty-six States estimate maximum MTBE-contaminated plumes between 1,000 and 5,000 feet, while 16 States do not know the maximum MTBE plume size (NEIWPCC, 2003).

Other compounds routinely tracked in gasoline spills (e.g., BTEX) are less water-soluble, more volatile (Zanardini *et al.*, 2002), and slightly more retarded by absorption onto soil solids (Squillace *et al.*, 1997). For instance, while the solubility of MTBE in water is about 50,000 mg/L, that of benzene is less than 2,000 mg/L (see Exhibit 13-1). BTEX plumes readily biodegrade, with half-lives ranging from 1 week to 2 years (Howard *et al.*, 1991 as cited in Squillace *et al.*, 1997). Frequently, BTEX plumes stabilize and recede less than 260 feet from the release source (Mace *et al.*, 1997 and Rice *et al.*, 1995, both as cited in Stocking *et al.,* 2000).

Older studies found that MTBE resists degradation under anaerobic methanogenic and sulfate-reducing conditions and anaerobic conditions in landfill-affected aquifer material, soils, and sludges (Squillace *et al.*, 1996). However, MTBE can be degraded in anaerobic conditions by naturally occurring microorganisms if nitrate (Bradley *et al.*, 2001a) or Fe(III) and humic substances (Finneran and Lovley, 2001) are available in the environment. The few anaerobic degradation studies report long incubation times (Zanardini *et al.*, 2002). The British Environmental Agency (2002 as cited in Chisala *et al.*, 2004) concludes from a literature search that anaerobic degradation rates range from 0.0035/day - 0.00035/day (half-lives of 0.54 years to 5.4 years) at hydrocarbon-contaminated sites. The rate of degradation can vary significantly from site to site, and in some cases no biodegradation at all is observed (British Environmental Agency, 2002 as cited in Chisala *et al.*, 2004).

Aerobic biodegradation can occur in the laboratory with MTBE supplied as the sole carbon and energy source (Mo *et al.*, 1997 and Bruns *et al.*, 2001, both as cited in Zanardini *et* *al.*, 2002), with a low microbial growth rate (Steffan *et al.*, 1997, as cited in Zanardini *et al.*, 2002). Other studies demonstrate co-metabolism of MTBE (Garnier *et al.*, 1999 as cited in Stocking *et al.*, 2000; Hardison *et al.*, 1997; Steffan *et al.*, 1997 as cited in Zanardini *et al.*, 2002). One column study noted that MTBE did not degrade in the presence of BTEX compounds (Church *et al.*, 1999, as cited by Deeb *et al.*, 2000). However, a field study noted that MTBE degraded simultaneously with benzene and toluene when dissolved oxygen increased from 2 mg/L or less up to 6-14 mg/L (Landmeyer *et al.*, 2001). MTBE can biodegrade to carbon dioxide, with intermediate products of tert-butyl alcohol and formaldehyde. Salanitro *et al.* (1998, as cited in Zanardini *et al.*, 2002) note that the toxicity of formaldehyde might limit microbial growth rate. In sediments, the amount of MTBE degradation increased with grain size, perhaps because oxygen diffusion is higher among larger grains (Bradley *et al.*, 2001b). Increasing dissolved oxygen stimulates MTBE degradation in field studies (Salanitro *et al.*, 1999 and Javanmardian and Glasser, 1997, both as cited in Deeb *et al.*, 2000; Wilson *et al.*, 2002).

Ground water containing MTBE commonly has low dissolved oxygen because preferential biodegradation of other fuel components consumes oxygen. Slow field degradation of MTBE may reflect the rate of re-aeration of the groundwater (Moyer and Kostecki, 2003, as cited in Chisala *et al.*, 2004). In field experiments, degradation rates of 0 - 0.007 per day (no degradation to half-lives as short as 99 days) have been reported (Borden *et al.*, 1997, Schirmer *et al.*, 1999, Moeri *et al.*, 2001, all as cited in Chisala *et al.*, 2004). In the laboratory, Schirmer *et al.* (2003, as cited in Chisala *et al.*, 2004) report aerobic rate constants that range from 0.07 to 0.001 per day (equivalent to half-lives of 10 to 693 days). Stocking *et al.* (2000) report aerobic biodegradation half-lives of less than a day to 29 days in the laboratory and 1.6 to 1.9 years in field studies. Several reports also discuss enhanced biodegradation (i.e., Stocking *et al.*, 2000; USEPA, 2001a; Fiorenza and Rifai, 2003; Fayolle *et al.*, 2001).

According to the Blue Ribbon Panel on Oxygenates in Gasoline (1999), limited data suggest that the half-life of MTBE is an order of magnitude longer than the half-life of benzene. Based on this estimate, Johnson *et al.* (2000) conclude that the half-life for MTBE from leaking underground fuel tanks would be at least 2 years. On the other hand, Borden *et al.* (1997) note that at a Sampson County, North Carolina underground storage tank site MTBE degraded from 10 ± 4.6 mg/L at the source to 0.3 ± 0.4 mg/L at points 88 meters downgradient, with little or no further degradation at points beyond. Laboratory experiments using soil from the same site confirmed that under aerobic conditions MTBE degraded from 2.1 mg/L to between 1.0 and 1.5 mg/L within 93 days and then remained relatively constant.

MTBE volatilizes from surface waters. Half-lives in rivers and streams can be greater than one day (Squillace *et al.*, 1996). Factors that affect the volatilization rate of MTBE in surface water include water velocity, water depth, water temperature, wind speed, and air temperature. In deep, slow-moving flows, MTBE volatilizes at rates similar to those of the BTEX compounds. In shallow, fast-moving flows, MTBE volatilizes more slowly than benzene (Squillace *et al.*, 1996). The USEPA's 1998 Research Needs document (USEPA, 1998a) notes that progress is being made on modeling the fate of MTBE in soils, ground water, and surface water.

If released to air, vapor-phase MTBE will be degraded in the atmosphere by reaction with nitrate radicals and photochemically-produced hydroxyl radicals; half-lives for these reactions in air are estimated to be 50 and 5.5 days, respectively. Direct photolysis is not expected to be an important removal process (HSDB, 2004). According to Squillace *et al.* (1997), the half-life of atmospheric MTBE can be as short as 3 days. Some vapor-phase MTBE will partition to atmospheric water, including precipitation. Squillace *et al.* (1997) observe that atmospheric MTBE can contribute as much as 3 µg/L MTBE to urban precipitation, but that precipitation does not significantly reduce the concentration of MTBE in air.

13.2 Health Effects

In 1997, EPA issued a drinking water advisory of 20 to 40 ppb based on taste and odor (USEPA, 1997). EPA is currently revising its health risk assessment for MTBE. The status of the MTBE health risk assessment can be found on the IRIS Chemical Assessment Tracking System at the following website: http://cfpub.epa.gov/iristrac/index.cfm (USEPA, 2006a).

13.3 Occurrence and Exposure

13.3.1 Use and Environmental Release

MTBE Production and Consumption

MTBE is primarily used as an additive in gasoline to enhance gasoline octane and/or to increase the oxygen content of gasoline. Limited amounts are used medically to dissolve gallstones and as a laboratory solvent for designated EPA analytical methods (ATSDR, 1996). The Agency for Toxic Substances and Disease Registry (ATSDR) reports a dramatic increase in MTBE production during the 1980s (ATSDR, 1996). According to the U.S. Department of Energy (USDOE, 2000), MTBE demand increased from 83,000 barrels per day in 1990 to 161,000 barrels per day in 1994 and 269,000 or more barrels per day in 1997. (One barrel is equivalent to 42 U.S. gallons.) Since 1993, MTBE has been the second most widely manufactured organic chemical in the United States (USEPA, 1998b). According to available estimates, annual MTBE production peaked in 1999 (see Exhibit 13-2). Figures compiled by USDOE (2003) indicate that domestic consumption of MTBE also peaked in 1999.

Exhibit 13-2: MTBE Production in the United States

Year	Production in Barrels[1]	Production in Liters
1980	1.65 million barrels[2]	0.26 billion L[5]
1995	68.0 million barrels[5]	10.8 billion L[3]
1998	75.0 million barrels[2,4]	11.9 billion L[5]
1999	78.9 million barrels[4]	12.5 billion L[5]
2000	77.5 million barrels[4]	12.3 billion L[5]
2001	77.5 million barrels[4]	12.3 billion L[5]
2002	74.6 million barrels[4]	11.9 billion L[5]
2003	61.2 million barrels[4]	9.7 billion L[5]
2004	48.1 million barrels[4]	7.6 billion L[5]

[1] One barrel = 42 U.S. gallons

[2] Grady and Casey, 2001

[3] Zogorski *et al.*, 1997 (converted from 8 billion kg using a ratio of 0.74 kg per liter)

[4] USDOE, 2005

[5] Calculated (1 barrel = approximately 159 liters)

Use of MTBE as an octane-enhancing replacement for lead additives in gasoline began in 1979 (USEPA, 1998b). The first standards for a gradual phase-out of lead were issued by EPA in 1973, and the lead ban was complete in 1995 (USEPA, 2005a). Today, regular unleaded gasoline generally contains approximately 3 to 8 percent MTBE (Maine, 1998). MTBE has been used to increase octane throughout the U.S. (Landmeyer *et al.*, 2001). Other octane enhancers widely used in gasoline include ethanol, alkylates, and aromatic compounds. According to one U.S. Department of Energy report, in 1997 approximately 12,000 barrels of MTBE per day, or close to 5 percent of total MTBE consumption, went toward octane enhancement in conventional gasoline (Lidderdale and Bohn, 1999; 65 FR 16097). A subsequent report suggests that the amount of MTBE used to raise octane in conventional gasoline has varied significantly from year to year, rising from negligible amounts in 1995 to approximately 46,500 gallons, or 16 percent of total MTBE consumption, in 2001 (Lidderdale, 2003).

In the 1990s, MTBE use increased due to two programs established by the 1990 Amendments to the Clean Air Act (CAA) that require oxygenated gasoline. In 1992 EPA implemented the Wintertime Oxygenated Fuel (wintertime oxyfuel) program for metropolitan areas with elevated levels of carbon monoxide. About 4 percent of the nation's gasoline is oxyfuel. The oxyfuel program requires gasoline to have an oxygen content of 2.7 percent by weight (USEPA, 1998b). Although ethanol is the most common oxygenate used to meet this requirement (7.3 percent by volume), MTBE is also sometimes used at concentrations of up to 15 percent by volume (USEPA, 1998b; 65 FR 16097).

In 1995 EPA established the Federal Reformulated Gasoline (RFG) program, which requires gasoline used in the nation‘s most polluted metropolitan areas to contain 2 percent oxygen by weight. In 1998 this requirement applied to about 30 percent of the nation’s gasoline. The requirement can be met with 11 percent MTBE or 5.4 percent ethanol (by volume) (USEPA, 1998b). MTBE is the primary oxygenate in over 87 percent of RFG, while ethanol is used in approximately 12 percent (65 FR 16097). The “non-attainment areas” required to participate in the program are metropolitan areas where ozone levels are too high. Other areas of the country voluntarily “opt in” to the RFG program to improve air quality. The total number of areas participating in the RFG program may change from year to year, depending on “opt-ins” (USEPA, 2000a). A list of participating and formerly participating areas is available on the Internet (USEPA, 2005b). There is considerable variation in the extent to which participating areas rely on MTBE. Some areas are in States or localities that have implemented MTBE bans (so other oxygenates are used). In Chicago, for example, MTBE was banned in 2000, and four years later a Statewide ban went into effect in Illinois (Lidderdale, 2003).

Information on the geographic distribution of MTBE consumption (see Exhibit 13-3) is available from Lidderdale (2003). In 2001, approximately 33 percent of the MTBE used to comply with Clean Air Act requirements was consumed in California. At that time, California had State emission standards that were stricter than the federal program, but had not yet banned MTBE. Other States consuming large amounts of MTBE in RFG and Oxygenated Fuel in 2001 included Texas (13 percent of U.S. consumption), New Jersey (11 percent), New York (9 percent), and Massachusetts (7 percent). The twelve Northeastern and Mid-Atlantic States studied in depth by the United States Geographical Survey (USGS) (Grady and Casey, 2001--see study description in Section 13.3.3, below) accounted for about 50 percent of the MTBE used to comply with Clean Air Act requirements in 2001.

Exhibit 13-3: Consumption of MTBE in RFG and Oxygenated Fuel in 2001

State	MTBE use (in 1,000 barrels/day)
Arizona	3.6
California	79.7
Connecticut	9.4
Delaware	3.0
District of Columbia	0.7
Kentucky	2.2
Maryland	12.6
Massachusetts	16.8
Montana	3.2
New Hampshire	3.2
New Jersey	27.1
New York	21.1
Pennsylvania	9.7
Rhode Island	2.6
Texas	30.5
Virginia	13.6

Note: These numbers do not include MTBE used for octane enhancement in conventional gasoline. MTBE is one of several oxygenates used to meet federal RFG and Oxygenated Fuel requirements.

Source: Lidderdale, 2003

The Energy Policy Act of 2005 (also known as the "Energy Bill," or H.R.6), signed on August 8, 2005, amended the CAA. Some of the amendments are expected to reduce the amount of MTBE used in gasoline. In particular, Section 211(k)(2) of the CAA no longer contains minimum oxygen content requirements for RFG (see 71 FR 8965 and 71 FR 26691). However, RFG must maintain the pollutant emissions reductions required by Section 211(k)(1). Unlike earlier House drafts, the bill does not give "safe harbor" to protect manufacturers of gasoline containing MTBE from defective product liability suits filed because of drinking water contamination (McCarthy and Tiemann, 2005). In response, at least one major U.S. oil refiner has announced it would cease MTBE production altogether (Vaughan, 2005). In addition, at least 25 states have passed laws banning or limiting the use of MTBE, with effective dates ranging from 2000 to 2009 (see Exhibit 13-22, below). The Department of Energy projects that MTBE use in gasoline will be entirely phased out in the United States by the end of 2008 (USDOE, 2006).

MTBE Releases to the Environment

MTBE's widespread use as a gasoline additive provides a number of opportunities for release of MTBE to the nation's ground and surface waters. According to the Alliance for Proper Gasoline Handling (1999), each year approximately 9 million gallons of gasoline are released to the environment in the United States from leaks and spills. Leakage from gasoline storage and distribution systems is a major source of both aboveground and underground contamination.

Underground storage tanks (USTs) and other gasoline storage and distribution facilities are responsible for releasing large volumes of gasoline into the environment. In 1984, the State of Maine estimated national releases from leaking USTs to be 11 million pounds (Feliciano, 1984 as cited in ATSDR, 1995). More recent estimates are not available. Releases cause high concentrations of MTBE in soil and ground water relatively near the contaminant release (or "source") area, and in the MTBE-containing plumes that extend outward from the source. There are approximately 760,000 regulated gasoline USTs in the U.S. In addition, there are approximately 3 to 4 million underground fuel storage tanks (*e.g.*, smaller farm and residential gasoline storage tanks and home heating oil tanks) exempt from Federal regulations (65 FR 16100). Some States regulate heating fuel tanks. A 2000 survey of State UST program offices by the NEIWPCC, funded by EPA's Office of Underground Storage Tanks, indicates that 35 States find MTBE at least 20 percent of the time they sample for it in ground water at gasoline-contaminated sites, and 24 States find MTBE at least 60 percent of the time, out of 46 States providing responses to that question (NEIWPCC, 2000). Results from a follow-up survey in 2003 are comparable (NEIWPCC, 2003). Forty-one States indicated that they request analysis for MTBE in ground water 80 to 100 percent of the time at LUST sites for at least one type of fuel (gasoline, heating oil, jet fuel, etc.) (NEIWPCC, 2003). In California, 78 percent of LUST sites where gasoline has impacted ground water are positive for MTBE (Happel *et al.*, 1999). See Exhibit 13-4 for a comparison of the number of States reporting contamination (at any concentration) at public and private drinking water wells in 2000 and 2003.

Exhibit 13-4: MTBE Contamination Reported by States

	2000 Survey		2003 Survey	
	private wells	**public wells**	**private wells**	**public wells**
Number of States reporting no detections at wells	3	5	3	3
Number of States reporting detections at between 1 and 50 wells	14	21	12	19
Number of States reporting detections at more than 50 wells	9	6	17	7
State reporting the highest number of contaminated wells	New York (866 wells)	Connecticut (255 wells)	New Hampshire (over 30,000 wells)	New Hampshire (350 wells)
Number of States that "don't know"	16	16	13	13
Total number of responding States	42	48	44	42

Note: In the 2000 survey, Puerto Rico was included among responding "States." In the 2003 survey, Idaho is double-counted, as both "none" and "between 1 and 10 private wells."

Sources: NEIWPCC, 2000 (question 16a); NEIWPCC, 2003 (question 27)

In 2000, twenty-five State UST program offices reported finding at least one case of soil or ground water MTBE contamination even where no release was documented (NEIWPCC, 2000). In 2003, twenty-three offices reported finding contamination that could not be attributable to USTs; suspected sources included above-ground storage tanks (ASTs), auto accidents, auto maintenance, lawn mowers, and improper handling and storage (NEIWPCC, 2003).

EPA requirements for USTs were phased in between December 1988 and December 1998 (USEPA, 1995b). Vapor recovery systems capture vapors released during the filling of the UST (Stage I) or the fueling of vehicles (Stage II) and return them to the vessel the liquid fuel came from (i.e., the tank truck or UST). Stage II vapor recovery systems are required in moderate or worse ozone non-attainment areas (USEPA, 2004a). Some vapor recovery systems, called "assisted" or "vacuum-assist" systems, use vacuum pumps to capture fumes from the vehicle's gasoline tank. EPA estimates that by September 2004, approximately 64 percent of active UST systems were in significant operational compliance with all leak detection and release prevention requirements (USEPA, 2005c). However, according to recent studies, summarized below, even fully compliant USTs can be sources of MTBE contamination. Recent research has focused on gasoline USTs and the role of vapor releases. With a pure-phase vapor pressure of 251 mg Hg, MTBE volatilizes more readily than BTEX compounds and ethanol, whose pure-phase vapor pressures are 2.5 to 31 times lower. The partial pressure of a constituent compound of gasoline is equal to its pure-phase vapor pressure multiplied by its fractional content in the gasoline. When MTBE is used in gasoline, it is often present at concentrations higher than the BTEX compounds, which makes it volatilize even more readily (Day *et al.*, 2001; API, 2000).

Levine-Fricke (1999) conducted a preliminary investigation of in-compliance UST facilities in Santa Clara, California, and found evidence of MTBE ground water contamination at 13 of 27 facilities. MTBE concentrations ranged from 1 µg/L to 200,000 µg/L; five facilities had concentrations above 1,000 µg/L. The study found a statistically significant correlation between facilities with assisted vapor recovery systems and facilities with MTBE contamination. A follow-up study by Tulloch (2000) evaluated 16 active UST facilities in Santa Clara known to have high concentrations of MTBE in ground water to determine the likely source and cause of contamination. The investigators found that in 13 of the 16 cases the contamination was likely due to undetected releases from the current UST system. In two cases the points of release were positively identified. In other cases no point of release could be confirmed, but inspection revealed deficiencies in tanks, sumps, lined trenches, and/or piping that could be responsible. Nine of the USTs had records of monitoring problems or violations. The investigators concluded that both single-walled and double-walled systems can fail, and that increased vigilance is necessary.

In a statewide California study, Young and Golding (2002) used a sensitive commercial leak detection method to monitor vapors at 182 USTs at 55 randomly selected facilities. Releases (as determined by the presence of a tracer chemical) were observed at 61 percent of the USTs and at 80 percent of the facilities. One release was a liquid phase release from a single-walled UST. The remaining cases were vapor-phase releases, and double-walled tanks appeared to be no better at preventing releases than single-walled tanks. The largest release was a vapor release of 0.4 gallons per day. Most releases (including the liquid release) were less than 0.04 gallons per day. It is likely that none of the releases observed in this study would be detected by conventional leak detection methods, since the greatest sensitivity required of leak detection methods under current regulations is 0.1 gallons per hour (or 2.4 gallons per day). Components of the tank top were the most likely source of tracer releases. According to Lynn (2004), Vermont remedial UST investigations confirm that vapor could escape from many tank-top components, including vent lines, ancillary risers, caps, in-tank monitor wiring fittings, and Stage I vapor-recovery poppets.

In an investigation of five USTs, the New Hampshire Department of Environmental Services (NHDES) (Lynn, 2004) determined that both USTs with vacuum-assist vapor recovery systems and those without vacuum-assist recovery systems had positive pressure. Further investigation of two vacuum-assist USTs with vapor releases showed that pressure decreased at night, suggesting that vapors were escaping the tank system. DES confirmed this using a technology to manipulate tank pressure and a tracer chemical. When pressure in the tank system was reduced, the amount of vapors released into the soil diminished.

Transport provides additional opportunities for potential MTBE contamination. Pipelines are used to transport billions of gallons of crude oil and refined products annually in the United States. Gasoline may travel through thousands of miles of pipelines, or be transported by truck to terminals and bulk stations. From there, it may be transported to fleet storage facilities, retail outlets, or above- or underground tank facilities by truck. Spills and accidental releases can occur at any point in these processes. Residual gasoline in transport conduits may also contaminate different types of fuels that are transported through the same conduits at other times, which may explain the presence of MTBE in home heating oil, jet fuel, and diesel fuel (65 FR 16100). The Michigan Department of Environmental Quality (MDEQ) surmised that gasoline containing less than 2.2 percent MTBE by volume results from mixing in pipeline distribution (MDEQ, 2000 as cited in Delzer and Ivahnenko, 2003a).

Releases from automobile accidents, tank truck spills, improper consumer disposal, and spills during fueling operations have been identified as sources of contamination of drinking water wells. Gasoline-powered watercrafts contribute to MTBE contamination of lakes and reservoirs. For example, Shasta Lake, California, reached 9-88 µg/L MTBE over the Labor Day weekend in 1996. Pre-1998 outboard and personal watercraft two-stroke engines can discharge up to 30 percent of gasoline as unburned hydrocarbons. Stormwater runoff and air deposition can also play a role in low-level MTBE contamination of water resources (65 FR 16096). Zogorski *et al.* (1997) report that ambient air concentrations of MTBE in a number of U.S. cities range from 0.13 to 4.6 parts per billion by volume.

When used as a gasoline additive, MTBE concentrations are high, starting at 20,000,000 parts per billion (ppb) for 2 percent volume to improve octane. Exhibit 13-5 compares some MTBE concentrations at the high end of the ranges found in various media.

Exhibit 13-5: Examples of High MTBE Concentrations in Various Media

Where Found	**MTBE concentration**	**Comments**
Oxygenated Gasoline[1]	110,000,000 ppb - 150,000,000 ppb	typically 11% to 15% by volume (API, 2000)
Conventional Gasoline[1]	20,000,000 ppb - 30,000,000 ppb	typically 2% to 3% by volume, when added for octane enhancement (API, 2000)
Ground Water	9,132,000 µg/L	measured at the core of a LUST plume in Texas (NEIWPCC, 2003)
Ground Water	1,000,000 µg/L	plumes with concentrations higher than this are rarely seen higher in the field, according to API (2000)
Ground Water	200,000 µg/L	measured near a gasoline spill (Zogorski *et al.*, 1997)
Ground Water	200,000 µg/L	measured near an in-compliance UST (Levine-Fricke, 1999)
Ground Water	100,000 µg/L	20 States report finding concentrations higher than this at the center of LUST plumes (NEIWPCC, 2003)
Ground Water	64,000 µg/L	measured near an in-compliance UST (Shively, 2004)
Private Well Water	6,500 µg/L	measured near an auto accident (65 FR 16099)

[1] As presented here, MTBE concentrations in gasoline are not converted from parts per billion (ppb) to micrograms per liter (µg/L). In water, 1 ppb = 1 µg/L (because 1 gram is the mass of 1 cubic centimeter of water and 1,000 cubic centimeters = 1 liter), but in gasoline, a less dense fluid, this equivalency does not hold. Nevertheless, if MTBE concentrations in gasoline were converted to µg/L, the results would be on the same order of magnitude as the ppb values presented here.

MTBE is listed as a Toxics Release Inventory (TRI) chemical. For a discussion of the nature and limitations of TRI data, see Chapter 2. TRI data for MTBE (see Exhibit 13-6) are reported for the years 1988 to 2003. On-site air emissions dominate total releases; these peaked in 1998 at over four million pounds. Annual releases by other routes fluctuated between hundreds of pounds and hundreds of thousands of pounds during the period on record. Releases of MTBE were reported from all States except North Dakota and Vermont (USEPA, 2006b).

Exhibit 13-6: Environmental releases (in pounds) of MTBE in the United States, 1988-2003

Year	On-Site Releases				Off-Site Releases	Total On- & Off-site Releases
	Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1988	2,588,247	21,499	14,400	370	4,602	2,629,118
1989	3,223,014	37,440	19,300	1,290	4,623	3,285,667
1990	2,976,906	42,668	112,400	1,501	7,696	3,141,171
1991	3,270,121	30,903	81,690	2,903	6,348	3,391,965
1992	3,139,291	102,869	68,445	288	15,329	3,326,222
1993	3,780,143	94,261	9,406	409	134,331	4,018,550
1994	3,188,678	92,140	29,645	2,226	117,854	3,430,543
1995	3,300,759	78,555	15,238	3,800	47,841	3,446,193
1996	3,098,099	117,760	179,624	26,569	243,430	3,665,482
1997	2,658,874	162,116	16,720	124	119,851	2,957,685
1998	4,225,523	66,347	51,707	3,209	265,679	4,612,465
1999	3,779,740	121,186	20,677	6,606	261,297	4,189,506
2000	3,462,233	123,536	33,336	10,556	34,756	3,664,417
2001	3,064,142	67,191	49,677	4,255	35,901	3,221,165
2002	2,957,648	68,693	79,089	1,527	80,570	3,187,527
2003	2,432,275	60,617	83,905	52,241	142,223	2,771,261

Source: USEPA, 2006b

Although MTBE production has been declining since 1999 and the use of MTBE in gasoline is expected to cease by 2008 (see above), contamination of drinking water wells is likely to continue because of existing soil and ground water contamination and continued MTBE-contaminated plume movement. Johnson *et al*. (2000) place the time scale of the threat of contamination in the range of tens to hundreds of years, based on the expected lifetime of LUSTs, the concentration of MTBE in such sources, estimated rates of attenuation in ground water, and the potential distance plumes might travel before reaching community water systems (CWSs).

13.3.2 Ambient Water Occurrence

Ambient waters are lakes, rivers, and aquifers that serve as sources of drinking water. Data on the occurrence of MTBE in ambient surface and ground water are available from the National Water Quality Assessment (NAWQA) program of the USGS. For details on this program, see the discussion in Chapter 2. NAWQA data have been analyzed independently by USGS and EPA. USGS has also collected data on MTBE occurrence in a review of highway and urban runoff studies. For additional perspective, State studies are also summarized in this section.

USGS NAWQA VOC National Synthesis

Random and Focused VOC Surveys and Literature Review

In collaboration with the Metropolitan Water District of Southern California and the Oregon Health & Science University, and with funding from the American Water Works Research Foundation, USGS recently conducted an assessment of the occurrence of MTBE and other VOCs in the nation's source waters. The assessment included a random survey of VOC occurrence in ground and surface water resources used by geographically representative CWSs in different size categories (Grady, 2003) and a focused survey of VOC occurrence patterns, including seasonal variability, in source waters considered particularly susceptible to MTBE contamination (Delzer and Ivahnenko, 2003b). Analytes included MTBE, three other ether oxygenates used in gasoline, and 62 additional VOCs. The reporting limit for MTBE was 0.2 µg/L (Ivahnenko *et al.*, 2001). The effort, which relied on data from NAWQA study units and others sources, was the culmination of USGS recently completed national VOC sampling program (or VOC National Synthesis).

The random survey sampled MTBE occurrence in ground and surface water sources used by 954 geographically representative CWSs in different size categories (Grady, 2003). Following a quality control review, 934 of the 954 samples were used to determine MTBE occurrence. At the reporting limit of 0.2 µg/L (25 times lower than the First Unregulated Contaminant Monitoring Regulation [UCMR 1] minimum reporting level), the random survey of source waters found MTBE in 8.7 % of the samples (5.4% of ground water samples and 14% of surface water samples). Among detections, the median concentrations in ground water, reservoirs, and rivers were 0.71 µg/L, 0.67 µg/L, and 0.32 µg/L, respectively (Grady, 2003). Only 3 samples (0.3%) had concentrations that exceeded 5 µg/L. These were from a surface water site in Texas (6.12 µg/L), a ground water site in Florida (6.31 µg/L), and a surface water site in California (19.5 µg/L) (USGS, 2003). Grady (2003) provides detection statistics for five different size categories. Aggregating these categories, it can be calculated that source waters of systems serving over 10,000 people had a combined detection frequency of 14.4%, while source waters of systems serving 10,000 people or fewer had a combined detection frequency of 4.2%. MTBE detections were five times more frequent in areas with high MTBE use than in areas with low or no MTBE use.

The focused survey investigated 134 CWS source waters (56 surface and 78 ground water) between 1999 and 2001 (Delzer and Ivahnenko, 2003b). Included were 57 source waters known to contain MTBE (including source waters found to have MTBE levels above 0.5 µg/L in the random survey), plus 77 source waters thought likely to be contaminated with MTBE, usually on the basis of high population density and high current or historical rates of MTBE use in gasoline. Each of 78 groundwater sites was sampled twice during a one-year period; 39 reservoir and lake sites were each sampled quarterly for one year, and 17 stream sites were each sampled eight times per year for one year. At the reporting limit of 0.2 µg/L, MTBE detections were found in 55.5% of sites (60.0% of ground water sites and 49.1% of surface water sites) (Delzer and Ivahnenko, 2003b). In ground water, the highest MTBE concentration was either 924 µg/L (as listed in Table D-1 of the published report) or 926 µg/L (according to the focused study data made available to the public in spreadsheet form) (Delzer and Ivahnenko, 2003b; USGS, 2003). Seventeen groundwater systems had MTBE detections that exceeded 5 µg/L, and seven of these systems had detections greater than 20 µg/L. The highest MTBE concentration in surface water was 14 µg/L. Four surface water systems had detections that exceeded 5 µg/L (USGS, 2003). Although the presence of gasoline oxygenates as a class varied seasonally in lakes and reservoirs, a phenomenon attributed by the study authors to increased use of motorized watercraft during the spring and summer months, no seasonal MTBE occurrence patterns were detected in any type of source water (Delzer and Ivahnenko, 2003b).

Before assessing MTBE in the nation's drinking water supplies, USGS conducted a literature review (Delzer and Ivahnenko, 2003a). Of greatest interest here (since most other studies in the literature review are discussed elsewhere in this chapter) is a compilation of results from individual States. Thirteen States conducted their own assessments of MTBE occurrence, primarily in source water. The State reports ranged from full inventories of CWS drinking water and selected private residential wells to results of contaminated domestic wells and voluntary sampling of source waters (see Exhibit 13-7). The States reported maximum MTBE concentrations of 8.39 µg/L in Alabama, 610 µg/L in California, 110 µg/L in Connecticut, 166 µg/L in Florida, 63 µg/L in Iowa, 1,250 µg/L in Kansas, 30.2 µg/L in New Jersey, and 1,700 µg/L in Wisconsin. Illinois, Maine, Maryland, Michigan, and Missouri also submitted data, but not enough to determine a maximum concentration. USGS noted that study findings from the various states could not be directly compared or used to estimate national exposures, given the different reporting levels, sampling frequencies, and sources (public source water, private wells, etc.).

Exhibit 13-7: Statewide Assessments of MTBE

State Survey Summary	Reporting Limit (RL)	Detection Frequency	Median Detected Concentration	Maximum Detected Concentration
Alabama: complete 2000 survey of 575 PWSs. Sampling at 1,053 sources (87 surface water sources, 27 springs, 939 wells)	0.5 - 2.0 µg/L	wells: 0.53% springs: 0% surface water sources: 0%	wells: NA springs: NA surface water sources: NA	wells: 8.4 µg/L springs: NA surface water sources: NA
California: partial survey of PWS source waters, covering 105 of 245 surface water sources (3,000 samples) and 2,988 of 13,919 PWS wells in 1996-1997; supplemented by mixed surface and ground water info from DHS database (50,748 samples collected between 1989 and 2001)	NA DHS database: NA	surface water sources: 46.7% wells: 1.2% DHS database: 1.1%	surface water sources: NA wells: NA DHS database: 3.6 µg/L	surface water sources: > 14 µg/L (26%) wells: NA DHS database: 610 µg/L
Connecticut: 1999 annual report on organics testing at PWSs (total number of PWSs not reported)	0.5 - 2.0 µg/L	NA (detected in 57 sources waters in 40 towns)	2.7 µg/L	110 µg/L
Florida: 8,739 samples collected from 1,692 public water supplies since early 1990s.	NA	4.9% of samples, 1.2% of PWSs (89% of the detects were from two PWSs)	1.4 µg/L	166 µg/L

State Survey Summary	Reporting Limit (RL)	Detection Frequency	Median Detected Concentration	Maximum Detected Concentration
Illinois: monitoring since 1994 at approximately 80% of the State's 1,200 CWSs, most of which (92%) utilize ground water	0.5 - 1.0 µg/L	2.7% of active systems, plus three systems that abandoned wells following MTBE contamination	NA	NA (IL states that most of the concentrations were unlikely to cause adverse health effects)
Iowa: 530 samples collected from 235 PWS wells in "vulnerable bedrock regions" in 1999; plus sampling of drinking water supplies in several cities since the 1990s	bedrock project: 15 µg/L cities: NA	bedrock project: 8 sample detections < 15 µg/L cities: NA	bedrock project: < 15 µg/L cities: NA	bedrock project: < 15 µg/L cities: 63 µg/L in Alvord's water supply before well abandoned
Kansas: 27,935 samples from 1,122 PWS wells, collected 1996 - 2000	NA	1.6% of wells	NA	1,250 µg/L
Maine: survey of 793 of 830 public water supplies and 951 private household water supplies in 1998	0.1 µg/L	public supplies: 15.8% (6% had concentrations in the range of 1-35 µg/L) private supplies: 15.8%; (6.6% had concentrations in the range of 1-35 µg/L)	public supplies: NA private supplies: NA	public supplies: < 35 µg/L private supplies: > 35 µg/L (1.1% of supplies)
Maryland: 1,084 PWSs surveyed since 1995; data also collected on private wells contaminated by LUSTs	0.5 µg/L	PWSs: 7.8% private wells: NA (270 wells with detections out of an unspecified number sampled)	PWSs: NA private wells: NA	PWSs: > 20 µg/L (11 systems) private wells: NA
Michigan: 31,557 samples from 18,046 CWS, NCWS, and private wells from 1987 through 1999	1.0 µg/L	2.9% of samples and 3.0% of wells	NA	> 240 µg/L (29 samples)
Missouri: MO has monitored MTBE in 1,685 PWSs since 1994	5 µg/L	0.1% of monitored PWSs statewide (2 PWSs)	NA	NA
New Jersey: samples from approximately 400 CWSs from 1997 to 1998; plus a random sampling of 104 domestic wells	PWSs: 0.5 µg/L private wells: 0.1 µg/L	PWSs: 14.8% private wells: 35.6%	PWSs: NA private wells: 0.48 µg/L (average of medians from 4 sampling areas)	PWSs: 8.4 µg/L private wells: 30.2 µg/L
Wisconsin: 2,271 wells (mostly private) sampled since 1990	12 µg/L	4.4% of wells (96 private wells and 3 public wells)	NA	1,700 µg/L (private well)

NA = not available
Source: Delzer and Ivahnenko, 2003a (see this literature review for full citations for State studies)

Compilation of Historical VOC Monitoring Data

USGS assessed VOC occurrence in untreated ambient ground water samples collected between 1985 and 1995 by local, State, and federal agencies (Squillace *et al.*, 1999). The samples represented both urban and rural areas, and both drinking water and non-drinking water wells. MTBE samples were collected from 225 urban wells and 1,312 rural wells. Of the 60 VOCs monitored at a reporting level of 0.2 µg/L, MTBE was one of the most frequently detected VOCs, particularly in urban areas. There was a 16.9 percent detection frequency in urban areas and a 3.4 percent detection frequency in rural areas. Detections ranged from the minimum reporting level (0.2 µg/L) to over 10,000 µg/L. The median detected concentration was less than 1 µg/L.

EPA Summary Analysis of NAWQA Data

While the NAWQA program often uses the most representative data for a site to calculate summary statistics, EPA, with the cooperation of USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1991-2001) for many of the Second Contaminant Candidate List (CCL 2) contaminants being considered for regulatory determination, including MTBE. Detection frequencies were simply computed as the percentage of samples and sites with detections (i.e., the percentage with at least one result equal to or greater than the reporting limit; note that reporting limits were not uniform). Sample detections can be biased by frequent sampling in areas with high (or low) occurrence. Calculating the percentage of sites with detections can reduce this bias. For more details on the NAWQA data set and the EPA analysis, see Chapter 2.

The results of the EPA analysis are presented Exhibit 13-8. Overall, MTBE was detected in 17.7 percent of samples and at 9.8 percent of sites. MTBE was detected more frequently in surface water but at higher concentrations in ground water.

Exhibit 13-8: EPA Summary Analysis of MTBE Data from NAWQA Study Units, 1992-2001

	Detection Frequency (detections are results ≥ RL[1])				Concentration Values (of detections, in µg/L)				
	Number of Samples	% Samples with Detections	Number of Sites	% Sites with Detections	Minimum	Median	95th Percen-tile	99th Percen-tile	Maximum
surface water	1,402	46.2%	182	62.1%	0.01	0.25	3.46	63	81.3
ground water	4,645	9.1%	4,146	7.5%	0.01	0.5	800	4,500	23,000
all sites	6,047	17.7%	4,328	9.8%	0.01	0.3	320	1,800	23,000

[1] RLs (Reporting Limits) for MTBE varied, but did not exceed 0.2 µg/L. For more information, see Chapter 2. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible. Some concentration values are rounded.

USGS Stormwater Studies

For the National Highway Runoff Data and Methodology Synthesis, USGS conducted a review of 44 highway and urban runoff studies implemented since 1970 (Lopes and Dionne, 1998). Three of these studies report results for MTBE.

Two of the three studies with MTBE results were stormwater studies conducted in specific major metropolitan areas in connection with National Pollutant Discharge Elimination System (NPDES) permitting. In metropolitan Phoenix (Maricopa County), USGS collected 35 samples from five drainage basins, and the City of Phoenix collected an additional 26 samples from seven sites (Lopes *et al.*, 1995). In Dallas-Fort Worth, 182 samples were collected from 26 stormwater drainage basins (Baldys *et al.*, 1998). The reporting limits were 0.2 µg/L in Phoenix and ranged from 0.2 to 10 µg/L in Dallas-Fort Worth. Not all samples were monitored for every contaminant. The maximum detected MTBE concentrations were 2.5 µg/L in Phoenix and 8.7 µg/L in Dallas-Fort Worth.

The third study was a summary of all NPDES-related stormwater monitoring data on MTBE and other compounds from sixteen cities from 1991-1995, including the two described above (Delzer *et al.*, 1996). This summary was undertaken to support an interagency assessment of the scientific basis and effectiveness of the nation's wintertime oxygenated gasoline program, coordinated by the Office of Science and Technology Policy, Executive Office of the President (Zogorski *et al.*, 1997). Of 592 stormwater samples, MTBE was detected in 41 samples, or 6.9 percent of samples. MTBE was the seventh most frequently detected VOC, behind toluene (23.2%), total xylene (17.5%), chloroform (13.4%), total trimethylbenzene (12.4%), tetrachloroethene (8.0%), and naphthalene (7.4%). MTBE was detected in stormwater from eight of the sixteen cities: Atlanta, Baton Rouge, Birmingham, Colorado Springs, Denver, Dallas-Fort Worth, San Antonio, and Phoenix. Detected concentrations ranged from 0.2 µg/L to 8.7 µg/L, with a median detected concentration of 1.5 µg/L. Of the 41 detections, 34 (or 83%) were from samples taken during the winter months (from October to March) when MTBE would be used in greater quantities in some areas to meet federal air quality standards. In Phoenix, Colorado Springs, and Denver, three cities known to use oxygenated fuels, all detections were in the October-March season. The detection rate in these three cities was 40 percent (16 of 40 samples), with concentrations ranging from 1.0 to 4.2 µg/L and a median detected concentration of 1.5 µg/L. Detection in the other five cities (Atlanta, Baton Rouge, Birmingham, Dallas-Fort Worth, and San Antonio) is attributed to use of MTBE in gasoline as an octane enhancer. Note that the reporting limit for the analytical method used to monitor MTBE was reduced from 1.0 µg/L to 0.2 µg/L in 1994. It is likely that had the lower reporting limit been used throughout, the frequency of detection would be higher and the median detected concentration would be lower (Delzer *et al.*, 1996). The interagency report (Zogorski *et al.*, 1997) points out that the results of this monitoring might not be nationally representative, since none of the 16 monitored cities are located in California or the Northeast, where MTBE use is greatest.

American Water System Survey

The American Water System (AWS) of the American Water Works Company owns utilities in 23 States. In 1997 and 1998, AWS conducted its own survey of MTBE occurrence in source water. Two hundred surface water samples were taken from 92 sites in 12 States, and 1,349 ground water samples were taken from 342 wells in 17 States. Monitoring at all of the surface water sites and most of the ground water sites (from 270 out of 342) represented untreated source water. Where finished water was sampled, the treatment processes used (chlorination, pH adjustment, iron or manganese sequestration, fluoride addition) are not expected to affect MTBE concentrations. The method reporting limit was 0.5 µg/L (Gullick and LeChevallier, 2000).

In ground water, there were 136 MTBE detections (10 percent of samples) in 30 wells (8.8 percent of wells) in eight States. In surface water, there were 12 detections (6.0 percent of samples) at 8 sites (8.7 percent of sites) in three States. States with detections included Connecticut, Indiana, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, and West Virginia. In four States, detections exceeded 5 µg/L: One or two wells in Massachusetts had concentrations as high as 5.9 µg/L, three wells in New Jersey had concentrations between 1.5 µg/L and 11.6 µg/L, a stream and two wells near a leaking underground storage tank in Pennsylvania had samples with MTBE concentrations as high as 25.1 µg/L, 5.5 µg/L, and 14.2 µg/L, respectively, and one well in West Virginia had MTBE concentrations as high as 6.6 µg/L (Gullick and LeChevallier, 2000).

13.3.3 Drinking Water Occurrence

Nationally representative data on MTBE occurrence in drinking water have been collected by large and small public water systems in accordance with EPA's first Unregulated Contaminant Monitoring Regulation (UCMR 1). For a complete description of the UCMR 1, see Chapter 2 and USEPA (2008).

UCMR 1

UCMR 1 monitoring was conducted primarily between 2001 and 2003, though some results were not collected and reported until as late as 2006. As a List 1 contaminant, MTBE was scheduled to be monitored by all large CWSs and non-transient non-community water systems (NTNCWSs) and a statistically representative sample of small CWSs and NTNCWSs. The data presented in this report reflect UCMR 1 analytical samples submitted and quality-checked under the regulation as of March 2006. MTBE data were collected and submitted by 796 (99.5 percent) of the 800 small systems selected for the small system sample and 3,075 (99.2 percent) of the 3,100 large systems defined as eligible for the UCMR 1 large system census. MTBE data have been analyzed at the level of simple detections (i.e., ≥ minimum reporting level, ≥ MRL, or ≥ 5 µg/L). Currently, there is no health reference level (HRL) for MTBE.

Results of the analysis are presented in Exhibits 13-9 and 13-10. For small systems, MTBE detections were reported by 0.38% of public water systems (PWSs), representing 0.15% of the population served, equivalent to approximately 147,000 people nationally. Among large systems, 16 systems (0.52%) had detections, affecting approximately 750,000 people (0.34% of the population served). MTBE was found much more frequently in ground water systems than in surface water systems.

A total of 26 MTBE detections were reported from 19 systems in 14 States. At the four surface water systems with detections, concentrations ranged from 8 µg/L to 33 µg/L, while at fifteen ground water systems with detections, concentrations ranged from 5 µg/L to 49 µg/L. Detections at concentrations higher than 20 µg/L were found at one small ground water system (49 µg/L), three large ground water systems (48 µg/L, 36 µg/L, and 33.2 µg/L), and one large surface water system (33 µg/L). California, Georgia, New Hampshire, New Jersey, and New York each had two systems with detections, while Connecticut, Illinois, Massachusetts, Missouri, New Mexico, Pennsylvania, South Dakota, Tennessee, and West Virginia each had one system with detections. When these results are combined with results from USGS's literature review (Delzer and Ivahnenko, 2003a), Random Survey (Grady, 2003), and Focused Survey (Delzer and Ivahnenko, 2003b), all but eight States (Alaska, Hawaii, Mississippi, Nebraska, Nevada, North Dakota, Utah, and Wyoming) have had at least one documented detection of MTBE in ambient or drinking water. Note that the MRL in these studies varied: in UCMR 1 the lowest reported detections were 5 µg/L, in the random and focused surveys they were 0.2 µg/L, and in the literature search they were 0.1 µg/L.

Exhibit 13-9: Summary UCMR 1 Occurrence Statistics for MTBE in Small Systems (Based on Statistically Representative National Sample of Small Systems)

Frequency Factors	**UCMR Data - Small Systems**		**National System & Population Numbers[1]**
Total Number of Samples	3,268		--
Percent of Samples with Detections	0.09%		--
99th Percentile Concentration (all samples)	< MRL		--
Health Reference Level (HRL)	N/A		--
Minimum Reporting Level (MRL)	5 µg/L		--
Maximum Concentration of Detections	49 µg/L		--
99th Percentile Concentration of Detections	49 µg/L		--
Median Concentration of Detections	12.7 µg/L		--
Total Number of PWSs	796		60,414
Number of GW PWSs	589		56,072
Number of SW PWSs	207		4,342
Total Population	2,758,082		45,414,590
Population of GW PWSs	1,937,327		36,224,336
Population of SW PWSs	820,755		9,190,254
Occurrence by System	**Number**	**Percentage**	**National Extrapolation[2]**
PWSs with Detections (≥ MRL)	3	0.38%	149
GW PWSs with Detections	3	0.51%	149
SW PWSs with Detections	0	0.00%	0
Occurrence by Population Served			
Population Served by PWSs with Detections	4,150	0.15%	147,000
Pop. Served by GW PWSs with Detections	4,150	0.21%	147,000
Pop. Served by SW PWSs with Detections	0	0.00%	0

1. Total PWS and population numbers are from EPA September 2004 Drinking Water Baseline Handbook, 4th edition.
2. National extrapolations are generated separately for each population-served size stratum and then added to yield the national estimate of GW PWSs with detections (and population served) and SW PWSs with detections (and population served). For intermediate calculations at the level of individual strata, see EPA's UCMR 1 Occurrence Report, entitled "The Analysis of Occurrence Data from the First Unregulated Contaminant Monitoring Regulation (UCMR 1) in Support of Regulatory Determinations for the Second Drinking Water Contaminant Candidate List."

Abbreviations:
PWS = Public Water Systems; GW = Ground Water; SW = Surface Water; N/A = Not Applicable; Total Number of Samples = the total number of samples on record for the contaminant; 99th Percentile Concentration = the concentration in the 99th percentile sample (out of either all samples or just samples with detections); Median Concentration of Detections = the concentration in the median sample (out of samples with detections); Total Number of PWSs = the total number of PWSs for which sampling results are available; Total Population Served = the total population served by PWSs for which sampling results are available; PWSs with detections, PWSs > ½ HRL, or PWSs > HRL = PWSs with at least one sampling result greater than or equal to the MRL, exceeding the ½ HRL benchmark, or exceeding the HRL benchmark, respectively; Population Served by PWSs with detections, by PWSs > ½ HRL, or by PWSs > HRL = population served by PWSs with at least one sampling result greater than or equal to the MRL, exceeding the ½ HRL benchmark, or exceeding the HRL benchmark, respectively.

Notes:
-Small systems are those that serve 10,000 persons or fewer.
-Only results at or above the MRL were reported as detections. Concentrations below the MRL are considered non-detects.
-Due to differences between the ratio of GW and SW systems with monitoring results and the national ratio, extrapolated GW and SW figures might not add up to extrapolated totals.

Exhibit 13-10: Summary UCMR 1 Occurrence Statistics for MTBE in Large Systems (Based on the Census of Large Systems)

Frequency Factors	**UCMR Data - Large Systems**	
Total Number of Samples	30,500	
Percent of Samples with Detections	0.08%	
99th Percentile Concentration (all samples)	< MRL	
Health Reference Level (HRL)	N/A	
Minimum Reporting Level (MRL)	5 µg/L	
Maximum Concentration of Detections	48 µg/L	
99th Percentile Concentration of Detections	48 µg/L	
Median Concentration of Detections	9 µg/L	
Total Number of PWSs	3,075	
Number of GW PWSs	1,381	
Number of SW PWSs	1,694	
Total Population	223,231,954	
Population of GW PWSs	53,273,126	
Population of SW PWSs	169,958,828	
Occurrence by System	**Number**	**Percentage**
PWSs with Detections (≥ MRL)	16	0.52%
GW PWSs with Detections	12	0.87%
SW PWSs with Detections	4	0.24%
Occurrence by Population Served		
Population Served by PWSs with Detections	749,483	0.34%
Pop. Served by GW PWSs with Detections	421,186	0.79%
Pop. Served by SW PWSs with Detections	328,297	0.19%

Abbreviations:
PWS = Public Water Systems; GW = Ground Water; SW = Surface Water; N/A = Not Applicable; Total Number of Samples = the total number of samples on record for the contaminant; 99th Percentile Concentration = the concentration in the 99th percentile sample (out of either all samples or just samples with detections); Median Concentration of Detections = the concentration in the median sample (out of samples with detections); Total Number of PWSs = the total number of PWSs for which sampling results are available; Total Population Served = the total population served by PWSs for which sampling results are available; PWSs with detections, PWSs > ½ HRL, or PWSs > HRL = PWSs with at least one sampling result greater than or equal to the MRL, exceeding the ½ HRL benchmark, or exceeding the HRL benchmark, respectively; Population Served by PWSs with detections, by PWSs > ½ HRL, or by PWSs > HRL = population served by PWSs with at least one sampling result greater than or equal to the MRL, exceeding the ½ HRL benchmark, or exceeding the HRL benchmark, respectively.

Notes:
-Large systems are those that serve more than 10,000 persons.
-Only results at or above the MRL were reported as detections. Concentrations below the MRL are considered non-detects.

The following maps, based on UCMR 1 data, give an indication of the geographic distribution of MTBE occurrence in drinking water. Exhibit 13-11 shows the distribution of States with at least one detection. Exhibit 13-12 shows the relative frequency of detection in these States. Exhibit 13-13 shows the maximum concentration of MTBE at each system where it was detected. Measured concentrations were variable and the map does not distinguish regions that might have had consistently high contamination.

Exhibit 13-11: Geographic Distribution of MTBE in UCMR 1 Monitoring – States With At Least One Detection At or Above the MRL (≥ 5 µg/L)

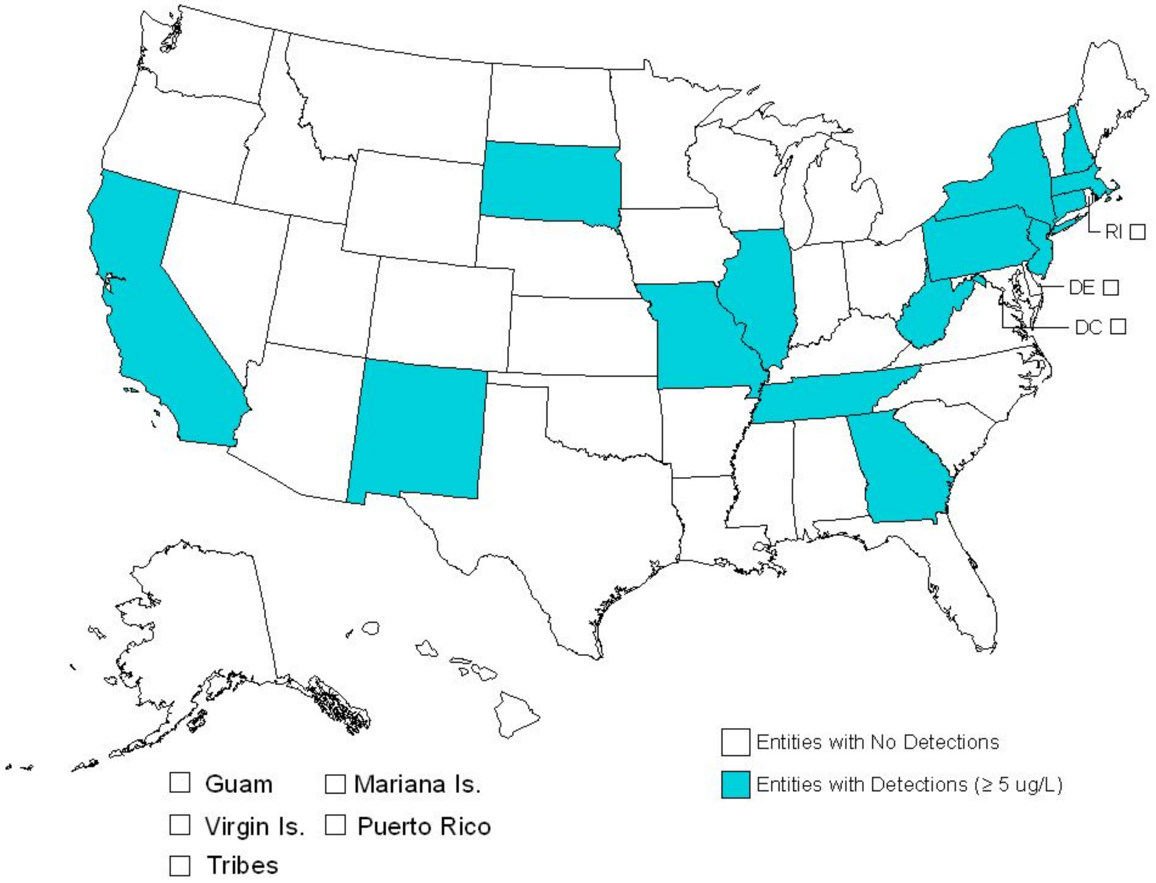
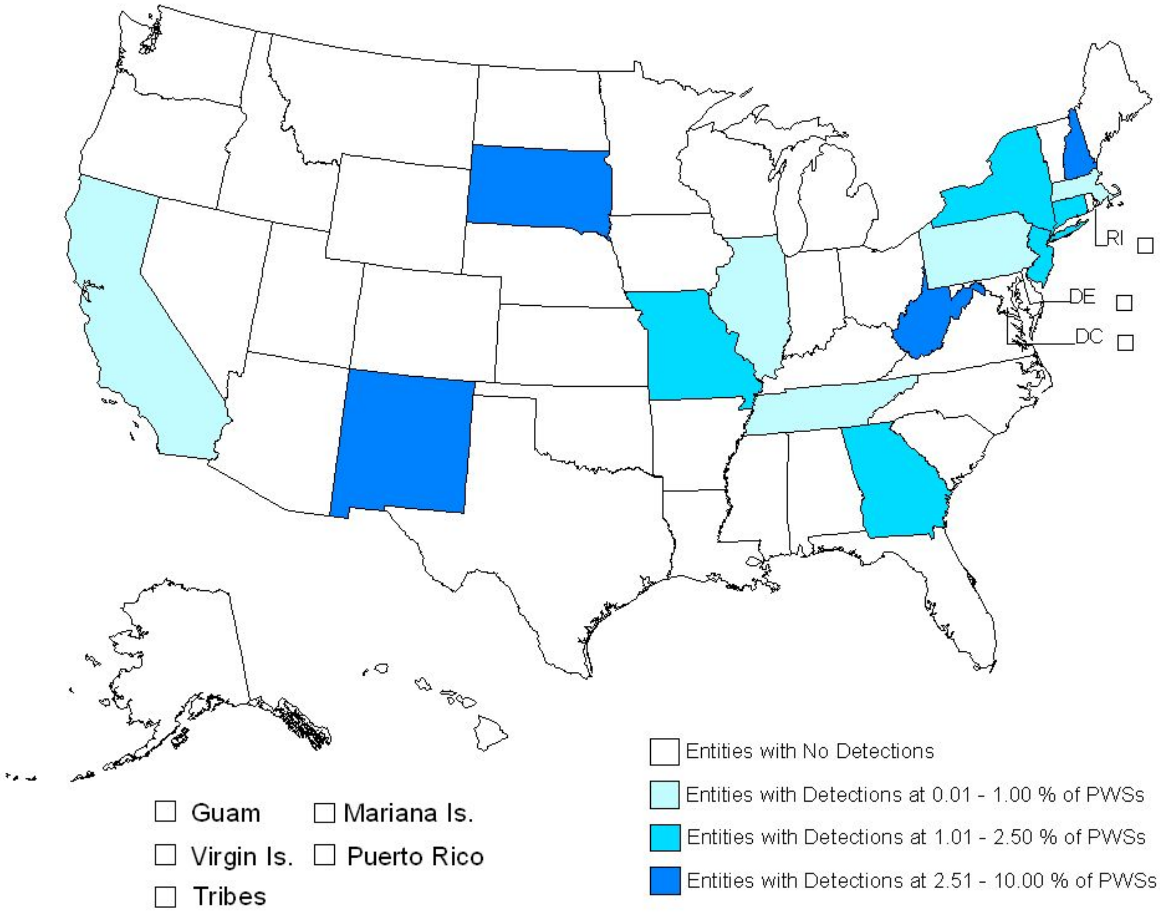


Exhibit 13-12: Geographic Distribution of MTBE in UCMR 1 Monitoring – Percentage of UCMR 1 PWSs With At Least One Detection At or Above the MRL (≥ 5 μg/L), By State



Note: This map depicts UCMR 1 results from both small systems and large systems. The statistical selection of UCMR 1 small systems was designed to be representative at the national level, but not at the state level. Therefore, this map should only be considered a rough approximation of state-level patterns of contaminant occurrence.

Exhibit 13-13: System-Level Geographic Distribution of MTBE in UCMR 1 Monitoring – Maximum Concentration at Each System with Detections

Compared with some national, regional, state, and local studies summarized in this report, the UCMR 1 occurrence data indicate low MTBE occurrence. When comparing UCMR 1 results to the results of other MTBE occurrence studies, several points should be considered. First, UCMR 1 is a survey of drinking water only. Many studies that report higher rates of MTBE occurrence (for example, USGS NAWQA studies and monitoring connected to UST investigations) are studies of ambient water.

Second, UCMR 1 was specifically designed to provide a statistically representative picture of national MTBE occurrence. In fact, UCMR 1 is the only study of MTBE in finished drinking water study that is both national in scope and statistically representative. (Among source water studies, the USGS Random Survey meets both criteria.) MTBE studies that target areas of known MTBE use or contamination, and/or have increased rates of sampling in such areas (e.g., the USGS Focused Survey and some state studies), are not representative, and likely overestimate MTBE occurrence.

Third, UCMR 1 sampling was undertaken in a specific timeframe: most samples were collected between 2001 and 2003 (with additional samples collected as late as 2006). Differences between UCMR 1 results and results of studies from the 1990s might be partially attributable to actual changes in MTBE use and release over time. In addition, some state MTBE occurrence databases (e.g., California's) include historical results from contaminated wells that are no longer in use.

Finally, UCMR 1 used a MRL of 5 µg/L. This is significantly higher than the reporting level used by most other studies, which was often the method detection limit. (All other things equal, the lower the MRL, the higher the rate of detections found and the higher the MRL, the lower the rate of detections.) For UCMR 1, EPA established MRLs for each VOC by multiplying by 10 either the VOC's published detection limit, or 0.5 µg/L, whichever is greater (USEPA, 2000b; 64 FR 50556). EPA set MRLs approximately an order of magnitude higher than detection limits to ensure consistency, accuracy, and reproducibility of results in a study that involved analyses by many laboratories across the country, using multiple analytical methods. The threshold of 5 µg/L is also low enough to capture trends of interest. It is below EPA's advisory range for organoleptic (taste and odor) effects (20 µg/L to 40 µg/L), and below all primary drinking water standards for MTBE established to date by individual states (ranging from 10 µg/L to 240 µg/L – see Exhibit 13-22.)

When compared at a common threshold of 5 µg/L, occurrence is fairly consistent across the UCMR 1 and other studies. UCMR 1 found MTBE in 0.52% of large systems and 0.38% of small systems using the 5 µg/L MRL. At the same threshold, the USGS Survey of Drinking Water in the Northeast and Mid-Atlantic States (a statistically representative regional study focused on a region of high MTBE use, discussed below) found MTBE in 1.5% of samples from 2.0% of systems. The USGS Random Survey (a nationally representative survey of source waters for community water systems, discussed above) found that MTBE concentrations exceeded 5 µg/L in three of 934 tested source waters (0.3%). The American Water System's survey (a large but not necessarily representative sampling of source and finished waters, discussed above) found MTBE at concentrations above 5 µg/L in 1 out of 92 surface water sources (1.1%) and up to 8 of 342 wells (2.3%).

For further analysis of UCMR 1 results for MTBE, see the UCMR 1 occurrence analysis background report (USEPA, 2008).

Summary Analysis of Combined Large and Small System UCMR Data

EPA found that 19 public water systems (0.49 percent of the 3,871 systems sampled) in 14 states (CA, CT, GA, IL, MA, MO, NH, NJ, NM, NY, PA, SD, TN, and WV) reported MTBE occurrence in drinking water. These 19 systems reported MTBE in 26 samples at or above the minimum reporting level of 5 µg/L, representing approximately 0.33 percent (or 754 thousand of 226 million) of the population served by the public water systems that sampled for MTBE. The average MTBE concentration among detections was 15.2 µg/L and the median concentration was 9.2 µg/L.

Community Water System Survey

The 2000 Community Water System Survey (CWSS) (USEPA, 2002a; 2002b) gathered data on the financial and operating characteristics of a random sample of community water systems nationwide. In addition, the Survey asked all "very large" community water systems, those that serve more than 500,000 people (a total of 83 systems), to provide monitoring results for five regulated compounds (arsenic, atrazine, 2,4-D, simazine, and glyphosate) and four unregulated compounds (radon, MTBE, metolachlor, and boron), including results from raw water at each intake and from finished water at treatment plants. EPA received responses from 58 systems. However, not all systems answered every question. Note that because reported results are incomplete, they are more illustrative than statistically representative.

Results of raw water monitoring are aggregated by type of intake. In raw ground water, 12 observations of MTBE occurrence were reported. In raw surface water, 27 observations of MTBE occurrence were reported (USEPA, 2002b).

Results of finished water monitoring are aggregated by system type. At systems primarily served by ground water, no MTBE observations were reported. At systems primarily served by surface water, 29 observations of MTBE occurrence were reported. At systems primarily served by purchased water, 3 observations of MTBE occurrence were reported (USEPA, 2002b).

The unpublished database from which the statistics above were drawn provides additional information. The 71 reported MTBE detections came from fifteen systems in eleven States (California, Georgia, Kentucky, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Texas, Virginia, and Wisconsin). All fifteen systems had raw water detections, four from ground water sources and 12 from surface water sources. (One Ohio system had detections in both surface and ground water sources.) Excluding two obvious outliers (most likely due to mislabeling of units), the highest reported concentration in raw water was 501 µg/L, from a ground water intake at a New York system that primarily uses surface water. Of 37 reported raw water detections (excluding outliers), 14 were of MTBE concentrations higher than 20 µg/L. Eleven of the fifteen systems reported finding MTBE contamination in finished water also. At one system the contaminated water came from a purchased source; at the other ten the contaminated water came from surface sources. Excluding one obvious outlier, the highest concentration in finished water was 50 µg/L, found twice at a California system served primarily by surface water. Of 31 reported MTBE detections in finished water (excluding the outlier), 4 were of concentrations higher than 20 µg/L. As noted above, because of incomplete responses and the low response rate, these survey results can not be considered statistically representative.

USGS Survey of Drinking Water in the Northeast and Mid-Atlantic States

USGS compiled and analyzed occurrence data for MTBE and other VOCs in finished drinking water in twelve Northeast and Mid-Atlantic States (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia), a region of high MTBE use (Grady and Casey, 2001). State agencies supplied USGS with VOC data collected during 1993-1998 for 20 percent of the CWSs in the twelve-State area, which were chosen to be representative in terms of geography, source of water, and system size. Delaware and Pennsylvania did not have any MTBE data, so the MTBE analysis was limited to 1,194 CWSs in ten States. After the trihalomethanes, MTBE was the most frequently detected VOC. Concentrations at levels ≥ 1 µg/L were found in 248 samples (4.8 %) from 84 CWSs (7.8%); concentrations at levels ≥ 5 µg/L were found in 82 samples (1.5%) from 23 CWSs (2.0%); and concentrations at levels ≥ 20 µg/L were found in 27 samples (0.5%) from 10 CWSs (0.8%). Extrapolating from these results, the study authors estimated that the number of CWSs in the 12-State area with MTBE concentrations of ≥ 1 µg/L, ≥ 5 µg/L, and ≥ 20 µg/L is approximately 820-890, 180, and 80, respectively.

At concentrations greater than 1 µg/L, MTBE was detected seven times more frequently in areas where MTBE is or has been added to gasoline as part of the oxygenated or reformulated fuel programs than in other areas, a difference that is statistically significant. Differences between MTBE concentrations inside and outside those areas, however, were not found to be statistically significant (Grady and Casey, 2001).

USGS Survey of Untreated Rural Self-Supplied Domestic Wells

As part of the NAWQA program, USGS studied the occurrence of MTBE and other VOCs in ground water from untreated rural self-supplied domestic wells between 1986 and 1999 (Moran *et al.*, 2002). These sources of drinking water are not subject to EPA drinking water regulations. At a reporting level of 0.2 µg/L, 30 out of 1,335 wells contained MTBE. Most of the contaminated wells were concentrated in the northeast (Pennsylvania, New Jersey, Connecticut and Massachusetts); the remainder were in Arkansas, Colorado, Georgia, and Illinois. The median detected MTBE concentration was 0.7 µg/L. The sample with the highest concentration, 30.2 µg/L, was the only sample that exceeded 20 µg/L.

Environmental Working Group (EWG) Report

In April 2005, the Environmental Working Group (EWG, 2005) released a report, *Like Oil and Water*, on their web page. In response to Freedom of Information Act requests, 29 State agencies submitted data to EWG. EPA informally evaluated the data posted by EWG to determine if this information might be useful in projecting state-wide occurrence. While EPA found the report interesting, the data as reported on the Web lacked some of the information needed to assess the representativeness and the quality of the data. For example, States submitted different time periods of monitoring data (e.g., Alaska submitted 7 months of data for 1 system during the 2000 timeframe and Illinois submitted data that spanned 1994 to 2003). States did not report monitoring results for every system. Also, the data do not indicate if the samples came from source water or finished water, or from ground water or surface water; also not reported are the analytical method used for analysis, the reporting level, the frequency of the sampling (e.g., annual, quarterly), the number of samples from each water system, and the number of non-detects.

13.3.4 Prominent Cases of MTBE Drinking Water Contamination

Several high-profile cases of MTBE contamination affecting drinking water are summarized here. These accounts are drawn from published studies and State agency reports where available. In other instances, the information comes from news reports and other secondary sources.

South Lake Tahoe, California

South Tahoe Public Utility District (STPUD) was among the first public water suppliers in the State of California to become aware of an MTBE contamination problem (Bourelle, 1998a). According to Bourelle (1998a), STPUD first detected MTBE at the Tata Lane No. 4 well in February of 1997. Another source suggests that STPUD may have detected trace amounts of the chemical even earlier, as early as 1996 (Primedia, 2002). Bourelle (1998a) states that the first two wells were shut down in September 1997. The Tata Lane No. 4 well itself continued in operation with treatment by air stripping until concentrations rose and traces of MTBE were detected in finished water. The Tata Lane No. 4 well was finally shut down in July of 1998. In addition to these three contaminated wells, STPUD shut down seven uncontaminated wells by August of 1998 as a precautionary measure. At least one other well was operated at half-capacity to prevent pulling the contaminant plume closer (Bourelle, 1998a).

The California Department of Health Services (California DHS) maintains a listing of MTBE detections at California PWSs on the Internet (California DHS, 2005). According to California DHS, only active or inactive sources that have had at least two detections are listed. “Sources” include raw and treated well water and surface water, distribution system water, etc. As of May 2005, the database lists 143 detection records from 14 sources at South Lake Tahoe (or 13 wells, because raw and treated water from the “Gardner Mt. WTP” well are listed separately). Sample dates range from June 1996 to July 2005. The median concentration for all South Lake Tahoe records is 1.3 µg/L, with a maximum concentration of 68 µg/L detected at Tata Lane Well No. 4 in July of 1999. See Exhibit 13-14 for a summary of South Lake Tahoe results posted by California DHS (2005).

Exhibit 13-14: MTBE detections in wells of South Tahoe PUD

Source Name	Concentration (µg/L)		
	Min	Median	Max
Arrowhead Well 01 - Destroyed	2.5	2.9	3.7
Arrowhead Well 02 - Destroyed	1.2	1.4	1.8
Bakersfield Well – Raw	0.25	0.28	0.6
Blackrock Well 01 – Monitoring Well	1.8	1.8	1.8
Chris Ave Well	0.23	0.23	0.23
Clement Ave Well	0.5	0.5	0.5
Country Club Well (Angora 07)	0.5	0.65	1
Gardner Mt. Wtp - Raw	1.4	3.9	5
Gardner Mt. Wtp - Treated	0.5	1.2	2.3
Julie Well	0.22	1.3	2.2
South Y Center Well - Inactive	0.7	2.15	4.2
Tata Lane Well 02	0.5	0.6	1
Tata Lane Well 03	0.5	0.7	1.2
Tata Well 04	0.5	18	68

Source: California DHS, 2005.

Authorities identified six contaminant plumes originating from South Lake Tahoe gas stations as sources of MTBE contamination (Bourelle, 1998a). The Lahontan Regional Water Quality Control Board published periodic reports listing all known discharges of MTBE in the region, including those in South Lake Tahoe. The most recent report (Dodds, 2004), from April 2004, lists 22 USTs in South Lake Tahoe (27 in El Dorado county) with known MTBE discharges, plus an additional UST in South Lake Tahoe with a ground water MTBE detection but no confirmed discharge. Most USTs were located at gas stations. The report also lists 5 MTBE discharges in South Lake Tahoe labeled “Spills, Leaks, Investigations, and Cleanups,” and one MTBE detection at a well. Most of the discharges and detections were first documented in 1998; the rest were first documented in 1999 (Dodds, 2004).

With 10 of 34 wells out of action and others operating at less than full capacity, water supply was 20 percent below normal in 1998. In the short term, STPUD responded to the shortage by implementing water usage restrictions, particularly during the summer (Bourelle, 1998a).

Soon after the wells were closed, STPUD filed suit against 31 companies, including large gasoline manufacturers and distributors and local gas stations (Bourelle, 1998b; Primedia, 2002). Between 1999 and 2002, the defendants agreed to settle for amounts totaling $69 million (Wood, 2002). STPUD netted $45 million from the settlements, $10 million of which had to be spent immediately to cope with the contamination. As of 2004, STPUD had installed an ozone treatment system and drilled several new, deeper wells. STPUD anticipated that water restrictions would remain in place indefinitely (Crofton, 2004).

Santa Monica, California

The City of Santa Monica has three well fields. In August of 1995, the City discovered MTBE contamination in the Arcadia and Charnock wellfields. In 1996, the City shut down all production at the two contaminated well fields (LARWQCB and USEPA Region 9, 1998; 65 FR 16094). These seven wells (2 wells in Arcadia and 5 wells in Charnock) represented approximately 50 percent of the City of Santa Monica’s drinking water supply (USEPA, 2005d). The California DHS database holds 39 records of MTBE ground water detections in the City of Santa Monica Water Division (California DHS, 2005). Basic statistics on concentrations detected at all Santa Monica wells listed by DHS are presented in Exhibit 13-15. The samples in the database date from 1995 and 1996.

Exhibit 13-15: MTBE Detections in Wells of the City of Santa Monica Water Division

Well Name	Concentration (µg/L)		
	Min	Median	Max
ARCADIA WELL 04	19.6	19.6	19.6
ARCADIA WELL 05	9.5	18.55	86.5
CHARNOCK WELL 13 - INACTIVE	44.4	133	490
CHARNOCK WELL 15 - INACTIVE	53.3	63.05	72.8
CHARNOCK WELL 16 - INACTIVE	3.1	3.1	3.1
CHARNOCK WELL 18 - INACTIVE	6.5	23.75	47.5
CHARNOCK WELL 19 - INACTIVE	8.2	300	610

Source: California DHS, 2005

The Los Angeles Regional Water Quality Control Board (LARWQCB) and EPA Region 9 identified a leaking UST system at one gas station as the source of MTBE at the Arcadia site (LARWQCB and USEPA Region 9, 1998). Investigation of USTs and gasoline pipelines near the Charnock wellfield revealed that 25 sites had released gasoline containing MTBE, and 12 of those releases had contaminated ground water (USEPA, 2005e).

The Southern California Water Company (SCWC), serving Culver City, also drew water from the Charnock Sub-basin. Though SCWC never detected MTBE in its two Charnock Sub-basin wells, it shut down both wells to prevent the migration of the contaminant plume (LARWQCB and USEPA Region 9, 1998).

Since 1996, the City of Santa Monica and the SCWC have replaced water from the contaminated wells by purchasing finished drinking water from the Metropolitan Water District of Southern California. The annual cost of this replacement water is approximately $3.2 million. Until 2000, the cost of replacing the water was paid by Shell, Chevron, and Exxon. From 2000 to 2005, under enforcement order by EPA and LARWQCB, 16 parties are responsible for funding the replacement water (USEPA, 2005d).

Glennville, California

In 1997, ground water in Glennville, California was contaminated with MTBE. The source was a leak from the town's only gas station (Weiser, 2004). Residential drinking wells had MTBE concentrations as high as 20,000 µg/L (65 FR 16094). Since 1997 the State has supplied water to Glennville (population c. 200) by truck. The town won a $500,000 settlement from oil companies toward the installation of a new community water system. State officials estimate that a new water system will cost $1.2 million (Weiser, 2004).

La Crosse, Kansas

La Crosse, Kansas, is served by several wells from a single aquifer. In May 1996, a resident complained of a strange odor in an irrigation well. Testing revealed that a nearby public well contained MTBE at a concentration of 200 µg/L (NFESC, 2000). In 1997, the Kansas Department of Health and Environment (DHE) found MTBE in excess of 1,000 µg/L at two public water supply wells (Hatten, 2000). Authorities attributed the contamination to gasoline releases at three gas stations eight tenths of a mile away from the public wells (Hatten and Blackburn, 1999).

In September of 1997, a new treatment system was installed, consisting of two air strippers in series. Each tower removes 80 to 90 percent of MTBE. Together, they reduce concentrations MTBE from 200 - 600 µg/L in influent water to 24 µg/L or less in finished water (NFESC, 2000). This treatment system, and at least three others designed to remediate MTBE-contaminated water in other Kansas communities, were paid for out of the State's Underground Storage Tank Trust Fund (KDHE, 2000).

Whitefield, Standish, and North Windham, Maine

Not all cases of MTBE contamination leading to well closures are due to leaking underground storage tanks. Three high-profile cases of MTBE contamination caused by surface spills of reformulated gasoline occurred in Maine in 1998. These events contributed to Maine's withdrawal from the Federal RFG program (described in Section 13.3.5, below).

In May 1998, MTBE contamination was discovered in a well serving an elementary school in the town of Whitefield. The MTBE concentration is variously reported as 500 µg/L, 800 µg/L, or 900 µg/L (Sullivan, 1998; Maine, 1998; NESCAUM, 1999a). State officials determined that the source of contamination was a spill of no more than 20 gallons in an area about 120 feet from the well where cars were parked on the grass (NESCAUM, 1999a). The school now filters the contaminated water for washing, and uses bottled water for drinking. At least one new well was drilled and installed (Sullivan, 1998).

Also in May 1998, MTBE was detected in private wells in Standish. Authorities attributed the contamination to a spill of 8 to 10 gallons of gasoline from a December 1997 car accident. The contamination affected a total of 24 private wells. Eleven wells were contaminated at levels above the State's 35 µg/L MTBE standard, requiring filtration; ten wells were contaminated at levels above 100 µg/L; two wells were contaminated at levels above 1,000 µg/L. The highest MTBE concentration, 6,500 µg/L, was recorded at the well nearest the accident site (Sullivan, 1998; Maine, 1998; NESCAUM, 1999a). The State responded to the contamination by removing 79 cubic yards of contaminated soil (NESCAUM, 1999a).

In the town of North Windham, MTBE was detected at two public water supply wells in concentrations ranging from 1 to 6 µg/L. Investigation revealed that the contamination originated from a new state-of-the-art gas station located 700 (or 900) and 1,100 feet, respectively, from the contaminated wells (Sullivan, 1998; NESCAUM, 1999a). A monitoring well near the gas station found MTBE at levels as high as 7140 µg/L (Sullivan, 1998). However, there was no leak in the double-walled UST and there was no evidence of vapor leaks. Investigators concluded that the source of the contamination must have been overfilling of the tank, and estimated that the amount of the spill was between 10 and 40 gallons (NESCAUM, 1999a). Extensive testing in North Windham following the initial detection found that 11 of 31 monitoring wells in the Windham aquifer had MTBE contamination above the detection limit (0.2 µg/L). North Windham now receives most of its water from Portland Water District (Nielson and Peckenham, 2000).

Merrimack River, Massachusetts

On the evening of January 28, 2000, a tanker truck rolled over in Lowell, Massachusetts, releasing a large amount of gasoline near the Merrimack River. According to a spokesman for the Lowell police, the amount spilled was "most of [the truck's] 11,900-gallon cargo" (Seymour, 2000). Responders attempted to contain that gasoline and vacuum it up. Warmer weather and the melting of river ice the next day allowed some gasoline into the river (Seymour, 2000).

Several downstream cities use the Merrimack River as a source of drinking water. Tewksbury and Lawrence temporarily closed their river intakes and drew water from reservoirs, but the treatment facility in Methuen remained open. The day after the spill, EPA and State officials found no MTBE in river water (Seymour, 2000). Later, MTBE was detected in the river water at elevated levels for a period of several days (65 FR 16094).

Pascoag, Rhode Island

In the summer of 2001, residents of Pascoag village (population 4000) in Burrillville, Rhode Island, complained of foul tastes and odors in their drinking water (Mello, 2001). On finding MTBE in the water, the Rhode Island Department of Health issued drinking and cooking restrictions in early September (RI Department of Health, 2002). The State provided a daily ration of ½ gallon of bottled water per person, installed an interim filtration system at the contaminated wells, and investigated possible alternative sources (Mello, 2001; USEPA, 2003b). In November, testing revealed that the new carbon filtration system successfully reduced MTBE levels from 1,100 µg/L in raw well water to non-detectable levels. Contamination in the distribution system fell to less than 10 µg/L (RI Department of Health, 2001). In January 2002, after the Pascoag system was linked to a new water supply in the neighboring village of Harrisville, the Department of Health lifted the drinking and cooking restrictions (RI Department of Health, 2002; USEPA, 2003b).

Investigation revealed that the source of the contamination was a leaking UST at a single gasoline station (USEPA, 2003b). By November 2001, the gas station had closed (Mello, 2001). In 2002, a $1 million grant from EPA's Leaking Underground Storage Tank Fund was used to remove the UST system and 2000 cubic yards of contaminated soil and to install a ground water remediation system. In June 2003, EPA announced that it would provide an additional $1 million. The funds would enable the Rhode Island Department of Environmental Management to install a second ground water treatment system that would include an experimental bio-reactor component, to be piloted for six months in collaboration with EPA's Office of Research and Development (USEPA, 2003b).

Dallas, Texas and Lake Tawakoni

On March 9, 2000, a ruptured 28-inch pipeline released approximately 600,000 gallons of reformulated gasoline in a pasture several miles northwest of Greenville, Texas. The spill drained into a creek approximately 28 miles upstream from Lake Tawakoni, a major reservoir used by the city of Dallas and other surrounding towns. On March 12, heavy rainfall washed the spill into the reservoir. Approximately 11,500 pounds of MTBE entered the reservoir by March

13. Monitoring at the time suggested that MTBE entered the reservoir as one "slug," rather than in a continuous stream (SRA, 2000).

Initial MTBE concentrations in the lake were as high as 6,000 µg/L. As the contamination spread through the lake, the highest concentrations were found to migrate along the banks, where the plume was not diluted by deep waters. At the first major intake, for the city of West Tawakoni, MTBE concentrations peaked at 740 µg/L on March 18. At the intake for the Cash Water Supply Corporation (Cash WSC), contamination peaked at 19 µg/L on March 20. On March 24, MTBE concentrations at the intakes for the cities of Commerce and Greenville peaked at 11 µg/L. By the time the plume reached the Dallas intake on March 25, detected concentrations did not exceed 1.3 µg/L. By April 19, detections throughout the reservoir were at or below 1.0 µg/L, and detections effectively ceased after May 30. Authorities attributed later sporadic detections of MTBE to the use of sport water craft on the lake (SRA, 2000).

The owner of the ruptured pipeline, Explorer Pipeline Company, responded to the spill under the supervision of EPA and State agencies. Explorer worked with the Sabine River Authority (SRA), which owns and operates the reservoir, to monitor the contamination in the lake and protect drinking water intakes. The responses of the various water customers on Lake Tawakoni varied, depending on their proximity to the point of contamination and the availability of alternative sources. The city of Dallas, which has rights to 80 percent of the water in the reservoir, shut off its intake from March 10 until August 16 and relied on alternative sources. According to SRA (2000), shutting down the large Dallas intake probably slowed the migration of the plume across the lake, giving others more time to respond. Explorer installed an aeration system on March 14 to try to volatilize the MTBE before the plume reached the first drinking water intake, but high MTBE concentrations forced the city of West Tawakoni to shut its intake on March 15. Explorer provided drinking water by truck to West Tawakoni from March 16 to March 24. Explorer also installed a carbon filtration system at the West Tawakoni treatment plant on March 22, which was found to successfully mitigate the MTBE contamination (45 µg/L at the time of installation). Cash WSC did not close its intake. The city of Commerce did not close the intake entirely, but restricted its use when the contamination was at its highest. Greenville shut down its intake on March 10 and relied instead on water from the city's private reservoir until April 25. Commerce and Greenville both installed aeration systems in late April as precautionary measures. Other water consumers on Lake Tawakoni, whose intakes were not contaminated, nevertheless were affected by the incident: they increased monitoring, considered contingency plans, and handled questions from the public (SRA, 2000).

13.3.5 The Experience of Representative States with MTBE

States vary widely both in the magnitude of the threat posed by MTBE to drinking water resources and the way they mobilize resources to handle the threat. Variation in MTBE occurrence is due in part to the different requirements on regions to meet standards of the Clean Air Act. Certain States are part of the Federal RFG or wintertime oxyfuel programs, which require higher oxygenate levels in gasoline (roughly 11 to 15 percent MTBE by volume, when MTBE is used), while others just use MTBE as an octane-enhancer (with levels as high as 8 percent by volume). Still others have banned MTBE use entirely. Furthermore, even in States that have not banned MTBE, other oxygenates are sometimes preferred for meeting federal requirements. Notably, in the corn-producing Midwest, ethanol is a particularly cost-efficient alternative. Other factors that influence nationwide heterogeneity in MTBE occurrence are the distribution of LUSTs, variations in the concentration of MTBE sold in gasoline in geographic regions, and the layout of the gasoline transportation network that allows contamination and mixing.

The following sections detail the experience of sixteen States with MTBE. The States chosen are those with "State Investigation Reports on MTBE" posted on EPA's Underground Storage Tank webpage (USEPA, 2004b). These States represent a variety of experiences with MTBE contamination. Not all States that would be expected to have the greatest impacts from MTBE (e.g., RFG States) are included. Information was gathered from available literature and web searches.

Arizona

Starting in 1989, Arizona required all gasoline sold in Maricopa County in wintertime to contain oxygenates (15 percent MTBE by volume, if MTBE was used). The requirement was extended to Pima County in 1990. Initially, MTBE was the most common oxygenate used to meet this requirement (80% MTBE v. 20% ethanol in Maricopa County). However, by 1993 ethanol was the preferred oxygenate for wintertime fuel (73% ethanol v. 27% MTBE in Maricopa County and 74% ethanol v. 26% MTBE in Pima County). By 1999, nearly 100% of wintertime gasoline in the two counties contained ethanol (ADEQ, 1999).

Phoenix and Maricopa County also participated in the Federal RFG program until 1998, when they were permitted to opt out because the State had adopted more stringent standards of its own (USEPA, 2005b). Starting in 1997, Arizona required all gasoline sold in Maricopa County in the summer months to be Arizona Clean-Burning Gasoline (CBG) (requiring 11% MTBE by volume, if MTBE is used). Because of the relatively high vapor pressure of ethanol-containing gasoline, MTBE was consistently the preferred oxygenate used to meet summertime CBG requirements (ADEQ, 1999). However, due to ground water contamination concerns, in 2004 the governor of Arizona signed a bill banning MTBE in gasoline, effective January 1, 2005 (U.S. Water News Online, 2004; Arizona Revised Statutes 41-2122).

The Arizona Department of Health Services (ADHS) has established a health-based guidance level of 35 µg/L for MTBE in ground water. The level is not a regulatory or compliance standard and therefore is not enforceable (ADEQ, 1999).

According to information available to EPA, there are 8,119 active USTs in Arizona, and there have been 8,137 confirmed releases. Cleanups have been performed on 5,540 of those releases (68 percent) (USEPA, 2005f). According to Dahlen *et al.* (2003), the State is aware of over 9,000 USTs (presumably including inactive USTs), about 4,300 of which have attained LUST status. ADEQ (1999) does not track MTBE occurrences within its UST database, but it has begun monitoring MTBE at "corrective action sites." Approximately 65 percent of Arizona's population uses ground water as their principal drinking water source (ADEQ, 1999).

Dahlen *et al.* (2003) reviewed 417 Arizona LUST site files and conducted additional field research, including collecting more than 700 supplemental ground water samples. Sites with known MTBE contamination were preferred over others, and 97 percent of the leaks occurred prior to the implementation of 1998 upgrade requirements. Dahlen *et al.* (2003) found that MTBE has been detected in Arizona ground water at levels above 20 µg/L in at least 54 cities, and that MTBE occurrence was relatively widespread in rural areas of the State as well. Among samples collected in source zones at gasoline-contaminated sites, MTBE was found in detectable concentrations (≥ 1 µg/L) in 71 percent of wells at 83 percent of sites. The median concentration was 330 µg/L, and the maximum concentration was 68,000 µg/L. Based on hydrological modeling and geographic information system (GIS) analysis, the study authors estimated that 6 percent of the approximately 10,000 municipal wells and 2.5 percent of the approximately 19,000 domestic wells in Arizona are in settings that make them vulnerable to LUST contamination.

In contrast, a joint monitoring effort by USGS and Arizona's State Water Quality Division in 1998 found no MTBE in 146 samples from the Upper Santa Cruz, Willcox, and Sacramento Valley Groundwater Basins (ADEQ, 1999). ADEQ reported that further ground water investigations were underway.

California

Gasoline in California has included MTBE in small quantities as an octane enhancer since the late 1970s. As in other States, MTBE use increased in 1992 when California entered into the wintertime Oxyfuel program. In 1994, the California Environmental Protection Agency (CAEPA, 1994) reported that Southern California was scheduled to join the Federal RFG program in 1995, and that a Statewide program would require all California gasoline to meet stringent RFG standards by June 1, 1996.

In 1999 California established a secondary (nonregulatory) taste and odor threshold of 5 µg/L for MTBE in drinking water. Effective in 2000, California established a health-based primary maximum contaminant level (MCL) of 13 µg/L (California DHS, 2000). This value is also the public health goal (PHG) for the State. California PWSs are required to report detections of MTBE to the California DHS when concentrations are greater than 3 µg/L (California DHS, 2004a). According to California's annual compliance reports, there were no violations of the MCL in 2002 or 2003, and two violations (at two different systems) in 2004 (California DHS, 2002; 2003; 2004b).

MTBE was first detected in California drinking water in 1989 and 1990 around San Francisco. California DHS first required monitoring of MTBE in some PWSs as an unregulated contaminant starting in 1997. Since then, California DHS has kept a database of every reported source and sample tested for MTBE in the State. A number of papers have reviewed this data, including Deeb *et al.* (2003), Williams (2001), and Williams *et al.* (2004). California DHS provides public access to data on MTBE occurrence at sites with two or more detections (California DHS, 2005). However, the public database does not systematically differentiate surface water from ground water or source water from drinking water, and it does not describe the number of tests per site.

Exhibit 13-16 contains an analysis by Deeb *et al.* (2003) of California source water monitoring data obtained from California DHS, updated through January 1, 2002. These statistics suggest that surface water contamination is a greater problem than ground water contamination, and that detections peaked in 1999. Deeb *et al.* (2003) suggest that the apparent decline in detections after 1999 could be due to watershed protection measures and other new regulations, or it might simply be an artifact of sampling patterns.

Exhibit 13-16: Detection of MTBE in California PWS Sources

	1995	1996	1997	1998	1999	2000	2001
Detections at Ground Water Sources							
3 < MTBE < 5 µg/L	1	0	1	4	8	5	7
5 < MTBE < 13 µg/L	0	0	0	3	4	5	5
MTBE > 13 µg/L	0	1	3	3	3	3	3
Total # detections	1	1	4	10	15	13	15
Total # detections > 5 µg/L	0	1	3	6	7	8	8
Total # sources sampled	89	1,666	2,289	3,151	3,208	2,868	5,248
% detection frequency	1.12%	0.06%	0.17%	0.32%	0.47%	0.45%	0.29%
Detections at Surface Water Sources							
3 < MTBE < 5 µg/L	0	1	1	3	6	5	2
5 < MTBE < 13 µg/L	0	2	5	3	5	3	4
MTBE > 13 µg/L	0	0	2	2	0	1	0
Total # detections	0	3	8	8	13	9	6
Total # detections > 5 µg/L	0	2	7	5	5	4	4
Total # sources sampled	4	96	176	197	228	251	300
% detection frequency	0.0%	3.1%	4.5%	4.1%	5.7%	3.4%	2.0%
Detections at Mixed/Unclassified PWS Sources							
Total # detections	0	0	0	0	0	0	0
Total sources sampled	15	121	162	221	262	248	389

Source: Deeb et al., 2003, using data from California DHS

Other analyses of California DHS data show similar patterns. Using the same data set but through the end of 2002, Williams *et al.* (2003) found that detection frequencies were significantly higher in surface water than in ground water. However, surface water detections tended to be at concentrations below State drinking water standards. Williams *et al.* (2003) presented evidence that despite increased monitoring between 1998 and 2002 in California, the rate of discovery of new instances of contamination leveled off or decreased. Also using California DHS data through 2002, Williams *et al.* (2004) reported that of 11,132 sites sampled for MTBE, 206 (or 1.9 percent) had at least one detection. The mean concentration of detections between 1998 and 2002 was 6.0 µg/L and the median was 3.0 µg/L. Of sites with detections, 9.2 percent of them had concentrations higher than 13 µg/L (the California MCL), and 6.3 percent had concentrations higher than 20 µg/L (the lower end of EPA's consumer advisory limit).

Of the 264 sources (i.e., wells) listed in the publicly available database (California DHS, 2005), 16% (41 sources) are currently designated as being "inactive," "abandoned," or "destroyed." These closed sources and their highest reported MTBE concentrations are listed in Exhibit 13-17. Note that occasionally sources are listed twice in the database, as when raw and finished water results are listed as separate entries.

Exhibit 13-17: Reported Closures of MTBE-Contaminated Water Sources in California (1989-2005)

County	System Name	Source Name	Maximum MTBE Conc. (µg/L)
BUTTE	Tank House	LPA REPORTED PRIMARY SOURCE - INACTIVE	4.5
	Cal-Water Service Co.-Chico	WELL 15-01 – INACTIVE	3.2
EL DORADO	South Tahoe PUD - Main	ARROWHEAD WELL 01 – DESTROYED	3.7
		ARROWHEAD WELL 02 – DESTROYED	1.8
		SOUTH Y CENTER WELL - INACTIVE	4.2
FRESNO	Musick Meadows #1	INACTIVE WELL	1.8
KERN	Caza Drilling California Inc	WELL 01 - INACTIVE	47
	CWS - Bakersfield	WELL 022-02 - RAW - INACTIVE	49.2
		WELL 064-01 - RAW - INACTIVE	12.3
		WELL 075-01 - RAW - INACTIVE	5.2
	Gaslite Mobile Home Park	WELL 01 - SYSTEM INACTIVATED	15.7
	Union Pacific Railroad Company	WELL 05 - INACTIVE	46
	Valley View Estates Mutual Water Co.	WELL 02 - INACTIVE	7.1
	Westside Industrial Center	WELL 01 - INACTIVE	0.74
LOS ANGELES	Calif State Polytechnical Univ - Pomona	WELL 01 - DESTROYED	2.8
	Los Angeles - City, Dept. of Water & Power	NORTH HOLLYWOOD WELL 17 - INACTIVE	3.5
		VERDUGO WELL 01 - INACTIVE	0.8
		VERDUGO WELL 02 - INACTIVE	13
	Santa Monica-City, Water Division	CHARNOCK WELL 13 - INACTIVE	490
		CHARNOCK WELL 15 - INACTIVE	72.8
		CHARNOCK WELL 16 - INACTIVE	3.1
		CHARNOCK WELL 18 - INACTIVE	47.5
		CHARNOCK WELL 19 - INACTIVE	610
	SCWC - Culver City	SENTNEY WELL 13 - ABANDONED	3.4
MERCED	Foster Farms Chicken Livehaul	WELL #2 - DESTROYED	2.71
MONTEREY	CWSC Salinas	13-02 GAC VESSEL -D- 25% - DESTROYED	4.81
		WELL 001-04 - DESTROYED	120
		WELL 013-02 - INACTIVE	400
NEVADA	Truckee-Donner PUD, Main	NEW DONNER CREEK WELL - INACTIVE	4.9
ORANGE	Southern Calif WC - Yorba	CONCERTO 01 - INACTIVE	40.9

County	System Name	Source Name	Maximum MTBE Conc. (µg/L)
	Linda		
PLUMAS	Quincy Community S.D.	WELL 01 - NORTON - DESTROYED	3.1
SACRAMENTO	Fruitridge Vista Water Company	WELL 11 - INACTIVE	26
SAN BENITO	Earthbound Farms	WELL 02 - MTBE & CL2 TREATMENT-INACTIVE	36
		WELL 02 - RAW - INACTIVE	25
SAN BERNARDINO	Sheep Creek Water Company	WELL 01 - DESTROYED	5.5
SAN DIEGO	Crystal Clear Water Company	WELL 01 - INACTIVE	10
SAN FRANCISCO	Presidio of San Francisco	WELL 06 - ABANDONED	23
		WELL 13 - ABANDONED	500
SANTA CLARA	Loma Prieta JUSD-Loma Prieta School	WELL 01 - INACTIVE	6.6
VENTURA	Calleguas Municipal Water District	FAIRVIEW ASR WELL - INACTIVE	0.59
YUBA	Cal-Water Service Co.-Marysville	WELL 03-01 - INACTIVE	234.1

Source: California DHS (2005)

A study at the Lawrence Livermore National Laboratory (Happel *et al.*, 1998) reported that 78 percent of 236 monitored LUST sites in California had detectable levels of MTBE, 74 percent had concentrations exceeding 5 µg/L, and 70 percent had concentrations greater than 20 µg/L. The study authors estimated that the number of MTBE-contaminated sites in the State is upwards of 10,000.

Cook *et al.* (2002) summarize data from multiple studies of MTBE occurrence in Santa Clara County ground water. One study analyzed drinking water from 51 domestic wells within a half-mile of LUST sites and found 4 detects, all at concentrations less than 10 µg/L. Another study sampled 104 drinking water wells every six months starting in 1999, and by the end of 2001, had not detected MTBE above the reporting limit of 3 µg/L. Although drinking water sources in Santa Clara County have not reported high levels of MTBE, ground water tests at LUST sites in the county have. Of 432 active LUST sites that tested for MTBE in 2001, 87 percent detected concentrations above 3 µg/L. Of those, 51 had concentrations exceeding 10,000 µg/L. A study by Tulloch (2000) found that of 16 locations in Santa Clara County that reported increasing trends in MTBE occurrence at significantly high levels, 13 had unreported leaks of gasoline that occurred after upgrading the storage tank. The report concluded that even after repairing and upgrading tanks, there can still be significant releases of fuel to soil and ground water.

In March 1999, Governor Gray Davis issued an executive order for the three-year phase-out of MTBE, making California the first State to officially ban the chemical. The order was codified by California SB 989, which also required refiners to submit quarterly reports on MTBE use and supply (NCSL, 2000). Because of complications, the ban was delayed beyond the original December 31, 2002 deadline. California's phaseout was complete on December 31, 2003 (USEPA, 2004c).

Connecticut

Widespread use of MTBE as an octane booster in Connecticut started in the mid-1980s. Two parts of the State used MTBE in elevated concentrations when they were required to participate in the wintertime Oxyfuel program from 1992 to 1999. The entire State began participating in the Federal RFG program in January 1995. In 2000, approximately 95 percent of RFG gasoline sold in Connecticut used MTBE as the oxygenate (Connecticut DEP, 2000).

MTBE was first discovered in Connecticut's drinking water wells in 1987. In 1987, the Connecticut Department of Public Health (Connecticut DPH) established an action level of 100 µg/L for MTBE in drinking water. In March of 1999, Connecticut DPH lowered the action level to 70 µg/L. As of 2000, the Connecticut Department of Environmental Protection (Connecticut DEP) had found MTBE at concentrations greater than the DPH action level in 236 water supply wells, of which only 4 were public. Fifty-one PWSs and many more private wells had detected MTBE at concentrations less than the action level (Connecticut DEP, 2000).

After 1995, when the percentage of MTBE used in gasoline throughout the State increased to conform to federal RFG standards (typically from 3 to 11 percent by volume), the fraction of drinking water wells in the State that detected trace levels of MTBE increased significantly. Between 15 and 30 percent of all drinking water wells tested by Connecticut DEP from 1995 to 2000 contained concentrations of MTBE between 0.5 and 10 µg/L. Connecticut DEP considers contaminated rain or runoff as likely sources of low-level contamination, while releases from underground storage tanks account for more than 90 percent of wells exceeding the action level (Connecticut DEP, 2000).

A report by the Northeast States for Coordinated Air Use Management (NESCAUM, 1999a) provides more details on MTBE detections in Connecticut PWSs between 1997 and 1998. NESCAUM reports that 80 percent of the 607 CWS and 33 percent of the 647 NTNCWS in the State tested for organic contaminants during that time period. Of those tested in 1997, 30 PWSs detected MTBE at some level, and four detected concentrations above 10 µg/L. The maximum concentration was 210 µg/L. Of PWSs tested in 1998, 45 detected MTBE at any level, and 13 detected concentrations above 10 µg/L. Four systems had concentrations greater than 100 µg/L: 17,000 µg/L in Brookfield, 3,982 µg/L in Wilton, 400 µg/L in Durham, and 240 µg/L in Salem (NESCAUM, 1999a).

Connecticut Public Act 00-175, enacted on July 1, 2000, called for a ban on the sale and use of MTBE in the State and required Connecticut DEP to develop a plan to implement the ban (Connecticut DEP, 2004). The ban of MTBE in Connecticut began on January 1, 2004, the same date that New York's ban took effect (USEPA, 2004c).

Florida

Florida is not subject to federal RFG or Oxyfuel requirements. According to the Florida Department of Environmental Protection (Florida DEP), most gasoline sold in the State contains

3 to 8 percent MTBE (Florida DEP, 2004a). Florida started monitoring for MTBE as an unregulated contaminant monitoring in PWSs in the early 1990s (Florida DEP, 2004b) and started monitoring for MTBE in ground water at petroleum-contaminated sites in 1990 (Florida DEP, 2004a).

The Florida DEP database (Florida DEP, 2004c) presents MTBE samples taken by the Florida Drinking Water Program between January 1993 and March 2000. The data set includes 8,439 samples from 1,692 PWSs. The data record 428 detections of MTBE at 20 PWSs (19 community water systems and 1 NTNCWS). The rate of detection is approximately 5.1 percent for samples, and 1.2 percent for systems. Of the detections, 101 (from 5 PWSs) ranged between 5 and 20 µg/L, and 3 (from 3 PWSs) exceeded 20 µg/L. The rest (324) were below 5 µg/L. On its webpage, Florida DEP (2000b) states that only two PWSs exceeded 20 µg/L (166 µg/L and 104 µg/L, both entry-point samples), but the database identifies a third PWS with a 41 µg/L plant sample. All of the detections were in ground water. Exhibit 13-18 presents the Florida MTBE detection data broken down by sample type. The detection rate of MTBE in treated drinking water (e.g., at the entry point or in the distribution system) was very low (< 0.5 percent).

Exhibit 13-18: MTBE Monitoring Results at Florida PWSs, Organized by Sample Type

Sample Type	Total Samples	Sample Detects	Percent Detects	Statistics for Recorded Detects		
				Minimum	Median	Maximum
Check	73	0	0.0%	-	-	-
Composite	373	1	0.3%	0.28	0.28	0.28
Distribution	1506	0	0.0%	-	-	-
Entry Point	3566	10	0.3%	0.82	2.80	166.00
Plant	43	3	7.0%	1.30	2.90	41.00
Quarterly	1814	258	14.2%	0.10	1.66	19.30
Raw	1317	154	11.7%	0.21	0.70	13.00
Special	47	2	4.3%	0.70	0.71	0.72
Total	8739	428	4.9%	0.10	1.39	166.00

Source: Florida DEP, 2004c

Hawaii

Hawaii is not required to sell or distribute either RFG or Oxyfuel, and consequently, has low levels of MTBE in its gasoline supplies. The Hawaii Department of Health conducted an inquiry in 1997 to determine the extent to which MTBE was used in the State's gasoline formulation. The inquiry revealed that a major refinery on Oahu had used MTBE in the past, and that this gasoline had likely been distributed to all major gasoline retailers and defense facilities in the State. There were also cases where gasoline containing MTBE had been imported into the State. Subsequent testing revealed a number of LUST sites with MTBE-contaminated soil and ground water (Hawaii DOH, 1998).

Based on these findings, Hawaii DOH amended its UST policy to require monitoring for MTBE at petroleum release sites. Hawaii DOH established an action level of 20 µg/L for MTBE in aquifers used for or potentially used for drinking water, and 202 mg/L (202,000 µg/L) in non-drinking water aquifers to protect aquatic life (Hawaii DOH, 1998).

Hawaii DOH (1998) did not provide specific information on MTBE detections, or on the impact of MTBE on Hawaii's drinking water resources. A single Hawaii DOH press release, dated November 23, 2004, documents the detection of MTBE in a drinking water well at a concentration of 1.2 µg/L (Hawaii DOH, 2004). This concentration is below that typically reported by State health departments.

Idaho

Idaho has never participated in Federal RFG and Oxyfuel programs. Like other States, it has had low levels of MTBE in gasoline since 1979 as a lead replacement.

Wicherski (1999) studied the occurrence of MTBE in Idaho ground water at 100 LUST sites with known petroleum contamination. MTBE was found at 50 percent of sites with recent gasoline releases (less than 5 years old), but only at 30 percent of sites with older gasoline releases. MTBE was found at no diesel release sites. The mean concentration of recent gasoline releases was 2,271 µg/L, and 312 µg/L for older releases. The maximum concentration, 15,900 µg/L, was found at a recent release site. MTBE was found at concentrations between 5 and 20 µg/L at seven sites, and at concentrations greater than 20 µg/L at 25 sites. Thus most contamination of ground water was either negligible (< 5 µg/L) or significant (> 20 µg/L), with few concentrations in between. No information was provided on the impact of drinking water wells by pollution of ground water at these sites (Wicherski, 1999).

Iowa

As of 2000, Iowa was not required to participate in Federal RFG program. According the Iowa Department of Agriculture and Land Stewardship and the Petroleum Marketers of Iowa, MTBE was neither used nor sold in Iowa at that time. However, MTBE was commonly used in the late 1970s and 1980s as an octane enhancer. In response to concern that MTBE could be harming ground water, in 1999 the Iowa legislature required that all soil and ground water samples collected from LUST sites after July 1, 1999 be analyzed for MTBE (Iowa DNR, 2000).

A report by the Iowa Department of Natural Resources (IDNR, 2000) describes the results of MTBE sampling at LUST sites between July 1, 1999 and December 17, 1999. Of 2,569 ground water samples collected during this period, about 32 percent of them reported MTBE above the quantitation limit of 15 µg/L. Almost 29 percent of samples had MTBE levels above 20 µg/L. Approximately 55 percent of sites had at least one ground water sample with an MTBE concentration greater than 20 µg/L. The mean concentration of MTBE in ground water samples with detections above the quantitation limit was 613 µg/L and the median was 81 µg/L. The mean concentration of MTBE in all ground water samples was 200 µg/L and the median was 5 µg/L. In soil, MTBE was detected in 60 percent of samples at 62 percent of sites. In addition, 53 water samples were collected from various "receptors" (e.g., drinking water wells, plastic water lines), of which only five samples had concentrations greater than 15 µg/L. One sample from a private drinking water well had an MTBE concentration higher than 20 µg/L (23.7 µg/L) (IDNR, 2000).

The same report also presented the results of a 1999 Iowa DNR study of 235 PWSs with wells in vulnerable bedrock (e.g., fractured systems). Only eight out of the 1048 samples (0.76 percent) contained MTBE, all of them at levels below the quantitation limit of 15 µg/L. In addition, the State is aware of MTBE detections at three other municipal water systems, all in northwest Iowa. Ida Grove has had low-level detections since 1997, reaching a maximum concentration of 12.0 µg/L in September 1998 (post-treatment, pre-blending). Galva detected MTBE at a concentration of 18 µg/L in 1996. Alford detected a maximum of 63 µg/L in 1994. In part because of MTBE contamination, the latter two cities have abandoned their wells and switched to other regional water sources (Iowa DNR, 2000).

The same bill that required MTBE monitoring at LUST sites also established a limit of 2 percent MTBE by volume in gasoline sold in the State, starting February 1, 2000 (Iowa DNR, 2000). Effective on July 1 of 2000, Iowa lowered the cap on MTBE ban in gasoline to 0.5 percent by volume (USEPA, 2004c).

Maine

Maine voluntarily chose to participate in the Federal RFG program. Seven Maine counties participated from 1995 until the State was officially allowed to "opt out" in 1999 (Maine DEP, 2005). Around 1997 the Maine legislature adopted an enforceable drinking water standard for MTBE of 35 µg/L−at the time the most stringent standard in any State−and the Maine Bureau of Health has monitored for MTBE in PWSs (Maine, 1998; Sullivan, 1998). At the same time, the Maine Department of Environmental Protection (Maine DEP) adopted an even more conservative action level of 25 µg/L for MTBE remediation (Maine, 1998; Sullivan, 1998).

The first known case of MTBE contamination in Maine occurred in 1984. A farmer's storage tank leaked gasoline containing 3 percent MTBE (by volume) and contaminated several local wells. Two years after the leak was discovered, levels of MTBE were still detected in local ground water at concentrations greater than 10,000 µg/L (Garrett *et al.*, 1986 as cited in NESCAUM, 1999a). In 1998, three incidents involving spills or tank overfills caused contamination of public and private wells with MTBE (described in Section 13.3.4, above). These incidents were highly publicized and created a sense of urgency about non-LUST sources of contamination.

In response to rising concern, Maine's governor directed State agencies to survey of MTBE occurrence in the State's drinking water resources. All of the State's public water systems and 1000 randomly selected private water supplies were to be sampled. The final study, published in 1998, used samples from 793 of the State's 830 nontransient public water supplies and 951 residential water supplies. Of the public water supplies, 125 sites (16 percent) had MTBE detections. Of these sites, 6.1 percent had MTBE concentrations of 1.0 µg/L or higher;

no detections exceeded 35 µg/L. Of the household water supplies, 150 (15.8 percent) had MTBE detections. Of these sites, 7.7 percent had concentrations of 1.0 µg/L or higher, and 1.1 percent had concentrations greater than 35 µg/L. Extrapolated Statewide, these findings suggest that approximately 1,400 - 5,200 private wells have MTBE contamination in excess of 35 µg/L Statewide. A comparison of results in different parts of the State showed that community water systems were 1.7 to 4.1 times more likely to be contaminated in areas of RFG use, depending on population density, and that private water supplies in such areas were 1.3 to 2.0 times more likely to be contaminated (Maine, 1998). It was on the basis of this study that Maine successfully petitioned to "opt out" of the Federal RFG program in 1999 (Maine DEP, 2005).

In 2000, the Maine legislature adopted a goal of eliminating MTBE in gasoline by January 1, 2003 (Maine DEP, 2005). In April of 2004, a bill was adopted that will phase-out MTBE use by January 1, 2007, and cap concentrations in gasoline at 0.5 percent by volume (USEPA, 2004c). Ironically, in 2004 MTBE levels in Maine gasoline rose for the first time since 2000. State officials were unsure of the cause, but guessed that it might be due to a shift of regional refiners' low-MTBE gasoline stocks to Connecticut and New York, where bans were already in effect (Maine DEP, 2005).

Maryland

Use of MTBE in significant quantities in Maryland began in 1995, when major metropolitan parts of the State were required to participate in the RFG program (MDE, 2002). In 2001, a task force estimated that approximately 220 million gallons of MTBE are consumed each year in Maryland (Maryland Task Force, 2001).

While Maryland has no health-based limit for MTBE exposure, the State considers concentrations of 20 µg/L or more in water a trigger for treatment or replacement. In addition, MTBE concentrations at or above the action level of 10 µg/L trigger an investigation to find the source of the contamination (Maryland Task Force, 2001).

The Maryland Department of the Environment (MDE) started sampling for MTBE in non-transient PWSs in 1995. By 2002, MDE had tested 1,203 PWSs, of which MTBE was detected in 116 (9.6 percent). Thirteen systems (1.1 percent) had detections over 20 µg/L (MDE, 2002). Surface water systems, which serve 68 percent of Maryland residents, were hardly affected at all: Only 2 of the 99 PWSs with detections by 2001 were surface water systems, and neither had MTBE concentrations above 2 µg/L (Maryland Task Force, 2001). In 1999, MDE started sampling for MTBE in private wells (Maryland Task Force, 2001). By 2002, LUST site investigations had identified 338 domestic wells contaminated with MTBE (MDE, 2002). Deeb *et al.* (2003) ran a query of the Maryland Water Supply Database and gathered several statistics of occurrence. The results of this query are presented in Exhibit 13-19.

Exhibit 13-19: Detection of MTBE in public water supply systems in Maryland

Occurrence Characteristics	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
3 < MTBE < 5 µg/L	0	2	17	19	15	27	32
5 < MTBE < 20 µg/L	2	7	10	8	5	5	8
MTBE > 20 µg/L	2	3	3	3	4	5	3
Total # detections > 3 µg/L	4	12	30	30	24	37	43
Total # detections > 5 µg/L	4	10	13	11	9	10	11
Total # systems sampled	940	596	555	659	388	384	323
% Detection Frequency (> 3 µg/L)	0.4%	2.0%	5.4%	4.6%	6.2%	9.6%	13.3%
% Detection Frequency (> 5 µg/L)	0.4%	1.7%	2.3%	1.7%	2.3%	2.6%	3.4%

Source: Deeb et al., 2003

As of 2001, Maryland had taken no significant action to ban or phase out the use of MTBE in gasoline (Maryland Task Force, 2001).

Michigan

As of 2002, Michigan did not participate in either federal fuels program. The presence of MTBE in conventional gasoline was monitored by the State's motor fuel quality program. Approximately 1800 samples were tested each year, though not in a statistical framework. Between 1994 and 1998, the percentage of gasoline samples containing MTBE in concentrations greater than 1 percent by volume declined from 40 percent to 13 percent. In 2000, 13 percent of samples contained MTBE in concentrations greater than 1 percent by volume, with an average concentration of 3 percent by volume, which suggests an estimated annual consumption of over four million gallons of MTBE in Michigan. In 2001, 17 percent of samples contained MTBE in concentrations greater than 1 percent, with an average concentration of 4.75 percent, suggesting estimated Statewide use of over 38 million gallons of MTBE (MDA, 2002).

Residual MTBE from pipelines was an additional source of MTBE in Michigan gasolines, in volumes as high as 2 percent. In 2000 and 2001, the State's motor fuel quality program found MTBE in 45 percent and 34 percent, respectively, of nominally non-blended gasoline samples (MDA, 2002).

According to the Michigan Department of Agriculture (MDA, 2002), the MDEQ has established a health-based MTBE limit of 240 µg/L in drinking water, and an aesthetic threshold of 40 µg/L. MDEQ's Surface Water Quality Division found no MTBE in a preliminary investigation of surface waters. MDEQ's Drinking Water and Radiological Protection Division found no MTBE detections in any major water supply, but did report isolated cases of MTBE in private wells near to LUST sites (MDA, 2002).

In 2000, Public Act 206 declared a ban on MTBE in Michigan, effective June 1, 2003. Michigan's single internal source of MTBE, a Detroit-area refinery that supplies approximately one quarter of the State's gasoline, planned to shut down its MTBE processor on October 1, 2002, and estimated that its MTBE stocks would be depleted by November 1, 2002 (MDA, 2002).

Missouri

Four Missouri counties and the city of St. Louis began participating in the Federal RFG program in 1999. Ethanol is the favored oxygenate in Missouri; MTBE is only used in approximately three percent of the reformulated gasoline sold in the St. Louis area (MDNR, 2004a).

Missouri has established three action levels for MTBE in drinking water. The limit for long-term exposure (equivalent to an MCL) is 20 µg/L. The limit for temporary exposure, such as while a PWS is searching for an alternate supply, is 400 µg/L. For acute exposures, 1000 µg/L is considered unsafe to drink for any length of time (MDNR, 2004a).

The State of Missouri began testing for MTBE at LUST sites in 1992 and in public water supplies in 1995 (MDNR, 2004a). Between 1992 and April of 2004, the State of Missouri found MTBE in 46 public and private drinking water wells at 30 currently active sites. These include 15 wells at 13 public supplies, with MTBE concentrations ranging from 1.48 µg/L to a high of 604 µg/L. MTBE concentrations at twelve of the wells peaked at less than 15 µg/L. Of 31 private wells, 25 had MTBE concentrations higher than 20 µg/L. The highest concentration in a private well was 17,000 µg/L (MDNR, 2004b).

As of 2000, the Missouri Public Drinking Water Program counted 1,444 CWSs and 241 NTNCWSs in the State (PSTIF, 2000). Based on those numbers, the 13 MTBE-contaminated PWSs represent less than 1 percent of Missouri public water systems.

In July of 2002, Missouri adopted a partial ban of MTBE, capping concentrations of gasoline sold or stored in the State at 0.5 percent by volume. The cap goes into full effect on July 31, 2005 (USEPA, 2004c).

Nevada

MTBE has been used in some premium fuels in Nevada since 1979. Both Las Vegas and Reno began using oxygenated fuels in 1989 to reduce wintertime air pollution, even before the federal program began in 1992 (NDEP, 1998). In early years, a combination of MTBE and ethanol was used to meet the oxygenation goals. However, by 2001, both metropolitan areas were using only ethanol to fulfill their oxygenate requirement (USEPA, 2001b).

In 1998, the Nevada Department of Environmental Protection (NDEP) set an interim action limit of 20 µg/L for MTBE in ground water at sites "in close proximity to receptors [e.g., people or fauna] and/or sensitive environments." At sites with "incomplete exposure pathways," the limit is 200 µg/L (NDEP, 1998).

New Hampshire

Four counties in southeast New Hampshire voluntarily opted into the Federal RFG program. Their participation began in 1995 (NHDES, 2002). In 2000, the NHDES compared the composition of gasoline in the six counties not required to have RFG to that in the four counties selling RFG. In the four-county RFG program area, all 40 samples met the RFG oxygen content requirement (2 percent). The MTBE content in these 40 samples ranged from 3.9 percent to 14 percent by volume. In the six-county area, they found that 5 percent of gasoline samples (7 of 140) contained enough MTBE and/or other oxygenates to qualify as RFG on the basis of oxygen content. An additional 18 percent (25 samples) had higher than expected levels of MTBE (4% to 10% by volume). In general, samples with elevated oxygen content were samples of mid- and higher grade gasoline. Other commonly detected oxygenates included TAME (126 of 140 samples) and ETBE (over 70 samples). A few samples also contained di-isopropyl ether (DIPE) and tertiary butyl alcohol (TBA), but none contained ethanol or methanol (NHDES, 2000a).

In 1993, New Hampshire began requiring all 1125 community and non-transient PWSs to monitor for VOCs. However, private State-certified labs were not required to test for MTBE until 1998. By March 1999, the State was aware of MTBE detections at 195 systems, including 171 active systems. Thirty systems (24 active) had detections greater than 5 µg/L, and 9 systems (4 active) had detections greater than 20 µg/L (NESCAUM, 1999a). In May of 2000, the State of New Hampshire lowered its drinking water standard for MTBE from 70 µg/L to 13 µg/L (NHDES, 2000b).

In 2000, 27 percent of private well samples analyzed in New Hampshire contained MTBE, and 4 percent exceeded the State standard of 13 µg/L. First-time detections of MTBE in public water supplies in 2000 were three to four times higher than pre-1995 levels. Also in 2000, NHDES found that 16.8 to 23.2 percent of the public water supplies in the four-county RFG area tested positive for MTBE, compared to 1.8 to 8.8 percent of public drinking water supplies in other areas of the State. Based on findings like these, New Hampshire petitioned EPA in 2001 for permission to opt out of the RFG program (NHDES, 2002).

In May of 2004, New Hampshire enacted a partial ban that caps MTBE concentrations in gasoline at 0.5 percent by volume. The ban will take place on either January 1, 2007, or 6 months after the State gains Federal approval to opt out of the RFG program, whichever date is later. New Hampshire's ban also applies to other gasoline ethers and TBA (USEPA, 2004c). In 2005, New Hampshire confirmed January 1, 2007 as the effective date of the ban (New Hampshire, 2005).

New Jersey

Twenty-one counties in New Jersey began participating in the wintertime Oxyfuel program in late 1992, and the entire State joined the Federal RFG program in 1995. The oxyfuel program ended in 1995 for the southern counties (the Philadelphia metropolitan area) and in 1999 for the northern counties (the New York/New Jersey metro area). In New Jersey, as in most other northeastern States, MTBE was and is the oxygenate most frequently used to meet oxyfuel and RFG requirement. For at least 20 years, MTBE has also been used to boost octane in conventional gasoline, in concentrations of 2 to 8 percent in premium grades, and somewhat less in regular grades (New Jersey DEP, 2003).

Development of a health-based standard for MTBE in drinking water in New Jersey began in the mid-1980s, when concentrations as high as 81 µg/L were discovered in public water supplies. The process culminated with the establishment of a MCL of 70 µg/L in 1996. The MCL was based on the finding of increased kidney weights and possible carcinogenicity in a subchronic oral rat study. The Department of Environmental Protection (New Jersey DEP) has received some reports of taste and odor problems at wells with MTBE in concentrations below 70 µg/L (New Jersey DEP, 2003).

New Jersey has been collecting data on MTBE occurrence in public water supplies since 1997. In the first year of sampling, MTBE was found in 15 percent of community water systems and 16 percent of non-transient non-community water systems. In 400 community water systems, the highest concentration was 8.4 µg/L. In 397 non-transient non-community water systems, two had concentrations exceeding 20 µg/L, and only one exceeded the MCL of 70 µg/L. The State was only able to find obvious sources of contamination for about two thirds of the contaminated PWSs (New Jersey DEP, 2003).

New Jersey stores large amounts of fuel in USTs. New Jersey DEP estimates that the State’s 34,000 gasoline-containing USTs have an annual throughput of about 1.7 billion gallons of gasoline, including about 187 million gallons of MTBE (New Jersey DEP, 2003). New Jersey has confirmed reports of 9,383 leaking storage tanks, of which 5,558 have been cleaned up (USEPA, 2005f). The State’s Bureau of Underground Storage Tanks (BUST) reported that 80 percent of the 2,400 LUST sites with ground water cleanups had MTBE concentrations above 70 µg/L in ground water (New Jersey DEP, 2003).

The New Jersey District Office of the USGS has been gathering data on MTBE detections in New Jersey surface and ground water through several projects. A compiled summary of all New Jersey data from the Ambient Ground Water Monitoring Network as well as several special studies conducted in the State by USGS is presented in Exhibit 13-20 (NESCAUM, 1999a). Note that the data are aggregated from several studies, and in some cases multiple detections are reported from a single site. According to NESCAUM (1999a), USGS researchers concluded that atmospheric deposition could account for the relatively high frequency of low-level MTBE contamination in New Jersey, though they did not rule out migration of MTBE from distant gasoline release sites. In its own summary of findings and recommendations for the region, NESCAUM (1999b) concludes that low-level MTBE contamination in the Northeast is probably attributable to a combination of atmospheric deposition, small surface spills, and storm water runoff.

Exhibit 13-20: Detection of MTBE in Ground and Surface Waters in New Jersey

Year	No. Samples	No. Detects	Median (µg/L)	Max (µg/L)	Percent detects
Ground Water					
1998	102	35	0.19	4.1	34%
1997	183	55	0.67	30.2	30%
1996	89	34	0.21	43.8	38%
1995	23	5	0.3	2.3	22%
1994	19	3	0.5	2.1	16%
Surface Water					
1998	161	112	1.09	29	70%
1997	98	94	0.52	16	96%
1996	107	80	0.41	4.9	75%
Total					
	782	418			53%

Source: USGS data, presented in NESCAUM, 1999a
Minimum detection limits ranged from 0.5 µg/L to 0.1 µg/L.
Percent detects calculated by dividing the number of detects by the number of samples.

New York

Parts of New York have participated in both the Federal RFG program and the wintertime Oxyfuel program. Both the New York City metro area and the Syracuse area were required to use oxygenated fuel starting in 1992 as part of the Oxyfuel program. Syracuse was released from the requirement in 1993 and New York City in 2000 (USEPA, 2001b). As of February 2004, thirteen counties were participating in the Federal RFG program (USEPA, 2005b).

New York did not require testing for MTBE until July 1998. Now, the New York State Department of Health requires MTBE information from ground water suppliers serving over 10,000 people. Additionally, New York State's Wadsworth Laboratories performs compliance monitoring for small PWSs. Sampling at Wadsworth is not representative of the entire State, but results of PWS samples from 1996 to 1998 are presented in Exhibit 13-21 (NESCAUM, 1999a).

Exhibit 13-21: MTBE in Public Water Systems Samples analyzed by Wadsworth Laboratory in New York

Year	No. Samples	No. Detects	Percent Detects	No. Detects > 10 µg/L	Maximum (µg/L)
1996	282	5	1.8%	5	66
1997	404	17	4.2%	1	17
1998	381	16	4.2%	3	33

Note: The minimum detection limit was 10 µg/L in 1996, either 1 or 10 µg/L in 1997, and 1 µg/L in 1998.
The data included multiple samples from some wells.
Source: NESCAUM, 1999a

One study provides an idea of contamination in private wells in New York. Lince *et al.* (2001) sampled 74 private wells near 21 gasoline stations in New York State, plus 21 control wells. Twenty-eight percent of the 74 study wells had MTBE in concentrations at or above the practical quantitation limit of 1 µg/L. The mean concentration was 12 µg/L, and the highest concentration was 61 µg/L. Seven percent of wells had concentrations between 20 and 49 µg/L, and 3 percent had concentrations of 50 µg/L or higher. Five percent of the control wells (1 well) exceeded 1 µg/L. Detections greater than 1 µg/L were more frequent in wells near stations selling reformulated gasoline (38 percent) than near stations selling conventional gasoline (20 percent) (Lince *et al.*, 2001).

In May of 2000, New York State adopted a complete ban of MTBE. The ban became effective January 1, 2004 (USEPA, 2004c).

Washington

Of the three urban areas initially regulated under the wintertime Oxyfuel program, the Seattle and Vancouver vicinities gained exemption from the program in 1996. The third area, Spokane, uses ethanol to meet its oxygenated fuel requirement (USEPA, 2001b). No part of Washington has ever participated in the RFG program (USEPA, 2005b). Washington's Department of Ecology (Washington DOE) has documented the use of MTBE as a fuel oxygenate in the State on only one occasion (Washington DOE, 2000).

A 2000~~,~~ Washington DOE conducted a study of MTBE contamination in ground water. As of May 2000, Washington had 6,000 regulated LUST sites, of which 1,900 (32 percent) had reportedly impacted ground water. Washington DOE chose 70 geographically representative sites from among the 1,900, and took one monitoring well sample from each. DOE found that 26 sites (42 percent) had detections at or above 1 µg/L and 24 percent had concentrations above 20 µg/L. The highest concentration was 7,150 µg/L. The median concentration of all samples at or exceeding 1 µg/L was 13 µg/L. A measured occurrence rate of 42 percent suggests that over 800 LUST sites might be point sources responsible for MTBE contamination of ground water in the State. However, Washington DOE notes that due to limitations of the study (e.g., sampling of only well per site, irregular quantitation limits, 80% of releases occurred five or more years previously, location of monitoring wells), the actual number might be much higher (Washington DOE, 2000).

The ground water clean-up level established by the State of Washington for MTBE is 20 µg/L (NEIWPCC, 2003). In May of 2001, the State legislature approved a partial ban of MTBE starting January 1, 2004. MTBE may not intentionally be added to fuel or knowingly mixed in gasoline to concentrations above 0.6 percent by volume (USEPA, 2004c).

13.3.6 State MTBE Regulations

At least 25 States have instituted partial or complete bans on MTBE. See Exhibit 13-22 for a list of such States and their phase-out dates.

Exhibit 13-22: State Actions Banning MTBE

State	Effective Date	Extent of MTBE Ban
Arizona	January 1, 2005	0.3% max volume in gasoline
California	December 31, 2003	complete ban in gasoline
Colorado	April 30, 2002	complete ban in gasoline
Connecticut	January 1, 2004	complete ban in gasoline
Illinois	July 24, 2004	0.5% max volume in gasoline
Indiana	July 24, 2004	0.5% max volume in gasoline
Iowa	July 1, 2000	0.5% max volume in gasoline
Kansas	July 1, 2004	0.5% max volume in gasoline
Kentucky	January 1, 2006	0.5% max volume in gasoline
Maine	January 1, 2007	0.5% max volume in gasoline
Michigan	June 1, 2003	complete ban in gasoline
Minnesota	July 2, 2005	complete ban in gasoline (following partial ban in 2000)
Missouri	July 1, 2005	0.5% max volume in gasoline
Montana	January 1, 2006	no more than trace amounts in gasoline
Nebraska	July 13, 2000	1% max volume in gasoline
New Hampshire	January 1, 2007	0.5% max volume in gasoline
New Jersey	January 1, 2009	0.5% max volume in gasoline
New York	January 1, 2004	complete ban in gasoline
North Carolina	January 1, 2008	0.5% max volume in gasoline
Ohio	July 1, 2005	0.5% max volume in gasoline
Rhode Island	June 1, 2007	0.5% max volume in gasoline
South Dakota	July 1, 2001	0.5% max volume in gasoline
Vermont	January 1, 2007	0.5% max volume in gasoline
Washington	January 1, 2004	0.6% max volume in gasoline
Wisconsin	August 1, 2004	0.5% max volume in gasoline

Source: This table is adapted from USEPA, 2004c and McCarthy and Tiemann, 2005. It has been further updated as more recent information has become available in the media. For current information, see individual State regulations. See also: http://www.epa.gov/ATHENS/research/regsupport/gasoline/mtbe.pdf.

In 2003, the NEIWPCC conducted a survey of MTBE contamination at LUST sites in the States. All 50 States replied to the survey, though not all States responded to every question. Forty-two States reported that they had action levels, cleanup levels, or drinking water standards for MTBE. Of these, 23 States had soil action levels, 27 had soil cleanup levels, 31 had ground water action levels, and 34 had ground water cleanup levels. Eleven States had established primary drinking water standards for MTBE (See Exhibit 13-23). Four of these States had standards below 20 µg/L, and another four had standards in EPA's health advisory range for organoleptic (taste and odor) effects (20 µg/L to 40 µg/L). The remaining primary drinking water standards were 50 µg/L, 70 µg/L, and 240 µg/L. Seven States had established secondary drinking water standards for MTBE, ranging from 5 µg/L to 400 µg/L. Eleven States had adopted EPA's drinking water advisory level (range of 20-40 µg/L, based on organoleptic effects), and thirteen States had established health advisory levels of their own, ranging from 20 µg/L to 200 µg/L (NEIWPCC, 2003).

Exhibit 13-23 State Primary Drinking Water Standards

State	Primary Drinking Water Standard
California	13 µg/L
Colorado	15 µg/L
Delaware	10 µg/L
Maine	35 µg/L
Mississippi	240 µg/L
Missouri	20 µg/L
New Hampshire	13 µg/L
New Jersey	70 µg/L
New York	50 µg/L
Oregon	20 µg/L
Vermont	40 µg/L

Source: NEIWPCC, 2003

Note: Two additional States, Illinois and Kansas, are listed by NEIWPCC as having primary drinking water standards, but apparently in error, as no numerical value for either standard is provided. Since this table is based on information collected in 2003, it is not guaranteed to be current. For the most up-to-date information and complete details, see State regulations.

In 2000, according to an earlier NEIWPCC survey, 20 of 38 responding States had established action levels for MTBE in soil, 28 had soil clean-up levels, 26 had action levels for MTBE in ground water, and 32 had ground water clean-up levels (NEIWPCC, 2000). In 2003, with all 50 States responding, the numbers were: 23 States with soil action levels, 27 with soil clean-up levels, 31 with ground water action levels, and 34 with ground water clean-up levels (NEIWPCC, 2003).

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