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Environmental Protection
Agency

Contaminant Occurrence Support Document for Category 1 Contaminants for the Second Six-Year Review of National Primary Drinking Water Regulations

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Disclaimer

This report is in support of the preliminary revise/take no action decisions for EPA's second Six-Year Review of Existing Drinking Water Standards Federal Register Notice. This report is intended to provide technical background for the second Six-Year Review.

This document is not a regulation itself, and it does not substitute for the Safe Drinking Water Act (SDWA) or EPA's regulations. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Acknowledgements

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EPA would like to thank the many states, territories, and tribes and their staff who contributed data sets and valuable advice during EPA's compilation and review of the contaminant occurrence (compliance monitoring) data. Thank you also to the many public water systems and their staff who conducted the monitoring that provided the extensive amount of regulated contaminant occurrence data used in this report.

Executive Summary

This document provides occurrence-related background information on 22 regulated drinking water contaminants in support of the Environmental Protection Agency's (EPA's) second Six-Year Review of National Primary Drinking Water Regulations (the "second Six-Year Review"). These 22 contaminants are referred to as "Category 1 contaminants" based on their: relatively high rates of occurrence at or near concentration thresholds of concern; new or ongoing health effects assessments; and potential new laboratory analytical capabilities. The 22 Category 1 contaminants are: benzene, carbofuran, carbon tetrachloride, chlordane, 1,2-dibromo-3-chloropropane, 1,2-dichloroethane, dichloromethane, 2,4-dichlorophenoxyacetic acid, 1,2-dichloropropane, endothall, heptachlor, heptachlor epoxide, hexachlorobenzene, hexachlorocyclopentadiene, oxamyl, tetrachloroethylene, toluene, toxaphene, 1,1,2-trichloroethane, trichloroethylene, vinyl chloride, and xylenes (total).

This support document is divided into contaminant-specific chapters. The individual contaminant chapters include background information (regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, an overview of occurrence in ambient water, and national estimates of contaminant occurrence in public drinking water systems.

The national drinking water occurrence estimates presented here are based on the data contained in the National Compliance Monitoring Information Collection Request Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"), which includes data collected from 1998 to 2005. This is the largest and most comprehensive drinking water contaminant dataset ever compiled by EPA's Drinking Water Program and includes 15 million records for 69 regulated contaminants submitted by 47 states/primacy agencies (45 states plus Region 8 and Region 9 tribes). Using this dataset, a variety of occurrence estimates were generated to characterize the national occurrence of regulated contaminants in public water systems (PWSs).

National occurrence estimates using the Six Year Review-ICR Dataset were generated using a two-stage analytical approach. In the first stage (Stage 1 analysis) the data were reviewed and quality-checked to ensure high quality and were then analyzed to generate simple, non-parametric estimates of contaminant occurrence. The Stage 1 analysis, based on maximum sample concentration values, is inherently conservative; it is designed not to underestimate occurrence and is therefore protective of public health. Simple counts are made of the number of systems, and populations served by those systems, with at least one sample analytical result (measured contaminant concentration) above a specified concentration threshold. The second stage (Stage 2 analysis) is based on estimated system mean concentrations of contaminants. Because it uses estimated mean concentrations rather than maximum sample concentrations, Stage 2 analysis is less conservative than the Stage 1 analysis. The Stage 2 analysis also provides occurrence assessments that may be more reflective of potential chronic exposure.

For the Stage 1 analyses, contaminant occurrence data were analyzed in several different ways to more fully characterize national occurrence. One measure is the percentage of systems with at least one sample detection of a contaminant. Using this measure, a wide range of occurrence was found among the 22 Category 1 contaminants assessed. Percentages ranged from a high of 7.592% of systems with at least one detection of xylenes to a low of 0.132% of systems with at least one toxaphene detection. The five Category 1 contaminants with the highest rates of occurrence nationally are xylenes (found in 7.592% of systems), toluene (5.764%), dichloromethane (3.903%), tetrachloroethylene (2.502%), and trichloroethylene (2.009%). (Both percentage and absolute system and populations-served numbers are presented in the report.) These detections represent single detections and are not representative of Maximum Contaminant Level (MCL) violations.

A related but different Stage 1 measure (a preliminary estimate of potential drinking water exposure to a contaminant), is estimated as the percent of the population-served by systems with at least one sample detection of a particular contaminant. Based on this measure, the five contaminants with the highest rates of occurrence or potential exposure are xylenes (17.480% of the population-served by systems had at least one detection), dichloromethane (16.542%), tetrachloroethylene (14.076%), toluene (13.215%), and trichloroethylene (13.018%). The size distribution of systems with detections influences the size of the potentially exposed population. (For example, a small number of very large systems with contaminant detections will result in a higher potentially exposed population than will a larger number of small systems with detections). These detections represent single detections and are not representative of chronic or long-term exposure.

In addition to characterizing the rates of contaminant occurrence, the Stage 1 analysis can provide information regarding the degree of contaminant occurrence by comparing data to an important health concentration threshold such as a contaminant's MCL. The percentage of systems with at least one sample detection greater than a contaminant's MCL concentration ranged from a high of 0.481% for tetrachloroethylene to a low of 0.000% for carbofuran, hexachlorocyclopentadiene, and xylenes. The five Category 1 contaminants with the highest Stage 1 occurrence relative to the MCL concentration are tetrachloroethylene (0.478%), 1,2-dibromo-3-chloropropane (0.388%), trichloroethylene (0.387%), dichloromethane (0.293%), and benzene (0.125%). These detections represent single detections greater than the MCL concentration and do not always represent a MCL violation.

A preliminary estimate of drinking water exposure is given by the percentage of the population-served by systems with at least one sample detection greater than an MCL concentration. Using this measure, the five Category 1 contaminants with the highest occurrence/potential exposure are tetrachloroethylene (6.448% of population), trichloroethylene (5.264%), carbon tetrachloride (2.189%), 1,2-dibromo-3-chloropropane (1.627%), and dichloromethane (1.298%).

The Stage 2 analysis, based on estimated contaminant mean concentrations (rather than the Stage 1 sample maximum concentration analyses), provides similar though not identical lists of more frequently occurring contaminants. The percentages of systems with estimated contaminant mean concentrations greater than the MCL concentrations ranged from a high of 0.112% for 1,2-dibromo-3-chloropropane to a low of 0.000% for carbofuran, 2,4-dichlorophenoxyacetic acid, endothall, hexachlorocyclopentadiene, 1,2-dichloropropane, oxamyl, 1,1,2-trichloroethane, and xylenes. Based on this measure, the five Category 1 contaminants with the highest occurrence are 1,2-dibromo-3-chloropropane (0.112%), trichloroethylene (0.050%), tetrachloroethylene (0.046%), dichloromethane (0.026%), and benzene (0.020%).

Similar to Stage 1 analysis, Stage 2 analysis allows for preliminary exposure assessments based on the percentages of the population-served by systems with estimated contaminant mean concentrations greater than the MCL concentration. Using this measure, the five Category 1 contaminants with the highest occurrence/exposure are tetrachloroethylene (0.277% of the population), trichloroethylene (0.181%), toxaphene (0.014%), 1,2-dibromo-3-chloropropane (0.013%), and benzene (0.006%).

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Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWS	Community Water System
DBCP	1,2-Dibromo-3-chloropropane
EPA	Environmental Protection Agency (United States)
EPCRA	Emergency Planning and Community Right-to-Know Act
EPHT	Environmental Public Health Tracking Program
EXTOXNET	EXtension TOXicology NETwork
FDA	Food and Drug Administration
IARC	International Agency for Research on Cancer
ICR	Information Collection Request
IUR	Inventory Update Reporting
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
Mg	milligram
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
MRL	Minimum Reporting Level
NAWQA	National Water Quality Assessment
NLM	National Library of Medicine
NPDWR	National Primary Drinking Water Regulation(s)
NTNCWS	Non-Transient Non-Community Water System
NWIS	National Water Information System
OGWDW	Office of Ground Water and Drinking Water
PDP	Pesticide Data Program
Ppb	parts per billion

Ppm	parts per million
PVC	Polyvinyl chloride
PWS	Public Water System
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RSC	Relative Source Contribution
SARA	Superfund Amendments and Reauthorization Act
SOC	Synthetic Organic Chemical
SRP	Scientific Review Panel
TOXNET	TOXicology Data NETwork
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound
µg	micrograms
µg/kg/day	micrograms per kilogram per day
µg/kg/year	micrograms per kilogram per year
µg/L	microgram per liter
$\mu g/m^3$	micrograms per cubic meter

1 Introduction

1.1 Purpose and Scope

The Environmental Protection Agency (EPA) performed a detailed review of compliance monitoring data of 69 National Primary Drinking Water Regulations (NPDWR) in support of the second Six-Year Review. This document summarizes contaminant occurrence information for 22 of those regulated contaminants. These 22 contaminants represent the “Category 1” contaminants which are those contaminants with relatively high levels of occurrence at or near concentration thresholds of concern, new or ongoing health effects assessments, and new potential laboratory methods capabilities. The remaining 47 were classified as “Category 2” contaminants (contaminants that meet some, but not all, of the occurrence, health effects, or laboratory methods criteria defining the Category 1 contaminants). The occurrence estimates reported are based on the National Compliance Monitoring Information Collection Request Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). The Six Year Review-ICR Dataset contains compliance monitoring data from 1998 to 2005. This dataset is the largest and most comprehensive compliance monitoring dataset ever compiled by EPA’s Drinking Water Program, and includes 15 million records for 69 regulated contaminants submitted by 47 states/primacy agencies (45 states plus Region 8 and Region 9 tribes). Using this dataset, a two-stage analytical approach was employed to estimate a variety of occurrence measures to characterize the national occurrence of regulated contaminants in public water systems (PWSs) to support the second Six-Year Review process.

This support document is organized so that information on one contaminant is presented in each chapter. This introductory Chapter 1 presents general background information applicable to all contaminants. This chapter includes a description of the information and data sources used for this assessment as well as the analytical approach used to estimate national contaminant occurrence from the compliance monitoring data. To provide regulatory context, the Six-Year Review process is also briefly described.

Chapters 2 through 23 present information specific to each of the Category 1 regulated drinking water contaminants that EPA is reviewing under this second Six-Year Review. The Table of Contents provides a list of the Category 1 contaminants included in the chapters in this report. (The contaminant chapters are arranged alphabetically.)

Each chapter includes a brief presentation of the contaminant’s uses, production, environmental releases, and occurrence in ambient water. Detailed information is then provided for a contaminant’s occurrence in drinking water and related information is given regarding preliminary exposure estimates (estimates of the populations-served by PWSs found to have contaminants occurring in their drinking water samples). USEPA (2009a) provides similar information for the Category 2 contaminants. For a complete description and presentation of all estimates of contaminant occurrence generated in support of the second Six-Year Review (for Category 1 and 2 contaminants), please refer to the accompanying report *The Analysis of the*

Regulated Contaminant Occurrence Data from Public Water Systems in Support of the Second Six-Year Review of National Primary Drinking Water Regulations (USEPA, 2009b).

1.2 The Six-Year Review Process

EPA's Office of Ground Water and Drinking Water (OGWDW) is responsible for implementing the provisions of the Safe Drinking Water Act (SDWA). The 1996 SDWA amendments require EPA to review existing NPDWRs no less often than every six years and, if appropriate, revise them. As long as an NPDWR revision maintains or provides for greater protection of public health, the SDWA 1996 amendments give the EPA Administrator discretion to determine if revision is appropriate. EPA believes any revision must continue to meet the basic statutory requirements of the SDWA (e.g., generally setting the maximum contaminant level (MCL) as close to the maximum contaminant level goal (MCLG) as is feasible). EPA also believes any revision must present significant opportunities to improve the level of public health protection and/or to achieve cost savings while maintaining or improving the level of public health protection. The Six-Year Review process evaluates the contaminant occurrence, health effects, analytical methodology, and treatment technology factors relevant to this formal re-assessment of each NPDWR. This support document presents information relevant to contaminant occurrence.

During the first Six-Year Review, EPA developed a protocol document — *EPA Protocol for the Review of Existing National Primary Drinking Water Regulations* (USEPA, 2003a) and updated USEPA (2009c) for the current review cycle — to describe the process and strategy for review that EPA will use to meet its statutory requirement. To most efficiently utilize limited resources, EPA conducts a series of analyses at the beginning of each Six-Year Review cycle, intended to target those NPDWRs that are the most appropriate candidates for revision. EPA uses available, scientifically sound data to make decisions regarding whether or not to revise a regulation. EPA reviews the following key information to make decisions regarding regulatory changes: current health risk assessments, technology assessments (including reviews of laboratory analytical methods and treatment techniques), and occurrence and exposure assessments.

EPA will consider regulatory revisions based on the various components of each primary drinking water regulation, including possible changes to MCLs, MCLGs, treatment techniques, analytical method and treatment capabilities. In some cases, EPA may also consider revisions to monitoring or system reporting requirements as part of the Six-Year Review; however, in most cases, these types of revisions will be considered through other vehicles. For any NPDWR that is a potential candidate for revision based on its review, EPA will also take economic considerations into account before making its "revise/no action" decision. Moreover, EPA will apply basic risk management principles to determine whether these candidate regulations warrant regulatory revision to ensure that any revision will present a meaningful opportunity to improve the level of public health protection and/or present a meaningful opportunity for cost savings while maintaining, or improving, the level of public health protection.

1.3 Data Sources

Several data sources were used in this report to provide information on contaminant use, production, occurrence, and potential exposure. The primary data source used for contaminant background and use information was the Agency for Toxic Substances and Disease Registry (ATSDR). The Toxics Release Inventory (TRI) provided data on contaminant releases. Production data were obtained from the Toxic Substances Control Act (TSCA) Chemical Substance Inventory. Information on contaminant occurrence in ambient water was primarily derived from the United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) Program. Drinking water contaminant occurrence analyses are generated using state drinking water compliance monitoring contaminant occurrence data that EPA obtained from 45 states and 2 Primacy Entities (the “Six-Year Review-ICR Dataset”). This dataset is the largest compliance monitoring data set compiled and analyzed to date by EPA’s Drinking Water Program. These primary data sources are described in detail in the subsequent sections of this chapter. The information from and the analyses generated using these data sources are summarized in the contaminant-specific chapters of this report.

1.3.1 Agency for Toxic Substances and Disease Registry

In 1980, Congress created the ATSDR to implement the health-related sections of laws that protect the public from hazardous wastes and environmental spills of hazardous substances (ATSDR, 2001). The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as the “Superfund” Act, provided the Congressional mandate to remove or clean up abandoned and inactive hazardous waste sites and to provide federal assistance in toxic emergencies. As the lead agency within the Public Health Service for implementing the health-related provisions of CERCLA, ATSDR is charged under the Superfund Act to assess the presence and nature of health hazards at specific Superfund sites, to help prevent or reduce further exposure and the illnesses that result from such exposures, and to expand the knowledge base about health effects from exposure to hazardous substances (ATSDR, 2001).

In the 1984 amendments to the Resource Conservation and Recovery Act of 1976 (RCRA), which provides for the management of legitimate hazardous waste storage or destruction facilities, ATSDR was authorized to conduct public health assessments at these sites, when requested by EPA, states, or individuals. ATSDR was also authorized to assist EPA in determining which substances should be regulated and the levels at which substances may pose a threat to human health (ATSDR, 2001).

With the passage of the Superfund Amendments and Reauthorization Act of 1986 (SARA), ATSDR received additional responsibilities in environmental public health. This act broadened ATSDR’s responsibilities in the areas of public health assessments, establishment and maintenance of toxicological databases, information dissemination, and medical education (ATSDR, 2001).

ATSDR issues Toxicological Profiles for over 250 substances, including 18 of the 22 contaminants discussed in this report. These profiles contain exhaustive reports on the substances' health effects, chemical and physical properties, use and production, potential for human exposure, and analytical methods. Whenever available, ATSDR was used as a primary source in this report for contaminant background and use information.

1.3.2 Extension Toxicology Network

The EXtension TOXicology NETwork (EXTOXNET) is a cooperative effort of University of California-Davis, Oregon State University, Michigan State University, Cornell University, and the University of Idaho (EXTOXNET, 2008). Primary files are maintained and archived at Oregon State University. The EXTOXNET InfoBase provides a variety of information about pesticide toxicology and environmental chemistry. These include: discussions of toxicological issues of concern; toxicology newsletters; other resources for toxicology information; toxicology fact sheets; Pesticide Information Profiles; and Toxicology Information Briefs. Pesticide Information Profiles were used to provide background information for some of the Category 1 contaminants. Pesticide Information Profiles are not based on an exhaustive literature search. The information does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements.

1.3.3 United States Geological Survey Pesticide Use Maps

The USGS has produced maps of pesticide use for 244 compounds used in United States crop production, 4 of which are Category 1 contaminants discussed in this report.. The pesticide use maps show the average annual pesticide use intensity expressed as average weight (in pounds) of a pesticide applied to each square mile of agricultural land in a county. The maps presented in this report were created by the USGS using state-level estimates of pesticide use rates for individual crops that were compiled by the CropLife Foundation, Crop Protection Research Institute based on information collected during 1999 through 2004, combined with county-level data on harvested crop acreage obtained from the 2002 Census of Agriculture. The maps do not represent a specific year, but rather show typical use patterns (i.e., average annual pesticide use) over the five year period of 1999 through 2004. Use intensity rates are expressed as the pounds applied per square mile of mapped agricultural land in a county (USGS, 2007).

USGS (2007) notes several key limitations of the data used to produce these maps. For instance, the estimates of applied pesticides are averaged at the state-level, while the maps extrapolate to the county-level by using county crop acreages from the Census of Agriculture. Consequently, the maps do not truly represent the local variability of cropping and management practices found within many states. Furthermore, the 2002 Census of Agriculture may not have represented all crop acreage, nor included all types of pasture. The maps are not intended for making local-scale estimates of pesticide use, such as estimates at the county-level (USGS, 2007).

1.3.4 Toxic Substances Control Act Chemical Substance Inventory

Information on chemicals manufactured in or imported into the United States and listed on the TSCA Chemical Substance Inventory is collected periodically by EPA. This collection commenced following the promulgation of the Inventory Update Reporting (IUR) regulation in 1986. The 1986 regulation required chemical manufacturers and importers to report to EPA every four years the identity of, and basic manufacturing information for, chemical substances manufactured and imported annually in quantities of 10,000 pounds or more (USEPA, 2003b).

Under the TSCA, companies that manufacture or import chemicals may be required to report information about these chemicals including, the identity of the chemicals, the amounts manufactured or processed, certain details about their manufacture, and other data. This information is stored in EPA's TSCA Chemical Substance Inventory Update System and is used by EPA and other government agencies to identify potential use and exposure scenarios so that they may protect human health and the environment (USEPA, 2003b).

EPA requires that chemical manufacturers periodically update their information in the TSCA Chemical Substance Inventory because the chemicals used in the United States may change and the quantity manufactured and industrial, commercial, and consumer uses of a chemical may change. In order to accomplish this update, EPA periodically holds an Inventory Update Reporting cycle. Inventory data are currently available for years 1986, 1990, 1994, 1998, and 2002. TSCA Inventory data are available for 15 of the 22 contaminants discussed in this report (USEPA, 2003b).

1.3.5 Toxics Release Inventory

EPA established the TRI in 1987 in response to Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA). EPCRA section 313 requires facilities to report to both EPA and the states annual information on toxic chemical releases from facilities that meet reporting criteria. This reported information is maintained in a database accessible through TRI Explorer (http://www.epa.gov/triexplorer). In 1990 Congress passed the Pollution Prevention Act, which required that additional data on waste management and source reduction activities be reported under TRI. The TRI database details not only the types and quantities of toxic chemicals released to the air, water, and land by facilities, but also provides information on the quantities of chemicals sent to other facilities for further management (USEPA, 2002 and 2003c). Today, TRI includes information on releases of nearly 650 chemicals (including 19 of the 22 contaminants discussed in this report).

Although TRI can provide a general idea of release trends, it has limitations. For example, not all facilities are required to report all releases. Facilities are required to report releases if they manufacture or process more than 25,000 pounds or use more than 10,000 pounds of a substance. Reporting requirements have changed over time (e.g., reporting thresholds have decreased); this creates the potential for misleading data trends over time (USEPA, 1996). TRI data are meant to reflect releases and should not be used to estimate general public exposure to a chemical (USEPA, 2002).

1.3.6 National Water Quality Assessment

Lakes, rivers, and aquifers are the sources of most drinking water. The USGS NAWQA program is a national-scale assessment of the occurrence of contaminants in surface and ground water. Monitoring contaminant occurrence in these ambient waters provides information for the potential for contaminants to adversely affect drinking water supplies and drinking water.

The USGS instituted the NAWQA program in 1992 to examine ambient water quality status and trends in the United States. The NAWQA program is designed to apply nationally consistent methods to provide a consistent basis for comparisons among study basins across the country and over time. These occurrence assessments serve to facilitate interpretation of natural and anthropogenic factors affecting national water quality. For more detailed information on the NAWQA program design and implementation, please refer to Leahy and Thompson (1994) and Hamilton *et al.* (2004).

The NAWQA program conducts monitoring and water quality assessments in significant watersheds and aquifers referred to as “study units.” The program’s sampling approach is not “statistically” designed (i.e., it does not involve random sampling), but it provides a representative view of the nation’s waters in its coverage and scope. Together, the 51 study units monitored between 1992 and 2001 include the aquifers and watersheds that supply more than 60% of the nation’s drinking water and water used for agriculture and industry. The NAWQA program monitors the occurrence of chemicals such as pesticides, nutrients, volatile organic compounds (VOCs), trace elements, and radionuclides, and the condition of aquatic habitats and fish, insects, and algal communities (NRC, 2002; Hamilton *et al.*, 2004). NAWQA has collected data from over 6,400 surface water and 7,000 ground water sampling points.

Monitoring of study units occurs in stages. Between 1992 and 2001, approximately one-third of the study units at a time were studied intensively for a period of three to five years, alternating with a period of less intensive research and monitoring that lasted between five and seven years. Thus, all participating study units rotated through intensive assessment in a ten-year cycle (Leahy and Thompson, 1994). The first ten-year cycle was designated Cycle 1. Summary reports are available for the 51 study units that underwent intensive monitoring in Cycle 1 (USGS, 2001). Cycle 2 monitoring is scheduled to proceed in 42 study units from 2002 to 2012 (Hamilton *et al.*, 2004).

Pesticide National Synthesis Project

The NAWQA Pesticide National Synthesis Project is a national-scale assessment of the occurrence and behavior of pesticides in streams and ground water of the United States and the potential for pesticides to adversely affect drinking water supplies or aquatic ecosystems.

Results from the most recent Pesticide National Synthesis analysis, based on complete Cycle 1 (1992-2001) data from NAWQA study units, are posted on the NAWQA Pesticide National Synthesis website (Gilliom *et al.*, 2007). Data for surface water and ground water are presented separately, and results in each category are subdivided by land use category. Land use categories include agricultural, urban, mixed (deeper aquifers of regional extent in the case of ground water), and undeveloped. The National Synthesis analysis for pesticides is a first step toward the USGS goals of describing the occurrence of pesticides in relation to different land use and land management patterns, and developing a deeper understanding of the relationship between spatial occurrence of contaminants and their fate, transport, persistence, and mobility characteristics.

The surface water summary data presented in the Pesticide National Synthesis (Gilliom *et al.*, 2007) only includes stream data. Sampling data from a single one-year period, generally the year with the most complete data, were used to represent each stream site. Sites with fewer data or significant gaps were excluded from the analysis. NAWQA stream sites were sampled repeatedly throughout the year to capture and characterize seasonal and hydrologic variability. In the National Synthesis analysis, the data were time-weighted to provide an estimate of the annual frequency of detection and occurrence at a given concentration (Gilliom *et al.*, 2007). For instance, the detection frequency can be thought of as the percent of the year in which detections are found at a typical site in this land use category and the 95th percentile concentration can be thought of as a concentration that is not exceeded for 95% of the year at a typical site in this land-use category.

The Pesticide National Synthesis only analyzed ground water data from wells; data from springs and agricultural tile drains were not included. The sampling regimen used for wells was different than that for surface water. In the National Synthesis analysis (Gilliom *et al.*, 2007), USGS uses a single sample to represent each well, generally the earliest sample with complete data for the full suite of analytes.

EPA Summary Analysis of NAWQA Study Unit Monitoring Results

Whereas 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 (1992 to 2001) for many of the regulated contaminants. EPA's analysis of the NAWQA data is analogous to the simple, straight-forward Stage 1 analysis the agency performed on drinking water data from PWS compliance monitoring. That is, all the occurrence data for a particular contaminant were compiled and analyzed using non-parametric methods to yield simple summary statistics to characterize contaminant occurrence.

All surface water data were included in the EPA summary analysis. For ground water, all well data were used; however, as with the USGS National Pesticide Synthesis, data from springs and drains were excluded. For each contaminant, EPA calculated detection frequencies simply as the percentage of samples and the percentage of sites with at least one detection. (A detection is an analytical result equal to or greater than the reporting limit.) EPA used USGS data without any censoring or weighting. From samples with detections a number of descriptive statistics were also calculated, including the minimum, median, 95th percentile, 99th percentile, and maximum concentrations. Reporting limits varied over time during the NAWQA program. The highest reporting limit used for each contaminant is presented with the results of the analysis. Note that because reporting limits varied, the minimum concentration reported as a detection can be lower than the highest reporting limit.

1.3.7 National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (Six-Year Review-ICR Dataset)

Because there existed no national database of complete public drinking water compliance monitoring data (all public drinking water contaminant sample results for analytical detections and non-detections), EPA conducted a voluntary data call-in for states' compliance monitoring records. These compliance monitoring data are the contaminant occurrence data collected under the SDWA as part of the program to maximize compliance with federal public drinking water standards. These data are collected by PWSs and reported to the states. EPA received compliance monitoring data from a total of 51 states/primacy agencies: 46 states, American Samoa, Washington, D.C., Region 8 tribes, Region 9 tribes, and the Navajo Nation.[1] Through extensive data management efforts, quality assurance evaluations, and communications with state/primacy agency data management staff, EPA established the Six-Year Review-ICR Dataset. This high quality, national contaminant occurrence database consists of data from 47 states/primacy agencies (see Exhibit 1-1 below). The data received from American Samoa, Washington, D.C., and the Navajo Nation could not be included in the second Six-Year Review data analyses because those data sets were in significantly different formats. The data from Kansas were received after the data assessment and quality assurance measures were completed and were not able to be included in this occurrence analysis.

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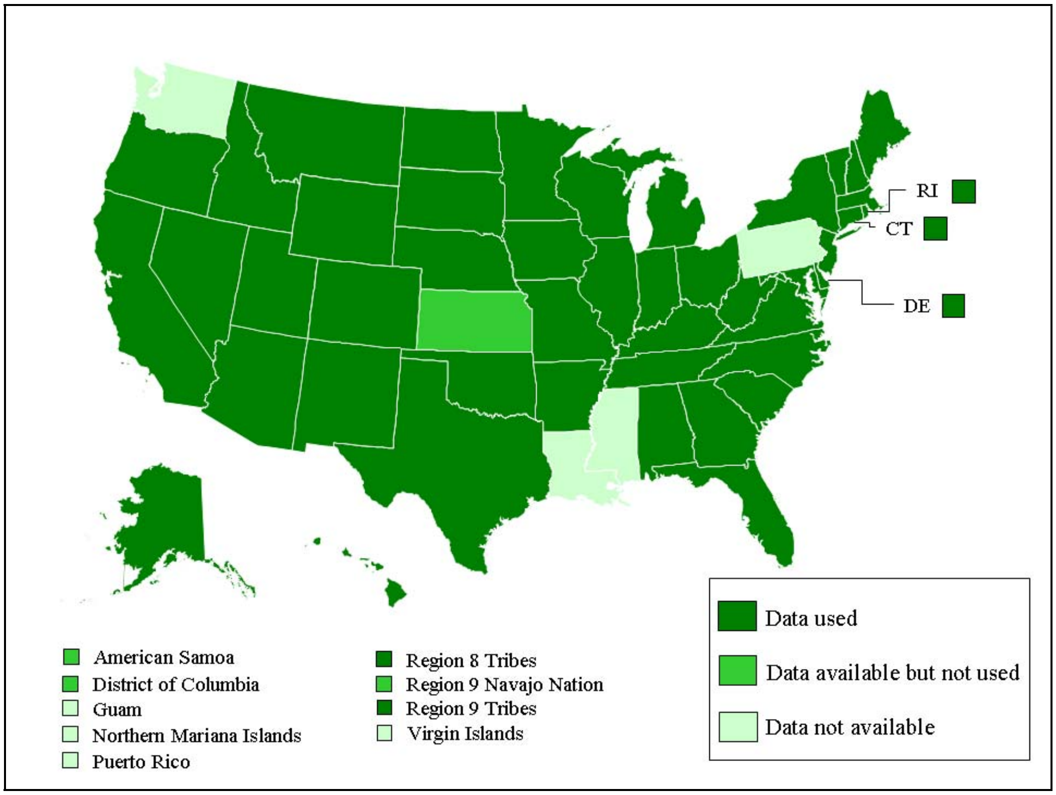
[1] Upon request, Regions 8 and 9 provided a crosswalk table that listed the state in which each tribal water system was located. All analyses conducted at the state-level (e.g., maps illustrating the geographic distribution of occurrence) present the tribal systems' data along with the state in which they are located.

Exhibit 1-1. States with Compliance Monitoring Data Included in the Six-Year Review-ICR Dataset



The contaminant occurrence data from these 47 states/primacy agencies (45 states plus Region 8 Tribes and Region 9 Tribes) comprise more than 15 million analytical records from approximately 132,000 PWSs. Approximately 254 million people are served by these PWSs nationally. The Six-Year Review-ICR Dataset is the largest, most comprehensive set of compliance monitoring data ever used by EPA's Drinking Water Program.

Data quality, completeness, and representativeness are key considerations for the dataset. Given the intended use of this national dataset as well as the size, scope, and variety of formats of the constituent data sets received from the states, EPA conducted extensive data management and quality assurance/quality control (QA/QC) assessments on the data to be included in the Six-Year Review-ICR Dataset. For a review of the completeness and representativeness of the data set, refer to USEPA (2009b). USEPA (2009b) also presents details of the tasks conducted for data management (establishing consistent formats across the numerous state data sets, setting uniform analytical results units, addressing non-numerical non-detection values, etc.) and data quality checks (addressing incorrect analytical units, outlier values, etc.). Exhibit 1-2 summarizes the Six-Year Review-ICR data for each contaminant used to generate the occurrence estimates presented in this report.

Exhibit 1-2. Overview of the Contaminant Occurrence Data in the Six-Year Review-ICR Data Set for the Category 1 Contaminants

Contaminant (MCL)	Number of States with Data	Total Number of Records	Total Number of Systems	Total Population-Served by Systems	MRL
Synthetic Organic Chemicals (SOCs)[1]					
Carbofuran (40 µg/L)	45	114,142	31,097	167,973,342	0.9 µg/L
Chlordane (2 µg/L)	44	128,453	31,841	182,036,975	0.2 µg/L
2,4-Dichlorophenoxyacetic acid (2,4-D) (70 µg/L)	43	124,285	33,187	187,451,183	0.1 µg/L
1,2-Dibromo-3-chloropropane (0.2 µg/L)	44	231,169	37,618	193,749,339	0.6 µg/L
Endothall [2] (100 µg/L)	38	49,820	14,156	118,536,801	9 µg/L
Heptachlor (0.4 µg/L)	44	133,726	33,020	184,443,784	0.04 µg/L
Heptachlor Epoxide (0.2 µg/L)	44	134,708	33,015	184,477,775	0.02 µg/L
Hexachlorobenzene (1 µg/L)	44	135,512	32,826	184,124,823	0.1 µg/L
Hexachlorocyclopentadiene (50 µg/L)	44	135,290	32,801	184,738,430	0.1 µg/L
Oxamyl (200 µg/L)	45	113,380	30,876	167,378,431	2 µg/L
Toxaphene (3 µg/L)	44	115,403	30,387	160,012,134	1 µg/L
Volatile Organic Compounds (VOCs)					
Benzene (5 µg/L)	45	374,503	50,435	226,947,293	0.5 µg/L
Carbon Tetrachloride (5 µg/L)	45	385,864	50,446	226,934,787	0.5 µg/L
1,2-Dichloroethane (5 µg/L)	45	375,636	50,442	226,933,991	0.5 µg/L
Dichloromethane (5 µg/L)	45	372,009	50,169	226,844,060	0.5 µg/L
1,2-Dichloropropane (5 µg/L)	45	374,409	50,437	226,912,134	0.5 µg/L
Tetrachloroethylene (5 µg/L)	45	410,042	50,436	227,008,555	0.5 µg/L
Toluene (1,000 µg/L)	45	374,250	50,451	226,955,301	0.5 µg/L
1,1,2-Trichloroethane (5 µg/L)	45	372,386	50,195	226,851,469	0.5 µg/L
Trichloroethylene (5 µg/L)	45	403,609	50,432	226,907,686	0.5 µg/L

Contaminant (MCL)	Number of States with Data	Total Number of Records	Total Number of Systems	Total Population-Served by Systems	MRL
Vinyl Chloride (2 µg/L)	45	373,161	50,411	226,464,423	0.5 µg/L
Xylenes (Total) (10,000 µg/L)	44	363,466	47,698	218,071,535	0.5 µg/L

1. The lower number of systems sampling for SOCs, as compared to VOCs, relates to waivers in some states that remove monitoring requirements for certain pesticides and herbicides at some water systems based on vulnerability assessments or non-detection of these contaminants in three consecutive annual samples.

2. Statewide waivers are frequently granted for endothall.

1.3.8 Additional Data

In addition to the primary data sources described above, supplemental contaminant occurrence information is also presented whenever available. This information generally includes reviews of occurrence surveys and studies of contaminant occurrence in both ground water and surface water drinking and non-drinking water sources. Furthermore, some of the information is national and some regional in nature, providing additional contaminant information that supplements the other contaminant occurrence, use, and production information presented in this report. However, the detailed national estimates of contaminant occurrence in drinking water, described in the following Section 1.4, were conducted only using the Six-Year Review-ICR contaminant occurrence data.

Summary of Selected United States Geological Survey Data on Domestic Well Water Quality for the Centers for Disease Control's National Environmental Public Health Tracking Program

USGS, in collaboration with the Centers for Disease Control and Prevention (CDC), has released an online report on the occurrence of 11 priority water-quality constituents of possible health concern in domestic wells located in 16 states across the United States. The states include California, Connecticut, Florida, Massachusetts, Maryland, Maine, Missouri, New Hampshire, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Utah, Washington, and Wisconsin. The overall purpose of the study is to demonstrate through a pilot effort how USGS water-quality, water-use, and associated geospatial data can be integrated in the CDC Environmental Public Health Tracking Program (EPHT) network.

The water quality of domestic (private) supplies is inconsistently regulated and generally not well characterized. The USGS has two water-quality data sets in the National Water Information System (NWIS) database that can be used to help define the water quality of domestic-water supplies: (1) data from the NAWQA Program, and (2) USGS state data. Data from domestic wells from the NAWQA Program were collected to meet one of the program's objectives, which was to define the water quality of major aquifers in the United States. These domestic wells were located primarily in rural areas. The NWIS database is a repository of USGS water data collected for a variety of projects; consequently, project objectives and analytical methods vary. This variability can bias statistical summaries of contaminant occurrence and concentrations; nevertheless, these data can be used to define the geographic distribution of contaminants.

Eleven water-quality constituents were selected for the pilot study (primarily on the basis of expected occurrence and potential human health impacts), including three Category 1 contaminants: carbon tetrachloride, tetrachloroethylene, and trichloroethylene. USGS samples were collected using nationally consistent field and analytical methodologies.

Bartholomay *et al.* (2007) notes that major-aquifer studies have three important characteristics: (1) samples were collected before any treatment to define the quality of water in the aquifer; (2) sampled wells were spatially distributed and randomly selected among existing wells within the aquifer so these should be representative of overall water quality; and (3) most of the samples were collected from domestic wells (one well that provides water to one home) in rural areas of the United States.

United States Department of Agriculture Pesticides Data Program

The USDA Pesticide Data Program (PDP) maintains a national pesticide residue database. PDP was initiated in 1991 to collect data on pesticide residues in food with sampling conducted on a statistically defensible representation of pesticide residuals in the United States food supply (USDA, 2006a). Sampling and testing are conducted on fruits and vegetables, select grains, milk, and (as of 2001) drinking water.

In 2001, the PDP water sampling pilot program was initiated at community water systems (CWSs) in New York and California. These sites were selected to reflect two highly populated regions with divergent climates and hydrogeological conditions. Sites reflected the diversity of land uses within California and New York and included major metropolitan areas, agricultural regions, and highly protected watersheds. Source waters for water systems participating in PDP finished drinking water sampling were primarily surface waters (USDA, 2003).

For the 2002 and 2003 data collection efforts, PDP continued sampling CWSs in New York and California but also added five new sites in Kansas, Colorado, and Texas. The sites in Colorado, Kansas, and Texas were small, rural community water systems in regions where EPA needed monitoring data. These sites served populations of fewer than 50,000 people, used surface water, and were regions for which EPA had ancillary data (such as agricultural pesticide usage) (USDA, 2004; USDA, 2005).

In 2004, PDP collected drinking water samples from CWSs in Michigan, North Carolina, Ohio, Oregon, Pennsylvania, and Washington. Water samples were collected from both the raw water intake and the finished drinking water after treatment. The untreated intake water and treated water were collected as paired samples, taking into account each individual plant’s processing time (USDA, 2006a).

In 2005, drinking water samples were collected from CWSs in California, Florida, Louisiana, Michigan, North Carolina, North Dakota, Ohio, Pennsylvania, and Washington. As in 2004, water samples were collected from both the raw water intake and the finished drinking water after treatment. The untreated intake water and treated water were collected as paired samples, taking into account each individual plant's processing time (USDA, 2006b).

For the 2004 and 2005 data collection efforts, site selection was conducted in collaboration with EPA's Office of Pesticide Programs Environmental Fate and Effects Division. All selected drinking water sites met the following criteria: (1) service to populations under 50,000; (2) use of surface water as the primary source of water; and (3) location in regions of heavy agriculture where known amounts of pesticides were applied (USDA, 2006b).

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs in ground water in regionally extensive aquifers or aquifer systems (Zogorski *et al.*, 2006). The assessment provides a foundation for subsequent decadal assessments of the USGS NAWQA Program to ascertain long-term trends of VOC occurrence in these aquifers. The assessment of ground water included analyses of about 3,500 water samples collected during 1985 to 2001 from various types of wells, representing almost 100 different aquifer studies. Also included (and discussed separately from aquifer studies) was an assessment of the occurrence of VOCs in samples collected from drinking water supply wells, specifically domestic and public wells. The additional data described in this report is for the VOC occurrence in samples from domestic and public wells only.

Occurrence findings are compared between domestic and public wells to distinguish the separate issues for these well types related to supply, environmental setting, and sources of VOCs. For this purpose, the occurrence of 55 VOCs is based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells. Findings from domestic well samples update earlier USGS studies and provide improved national coverage of sampled wells. Findings for public well samples constitute the most current understanding of the occurrence of a large number of VOCs in untreated ground water used by systems across the United States. This assessment of public well water complements compliance monitoring by water utilities that typically focus on drinking water delivered to the public. For more details on this study, refer to Zogorski *et al.* (2006).

The VOC occurrence information used in this study came from three sources: (1) the NAWQA Program that sampled aquifers throughout the United States from 1993 to 2002; (2) local, state, and federal agencies that sampled aquifers in various parts of the United States from 1985 to 1997 (referred to as retrospective data); and (3) a collaborative study by several entities including the USGS, that sampled ground waters used by community water systems (CWSs) throughout the United States from 1999 to 2000. Various criteria were used to select wells for inclusion in this assessment including: study type, number of wells in the study, intended purpose of the sample, minimum number of compounds analyzed in each well sample, analytical method, laboratory reporting levels, and minimum distance between wells. Additional information on the sources of the data and the procedures used to select wells can be found in Moran *et al.* (2006).

United States Geological Survey Pilot Monitoring Program

In 1999, a Pilot Monitoring Program (PMP) was initiated by USGS and EPA to provide information on pesticide concentrations in drinking water. This study focused on small drinking water supply reservoirs in areas with high pesticide use in order to test the sampling approach in areas where pesticides are probably present (Blomquist *et al.*, 2001). Sampling sites represent a variety of geographic regions, as well as different cropping patterns. The ideal site candidates were mostly small reservoirs located in high pesticide-use areas, with a high runoff potential. Twelve water-supply reservoirs, considered vulnerable to pesticide contamination, were selected from the list of candidates. These 12 sites were located in: California, Indiana, Louisiana, Missouri, Ohio, Oklahoma, South Carolina, South Dakota, New York, North Carolina, Pennsylvania, and Texas.

Samples were collected quarterly throughout the year and at weekly or biweekly intervals following the primary pesticide-application periods. Water samples were collected from the raw-water intake and from the finished drinking water tap prior to entering the distribution system. At some sites, samples were also collected at the reservoir outflow.

Three different laboratory methods were used in the PMP – a USGS approved method, and two provisional methods. (Note: Since the completion of the study, both provisional methods have been approved by USGS without any changes to the procedures.)

First Six-Year Review of National Primary Drinking Water Regulations

Occurrence estimates for regulated contaminants were developed in support of EPA’s first Six-Year Review of NPDWRs. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. The occurrence estimates are based on compliance monitoring data from 1993 to 1997 (USEPA, 2003d).

The state compliance monitoring occurrence data used in the first Six-Year Review analysis were submitted by states for EPA review and study of the occurrence of regulated contaminants in PWSs (USEPA, 1999). In the USEPA (1999) review, all 50 states were evaluated through a methodology that included ranking of states’ pollution potential, dividing states into quartiles based on these rankings, and then selecting states that equally represent the four pollution-potential quartiles. Another factor considered (when selecting states equally across the four pollution-potential quartiles) was selection of states distributed geographically to include a broad representation of climatic and hydrologic variability across the United States. In this way, a subset, or cross-section, of states could be selected to reflect a national representation of pollution potentials and climatic/hydrologic difference.

The 16-state national cross-section was selected because it provided a balanced national cross-section of state occurrence data, was based only on high quality and adequately complete state occurrence data sets, and that, in aggregate, is indicative of national contaminant occurrence (USEPA, 2003d). The analyses are based on data from the group of 16 states, including Alabama, California, Florida, Illinois, Indiana, Kentucky, Michigan, Montana, Nebraska, New Jersey, New Mexico, Oregon, South Carolina, South Dakota, Texas, and Vermont. All of these states are also in the Six-Year Review-ICR dataset.

1.4 Occurrence Analysis

A two-stage analytical approach was used to evaluate the Six-Year Review-ICR contaminant occurrence data. The first stage of analysis provides a straightforward evaluation of occurrence of all contaminants under consideration. The Stage 1 analysis consists of simple counts and descriptive statistics of analytical occurrence data for each of the contaminants. These conservative assessments provide a broad evaluation of contaminant occurrence. Occurrence analyses for each contaminant are assessed for systems and population-served by systems. A typical Stage 1 analysis is a simple count of the number (or percentage) of systems with at least one analytical detection (at least one sample analytical result greater than or equal to the minimum reporting level, MRL) of a specific contaminant, or at least one sample analytical detection with a concentration greater than the MCL concentration. For a complete description of the Stage 1 methodology, refer to USEPA (2009b). These findings for either the Stage 1 or Stage 2 analyses are not representative of MCL violations.

The basic Stage 1 analytical methodology is a conservative approach: occurrence measures are based on simple counts of whether or not a system reported at least one sample analytical detection greater than a specified concentration threshold.[2] The approach implicitly incorporates another conservative assumption that if a detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to the detected contaminant (even though other entry points/sampling points at the system, and the populations-served by those entry/sample points, may exhibit no contaminant occurrence). In reality, many systems obtain water from multiple water sources (such as a mix of purchased and non-purchased water, ground water wells and surface water intakes, etc.). In systems with multiple water sources or water intakes, contaminant occurrence in one source or sample point does not necessarily mean occurrence in all sources or sample points that distribute water to consumers. Because of this identified potential over-estimation of populations-served by systems with contaminant detections using the system-level analysis, additional Stage 1 analyses were conducted for sample points to provide added details of contaminant occurrence.

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[2] These Stage 1 analyses are conservative in the sense that they are protective of human health (i.e., because they are based on a single, maximum sample detection value rather than an average value for each system. The Stage 1 analyses are more likely to overestimate occurrence and potential risks to human health than underestimate them).

Partly based on the findings of the Stage 1 analysis, EPA selected a set of contaminants for which additional parametric statistical estimations, the Stage 2 analyses, were conducted. The Stage 2 analysis estimates national contaminant occurrence by generating estimated long-term mean concentrations of a specific contaminant at systems nationally. These system means were calculated using a simple arithmetic average of all detection and non-detection sample analytical results for each public water system.

The analyses conducted here, though, are not equivalent to the analyses conducted to estimate a potential MCL violation. Both these Stage 1 and Stage 2 analyses are based on every analytical sample result from all years with data in the Six Year Review-ICR Dataset. The Stage 2 analysis (based on an estimated long-term average concentration) is similar to the calculation conducted to determine an MCL violation, but the two calculations are different. For most regulated drinking water contaminants, an MCL violation occurs when the concentration equal to a contaminant's MCL is exceeded by the estimated annual average concentration based on a limited number of consecutive quarterly compliance monitoring samples (typically four for surface water systems and two for ground water systems). In contrast, a "Stage 2 MCL exceedance" occurs when the concentration threshold equal to a particular contaminant's MCL is exceeded by the estimated system average concentration based on multiple years (not two or four consecutive quarters) of compliance monitoring samples. Calculations of MCL violations are not conducted in this report.

A "detection" is when the presence of a contaminant is identified and quantified in a water sample at or above the analytical method MRL.[3] A "non-detection" is when the contaminant has not been identified in a sample at or above the MRL. (Note that a "non-detection" does not indicate zero concentration of the contaminant in the sample; it only indicates that the contaminant is not present at a concentration at or above the MRL, but may be present in the sample at any concentration ranging from slightly less than the MRL to zero.)

Sample non-detection records in the state data sets tend to be less uniform and less complete than detections records. Non-detection records are typically reported with non-numeric values (such as "ND"), are blank (missing), do not include the numeric value of the relevant MRL, or report MRL values that are obviously wrong (e.g., higher than the MCL concentration). In these cases, data management work was required to identify and replace any non-numeric, missing, or incorrect non-detection data.

A convention was developed to replace any of these problematic non-detection results in the records with the most common (modal) MRL value for the state in which the system was located. A non-detection is indicated as "<MRL." For some states, though, there were no MRL data (all MRL data were missing for the entire state). In these cases, the missing values were replaced with the national modal MRL (derived as the mode of state modal MRL values for that contaminant). For more details, see Section 3.2 and 3.3 of USEPA (2009b).

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[3] The MRL is the lowest concentration value (level) that can be reliably achieved under routine laboratory operating conditions.

The Stage 1 analyses are not affected by how non-detections are recorded. However, to estimate mean contaminant concentration values for each system in the Stage 2 analyses, it was necessary to substitute a numeric value for each reported non-detection result (each "<MRL"). For the Stage 2 analyses, EPA decided to use three different substitution values –zero, one-half the MRL value, and the full MRL value– to replace each non-detection record. EPA then calculated three arithmetic means for each contaminant at each system using the zero, one-half MRL and full MRL substitution values.

These system contaminant mean calculations were completed for all systems and the percent of all systems with a contaminant mean concentration greater than each contaminant's MCL concentration was then calculated. The results from these Stage 2 analyses that were generated using all three substitution value are presented below in the individual contaminant chapters.

EPA assessed the generated occurrence estimates of the regulated contaminants relative to several different thresholds. Simple assessments of occurrence were made relative to the MRL, identifying the presence of any detection of a contaminant. Analytical detections were also evaluated relative to higher contaminant concentrations including the MCL concentration and alternate threshold levels. Stage 1 and Stage 2 analyses were conducted at greater than the MCL concentration and alternate threshold levels.

The Stage 2 analyses based on estimated mean concentrations provide occurrence estimates that are less conservative than the Stage 1 analyses based on maximum sample concentrations. The Stage 2 analyses also provide estimates of potential chronic exposure since they are based on estimated long-term mean concentrations of contaminant occurrence. In a general sense, the Stage 1 analysis reflects a rough approximation of peak occurrence while the Stage 2 analysis estimates long-term, average occurrence. For a complete description of the Stage 2 methodology and a comprehensive presentation of the stratified Stage 2 findings, refer to USEPA (2009a).

The two-stage analytical approach was previously developed for other EPA OGWDW national occurrence studies and was used to generate occurrence analyses that supported the first Six-Year Review of National Primary Drinking Water Regulations (see USEPA, 2003d). This data management and occurrence analytical approach was peer-reviewed for use under the first Six-Year Review. Contaminant occurrence findings based on the Stage 1 and Stage 2 analyses (using the Six-Year Review – ICR data) are summarized in tables presented in the specific contaminant chapters that follow this introductory chapter.

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2 Benzene

This chapter on benzene is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and benzene occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

2.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for benzene on July 8, 1987 (52 FR 25690 (USEPA, 1987)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of A, known human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2007), benzene (C_6H_6) is a colorless sweet-smelling liquid that is highly flammable and slightly water soluble. It can be smelled at 60 ppm in the air and tasted at 0.5 to 4.5 ppm in water. Benzene is produced industrially from petroleum and ranks in the top 20 chemicals in terms of United States production volume (ATSDR, 2007).

The main sources of benzene to the environment are industrial. Benzene is released to the air through the burning of oil, coal, and motor gasoline. It may also leak from waste storage operations and gasoline service stations. Gas emissions from forest fires and volcanoes are the primary natural sources of benzene. Tobacco smoke is a primary indoor source (ATSDR, 2007).

Once in the air, benzene reacts with other chemicals and breaks down within a few days. Releases of benzene to the soil and water may result from industrial discharges, disposal of benzene-containing products, and leakage from underground gasoline storage tanks. Benzene's solubility in water allows it to infiltrate into ground water. Once in the ground or water, benzene breaks down slowly. Benzene does not build up in plants or animals (ATSDR, 2007).

Levels of benzene in outdoor air range from 0.00002 to 0.034 ppm. As a result, most humans are exposed to at least a small amount of benzene daily. Inhalation of auto exhaust is a typical mode of outdoor exposure. Indoors, the likelihood of exposure is also high because benzene tends to volatilize from glues, paints, furniture, wax, and detergents. It is estimated that smoking increases ones exposure to benzene by about tenfold, although those exposed to the highest levels are typically industrial workers. It is possible for drinking water to become contaminated with benzene, but for most of the population, airborne benzene presents a more significant level of exposure (ATSDR, 2007).

2.2 Use, Production, and Releases

Benzene has a wide variety of uses. It is integral in the synthesis of other chemicals, such as styrene, cumene, and cyclohexane. It is also used in the manufacture of rubbers, lubricants, dyes, detergents, drugs, and pesticides (ATSDR, 2007).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 2-1 presents the production of benzene in the United States from 1986 to 2002. Note that the production of benzene in the United States has consistently been above 1 billion pounds since 1986.

Exhibit 2-1: Production of Benzene in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 billion pounds
1990 Range	> 1 billion pounds
1994 Range	> 1 billion pounds
1998 Range	> 1 billion pounds
2002 Range	> 1 billion pounds

Source: USEPA, 2003a

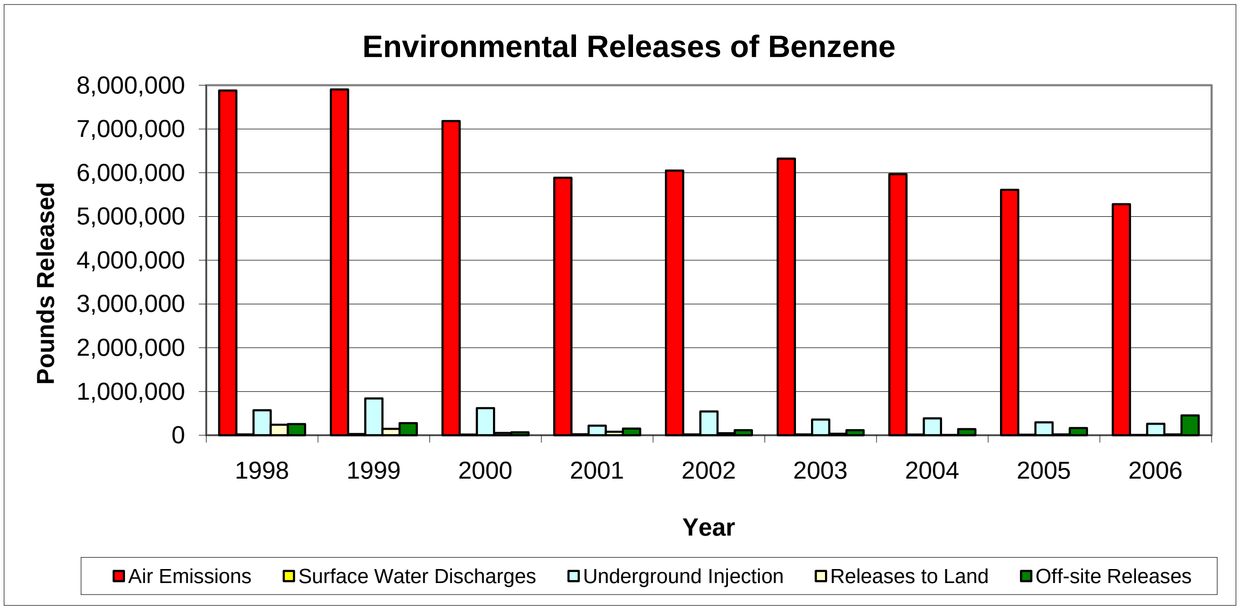
Benzene is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 2-2a lists the environmental releases of benzene from 1988 to 2006. (Exhibit 2-2b provides a graphical presentation of the environmental releases.) Air emissions constituted most of the on- and off-site releases (greater than 80%). Underground injection was the second largest pathway of environmental release; underground injection releases fluctuated over the period of record, falling to a minimum in 2001. Releases to land (e.g., spills or leaks within the boundaries of the reporting facility) have decreased since 1998. Over the eight year period, releases of benzene were reported by 49 states (all states but VT), as well as American Samoa, Guam, Puerto Rico, the Northern Mariana Islands, and the Virgin Islands. All states/entities, except for American Samoa, Nevada, and New Hampshire, reported benzene releases in all nine years.

Exhibit 2-2a: Table of Toxics Release Inventory (TRI) Data for Benzene

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	7,878,844	18,878	570,781	240,289	255,906	8,964,698
1999	7,901,923	27,829	840,628	144,675	275,305	9,190,360
2000	7,180,688	13,852	620,190	51,034	65,788	7,931,552
2001	5,885,935	20,867	217,828	77,841	150,813	6,353,284
2002	6,047,311	19,560	544,053	44,909	115,542	6,771,374
2003	6,322,790	18,496	357,108	33,339	115,583	6,847,316
2004	5,966,169	16,051	386,819	7,525	140,329	6,516,892
2005	5,609,884	11,426	294,416	17,005	162,553	6,095,284
2006	5,279,355	7,384	262,374	18,521	452,719	6,020,353

Source: USEPA, 2008

Exhibit 2-2b: Graph of Toxics Release Inventory (TRI) Data for Benzene



Source: USEPA, 2008

2.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of benzene in ambient water are available from the NAWQA program.

2.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for benzene. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 2-3. Overall, benzene was detected in 11.8% of samples and at 6.4% of sites. Benzene was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.0235 µg/L. The 99th percentile concentration, based on detections from all sites, was 89 µg/L.

Exhibit 2-3: EPA Summary Analysis of Benzene 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
ground water	4,652	5.1%	4,152	4.8%	0.004	0.04	42	290	1,900
surface water	1,402	34.3%	182	42.9%	0.0038	0.0211	0.714	16.5	24
all sites	6,054	11.8%	4,334	6.4%	0.0038	0.0235	13.6	89	1,900

1. RLs (Reporting Limits) for benzene varied, but did not exceed 0.004 µg/L.

2.4 Occurrence in Drinking Water

Benzene is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of benzene occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for benzene. These data consist of 374,503 analytical results from 50,435 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for benzene in the dataset is 0.5 µg/L.

2.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 2-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For benzene, 0.884% of 50,435 systems reported detections. Exhibit 2-5 lists the minimum, median, 90th percentile, and maximum benzene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of benzene, based on detections from all systems, was 1.1 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 2-4: Benzene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	289,855	46,177	80,534	86,395,538	86,395,538
Surface Water	84,648	4,258	10,868	140,551,755	140,551,755
Combined Ground & Surface Water	374,503	50,435	91,402	226,947,293	226,947,293
Percent with Detections					
Ground Water	0.523%	0.836%	0.577%	2.382%	0.901%
Surface Water	0.146%	1.409%	0.690%	7.210%	1.598%
Combined Ground & Surface Water	0.438%	0.884%	0.591%	5.372%	1.333%

Exhibit 2-5: Benzene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.03	1.2	8	93
Surface Water	0.05	0.7	3.19	22
Combined Ground & Surface Water	0.03	1.1	7.8	93

The following maps illustrate the geographic distributions of benzene occurrence in drinking water. Exhibit 2-6 shows the states with systems with at least one benzene detection and Exhibit 2-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of benzene is geographically dispersed. Detection rates were generally low, although only one state reported no systems with detections. The remaining 44 states reported low benzene detection rates. Twenty-eight states reported

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

detections greater than the MCL concentration of 5 µg/L, although only one state reported more than 0.5% of systems with detections greater than 5 µg/L.

Exhibit 2-6: Percentage of Systems with at Least One Benzene Detection, by State

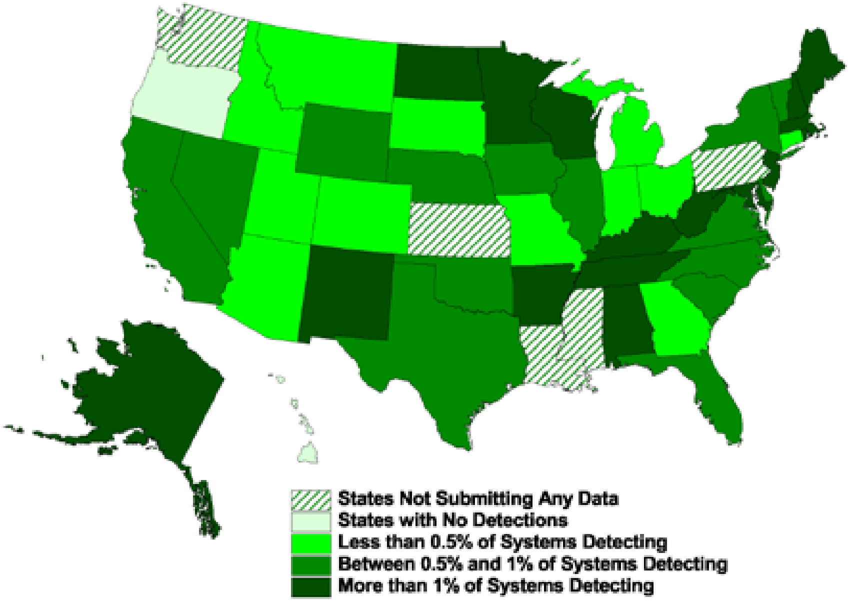

Exhibit 2-7: Percentage of Systems with at Least One Benzene Detection Greater than the MCL Concentration (> 5 µg/L), by State

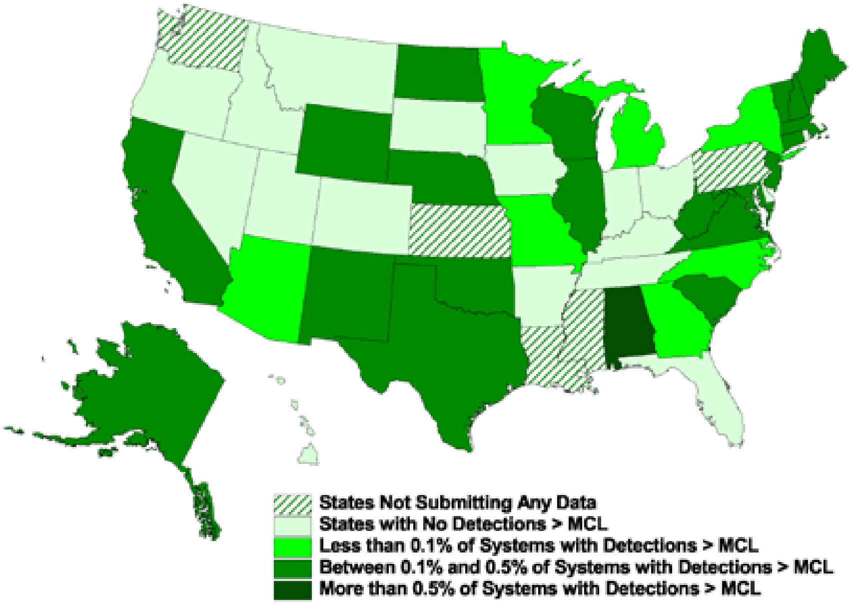

Exhibit 2-8 presents the Stage 1 analysis of benzene occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. About 110 systems (0.218% of all systems), serving about 884,000 persons, reported at least one detection greater than or equal to 2.5 µg/L; and 63 systems (approximately 0.125% of all systems), serving nearly 487,000 persons, reported at least one detection greater than 5 µg/L.

Exhibit 2-8: Benzene Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 5 µg/L	57	0.123%	338,086	0.391%
	≥ 2.5 µg/L	100	0.217%	700,772	0.811%
	≥ 1 µg/L	206	0.446%	1,079,744	1.250%
	> 0.5 µg/L	283	0.613%	1,486,410	1.720%
Surface Water	> 5 µg/L	6	0.141%	148,852	0.106%
	≥ 2.5 µg/L	10	0.235%	183,093	0.130%
	≥ 1 µg/L	22	0.517%	4,038,337	2.873%
	> 0.5 µg/L	39	0.916%	7,433,993	5.289%
Combined Ground & Surface Water	> 5 µg/L	63	0.125%	486,938	0.215%
	≥ 2.5 µg/L	110	0.218%	883,865	0.389%
	≥ 1 µg/L	228	0.452%	5,118,081	2.255%
	> 0.5 µg/L	322	0.638%	8,920,403	3.931%

The occurrence estimates presented above (in Exhibit 2-8) are based on the conservative assumption that if a benzene detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to benzene (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of benzene). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of benzene because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of benzene (rather than the entire population-served by the system).

Exhibit 2-9 presents the Stage 1 analysis of benzene occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. A total of 131 (0.143% of) sample points, serving an estimated 221,000 persons, reported at least one detection greater than or equal to 2.5 µg/L; and 72 (0.079% of) sample points, serving an estimated 121,000 persons, reported at least one detection greater than 5 µg/L.

Exhibit 2-9: Benzene Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 5 µg/L	66	0.082%	92,882	0.108%
	≥ 2.5 µg/L	118	0.147%	164,756	0.191%
	≥ 1 µg/L	249	0.309%	361,001	0.418%
	> 0.5 µg/L	347	0.431%	544,841	0.631%
Surface Water	> 5 µg/L	6	0.055%	27,765	0.020%
	≥ 2.5 µg/L	13	0.120%	56,532	0.040%
	≥ 1 µg/L	28	0.258%	687,435	0.489%
	> 0.5 µg/L	48	0.442%	913,601	0.650%
Combined Ground & Surface Water	> 5 µg/L	72	0.079%	120,647	0.053%
	≥ 2.5 µg/L	131	0.143%	221,288	0.098%
	≥ 1 µg/L	277	0.303%	1,048,436	0.462%
	> 0.5 µg/L	395	0.432%	1,458,442	0.643%

2.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean benzene concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than the each threshold were calculated.

Exhibit 2-10 presents the Stage 2 analysis of estimated system mean concentrations for benzene occurrence in drinking water relative to several thresholds. The thresholds are: 0.5 µg/L, 1 µg/L, 2.5 µg/L, and 5 µg/L. Exhibit 2-11 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than 16 systems (approximately 0.032% of all systems) had an estimated system mean greater than or equal to 2.5 µg/L. These systems serve about 111,000 persons. Ten systems (0.020% of all systems), serving about 14,000 persons, had an estimated system mean greater than the MCL concentration of 5 µg/L.

Exhibit 2-10: Benzene Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	9	9	9	0.019%	0.019%	0.019%
	≥ 2.5 µg/L	15	13	13	0.032%	0.028%	0.028%
	≥ 1 µg/L	67	55	49	0.145%	0.119%	0.106%
	> 0.5 µg/L	264	114	90	0.572%	0.247%	0.195%
Surface Water	> 5 µg/L	1	1	1	0.023%	0.023%	0.023%
	≥ 2.5 µg/L	1	1	1	0.023%	0.023%	0.023%
	≥ 1 µg/L	3	3	3	0.070%	0.070%	0.070%
	> 0.5 µg/L	37	9	5	0.869%	0.211%	0.117%
Combined Ground & Surface Water	> 5 µg/L	10	10	10	0.020%	0.020%	0.020%
	≥ 2.5 µg/L	16	14	14	0.032%	0.028%	0.028%
	≥ 1 µg/L	70	58	52	0.139%	0.115%	0.103%
	> 0.5 µg/L	301	123	95	0.597%	0.244%	0.188%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 2-11: Benzene Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	14,152	14,152	14,152	0.016%	0.016%	0.016%
	≥ 2.5 µg/L	110,807	109,663	109,663	0.128%	0.127%	0.127%
	≥ 1 µg/L	169,570	148,699	147,729	0.196%	0.172%	0.171%
	> 0.5 µg/L	1,364,591	398,783	282,886	1.579%	0.462%	0.327%
Surface Water	> 5 µg/L	50	50	50	0.00004%	0.00004%	0.00004%
	≥ 2.5 µg/L	50	50	50	0.00004%	0.00004%	0.00004%
	≥ 1 µg/L	10,625	10,625	10,625	0.008%	0.008%	0.008%
	> 0.5 µg/L	7,318,292	86,052	21,533	5.207%	0.061%	0.015%

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 5 µg/L	14,202	14,202	14,202	0.006%	0.006%	0.006%
	≥ 2.5 µg/L	110,857	109,713	109,713	0.049%	0.048%	0.048%
	≥ 1 µg/L	180,195	159,324	158,354	0.079%	0.070%	0.070%
	> 0.5 µg/L	8,682,883	484,835	304,419	3.826%	0.214%	0.134%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

2.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including benzene, in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, benzene had a detection frequency of 0.21% at an assessment level of 0.2 µg/L (based on 2,401 samples). The median concentration of detections was 0.015 µg/L. Two detections were within one order of magnitude of the MCL concentration (of 5 µg/L). No detections were greater than the MCL concentration.

In public wells, benzene had a detection frequency of 0.46% at an assessment level of 0.2 µg/L (based on 1,095 samples). The median concentration of detections was 0.13 µg/L. Five detections were within one order of magnitude of the MCL concentration. No detections were greater than the MCL concentration.

Occurrence of Water-Quality Constituents in Domestic Wells across the United States

The USGS, in collaboration with the Centers for Disease Control and Prevention (CDC), released an online report on the occurrence of 11 priority water-quality constituents of possible health concern in domestic wells located in 16 states across the United States (Bartholomay *et al.*, 2007). Two water-quality data sets were used to define the water quality of domestic-water supplies: (1) data from the NAWQA Program, and (2) USGS state data. The common assessment level used to quantify the detection frequency of benzene was 0.2 µg/L.

A total of 1,036 wells were sampled for benzene. The detection frequency for benzene was 0.1%. All of the detections of benzene had concentrations less than, but within one order of magnitude, of the MCL concentration (5 µg/L).

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 305 systems (approximately 1.31% of about 23,000 systems), reported at least one detection of benzene. Forty-four systems (approximately 0.19% of all systems), reported at least one detection greater than the MCL concentration.

2.6 Summary of Data

TRI data indicate that total off-site and on-site releases of benzene for the period 1998-2006 ranged from approximately 6 million pounds to approximately 9 million pounds, with the greatest releases in 1998 and 1999. Air emissions constituted at least 80% of the total amount released. Off-site releases were the second largest category.

Ambient water data from the NAWQA program indicate that benzene was detected in 11.8% of 6,054 ground and surface water samples and at 6.4% of 4,334 sites. The median concentration, based on detections from all sites, was 0.024 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that benzene was detected in 0.884% of 50,435 surface water and ground water systems. The median concentration, based on detections from all systems, was 1.1 µg/L. In total, 0.125% of systems (serving 0.215% of the population) reported benzene detections greater than the MCL concentration of 5 µg/L. Detections of benzene were generally more common in ground water systems than surface water systems, and a greater population was served by ground water systems reporting at least one detection greater than the MCL concentration. A similar pattern was seen for ground water and surface water sample points.

In the Stage 2 analysis, approximately 0.020% of surface and ground water systems (serving 0.006% of the population) had an estimated system mean concentration of benzene greater than the MCL concentration. The number of systems with threshold exceedances was greater for ground water system means and a larger population was served by ground water systems with means exceeding all thresholds.

2.7 References

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3 Carbofuran

This chapter on carbofuran is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and carbofuran occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009a).

3.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for carbofuran on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 40 µg/L. EPA based the MCLG on a reference dose (RfD) of 5 µg/kg-day (0.005 mg/kg-day) and a cancer classification of E, evidence of non-carcinogenicity for humans.

According to USEPA (2006), carbofuran ($C_{12}H_{15}NO_3$), classified as a restricted use pesticide, was first registered for use in the United States in 1969. Carbofuran is available in liquid and granular formulations. Sales of granular carbofuran have been limited to 2,500 pounds per year in the United States since 1994, and it can only be used on spinach grown for seed, pine seedlings, cucurbits, and bananas (USEPA, 2006). (Before 1991, 80% of the total usage of carbofuran was in granular formulations. The restrictions on use of granular carbofuran were established to protect birds and were not related to human health concerns (EXTOXNET, 1996).)

Carbofuran is highly mobile in soils and enters surface water via runoff from treated fields and enters ground water through the leaching of treated crops (USEPA, 2006). Carbofuran is stable under neutral and acidic conditions, but degrades in alkaline conditions. If carbofuran is released to soil or water, it will be broken down by hydrolysis and photodegradation. Bacterial degradation rates vary depending on environmental conditions. Carbofuran is not expected to bioaccumulate (USEPA, 2006).

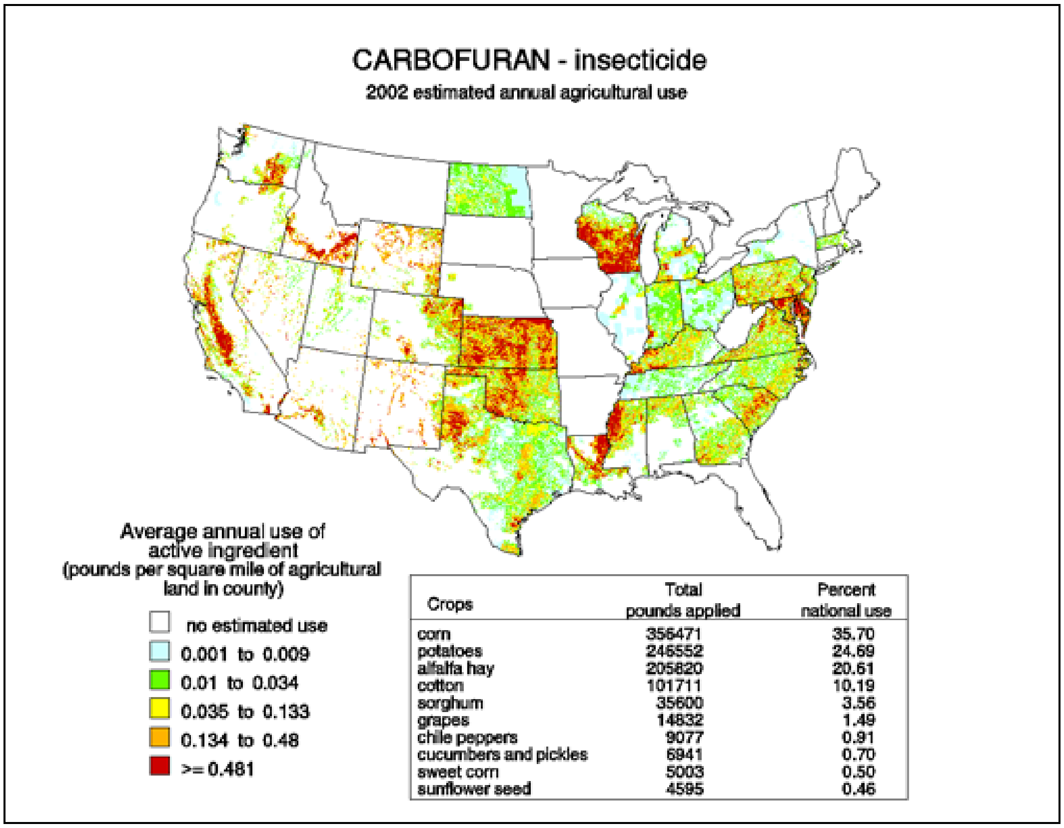
3.2 Use, Production, and Releases

Carbofuran is a broad spectrum insecticide used primarily to control soil and foliar pests on a variety of field, vegetable, and fruit crops. It is used to control weevils, aphids, corn borers, beetles, nematodes, and rootworm. There are no residential uses of carbofuran (USEPA, 2006).

The process to cancel the remaining carbofuran registrations is currently underway by EPA. Under the Agency's May 15, 2009 final rule, EPA's revocation of carbofuran tolerances became effective on December 31, 2009, due to considerable risks associated with this pesticide in food and drinking water (USEPA, 2009b).

Exhibit 3-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual carbofuran use in the United States from 1999 through 2004. A breakdown of use by crop is also included. The map was created by the USGS using state-level data sets on pesticide use rates from 1999-2004 compiled by the CropLife Foundation, at the Crop Protection Research Institute, combined with county-level data on harvested crop acreage obtained from the 2002 Census of Agriculture. Due to the nature of the data sources, non-agricultural uses are not reflected here, and variations in use at the county-level are also not well represented (Thelin and Gianessi, 2000). The USGS (2007) estimates that almost 1 million pounds of carbofuran active ingredient were used on average each year between 1999 and 2004. The greatest use of carbofuran is in the Midwest.

Exhibit 3-1: Estimated Annual Agricultural Use for Carbofuran (c. 2002)



Crops	Total pounds applied	Percent national use
corn	356471	35.70
potatoes	246552	24.69
alfalfa hay	205820	20.61
cotton	101711	10.19
sorghum	35600	3.56
grapes	14832	1.49
chile peppers	9077	0.91
cucumbers and pickles	6941	0.70
sweet corn	5003	0.50
sunflower seed	4595	0.46

Source: USGS, 2007

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 3-2 presents the production of carbofuran in the United States from 1986 to 2002. Note that the production of carbofuran in the United States increased after 1986.

Exhibit 3-2: Production of Carbofuran in the United States

Inventory Update Year	Production Volume
1986 Range	10,000 – 500,000 pounds
1990 Range	> 1 million – 10 million pounds
1994 Range	> 1 million – 10 million pounds
1998 Range	> 1 million – 10 million pounds
2002 Range	> 1 million – 10 million pounds

Source: USEPA, 2003a

Carbofuran is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 3-3a lists the environmental releases of carbofuran in the United States from 1998 to 2006. (Exhibit 3-3b provides a graphical presentation of the environmental releases.) Carbofuran air emissions generally decreased over the years, but constituted nearly all of the releases, both on- and off-site. Surface water discharges peaked in 1999, but were otherwise negligible. There were no underground injections or releases to land for the period of record. Off-site releases of carbofuran were also minimal. The TRI data for carbofuran were reported from 10 states (Arkansas, Florida, Iowa, Illinois, Indiana, Kentucky, Louisiana, New York, Texas, and West Virgina), with only Arkansas, Louisiana, New York, and West Virginia reporting every year.

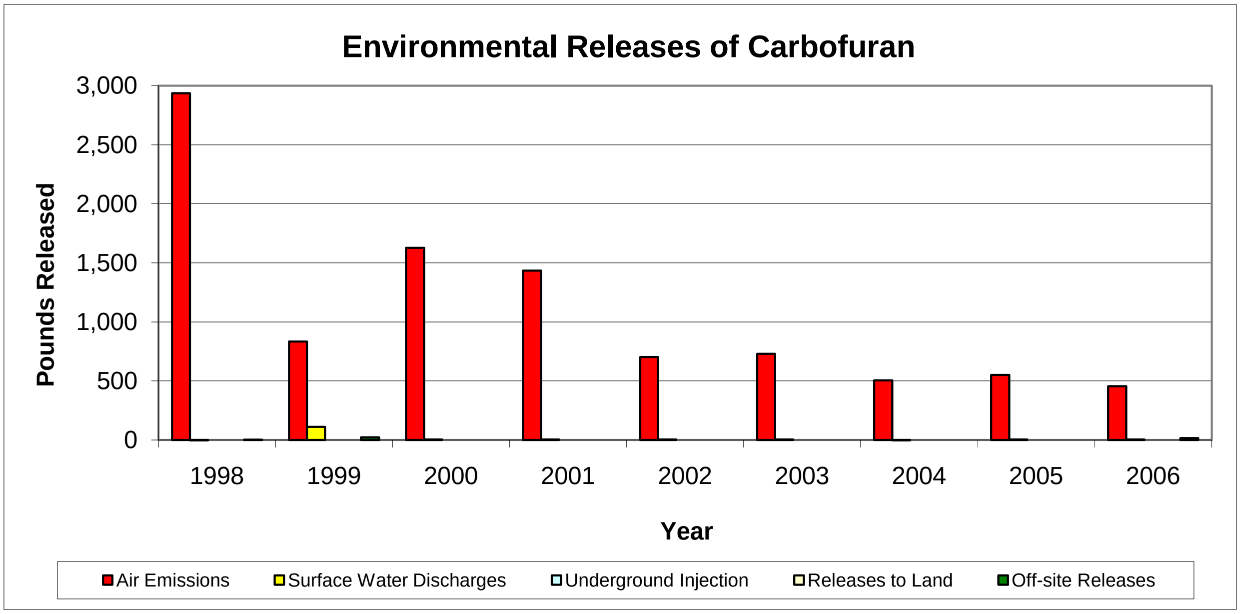
Exhibit 3-3a: Table of Toxics Release Inventory (TRI) Data for Carbofuran

Year	On-Site Releases (pounds)				Off-Site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	2,937	1	0	0	2	2,940
1999	834	112	0	0	23	969
2000	1,628	5	0	0	0	1,633
2001	1,435	5	0	0	0	1,440

Year	On-Site Releases (pounds)				Off-Site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
2002	703	5	0	0	0	708
2003	729	6	0	0	0	735
2004	506	1	0	0	0	507
2005	550	6	0	0	0	556
2006	455	5	0	0	16	476

Source: USEPA, 2008

Exhibit 3-3b: Graph of Toxics Release Inventory (TRI) Data for Carbofuran



Source: USEPA, 2008

3.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The USGS National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of carbofuran in ambient water are available from the NAWQA program for both the Pesticide National Synthesis Project and a summary analysis of all Cycle 1 water monitoring data.

3.3.1 NAWQA Pesticide National Synthesis Project

The NAWQA Pesticide National Synthesis Project is a national-scale assessment of the occurrence and behavior of pesticides in streams and ground water of the United States and the potential for pesticides to adversely affect drinking water supplies or aquatic ecosystems. Under the National Synthesis Project, the USGS monitored carbofuran between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for carbofuran was 0.010 µg/L.

In NAWQA stream samples (Exhibit 3-4), carbofuran was found at frequencies ranging from 1.59% of samples in urban areas to 2.07% in undeveloped areas, 3.99% in mixed land use settings, and 10.37% of samples in agricultural settings. The 95th percentile concentrations were less than the method detection limit in mixed, undeveloped, and urban settings, and 0.044 µg/L in agricultural settings. The highest concentration, 7.00 µg/L, was found at an agricultural site.

Exhibit 3-4: USGS National Synthesis Summary of NAWQA Monitoring of Carbofuran in Streams, 1992-2001

Land Use Type	No. of Samples (No. of Sites)	Detection Frequency	50th Percentile (Median) Concentration (in µg/L)	95th Percentile Concentration (in µg/L)	Maximum Concentration (in µg/L)
Agricultural	2,003 (83)	10.37%	ND[1]	0.044	7.000
Mixed	1,371 (65)	3.99%	ND[1]	ND[1]	1.690
Undeveloped	144 (8)	2.07%	ND[1]	ND[1]	0.220
Urban	811 (30)	1.59%	ND[1]	ND[1]	0.055

Source: Gilliom et al., 2007

1. ND = not detected (Concentration is less than the maximum long term method detection limit and is expected to be less than any higher percentile concentration shown in the table)

In ground water NAWQA samples (Exhibit 3-5), carbofuran was found at frequencies ranging from 0% of samples in undeveloped areas to 0.40% in mixed land use settings, 0.70% of samples in urban areas, and 1.71% of samples in agricultural settings. The 95th percentile concentrations were less than the method detection limit in all settings. The highest concentration, 1.3 µg/L, was found at an agricultural site.

Exhibit 3-5: USGS National Synthesis Summary of NAWQA Monitoring of Carbofuran in Ground Water, 1992-2001

Land Use Type	Number of Wells	Detection Frequency	50th Percentile (Median) Concentration (in µg/L)	95th Percentile Concentration (in µg/L)	Maximum Concentration (in µg/L)
Agricultural	1,404	1.71%	ND[1]	ND[1]	1.3
Mixed	2,727	0.40%	ND[1]	ND[1]	0.218

Land Use Type	**Number of Wells**	**Detection Frequency**	**50th Percentile (Median) Concentration (in µg/L)**	**95th Percentile Concentration (in µg/L)**	**Maximum Concentration (in µg/L)**
Undeveloped	34	0%	ND[1]	ND[1]	ND[1]
Urban	853	0.70%	ND[1]	ND[1]	0.093

Source: Gilliom et al., 2007

1. ND = not detected (Concentration is less than the maximum long term method detection limit and is expected to be less than any higher percentile concentration shown in the table)

3.3.2 EPA Summary Analysis of NAWQA Data

Whereas the NAWQA program often uses the most representative data for a site to calculate summary statistics, EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for carbofuran. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 3-6. Overall, carbofuran was detected in 3.8% of samples and at 4.4% of sites. It was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.035 µg/L. The 99th percentile concentration, based on detections from all sites, was 2.6 µg/L.

Exhibit 3-6: EPA Summary Analysis of Carbofuran 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
ground water	10,113	0.6%	5,234	0.9%	0.0018	0.0351	0.563	1.3	1.3
surface water	20,417	5.3%	1,908	14.2%	0.002	0.0352	0.784	2.63	9.87
all sites	30,530	3.8%	7,142	4.4%	0.0018	0.0352	0.782	2.6	9.87

1. RLs (Reporting Limits) for carbofuran varied, but did not exceed 0.002 µg/L. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible.

3.4 Occurrence in Drinking Water

Carbofuran is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems

(NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of carbofuran occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for carbofuran. These data consist of 114,142 analytical results from 31,097 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for carbofuran in the dataset is 0.9 µg/L.

3.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 3-7 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For carbofuran, 0.145% of 31,097 systems reported detections. Exhibit 3-8 lists the minimum, median, 90th percentile, and maximum carbofuran concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of carbofuran, based on detections from all systems, was 0.54 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 3-7: Carbofuran Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	94,395	28,289	45,392	61,793,025	61,793,025
Surface Water	19,747	2,808	6,020	106,180,317	106,180,317
Combined Ground & Surface Water	114,142	31,097	51,412	167,973,342	167,973,342
Percent with Detections					
Ground Water	0.044%	0.120%	0.082%	5.154%	5.074%
Surface Water	0.096%	0.392%	0.249%	2.246%	1.968%
Combined Ground & Surface Water	0.053%	0.145%	0.101%	3.315%	3.111%

Exhibit 3-8: Carbofuran Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.23	0.54	1	3
Surface Water	0.5	0.9	2.5	8
Combined Ground & Surface Water	0.23	0.54	1.05	8

The following maps illustrate the geographic distribution of carbofuran occurrence in drinking water. Exhibit 3-9 shows the states with systems with at least one detection and Exhibit 3-10 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

The distribution of systems with detections of carbofuran is geographically dispersed. Detection rates were generally low, with only three states having greater than 1% of their systems detecting carbofuran. No states reported detections greater than the MCL concentration of 40 µg/L.

Exhibit 3-9: Percentage of Systems with at Least One Carbofuran Detection, by State

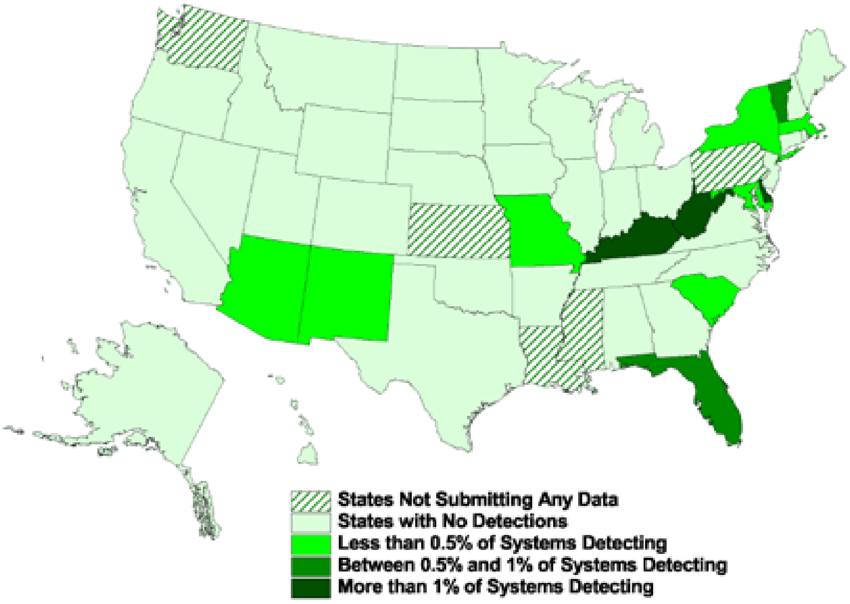

Exhibit 3-11 presents the Stage 1 analysis of carbofuran occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 0.9 µg/L, 7 µg/L, 20 µg/L, and 40 µg/L. No systems reported detections greater than 7 µg/L, 20 µg/L, or 40 µg/L.

Exhibit 3-11: Carbofuran Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 40 µg/L	0	0.000%	0	0.000%
	≥ 20 µg/L	0	0.000%	0	0.000%
	≥ 7 µg/L	0	0.000%	0	0.000%
	> 0.9 µg/L	7	0.025%	71,762	0.116%

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Surface Water	> 40 µg/L	0	0.000%	0	0.000%
	≥ 20 µg/L	0	0.000%	0	0.000%
	≥ 7 µg/L	1	0.036%	3,186	0.003%
	> 0.9 µg/L	2	0.071%	257,648	0.243%
Combined Ground & Surface Water	> 40 µg/L	0	0.000%	0	0.000%
	≥ 20 µg/L	0	0.000%	0	0.000%
	≥ 7 µg/L	1	0.003%	3,186	0.002%
	> 0.9 µg/L	9	0.029%	329,410	0.196%

The occurrence estimates presented above (in Exhibit 3-11) are based on the conservative assumption that if a carbofuran detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to carbofuran (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of carbofuran). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of carbofuran because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of carbofuran (rather than the entire population-served by the system).

Exhibit 3-12 presents the Stage 1 analysis of carbofuran occurrence in drinking water from sample points and the population-served by those sample points in the Six-Year Review-ICR Dataset. No sample points reported detections greater than 20 µg/L or 40 µg/L.

Exhibit 3-12: Carbofuran Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 40 µg/L	0	0.000%	0	0.000%
	≥ 20 µg/L	0	0.000%	0	0.000%
	≥ 7 µg/L	0	0.000%	0	0.000%
	> 0.9 µg/L	7	0.015%	70,287	0.114%

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Surface Water	> 40 µg/L	0	0.000%	0	0.000%
	≥ 20 µg/L	0	0.000%	0	0.000%
	≥ 7 µg/L	1	0.017%	3,186	0.003%
	> 0.9 µg/L	4	0.066%	257,648	0.243%
Combined Ground & Surface Water	> 40 µg/L	0	0.000%	0	0.000%
	≥ 20 µg/L	0	0.000%	0	0.000%
	≥ 7 µg/L	1	0.002%	3,186	0.002%
	> 0.9 µg/L	11	0.021%	327,935	0.195%

3.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean carbofuran concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 3-13 presents the Stage 2 analysis of estimated system mean concentrations for carbofuran occurrence in drinking water relative to several thresholds. The thresholds are: 0.9 µg/L, 7 µg/L, 20 µg/L, and 40 µg/L. Exhibit 3-14 presents similar information based on population-served by the systems. No systems had an estimated system mean exceeding 20 µg/L or 40 µg/L.

Exhibit 3-13: Carbofuran Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 20 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 7 µg/L	0	0	0	0.000%	0.000%	0.000%
	> 0.9 µg/L	30	1	0	0.106%	0.004%	0.000%
Surface Water	> 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 20 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 7 µg/L	1	1	1	0.036%	0.036%	0.036%

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
	> 0.9 µg/L	25	1	1	0.890%	0.036%	0.036%
Combined Ground & Surface Water	> 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 20 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 7 µg/L	1	1	1	0.003%	0.003%	0.003%
	> 0.9 µg/L	55	2	1	0.177%	0.006%	0.003%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 3-14: Carbofuran Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 20 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 7 µg/L	0	0	0	0.000%	0.000%	0.000%
	> 0.9 µg/L	1,138,494	220	0	1.842%	0.0004%	0.000%
Surface Water	> 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 20 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 7 µg/L	3,186	3,186	3,186	0.003%	0.003%	0.003%
	> 0.9 µg/L	7,701,631	3,186	3,186	7.253%	0.003%	0.003%
Combined Ground & Surface Water	> 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 20 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 7 µg/L	3,186	3,186	3,186	0.002%	0.002%	0.002%
	> 0.9 µg/L	8,840,125	3,406	3,186	5.263%	0.002%	0.002%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

3.5 Additional Occurrence Data

United States Department of Agriculture (USDA) Pesticide Data Program

Carbofuran was included in the USDA Pesticide Data Program (PDP; USDA, 2007). Note that temporal trends cannot be evaluated based on these data since, with the exception of 2002 and 2003, samples were not collected from the same sites and states in consecutive years.

Exhibit 3-15: PDP Monitoring of Carbofuran in Drinking Water, 2001-2005

Year	Treated/ Untreated	# of Sites	States	# of Samples	Samples with Detects	% of Samples with Detects	Range of Values Detected (µg/L)	Range of LODs (µg/L)
2001	Treated	21	CA, NY	296	0	0%	--	0.020-0.0225
2002	Treated	27	CA, CO, KS, NY, TX	550	6	1.1%	0.001-0.079	0.0006-0.0225
2003	Treated	27	CA, CO, KS, NY, TX	583	8	1.4%	0.005-0.020	0.0006-0.016
2004	Treated	16	MI, NC, OH, OR, PA, WA	379	0	0%	--	0.0006-0.017
	Untreated			380	0	0%	--	0.0006-0.017
2005	Treated	16	CA, FL, LA, MI, NC, ND, OH, PA, WA	374	0	0%	--	0.0006-0.017
	Untreated			375	0	0%	--	0.0006-0.017

USGS 1999 Pilot Monitoring Program

Carbofuran was an analyte in the 1999 Pilot Monitoring Program (Blomquist *et al.*, 2001). Carbofuran was detected in less than 1% of the 323 raw water samples and approximately 1.3% of the 228 finished water samples. The 95th percentile value was reported as less than the MRL for both raw and finished water samples. The maximum concentration of carbofuran in raw water was 0.050 µg/L. In finished water, the maximum concentration of carbofuran was 0.030 µg/L.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 9 systems (approximately 0.06% of about 14,000 systems), reported at least one detection of carbofuran. No systems reported a detection greater than the MCL.

3.6 Summary of Data

TRI data indicate that the total off-site and on-site releases of carbofuran for the period 1998-2006 ranged from about 500 to about 2,900 pounds, with the greatest release occurring in 1998. Air emissions constituted nearly all of the releases; surface water and off-site discharges were minimal and underground injection and releases to land were non-existent.

Ambient water data from the NAWQA Pesticide National Synthesis Project show that most carbofuran detections occurred at agricultural sites. It was detected in 10.37% of 2,003 agricultural stream samples taken at 83 sites. It was detected in 1.71% of samples taken from 1,404 ground water agricultural wells. Additional ambient water data from the NAWQA program indicate that carbofuran was detected in 3.8% of 30,530 ground and surface water samples and at 4.4% of 7,142 sites. The median concentration, based on detections from all sites, was 0.035 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that carbofuran was detected in 0.145% of 31,097 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.54 µg/L. No systems reported detections greater than the MCL.

In the Stage 2 analysis, no systems had an estimated mean greater than 40 µg/L (the MCL concentration).

Recent Agency actions to revoke all carbofuran tolerances are expected to reduce exposure to carbofuran and its metabolite (3-hydroxycarbofuran) in food products and in water.

3.7 References

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4 Carbon Tetrachloride

This chapter on carbon tetrachloride is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and carbon tetrachloride occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

4.1 Background

The United States Environmental Protection Agency (EPA) published the current maximum contaminant level goal (MCLG) for carbon tetrachloride on July 8, 1987 (52 FR 25690 (USEPA, 1987)). The National Primary Drinking Water Regulations (NPDWR) established a MCLG of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2005), carbon tetrachloride (CCl_4) is a clear liquid with a sweet odor. It has low flammability, but volatilizes quite easily, typically escaping to the environment in gaseous form. However, the environmental effects of this chemical prompted sharp declines in use since the 1970s. Carbon tetrachloride in the atmosphere has been linked to the thinning of the ozone layer, a component of the stratosphere responsible for shielding humans from cancer-causing ultraviolet solar radiation (ATSDR, 2005).

Carbon tetrachloride does not occur naturally. It is expected that discharges to surface water during production and use, and leaching into ground water from wastes deposited in landfills are primary causes of carbon tetrachloride contamination of drinking water. Generally, it makes its way to the air because it tends to evaporate from surface waters and soils and is not chemically inclined to adhere to soil particles. In the air, it may take several years to break down into other chemicals. If it becomes trapped in ground water, however, its breakdown time accelerates to months (ATSDR, 2005).

A low background concentration of 0.1 ppb of carbon tetrachloride exists in the air around the world, though levels in cities frequently rise to between 0.2 and 0.6 ppb. Its past use has also resulted in low background levels in the soil and water around the world. Human exposure to increased levels of carbon tetrachloride is typical only at specific industrial locations where carbon tetrachloride is still used or near chemical waste sites where emissions into air, water, or soil are not properly controlled. Carbon tetrachloride has been found in water or soil at about 26% of the waste sites investigated under Superfund, at concentrations ranging from less than 50 to over 1,000 ppb (ATSDR, 2005).

4.2 Use, Production, and Releases

Carbon tetrachloride has been produced in large quantities to make refrigeration fluid and propellants for aerosol cans. It has also been used as a cleaning fluid (as a degreasing agent and as a spot remover for clothing, furniture, and carpets). Other applications include use in fire extinguishers and as a fumigant to kill insects in grain. Most of these uses were discontinued in the mid-1960s. Use as a pesticide was discontinued in 1986 (ATSDR, 2005).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 4-1 presents the production of carbon tetrachloride in the United States from 1986 to 2002. Production decreased between 1990 and 1994 and has remained within the same production range since 1994.

Exhibit 4-1: Production of Carbon tetrachloride in the United States

Inventory Update Year	Production Volume
1986 Range	> 500 million - 1 billion pounds
1990 Range	> 500 million - 1 billion pounds
1994 Range	> 100 million - 500 million pounds
1998 Range	> 100 million - 500 million pounds
2002 Range	> 100 million - 500 million pounds

Source: USEPA, 2003a

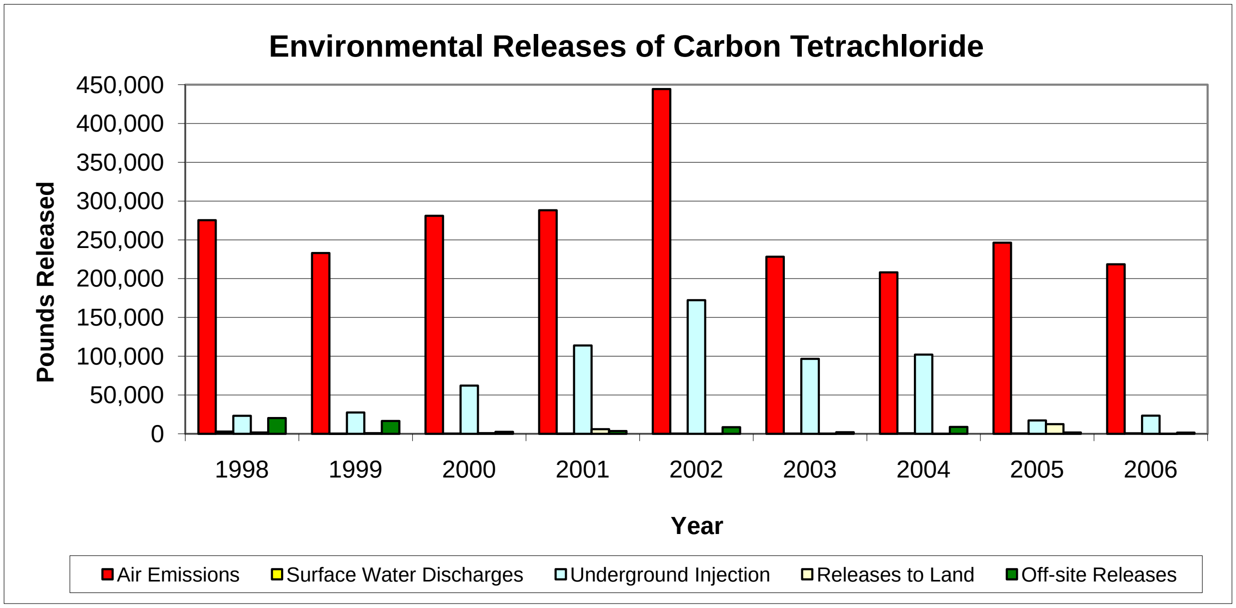
Carbon tetrachloride is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 4-2a lists the environmental releases of carbon tetrachloride from 1998 to 2006. (Exhibit 4-2b provides a graphical presentation of the environmental releases.) Air emissions constitute the vast majority of the on-site releases and, except for a peak in 2002, remained relatively constant over the years. Surface water discharges constituted less than 1% of total releases. Underground injection increased until 2002 and then decreased. Off-site releases were small and generally decreased over the period of record. On-site surface water discharges, which were highest in 1998, dropped in subsequent years. Off-site releases decreased gradually over the period of record. These TRI data were reported from 31 states, Puerto Rico, and the Virgin Islands. Thirteen of the 31 states reported every year.

Exhibit 4-2a: Table of Toxics Release Inventory (TRI) Data for Carbon Tetrachloride

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	275,342	2,836	23,168	1,679	20,251	323,276
1999	232,988	85	27,548	938	16,566	278,125
2000	281,033	184	62,203	835	2,546	346,801
2001	288,214	85	113,881	5,929	3,557	411,666
2002	444,436	320	172,247	47	8,493	625,544
2003	228,158	308	96,698	193	2,067	327,424
2004	208,080	678	102,061	25	8,906	319,749
2005	246,416	385	17,266	12,527	1,647	278,241
2006	218,445	543	23,363	21	1,487	243,859

Source: USEPA, 2008

Exhibit 4-2b: Graph of Toxics Release Inventory (TRI) Data for Carbon Tetrachloride



Source: USEPA, 2008

4.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of carbon tetrachloride in ambient water are available from the NAWQA program.

4.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for carbon tetrachloride. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 4-3. Overall, carbon tetrachloride was detected in 1.5% of samples and at 1.2% of sites. Carbon tetrachloride was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.045 µg/L. The 99th percentile concentration, based on detections from all sites, was 2.38 µg/L.

Exhibit 4-3: EPA Summary Analysis of Carbon Tetrachloride 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 Percentile	99th Percentile	Maximum
ground water	4,658	1.3%	4,159	1.0%	0.01	0.0535	1.1	2.377	2.377
surface water	1,413	2.0%	190	4.7%	0.016	0.03395	0.3747	0.4023	0.4023
all sites	6,071	1.5%	4,349	1.2%	0.01	0.04525	0.9	2.377	2.377

1. RLs (Reporting Limits) for carbon tetrachloride varied, but did not exceed 0.016 µg/L.

4.4 Occurrence in Drinking Water

Carbon tetrachloride is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of carbon tetrachloride occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for carbon tetrachloride. These data consist of 385,864 analytical results from 50,446 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for carbon tetrachloride in the dataset is 0.5 µg/L.

4.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 4-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For carbon tetrachloride, 1.289% of 50,446 systems reported detections. Exhibit 4-5 lists the minimum, median, 90th percentile, and maximum carbon tetrachloride concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of carbon tetrachloride, based on detections from all systems, was 1.1 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 4-4: Carbon Tetrachloride Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	295,112	46,190	80,583	86,397,574	86,397,574
Surface Water	90,752	4,256	10,885	140,537,213	140,537,213
Combined Ground & Surface Water	385,864	50,446	91,468	226,934,787	226,934,787
Percent with Detections					
Ground Water	0.815%	0.935%	0.635%	3.419%	1.243%
Surface Water	2.534%	5.122%	2.839%	13.773%	5.827%
Combined Ground & Surface Water	1.220%	1.289%	0.898%	9.831%	4.082%

Exhibit 4-5: Carbon Tetrachloride Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.03	1.24	3.5	300
Surface Water	0.003	1	5.04	27
Combined Ground & Surface Water	0.003	1.1	3.9	300

The following maps illustrate the geographic distribution of carbon tetrachloride occurrence in drinking water. Exhibit 4-6 shows the states with systems with at least one detection and Exhibit 4-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas2, Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of carbon tetrachloride is geographically dispersed. Detection rates were generally low, although 43 states reported carbon tetrachloride

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

detections. Only 4 of the 43 states reported detections in more than 5% of their systems. Twenty-five states reported detections greater than the MCL concentration of 5 µg/L, although only two states reported more than 0.5% of systems with detections greater than 5 µg/L.

Exhibit 4-6: Percentage of Systems with at Least One Carbon Tetrachloride Detection, by State

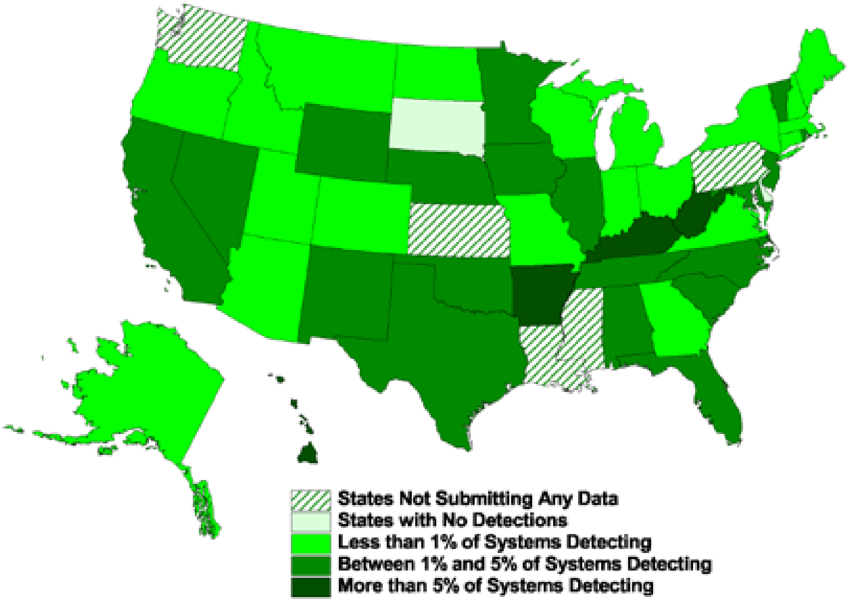

Exhibit 4-7: Percentage of Systems with at Least One Carbon Tetrachloride Detection Greater than the MCL Concentration (> 5 µg/L), by State

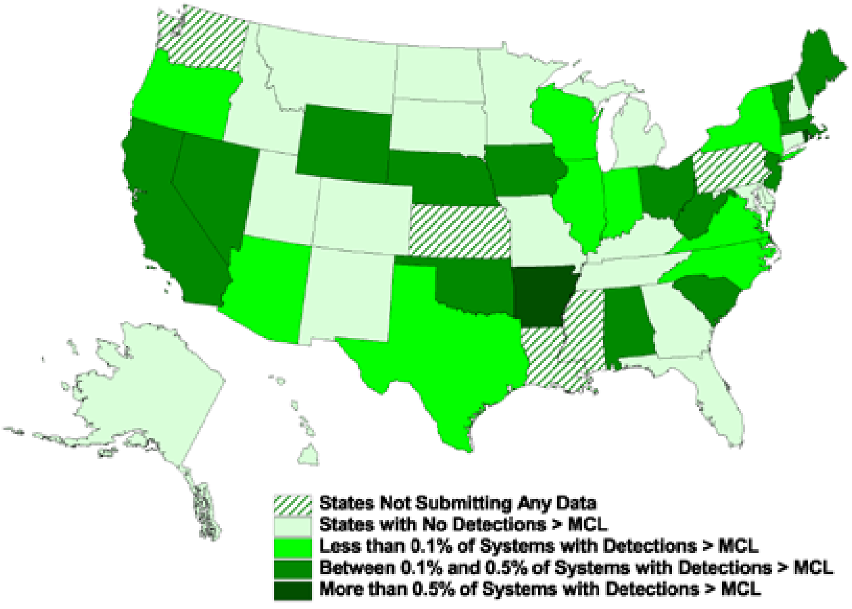

Exhibit 4-8 presents the Stage 1 analysis of carbon tetrachloride occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 0.5 µg/L, 1 µg/L, 2.5 µg/L, and 5 µg/L. A total of 106 (0.210% of) systems, serving about 5.5 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 57 (0.113% of) systems, serving nearly 5 million persons, reported at least one detection exceeding 5 µg/L. Detections greater than the thresholds were more common in ground water systems than surface water systems. However, because surface water systems tend to be larger, a greater population was served by surface water systems reporting at least one detection greater than the thresholds.

Exhibit 4-8: Carbon Tetrachloride Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 5 µg/L	49	0.106%	146,334	0.169%
	≥ 2.5 µg/L	81	0.175%	313,180	0.362%
	≥ 1 µg/L	179	0.388%	1,010,901	1.170%
	> 0.5 µg/L	312	0.675%	1,813,677	2.099%

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Surface Water	> 5 µg/L	8	0.188%	4,821,230	3.431%
	≥ 2.5 µg/L	25	0.587%	5,174,513	3.682%
	≥ 1 µg/L	82	1.927%	7,071,752	5.032%
	> 0.5 µg/L	147	3.454%	12,609,728	8.973%
Combined Ground & Surface Water	> 5 µg/L	57	0.113%	4,967,564	2.189%
	≥ 2.5 µg/L	106	0.210%	5,487,693	2.418%
	≥ 1 µg/L	261	0.517%	8,082,653	3.562%
	> 0.5 µg/L	459	0.910%	14,423,405	6.356%

The occurrence estimates presented above (in Exhibit 4-8) are based on the conservative assumption that if a carbon tetrachloride detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to carbon tetrachloride (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of carbon tetrachloride). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of carbon tetrachloride because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of carbon tetrachloride (rather than the entire population-served by the system).

Exhibit 4-9 presents the Stage 1 analysis of carbon tetrachloride occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. A total of 135 (0.148% of) sample points, serving an estimated 578,000 persons, reported at least one detection greater than or equal to 2.5 µg/L; and 67 (0.073% of) sample points, serving an estimated 160,000 persons, reported at least one detection exceeding 5 µg/L. The percentages of sample points exceeding 5 µg/L were small for both ground water and surface sample points, but a larger population was served by surface water sample points with threshold exceedances.

Exhibit 4-9: Carbon Tetrachloride Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 5 µg/L	52	0.065%	29,169	0.034%
	≥ 2.5 µg/L	90	0.112%	76,401	0.088%
	≥ 1 µg/L	202	0.251%	266,717	0.309%
	> 0.5 µg/L	375	0.465%	552,059	0.639%
Surface Water	> 5 µg/L	15	0.138%	130,663	0.093%
	≥ 2.5 µg/L	45	0.413%	501,204	0.357%
	≥ 1 µg/L	135	1.240%	1,599,997	1.138%
	> 0.5 µg/L	221	2.030%	4,333,382	3.083%
Combined Ground & Surface Water	> 5 µg/L	67	0.073%	159,832	0.070%
	≥ 2.5 µg/L	135	0.148%	577,605	0.255%
	≥ 1 µg/L	337	0.368%	1,866,714	0.823%
	> 0.5 µg/L	596	0.652%	4,885,441	2.153%

4.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean carbon tetrachloride concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 4-10 presents the Stage 2 analysis of estimated system mean concentrations for carbon tetrachloride occurrence in drinking water relative to several thresholds. The thresholds are: 0.5 µg/L, 1 µg/L, 2.5 µg/L, and 5 µg/L. Exhibit 4-11 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than 13 ground water systems (approximately 0.026% of all systems) had an estimated system mean greater than or equal to 2.5 µg/L. These 13 systems serve 5,808 persons. Five systems (approximately 0.010% of all systems), serving 1,746 persons, had an estimated system mean greater than the MCL concentration. No system mean exceedances of the MCL concentration occurred in surface water systems.

Exhibit 4-10: Carbon Tetrachloride Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	5	5	5	0.011%	0.011%	0.011%
	≥ 2.5 µg/L	13	12	12	0.028%	0.026%	0.026%
	≥ 1 µg/L	54	46	36	0.117%	0.100%	0.078%
	> 0.5 µg/L	293	101	76	0.634%	0.219%	0.165%
Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	5	4	4	0.117%	0.094%	0.094%
	> 0.5 µg/L	133	17	8	3.125%	0.399%	0.188%
Combined Ground & Surface Water	> 5 µg/L	5	5	5	0.010%	0.010%	0.010%
	≥ 2.5 µg/L	13	12	12	0.026%	0.024%	0.024%
	≥ 1 µg/L	59	50	40	0.117%	0.099%	0.079%
	> 0.5 µg/L	426	118	84	0.844%	0.234%	0.167%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 4-11: Carbon Tetrachloride Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	1,746	1,746	1,746	0.002%	0.002%	0.002%
	≥ 2.5 µg/L	5,808	5,508	5,508	0.007%	0.006%	0.006%
	≥ 1 µg/L	60,156	58,138	35,883	0.070%	0.067%	0.042%
	> 0.5 µg/L	1,638,978	159,018	131,766	1.897%	0.184%	0.153%
Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	204,708	153,958	153,958	0.146%	0.110%	0.110%
	> 0.5 µg/L	9,450,131	590,725	236,026	6.724%	0.420%	0.168%

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 5 µg/L	1,746	1,746	1,746	0.001%	0.001%	0.001%
	≥ 2.5 µg/L	5,808	5,508	5,508	0.003%	0.002%	0.002%
	≥ 1 µg/L	264,864	212,096	189,841	0.117%	0.093%	0.084%
	> 0.5 µg/L	11,089,109	749,743	367,792	4.886%	0.330%	0.162%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

4.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including carbon tetrachloride, in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, carbon tetrachloride had a detection frequency of 0.21% at an assessment level of 0.2 µg/L (based on 2,400 samples). The median concentration of detections was 0.043 µg/L. Three detections were within one order of magnitude of the MCL concentration (of 5 µg/L). No detections were greater than the MCL concentration.

In public wells, carbon tetrachloride had a detection frequency of 0.73% at an assessment level of 0.2 µg/L (based on 1,096 samples). The median concentration of detections was 0.38 µg/L. Five detections were within one order of magnitude of the MCL concentration. No detections were greater than the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 458 systems (approximately 1.99% of about 23,000 systems), reported at least one detection of carbon tetrachloride. Forty-six systems (approximately 0.2% of all systems), reported at least one detection greater than the MCL concentration.

4.6 Summary of Data

TRI data indicate that total off-site and on-site releases of carbon tetrachloride for the period 1998-2006 ranged from about 244,000 pounds to about 626,000 pounds, with a peak in

2002. Most of the releases were in the form of air emissions. Underground injection was the second most important source of releases. Surface water releases, releases to land, and off-site releases were relatively minor.

Ambient water data from the NAWQA program indicate that carbon tetrachloride was detected in 1.5% of 6,071 ground and surface water samples and at 1.2% of 4,349 sites. The median concentration, based on detections from all sites, was 0.045 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that carbon tetrachloride was detected in 1.289% of 50,446 surface water and ground water systems. The median concentration, based on detections from all systems, was 1.1 µg/L. In total, 0.113% of systems (serving 2.189% of the population) reported at least one detection greater than the MCL concentration of 5 µg/L. Detections were more common in ground water systems than in surface water systems. However, because surface water systems tend to be larger, a greater population was served by surface water systems reporting at least one detection greater than the thresholds. The pattern was similar for sample points.

In the Stage 2 analysis, 0.010% of systems (serving 0.001% of the total population) had an estimated system mean concentration of carbon tetrachloride greater than the MCL concentration. No surface water systems had mean values exceeding the MCL concentration.

4.7 References

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5 Chlordane

This chapter on chlordane is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and chlordane occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

5.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for chlordane on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 2 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1994), chlordane ($C_{10}H_6Cl_8$) is not a single chemical but a mixture of many related chemicals used as a pesticide in the United States between 1948 and 1988. Some of the major components are trans-chlordane, cis-chlordane, beta-chlordene, heptachlor, and trans-nonachlor. The mixture forms a thick liquid, which may range in color from clear to amber, and may vary in smell between odorless and irritatingly acrid. Chlordane is produced by chlorinating cyclopentadiene to form hexachlorocyclopentadiene and condensing the latter with cyclopentadiene to form chlordene. The chlordene is further chlorinated at high temperature and pressure to chlordane. Because of wide-ranging health and environmental concerns, chlordane’s use was restricted to termite control in the 1980s and has since been banned entirely. Nonetheless, production for export is still permitted (ATSDR, 1994).

When chlordane is applied to surface soils, about half of it evaporates within two to three days. However, once the soil is tilled, it may remain underground for over 20 years, especially if the soil is heavy, clayey, or largely organic. Because it attaches strongly to particles in the upper layers of soil, chlordane is not likely to infiltrate into ground water. It is not known to what extent chlordane breaks down in soil or water. In the air, it breaks down by reacting with light and other chemicals, but it is long-lived enough that it may redeposit on land or water far away from its source. Chlordane is remarkably persistent in the environment, and even though it has long been banned in the United States, it was still detectable in the fat of fish, birds, mammals, and almost all humans as of the 1990s (ATSDR, 1994).

Since use of chlordane has been banned, those at the highest risk for high exposure are individuals living in houses that were treated for termites using chlordane. Over 50 million persons in the United States have lived in such homes, where maximum concentrations have been measured as high as 0.06 mg/m³. Chlordane also remains in the food supply because much of the farmland was treated with chlordane in the 1960s and 1970s and the chemical persists in the soil. A survey conducted by the Food and Drug Administration (FDA) determined the daily intake of chlordane from food to be between 0.0005 and 0.0015 µg/kg for teenagers and adults (ATSDR, 1994).

5.2 Use, Production, and Releases

The commercial use of chlordane in the United States was banned April 14, 1988; however it is still manufactured for export. Chlordane and a chlordane-heptachlor combination were used in Canada and the United States as insecticides on various types of agricultural crops and vegetation, in the home, on food and nonfood crops, and on lawns and gardens (ASTDR, 1994). In the mid 1970's 35% of chlordane was used by pest control operators, mostly on termites; 28% was used on agricultural crops, including corn and citrus; 30% was used for home lawn and garden use; and 7% was applied on turf and ornamentals (ASTDR, 1994). The only commercial use of chlordane products still permitted is for fire ant control in power transformers.

The Chemical Substance Inventory Update System contains confidential data reported by industry as a partial update of the Toxic Substances Control Act (TSCA) Inventory. The TSCA Chemical Substance Inventory does not report production data for chlordane.

Chlordane is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 5-1a lists the environmental releases of chlordane from 1998 to 2006. (Exhibit 5-1b provides a graphical presentation of the environmental releases.) The majority of chlordane releases were releases to land, with generally minimal releases to air and surface water. There has been no underground injection except for in 1998, when large amounts of chlordane were both injected underground and released to land. Off-site releases have also been generally only a few percent of the total. These TRI data for chlordane were reported from 20 states, with only 4 of the 20 states (Arkansas, New Jersey, Ohio, and Texas) reporting every year.

Exhibit 5-1a: Table of Toxics Release Inventory (TRI) Data for Chlordane

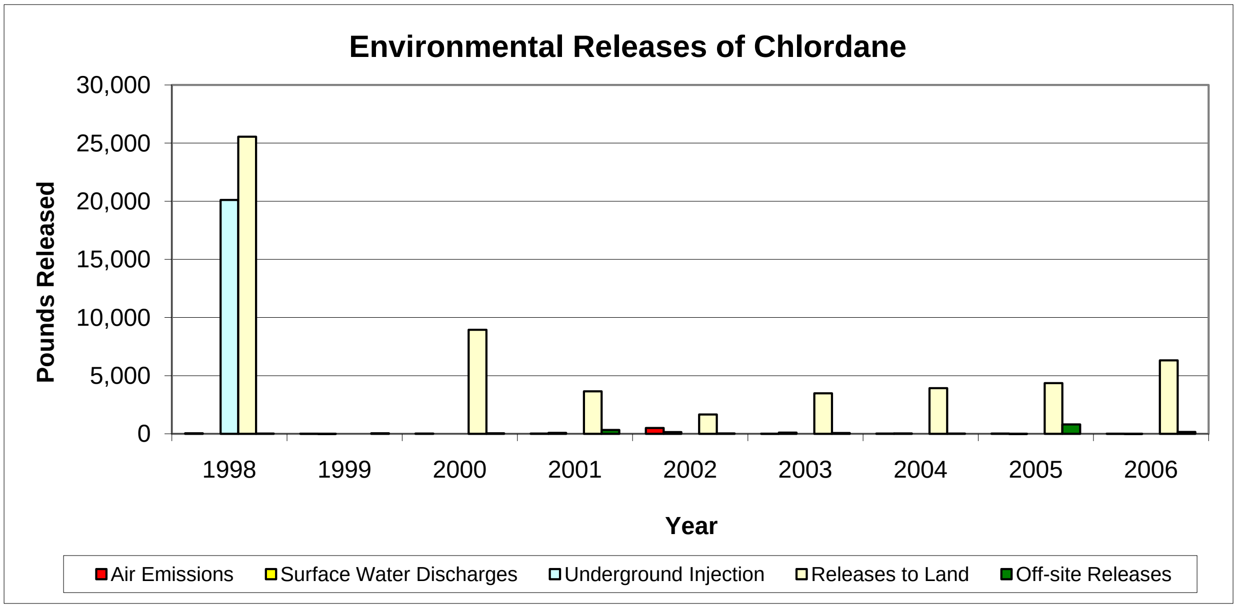
Year	On-Site Releases (pounds)				Off-Site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	45	- [1]	20,106	25,548	22	45,721
1999	8	1	0	0	40	49
2000	14	0	0	8,948	47	9,008
2001	15	80	0	3,648	336	4,079
2002	501	147	0	1,659	35	2,343
2003	12	107	0	3,483	67	3,669

Year	On-Site Releases (pounds)				Off-Site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
2004	16	35	0	3,928	22	4,001
2005	16	1	0	4,355	811	5,184
2006	7	0	0	6,321	164	6,493

Source: USEPA, 2008

1. There is a hyphen in this cell because the facility that reported releases left that particular cell blank in its data submission (a zero in a cell denotes either that the facility reported "0" or "NA" in its data submission).

Exhibit 5-1b: Graph of Toxics Release Inventory (TRI) Data for Chlordane



Source: USEPA, 2008

5.3 Occurrence in Ambient Water

No National Water Quality Assessment (NAWQA) Program data are available from the United States Geological Survey (USGS) on the occurrence of chlordane in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

5.4 Occurrence in Drinking Water

Chlordane is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of chlordane occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

Forty-four of the Six-Year Review-ICR states provided occurrence data for chlordane. (There were no chlordane data from Oklahoma.) These data consist of 128,453 analytical results from 31,841 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for chlordane in the dataset is 0.2 µg/L.

5.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 5-2 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For chlordane, 0.210% of 31,841 systems reported detections. Exhibit 5-3 lists the minimum, median, 90th percentile, and maximum chlordane concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of chlordane, based on detections from all systems, was 0.38 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 5-2: Chlordane Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	101,389	28,808	45,986	66,936,780	66,936,780
Surface Water	27,064	3,033	6,686	115,100,195	115,100,195
Combined Ground & Surface Water	128,453	31,841	52,672	182,036,975	182,036,975
Percent with Detections					
Ground Water	0.152%	0.205%	0.139%	4.124%	3.984%
Surface Water	0.059%	0.264%	0.194%	0.571%	0.374%
Combined Ground & Surface Water	0.132%	0.210%	0.146%	1.878%	1.701%

Exhibit 5-3: Chlordane Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.005	0.4	1.6	5.4
Surface Water	0.02	0.1	0.5	0.9
Combined Ground & Surface Water	0.005	0.38	1.59	5.4

The following maps illustrate the geographic distribution of chlordane occurrences in drinking water. Exhibit 5-4 shows the states with systems with at least one detection and Exhibit 5-5 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Oklahoma did submit Six-Year data for most contaminants; however, there is a statewide waiver for chlordane in Oklahoma so no chlordane data were available from that state.

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

The distribution of systems with detections of chlordane is geographically dispersed. Detection rates were low overall, with a few states on the eastern seaboard and in the southeast having somewhat higher detection rates (0.5% to 1% of their systems). Two states had detections greater than the MCL concentration of 2 µg/L.

Exhibit 5-4: Percentage of Systems with at Least One Chlordane Detection, by State

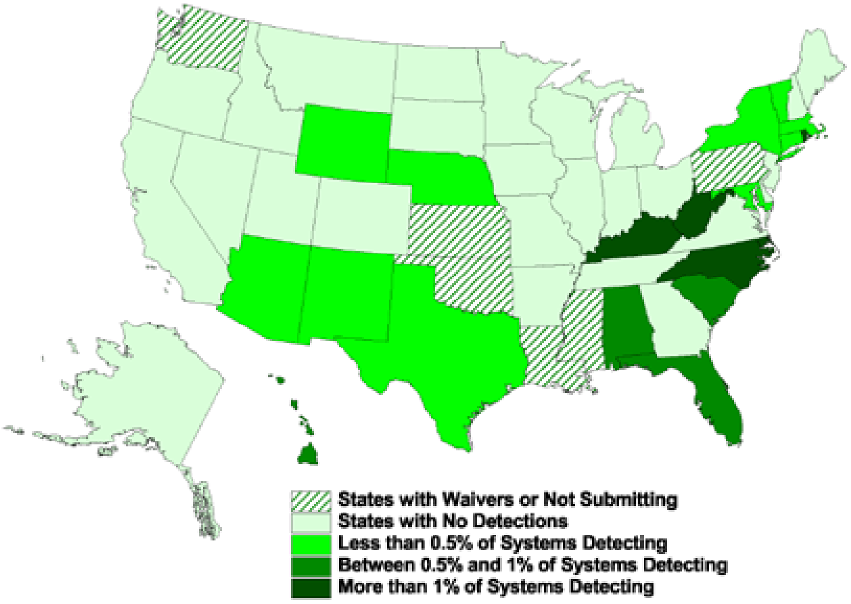

Exhibit 5-5: Percentage of Systems with at Least One Chlordane Detection Greater than the MCL Concentration (> 2 µg/L), by State

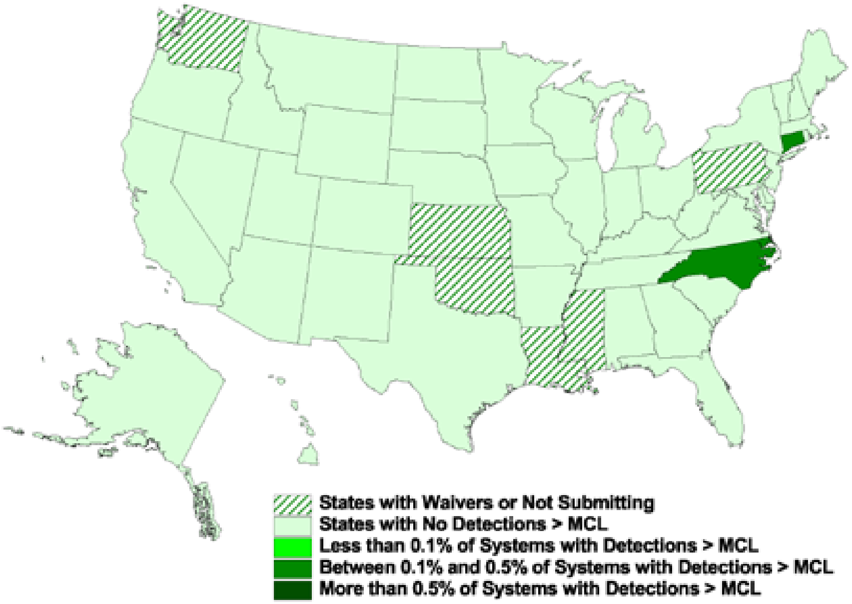

Exhibit 5-6 presents the Stage 1 analysis of chlordane occurrences in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 2 µg/L and 1 µg/L. Twelve (0.038% of) systems, serving about 1,600 persons, reported at least one detection greater than or equal to 1 µg/L; four systems (0.013% of all systems), serving 625 persons, reported at least one detection greater than 2 µg/L. All detections of chlordane greater than or equal to 1 µg/L and greater than 2 µg/L were in ground water systems.

Exhibit 5-6: Chlordane Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 2 µg/L	4	0.014%	625	0.001%
	≥ 1 µg/L	12	0.042%	1,645	0.002%
Surface Water	> 2 µg/L	0	0.000%	0	0.000%
	≥ 1 µg/L	0	0.000%	0	0.000%

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Combined Ground & Surface Water	> 2 µg/L	4	0.013%	625	0.0003%
	≥ 1 µg/L	12	0.038%	1,645	0.001%

The occurrence estimates presented above (in Exhibit 5-6) are based on the conservative assumption that if a chlordane detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to chlordane (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of chlordane). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of chlordane because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of chlordane (rather than the entire population-served by the system).

Exhibit 5-7 presents the Stage 1 analysis of chlordane occurrences in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Sixteen (0.030% of) sample points, serving an estimated 1,053 persons, had at least one result greater than or equal to 1 µg/L; and six (0.011% of) sample points, serving an estimated 433 persons, had at least one result exceeding 2 µg/L. Similar to the system-level occurrence analysis, all detections of chlordane greater than or equal to 1 µg/L and greater than 2 µg/L were in sample points from ground water systems.

Exhibit 5-7: Chlordane Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 2 µg/L	6	0.013%	433	0.001%
	≥ 1 µg/L	16	0.035%	1,053	0.002%
Surface Water	> 2 µg/L	0	0.000%	0	0.000%
	≥ 1 µg/L	0	0.000%	0	0.000%

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Combined Ground & Surface Water	> 2 µg/L	6	0.011%	433	0.0002%
	≥ 1 µg/L	16	0.030%	1,053	0.001%

5.4.2 *Stage 2 Analysis of Occurrence Data*

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean chlordane concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 5-8 presents the Stage 2 analysis of estimated system mean concentrations for chlordane in drinking water relative to two thresholds: 2 µg/L and 1 µg/L. Exhibit 5-9 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than two ground water systems (approximately 0.006% of all systems) had estimated system means greater than or equal to 1 µg/L. These two systems serve about 116 persons. One ground water system (0.003%), serving about 80 persons, had estimated system means greater than 2 µg/L. No surface water systems had estimated means greater than either threshold.

Exhibit 5-8: Chlordane Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 2 µg/L	1	1	1	0.003%	0.003%	0.003%
	≥ 1 µg/L	2	2	1	0.007%	0.007%	0.003%
Surface Water	> 2 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	0	0	0	0.000%	0.000%	0.000%

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 2 µg/L	1	1	1	0.003%	0.003%	0.003%
	≥ 1 µg/L	2	2	1	0.006%	0.006%	0.003%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 5-9: Chlordane Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 2 µg/L	80	80	80	0.0001%	0.0001%	0.0001%
	≥ 1 µg/L	116	116	80	0.0002%	0.0002%	0.0001%
Surface Water	> 2 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 2 µg/L	80	80	80	0.00004%	0.00004%	0.00004%
	≥ 1 µg/L	116	116	80	0.0001%	0.0001%	0.00004%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

5.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003), 157 systems (approximately 1.19% of about 13,000 systems), reported at least one detection of chlordane. One system (approximately 0.01% of all systems), reported at least one detection greater than the MCL concentration.

5.6 Summary of Data

TRI data indicate that the total off-site and on-site releases of chlordane for the period 1998-2006 ranged from about 50 pounds to about 46,000 pounds; most years had total releases between approximately 2,000 and 9,000 pounds. Releases to land constituted the majority of releases. Surface water discharges and air emissions were much less than releases to land, and underground injection was non-existent except for 1998.

No data are available from the NAWQA program on chlordane in ambient waters.

The Stage 1 analysis of occurrences in drinking water indicates that chlordane was detected in 0.210% of 31,841 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.38 µg/L. In total, 0.013% of systems (serving 0.0003% of the total population) reported at least one detection greater than the MCL concentration of 2 µg/L. No surface water systems reported detections greater than the MCL concentration. A similar pattern was seen for ground water and surface water sample points.

In the Stage 2 analysis, 0.003% of all water systems (serving 0.00004% of the total population) had an estimated system mean concentration of chlordane greater than the MCL concentration. There were no system mean threshold exceedances for surface water. Only one ground water system (serving 80 persons) had a mean exceeding the MCL concentration.

5.7 References

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6 1,2-Dibromo-3-chloropropane (DBCP)

This chapter on 1,2-dibromo-3-chloropropane (DBCP) is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and DBCP occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

6.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for DBCP on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 0.2 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1992), DBCP ($C_3H_5Br_2Cl$) is a colorless liquid with a sharp smell. It does not evaporate quickly and is only weakly soluble in water.

DBCP is not usually found in the environment. It was once produced in large amounts as a pesticide, but this use has been discontinued in the United States since the 1980s. Some industries still use DBCP to make fire-resistant substances. Because production is very limited, it is difficult to determine exactly how much is being used currently. DBCP is sometimes found in the soil and ground water near cropland where it has been used. It may also enter the environment during production or use in industry and research (ATSDR, 1992).

When DBCP is deposited on soil or released to surface water, much of it evaporates to the air, where it breaks down over the course of months. DBCP applied to soil may also penetrate downward into deeper soils and ground water. In such cases it may take a number of years for the chemical to break down. Based on the limited usage in the past 5 to 10 years, it is expected that levels where the chemical has not been used or discarded are either low or nonexistent (ATSDR, 1992).

6.2 Use, Production, and Releases

Until 1977, DBCP was used extensively as a soil fumigant and nematocide on over 40 different crops in efforts to protect field crops, vegetables, fruits and nuts, nursery and greenhouse crops, and turf from pests. From 1977 to 1979, EPA suspended registration for all DBCP-containing products except for use on pineapples in Hawaii. In 1985, EPA canceled all registrations for DBCP, including use on pineapples (ATSDR, 1992).

The Chemical Substance Inventory Update System contains confidential data reported by industry as a partial update of the Toxic Substances Control Act (TSCA) Inventory. The TSCA Chemical Substance Inventory does not report production data for DBCP.

DBCP is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 6-1a lists the environmental releases of DBCP from 1998 to 2006. (Exhibit 6-1b provides a graphical presentation of the environmental releases.) Releases were negligible until 2001. Almost all DBCP releases were off-site. In isolated instances, negligible quantities were released to the air. No DBCP was reported as being injected underground, or as being released to the land or surface water. Arkansas and Ohio are the only two states that reported any releases of DBCP for the period of record. (Ohio reported releases for all years. Arkansas reported releases for all years except 1998.)

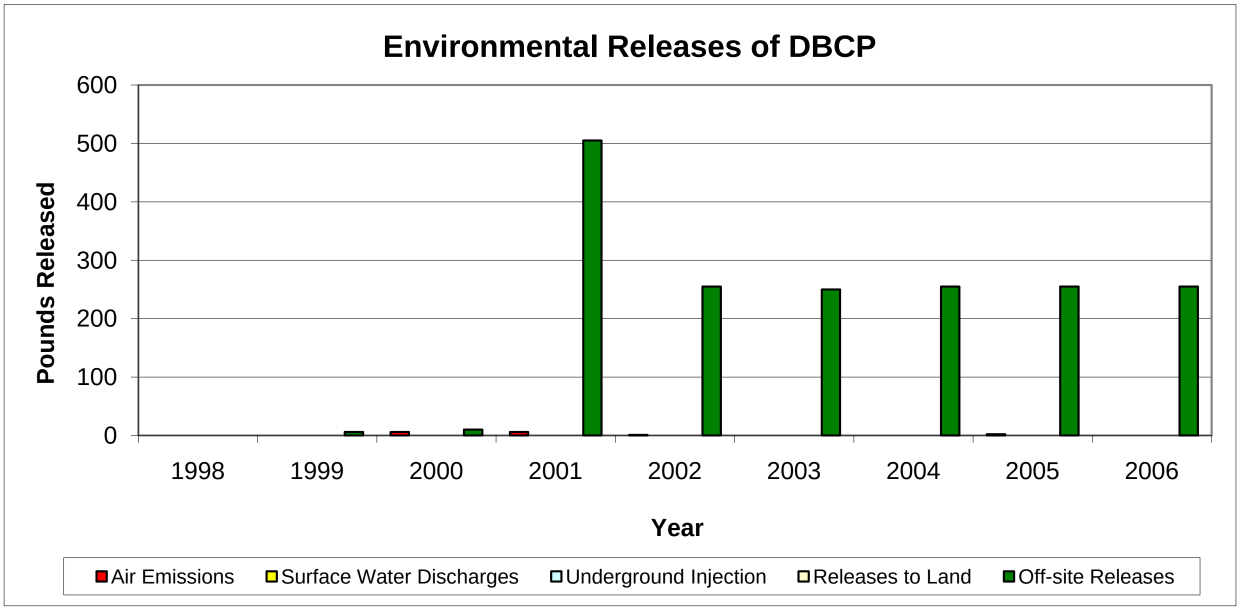
Exhibit 6-1a: Table of Toxics Release Inventory (TRI) Data for DBCP

Year	On-Site Releases (pounds)				Off-Site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998[1]	.	.	.	.	.	0
1999	0	0	0	0	6	6
2000	6	0	0	0	10	16
2001	6	0	0	0	505	511
2002	1	0	0	0	255	256
2003	0	0	0	0	250	250
2004	0	0	0	0	255	255
2005	2	0	0	0	255	257
2006	0	0	0	0	255	255

Source: USEPA, 2008

1. There are decimal points in this row because the facility certified that its total annual reportable amount is less than 500 pounds, and does not manufacture, process, or otherwise use more than 1 million pounds.

Exhibit 6-1b: Graph of Toxics Release Inventory (TRI) Data for DBCP



Source: USEPA, 2008

6.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of DBCP in ambient water are available from the NAWQA program.

6.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for DBCP. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 6-2. Overall, DBCP was detected in 1.7% of samples and at 1.4% of sites. DBCP was detected more frequently in ground water than in surface water. The median concentration, based on detections from all sites, was 1.2 µg/L. The 99th percentile concentration, based on detections from all sites, was 4 µg/L.

Exhibit 6-2: EPA Summary Analysis of 1,2-Dibromo-3-chloropropane (DBCP) 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
ground water	4,920	2.2%	4,148	1.4%	0.0252	1.2885	3.2	4	6.4
surface water	1,393	0.2%	185	1.6%	0.09	0.1	0.11	0.11	0.11
all sites	6,313	1.7%	4,333	1.4%	0.0252	1.2	3.2	4	6.4

1. RLs (Reporting Limits) for DBCP varied, but did not exceed 0.03 µg/L.

6.4 Occurrence in Drinking Water

DBCP is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.) Statewide waivers are often granted for DBCP.

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of DBCP occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Forty-four of the Six-Year Review-ICR states provided occurrence data for DBCP. (Oklahoma provided no DBCP data.) These data consist of 231,169 analytical results from 37,618 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for DBCP in the dataset is 0.02 µg/L.

6.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 6-3 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For DBCP, 1.029% of 37,618 systems reported detections. Exhibit 6-4 lists the minimum, median, 90th percentile, and maximum DBCP concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of DBCP, based on detections from all systems, was 0.3 µg/L.

Exhibit 6-3: DBCP Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	178,958	34,602	59,021	73,552,992	73,552,992
Surface Water	52,211	3,016	7,762	120,196,347	120,196,347
Combined Ground & Surface Water	231,169	37,618	66,783	193,749,339	193,749,339
Percent with Detections					
Ground Water	4.675%	0.922%	1.166%	9.820%	6.454%
Surface Water	21.806%	2.255%	5.037%	8.929%	4.555%
Combined Ground & Surface Water	8.544%	1.029%	1.616%	9.268%	5.276%

Exhibit 6-4: DBCP Summary Statistics

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.02	0.3	2	70
Surface Water	0.009	0.29	1.1	230
Combined Ground & Surface Water	0.009	0.3	1.5	230

The following maps illustrate the geographic distribution of DBCP occurrence in drinking water. Exhibit 6-5 shows the states with systems with at least one detection and Exhibit 6-6 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Oklahoma did submit Six-Year data for most contaminants; however, there is a statewide waiver for DBCP in Oklahoma so no DBCP data were available from that state.

The distribution of systems with detections of DBCP is geographically dispersed. Detection rates were generally low, with only three states having greater than 5% of their systems detecting DBCP. Fourteen states reported at least one detection greater than the MCL concentration of 0.2 µg/L, although only 9 of these states had more than 0.5% of systems with at least one detection greater than the MCL concentration.

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Exhibit 6-5: Percentage of Systems with at Least One DBCP Detection, by State

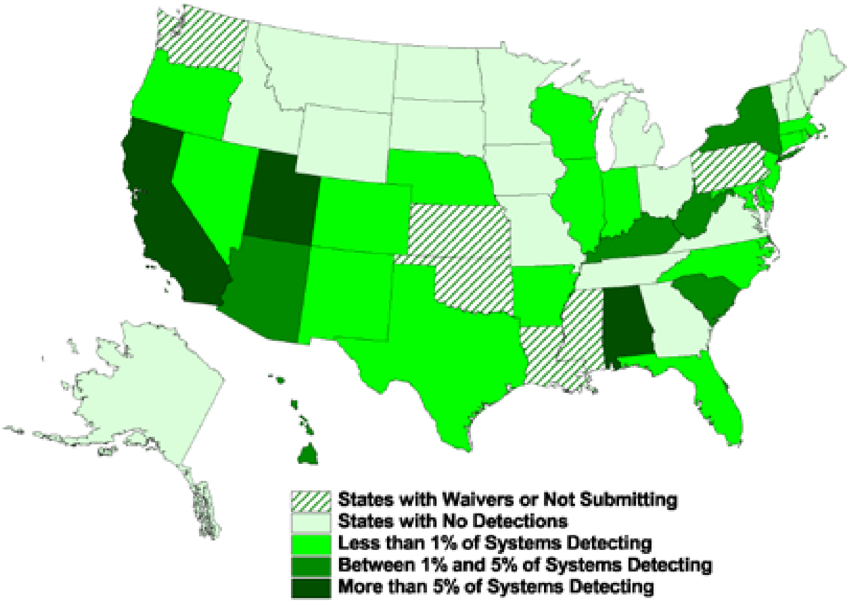


Exhibit 6-6: Percentage of Systems with at Least One DBCP Detection Greater than the MCL Concentration (> 0.2 μg/L), by State

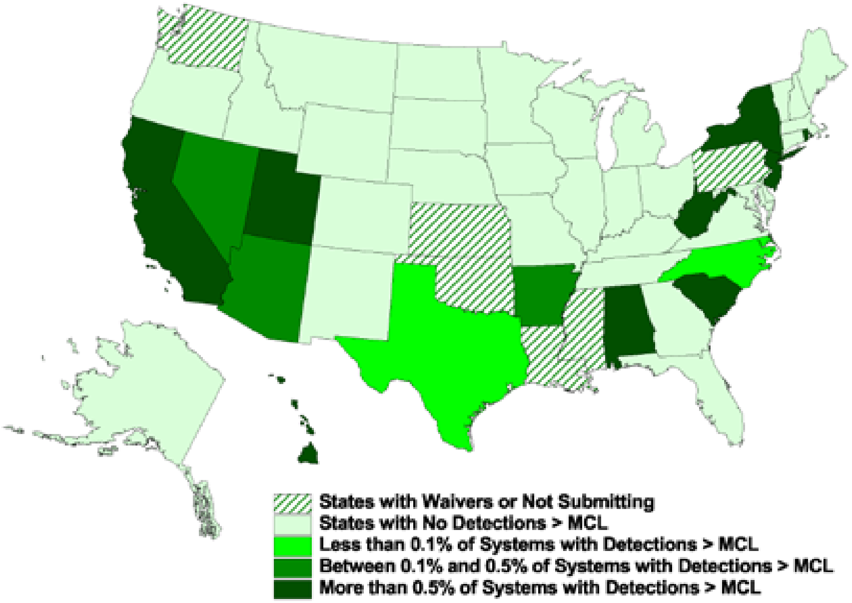


Exhibit 6-7 presents the Stage 1 analysis of DBCP occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.2 µg/L and 0.1 µg/L. A total of 201 (0.534% of) systems, serving about 7 million persons, reported at least one detection greater than or equal to 0.1 µg/L; and 146 (0.388% of) systems, serving 3 million persons, reported at least one detection greater than 0.2 µg/L. Detections greater than the thresholds occurred in more ground water than surface water systems. However, because surface water systems tend to be larger, more people were served by surface water systems reporting at least one detection at greater than threshold values.

Exhibit 6-7: DBCP Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 0.2 µg/L	120	0.347%	1,032,709	1.404%
	≥ 0.1 µg/L	168	0.486%	1,370,317	1.863%
Surface Water	> 0.2 µg/L	26	0.862%	2,118,782	1.763%
	≥ 0.1 µg/L	33	1.094%	5,730,210	4.767%
Combined Ground & Surface Water	> 0.2 µg/L	146	0.388%	3,151,491	1.627%
	≥ 0.1 µg/L	201	0.534%	7,100,527	3.665%

The occurrence estimates presented above (in Exhibit 6-7) are based on the conservative assumption that if a DBCP detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to DBCP (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of DBCP). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of DBCP because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of DBCP (rather than the entire population-served by the system).

Exhibit 6-8 presents the Stage 1 analysis of DBCP occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. A total of 540 (0.809% of) sample points, serving an estimated 3.8 million persons, reported at least one detection greater than or equal to 0.1 µg/L; and 346 (0.518% of) sample points, serving an estimated 818,000 persons, reported at least one detection exceeding 0.2 µg/L.

Exhibit 6-8: DBCP Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 0.2 µg/L	199	0.337%	217,321	0.295%
	≥ 0.1 µg/L	318	0.539%	394,293	0.536%
Surface Water	> 0.2 µg/L	147	1.894%	600,798	0.500%
	≥ 0.1 µg/L	222	2.860%	3,365,848	2.800%
Combined Ground & Surface Water	> 0.2 µg/L	346	0.518%	818,119	0.422%
	≥ 0.1 µg/L	540	0.809%	3,760,140	1.941%

6.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean DBCP concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than the each threshold were calculated.

Exhibit 6-9 presents the Stage 2 analysis of estimated system mean concentrations for DBCP occurrence in drinking water relative to two thresholds: 0.2 µg/L and 0.1 µg/L. Exhibit 6-10 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than 97 ground water and surface water systems (approximately 0.258%) had an estimated system mean greater than or equal to 0.1 µg/L. These 97 systems serve about 1.4 million persons. A total of 42 systems (approximately 0.112% of all systems), serving 25,000 persons, had an estimated system mean greater than 0.2 µg/L. Similar to the Stage 1 analysis, more ground water than surface water systems had exceedances of both thresholds. However, nearly the same number of people was served by ground water and surface water systems with mean concentrations greater than 0.2 µg/L.

Exhibit 6-9: DBCP Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 0.2 µg/L	38	38	38	0.110%	0.110%	0.110%
	≥ 0.1 µg/L	85	82	81	0.246%	0.237%	0.234%
Surface Water	> 0.2 µg/L	4	4	4	0.133%	0.133%	0.133%
	≥ 0.1 µg/L	12	11	11	0.398%	0.365%	0.365%
Combined Ground & Surface Water	> 0.2 µg/L	42	42	42	0.112%	0.112%	0.112%
	≥ 0.1 µg/L	97	93	92	0.258%	0.247%	0.245%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 6-10: DBCP Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 0.2 µg/L	15,947	15,947	15,947	0.022%	0.022%	0.022%
	≥ 0.1 µg/L	391,923	385,285	195,179	0.533%	0.524%	0.265%
Surface Water	> 0.2 µg/L	9,246	9,246	9,246	0.008%	0.008%	0.008%
	≥ 0.1 µg/L	990,387	986,013	986,013	0.824%	0.820%	0.820%
Combined Ground & Surface Water	> 0.2 µg/L	25,193	25,193	25,193	0.013%	0.013%	0.013%
	≥ 0.1 µg/L	1,382,310	1,371,298	1,181,192	0.713%	0.708%	0.610%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

6.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003), 226 systems (approximately 1.61% of about 14,000 systems), reported at least one detection of DBCP. One hundred and twenty-eight systems (approximately 0.91% of all systems), reported at least one detection greater than the MCL concentration.

6.6 Summary of Data

TRI data indicate that total off-site and on-site release of DBCP for the period 1998-2006 were minimal and ranged from 0 to about 500 pounds. There were no releases to surface water, to land, or through underground injection. Air emissions of DBCP were extremely low. DBCP releases were almost exclusively off-site.

Ambient water data from the NAWQA program indicate that DBCP was detected in 1.7% of 6,313 ground and surface water samples and at 1.4% of 4,333 sites. The median concentration, based on detections from all sites, was 1.2 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that DBCP was detected in 1.029% of 37,618 surface and ground water systems. The median concentration, based on detections from all systems, was 0.09 µg/L. In total, 0.388% of systems (serving 1.627% of the total population) reported at least one detection greater than the MCL concentration of 0.2 µg/L. Detections are more common in ground water systems than surface water systems. However, because surface water systems tend to be larger than ground water systems, a greater population was served by surface water systems with at least one detection greater than the MCL concentration. A similar pattern was seen for sample points.

In the Stage 2 analysis, 0.112% of all systems (serving 0.013% of the population) had an estimated system mean concentration of DBCP greater than the MCL concentration. More ground water systems had mean concentrations exceeding the MCL concentration, but the population-served by ground water systems and surface water systems were similar.

6.7 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological Profile for 1,2-Dibromo-3-chloropropane*. September 1992. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp36.html.

United States Environmental Protection Agency (USEPA). 1991. National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; Monitoring for Unregulated Contaminants; National Primary Drinking Water Regulations Implementation; National Secondary Drinking Water Regulations; Final Rule Federal Register. Vol. 56, No. 30. p. 3526, January 30, 1991.

USEPA. 2003. *Occurrence Estimation Methodology and Occurrence Findings for Six-Year Review of National Primary Drinking Water Regulations*. Office of Water. EPA-815-R-03-006. June 2003.

USEPA. 2008. TRI Explorer: Trends – 1,2-Dibromo-3-chloropropane. Released February 21, 2008b. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for 1,2-dibromo-3-chloropropane.] Accessed February 29, 2008.

USEPA. 2009. *The Analysis of Regulated Contaminant Occurrence Data from Public Water Systems in Support of the Second Six-Year Review of National Primary Drinking Water Regulations*. Office of Water. EPA-815-B-09-006. October 2009.

7 1,2-Dichloroethane

This chapter on 1,2-dichloroethane is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and 1,2-dichloroethane occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

7.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for 1,2-dichloroethane on July 8, 1987 (52 FR 25690 (USEPA, 1987)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2001), 1,2-dichloroethane ($C_2H_4Cl_2$) is a clear, manufactured liquid that evaporates quickly at room temperature. It has a pleasant smell and sweet taste and burns with a smoky flame. Other names for 1,2-dichloroethane are ethylene dichloride, dichloroethane, and EDC (ATSDR, 2001).

There are no known natural sources of 1,2-dichloroethane. The major routes of entry of 1,2-dichloroethane to the environment are consequences of industrial activity. Emissions to the atmosphere comprise the largest fraction of all releases of 1,2-dichloroethane to the environment. Once in the atmosphere, it can last more than five months before being broken down by sunlight. During this time, it can travel large distances and be washed out by precipitation far from its point of origin. It is believed that discharges to surface water and leaching from solid waste are the primary causes of 1,2-dichloroethane contamination in drinking water. It is not known how long 1,2-dichloroethane lasts in surface water; however, it has been observed to last longer in lakes than in rivers. Once underground, it can travel long distances and contaminate wells (ATSDR, 2001).

Human exposure to 1,2-dichloroethane typically occurs because of improper disposal, but 1,2-dichloroethane also has been detected in the air in urban and industrial areas at levels between 0.003 and 1.5 ppb. There is also a small chance that humans might be exposed to 1,2-dichloroethane through contact with old chemical products made with it, such as leaded gasoline, cleaning agents, pesticides, and household adhesives (ATSDR, 2001).

7.2 Use, Production, and Releases

Although large amounts of 1,2-dichloroethane are produced today, most of it is used as a chemical intermediate for vinyl chloride. This accounts for 98% of its usage. 1,2-Dichloroethane is also used in smaller amounts to synthesize other organic compounds such as vinylidene chloride, 1,1,1-trichloroethane, trichloroethylene, tetrachloroethylene, aziridines, ethylene diamines, and various chlorinated solvents. In the past it was added to leaded gasoline to remove the lead (ATSDR, 2001).

Some uses of 1,2-dichloroethane have been discontinued, especially in many consumer products. It is no longer used in varnish and finish removers, soaps and scouring compounds, metal degreasers, ore flotation, paints, coatings, or adhesives. Its use in organic synthesis for extraction and cleaning purposes has also been discontinued. It was also formerly used as a grain, household, and soil fumigant (ATSDR, 2001).

Every year 17.5 million tons of 1,2-dichloroethane are produced in the United States, Western Europe, and Japan (Field and Sierra-Alvarez, 2004). The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 7-1 presents the production of 1,2-dichloroethane in the United States from 1986 to 2002. Note that the production of 1,2-dichloroethane in the United States has remained in excess of 1 billion pounds since 1986.

Exhibit 7-1: Production of 1,2-Dichloroethane in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 billion pounds
1990 Range	> 1 billion pounds
1994 Range	> 1 billion pounds
1998 Range	> 1 billion pounds
2002 Range	> 1 billion pounds

Source: USEPA, 2003a

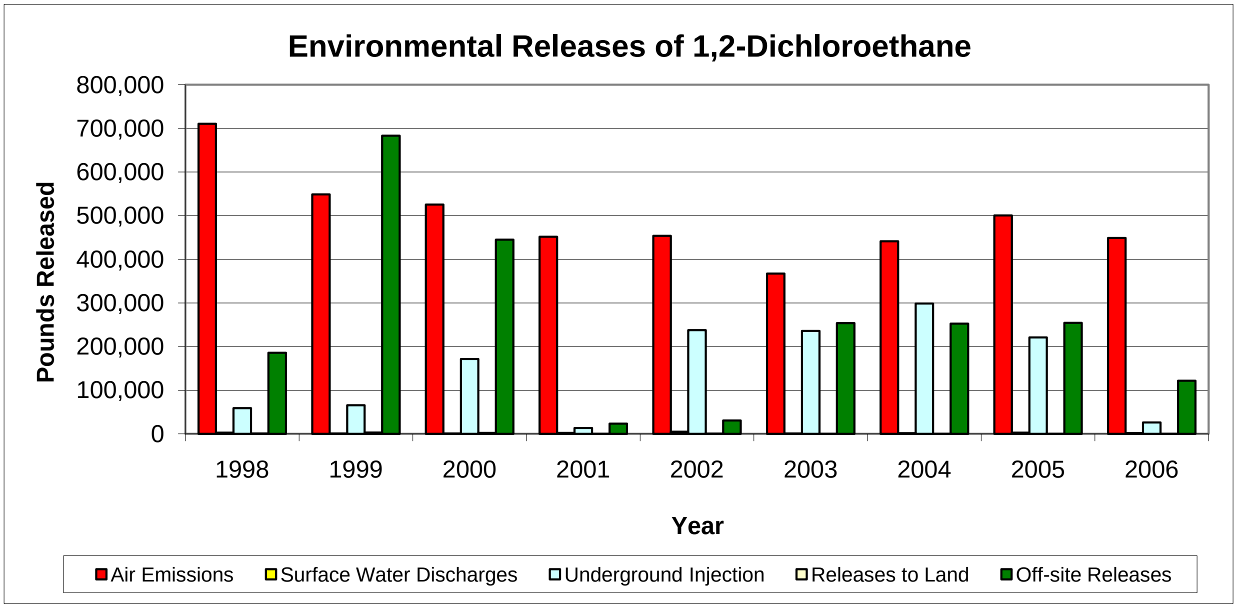
1,2-Dichloroethane is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 7-2a lists the environmental releases of 1,2-dichloroethane from 1998 to 2006. (Exhibit 7-2b provides a graphical presentation of the environmental releases.) In most years, on-site releases were greater than off-site releases, except in 1999. Air emissions and underground injection accounted for most on-site releases. Surface water discharges and releases to land were always well under 1% of total releases. The TRI data for 1,2-dichloroethane were reported from 30 states, plus Puerto Rico, with 18 states and Puerto Rico reporting releases in all 9 years.

Exhibit 7-2a: Table of Toxics Release Inventory (TRI) Data for 1,2-Dichloroethane

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	710,621	2,608	58,994	886	185,688	958,797
1999	548,798	904	65,465	2,983	683,304	1,301,454
2000	525,366	839	171,423	2,271	444,832	1,144,731
2001	451,555	2,227	13,463	141	23,386	490,772
2002	453,569	4,797	237,560	574	30,538	727,038
2003	367,312	864	235,948	148	253,746	858,018
2004	441,171	1,377	298,546	69	252,616	993,780
2005	500,487	2,785	220,963	68	254,288	978,591
2006	448,864	1,923	26,134	38	121,616	598,576

Source: USEPA, 2008

Exhibit 7-2b: Graph of Toxics Release Inventory (TRI) Data for 1,2-Dichloroethane



Source: USEPA, 2008

7.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of 1,2-dichloroethane in ambient water are available from the NAWQA program.

7.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for 1,2-dichloroethane. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 7-3. Overall, 1,2-dichloroethane was detected in 0.3% of samples and at 0.5% of sites. 1,2-Dichloroethane was detected more frequently in ground water than in surface water. The median concentration, based on detections from all sites, was 0.377 µg/L. The 99th percentile concentration, based on detections from all sites, was 33.4 µg/L.

Exhibit 7-3: EPA Summary Analysis of 1,2-Dichloroethane 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 Percentile	99th Percentile	Maximum
ground water	4,622	0.4%	4,137	0.4%	0.035	0.3987	33.4	33.4	33.4
surface water	1,402	0.2%	182	1.6%	0.0291	0.0512	0.247	0.247	0.247
all sites	6,024	0.3%	4,319	0.5%	0.0291	0.3765	3	33.4	33.4

1. RLs (Reporting Limits) for 1,2-dichloroethane varied, but did not exceed 0.035 µg/L.

7.4 Occurrence in Drinking Water

1,2-dichloroethane is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of 1,2-dichloroethane occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for 1,2-dichloroethane. These data consist of 375,636 analytical results from 50,442 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

completeness. The national modal minimum reporting level (MRL) for 1,2-dichloroethane in the dataset is 0.5 µg/L.

7.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 7-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 1,2-dichloroethane, 0.745% of 50,442 systems reported detections. Exhibit 7-5 lists the minimum, median, 90th percentile, and maximum 1,2-dichloroethane concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 1,2-dichloroethane, based on detections from all systems, was 0.9 µg/L.

Exhibit 7-4: 1,2-Dichloroethane Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	290,308	46,185	80,541	86,392,793	86,392,793
Surface Water	85,328	4,257	10,862	140,541,198	140,541,198
Combined Ground & Surface Water	375,636	50,442	91,403	226,933,991	226,933,991
Percent with Detections					
Ground Water	0.526%	0.686%	0.559%	3.361%	1.377%
Surface Water	0.661%	1.386%	1.234%	7.909%	2.867%
Combined Ground & Surface Water	0.557%	0.745%	0.639%	6.178%	2.300%

Exhibit 7-5: 1,2-Dichloroethane Summary Statistics

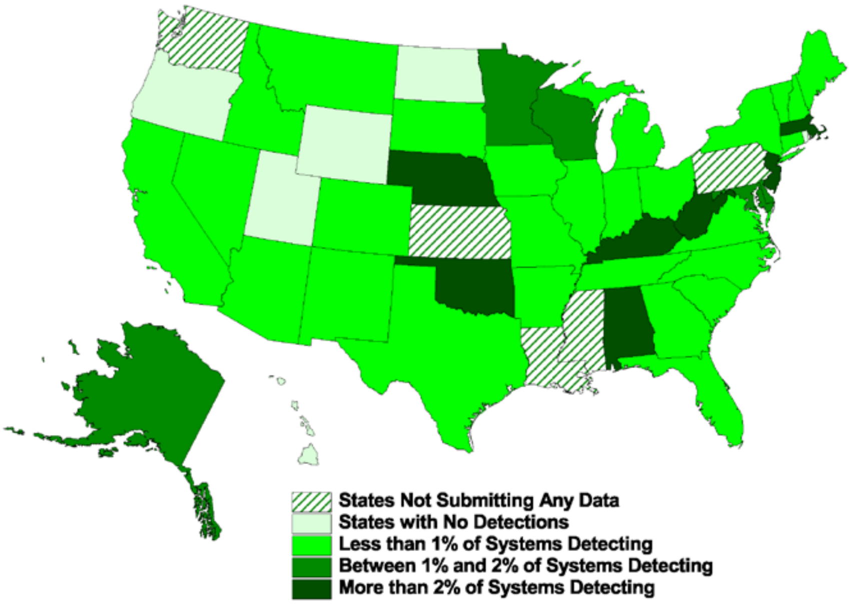
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	1	3.6	135.8

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Surface Water	0.005	0.745	2	47
Combined Ground & Surface Water	0.005	0.9	3.1	135.8

The following maps illustrate the geographic distribution of 1,2-dichloroethane occurrence in drinking water. Exhibit 7-6 shows the states with systems with at least one detection and Exhibit 7-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of 1,2-dichloroethane is geographically dispersed. Detection rates were generally low; only seven states reported detections in more than 2% of their systems. Twenty-seven states reported detections in less than 1% of their systems. Eighteen states reported detections greater than the MCL concentration of 5 µg/L, although only 4 of those states reported detections greater than 5 µg/L in more than 0.2% of their systems.

Exhibit 7-6: Percentage of Systems with at Least One 1,2-Dichloroethane Detection, by State



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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Exhibit 7-7: Percentage of Systems with at Least One 1,2-Dichloroethane Detection Greater than the MCL Concentration (> 5 µg/L), by State

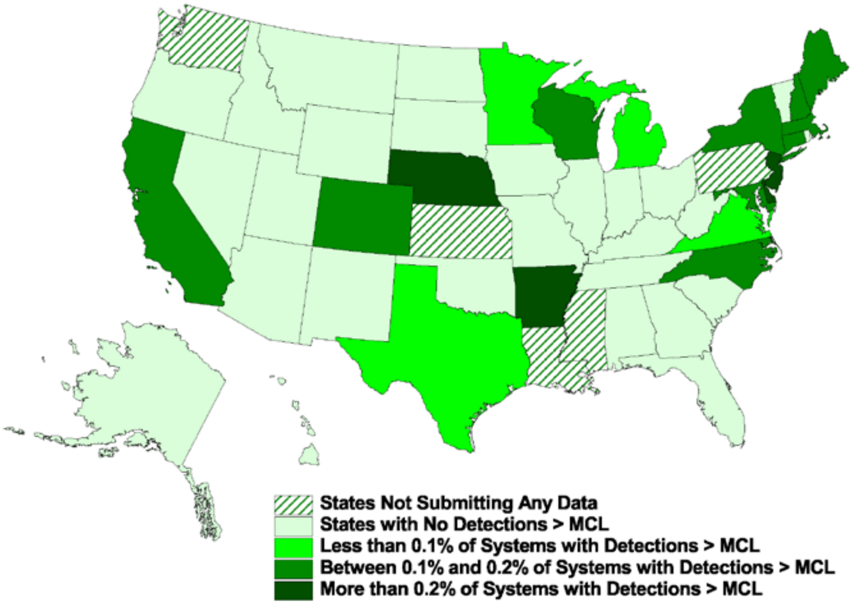

Exhibit 7-8 presents the Stage 1 analysis of 1,2-dichloroethane occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. A total of 66 systems (0.131% of all systems), serving about 4.8 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 36 systems (0.071% of all systems), serving nearly 438,000 persons, reported at least one detection greater than 5 µg/L. Detections greater than the thresholds were more common in more ground water than surface water systems. However, with the exception of the 5 µg/L threshold, the population-served by the surface water systems reporting at least one detection greater than each threshold was greater the population-served by ground water systems. This is likely due to the fact that surface water systems tend to be larger.

Exhibit 7-8: 1,2-Dichloroethane Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 5 µg/L	33	0.071%	247,240	0.286%
	≥ 2.5 µg/L	58	0.126%	337,994	0.391%
	≥ 1 µg/L	139	0.301%	858,498	0.994%
	> 0.5 µg/L	214	0.463%	1,399,602	1.620%

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Surface Water	> 5 µg/L	3	0.070%	190,972	0.136%
	≥ 2.5 µg/L	8	0.188%	4,412,609	3.140%
	≥ 1 µg/L	25	0.587%	5,428,439	3.863%
	> 0.5 µg/L	41	0.963%	7,551,832	5.373%
Combined Ground & Surface Water	> 5 µg/L	36	0.071%	438,212	0.193%
	≥ 2.5 µg/L	66	0.131%	4,750,603	2.093%
	≥ 1 µg/L	164	0.325%	6,286,937	2.770%
	> 0.5 µg/L	255	0.506%	8,951,434	3.945%

The occurrence estimates presented above (in Exhibit 7-8) are based on the conservative assumption that if a 1,2-dichloroethane detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to 1,2-dichloroethane (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of 1,2-dichloroethane). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of 1,2-dichloroethane because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of 1,2-dichloroethane (rather than the entire population-served by the system).

Exhibit 7-9 presents the Stage 1 analysis of 1,2-dichloroethane occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. A total of 82 (0.090% of) sample points, serving an estimated 189,000 persons, reported at least one detection exceeding 2.5 µg/L; and 48 (0.053% of) sample points, serving an estimated 73,000 persons, reported at least one detection exceeding 5 µg/L. Similar to the system-level occurrence analysis, 1,2-dichloroethane was detected in more ground water than surface water sample points at levels greater than 5 µg/L.

Exhibit 7-9: 1,2-Dichloroethane Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 5 µg/L	45	0.056%	40,325	0.047%
	≥ 2.5 µg/L	72	0.089%	55,370	0.064%
	≥ 1 µg/L	186	0.231%	196,208	0.227%
	> 0.5 µg/L	316	0.392%	346,010	0.401%
Surface Water	> 5 µg/L	3	0.028%	32,358	0.023%
	≥ 2.5 µg/L	10	0.092%	133,818	0.095%
	≥ 1 µg/L	45	0.414%	682,144	0.485%
	> 0.5 µg/L	111	1.022%	2,596,932	1.848%
Combined Ground & Surface Water	> 5 µg/L	48	0.053%	72,683	0.032%
	≥ 2.5 µg/L	82	0.090%	189,188	0.083%
	≥ 1 µg/L	231	0.253%	878,353	0.387%
	> 0.5 µg/L	427	0.467%	2,942,942	1.297%

7.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean 1,2-dichloroethane concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 7-10 presents the Stage 2 analysis of estimated system mean concentrations for 1,2-dichloroethane occurrence in drinking water relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. Exhibit 7-11 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than 9 ground water and surface water systems (approximately 0.018% of all systems) had an estimated system mean greater than or equal to 2.5 µg/L. These 9 systems serve 873 persons. Three systems (0.006% of all systems), serving 151 persons, had an estimated system mean greater than 5 µg/L. No surface water systems had estimated means greater than 5 µg/L.

Exhibit 7-10: 1,2-Dichloroethane Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	3	3	3	0.006%	0.006%	0.006%
	≥ 2.5 µg/L	9	9	9	0.019%	0.019%	0.019%
	≥ 1 µg/L	43	35	29	0.093%	0.076%	0.063%
	> 0.5 µg/L	190	77	60	0.411%	0.167%	0.130%
Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	3	2	1	0.070%	0.047%	0.023%
	> 0.5 µg/L	38	5	3	0.893%	0.117%	0.070%
Combined Ground & Surface Water	> 5 µg/L	3	3	3	0.006%	0.006%	0.006%
	≥ 2.5 µg/L	9	9	8	0.018%	0.018%	0.016%
	≥ 1 µg/L	46	37	30	0.091%	0.073%	0.059%
	> 0.5 µg/L	228	82	63	0.452%	0.163%	0.125%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 7-11: 1,2-Dichloroethane Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	151	151	151	0.0002%	0.0002%	0.0002%
	≥ 2.5 µg/L	873	873	833	0.001%	0.001%	0.001%
	≥ 1 µg/L	99,274	90,942	82,396	0.115%	0.105%	0.095%
	> 0.5 µg/L	963,134	135,637	119,232	1.115%	0.157%	0.138%
Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	90,390	54,260	4,750	0.064%	0.039%	0.003%
	> 0.5 µg/L	7,359,474	141,310	90,390	5.237%	0.101%	0.064%

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 5 µg/L	151	151	151	0.0001%	0.0001%	0.0001%
	≥ 2.5 µg/L	873	873	833	0.0004%	0.0004%	0.0004%
	≥ 1 µg/L	189,664	145,202	87,146	0.084%	0.064%	0.038%
	> 0.5 µg/L	8,322,608	276,947	209,622	3.667%	0.122%	0.092%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

7.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including 1,2-dichloroethane, in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, 1,2-dichloroethane had a detection frequency of 0.21% at an assessment level of 0.2 µg/L (based on 2,383 samples). The median concentration of detections was 1.3 µg/L. Three detections were within one order of magnitude of the MCL concentration (5 µg/L). No detections were greater than the MCL concentration.

In public wells, 1,2-dichloroethane had a detection frequency of 0.56% at an assessment level of 0.2 µg/L (based on 1,073 samples). The median concentration of detections was 0.39 µg/L. Two detections were within one order of magnitude of the MCL concentration. No detections were greater than the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 302 systems (approximately 1.31% of about 23,000 systems), reported at least one detection of 1,2-dichloroethane. Thirty systems (approximately 0.13% of all systems), reported at least one detection greater than the MCL concentration.

7.6 Summary of Data

TRI data indicate that total off-site and on-site releases of 1,2-dichloroethane for the period 1998-2006 ranged from approximately 491,000 pounds to about 1.3 million pounds. Off-site releases and air emissions were the largest contributors. Discharges to surface water and releases to land were the smallest fractions.

Ambient water data from the NAWQA program indicate that 1,2-dichloroethane was detected in 0.3% of 6,024 ground and surface water samples and at 0.5% of 4,319 sites. The median concentration, based on detections from all sites, was 0.38 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that 1,2-dichloroethane was detected in 0.745% of 50,442 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.9 µg/L. In total, 0.071% of systems (serving 0.193% of the population) reported at least one detection greater than the MCL concentration of 5 µg/L.

In the Stage 2 analysis, 0.006% of ground water systems (serving 0.0001% of the population) had an estimated system mean concentration of 1,2-dichloroethane greater than the MCL concentration. No surface water systems had mean concentrations exceeding the MCL concentration.

7.7 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2001. *Toxicological Profile for 1,2-Dichloroethane*. September 2001. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp38.html.

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8 Dichloromethane (Methylene Chloride)

This chapter on dichloromethane (methylene chloride) is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and dichloromethane occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

8.1 Background

The United States Environmental Protection Agency (EPA) published the National Primary Drinking Water Regulations (NPDWR) for dichloromethane on July 17, 1992 (57 FR 31776 (USEPA, 1992)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2000), dichloromethane is a colorless liquid with a mild, sweet odor. It does not occur naturally in the environment.

Dichloromethane (CH_2Cl_2) is typically released into the environment in air as it is highly volatile. It is also found in minimal amounts in water and soil. The major releases of dichloromethane come from its use as an industrial solvent and paint stripper. Releases also come from certain aerosol and pesticide products, its use in manufacturing photographic film, as well as some spray paints, automotive cleaners, and other household products. In air, dichloromethane reacts readily with other chemicals in the presence of light. In water, it is broken down by bacterial action or through reactions with other chemicals (ATSDR, 2000).

The general population may be exposed to dichloromethane through contaminated air or exposure to consumer products containing dichloromethane. On an average, adults in the urban United States take in an estimated 30 to 309 µg of dichloromethane daily from outdoor air. However, the highest and most common form of exposure is in workplaces where the chemical is used in manufacturing. It can be particularly damaging if workplaces are not adequately ventilated. Although not as common, exposure may also occur through contaminated water or food (ATSDR, 2000).

8.2 Use, Production, and Releases

Dichloromethane is most often used as a paint remover. It is also used as a solvent and cleaning agent in a variety of industries, and approved as a fumigant for strawberries and grains, and to extract substances from foodstuffs. It may also occur in aerosols, pesticide products, spray paints, automotive cleaners, and other household products. It is also used in the manufacture of photographic film. Dichloromethane is produced from methane gas or wood alcohol. Most dichloromethane releases to the environment are from its use as an end product by various industries, and from the use of aerosol products and paint removers in the home (ATSDR, 2000).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 8-1 presents the production of dichloromethane in the United States from 1986 to 2002. Note that the production of dichloromethane in the United States decreased between 1990 and 1994 and has remained within the same range since then.

Exhibit 8-1: Production of Dichloromethane in the United States

Inventory Update Year	Production Volume
1986 Range	> 500 million - 1 billion pounds
1990 Range	> 500 million - 1 billion pounds
1994 Range	> 100 million - 500 million pounds
1998 Range	> 100 million - 500 million pounds
2002 Range	> 100 million - 500 million pounds

Source: USEPA, 2003a

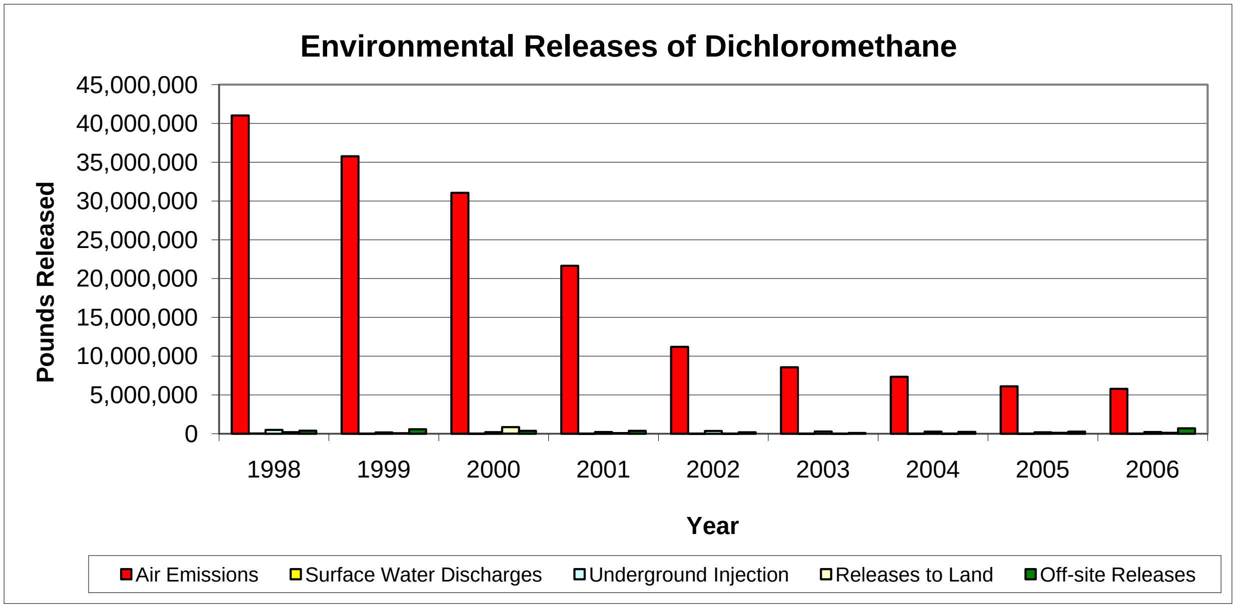
Dichloromethane is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 8-2a lists the environmental releases of dichloromethane from 1998 to 2006. (Exhibit 8-2b provides a graphical presentation of the environmental releases.) Air emissions generally comprised more than 90% of all releases for the period of record, and they decreased substantially over time. Underground injection and off-site releases were the next largest categories, contributing a few percent each to the total. Surface water discharges were the smallest portion, and they decreased from their highest value in 1998 over the period of record. These TRI data for dichloromethane were reported from 43 states plus Puerto Rico. Forty states and Puerto Rico reported dichloromethane releases every year between 1998 and 2006.

Exhibit 8-2a: Table of Toxics Release Inventory (TRI) Data for Dichloromethane

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	41,025,447	15,754	490,664	183,719	389,826	42,105,410
1999	35,761,445	12,072	166,859	61,574	576,516	36,578,466
2000	31,045,357	10,292	199,809	838,111	367,190	32,460,759
2001	21,651,731	4,668	218,992	63,523	376,324	22,315,238
2002	11,192,849	4,149	354,396	4,423	190,825	11,746,642
2003	8,567,874	4,610	284,248	3,642	94,115	8,954,489
2004	7,345,231	6,774	274,967	3,382	231,712	7,862,066
2005	6,113,157	5,703	195,903	100,717	281,171	6,696,653
2006	5,781,544	3,896	214,187	102,681	699,803	6,802,111

Source: USEPA, 2008

Exhibit 8-2b: Graph of Toxics Release Inventory (TRI) Data for Dichloromethane



Source: USEPA, 2008

8.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of dichloromethane in ambient water are available from the NAWQA program.

8.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for dichloromethane. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 8-3. Overall, dichloromethane was detected in 5.6% of samples and at 4.4% of sites. Dichloromethane was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.037 µg/L. The 99th percentile concentration, based on detections from all sites, was 4.09 µg/L.

Exhibit 8-3: EPA Summary Analysis of Dichloromethane 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	Maxi-mum
ground water	4,653	2.9%	4,154	3.2%	0.008	0.05	1.6	21.6	25.8
surface water	1,414	14.6%	191	31.9%	0.0055	0.03455	1	1.55	34
all sites	6,067	5.6%	4,345	4.4%	0.0055	0.037	1.2	4.09	34

1. RLs (Reporting Limits) for dichloromethane varied, but did not exceed 0.008 µg/L.

8.4 Occurrence in Drinking Water

Dichloromethane is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of dichloromethane occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for dichloromethane. These data consist of 372,009 analytical results from 50,169 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for dichloromethane in the dataset is 0.5 µg/L.

8.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 8-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For dichloromethane, 3.903% of 50,169 systems reported detections. Exhibit 8-5 lists the minimum, median, 90th percentile, and maximum dichloromethane concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of dichloromethane, based on detections from all systems, was 0.9 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 8-4: Dichloromethane Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	287,552	45,918	80,241	86,307,048	86,307,048
Surface Water	84,457	4,251	10,869	140,537,012	140,537,012
Combined Ground & Surface Water	372,009	50,169	91,110	226,844,060	226,844,060
Percent with Detections					
Ground Water	0.874%	3.513%	2.357%	10.521%	3.902%
Surface Water	0.909%	8.116%	4.481%	20.240%	5.707%
Combined Ground & Surface Water	0.882%	3.903%	2.610%	16.542%	5.020%

Exhibit 8-5: Dichloromethane Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.0041	0.9	3.62	315.9
Surface Water	0.005	1	3.2	31
Combined Ground & Surface Water	0.0041	0.9	3.4	315.9

The following maps illustrate the geographic distribution of dichloromethane occurrence in drinking water. Exhibit 8-6 shows the states with systems with at least one detection and Exhibit 8-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of dichloromethane is geographically dispersed. Detection rates were generally high; all states that submitted data except for Hawaii

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[2] Kansas submitted data after the data management and analyses had been conducted; data for Kansas are not included in the analyses.

reported detections. Only five states reported detections in more than 10% of their systems. Eight states reported detections in between 5 and 10% of their systems. A total of 37 states reported detections greater than the MCL concentration of 5 μg/L. Only 4 of these 37 states reported that more than 1% of their systems reported detections greater than 5 μg/L.

Exhibit 8-6: Percentage of Systems with at Least One Dichloromethane Detection, by State

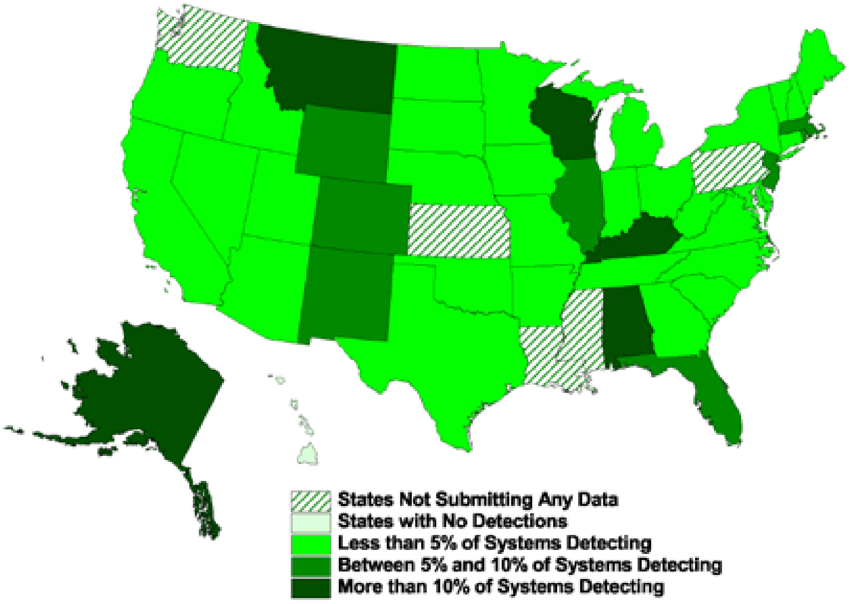

Exhibit 8-7: Percentage of Systems with at Least One Dichloromethane Detection Greater than the MCL Concentration (> 5 µg/L), by State

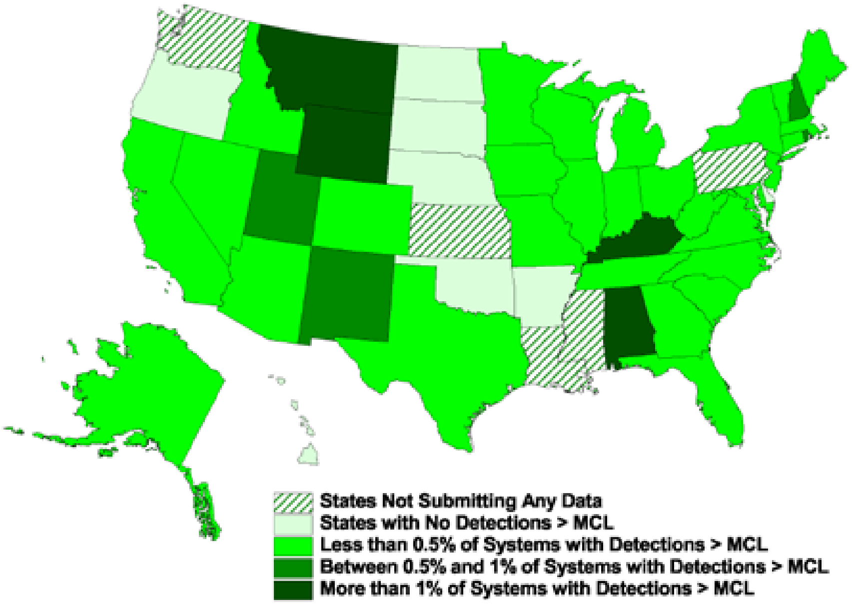

Exhibit 8-7 presents the Stage 1 analysis of dichloromethane occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. A total of 398 systems (0.793% of all systems), serving about 8.1 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 147 systems (0.293% of all systems), serving 2.9 million persons, reported at least one detection exceeding 5 µg/L. Detections greater than the thresholds were more common in more ground water than surface water systems. However, because surface water systems tend to be larger, a greater population was served by the systems reporting at least one detection greater than the thresholds.

Exhibit 8-7: Dichloromethane Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 5 µg/L	125	0.272%	426,870	0.495%
	≥ 2.5 µg/L	319	0.695%	1,996,422	2.313%
	≥ 1 µg/L	783	1.705%	4,262,402	4.939%
	> 0.5 µg/L	1,319	2.873%	6,991,178	8.100%

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Surface Water	> 5 µg/L	22	0.518%	2,516,579	1.791%
	≥ 2.5 µg/L	79	1.858%	6,112,617	4.349%
	≥ 1 µg/L	193	4.540%	11,712,322	8.334%
	> 0.5 µg/L	313	7.363%	25,538,096	18.172%
Combined Ground & Surface Water	> 5 µg/L	147	0.293%	2,943,449	1.298%
	≥ 2.5 µg/L	398	0.793%	8,109,039	3.575%
	≥ 1 µg/L	976	1.945%	15,974,724	7.042%
	> 0.5 µg/L	1,632	3.253%	32,529,274	14.340%

The occurrence estimates presented above (in Exhibit 8-7) are based on the conservative assumption that if a dichloromethane detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to dichloromethane (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of dichloromethane). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of dichloromethane because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of dichloromethane (rather than the entire population-served by the system).

Exhibit 8-8 presents the Stage 1 analysis of dichloromethane occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. A total of 448 (0.492% of) sample points, serving an estimated 3 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 164 (0.180% of) sample points, serving an estimated 1.2 million persons, reported at least one detection exceeding 5 µg/L. Similar to the system-level occurrence analysis, more ground water sample points had threshold exceedances. However, because surface water systems tend to be larger, a greater population was served by sample points with threshold exceedances.

Exhibit 8-8: Dichloromethane Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 5 µg/L	137	0.171%	164,062	0.190%
	≥ 2.5 µg/L	351	0.437%	1,167,914	1.353%
	≥ 1 µg/L	894	1.114%	2,018,857	2.339%
	> 0.5 µg/L	1,535	1.913%	2,815,719	3.262%
Surface Water	> 5 µg/L	27	0.248%	1,081,905	0.770%
	≥ 2.5 µg/L	97	0.892%	1,875,293	1.334%
	≥ 1 µg/L	267	2.457%	4,355,464	3.099%
	> 0.5 µg/L	440	4.048%	7,099,967	5.052%
Combined Ground & Surface Water	> 5 µg/L	164	0.180%	1,245,967	0.549%
	≥ 2.5 µg/L	448	0.492%	3,043,207	1.342%
	≥ 1 µg/L	1,161	1.274%	6,374,321	2.810%
	> 0.5 µg/L	1,975	2.168%	9,915,686	4.371%

8.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean dichloromethane concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 8-9 presents the Stage 2 analysis of estimated system mean concentrations for dichloromethane occurrence in drinking water relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. Exhibit 8-10 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than 53 ground water and surface water systems (approximately 0.106% of all systems) had an estimated system mean greater than or equal to 2.5 µg/L. These 53 systems serve 43,953 persons. No more than 17 (approximately 0.034% of all systems) systems serving 12,019 persons had an estimated system mean greater than 5 µg/L. The percentages of systems with MCL concentration exceedances were similarly low for both surface water and ground water systems, but a larger number of ground water systems had an estimated system mean greater than the MCL concentration of 5 µg/L.

Exhibit 8-9: Dichloromethane Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	16	15	12	0.035%	0.033%	0.026%
	≥ 2.5 µg/L	48	46	42	0.105%	0.100%	0.091%
	≥ 1 µg/L	240	181	151	0.523%	0.394%	0.329%
	> 0.5 µg/L	1,251	494	329	2.724%	1.076%	0.716%
Surface Water	> 5 µg/L	1	1	1	0.024%	0.024%	0.024%
	≥ 2.5 µg/L	5	5	4	0.118%	0.118%	0.094%
	≥ 1 µg/L	36	27	18	0.847%	0.635%	0.423%
	> 0.5 µg/L	306	85	54	7.198%	2.000%	1.270%
Combined Ground & Surface Water	> 5 µg/L	17	16	13	0.034%	0.032%	0.026%
	≥ 2.5 µg/L	53	51	46	0.106%	0.102%	0.092%
	≥ 1 µg/L	276	208	169	0.550%	0.415%	0.337%
	> 0.5 µg/L	1,557	579	383	3.104%	1.154%	0.763%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 8-10: Dichloromethane Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	10,219	10,119	9,148	0.012%	0.012%	0.011%
	≥ 2.5 µg/L	36,518	33,009	31,607	0.042%	0.038%	0.037%
	≥ 1 µg/L	1,273,387	1,152,919	791,105	1.475%	1.336%	0.917%
	> 0.5 µg/L	6,645,442	1,910,810	1,385,316	7.700%	2.214%	1.605%
Surface Water	> 5 µg/L	1,800	1,800	1,800	0.001%	0.001%	0.001%
	≥ 2.5 µg/L	7,435	7,435	7,350	0.005%	0.005%	0.005%
	≥ 1 µg/L	243,772	232,890	154,950	0.173%	0.166%	0.110%
	> 0.5 µg/L	25,125,784	1,586,371	458,789	17.878%	1.129%	0.326%

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 5 µg/L	12,019	11,919	10,948	0.005%	0.005%	0.005%
	≥ 2.5 µg/L	43,953	40,444	38,957	0.019%	0.018%	0.017%
	≥ 1 µg/L	1,517,159	1,385,809	946,055	0.669%	0.611%	0.417%
	> 0.5 µg/L	31,771,226	3,497,181	1,844,105	14.006%	1.542%	0.813%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

8.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including dichloromethane (referred to as methylene chloride in the study) in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, dichloromethane had a detection frequency of 0.67% at an assessment level of 0.2 µg/L (based on 2,398 samples). The median concentration of detections was 0.029 µg/L. Nine detections were within one order of magnitude of the MCL concentration (5 µg/L). No detections were greater than the MCL concentration.

In public wells, dichloromethane had a detection frequency of 0.46% at an assessment level of 0.2 µg/L (based on 1,094 samples). The median concentration of detections was 1.6 µg/L. Two detections were within one order of magnitude of the MCL concentration and two detections were greater than the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 1,850 systems (approximately 8.59% of about 22,000 systems), reported at least one detection of dichloromethane. One hundred and forty-four systems (approximately 0.67% of all systems), reported at least one detection greater than the MCL concentration.

8.6 Summary of Data

TRI data indicate that total off-site and on-site releases of dichloromethane ranged from about 6.7 million pounds to about 42 million pounds, decreasing steadily with time. Air emissions generally constituted over 90% of the total. Surface water discharges were the smallest fraction.

Ambient water data from the NAWQA program indicate that dichloromethane was detected in 5.6% of 6,067 ground and surface water samples and at 4.4% of 4,345 sites. The median concentration, based on detections from all sites, was 0.037 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that dichloromethane was detected in 3.903% of 50,169 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.9 µg/L. In total, 0.293% of systems (serving 1.298% of the population) reported at least one detection greater than the MCL concentration of 5 µg/L. Detections greater than the MCL concentration were more common in ground water systems than surface water systems. However, because surface water systems tend to be larger, a greater population was served by surface water systems with at least one detection greater than the MCL concentration. A similar pattern was seen for sample points.

In the Stage 2 analysis, 0.034% of surface water and ground water systems (serving 0.005% of the population) had an estimated system mean concentration greater than the MCL concentration. System mean exceedances of all thresholds were greater for ground water systems, and a larger population was served by ground water systems with means exceeding the thresholds.

8.7 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. *Toxicological Profile for Methylene Chloride. September 2005*. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp14.html.

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9 2,4-Dichlorophenoxyacetic Acid (2,4-D)

This chapter on 2,4-Dichlorophenoxyacetic acid (2,4-D) is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and 2,4-D occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

9.1 Background

The United States Environmental Protection Agency (EPA) published the National Primary Drinking Water Regulations (NPDWR) for 2,4-D on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 70 µg/L. EPA developed the MCLG based on a reference dose (RfD) of 10 µg/kg-day (0.01 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity. Note that in 2005, EPA updated its health effects assessment of 2,4-D (USEPA, 2005). The assessment reduced the RfD from 10 µg/kg-day (0.01 mg/kg-day) to 5 µg/kg-day (0.005 mg/kg-day).

According to the Extension Toxicology Network (EXTOXNET, 1996), 2,4-D ($C_8H_6Cl_2O_3$) is a white powder used as a systemic herbicide. While there are many forms or derivatives of 2,4-D including esters, amines, and salts, toxicological and ecological information is generally given for the acid form. It may be formulated as an emulsion, in aqueous solution (salts), and as a dry compound (EXTOXNET, 1996).

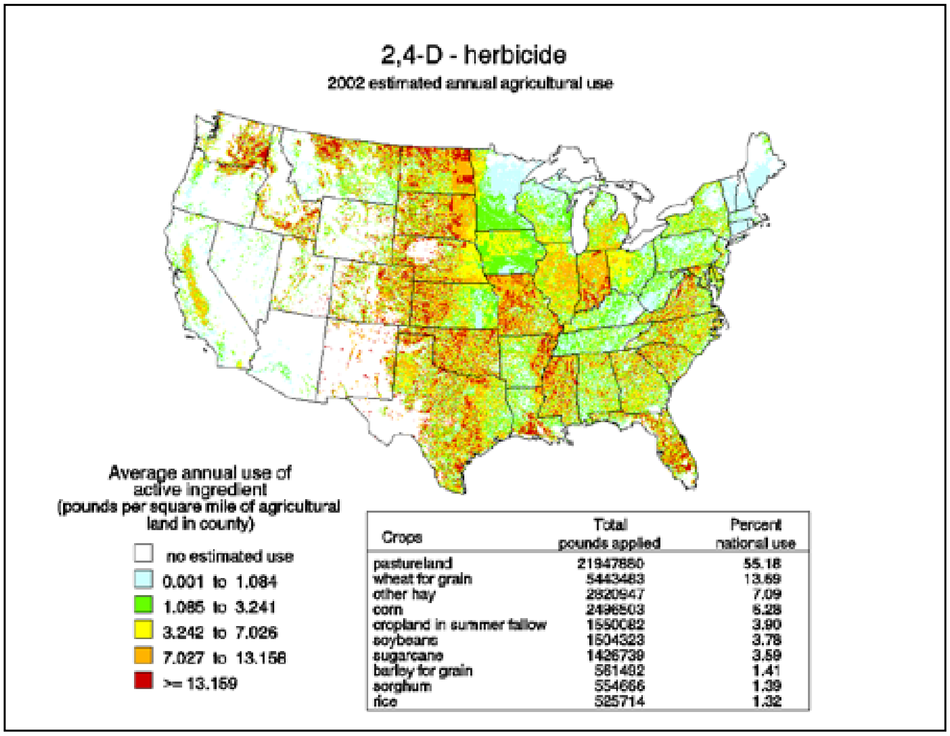
2,4-D is degraded by microbes in soil and water. The half-life in soil is less than seven days. In water, breakdown rates increase with increased nutrients, sediment load, and dissolved organic carbon. Under oxygenated conditions the half-life is one week to several weeks. Despite its short half-life in soil and in aquatic environments, the compound has been detected in groundwater supplies in at least five states. Very low concentrations have also been detected in surface waters throughout the United States (EXTOXNET, 1996).

9.2 Use, Production, and Releases

2,4-D has been used as a systemic herbicide to control many types of broadleaf weeds. It has been used in cultivated agriculture, in pasture and rangeland applications, forest management, home gardens, and to control aquatic vegetation (EXTOXNET, 1996).

Exhibit 9-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual 2,4-D use in the United States from 1999 through 2004. A breakdown of use by crop is also included. The map was created by the USGS using state-level data sets on pesticide use rates from 1999-2004 compiled by the CropLife Foundation, at the Crop Protection Research Institute, combined with county-level data on harvested crop acreage obtained from the 2002 Census of Agriculture. Due to the nature of the data sources, non-agricultural uses are not reflected here, and variations in use at the county-level are also not well represented (Thelin and Gianessi, 2000). The USGS (2007) estimates that nearly 40 million pounds of 2,4-D active ingredient were used on average each year between 1999 and 2004. The greatest use of 2,4-D is in the middle of the country, from North Dakota to Texas.

Exhibit 9-1: Estimated Annual Agricultural Use for 2,4-D (c. 2002)



Crops	Total pounds applied	Percent national use
pastureland	21947880	55.18
wheat for grain	5443483	13.69
other hay	2820947	7.09
corn	2496503	6.28
cropland in summer fallow	1550082	3.90
soybeans	1504323	3.78
sugarcane	1426739	3.59
barley for grain	561482	1.41
sorghum	554666	1.39
rice	525714	1.32

Source: USGS, 2007

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 9-2 presents the production of 2,4-D in the United States from 1986 to 2002. Note that, although the production of 2,4-D in the United States increased since 1986, production remained within the same range since 1990.

Exhibit 9-2: Production of 2,4-D in the United States

Inventory Update Year	Production Volume
1986 Range	> 10 million - 50 million
1990 Range	> 50 million - 100 million
1994 Range	> 50 million - 100 million
1998 Range	> 50 million - 100 million
2002 Range	> 50 million - 100 million

Source: USEPA, 2003a

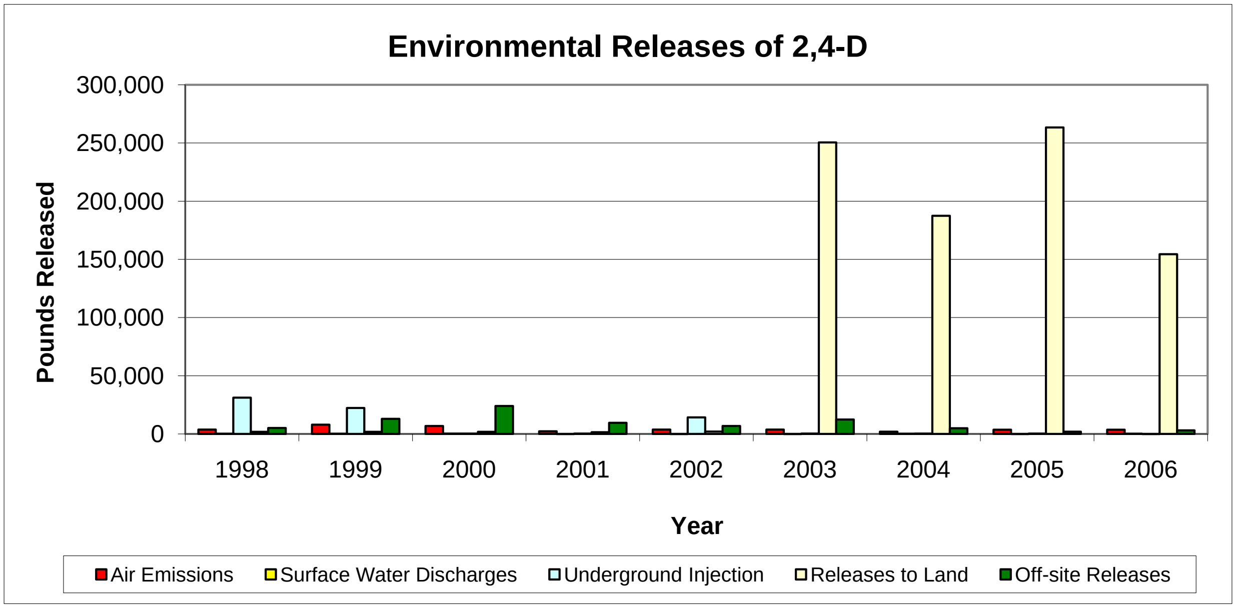
2,4-D is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 9-3a lists the environmental releases of 2,4-D from 1998 to 2006. (Exhibit 9-3b provides a graphical presentation of the environmental releases.) Underground injection was the most significant mode of release of 2,4-D in 1998, 1999, and 2002, and was much less significant in the other years. Surface water discharges remained steady and small relative to other modes of release. Air releases remained relatively steady, and were generally greater than underground injection and surface water discharges. Releases to land increased dramatically after 2002. The TRI data for 2,4-D were reported from 21 states, with 13 states reporting (Alabama, Arkansas, California, Iowa, Illinois, Kansas, Michigan, Missouri, Montana, Nebraska, Ohio, Pennsylvania, and Texas) in all 9 years.

Exhibit 9-3a: Table of Toxics Release Inventory (TRI) Data for 2,4-D

Year	On-Site Releases (pounds)				Off-Site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	3,738	88	31,209	1,798	5,112	41,945
1999	7,913	74	22,290	1,798	12,994	45,069
2000	6,816	256	250	1,831	23,964	33,117
2001	2,247	13	250	1,509	9,597	13,616
2002	3,706	13	14,250	2,100	6,851	26,920
2003	3,765	10	250	250,458	12,452	266,935
2004	1,884	165	250	187,431	4,897	194,627
2005	3,622	10	250	263,396	1,879	269,156
2006	3,607	125	5	154,491	3,032	161,260

Source: USEPA, 2008

Exhibit 9-3b: Graph of Toxics Release Inventory (TRI) Data for 2,4-D



Source: USEPA, 2008

9.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The USGS National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of 2,4-D in ambient water are available from the NAWQA program for both the Pesticide National Synthesis Project and a summary analysis of all Cycle 1 water monitoring data.

9.3.1 NAWQA Pesticide National Synthesis Project

The NAWQA Pesticide National Synthesis Project is a national-scale assessment of the occurrence and behavior of pesticides in streams and ground water of the United States and the potential for pesticides to adversely affect drinking water supplies or aquatic ecosystems. Under the National Synthesis Project, the USGS monitored 2,4-D between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for 2,4-D was 0.080 µg/L.

In NAWQA stream samples (Exhibit 9-4), 2,4-D was found at frequencies ranging from 0.38% of samples in undeveloped areas to 6.38% of samples in mixed land use settings, 13.08% of samples in agricultural settings, and 13.10% of samples in urban areas. The 95th percentile concentration was less than the method detection limit in undeveloped areas, 0.080 µg/L in mixed land use settings, 0.270 µg/L in agricultural settings, and 0.450 µg/L in urban land use settings. The highest concentration, 15.0 µg/L, was found at an agricultural site.

Exhibit 9-4: USGS National Synthesis Summary of NAWQA Monitoring of 2,4-D in Streams, 1992-2001

Land Use Type	No. of Samples (No. of Sites)	Detection Frequency	50th Percentile (Median) Concentration (in µg/L)	95th Percentile Concentration (in µg/L)	Maximum Concentration (in µg/L)
Agricultural	1,465 (62)	13.08%	ND[1]	0.270	15.000
Mixed	801 (36)	6.38%	ND[1]	0.080	1.400
Undeveloped	101 (5)	0.38%	ND[1]	ND[1]	0.060
Urban	523 (19)	13.10%	ND[1]	0.450	5.530

Source: Gilliom et al., 2007

1. ND = not detected (Concentration is less than the maximum long term method detection limit and is expected to be less than any higher percentile concentration shown in the table)

In ground water NAWQA samples (Exhibit 9-5), 2,4-D was found at frequencies ranging from 0% of samples in undeveloped areas to 0.38% in mixed land use settings, 0.66% of samples in agricultural settings, and 0.75% of samples in urban areas. The 95th percentile concentrations were less than the method detection limit in all settings. The highest concentration, 14.8 µg/L, was detected at an urban site.

Exhibit 9-5: USGS National Synthesis Summary of NAWQA Monitoring of 2,4-D in Ground Water, 1992-2001

Land Use Type	Number of Wells	Detection Frequency	50th Percentile (Median) Concentration (in µg/L)	95th Percentile Concentration (in µg/L)	Maximum Concentration (in µg/L)
Agricultural	1,208	0.66%	ND[1]	ND[1]	4.54
Mixed	1,568	0.38%	ND[1]	ND[1]	0.15
Undeveloped	22	0%	ND[1]	ND[1]	ND[1]
Urban	666	0.75%	ND[1]	ND[1]	14.8

Source: Gilliom et al., 2007

1. ND = not detected (Concentration is less than the maximum long term method detection limit and is expected to be less than any higher percentile concentration shown in the table)

9.3.2 EPA Summary Analysis of NAWQA Data

Whereas the NAWQA program often uses the most representative data for a site to calculate summary statistics, EPA, with the cooperation of USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for 2,4-D. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 9-6. Overall, 2,4-D was detected in 8.1% of samples and at 5.1% of sites. 2,4-D was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.2 µg/L. The 99th percentile concentration, based on detections from all sites, was 5.83 µg/L.

Exhibit 9-6: EPA Summary Analysis of 2,4-D 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
ground water	4,018	0.5%	3,645	0.5%	0.01	0.11	14.8	14.8	14.8
surface water	5,535	13.6%	894	23.8%	0.007	0.2	1.76	5.53	74.5718
all sites	9,553	8.1%	4,539	5.1%	0.007	0.2	1.8	5.83	74.5718

1. RLs (Reporting Limits) for 2,4-D varied, but did not exceed 0.01 µg/L. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible.

9.4 Occurrence in Drinking Water

2,4-D is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of 2,4-D occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

Forty-three of the Six-Year Review-ICR states provided occurrence data for 2,4-D. (There were no 2,4-D data from Hawaii or Oklahoma.) These data consist of 124,285 analytical results from 33,187 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for 2,4-D in the dataset is 0.1 µg/L.

9.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 9-7 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 2,4-D, 0.901% of 33,187 systems reported detections. Exhibit 9-8 lists the minimum, median, 90th percentile, and maximum 2,4-D concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 2,4-D, based on detections from all systems, was 0.3 µg/L.

Exhibit 9-7: 2,4-D Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	101,329	30,172	48,417	67,200,878	67,200,878
Surface Water	22,956	3,015	6,980	120,250,305	120,250,305
Combined Ground & Surface Water	124,285	33,187	55,397	187,451,183	187,451,183
Percent with Detections					
Ground Water	0.283%	0.669%	0.489%	5.317%	4.452%

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Surface Water	0.640%	3.217%	1.605%	10.613%	6.221%
Combined Ground & Surface Water	0.349%	0.901%	0.630%	8.714%	5.587%

Exhibit 9-8: 2,4-D Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.02	0.3	2	70
Surface Water	0.009	0.29	1.1	230
Combined Ground & Surface Water	0.009	0.3	1.5	230

The following maps illustrate the geographic distribution of 2,4-D occurrence in drinking water. Exhibit 9-9 shows the states with systems with at least one detection and Exhibit 9-10 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Hawaii and Oklahoma did submit Six-Year data for most contaminants but neither state submitted data for 2,4-D.

The distribution of systems with detections of 2,4-D is geographically dispersed. Detection rates were generally low, with only two states having greater than 5% of their systems detecting 2,4-D. Only one state reported detections greater than the MCL concentration of 70 µg/L.

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Exhibit 9-9: Percentage of Systems with at Least One 2,4-D Detection, by State

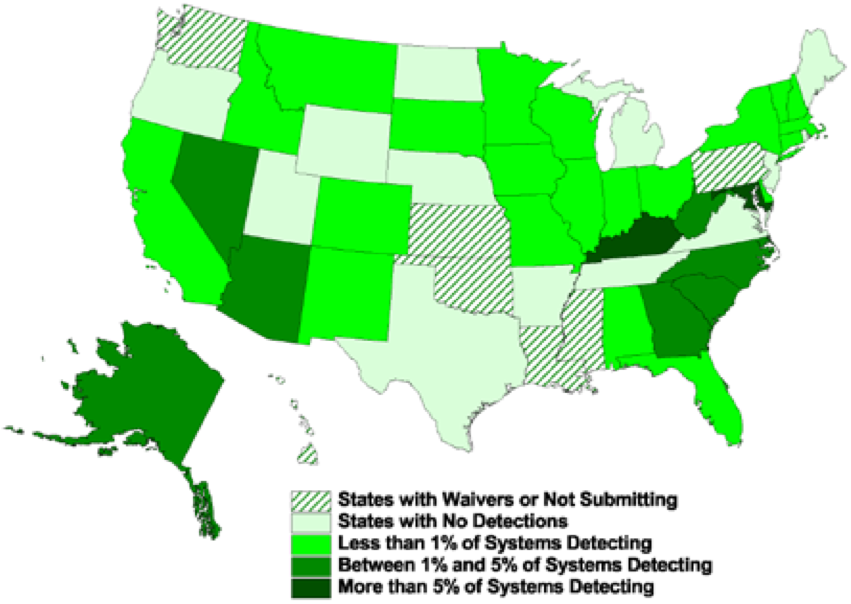

Exhibit 9-10: Percentage of Systems with at Least One 2,4-D Detection Greater than the MCL Concentration (> 70 µg/L), by State

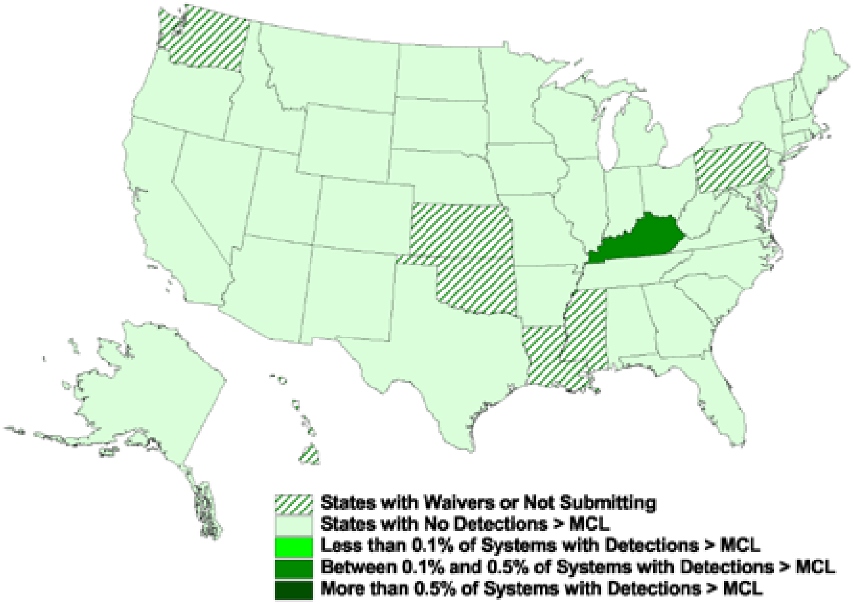

Exhibit 9-11 presents the Stage 1 analysis of 2,4-D occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 70 µg/L, 40 µg/L, and 35 µg/L. Three (0.009% of) systems, serving about 16,000 persons, reported at least one detection greater than or equal to 35 µg/L; and one (0.003% of) systems, serving about 14,000 persons, reported at least one detection greater than 70 µg/L. The numbers of surface water and ground water systems reporting at least one detection greater than the thresholds were similarly low. Only one surface water system, serving 13,933 persons, reported at least one detection greater than any of the thresholds. This system serves a larger population than the ground water systems.

Exhibit 9-11: 2,4-D Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 70 µg/L	0	0.000%	0	0.000%
	≥ 40 µg/L	1	0.003%	1,810	0.003%
	≥ 35 µg/L	2	0.007%	1,845	0.003%
Surface Water	> 70 µg/L	1	0.033%	13,933	0.012%
	≥ 40 µg/L	1	0.033%	13,933	0.012%
	≥ 35 µg/L	1	0.033%	13,933	0.012%
Combined Ground & Surface Water	> 70 µg/L	1	0.003%	13,933	0.007%
	≥ 40 µg/L	2	0.006%	15,743	0.008%
	≥ 35 µg/L	3	0.009%	15,778	0.008%

The occurrence estimates presented above (in Exhibit 9-11) are based on the conservative assumption that if a 2,4-D detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to 2,4-D (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of 2,4-D). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of 2,4-D because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of 2,4-D (rather than the entire population-served by the system).

Exhibit 9-12 presents the Stage 1 analysis of 2,4-D occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Three (0.005% of) sample points, serving 15,778 persons, reported at least one detection exceeding 35 µg/L; and one (0.005% of) sample points, serving 13,933 persons, reported at least one detection exceeding 70 µg/L.

Exhibit 9-12: 2,4-D Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 70 µg/L	0	0.000%	0	0.000%
	≥ 40 µg/L	1	0.002%	1,810	0.003%
	≥ 35 µg/L	2	0.004%	1,845	0.003%
Surface Water	> 70 µg/L	1	0.014%	13,933	0.012%
	≥ 40 µg/L	1	0.014%	13,933	0.012%
	≥ 35 µg/L	1	0.014%	13,933	0.012%
Combined Ground & Surface Water	> 70 µg/L	1	0.002%	13,933	0.007%
	≥ 40 µg/L	2	0.004%	15,743	0.008%
	≥ 35 µg/L	3	0.005%	15,778	0.008%

9.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean 2,4-D concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than the each threshold were calculated.

Exhibit 9-13 presents the Stage 2 analysis of estimated system mean concentrations for 2,4-D occurrence in drinking water relative to several thresholds. The thresholds are: 70 µg/L, 40 µg/L, and 35 µg/L. Exhibit 9-14 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no systems had an estimated system mean greater than or equal to any of the thresholds.

Exhibit 9-13: 2,4-D Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 70 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 35 µg/L	0	0	0	0.000%	0.000%	0.000%
Surface Water	> 70 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 35 µg/L	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 70 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 35 µg/L	0	0	0	0.000%	0.000%	0.000%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 9-14: 2,4-D Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 70 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 35 µg/L	0	0	0	0.000%	0.000%	0.000%
Surface Water	> 70 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 35 µg/L	0	0	0	0.000%	0.000%	0.000%

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 70 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 40 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 35 µg/L	0	0	0	0.000%	0.000%	0.000%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

9.5 Additional Occurrence Data

United States Department of Agriculture (USDA) Pesticide Data Program

2,4-D was included in the 2004 annual summary of the USDA Pesticide Data Program (PDP; USDA, 2006). In finished drinking water, 2,4-D was detected in 134 (35.4 percent) of 379 samples; concentrations ranged from 0.006 µg/L to 0.401 µg/L. In untreated drinking water, 2,4-D was detected in 126 (33.2 percent) of 380 samples; concentrations ranged from 0.006 µg/L to 0.493 µg/L.

USGS 1999 Pilot Monitoring Program

2,4-D was an analyte in the 1999 Pilot Monitoring Program (Blomquist *et al.*, 2001). 2,4-D was detected in approximately 57 percent of the 312 raw water samples and almost 44 percent of the 225 finished water samples. In raw water, the 95th percentile value was 0.158 µg/L and the maximum concentration was 0.414 µg/L. In finished water, the 95th percentile value was 0.132 µg/L and the maximum concentration of 2,4-D was 0.634 µg/L.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 19 systems (approximately 0.12% of about 16,000 systems), reported at least one detection of 2,4-D. Three systems (approximately 0.02% of all systems), reported at least one detection greater than the MCL concentration.

9.6 Summary of Data

TRI data indicate that total off-site and on-site releases of 2,4-D for the period 1998-2006 ranged from about 14,000 pounds to about 269,000 pounds, with a substantial increase from

2003 to 2006. The increase was due to a steep rise in releases to land. Underground injection constituted most on- and off-site releases between 1998 and 1999. Off-site releases were greater than on-site releases from 2000 to 2002.

Ambient water data from the NAWQA Pesticide National Synthesis Project show that most 2,4-D detections occurred at agricultural and urban sites. It was detected in 13.08% of 1,465 agricultural stream samples taken at 62 sites. It was detected in 13.10% of 523 urban stream samples taken at 19 sites. 2,4-D was detected in 0.66% of samples taken from 1,208 ground water agricultural wells and in 0.75% of samples taken from 666 urban wells. Additional ambient water data from the NAWQA program indicate that 2,4-D was detected in 8.1% of 9,553 ground and surface water samples and at 5.1% of 4,539 sites. The median concentration, based on detections from all sites, was 0.2 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that 2,4-D was detected in 0.901% of 33,187 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.3 µg/L. Only one surface water system (serving almost 14,000 persons) reported at least one detection greater than the MCL concentration. No ground water systems reported detections greater than the MCL concentration.

In the Stage 2 analysis, no systems had an estimated mean concentration exceeding the MCL concentration.

9.7 References

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10 1,2-Dichloropropane

This chapter on 1,2-dichloropropane is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and 1,2-dichloropropane occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

10.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for 1,2-dichloropropane on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1989), 1,2-dichloropropane (also known as 1,2-DCP) is a colorless organic liquid with a chloroform-like odor. It is moderately soluble in water and evaporates readily at room temperature (ATSDR, 1989).

1,2-Dichloropropane ($C_3H_6Cl_2$) is a man-made chemical whose presence in the environment results from anthropogenic activity. The major releases of 1,2-dichloropropane are to the atmosphere and to soil. Most of the 1,2-dichloropropane released into the environment ends up in the air or ground water. The half-life of 1,2-dichloropropane in air is not known exactly, but it is longer than 23 days, which means that 1,2-dichloropropane can spread to areas far from where it is released. Nonetheless, air levels of 1,2-dichloropropane are usually quite low - in urban areas of the United States, the average amount in air is about 22 parts per trillion (ppt). In ground water, the half-life of 1,2-dichloropropane is estimated to be between six months and two years. Private wells in farming areas where 1,2-dichloropropane was once used as a soil fumigant have the greatest risk for contamination (ATSDR, 1989).

10.2 Use, Production, and Releases

1,2-Dichloropropane use today is limited primarily to research and industry as a chemical intermediate to make perchloroethylene and several other related chlorinated chemicals. Before the early 1980s, 1,2-dichloropropane was used in farming as a soil fumigant and was found in some paint strippers, varnishes, and furniture finish removers (ATSDR, 1989).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 10-1 presents the production of 1,2-dichloropropane in the United States from 1986 to 2002. Note that the production of 1,2-dichloropropane in the United States has been in the same range for much of the reporting period.

Exhibit 10-1: Production of 1,2-Dichloropropane in the United States

Inventory Update Year	Production Volume
1986 Range	> 100 million - 500 million pounds
1990 Range	> 50 million - 100 million pounds
1994 Range	No Reports
1998 Range	> 100 million - 500 million pounds
2002 Range	> 100 million - 500 million pounds

Source: USEPA, 2003a

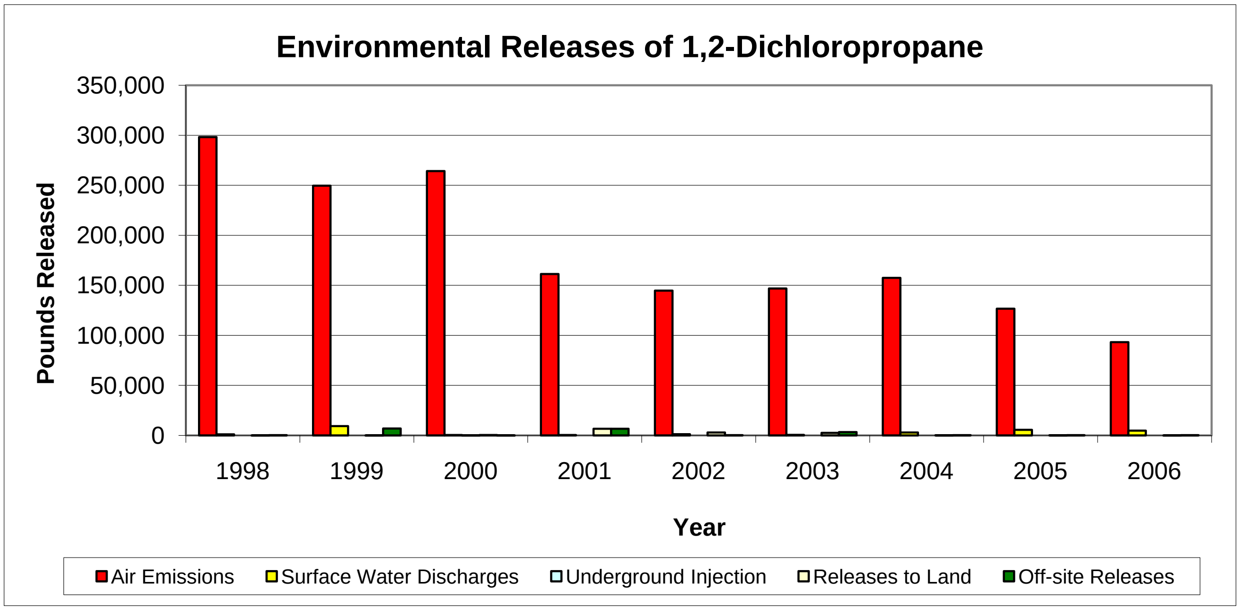
1,2-Dichloropropane is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 10-2a lists the environmental releases of 1, 2-dichloropropane from 1998 to 2006. (Exhibit 10-2b provides a graphical presentation of the environmental releases.) On-site releases were greater than off-site releases. Air emissions generally constituted greater than 95% of total releases and declined considerably during the period of record. Surface water discharges, releases to land, and off-site releases fluctuated during the period of record but were minor. There were virtually no underground injection releases. The TRI data for 1,2-dichloropropane were reported from 13 states, with six states (Louisiana, New Jersey, New York, Ohio, Texas, and Virginia) reporting in all 9 years.

Exhibit 10-2a: Table of Toxics Release Inventory (TRI) Data for 1,2-Dichloropropane

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	298,158	1,122	0	32	267	299,579
1999	249,678	9,243	0	30	6,869	265,820
2000	264,196	436	5	382	16	265,035
2001	161,265	463	0	6,608	6,662	174,998
2002	144,703	1,229	0	2,950	283	149,165
2003	146,803	560	0	2,515	3,331	153,209
2004	157,499	2,921	0	138	309	160,867
2005	126,643	5,585	0	98	259	132,585
2006	93,224	4,768	0	8	255	98,255

Source: USEPA, 2008

Exhibit 10-2b: Graph of Toxics Release Inventory (TRI) Data for 1,2-Dichloropropane



Source: USEPA, 2008

10.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of 1,2-dichloropropane in ambient water are available from the NAWQA program.

10.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for 1,2-dichloropropane. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 10-3. Overall, 1,2-dichloropropane was detected in 1.7% of samples and at 1.8% of sites. It was detected more frequently in ground water than in surface water. The median concentration, based on detections from all sites, was 0.129 µg/L. The 99th percentile concentration, based on detections from all sites, was 11.4 µg/L.

Exhibit 10-3: EPA Summary Analysis of 1,2-Dichloropropane 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
ground water	4,658	1.9%	4,159	1.8%	0.002	0.1649	6.6	19.4	19.4
surface water	1,413	0.8%	190	1.6%	0.01	0.02	0.091	0.091	0.091
all sites	6,071	1.7%	4,349	1.8%	0.002	0.1288	1.6	11.4	19.4

1. RLs (Reporting Limits) for 1,2-dichloropropane varied, but did not exceed 0.01 µg/L.

10.4 Occurrence in Drinking Water

1,2-Dichloropropane is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of 1,2-dichloropropane occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for 1,2-dichloropropane. These data consist of 374,409 analytical results from 50,437 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for 1,2-dichloropropane in the dataset is 0.5 µg/L.

10.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 10-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 1,2-dichloropropane, 0.480% of 50,437 systems reported detections. Exhibit 10-5 lists the minimum, median, 90th percentile, and maximum 1,2-dichloropropane concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 1,2-dichloropropane, based on detections from all systems, was 1 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 10-4: 1,2-Dichloropropane Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	289,938	46,180	80,535	86,395,709	86,395,709
Surface Water	84,471	4,257	10,856	140,516,425	140,516,425
Combined Ground & Surface Water	374,409	50,437	91,391	226,912,134	226,912,134
Percent with Detections					
Ground Water	0.231%	0.468%	0.308%	1.644%	0.765%
Surface Water	0.300%	0.611%	0.405%	6.229%	0.704%
Combined Ground & Surface Water	0.246%	0.480%	0.320%	4.483%	0.727%

Exhibit 10-5: 1,2-Dichloropropane Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.9	3.1	11.3
Surface Water	0.005	1.1	2.5	26.2
Combined Ground & Surface Water	0.005	1	2.9	26.2

The following maps illustrate the geographic distribution of 1,2-dichloropropane occurrence in drinking water. Exhibit 10-6 shows the states with systems with at least one detection and Exhibit 10-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of 1,2-dichloropropane is geographically dispersed. Detection rates were generally low; although 37 states reported detections, only six

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

states reported detections in more than 1% of their systems. Only eight states reported detections greater than the MCL concentration of 5 µg/L.

Exhibit 10-6: Percentage of Systems with at Least One 1,2-Dichloropropane Detection, By State

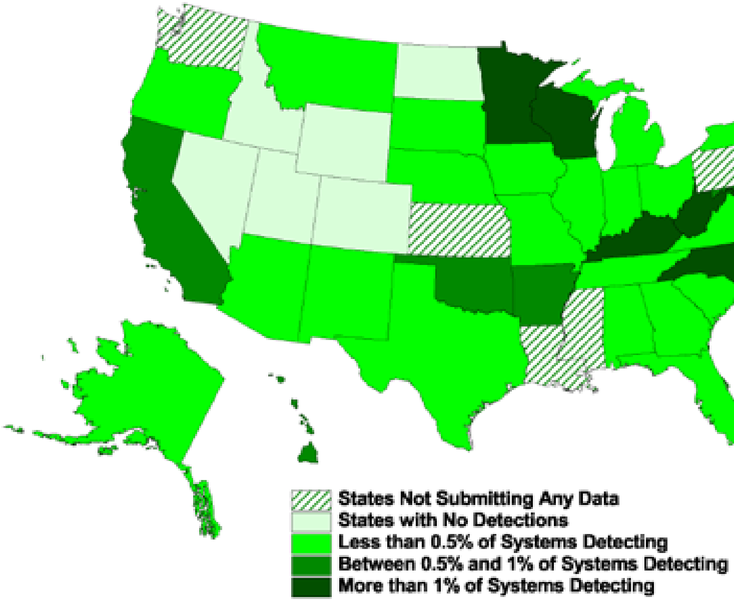

Exhibit 10-7: Percentage of Systems with at Least One 1,2-Dichloropropane Detection Greater than the MCL Concentration (> 5 µg/L), by State

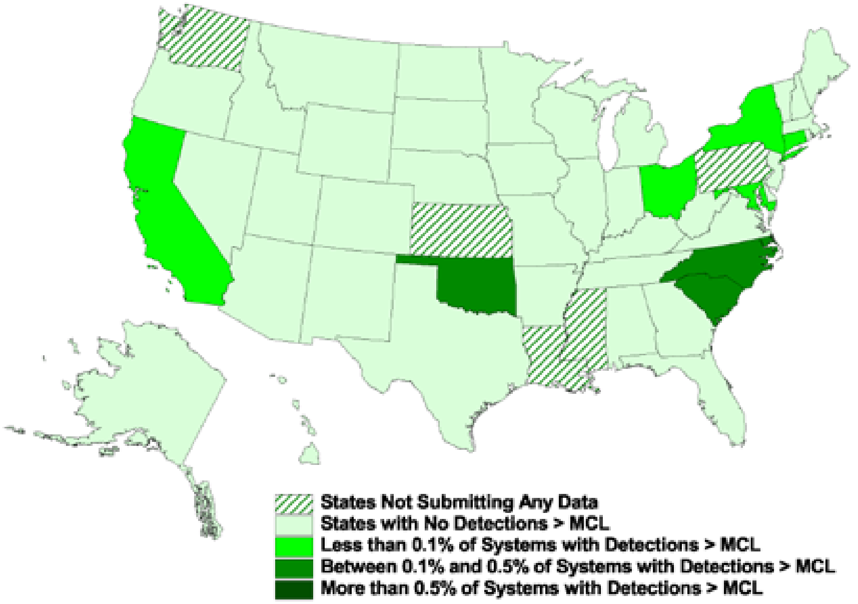

Exhibit 10-8 presents the Stage 1 analysis of 1,2-dichloropropane occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. Thirty-nine (0.077% of) systems, serving about 1.1 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 10 (0.020% of) systems, serving about 352,000 persons, reported at least one detection greater than 5 µg/L. Detections greater than the thresholds were more common in ground water systems than surface water systems. However, because surface water systems tend to be larger, a greater population was served by surface water systems reporting detections greater than the thresholds.

Exhibit 10-8: 1,2-Dichloropropane Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 5 µg/L	8	0.017%	16,691	0.019%
	≥ 2.5 µg/L	33	0.071%	43,469	0.050%
	≥ 1 µg/L	84	0.182%	464,180	0.537%
	> 0.5 µg/L	150	0.325%	666,040	0.771%
Surface Water	> 5 µg/L	2	0.047%	334,996	0.238%
	≥ 2.5 µg/L	6	0.141%	1,094,057	0.779%
	≥ 1 µg/L	14	0.329%	7,662,775	5.453%
	> 0.5 µg/L	15	0.352%	8,053,925	5.732%
Combined Ground & Surface Water	> 5 µg/L	10	0.020%	351,687	0.155%
	≥ 2.5 µg/L	39	0.077%	1,137,526	0.501%
	≥ 1 µg/L	98	0.194%	8,126,955	3.582%
	> 0.5 µg/L	165	0.327%	8,719,965	3.843%

The occurrence estimates presented above (in Exhibit 10-8) are based on the conservative assumption that if a 1,2-dichloropropane detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to 1,2-dichloropropane (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of 1,2-dichloropropane). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of 1,2-dichloropropane because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of 1,2-dichloropropane (rather than the entire population-served by the system).

Exhibit 10-9 presents the Stage 1 analysis of 1,2-dichloropropane occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Forty-two (0.046% of) sample points, serving an estimated 228,000 persons, reported at least one detection greater than or equal to 2.5 µg/L; and 13 (0.014% of) sample points, serving an estimated 182,000 persons, reported at least one detection exceeding 5 µg/L. Similar to the system-level occurrence analysis, more ground water sample points had threshold exceedances. However, because surface water systems tend to be larger, a greater population was served by sample points with threshold exceedances.

Exhibit 10-9: 1,2-Dichloropropane Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 5 µg/L	10	0.012%	3,884	0.004%
	≥ 2.5 µg/L	35	0.043%	24,739	0.029%
	≥ 1 µg/L	99	0.123%	95,285	0.110%
	> 0.5 µg/L	169	0.210%	151,688	0.176%
Surface Water	> 5 µg/L	3	0.028%	178,346	0.127%
	≥ 2.5 µg/L	7	0.064%	203,597	0.145%
	≥ 1 µg/L	21	0.193%	523,178	0.372%
	> 0.5 µg/L	29	0.267%	641,646	0.457%
Combined Ground & Surface Water	> 5 µg/L	13	0.014%	182,230	0.080%
	≥ 2.5 µg/L	42	0.046%	228,336	0.101%
	≥ 1 µg/L	120	0.131%	618,463	0.273%
	> 0.5 µg/L	198	0.217%	793,334	0.350%

10.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean 1,2-dichloropropane concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 10-10 presents the Stage 2 analysis of estimated system mean concentrations for 1,2-dichloropropane occurrence in drinking water relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. Exhibit 10-11 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, two ground water systems (approximately 0.004% of all systems) had an estimated system mean greater than or equal to 2.5 µg/L. No surface water system had an estimated system mean greater than or equal to 2.5 µg/L. These two systems serve 120 persons. No systems had an estimated system mean greater than 5 µg/L.

Exhibit 10-10: 1,2-Dichloropropane Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	2	2	2	0.004%	0.004%	0.004%
	≥ 1 µg/L	26	23	20	0.056%	0.050%	0.043%
	> 0.5 µg/L	138	59	46	0.299%	0.128%	0.100%
Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	1	1	1	0.023%	0.023%	0.023%
	> 0.5 µg/L	14	2	1	0.329%	0.047%	0.023%
Combined Ground & Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	2	2	2	0.004%	0.004%	0.004%
	≥ 1 µg/L	27	24	21	0.054%	0.048%	0.042%
	> 0.5 µg/L	152	61	47	0.301%	0.121%	0.093%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 10-11: 1,2-Dichloropropane Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	120	120	120	0.0001%	0.0001%	0.0001%
	≥ 1 µg/L	20,445	20,057	18,656	0.024%	0.023%	0.022%
	> 0.5 µg/L	647,056	86,764	30,337	0.749%	0.100%	0.035%
Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	265,696	265,696	265,696	0.189%	0.189%	0.189%
	> 0.5 µg/L	7,377,671	407,696	265,696	5.250%	0.290%	0.189%

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 2.5 µg/L	120	120	120	0.0001%	0.0001%	0.0001%
	≥ 1 µg/L	286,141	285,753	284,352	0.126%	0.126%	0.125%
	> 0.5 µg/L	8,024,727	494,460	296,033	3.536%	0.218%	0.130%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

10.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including 1,2-dichloropropane, in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, 1,2-dichloropropane had a detection frequency of 0.58% at an assessment level of 0.2 µg/L (based on 2,400 samples). The median concentration of detections was 0.30 µg/L. Six detections were within one order of magnitude of the MCL concentration (5 µg/L) and three detections were greater than the MCL concentration.

In public wells, 1,2-dichloropropane had a detection frequency of 0.74% at an assessment level of 0.2 µg/L (based on 1,078 samples). The median concentration of detections was 0.17 µg/L. Two detections were within one order of magnitude of the MCL concentration. No detections were greater than the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 148 systems (approximately 0.67% of about 22,000 systems), reported at least one detection of 1,2-dichloropropane. Fifteen systems (approximately 0.07% of all systems), reported at least one detection greater than the MCL concentration.

10.6 Summary of Data

TRI data indicate that total off-site and on-site releases of 1,2-dichloropropane for the period 1998-2006 ranged from approximately 98,000 pounds to about 300,000 pounds, with a steady decrease over time. Releases were almost entirely emissions to air. Surface water discharges, releases to land, and off-site releases were minor. Releases via underground injection were virtually non-existent.

Ambient water data from the NAWQA program indicate that 1,2-dichloropropane was detected in 1.7% of 6,071 ground and surface water samples and at 1.8% of 4,349 sites. The median concentration, based on detections from all sites, was 0.13 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that 1,2-dichloropropane was detected in 0.480% of 50,437 surface water and ground water systems. The median concentration, based on detections from all systems, was 1 µg/L. Approximately 0.020% of all systems (serving 0.155% of the population) reported at least one detection greater than the MCL concentration of 5 µg/L. The number of systems reporting at least one detection greater than the MCL concentration was greater for ground water systems. However, because surface water systems tend to be larger than ground water systems, a greater population was served by surface water systems reporting at least one detection greater than the MCL concentration. A similar pattern was seen for sample points.

In the Stage 2 analysis, 0.004% of ground water systems (serving 0.0001% of the population) had an estimated system mean concentration of 1,2-dichloropropane greater than 2.5 µg/L. No surface or ground water system had a mean concentration exceeding the MCL concentration.

10.7 References

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11 Endothall

This chapter on endothall is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and endothall occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

11.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for endothall on July 17, 1992 (57 FR 31776 (USEPA, 1992)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 100 µg/L. EPA developed the MCLG based on a reference dose (RfD) of 20 µg/kg-day (0.02 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

According to USEPA (2005), endothall ($C_8H_{10}O_5$) is an organic solid consisting of white, odorless crystals. It is applied as either a dipotassium salt or an N, N-dimethylalkylamine salt; the latter form accounts for the most use. Endothall acid is not directly applied, but rather is formed as a breakdown product resulting from application of the salt forms (USEPA, 2005).

Endothall is quickly broken down by microbes once deposited on soil or water. In aqueous environments it is expected to persist for less than ten days. In terrestrial environments, endothall degrades with a half-life of approximately ten days. Endothall does not bioaccumulate (USEPA, 2005).

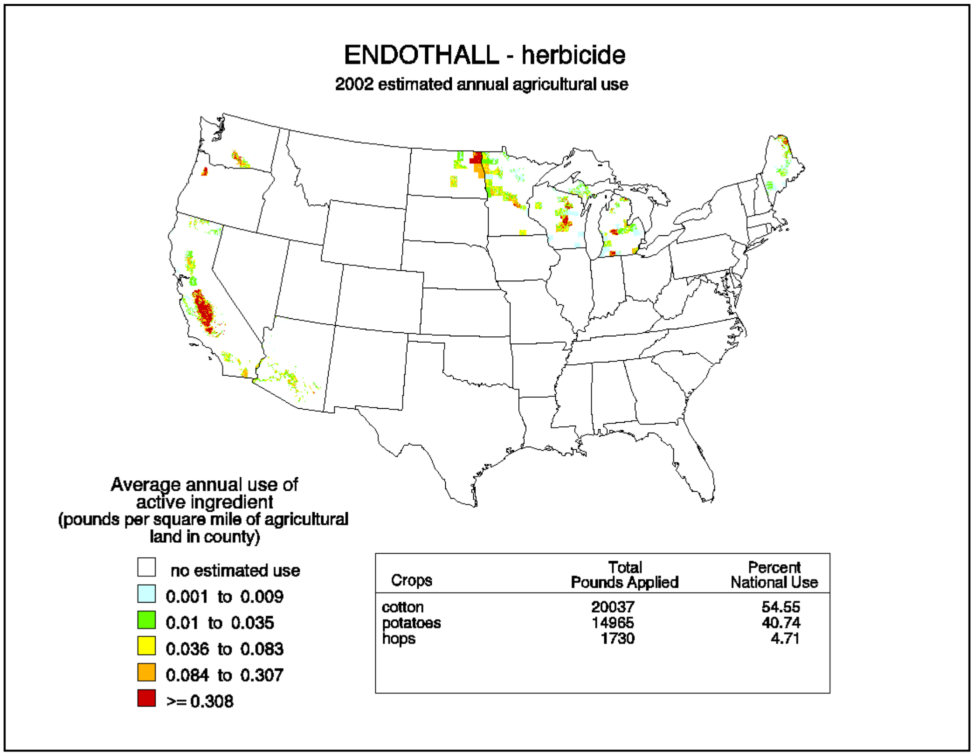
11.2 Use, Production, and Releases

According to USEPA (2005), endothall is most often used as an aquatic herbicide to control submerged vegetation and algae in lakes, ponds, and irrigation canals. It is also used terrestrially as an herbicide, where it is applied to cotton, potatoes, hops, clover, and alfalfa (USEPA, 2005).

Exhibit 11-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual endothall use in the United States from 1999 through 2004. A breakdown of use by crop is also included. The map was created by the USGS using state-level data sets on pesticide use rates from 1999-2004 compiled by the CropLife

Foundation, at the Crop Protection Research Institute, combined with county-level data on harvested crop acreage obtained from the 2002 Census of Agriculture. Due to the nature of the data sources, non-agricultural uses are not reflected here, and variations in use at the county-level are also not well represented (Thelin and Gianessi, 2000). The USGS (2007) estimates that about 37,000 pounds of endothall active ingredient were used on average each year between 1999 and 2004. The greatest use of endothall is in the Midwest, the Pacific Northwest, and California.

Exhibit 11-1: Estimated Annual Agricultural Use for Endothall (c. 2002)



Crops	Total Pounds Applied	Percent National Use
cotton	20037	54.55
potatoes	14965	40.74
hops	1730	4.71

Source: USGS, 2007

The Chemical Substance Inventory Update System contains confidential data reported by industry as a partial update of the Toxic Substances Control Act (TSCA) Inventory. The TSCA Chemical Substance Inventory does not report production data for endothall.

Endothall is not listed as a Toxics Release Inventory (TRI) chemical; thus no TRI release records are available. Therefore, the use of endothall (described in the previous section) may provide the primary indication of where releases are most likely to occur.

11.3 Occurrence in Ambient Water

No National Water Quality Assessment (NAWQA) Program data are available from the United States Geological Survey (USGS) on the occurrence of endothall in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

11.4 Occurrence in Drinking Water

Endothall is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.) Statewide waivers are often granted for endothall.

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of endothall occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

Thirty-eight of the Six-Year Review-ICR states provided occurrence data for endothall. (There were no endothall data from Hawaii, Minnesota, Missouri, North Carolina, New Hampshire, Oklahoma, and Texas.) These data consist of 49,820 analytical results from 14,156 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for endothall in the dataset is 9 µg/L.

11.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 11-2 presents the number of samples, systems, and

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For endothall, 0.233% of 14,156 systems reported detections. Exhibit 11-3 lists the minimum, median, 90th percentile, and maximum endothall concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of endothall, based on detections from all systems, was 9.8 µg/L.

Exhibit 11-2: Endothall Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	38,414	12,632	20,422	44,124,258	44,124,258
Surface Water	11,406	1,524	3,593	74,412,543	74,412,543
Combined Ground & Surface Water	49,820	14,156	24,015	118,536,801	118,536,801
Percent with Detections					
Ground Water	0.081%	0.158%	0.118%	7.222%	7.130%
Surface Water	0.149%	0.853%	0.417%	3.934%	1.885%
Combined Ground & Surface Water	0.096%	0.233%	0.162%	5.158%	3.837%

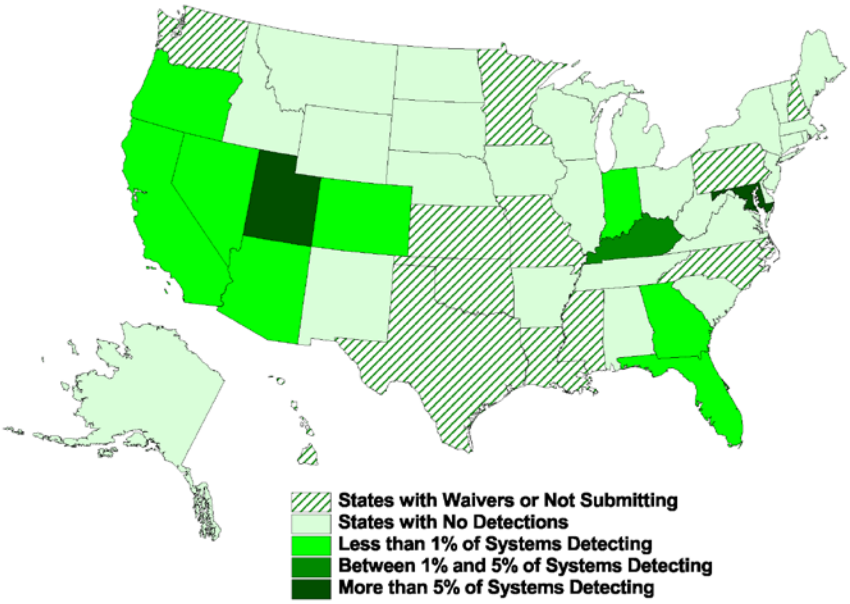
Exhibit 11-3: Endothall Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	1.5	11.5	13.6	450
Surface Water	0.1	9	171.2	548.1
Combined Ground & Surface Water	0.1	9.8	55	548.1

The following maps illustrate the geographic distribution of endothall occurrence in drinking water. Exhibit 11-4 shows the states with systems with at least one detection and Exhibit 11-5 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Hawaii, Minnesota, Missouri, North Carolina, New Hampshire, Oklahoma, and Texas did submit Six-Year data for most contaminants; however, these states did not submit endothall data.

The distribution of systems with detections of endothall is geographically dispersed. Detection rates were generally low; only three states reported detections in more than 1% of their systems. Only one state reported detections greater than the MCL concentration of 100 µg/L.

Exhibit 11-4: Percentage of Systems with at Least One Endothall Detection, by State



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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Exhibit 11-5: Percentage of Systems with at Least One Endothall Detection Greater than the MCL Concentration (> 100 µg/L), by State

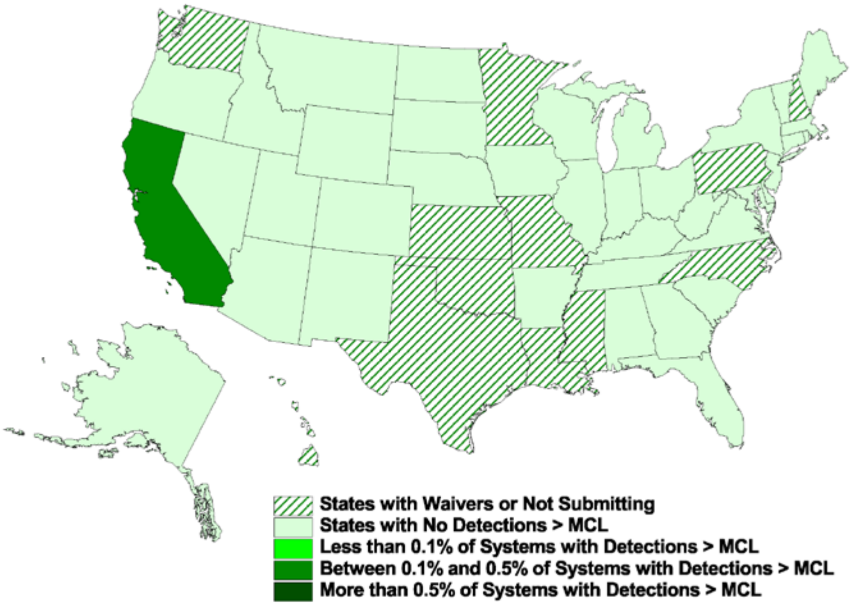

Exhibit 11-6 presents the Stage 1 analysis of endothall occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to 100 µg/L and 50 µg/L. Four systems (0.028% of all systems), serving about 87,000 persons, had at least one detection greater than or equal to 50 µg/L; and three systems (0.021% of all systems), serving 75,000 persons, had at least one detection greater than 100 µg/L. Only one ground water system, which serves 20,000 persons, reported at least one detection of endothall greater than or equal to 50 µg/L or greater than 100 µg/L. Two surface water systems (serving about 55,000 persons) reported at least one detection of endothall greater than 100 µg/L.

Exhibit 11-6: Endothall Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 100 µg/L	1	0.008%	20,000	0.045%
	≥ 50 µg/L	1	0.008%	20,000	0.045%
Surface Water	> 100 µg/L	2	0.131%	54,657	0.073%
	≥ 50 µg/L	3	0.197%	66,657	0.090%

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Combined Ground & Surface Water	> 100 µg/L	3	0.021%	74,657	0.063%
	≥ 50 µg/L	4	0.028%	86,657	0.073%

The occurrence estimates presented above (in Exhibit 11-6) are based on the conservative assumption that if an endothall detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to endothall (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of endothall). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of endothall because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of endothall (rather than the entire population-served by the system).

Exhibit 11-7 presents the Stage 1 analysis of endothall occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Four (0.017% of) sample points (serving approximately 29,000 persons) had at least one detection greater than or equal to 50 µg/L; and three (0.012% of) sample points (serving approximately 28,000 persons) had at least one detection exceeding 100 µg/L.

Exhibit 11-7: Endothall Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 100 µg/L	1	0.005%	20,000	0.045%
	≥ 50 µg/L	1	0.005%	20,000	0.045%
Surface Water	> 100 µg/L	2	0.056%	7,977	0.011%
	≥ 50 µg/L	3	0.083%	8,549	0.011%
Combined Ground & Surface Water	> 100 µg/L	3	0.012%	27,977	0.024%
	≥ 50 µg/L	4	0.017%	28,549	0.024%

11.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean endothall concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 11-8 presents the Stage 2 analysis of estimated system mean concentrations for endothall occurrence in drinking water relative to 100 µg/L and 50 µg/L. Exhibit 11-9 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, none of the systems had an estimated mean greater than 100 µg/L. None of the ground water systems had a mean exceeding 50 µg/L. Among the surface water systems, one system had a mean equal to or greater than 50 µg/L. That system serves about 10,000 persons.

Exhibit 11-8: Endothall Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 100 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 50 µg/L	0	0	0	0.000%	0.000%	0.000%
Surface Water	> 100 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 50 µg/L	1	1	1	0.066%	0.066%	0.066%
Combined Ground & Surface Water	> 100 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 50 µg/L	1	1	1	0.007%	0.007%	0.007%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 11-9: Endothall Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 100 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 50 µg/L	0	0	0	0.000%	0.000%	0.000%
Surface Water	> 100 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 50 µg/L	10,000	10,000	10,000	0.013%	0.013%	0.013%
Combined Ground & Surface Water	> 100 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 50 µg/L	10,000	10,000	10,000	0.008%	0.008%	0.008%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

11.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003), 13 systems (approximately 0.15% of about 9,000 systems), reported at least one detection of endothall. Three systems (approximately 0.03% of all systems), reported at least one detection greater than the MCL concentration.

11.6 Summary of Data

Endothall is not listed as a TRI chemical; no release records are available. There are also no ambient water data available from the NAWQA program for endothall.

The Stage 1 analysis of occurrence in drinking water indicates that endothall was detected in 0.233% of 14,156 surface water and ground water systems. The median concentration, based on detections from all systems, was 9.8 µg/L. In total, 0.021% of systems (serving 0.063% of the population) reported at least one detection greater than the MCL concentration of 100 µg/L. Only one ground water system, serving 20,000 persons, reported at least one detection greater than the 100 µg/L or 50 µg/L. Two surface water systems, serving about 55,000 persons, reported at least one detection greater than 100 µg/L. Three surface water systems, serving about 67,000 persons, reported at least one detection greater than 50 µg/L.

In the Stage 2 analysis, no ground water systems had a system mean concentration of endothall exceeding either 100 µg/L or 50 µg/L. Surface water system means did not exceed 100 µg/L. However, one surface water system (serving 10,000 persons) had a mean concentration greater than 50 µg/L.

11.7 References

Gilliom, R.J., J.E. Barbash, C.G. Crawford, P.A. Hamilton, J.D. Martin, N. Nakagaki, L.H. Nowell, J.C. Scott, P.E. Stackelberg, G.P. Thelin, and D.M. Wolock. 2007. The Quality of Our Nation's Waters - Pesticides in the Nation's Streams and Ground Water, 1992–2001. Appendix 7. Statistical summaries of water-quality data. U.S. Geological Survey Circular 1291, 172 p. Available on the Internet at: http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix7/.

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12 Heptachlor

This chapter on heptachlor is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and heptachlor occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

12.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for heptachlor on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 0.4 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2007), heptachlor ($C_{10}H_5Cl_7$) is a white to tan powder that smells somewhat like camphor. It is not very soluble in water and does not explode easily. In the past it was both a breakdown product and a component of the pesticide chlordane (approximately 10% by weight). Since 1988, heptachlor has been banned from all uses except fire ant control. The principal breakdown product of heptachlor is heptachlor epoxide (ATSDR, 2007).

From 1953 to 1974, heptachlor entered the soil and surface water when farmers used it to kill insects in seed grains and on crops. It also entered the air and soil due to use by homeowners and professional exterminators for termite eradication. Heptachlor can enter the air, soil, ground water, and surface water from leaks at hazardous waste sites or landfills (ATSDR, 2007).

Heptachlor adheres to soil very strongly and evaporates slowly into the air. When heptachlor is released to the air, it can travel very long distances and can be deposited elsewhere. In soils and water, heptachlor tends to break down into heptachlor epoxide, which, in addition to being more toxic, can persist in the environment for many years. Both heptachlor and heptachlor epoxide reside in fatty tissues and can build up in fish, cattle, and humans (ATSDR, 2007).

Exposure to heptachlor and heptachlor epoxide most commonly occurs through ingestion of contaminated foods, which might include fish, shellfish, dairy products, meat, and poultry. Contaminated fish and shellfish have been found to contain 2 to 750 ppb of heptachlor. Exposure may also occur through water, air, and soil. In particular, those living in homes treated for termites using heptachlor and those living near contaminated soils may inhale heptachlor and heptachlor epoxide (ATSDR, 2007).

12.2 Use, Production, and Releases

Until 1988, heptachlor was used extensively for killing insects in homes, buildings, and on food crops. Currently it can only be used for fire ant control in underground power transformers (ATSDR, 2007).

The Chemical Substance Inventory Update System contains confidential data reported by industry as a partial update of the Toxic Substances Control Act (TSCA) Inventory. The TSCA Chemical Substance Inventory does not report production data for heptachlor.

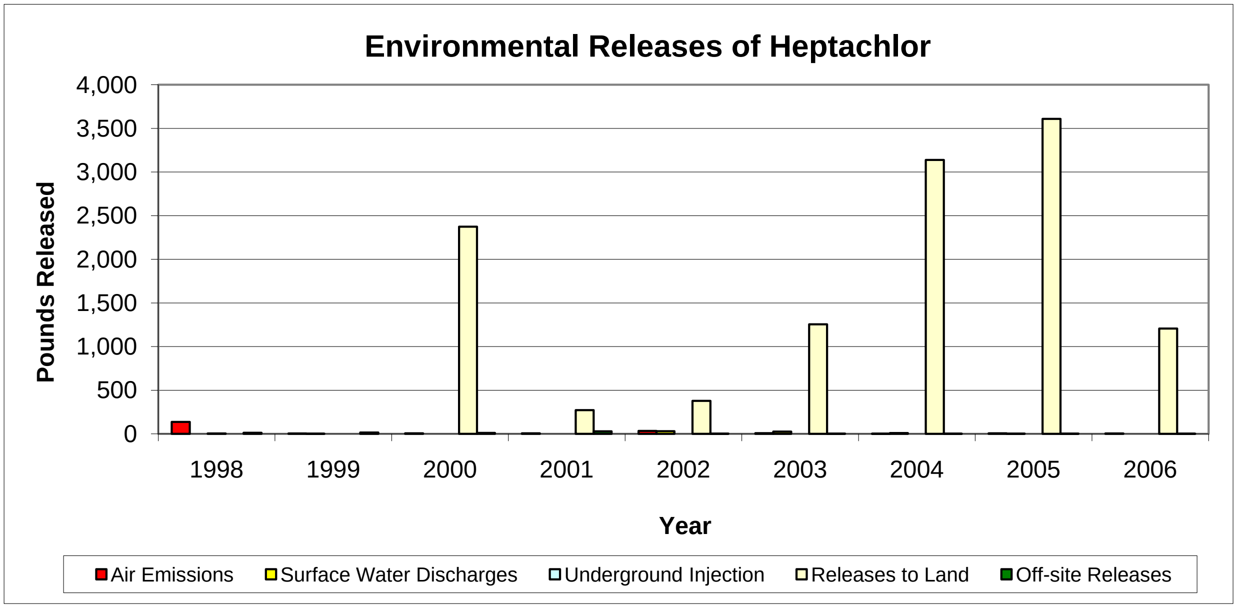
Heptachlor is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 12-1a lists the environmental releases of heptachlor from 1998 to 2006. (Exhibit 12-1b provides a graphical presentation of the environmental releases.) On-site releases of heptachlor exceeded off-site releases in every year except in 1999. Releases to land constituted most of the emissions for the period of record (generally in excess of 95%) except in 1998, when air emissions peaked. Relative to releases to land, releases to air, via underground injection, and by discharge to surface water contributed negligible amounts. Off-site releases remained low throughout the period of record. The TRI data for heptachlor were reported from 15 states, with 4 states (Arkansas, New Jersey, Ohio, and Texas) reporting releases in all 9 years.

Exhibit 12-1a: Table of Toxics Release Inventory (TRI) Data for Heptachlor

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	137	0	5	0	12	154
1999	5	1	0	0	14	20
2000	7	0	0	2,373	10	2,390
2001	6	0	0	272	28	306
2002	33	30	0	378	2	442
2003	8	25	0	1,254	2	1,289
2004	2	9	0	3,138	1	3,150
2005	5	2	0	3,608	3	3,619
2006	5	0	0	1,207	1	1,212

Source: USEPA, 2008

Exhibit 12-1b: Graph of Toxics Release Inventory (TRI) Data for Heptachlor



Source: USEPA, 2008

12.3 Occurrence in Ambient Water

No National Water Quality Assessment (NAWQA) Program data are available from the United States Geological Survey (USGS) on the occurrence of heptachlor in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

12.4 Occurrence in Drinking Water

Heptachlor is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of heptachlor occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

Forty-four of the Six-Year Review-ICR states provided occurrence data for heptachlor. (There were no heptachlor data from Oklahoma.) These data consist of 133,726 analytical results from 33,020 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for heptachlor in the dataset is 0.04 µg/L.

12.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 12-2 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For heptachlor, 0.796% of 33,020 systems reported detections. Exhibit 12-3 lists the minimum, median, 90th percentile, and maximum heptachlor concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of heptachlor, based on detections from all systems, was 0.1 µg/L.

Exhibit 12-2: Heptachlor Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	106,106	29,965	48,681	67,922,151	67,922,151
Surface Water	27,620	3,055	6,733	116,521,633	116,521,633
Combined Ground & Surface Water	133,726	33,020	55,414	184,443,784	184,443,784

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Percent with Detections					
Ground Water	0.491%	0.761%	0.768%	4.819%	4.179%
Surface Water	0.275%	1.146%	0.713%	4.528%	3.838%
Combined Ground & Surface Water	0.446%	0.796%	0.762%	4.635%	3.964%

Exhibit 12-3: Heptachlor Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.001	0.1	0.1	0.5
Surface Water	0.001	0.1	0.12	0.5
Combined Ground & Surface Water	0.001	0.1	0.1	0.5

The following maps illustrate the geographic distribution of heptachlor occurrence in drinking water. Exhibit 12-4 shows the states with systems with at least one detection and Exhibit 12-5 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Oklahoma did submit Six-Year data for most contaminants; however, there is a statewide waiver for heptachlor in Oklahoma, so no heptachlor data were available from that state.

The distribution of systems with detections of heptachlor is geographically dispersed. Detection rates were generally low, with only three states detecting heptachlor in more than 1% of their systems. Only one state reported detections of heptachlor greater than the MCL concentration of 0.4 µg/L.

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Exhibit 12-4: Percentage of Systems with at Least One Heptachlor Detection, by State

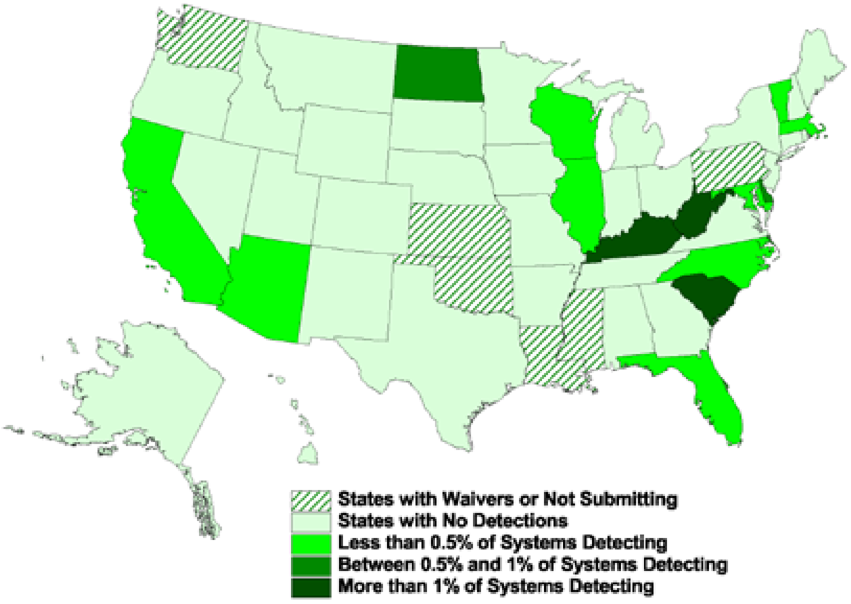

Exhibit 12-5: Percentage of Systems with at Least One Heptachlor Detection Greater than the MCL Concentration (> 0.4 µg/L), by State

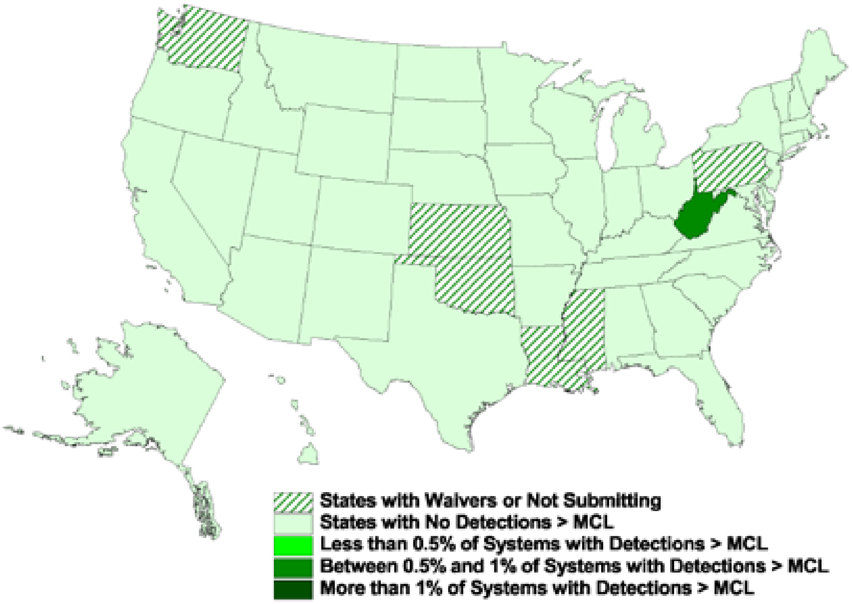

Exhibit 12-6 presents the Stage 1 analysis of heptachlor occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 0.4 µg/L, 0.2 µg/L, and 0.1 µg/L. Seven (0.021% of) systems, serving about 268,000 persons, reported at least one detection greater than or equal to 0.2 µg/L; and 2 (0.006% of) systems, serving almost 4,700 persons, reported at least one detection greater than 0.4 µg/L. The numbers of surface and ground water systems reporting at least one detection greater than 0.4 µg/L were similarly low; however, because surface water systems tend to be larger, more people were served by surface water systems than ground water systems reporting at least one detection greater than 0.4 µg/L.

Exhibit 12-6: Heptachlor Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 0.4 µg/L	1	0.003%	325	0.000%
	≥ 0.2 µg/L	3	0.010%	5,615	0.008%
	≥ 1 µg/L	207	0.691%	470,220	0.692%
Surface Water	> 0.4 µg/L	1	0.033%	4,374	0.004%
	≥	4	0.131%	262,286	0.225%
	≥ 1	27	0.884%	3,435,360	2.948%
Combined Ground & Surface Water	> 0.4 µg/L	2	0.006%	4,699	0.003%
	≥	7	0.021%	267,901	0.145%
	≥ 1	234	0.709%	3,905,580	2.117%

The occurrence estimates presented above (in Exhibit 12-6) are based on the conservative assumption that if a heptachlor detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to heptachlor (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of heptachlor). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of heptachlor because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of heptachlor (rather than the entire population-served by the system).

Exhibit 12-7 presents the Stage 1 analysis of heptachlor occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Nine (0.016% of) sample points, serving an estimated 261,000 persons, reported at least one detection greater than or equal to 0.2 µg/L and two (0.004% of) sample points, serving an estimated 2,500 persons, reported at least one detection exceeding 0.4 µg/L.

Exhibit 12-7: Heptachlor Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 0.4 µg/L	1	0.002%	325	0.000%
	≥	3	0.006%	1,186	0.002%
	≥ 1	350	0.719%	206,377	0.304%
Surface Water	> 0.4 µg/L	1	0.015%	2,187	0.002%
	≥	6	0.089%	260,099	0.223%
	≥ 1	36	0.535%	1,789,231	1.536%
Combined Ground & Surface Water	> 0.4 µg/L	2	0.004%	2,512	0.001%
	≥	9	0.016%	261,285	0.142%
	≥ 1	386	0.697%	1,995,607	1.082%

12.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean heptachlor concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 12-8 presents the Stage 2 analysis of estimated system mean concentrations for heptachlor in drinking water relative to several thresholds. The thresholds are: 0.4 µg/L, 0.2 µg/L, and 0.1 µg/L. Exhibit 12-9 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, one ground water system (approximately 0.003% of all systems) had an estimated system mean greater than or equal to 0.2 µg/L and 0.4 µg/L. This system serves 325 persons.

Exhibit 12-8: Heptachlor Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 0.4 µg/L	1	1	1	0.003%	0.003%	0.003%
	≥	1	1	1	0.003%	0.003%	0.003%
	≥ 1	41	41	41	0.137%	0.137%	0.137%
Surface Water	> 0.4 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥ 1	1	1	1	0.033%	0.033%	0.033%
Combined Ground & Surface Water	> 0.4 µg/L	1	1	1	0.003%	0.003%	0.003%
	≥	1	1	1	0.003%	0.003%	0.003%
	≥ 1	42	42	42	0.127%	0.127%	0.127%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 12-9: Heptachlor Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 0.4 µg/L	325	325	325	0.0005%	0.0005%	0.0005%
	≥	325	325	325	0.0005%	0.0005%	0.0005%
	≥ 1	23,112	23,112	23,112	0.034%	0.034%	0.034%
Surface Water	> 0.4 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥ 1	8,380	8,380	8,380	0.007%	0.007%	0.007%
Combined Ground & Surface Water	> 0.4 µg/L	325	325	325	0.0002%	0.0002%	0.0002%
	≥ 0.2 µg/L	325	325	325	0.0002%	0.0002%	0.0002%
	≥ 1	31,492	31,492	31,492	0.017%	0.017%	0.017%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

12.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003), 12 systems (approximately 0.08% of about 14,000 systems), reported at least one detection of heptachlor. One system (approximately 0.01% of all systems), reported at least one detection greater than the MCL concentration.

12.6 Summary of Data

TRI data indicate that total off-site and on-site releases of heptachlor for the period 1998-2006 ranged from 20 pounds to about 3,600 pounds. Releases to land constituted the overwhelming majority of material released, except during 1998 and 1999. Amounts released off-site were minor compared to releases to land.

There are no ambient water data available from the NAWQA program for heptachlor.

The Stage 1 analysis of occurrence in drinking water indicates that heptachlor was detected in 0.796% of 33,020 surface and ground water systems. The median concentration, based on detections from all systems, was 0.1 µg/L. In total, 0.006% of systems (serving approximately 0.003% of total the population) reported at least one detection greater than the MCL concentration of 0.4 µg/L. Similar numbers of ground water and surface water systems reported at least one detection greater than the MCL concentration. However, because surface water systems tend to be larger, a greater population was served by surface water systems reporting at least one detection greater than the MCL concentration. A similar pattern was seen for ground water and surface water sample points.

In the Stage 2 analysis, one ground water system (approximately 0.003% of all systems, serving 0.0002% of the population) had an estimated system mean concentration of heptachlor greater than the MCL concentration.

12.7 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. *Toxicological Profile for Heptachlor and Heptachlor Epoxide.* August 2007. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp12.html.

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USEPA. 2009. *The Analysis of Regulated Contaminant Occurrence Data from Public Water Systems in Support of the Second Six-Year Review of National Primary Drinking Water Regulations.* Office of Water. EPA-815-B-09-006. October 2009.

13 Heptachlor Epoxide

This chapter on heptachlor epoxide is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and heptachlor epoxide occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

13.1 Background

On January 30, 1991, the United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for heptachlor epoxide, a product of heptachlor degradation (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 0.2 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2007), heptachlor epoxide ($C_{10}H_5Cl_7O$) is a white powder and the principal breakdown product of the pesticide heptachlor, which is itself a breakdown product and a component of the pesticide chlordane. Within hours after application, bacteria and other organisms degrade about 20% of the applied heptachlor into heptachlor epoxide (ATSDR, 2007).

From 1953 to 1974, heptachlor epoxide entered the soil and surface water when farmers used heptachlor to kill insects in seed grains and on crops. It also entered the air and soil when homeowners and professional insect exterminators used heptachlor to kill termites. Heptachlor epoxide can enter the air, soil, ground water, and surface water from leaks at hazardous waste sites or landfills. It is more toxic than heptachlor and can persist in the environment for many years. When heptachlor epoxide is released to the air, it can travel very long distances and can be deposited elsewhere. Both heptachlor and heptachlor epoxide accumulate in fish, cattle, and humans and can reside in fatty tissues for years (ATSDR, 2007).

Exposure to heptachlor and heptachlor epoxide most commonly occurs through ingestion of contaminated foods, which might include fish, shellfish, dairy products, meat, and poultry. Contaminated fish and shellfish have been found to contain 0.1 to 480 ppb of heptachlor epoxide. Heptachlor epoxide has been found in human milk samples at levels ranging from 0.13 to 128 ppb. Exposure may also occur through water, air, and soil. In particular, those living in homes treated for termites using heptachlor and those living near contaminated soils may inhale heptachlor and heptachlor epoxide (ATSDR, 2007).

13.2 Use, Production, and Releases

Until 1988, heptachlor was used extensively for killing insects in homes, buildings, and on food crops. Currently it can only be used for fire ant control in underground power transformers (ATSDR, 2007). Heptachlor epoxide is not produced commercially, but rather is formed by the chemical and biological transformation of heptachlor in the environment.

The Chemical Substance Inventory Update System contains confidential data reported by industry as a partial update of the Toxic Substances Control Act (TSCA) Inventory. The TSCA Chemical Substance Inventory does not report production data for heptachlor epoxide.

Heptachlor epoxide is not listed as a Toxics Release Inventory (TRI) chemical; thus no TRI release records are available. Therefore, the use of heptachlor epoxide (described in the previous section) may provide the primary indication of where releases are most likely to occur.

13.3 Occurrence in Ambient Water

No National Water Quality Assessment (NAWQA) Program data are available from the United States Geological Survey (USGS) on the occurrence of heptachlor epoxide in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

13.4 Occurrence in Drinking Water

Heptachlor epoxide is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of heptachlor epoxide occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

Forty-four of the Six-Year Review-ICR states provided occurrence data for heptachlor epoxide. (There were no heptachlor epoxide data from Oklahoma.) These data consist of 134,708 analytical results from 33,015 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for heptachlor epoxide in the dataset is 0.02 µg/L.

13.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 13-1 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For heptachlor epoxide, 0.221% of 33,015 systems reported detections. Exhibit 13-2 lists the minimum, median, 90th percentile, and maximum heptachlor epoxide concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of heptachlor epoxide, based on detections from all systems, was 0.03 µg/L.

Exhibit 13-1: Heptachlor Epoxide Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	106,551	29,961	48,713	67,983,066	67,983,066
Surface Water	28,157	3,054	6,810	116,494,709	116,494,709

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Combined Ground & Surface Water	134,708	33,015	55,523	184,477,775	184,477,775
Percent with Detections					
Ground Water	0.148%	0.194%	0.146%	4.608%	4.395%
Surface Water	0.071%	0.491%	0.279%	0.656%	0.503%
Combined Ground & Surface Water	0.132%	0.221%	0.162%	2.112%	1.937%

Exhibit 13-2: Heptachlor Epoxide Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.003	0.03	0.09	2
Surface Water	0.001	0.03	0.2	0.5
Combined Ground & Surface Water	0.001	0.03	0.1	2

The following maps illustrate the geographic distribution of heptachlor epoxide occurrence in drinking water. Exhibit 13-3 shows the states with systems with at least one detection and Exhibit 13-4 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Oklahoma did submit Six-Year data for most contaminants; however, there is a statewide waiver for heptachlor epoxide in Oklahoma so no data were available from that state.

The distribution of systems with detections of heptachlor epoxide is geographically dispersed. Detection rates were generally low, with only four states having greater than 1% of their systems detecting heptachlor epoxide. Only three states reported detections greater than the MCL concentration of 0.2 µg/L.

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Exhibit 13-3: Percentage of Systems with at Least One Heptachlor Epoxide Detection, by State

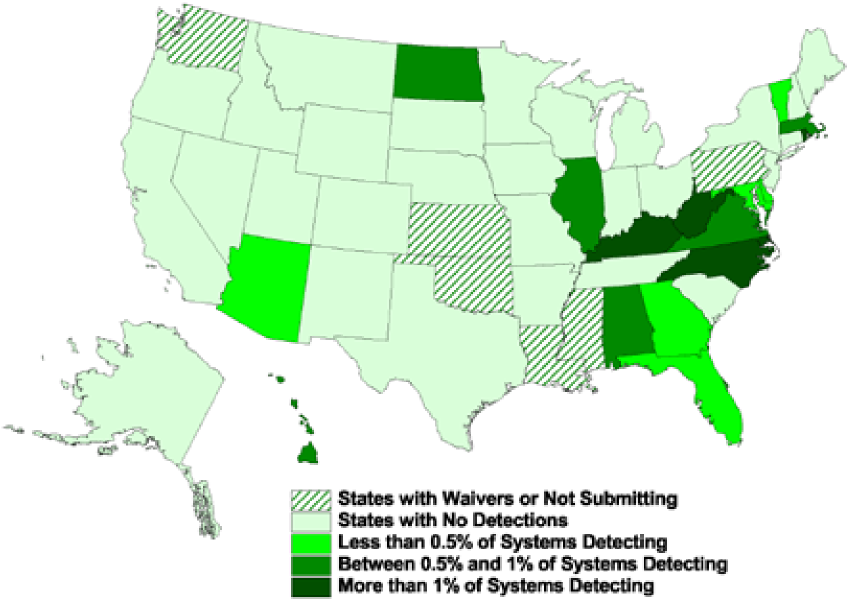

Exhibit 13-4: Percentage of Systems with at Least One Heptachlor Epoxide Detection Greater than the MCL Concentration (> 0.2 µg/L), by State

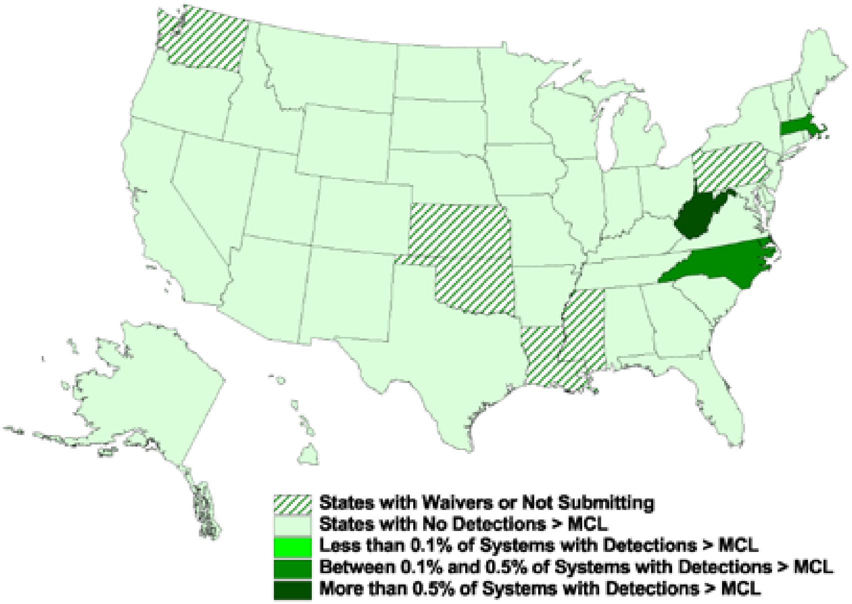

Exhibit 13-5 presents the Stage 1 analysis of heptachlor epoxide occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.2 µg/L and 0.1 µg/L. Fifteen (0.045% of) systems, serving more than 462,000 persons, reported at least one detection greater than or equal to 0.1 µg/L; and six (0.018% of) systems, serving more than 19,000 persons, reported at least one detection greater than 0.2 µg/L. More people were served by surface water systems with at least one detection of heptachlor epoxide greater than or equal to 0.1 µg/L, but more people were served by ground water systems with at least one detection greater than 0.2 µg/L.

Exhibit 13-5: Heptachlor Epoxide Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 0.2 µg/L	5	0.017%	14,973	0.022%
	≥ 1 µg/L	11	0.037%	22,458	0.033%
Surface Water	> 0.2 µg/L	1	0.033%	4,374	0.004%
	≥ 1	4	0.131%	439,554	0.377%
Combined Ground & Surface Water	> 0.2 µg/L	6	0.018%	19,347	0.010%
	≥ 1	15	0.045%	462,012	0.250%

The occurrence estimates presented above (in Exhibit 13-5) are based on the conservative assumption that if a heptachlor epoxide detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to heptachlor epoxide (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of heptachlor epoxide). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of heptachlor epoxide because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of heptachlor epoxide (rather than the entire population-served by the system).

Exhibit 13-6 presents the Stage 1 analysis of heptachlor epoxide occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Sixteen (0.029% of) sample points, serving an estimated 357,000 persons, reported at least one detection greater than or equal to 0.1 µg/L; and 6 (0.011% of) sample points, serving an estimated 4,900 persons, reported at least one detection exceeding 0.2 µg/L.

Exhibit 13-6: Heptachlor Epoxide Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 0.2 µg/L	5	0.010%	2,703	0.004%
	≥ 1	11	0.023%	4,062	0.006%
Surface Water	> 0.2 µg/L	1	0.015%	2,187	0.002%
	≥ 1 µg/L	5	0.073%	352,546	0.303%
Combined Ground & Surface Water	> 0.2 µg/L	6	0.011%	4,890	0.003%
	≥ 1	16	0.029%	356,608	0.193%

13.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean heptachlor epoxide concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 13-7 presents the Stage 2 analysis of estimated system mean concentrations for heptachlor epoxide occurrence in drinking water relative to two thresholds: 0.2 µg/L and 0.1 µg/L. Exhibit 13-8 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, three ground water systems (approximately 0.009% of all systems) had an estimated system mean greater than or equal to 0.1 µg/L. These three systems serve about 14,419 persons. One ground water system (0.003% of all systems), serving 325 persons, had an estimated system mean greater than 0.2 µg/L. No surface water systems had means exceeding the thresholds.

Exhibit 13-7: Heptachlor Epoxide Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 0.2 µg/L	1	1	1	0.003%	0.003%	0.003%
	≥ 1	3	3	3	0.010%	0.010%	0.010%
Surface Water	> 0.2 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 0.2 µg/L	1	1	1	0.003%	0.003%	0.003%
	≥ 1	3	3	3	0.009%	0.009%	0.009%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 13-8: Heptachlor Epoxide Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 0.2 µg/L	325	325	325	0.0005%	0.0005%	0.0005%
	≥ 1	14,419	14,419	14,419	0.021%	0.021%	0.021%
Surface Water	> 0.2 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 0.2 µg/L	325	325	325	0.0002%	0.0002%	0.0002%
	≥ 1	14,419	14,419	14,419	0.008%	0.008%	0.008%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

13.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003), 13 systems (approximately 0.09% of about 14,000 systems), reported at least one detection of heptachlor epoxide. Four systems (approximately 0.03% of all systems), reported at least one detection greater than the MCL concentration.

13.6 Summary of Data

Heptachlor epoxide is not listed as a TRI chemical; no release records are available. No data are available from the NAWQA program for heptachlor epoxide.

The Stage 1 analysis of occurrence in drinking water indicates that heptachlor epoxide was detected in 0.221% of 33,015 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.03 µg/L. In total, 0.018% of systems (serving 0.010% of the population) reported at least one detection greater than the MCL concentration of 0.2 µg/L. A larger population was served by ground water systems than surface water systems reporting at least one detection greater than the MCL concentration.

In the Stage 2 analysis, one ground water system (0.003% of systems, serving 0.0002% of the total population) had an estimated system mean concentration of heptachlor epoxide greater than the MCL concentration. No surface water systems had mean concentrations exceeding the MCL concentration.

13.7 References

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14 Hexachlorobenzene

This chapter on hexachlorobenzene is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and hexachlorobenzene occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

14.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for hexachlorobenzene on July 17, 1992 (57 FR 31776 (USEPA, 1992)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 1 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2002), hexachlorobenzene (C_6Cl_6) is a white crystalline solid that does not occur naturally in the environment. It is formed as a by-product during the manufacturing of chemical solvents, other chlorine-containing compounds, and pesticides. Small amounts of hexachlorobenzene can also be produced as a by-product during combustion processes, such as waste incineration, and during certain wood preservation processes (ATSDR, 2002).

Hexachlorobenzene breaks down very slowly in the environment. Its half-life in soil is three to six years. In surface water its half-life is 2.7 to 5.7 years, and in ground water it is 5.3 to 11.4 years. It tends to bind to sediments at the bottom of lakes because it is relatively insoluble in water. Hexachlorobenzene tends not to evaporate, but once in the air, it may be carried over large distances (ATSDR, 2002).

Exposure to hexachlorobenzene can occur near industrial sites where it is produced as an unintentional by-product or as a minor part of another chemical product. Levels in urban air are typically very low (about 0.03 ppb). Exposure by inhalation is estimated to be 0.01 µg/kg/year. Contact with contaminated soils and the ingestion of contaminated foods are other modes of exposure. Hexachlorobenzene’s poor solubility in water helps mitigate its occurrence in drinking water (ATSDR, 2002).

14.2 Use, Production, and Releases

Although it is not used commercially in the United States today, hexachlorobenzene was widely used as a pesticide until 1965. It was also used to make fireworks, ammunition, and synthetic rubber (ATSDR, 2002).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 14-1 presents the production of hexachlorobenzene in the United States from 1986 to 2002. Note that the production of hexachlorobenzene in the United States was not documented in the Chemical Update System until 1998 and its production volume has remained within the same range since then.

Exhibit 14-1: Production of Hexachlorobenzene in the United States

Inventory Update Year	Production Volume
1986 Range	No Reports
1990 Range	No Reports
1994 Range	No Reports
1998 Range	10,000 - 500,000 pounds
2002 Range	10,000 - 500,000 pounds

Source: USEPA, 2003a

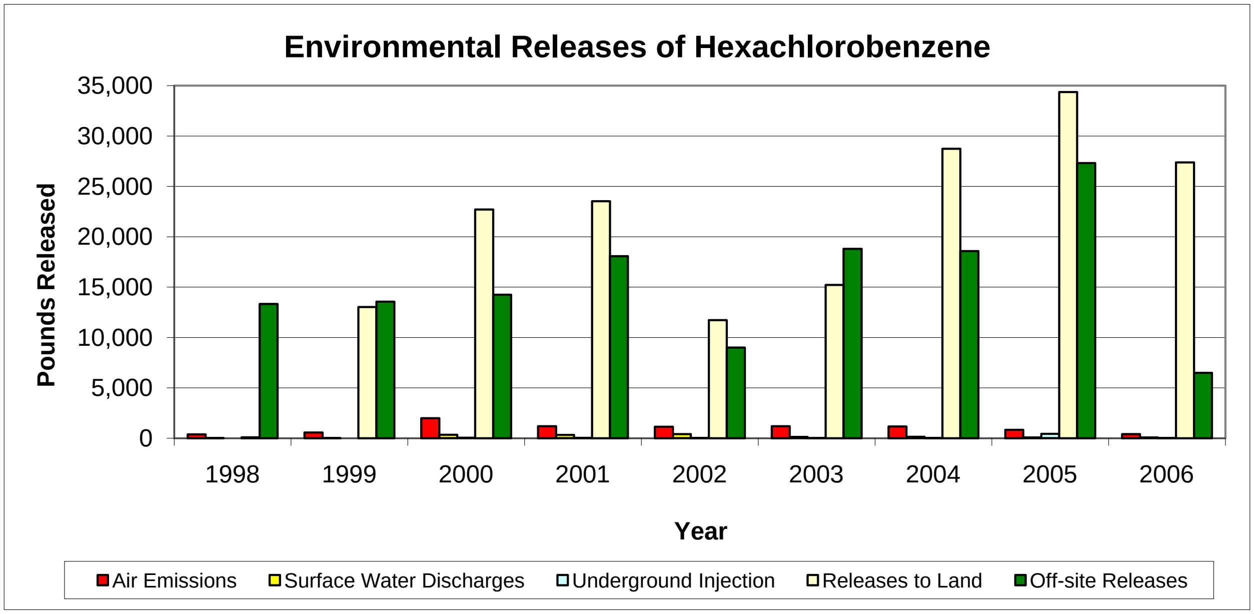
Hexachlorobenzene is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 14-2a lists the environmental releases of hexachlorobenzene from 1998 to 2006. (Exhibit 14-2b provides a graphical presentation of the environmental releases.) Most releases were to land or off-site. Air emissions were 5% or less of the total; surface water discharges and releases via underground injection were even smaller. The TRI data for hexachlorobenzene were reported from 37 states, with 7 states (California, Kentucky, Louisiana, New Jersey, Ohio, Tennessee, and Texas) reporting releases in all 9 years.

Exhibit 14-2a: Table of Toxics Release Inventory (TRI) Data for Hexachlorobenzene

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	386	4	0	96	13,328	13,814
1999	571	8	0	13,023	13,559	27,161
2000	1,994	331	48	22,700	14,253	39,327
2001	1,199	322	22	23,525	18,073	43,141
2002	1,138	397	12	11,725	8,999	22,270
2003	1,197	120	7	15,214	18,795	35,334
2004	1,169	133	19	28,733	18,570	48,624
2005	842	69	429	34,366	27,307	63,013
2006	412	71	2	27,377	6,497	34,359

Source: USEPA, 2008

Exhibit 14-2b: Graph of Toxics Release Inventory (TRI) Data for Hexachlorobenzene



Source: USEPA, 2008

14.3 Occurrence in Ambient Water

No National Water Quality Assessment (NAWQA) Program data are available from the United States Geological Survey (USGS) on the occurrence of hexachlorobenzene in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

14.4 Occurrence in Drinking Water

Hexachlorobenzene is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of hexachlorobenzene occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

Forty-four of the Six-Year Review-ICR states provided occurrence data for hexachlorobenzene. (There were no hexachlorobenzene data from Oklahoma.) These data consist of 135,512 analytical results from 32,826 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for hexachlorobenzene in the dataset is 0.1 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

14.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 14-3 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For hexachlorobenzene, 0.341% of 32,826 systems reported detections. Exhibit 14-4 lists the minimum, median, 90th percentile, and maximum hexachlorobenzene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of hexachlorobenzene, based on detections from all systems, was 0.1 µg/L.

Exhibit 14-3: Hexachlorobenzene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	106,879	29,793	48,753	67,957,193	67,957,193
Surface Water	28,633	3,033	6,791	116,167,630	116,167,630
Combined Ground & Surface Water	135,512	32,826	55,544	184,124,823	184,124,823
Percent with Detections					
Ground Water	0.067%	0.205%	0.135%	4.099%	3.946%
Surface Water	0.234%	1.682%	0.825%	0.988%	0.878%
Combined Ground & Surface Water	0.103%	0.341%	0.220%	2.136%	2.011%

Exhibit 14-4: Hexachlorobenzene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.002	0.045	0.5	10
Surface Water	0.01	0.5	0.5	2
Combined Ground & Surface Water	0.002	0.1	0.5	10

The following maps illustrate the geographic distribution of hexachlorobenzene occurrence in drinking water. Exhibit 14-5 shows the states with systems with at least one detection and Exhibit 14-6 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Oklahoma did submit Six-Year data for most contaminants. There is, however, a statewide waiver for hexachlorobenzene in Oklahoma so no hexachlorobenzene data were available from that state.

The distribution of systems with detections of hexachlorobenzene is geographically dispersed. Detection rates were generally low, with only six states reporting more than 0.5% of their systems with hexachlorobenzene detections. Only four states reported detections greater than the MCL concentration of 1 µg/L.

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Exhibit 14-5: Percentage of Systems with at Least One Hexachlorobenzene Detection, by State

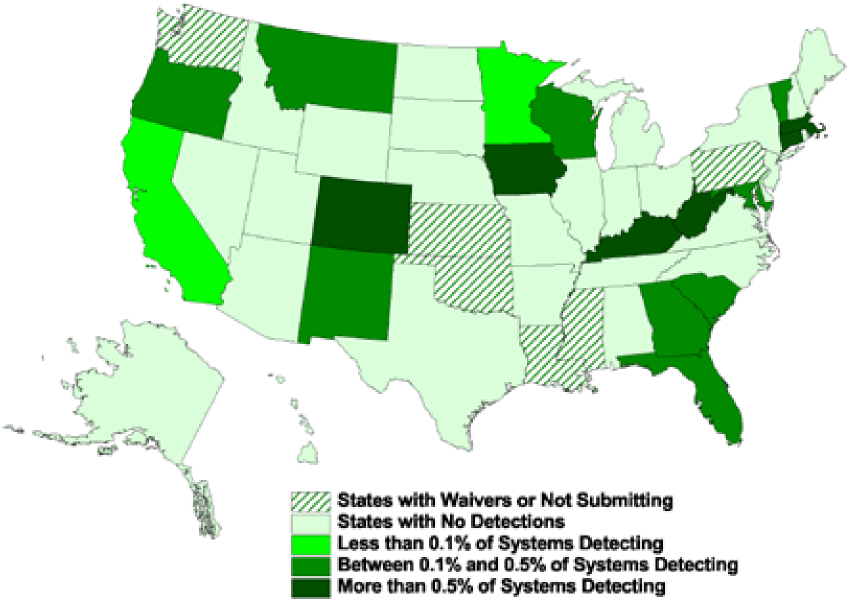

Exhibit 14-6: Percentage of Systems with at Least One Hexachlorobenzene Detection Greater than the MCL Concentration (> 1 μg/L), by State

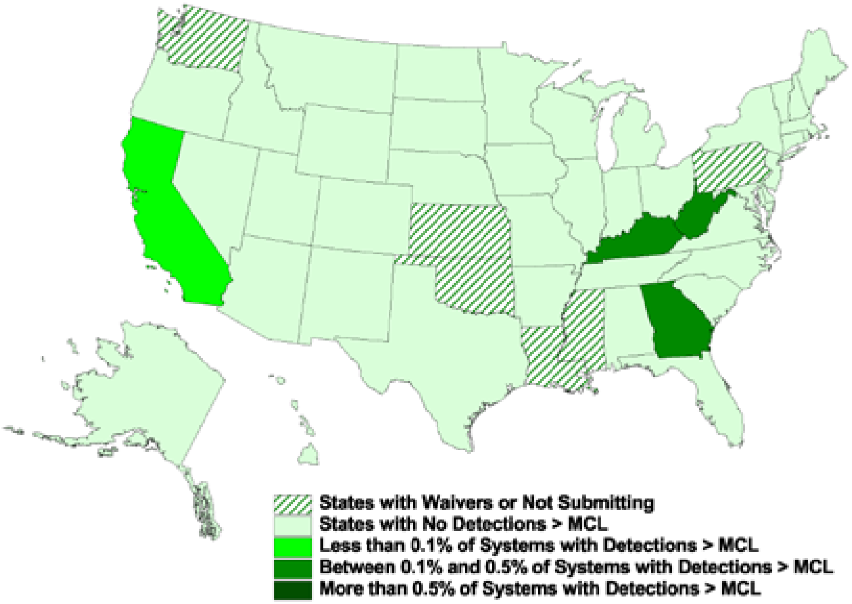

Exhibit 14-7 presents the Stage 1 analysis of hexachlorobenzene occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 1 µg/L, 0.5 µg/L, and 0.1 µg/L. Forty-six systems (0.140% of all systems), serving about 617,000 persons, reported at least one detection greater than or equal to 0.5 µg/L; and four systems (0.012% of all systems), serving about 5,000 persons, reported at least one detection greater than the MCL concentration of 1 µg/L. Hexachlorobenzene occurred in more surface water systems than ground water systems at levels greater than or equal to 0.5 µg/L and 0.1 µg/L. Very few systems of either type reported at least one detection greater than 1 µg/L.

Exhibit 14-7: Hexachlorobenzene Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 1 µg/L	3	0.010%	2,273	0.003%
	≥ 0.5 µg/L	12	0.040%	18,893	0.028%
	> 0.1 µg/L	18	0.060%	23,963	0.035%
Surface Water	> 1 µg/L	1	0.033%	2,671	0.002%
	≥	34	1.121%	597,830	0.515%
	> 0.1 µg/L	39	1.286%	912,379	0.785%
Combined Ground & Surface Water	> 1 µg/L	4	0.012%	4,944	0.003%
	≥	46	0.140%	616,723	0.335%
	> 0.1 µg/L	57	0.174%	936,342	0.509%

The occurrence estimates presented above (in Exhibit 14-7) are based on the conservative assumption that if a hexachlorobenzene detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to hexachlorobenzene (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of hexachlorobenzene). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of hexachlorobenzene because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of hexachlorobenzene (rather than the entire population-served by the system).

Exhibit 14-8 presents the Stage 1 analysis of hexachlorobenzene occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Forty-six (0.083% of) sample points, serving an estimated 605,000 persons, reported at least one detection greater than or equal to 0.5 µg/L; and four (0.007% of) sample points, serving an estimated 4,900 persons, reported at least one detection exceeding 1 µg/L. Similar to the system-level occurrence analysis, very few sample points reported detections at levels greater than 1 µg/L.

Exhibit 14-8: Hexachlorobenzene Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 1 µg/L	3	0.006%	2,273	0.003%
	≥	12	0.025%	15,610	0.023%
	> 0.1 µg/L	18	0.037%	20,250	0.030%
Surface Water	> 1 µg/L	1	0.015%	2,671	0.002%
	≥ 0.5 µg/L	34	0.501%	589,039	0.507%
	> 0.1 µg/L	41	0.604%	858,215	0.739%
Combined Ground & Surface Water	> 1 µg/L	4	0.007%	4,944	0.003%
	≥	46	0.083%	604,649	0.328%
	> 0.1 µg/L	59	0.106%	878,465	0.477%

14.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean hexachlorobenzene concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 14-9 presents the Stage 2 analysis of estimated system mean concentrations for hexachlorobenzene occurrence in drinking water relative to several thresholds. The thresholds are: 1 µg/L, 0.5 µg/L, and 0.1 µg/L. Exhibit 14-10 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, four systems (approximately 0.012% of all systems) had an estimated system mean greater than or equal to 0.5 µg/L. Together, these four systems serve about 4,944 persons. Three systems (approximately 0.009% of all systems), serving 2,273 persons, had an estimated system mean greater than the MCL concentration of 1 µg/L.

Exhibit 14-9: Hexachlorobenzene Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 1 µg/L	3	3	3	0.010%	0.010%	0.010%
	≥	3	3	3	0.010%	0.010%	0.010%
	> 0.1 µg/L	20	8	8	0.067%	0.027%	0.027%
Surface Water	> 1 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	1	1	1	0.033%	0.033%	0.033%
	> 0.1 µg/L	39	8	1	1.286%	0.264%	0.033%
Combined Ground & Surface Water	> 1 µg/L	3	3	3	0.009%	0.009%	0.009%
	≥	4	4	4	0.012%	0.012%	0.012%
	> 0.1 µg/L	59	16	9	0.180%	0.049%	0.027%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 14-10: Hexachlorobenzene Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 1 µg/L	2,273	2,273	2,273	0.003%	0.003%	0.003%
	≥	2,273	2,273	2,273	0.003%	0.003%	0.003%
	> 0.1 µg/L	639,313	6,741	6,741	0.941%	0.010%	0.010%
Surface Water	> 1 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	2,671	2,671	2,671	0.002%	0.002%	0.002%
	> 0.1 µg/L	2,485,099	87,448	2,671	2.139%	0.075%	0.002%

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 1 µg/L	2,273	2,273	2,273	0.001%	0.001%	0.001%
	≥	4,944	4,944	4,944	0.003%	0.003%	0.003%
	> 0.1 µg/L	3,124,412	94,189	9,412	1.697%	0.051%	0.005%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

14.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 13 systems (approximately 0.09% of about 14,000 systems), reported at least one detection of hexachlorobenzene. One system (approximately 0.01% of all systems), reported at least one detection greater than the MCL concentration.

14.6 Summary of Data

TRI data indicate that total off-site and on-site releases of hexachlorobenzene for the period 1998-2006 ranged from approximately 14,000 pounds to approximately 63,000 pounds. Releases to land and off-site releases constituted the majority of total on- and off-site releases. Air emissions and underground injection were less than 5% of the total releases.

Ambient water quality data from the NAWQA program were not available for hexachlorobenzene.

The Stage 1 analysis of occurrence in drinking water indicates that hexachlorobenzene was detected in 0.341% of 32,826 surface and ground water systems. The median concentration, based on detections from all systems, was 0.1 µg/L. In total, 0.012% of systems (serving 0.003% of the population) reported at least one detection greater than the MCL concentration of 1 µg/L.

In the Stage 2 analysis, approximately 0.009% of systems (serving 0.001% of the population) had an estimated system mean concentration of hexachlorobenzene greater than the MCL concentration. No surface water systems had mean concentrations exceeding the MCL concentration. Only 3 ground water systems, serving 2,273 persons, had mean concentrations exceeding the MCL concentration.

14.7 References

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15 Hexachlorocyclopentadiene

This chapter on hexachlorocyclopentadiene is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and hexachlorocyclopentadiene occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

15.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for hexachlorocyclopentadiene on July 17, 1992 (57 FR 31776 (USEPA, 1992)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 50 µg/L. EPA based the MCLG on a reference dose (RfD) of 7 µg/kg-day (0.007 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1999a), hexachlorocyclopentadiene (C_5Cl_6) is a manufactured chemical that does not occur naturally. It is a light, lemon-yellow liquid with a sharp musty odor that easily evaporates into the air. The vapor looks like a blue haze. Hexachlorocyclopentadiene is also known as HCCPD (ATSDR, 1999a).

Hexachlorocyclopentadiene is released as vapor during manufacture and use. Hexachlorocyclopentadiene degrades quickly in both soil and in water. It doesn’t dissolve readily in water and will evaporate from the water surface. Hexachlorocyclopentadiene that gets into soil binds to decaying plant and animal matter and can move through sandy soil to reach ground water. The half life in soil ranges from one to two weeks, while in water about half of the hexachlorocyclopentadiene is broken into other chemicals by light in as little as four minutes (ASTDR, 1999a).

The general population’s exposure to hexachlorocyclopentadiene is thought to be insignificant. Exposure occurs primarily in occupational settings. Individuals in the general population who live in the vicinity of industrial facilities or hazardous waste sites where contamination has been detected may be exposed to potentially higher levels of hexachlorocyclopentadiene. Young children may be exposed if they play in or around contaminated soil or sediment in the vicinity of production facilities or hazardous waste sites. (ATSDR, 1999b).

15.2 Use, Production, and Releases

Hexachlorocyclopentadiene is used in the manufacture of certain pesticides, including heptachlor, chlordane, aldrin, dieldrin, and endrin (USEPA, 2000). It is also used to make flame retardants, resins that do not burn, shock-proof plastics, esters, ketones, fluorocarbons, and dyes. Most of the hexachlorocyclopentadiene in the environment results from releases during its production and disposal (ATSDR, 1999a).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production-volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 15-1 presents the production of hexachlorocyclopentadiene in the United States from 1986 to 2002. Note that the production of hexachlorocyclopentadiene in the United States has consistently been between 10 million and 50 million pounds since 1986.

Exhibit 15-1: Production of Hexachlorocyclopentadiene in the United States

Inventory Update Year	Production Volume
1986 Range	> 10 million - 50 million pounds
1990 Range	> 10 million - 50 million pounds
1994 Range	> 10 million - 50 million pounds
1998 Range	> 10 million - 50 million pounds
2002 Range	> 10 million - 50 million pounds

Source: USEPA, 2003a

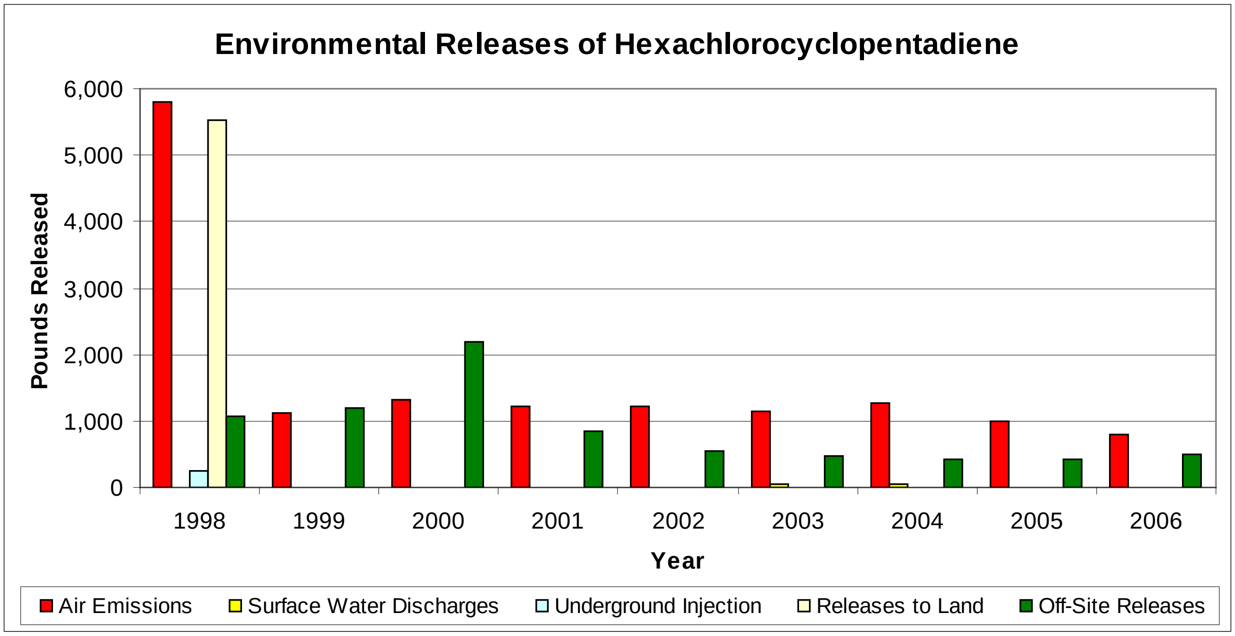
Hexachlorocyclopentadiene is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 15-2a lists the environmental releases of hexachlorocyclopentadiene from 1998 to 2006. (Exhibit 15-2b provides a graphical presentation of the environmental releases.) Most releases were to air or off-site. Underground injection and releases to land were only present in 1998. Surface water discharges were negligible for all years. The TRI data for hexachlorocyclopentadiene were reported from 11 states, with 3 states (New York, Ohio, and Tennessee) reporting releases in all 9 years.

Exhibit 15-2a: Table of Toxics Release Inventory (TRI) Data for Hexachlorocyclopentadiene

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	5,801	0	250	5,520	1,067	12,638
1999	1,114	2	0	0	1,196	2,312
2000	1,310	0	0	0	2,186	3,496
2001	1,229	0	0	0	849	2,078
2002	1,208	5	0	0	560	1,773
2003	1,133	61	0	0	464	1,659
2004	1,265	54	0	0	433	1,752
2005	1,000	0	0	0	430	1,430
2006	786	0	0	0	503	1,289

Source: USEPA, 2008

Exhibit 15-2b: Graph of Toxics Release Inventory (TRI) Data for Hexachlorocyclopentadiene



Source: USEPA, 2008

15.3 Occurrence in Ambient Water

No National Water Quality Assessment (NAWQA) Program data are available from the United States Geological Survey (USGS) on the occurrence of hexachlorocyclopentadiene in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

15.4 Occurrence in Drinking Water

Hexachlorocyclopentadiene is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of hexachlorocyclopentadiene occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

Forty-four of the Six-Year Review-ICR states provided occurrence data for hexachlorocyclopentadiene. (There were no hexachlorocyclopentadiene data from Oklahoma.) These data consist of 135,290 analytical results from 32,801 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for hexachlorocyclopentadiene in the dataset is 0.1 µg/L.

15.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 15-3 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For hexachlorocyclopentadiene, 0.686% of 32,801 systems reported detections. Exhibit 15-4 lists the minimum, median, 90th percentile, and maximum hexachlorocyclopentadiene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of hexachlorocyclopentadiene, based on detections from all systems, was 0.15 µg/L.

Exhibit 15-3: Hexachlorocyclopentadiene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	106,621	29,767	48,670	67,981,852	67,981,852
Surface Water	28,669	3,034	6,771	116,756,578	116,756,578
Combined Ground & Surface Water	135,290	32,801	55,441	184,738,430	184,738,430
Percent with Detections					
Ground Water	0.098%	0.262%	0.173%	5.641%	4.329%
Surface Water	0.949%	4.845%	2.452%	9.882%	6.297%
Combined Ground & Surface Water	0.278%	0.686%	0.451%	8.321%	5.573%

Exhibit 15-4: Hexachlorocyclopentadiene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.005	0.275	10	15
Surface Water	0.001	0.13	10	10
Combined Ground & Surface Water	0.001	0.15	10	15

The following maps illustrate the geographic distribution of hexachlorocyclopentadiene occurrence in drinking water. Exhibit 15-5 shows the states with systems with at least one detection and Exhibit 15-6 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Oklahoma submitted Six-Year data for most contaminants; however, there is a statewide waiver for hexachlorocyclopentadiene in Oklahoma so no hexachlorocyclopentadiene data were available from that state.

The distribution of systems with detections of hexachlorocyclopentadiene is geographically dispersed and detection rates were generally low. Ten states reported detections in more than 1% of their systems. In three states, between 0.5% and 1% of systems reported detections. Fourteen states reported no detections. No states reported detections greater than the MCL concentration of 50 µg/L.

Exhibit 15-5: Percentage of Systems with at Least One Hexachlorocyclopentadiene Detection, by State

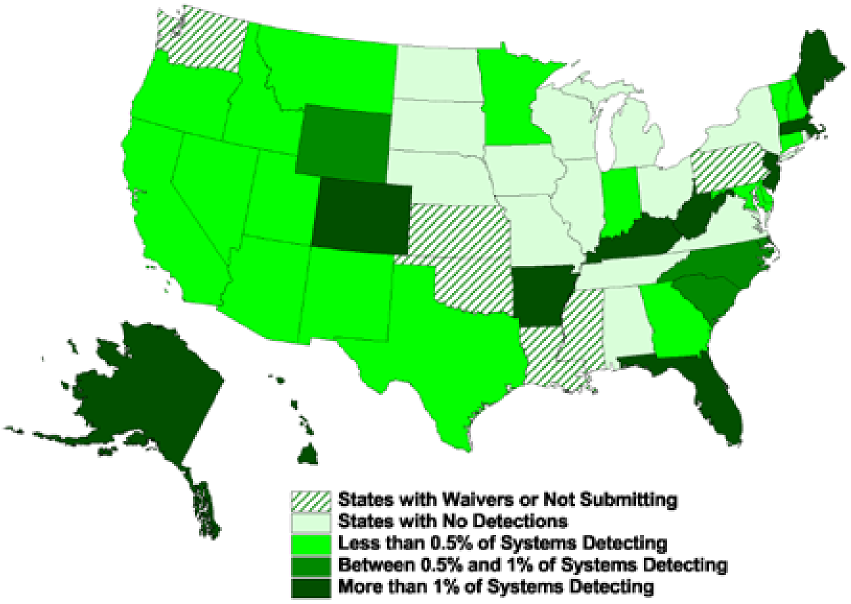

Exhibit 15-7 presents the Stage 1 analysis of hexachlorocyclopentadiene occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 50 µg/L, 40 µg/L, and 25 µg/L. No systems reported detections greater than any of the thresholds.

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[2] Kansas submitted data after the data management and analyses had been conducted; data for Kansas are not included in the analyses.

Exhibit 15-7: Hexachlorocyclopentadiene Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 50 µg/L	0	0.000%	0	0.000%
	≥ 40 µg/L	0	0.000%	0	0.000%
	≥ 25 µg/L	0	0.000%	0	0.000%
Surface Water	> 50 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 50 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%

The occurrence estimates presented above (in Exhibit 15-7) are based on the conservative assumption that if a hexachlorocyclopentadiene detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to hexachlorocyclopentadiene (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of hexachlorocyclopentadiene). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of hexachlorocyclopentadiene because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of hexachlorocyclopentadiene (rather than the entire population-served by the system).

Exhibit 15-8 presents the Stage 1 analysis of hexachlorocyclopentadiene occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. No sample points reported detections greater than any of the thresholds.

Exhibit 15-8: Hexachlorocyclopentadiene Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 50 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
	≥	0	0.000%	0	0.000%
Surface Water	> 50 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 50 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%

15.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean hexachlorocyclopentadiene concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 15-9 presents the Stage 2 analysis of estimated system mean concentrations for hexachlorocyclopentadiene in drinking water relative to several thresholds. The thresholds are: 50 µg/L, 40 µg/L, and 25 µg/L. Exhibit 15-10 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no systems had an estimated system mean greater than or equal to any of the thresholds.

Exhibit 15-9: Hexachlorocyclopentadiene Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 50 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
Surface Water	> 50 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	**½ MRL**	**Zero**	**Full MRL**	**½ MRL**	**Zero**
Combined Ground & Surface Water	> 50 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 15-10: Hexachlorocyclopentadiene Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	**½ MRL**	**Zero**	**Full MRL**	**½ MRL**	**Zero**
Ground Water	> 50 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
Surface Water	> 50 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 50 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

15.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 124 systems (approximately 0.89% of about 14,000 systems), reported at least one detection of hexachlorocyclopentadiene. No systems reported detections greater than the MCL concentration.

15.6 Summary of Data

Hexachlorocyclopentadiene is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of hexachlorocyclopentadiene for the period 1998-2006 ranged from about 1,300 pounds to approximately 13,000 pounds, with a decrease over time. In most years, on-site releases were greater than off-site releases.

Ambient water quality data from the NAWQA program were not available for hexachlorocyclopentadiene.

The Stage 1 analysis of occurrence in drinking water indicates that hexachlorocyclopentadiene was detected in 0.686% of 32,801 surface and ground water systems. The median concentration, based on detections from all sites, was 0.15 µg/L. No systems reported detections greater than the MCL concentration of 50 µg/L.

In the Stage 2 analysis, no systems had an estimated system mean greater than the MCL concentration.

15.7 References

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16 Oxamyl (Vydate)

This chapter on oxamyl (vydate) is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and oxamyl occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

16.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for oxamyl on July 17, 1992 (57 FR 31776 (USEPA, 1992)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 200 µg/L. EPA based the MCLG on a reference dose (RfD) of 25 µg/kg-day (0.025 mg/kg-day) and a cancer classification of E, evidence of non-carcinogenicity for humans.

According to the Extension Toxicology Network (EXTOXNET, 1996), oxamyl (also known as Vydate) is a colorless or white crystalline solid with a garlic-like odor. It is a restricted use pesticide that is available in both liquid and granular form; however, the granular form is banned in the United States (EXTOXNET, 1996).

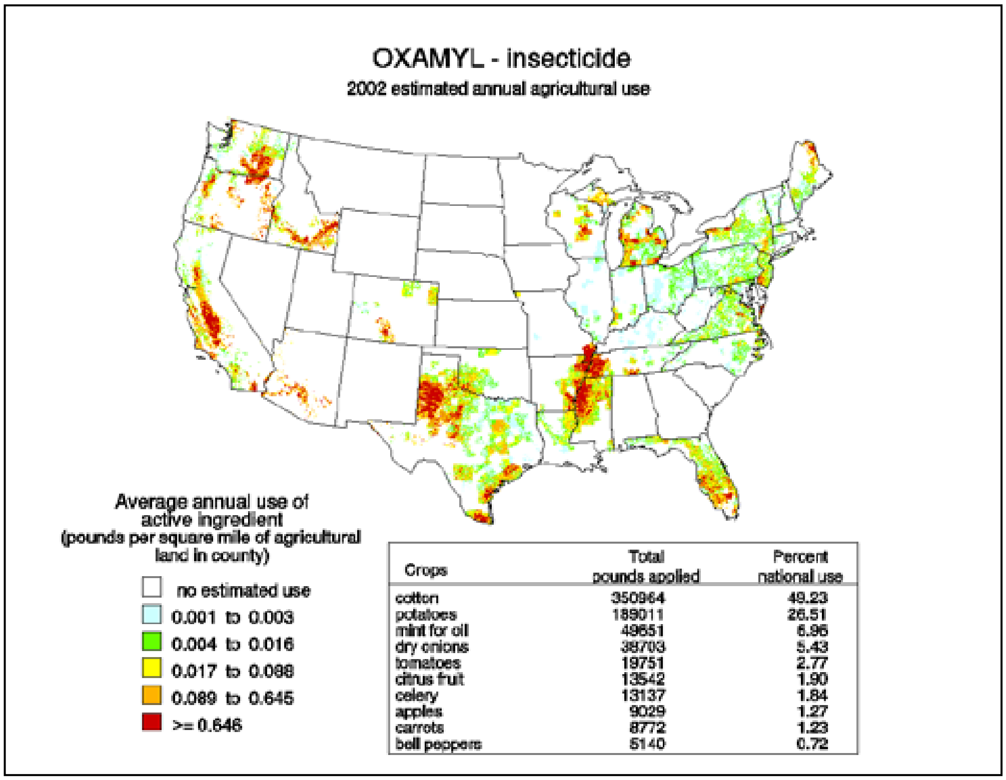
Oxamyl ($C_7H_{13}N_3O_3S$) is released directly to the environment through its use as an insecticide and during its manufacture, handling, and storage. Oxamyl is rapidly broken down in water, with a half-life of one to two days. Degradation is also rapid in soils by aerobic and anaerobic bacteria. As a result, it is more likely to be found in groundwater than in surface water. Oxamyl is excreted rapidly and does not accumulate in mammalian tissue (EXTOXNET, 1996).

16.2 Use, Production, and Releases

Oxamyl is widely used for control of insects, mites and nematodes on field crops, fruits and ornamentals. There are no residential uses of oxamyl (USEPA, 2000).

Exhibit 16-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual oxamyl use in the United States from 1999 through 2004. A breakdown of use by crop is also included. The map was created by the USGS using state-level data sets on pesticide use rates from 1999-2004 compiled by the CropLife Foundation, at the Crop Protection Research Institute, combined with county-level data on harvested crop acreage obtained from the 2002 Census of Agriculture. Due to the nature of the data sources, non-agricultural uses are not reflected here, and variations in use at the county-level are also not well represented (Thelin and Gianessi, 2000). The USGS (2007) estimates that more than 700,000 pounds of oxamyl active ingredient were used on average each year between 1999 and 2004. The greatest use of oxamyl is in the Pacific Northwest, California, and the South.

Exhibit 16-1: Estimated Annual Agricultural Use for Oxamyl (c. 2002)



Crops	Total pounds applied	Percent national use
cotton	350964	49.23
potatoes	189011	26.51
mint for oil	49651	6.96
dry onions	38703	5.43
tomatoes	19751	2.77
citrus fruit	13542	1.90
celery	13137	1.84
apples	9029	1.27
carrots	8772	1.23
bell peppers	5140	0.72

Source: USGS, 2007

The Chemical Substance Inventory Update System contains confidential data reported by industry as a partial update of the Toxic Substances Control Act (TSCA) Inventory. The TSCA Chemical Substance Inventory does not report production data for oxamyl.

Oxamyl is not listed as a Toxics Release Inventory (TRI) chemical; thus no TRI release records are available. Therefore, information on the use of oxamyl (described in the previous section) may provide the primary indication of where releases are most likely to occur.

16.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The USGS National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of oxamyl in ambient water are available from the NAWQA program for both the Pesticide National Synthesis Project and a summary analysis of all Cycle 1 water monitoring data.

16.3.1 NAWQA Pesticide National Synthesis Project

The NAWQA Pesticide National Synthesis Project is a national-scale assessment of the occurrence and behavior of pesticides in streams and ground water of the United States and the potential for pesticides to adversely affect drinking water supplies or aquatic ecosystems. Under the National Synthesis Project, the USGS monitored oxamyl between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for oxamyl was 0.080 µg/L.

In NAWQA stream samples (Exhibit 16-2), oxamyl was only detected at agricultural sites (at a frequency of 0.57%). The highest concentration at an agricultural site was 0.160 µg/L.

Exhibit 16-2: USGS National Synthesis Summary of NAWQA Monitoring of Oxamyl in Streams, 1992-2001

Land Use Type	No. of Samples (No. of Sites)	Detection Frequency	50th Percentile (Median) Concentration (in µg/L)	95th Percentile Concentration (in µg/L)	Maximum Concentration (in µg/L)
Agricultural	1,469 (62)	0.57%	ND[1]	ND[1]	0.160
Mixed	800 (36)	0.00%	ND[1]	ND[1]	ND[1]
Undeveloped	100 (5)	0.00%	ND[1]	ND[1]	ND[1]
Urban	524 (19)	0.00%	ND[1]	ND[1]	ND[1]

Source: Gilliom et al., 2007

1. ND = not detected (Concentration is less than the maximum long term method detection limit and is expected to be less than any higher percentile concentration shown in the table)

In ground water NAWQA samples (Exhibit 16-3), oxamyl was found at frequencies ranging from 0% of samples in undeveloped areas to 0.06% in mixed land use settings, 0.15% in urban areas, and 0.85% in agricultural settings. The 95th percentile concentrations were less than the method detection limit in all settings. The highest concentration, 2.06 µg/L, was found at an agricultural site.

Exhibit 16-3: USGS National Synthesis Summary of NAWQA Monitoring of Oxamyl in Ground Water, 1992-2001

Land Use Type	Number of Wells	Detection Frequency	50th Percentile (Median) Concentration (in µg/L)	95th Percentile Concentration (in µg/L)	Maximum Concentration (in µg/L)
Agricultural	1,174	0.85%	ND[1]	ND[1]	2.06
Mixed	1,542	0.06%	ND[1]	ND[1]	0.03

Land Use Type	Number of Wells	Detection Frequency	50th Percentile (Median) Concentration (in µg/L)	95th Percentile Concentration (in µg/L)	Maximum Concentration (in µg/L)
Undeveloped	23	0%	ND[1]	ND[1]	ND[1]
Urban	653	0.15%	ND[1]	ND[1]	0.26

Source: Gilliom et al., 2007

1. ND = not detected (Concentration is less than the maximum long term method detection limit and is expected to be less than any higher percentile concentration shown in the table)

16.3.2 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for oxamyl. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 16-4. Overall, oxamyl was detected in 0.3% of samples and at 0.3% of sites. Oxamyl was detected at more ground water sites than surface water sites. The median concentration, based on detections from all sites, was 0.155 µg/L. The 99th percentile concentration, based on detections from all sites, was 2.06 µg/L.

Exhibit 16-4: EPA Summary Analysis of Oxamyl 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
ground water	3,985	0.3%	3,609	0.3%	0.02	1.245	2.06	2.06	2.06
surface water	5,522	0.2%	894	0.2%	0.01	0.11	0.16	0.16	0.16
all sites	9,507	0.3%	4,503	0.3%	0.01	0.155	1.55	2.06	2.06

1. RLs (Reporting Limits) for oxamyl varied, but did not exceed 0.012 µg/L. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible.

16.4 Occurrence in Drinking Water

Oxamyl is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of oxamyl occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for oxamyl. These data consist of 113,380 analytical results from 30,876 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for oxamyl in the dataset is 2 µg/L.

16.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 16-5 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For oxamyl, 0.230% of 30,876 systems reported detections. Exhibit 16-6 lists the minimum, median, 90th percentile, and maximum oxamyl concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of oxamyl, based on detections from all systems, was 1 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 16-5: Oxamyl Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	93,766	28,100	45,236	61,701,854	61,701,854
Surface Water	19,614	2,776	5,989	105,676,577	105,676,577
Combined Ground & Surface Water	113,380	30,876	51,225	167,378,431	167,378,431
Percent with Detections					
Ground Water	0.075%	0.203%	0.137%	6.233%	5.100%
Surface Water	0.092%	0.504%	0.267%	2.303%	1.114%
Combined Ground & Surface Water	0.078%	0.230%	0.152%	3.752%	2.583%

Exhibit 16-6: Oxamyl Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.18	1	5	5.01
Surface Water	0.5	2	40	531.1
Combined Ground & Surface Water	0.18	1	5	531.1

The following maps illustrate the geographic distribution of oxamyl occurrences in drinking water. Exhibit 16-7 shows the states with systems with at least one detection and Exhibit 16-8 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of oxamyl is geographically dispersed. Detection rates were generally low, with only 3 states reporting detections in more than 2% of

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

their systems. Only one state reported detections greater than the MCL concentration of 200 µg/L.

Exhibit 16-7: Percentage of Systems with at Least One Oxamyl Detection, by State

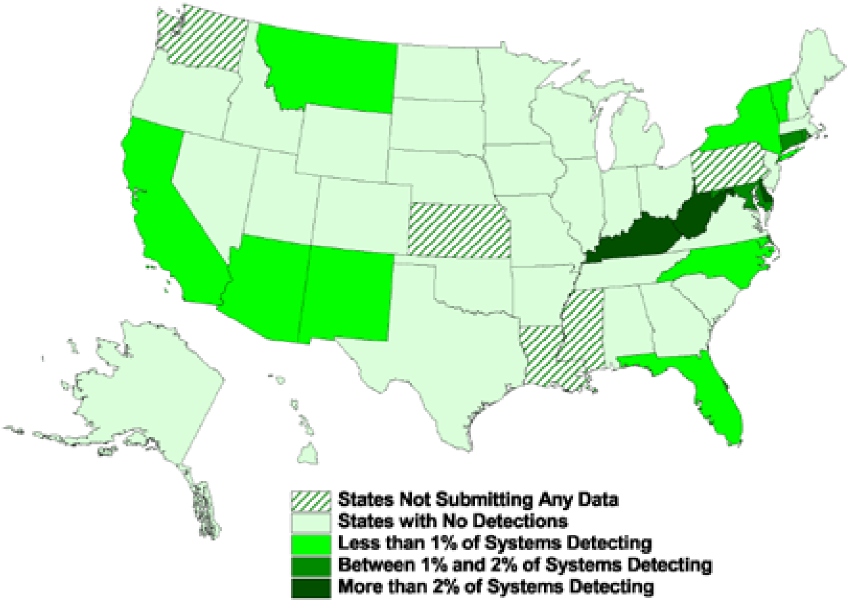

Exhibit 16-8: Percentage of Systems with at Least One Oxamyl Detection Greater than the MCL Concentration (> 200 µg/L), by State

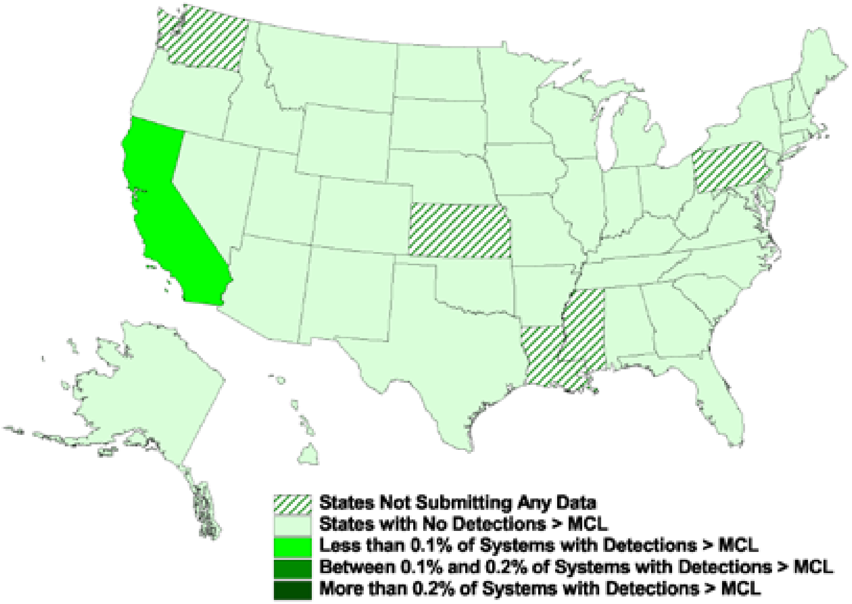

Exhibit 16-9 presents the Stage 1 analysis of oxamyl occurrences in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 200 µg/L, 100 µg/L, and 2 µg/L. One surface water system (0.003% of all systems), serving 200 persons, reported at least one detection greater than or equal to 100 µg/L and greater than the MCL concentration of 200 µg/L. No ground water systems reported detections greater than 100 µg/L or 200 µg/L.

Exhibit 16-9: Oxamyl Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 200 µg/L	0	0.000%	0	0.000%
	≥ 1	0	0.000%	0	0.000%
	> 2 µg/L	14	0.050%	38,142	0.062%
Surface Water	> 200 µg/L	1	0.036%	200	0.0002%
	≥ 1	1	0.036%	200	0.0002%
	> 2 µg/L	4	0.144%	258,348	0.244%
Combined Ground & Surface Water	> 200 µg/L	1	0.003%	200	0.0001%
	≥ 1	1	0.003%	200	0.0001%
	> 2 µg/L	18	0.058%	296,490	0.177%

The occurrence estimates presented above (in Exhibit 16-9) are based on the conservative assumption that if an oxamyl detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to oxamyl (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of oxamyl). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of oxamyl because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of oxamyl (rather than the entire population-served by the system).

Exhibit 16-10 presents the Stage 1 analysis of oxamyl occurrences in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. One (0.002%) sample point, serving an estimated 29 persons, had at least one detection greater than or equal to 100 µg/L and greater than the MCL concentration of 200 µg/L.

Exhibit 16-10: Oxamyl Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 200 µg/L	0	0.000%	0	0.000%
	≥ 1	0	0.000%	0	0.000%
	> 2 µg/L	16	0.035%	35,868	0.058%
Surface Water	> 200 µg/L	1	0.017%	29	0.00003%
	≥ 1	1	0.017%	29	0.00003%
	> 2 µg/L	5	0.083%	173,356	0.164%
Combined Ground & Surface Water	> 200 µg/L	1	0.002%	29	0.00002%
	≥ 1 µg/L	1	0.002%	29	0.00002%
	> 2 µg/L	21	0.041%	209,223	0.125%

16.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean oxamyl concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 16-11 presents the Stage 2 analysis of estimated system mean concentrations for oxamyl occurrences in drinking water relative to several thresholds. The thresholds are: 200 µg/L, 100 µg/L, and 2 µg/L. Exhibit 16-12 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no systems had an estimated system mean greater than or equal to 100 µg/L and greater than the MCL concentration of 200 µg/L.

Exhibit 16-11: Oxamyl Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 200 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
	> 2 µg/L	14	11	6	0.050%	0.039%	0.021%

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Surface Water	> 200 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
	> 2 µg/L	3	2	2	0.108%	0.072%	0.072%
Combined Ground & Surface Water	> 200 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
	> 2 µg/L	17	13	8	0.055%	0.042%	0.026%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 16-12: Oxamyl Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 200 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1 µg/L	0	0	0	0.000%	0.000%	0.000%
	> 2 µg/L	38,142	37,979	3,669	0.062%	0.062%	0.006%
Surface Water	> 200 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
	> 2 µg/L	257,848	3,386	3,386	0.244%	0.003%	0.003%
Combined Ground & Surface Water	> 200 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
	> 2 µg/L	295,990	41,365	7,055	0.177%	0.025%	0.004%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

16.5 Additional Occurrence Data

USGS 1999 Pilot Monitoring Program

Oxamyl was an analyte in the 1999 Pilot Monitoring Program (Blomquist *et al.*, 2001); however, it was not detected in any raw or finished water samples.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003), 10 systems (approximately 0.08% of about 13,000 systems), reported at least one detection of oxamyl. No systems reported a detection greater than the MCL concentration.

16.6 Summary of Data

Oxamyl is not listed as a TRI chemical; no release records are available.

Ambient water data from the NAWQA Pesticide National Synthesis Project show that most oxamyl detections occurred at agricultural sites. It was detected in 0.57% of 1,469 agricultural stream samples taken at 62 sites and was detected in 0.85% of samples taken from 1,174 ground water agricultural wells. Additional ambient water data from the NAWQA program indicate that oxamyl was detected in 0.3% of 9,507 ground and surface water samples and at 0.3% of 4,503 sites. The median concentration, based on detections from all sites, was 0.16 µg/L.

The Stage 1 analysis of occurrences in drinking water indicates that oxamyl was detected in 0.230% of 30,876 surface water and ground water systems. The median concentration, based on detections from all systems, was 1 µg/L. One surface water system (0.003% of all systems), serving 200 persons, reported at least one detection greater than the MCL concentration of 200 µg/L. No ground water systems reported detections greater than the MCL concentration.

In the Stage 2 analysis, no systems had an estimated system mean greater than or equal to 100 µg/L and greater than the MCL concentration of 200 µg/L.

16.7 References

Blomquist, J.D., J.M. Denis, J.L. Cowles, J.A. Hetrick, R.D. Jones, and N.B. Birchfield. 2001. *Pesticides in Selected Water-Supply Reservoirs and Finished Drinking Water, 1999-2000: Summary of Results from a Pilot Monitoring Program.* U.S. Geological Survey Water-Resources Investigations Report 01-456, 65 p. Available on the Internet at: http://md.water.usgs.gov/nawqa/OFR_01-456.pdf.

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17 Tetrachloroethylene (PCE)

This chapter on tetrachloroethylene (PCE) is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and tetrachloroethylene occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

17.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for tetrachloroethylene on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1997), tetrachloroethylene (C_2Cl_4) is a manufactured organic compound that has a sharp, sweet odor. It is a nonflammable liquid at room temperature and evaporates easily into the air. Other names for tetrachloroethylene include perchloroethylene, PCE, and tetrachloroethene (ATSDR, 1997).

Tetrachloroethylene typically enters the environment by evaporating into the air during use. It can also leach into water supplies and soil during disposal of sewage sludge and factory waste and when leaking from underground storage tanks. Tetrachloroethylene can remain in the air for several months before it is broken down into other chemicals or is brought back down to the soil and water by rain. Much of the tetrachloroethylene that gets into water and soil will evaporate. However, because tetrachloroethylene can travel through soils quite easily, it can contaminate underground drinking water supplies. If it infiltrates ground water, it may stay there for many months without breaking down. Under certain conditions, ambient bacteria break down tetrachloroethylene, but, some of the chemicals formed may also be harmful. Tetrachloroethylene also may adhere to the soil under some conditions and remain there (ATSDR, 1997).

Tetrachloroethylene levels in air are generally higher in cities or industrial areas of higher use compared to more rural or remote areas. It can be smelled at levels of 1,000 ppb in air, but background levels in air are usually less than 1 ppb. The air close to dry cleaning shops and chemical waste sites typically has levels higher than background levels but less than 1,000 ppb.

Both surface water and ground water may contain tetrachloroethylene, typically at levels less than 1 ppb (ATSDR, 1997).

17.2 Use, Production, and Releases

According to ATSDR (1997), tetrachloroethylene was first commercially produced in the United States in 1925. Its greatest uses are as a solvent in the textile and dry-cleaning industries. It is a frequently used chlorinated hydrocarbon solvent and plays a pivotal role as a chemical intermediate in the production of chlorofluorocarbons. Tetrachloroethylene is also used as a vapor degreasing agent in metal-cleaning operations (ATSDR, 1997).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 17-1 presents the production of tetrachloroethylene in the United States from 1986 to 2002. The production of tetrachloroethylene increased after 1994 and has remained in the same range since then.

Exhibit 17-1: Production of Tetrachloroethylene in the United States

Inventory Update Year	Production Volume
1986 Range	> 500 million - 1 billion pounds
1990 Range	> 500 million - 1 billion pounds
1994 Range	> 100 million - 500 million pounds
1998 Range	> 100 million - 500 million pounds
2002 Range	> 100 million - 500 million pounds

Source: USEPA, 2003a

Tetrachloroethylene is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 17-2a lists the environmental releases of tetrachloroethylene between 1998 and 2006. (Exhibit 17-2b provides a graphical presentation of the environmental releases.) Air emissions comprised the majority of on- and off-site releases. They decreased steadily over the period of record, as did total releases. Underground injection, releases to land, and off-site releases varied, reaching peaks in 2002 and 2003. The TRI data for tetrachloroethylene were reported from 46 states, plus

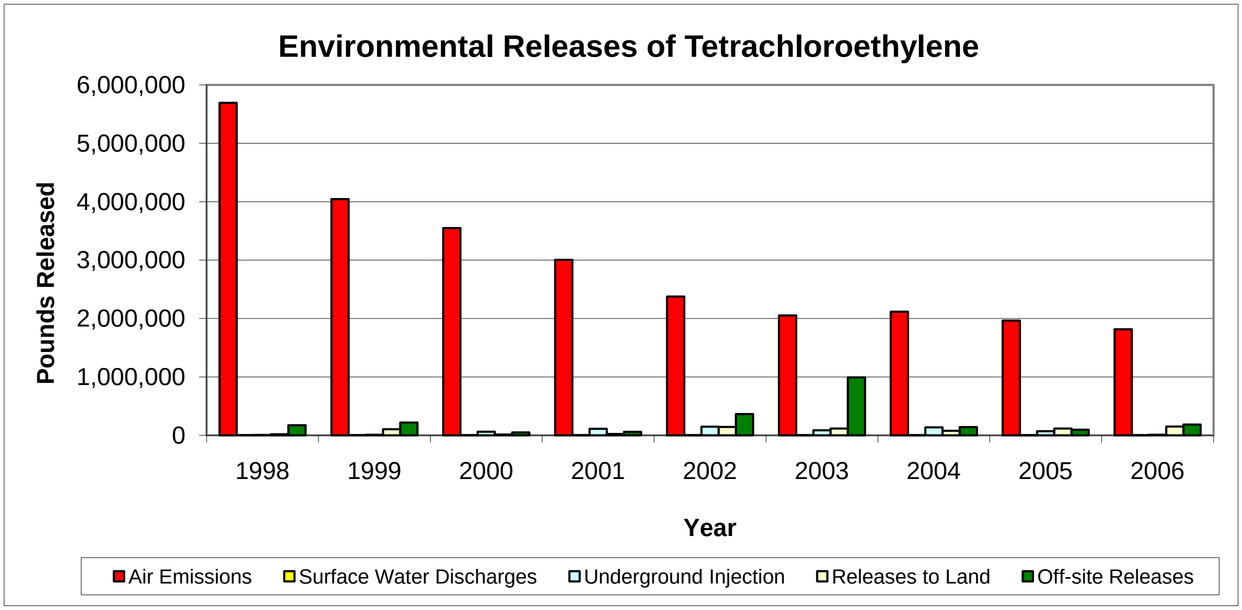
Puerto Rico and the Virgin Islands, with 41 states and the Virgin Islands reporting releases in all 9 years. No tetrachloroethylene releases were reported from Alaska, Maine, South Dakota, or Vermont.

Exhibit 17-2a: Table of Toxics Release Inventory (TRI) Data for Tetrachloroethylene

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	5,693,129	1,741	6,560	18,986	172,389	5,892,805
1999	4,044,192	1,794	9,185	104,885	217,741	4,377,797
2000	3,548,773	1,159	60,391	13,262	50,061	3,673,646
2001	3,003,539	556	111,606	23,082	58,129	3,196,912
2002	2,375,578	812	149,077	144,522	363,765	3,033,754
2003	2,053,684	1,064	87,075	116,064	992,243	3,250,131
2004	2,116,601	519	136,528	78,470	140,650	2,472,768
2005	1,963,224	673	69,701	115,763	95,467	2,244,828
2006	1,816,903	663	9,565	149,569	184,590	2,161,291

Source: USEPA, 2008

Exhibit 17-2b: Graph of Toxics Release Inventory (TRI) Data for Tetrachloroethylene



Source: USEPA, 2008

17.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of tetrachloroethylene in ambient water are available from the NAWQA program.

17.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for tetrachloroethylene. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 17-3. Overall, tetrachloroethylene was detected in 19.6% of samples and at 13.2% of sites. Tetrachloroethylene was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.037 µg/L. The 99th percentile concentration, based on detections from all sites, was 29 µg/L.

Exhibit 17-3 EPA Summary Analysis of Tetrachloroethylene 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
ground water	4,578	12.4%	4,105	11.7%	0.002	0.05	6.5	130	6,000
surface water	1,413	42.9%	190	44.7%	0.001	0.0339	0.4119	2.3	7.2
all sites	5,991	19.6%	4,295	13.2%	0.001	0.037	2.14	29	6,000

1. RLs (Reporting Limits) for tetrachloroethylene varied, but did not exceed 0.002 µg/L.

17.4 Occurrence in Drinking Water

Tetrachloroethylene is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of tetrachloroethylene occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for tetrachloroethylene. These data consist of 410,042 analytical results from 50,436 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for tetrachloroethylene in the dataset is 0.5 µg/L.

17.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 17-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For tetrachloroethylene, 2.502% of 50,436 systems reported detections. Exhibit 17-5 lists the minimum, median, 90th percentile, and maximum tetrachloroethylene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of tetrachloroethylene, based on detections from all systems, was 1.6 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 17-4: Tetrachloroethylene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	309,579	46,180	81,142	86,396,173	86,396,173
Surface Water	100,463	4,256	11,030	140,612,382	140,612,382
Combined Ground & Surface Water	410,042	50,436	92,172	227,008,555	227,008,555
Percent with Detections					
Ground Water	6.961%	2.362%	2.780%	15.923%	4.798%
Surface Water	13.200%	4.018%	6.192%	12.940%	4.299%
Combined Ground & Surface Water	8.490%	2.502%	3.189%	14.076%	4.489%

Exhibit 17-5: Tetrachloroethylene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	1.6	6.5	177
Surface Water	0.001	1.6	14	88
Combined Ground & Surface Water	0.001	1.6	8.5	177

The following maps illustrate the geographic distribution of tetrachloroethylene occurrence in drinking water. Exhibit 17-6 shows the states with systems with at least one detection and Exhibit 17-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of tetrachloroethylene is geographically dispersed. Detection rates were high; systems in all states except Hawaii reported detections of

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

tetrachloroethylene, although only 5 states reported detections in more 5% of their systems. Thirty-six states reported at least one system that detected tetrachloroethylene greater than the MCL concentration of 5 µg/L.

Exhibit 17-6: Percentage of Systems with at Least One Tetrachloroethylene Detection, by State

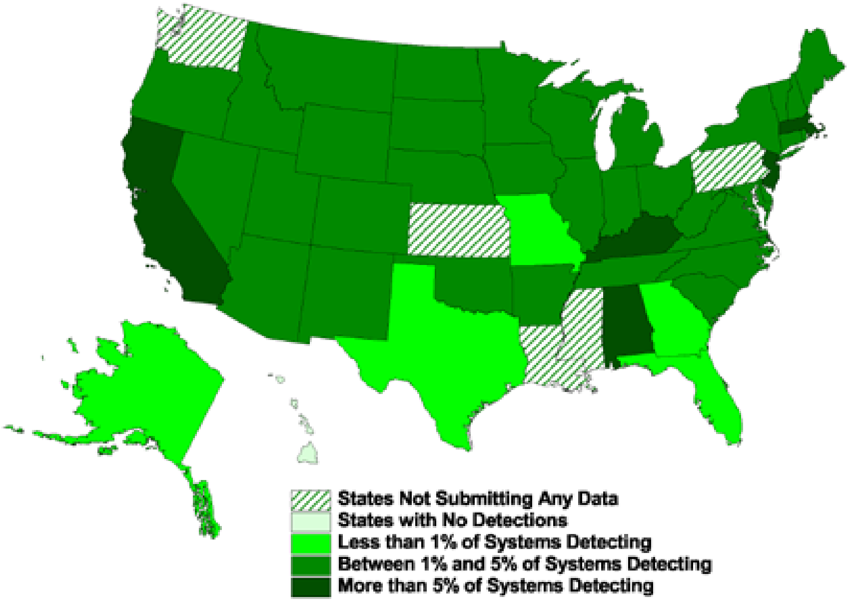

Exhibit 17-7: Percentage of Systems with at Least One Tetrachloroethylene Detection Greater than the MCL Concentration (> 5 µg/L), by State

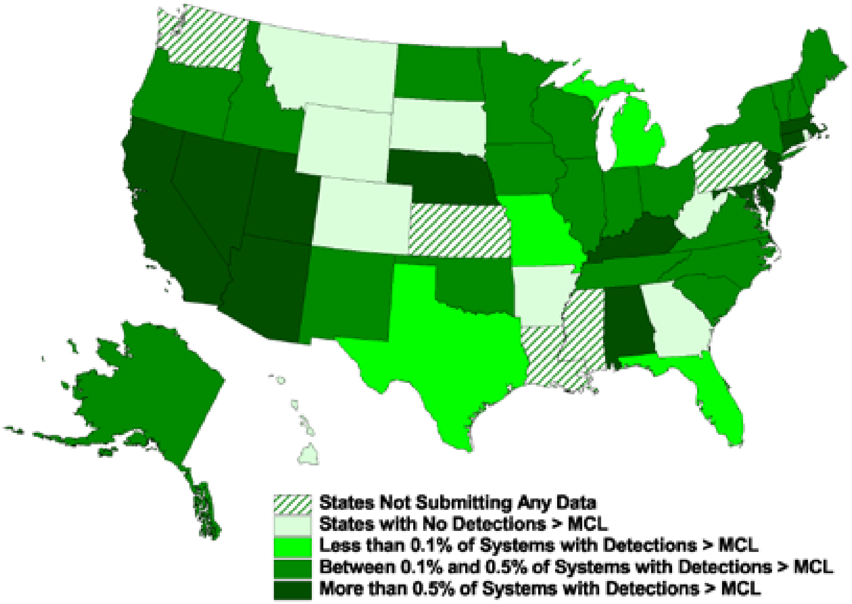

Exhibit 17-8 presents the Stage 1 analysis of tetrachloroethylene occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. A total of 404 systems (0.801% of all systems), serving more than 17.5 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 241 systems (0.478% of all systems), serving about 14.6 million persons, reported at least one detection greater than the MCL concentration of 5 µg/L. More ground water systems than surface water systems reported at least one detection greater than thresholds. However, because surface water systems tend to be larger, a greater population was served by the surface water systems reporting at least one detection greater than thresholds.

Exhibit 17-8: Tetrachloroethylene Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 5 µg/L	185	0.401%	3,823,729	4.426%
	≥ 2.5 µg/L	331	0.717%	6,157,866	7.127%
	≥ 1 µg/L	615	1.332%	10,479,911	12.130%
	> 0.5 µg/L	915	1.981%	12,472,505	14.436%
Surface Water	> 5 µg/L	56	1.316%	10,814,217	7.691%
	≥ 2.5 µg/L	73	1.715%	11,524,206	8.196%
	≥ 1 µg/L	118	2.773%	15,318,905	10.894%
	> 0.5 µg/L	148	3.477%	17,083,237	12.149%
Combined Ground & Surface Water	> 5 µg/L	241	0.478%	14,637,946	6.448%
	≥ 2.5 µg/L	404	0.801%	17,682,072	7.789%
	≥ 1 µg/L	733	1.453%	25,798,816	11.365%
	> 0.5 µg/L	1,063	2.108%	29,555,742	13.020%

The occurrence estimates presented above (in Exhibit 17-8) are based on the conservative assumption that if a tetrachloroethylene detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to tetrachloroethylene (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of tetrachloroethylene). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of tetrachloroethylene because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of tetrachloroethylene (rather than the entire population-served by the system).

Exhibit 17-9 presents the Stage 1 analysis of tetrachloroethylene occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. A total of 921 (0.999% of) sample points, serving an estimated 4.2 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 481 (0.522% of) sample points, serving an estimated 2.8 million persons, reported at least one detection exceeding 5 µg/L. Similar to the system-level occurrence analysis, more ground water sample points had threshold exceedances. However, because surface water systems tend to be larger, a greater population was served by sample points with threshold exceedances.

Exhibit 17-9: Tetrachloroethylene Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 5 µg/L	324	0.399%	806,193	0.933%
	≥ 2.5 µg/L	649	0.800%	1,347,724	1.560%
	≥ 1 µg/L	1,360	1.676%	2,621,338	3.034%
	> 0.5 µg/L	1,973	2.432%	3,679,955	4.259%
Surface Water	> 5 µg/L	157	1.423%	1,944,714	1.383%
	≥ 2.5 µg/L	272	2.466%	2,823,497	2.008%
	≥ 1 µg/L	479	4.343%	4,243,036	3.018%
	> 0.5 µg/L	640	5.802%	5,346,124	3.802%
Combined Ground & Surface Water	> 5 µg/L	481	0.522%	2,750,906	1.212%
	≥ 2.5 µg/L	921	0.999%	4,171,221	1.837%
	≥ 1 µg/L	1,839	1.995%	6,864,374	3.024%
	> 0.5 µg/L	2,613	2.835%	9,026,080	3.976%

17.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean tetrachloroethylene concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 17-10 presents the Stage 2 analysis of estimated system mean concentrations for tetrachloroethylene occurrence in drinking water relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. Exhibit 17-11 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than 75 ground water and surface water systems (approximately 0.149% of all systems) had an estimated system mean greater than or equal to 2.5 µg/L. These 75 systems serve about 1.7 million persons. No more than 25 systems (0.050% of all systems), serving about 1.1 million persons, had an estimated system mean greater than the MCL concentration of 5 µg/L.

Exhibit 17-10: Tetrachloroethylene Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	20	20	20	0.043%	0.043%	0.043%
	≥ 2.5 µg/L	61	58	55	0.132%	0.126%	0.119%
	≥ 1 µg/L	244	214	190	0.528%	0.463%	0.411%
	> 0.5 µg/L	860	446	356	1.862%	0.966%	0.771%
Surface Water	> 5 µg/L	5	3	3	0.117%	0.070%	0.070%
	≥ 2.5 µg/L	14	13	13	0.329%	0.305%	0.305%
	≥ 1 µg/L	42	37	30	0.987%	0.869%	0.705%
	> 0.5 µg/L	145	73	56	3.407%	1.715%	1.316%
Combined Ground & Surface Water	> 5 µg/L	25	23	23	0.050%	0.046%	0.046%
	≥ 2.5 µg/L	75	71	68	0.149%	0.141%	0.135%
	≥ 1 µg/L	286	251	220	0.567%	0.498%	0.436%
	> 0.5 µg/L	1,005	519	412	1.993%	1.029%	0.817%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 17-11: Tetrachloroethylene Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	81,488	81,488	81,488	0.094%	0.094%	0.094%
	≥ 2.5 µg/L	461,738	455,716	411,244	0.534%	0.527%	0.476%
	≥ 1 µg/L	2,498,326	2,122,956	1,933,039	2.892%	2.457%	2.237%
	> 0.5 µg/L	11,851,080	4,827,257	3,399,163	13.717%	5.587%	3.934%

Source Water Type	**Threshold**	**Population-Served by Systems with Mean Exceeding Threshold[1]**			**Percent of Population-Served by Systems with Mean Exceeding Threshold[1]**		
		Full MRL	**½ MRL**	**Zero**	**Full MRL**	**½ MRL**	**Zero**
Surface Water	> 5 µg/L	992,445	546,718	546,718	0.706%	0.389%	0.389%
	≥ 2.5 µg/L	1,244,255	1,236,118	1,236,118	0.885%	0.879%	0.879%
	≥ 1 µg/L	8,207,545	8,053,939	7,691,532	5.837%	5.728%	5.470%
	> 0.5 µg/L	16,303,826	9,744,394	9,009,278	11.595%	6.930%	6.407%
Combined Ground & Surface Water	> 5 µg/L	1,073,933	628,206	628,206	0.473%	0.277%	0.277%
	≥ 2.5 µg/L	1,705,993	1,691,834	1,647,362	0.752%	0.745%	0.726%
	≥ 1 µg/L	10,705,871	10,176,895	9,624,571	4.716%	4.483%	4.240%
	> 0.5 µg/L	28,154,906	14,571,651	12,408,441	12.403%	6.419%	5.466%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

17.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including tetrachloroethylene (referred to as perchloroethene in the study), in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, tetrachloroethylene had a detection frequency of 2.0% at an assessment level of 0.2 µg/L (based on 2,371 samples). The median concentration of detections was 0.058 µg/L. Seventeen detections were within one order of magnitude of the MCL concentration (5 µg/L) and five detections were greater than the MCL concentration.

In public wells, tetrachloroethylene had a detection frequency of 5.3% at an assessment level of 0.2 µg/L (based on 1,093 samples). The median concentration of detections was 0.20 µg/L. Twenty-six detections were within one order of magnitude of the MCL concentration and nine detections were greater than the MCL concentration.

Occurrence of Water-Quality Constituents in Domestic Wells across the United States

The USGS, in collaboration with the Centers for Disease Control and Prevention (CDC), released an online report on the occurrence of 11 priority water-quality constituents of possible health concern in domestic wells located in 16 states across the United States (Bartholomay *et al.*, 2007). Two water-quality data sets were used to define the water quality of domestic-water supplies: (1) data from the NAWQA Program, and (2) USGS state data. The common assessment level used to quantify the detection frequency of tetrachloroethylene was 0.2 µg/L.

A total of 1,039 wells were sampled for tetrachloroethylene (referred to as perchloroethene (PCE) in the study). The detection frequency for tetrachloroethylene was 1.3%. Less than 1% of samples had concentrations of tetrachloroethylene less than but within one order of magnitude of the MCL concentration (5 µg/L); 0.1% of samples had concentrations greater than the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 751 systems (approximately 3.36% of about 22,000 systems), reported at least one detection of tetrachloroethylene. One hundred and seventy-four systems (approximately 0.78% of all systems), reported at least one detection greater than the MCL concentration.

17.6 Summary of Data

TRI data indicate that the total off-site and on-site releases of tetrachloroethylene for the period 1998-2006 ranged from nearly 2.2 million pounds to about 5.9 million pounds. The majority of releases (63-97%) were air emissions. Surface water discharges were the smallest fraction. Air emissions and total releases decreased during the period of record.

Ambient water data from the NAWQA program indicate that tetrachloroethylene was detected in 19.6% of 5,991 ground and surface water samples and at 13.2% of 4,295 sites. The median concentration, based on detections from all sites, was 0.037 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that tetrachloroethylene was detected in 2.502% of 50,436 surface water and ground water systems. The median concentration, based on detections from all systems, was 1.6 µg/L. In total, 0.478% of systems (serving 6.448% of the population) reported at least one detection greater than the MCL concentration of 5 µg/L. Detections greater than the MCL concentration were more common in more ground water systems than surface water systems. However, because surface water systems tend to be larger, more people were served by surface water systems reporting at least one detection greater than the MCL concentration. A similar pattern was seen for sample points.

In the Stage 2 analysis, 0.050% of all systems (serving 0.473 of the population) had an estimated system mean of tetrachloroethylene greater than the MCL concentration. The number of systems with threshold exceedances was greater for ground water systems, but larger population were served by surface water systems with mean exceedances.

17.7 References

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18 Toluene

This chapter on toluene is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and toluene occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

18.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for toluene on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 1,000 µg/L. The Agency based the MCLG on a reference dose (RfD) of 200 µg/kg-day (0.2 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2000), toluene ($C_6H_5CH_3$) is a clear, colorless liquid with a distinctive smell. Toluene occurs naturally in crude oil and in the tolu tree. It is also produced in the process of making gasoline and other fuels from crude oil, in making coke from coal, and as a by-product in the manufacture of styrene (ATSDR, 2000).

Toluene evaporates very easily and enters the air when products that contain it are used. It enters surface water and ground water from spills of solvents and petroleum products as well as from leaking underground storage tanks at gasoline stations. Because toluene is frequently used to dissolve other substances, it often accompanies other chemicals to waste sites, where it can contaminate surrounding soil and water. Once in the environment, toluene tends to break down rapidly, especially in the presence of microorganisms. It does not tend to accumulate in animals or plants because it is metabolized (ATSDR, 2000).

Persons who smoke or who work with gasoline, kerosene, heating oil, paints, and lacquers are at the greatest risk of toluene exposure. Common household products, such as nail polish, cosmetics, rubber cement, stain removers, fabric dyes, inks, and adhesives, also provide exposure to toluene. Waste sites are a risk factor as well. EPA reported in 1991 that toluene was found in well water, surface water, or soil at 63% of the hazardous waste sites surveyed. Toluene concentrations, inside and outside, are usually less than 1 ppm when not close to industry. Non-smokers who do not work with toluene-containing products are probably only exposed to about

300 µg of toluene a day. Smoking a pack of cigarettes a day can add another 1,000 µg to daily exposure (ATSDR, 2000).

18.2 Use, Production, and Releases

Toluene is a good solvent and is often added to gasoline along with benzene and xylene to improve octane ratings (ATSDR, 2000). In addition, it is used in the manufacture of paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber, as well as in some printing and leather tanning processes.

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 18-1 presents the production of toluene in the United States from 1986 to 2002. Note that the production of toluene in the United States exceeded 1 billion pounds since 1986.

Exhibit 18-1: Production of Toluene in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 billion pounds
1990 Range	> 1 billion pounds
1994 Range	> 1 billion pounds
1998 Range	> 1 billion pounds
2002 Range	> 1 billion pounds

Source: USEPA, 2003a

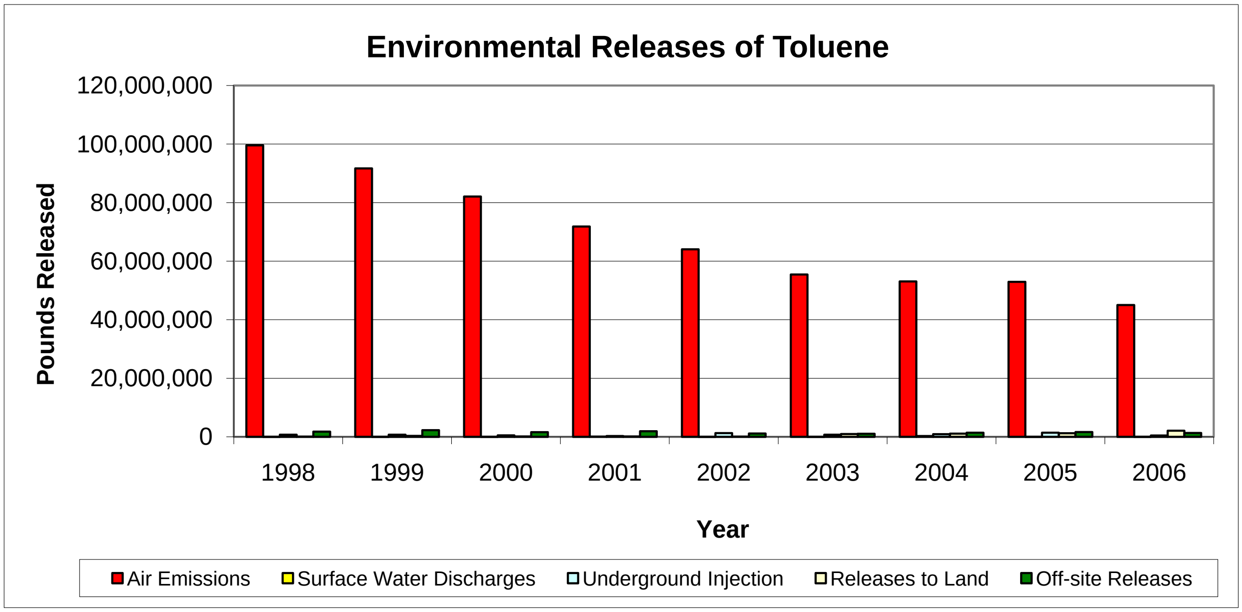
Toluene is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 18-2a lists the environmental releases of toluene from 1998 to 2006. (Exhibit 18-2b provides a graphical presentation of the environmental releases.) Air emissions constituted more than 90% of total releases and declined steadily over the period of record. Off-site releases were the next largest fraction and generally comprised 1 to 3% of the total. Surface water discharges, underground injection, and releases to land contributed variable but small fractions. The TRI data for toluene were reported from all 50 states, plus American Samoa, Guam, the Northern Mariana Islands, Puerto Rico and the Virgin Islands. All states and territories except for American Samoa reported toluene releases in all nine years.

Exhibit 18-2a: Table of Toxics Release Inventory (TRI) Data for Toluene

Year	**On-Site Releases (pounds)**				**Off-site Releases (pounds)**	**Total On- & Off-site Releases (pounds)**
	Total Air Emissions	**Surface Water Discharges**	**Underground Injection**	**Releases to Land**		
1998	99,562,995	43,783	724,075	94,628	1,797,274	102,222,755
1999	91,706,170	44,609	728,385	310,517	2,295,834	95,085,515
2000	82,067,078	40,494	513,810	148,061	1,615,834	84,385,276
2001	71,820,887	75,415	265,020	127,657	1,891,934	74,180,913
2002	64,034,648	28,798	1,281,792	87,574	1,129,282	66,562,093
2003	55,454,167	28,578	732,951	938,753	1,067,495	58,221,944
2004	53,079,139	266,254	915,605	1,112,241	1,389,014	56,762,253
2005	52,948,091	30,222	1,389,513	1,232,729	1,660,673	57,261,229
2006	45,002,472	31,971	468,857	2,072,125	1,312,985	48,888,410

Source: USEPA, 2008

Exhibit 18-2b: Graph of Toxics Release Inventory (TRI) Data for Toluene



Source: USEPA, 2008

18.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of toluene in ambient water are available from the NAWQA program.

18.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for toluene. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 18-3. Overall, toluene was detected in 26.3% of samples and at 15.9% of sites. Toluene was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.052 µg/L. The 99th percentile concentration, based on detections from all sites, was 3.48 µg/L.

Exhibit 18-3: EPA Summary Analysis of Toluene 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
ground water	4,545	13.1%	4,061	13.9%	0.003	0.0356	0.8845	12	1300
surface water	1,394	69.4%	182	60.4%	0.006	0.06	0.42	1.289	11
all sites	5,939	26.3%	4,243	15.9%	0.003	0.0515	0.6	3.483	1300

1. RLs (Reporting Limits) for toluene varied, but did not exceed 0.006 µg/L.

18.4 Occurrence in Drinking Water

Toluene is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of toluene occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for toluene. These data consist of 374,250 analytical results from about 50,451 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for toluene in the dataset is 0.5 µg/L.

18.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 18-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For toluene, 5.764% of 50,451 systems reported detections. Exhibit 18-5 lists the minimum, median, 90th percentile, and maximum toluene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of toluene, based on detections from all systems, was 0.94 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 18-4: Toluene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	289,635	46,193	80,577	86,403,546	86,403,546
Surface Water	84,615	4,258	10,870	140,551,755	140,551,755
Combined Ground & Surface Water	374,250	50,451	91,447	226,955,301	226,955,301
Percent with Detections					
Ground Water	1.381%	5.535%	3.561%	9.361%	2.912%
Surface Water	0.779%	8.243%	3.947%	15.584%	4.391%
Combined Ground & Surface Water	1.245%	5.764%	3.606%	13.215%	3.828%

Exhibit 18-5: Toluene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.0077	1	6	5,100
Surface Water	0.002	0.7	2.9	740
Combined Ground & Surface Water	0.002	0.94	5.4	5,100

The following maps illustrate the geographic distribution of toluene occurrence in drinking water. Exhibit 18-6 shows the states with systems with at least one detection and Exhibit 18-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of toluene is geographically dispersed. Detection rates were high; systems in all states except Hawaii reported detections of toluene, although only 8 states reported detections in more 10% of their systems. Although toluene

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

detection rates were high, only Michigan reported detections greater than the MCL concentration of 1,000 µg/L.

Exhibit 18-6: Percentage of Systems with at Least One Toluene Detection, by State

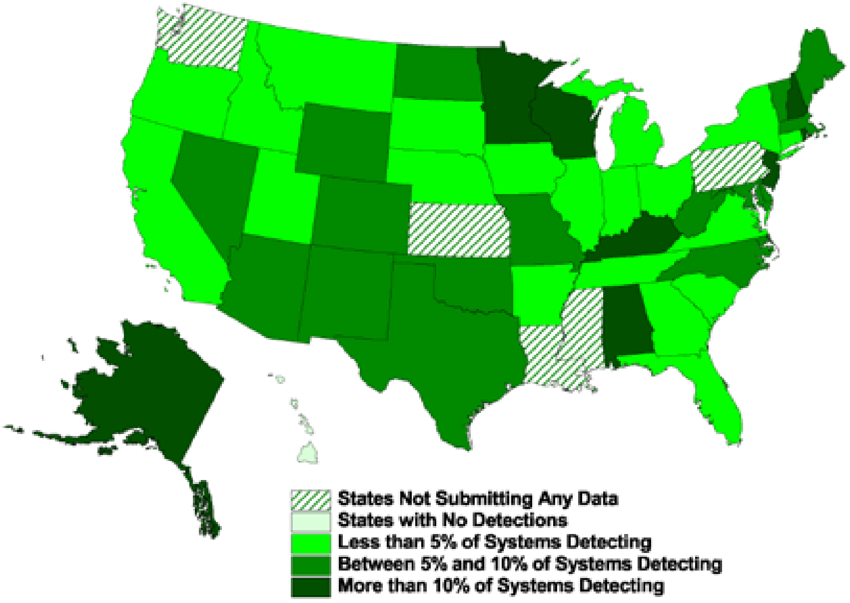


Exhibit 18-7: Percentage of Systems with at Least One Toluene Detection Greater than the MCL Concentration (> 1,000 µg/L), by State

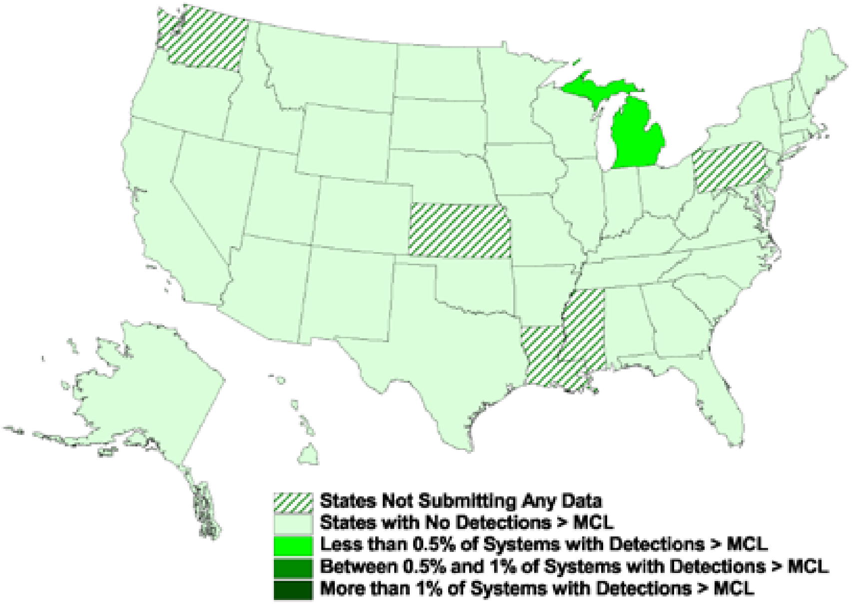


Exhibit 18-8 presents the Stage 1 analysis of toluene occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 1,000 µg/L, 600 µg/L, and 500 µg/L. Eighteen systems (0.036% of all systems), serving about 22,000 persons, reported at least one detection greater than or equal to 500 µg/L; and one system, serving 500 persons, reported at least one detection greater than the MCL concentration of 1,000 µg/L. Toluene was detected in more ground water systems than surface water systems at levels greater than all thresholds. No surface water systems detected toluene at a level greater than 1,000 µg/L.

Exhibit 18-8: Toluene Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 1,000 µg/L	1	0.002%	500	0.001%
	≥	14	0.030%	15,689	0.018%
	≥ µg/L	15	0.032%	15,757	0.018%
Surface Water	> 1,000 µg/L	0	0.000%	0	0.000%
	≥	1	0.023%	1,612	0.001%
	≥	3	0.070%	6,212	0.004%
Combined Ground & Surface Water	> 1,000 µg/L	1	0.002%	500	0.000%
	≥	15	0.030%	17,301	0.008%
	≥	18	0.036%	21,969	0.010%

The occurrence estimates presented above (in Exhibit 18-8) are based on the conservative assumption that if a toluene detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to toluene (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of toluene). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of toluene because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of toluene (rather than the entire population-served by the system).

Exhibit 18-9 presents the Stage 1 analysis of toluene occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Eighteen (0.020% of) sample points, serving an estimated 11,500 persons, had at least one detection greater than or equal to 500 µg/L; and one sample point, serving an estimated 500 persons, had at least one detection exceeding 1,000 µg/L. Similar to the system-level occurrence analysis, toluene was detected in more ground water than surface water sample points at all thresholds.

Exhibit 18-9: Toluene Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 1,000 µg/L	1	0.001%	500	0.001%
	≥	14	0.017%	6,243	0.007%
	≥	15	0.019%	6,311	0.007%
Surface Water	> 1,000 µg/L	0	0.000%	0	0.000%
	≥	1	0.009%	1,612	0.001%
	≥	3	0.028%	5,212	0.004%
Combined Ground & Surface Water	> 1,000 µg/L	1	0.001%	500	0.0002%
	≥	15	0.016%	7,855	0.003%
	≥	18	0.020%	11,523	0.005%

18.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean toluene concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 18-10 presents the Stage 2 analysis of estimated system mean concentrations for toluene occurrence in drinking water relative to several thresholds. The thresholds are: 1,000 µg/L, 600 µg/L, and 500 µg/L. Exhibit 18-11 presents similar information based on population-served by the systems. Based on the three substitution methods, two ground water systems (approximately 0.004% of all systems) had estimated system means greater than or equal to 500 µg/L. These 2 systems serve 840 persons. One ground water system (0.002% of all systems), serving 500 persons, had an estimated system mean greater than the MCL concentration of 1,000 µg/L. None of the surface water systems had a mean greater than or equal to any of the thresholds.

Exhibit 18-10: Toluene Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 1,000 µg/L	1	1	1	0.002%	0.002%	0.002%
	≥	2	2	2	0.004%	0.004%	0.004%
	≥	2	2	2	0.004%	0.004%	0.004%
Surface Water	> 1,000 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 1,000 µg/L	1	1	1	0.002%	0.002%	0.002%
	≥	2	2	2	0.004%	0.004%	0.004%
	≥	2	2	2	0.004%	0.004%	0.004%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 18-11: Toluene Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 1,000 µg/L	500	500	500	0.001%	0.001%	0.001%
	≥	840	840	840	0.001%	0.001%	0.001%
	≥	840	840	840	0.001%	0.001%	0.001%
Surface Water	> 1,000 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%

Source Water Type	**Threshold**	**Population-Served by Systems with Mean Exceeding Threshold**[1]			**Percent of Population-Served by Systems with Mean Exceeding Threshold**[1]		
		Full MRL	**½ MRL**	**Zero**	**Full MRL**	**½ MRL**	**Zero**
Combined Ground & Surface Water	> 1,000 µg/L	500	500	500	0.0002%	0.0002%	0.0002%
	≥	840	840	840	0.0004%	0.0004%	0.0004%
	≥	840	840	840	0.0004%	0.0004%	0.0004%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

18.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a "national cross-section" that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 1,133 systems (approximately 4.73% of about 24,000 systems), reported at least one detection of toluene. No systems reported a detection greater than the MCL concentration.

18.6 Summary of Data

TRI data indicate that total off-site and on-site releases of toluene for the period 1998-2006 ranged from approximately 49 million to 102 million pounds, with an overall decrease with time. Air emissions constituted almost all of the volume released. Off-site releases and the other on-site releases comprised only a few percent of the total amounts released.

Ambient water data from the NAWQA program indicate that toluene was detected in 26.3% of 5,939 ground and surface water samples and at 15.9% of 4,243 sites. The median concentration, based on detections from all sites, was 0.05 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that toluene was detected in 5.764% of 50,451 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.94 µg/L. Only one ground water system (serving 500 persons) reported at least one detection of toluene greater than the MCL concentration. That system represents 0.002% of all systems and 0.0002% of the population. None of the surface water systems reported any detections greater than the MCL concentration. The same pattern was seen for ground water and surface water sample points.

In the Stage 2 analysis, one ground water system (serving 500 persons) had a system mean concentration of toluene greater than the MCL concentration. No surface water systems had a system mean exceeding the MCL concentration.

18.7 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. *Toxicological Profile for Toluene.* September 2000. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp56.html.

United States Environmental Protection Agency (USEPA). 1991. National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; Monitoring for Unregulated Contaminants; National Primary Drinking Water Regulations Implementation; National Secondary Drinking Water Regulations; Final Rule Federal Register. Vol. 56, No. 30. p. 3526, January 30, 1991.

USEPA. 2003a. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Toluene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for toluene.] Accessed February 21, 2008.

USEPA. 2003b. *Occurrence Estimation Methodology and Occurrence Findings for Six-Year Review of National Primary Drinking Water Regulations*. Office of Water. EPA-815-R-03-006. June 2003.

USEPA. 2008. TRI Explorer: Trends – Toluene. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for toluene.] Accessed February 29, 2008.

USEPA. 2009. *The Analysis of Regulated Contaminant Occurrence Data from Public Water Systems in Support of the Second Six-Year Review of National Primary Drinking Water Regulations.* Office of Water. EPA-815-B-09-006. October 2009.

19 Toxaphene

This chapter on toxaphene is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and toxaphene occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

19.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for toxaphene on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 3 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1996), toxaphene ($C_{10}H_{10}Cl_8$) is a manufactured insecticide containing over 670 chemicals. In its original form, toxaphene is a yellow to amber waxy solid that smells like turpentine, but it may also exist as a gas. It evaporates when in solid form or when mixed with liquids, but it does not burn (ATSDR, 1996).

Toxaphene enters the environment after it is applied to a crop or poured into a lake (to kill unwanted fish). It does not dissolve well in water, so it is more likely to be found in air, soil, or the sediment at the bottom of lakes and streams. Toxaphene breaks down very slowly in the environment, so it still represents a health risk even though it has not been widely used for over 20 years. Levels may be high in some predatory fish and mammals because toxaphene accumulates in fatty tissues (ATSDR, 1996).

Because the use of toxaphene is now banned in the United States, individuals can probably only be exposed to it in areas where it is concentrated, such as waste sites. Wildlife in such areas may be dangerous to eat. Toddlers, who are likely to put things in their mouths, are at risk of eating contaminated soil. Though one can be exposed to toxaphene by inhaling contaminated air, concentrations are likely too low to cause health effects (ATSDR, 1996).

19.2 Use, Production, and Releases

Toxaphene was one of the most heavily used insecticides in the United States until 1982. It was used primarily in the southern United States to control insect pests on cotton and other crops. Toxaphene was also used to control insect pests on livestock and to kill unwanted fish in lakes (ATSDR, 1996).

The Chemical Substance Inventory Update System contains confidential data reported by industry as a partial update of the Toxic Substances Control Act (TSCA) Inventory. The TSCA Chemical Substance Inventory does not report production data for toxaphene.

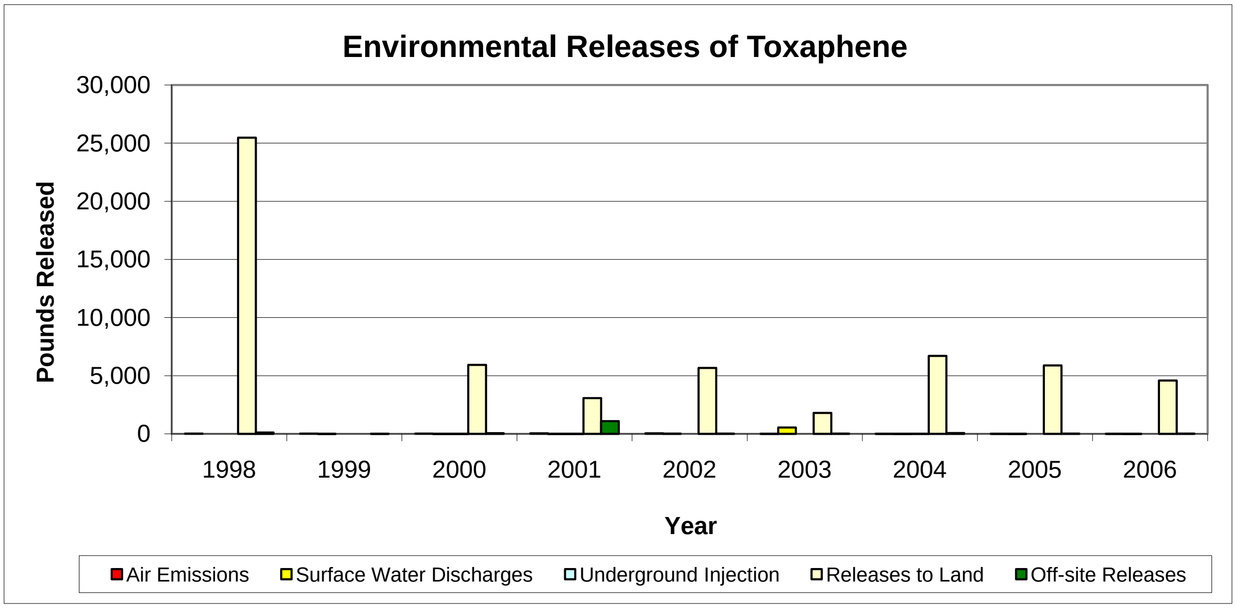
Toxaphene is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 19-1a lists the environmental releases of toxaphene from 1998 to 2006. (Exhibit 19-1b provides a graphical presentation of the environmental releases.) On-site releases of toxaphene consistently exceeded off-site releases. Releases to land constituted most of the on-site releases, except in 1999 when no toxaphene was released to land. Toxaphene was only injected underground in 2004 at negligible levels. Surface was discharges were also negligible, except for 2003. Off-site releases remained at low levels during the period of record, except for an anomalously high value in 2001. The TRI data for toxaphene were reported from 19 states, with Arkansas, Ohio and Texas reporting releases in all nine years.

Exhibit 19-1a: Table of Toxics Release Inventory (TRI) Data for Toxaphene

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	13	0	0	25,476	113	25,602
1999	16	1	0	0	14	31
2000	21	2	0	5,928	55	6,006
2001	43	6	0	3,074	1,090	4,213
2002	38	24	0	5,666	18	5,747
2003	7	547	0	1,802	19	2,374
2004	7	1	10	6,699	70	6,787
2005	4	1	0	5,881	22	5,908
2006	9	1	0	4,584	23	4,616

Source: USEPA, 2008

Exhibit 19-1b: Graph of Toxics Release Inventory (TRI) Data for Toxaphene



Source: USEPA, 2008

19.3 Occurrence in Ambient Water

No National Water Quality Assessment (NAWQA) Program data are available from the United States Geological Survey (USGS) on the occurrence of toxaphene in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

19.4 Occurrence in Drinking Water

Toxaphene is regulated as a synthetic organic chemical (SOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for SOCs. The maximum waiver period for SOCs is three years, but this waiver can be renewed indefinitely. (Systems may receive a waiver at any time without having collected an SOC sample. With a waiver, systems are not required to collect an SOC sample.)

All CWSs and NTNCWSs without an SOC waiver must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then a system serving less than 3,300 persons may reduce to one sample during each

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

consecutive compliance period; a system serving more than 3,300 persons may reduce to two quarterly samples within a 12-month period during a 3-year compliance period. If a chemical is detected (but is less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a chemical is detected at a level greater than the MCL, the system (whether ground water or surface water) must take quarterly samples until four consecutive quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of toxaphene occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

Forty-four of the Six-Year Review-ICR states provided occurrence data for toxaphene. (There were no toxaphene data from Oklahoma.) These data consist of 115,403 analytical results from 30,387 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for toxaphene in the dataset is 1 µg/L.

19.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 19-2 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For toxaphene, 0.132% of 30,387 systems reported detections. Exhibit 19-3 lists the minimum, median, 90th percentile, and maximum toxaphene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of toxaphene, based on detections from all systems, was 1 µg/L.

Exhibit 19-2: Toxaphene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	94,872	27,718	44,769	60,886,049	60,886,049

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Surface Water	20,531	2,669	5,945	99,126,085	99,126,085
Combined Ground & Surface Water	115,403	30,387	50,714	160,012,134	160,012,134
Percent with Detections					
Ground Water	0.062%	0.094%	0.058%	4.344%	4.328%
Surface Water	0.107%	0.525%	0.353%	0.901%	0.669%
Combined Ground & Surface Water	0.070%	0.132%	0.093%	2.211%	2.061%

Exhibit 19-3: Toxaphene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.04	1.5	5	6.8
Surface Water	0.07	1	2.5	2.5
Combined Ground & Surface Water	0.04	1	4.9	6.8

The following maps illustrate the geographic distribution of toxaphene occurrence in drinking water. Exhibit 19-4 shows the states with systems with at least one detection and Exhibit 19-5 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Oklahoma did submit Six-Year data for most contaminants; however, there is a statewide waiver for toxaphene in Oklahoma so no toxaphene data were available from that state.

The distribution of systems with detections of toxaphene is geographically dispersed. Detection rates were generally low; only three states reported detections in more than 1% of their

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

systems. Eight states reported detections in less than 1% of their systems. Only two states reported detections greater than the MCL concentration of 3 µg/L.

Exhibit 19-4: Percentage of Systems with at Least One Toxaphene Detection, by State

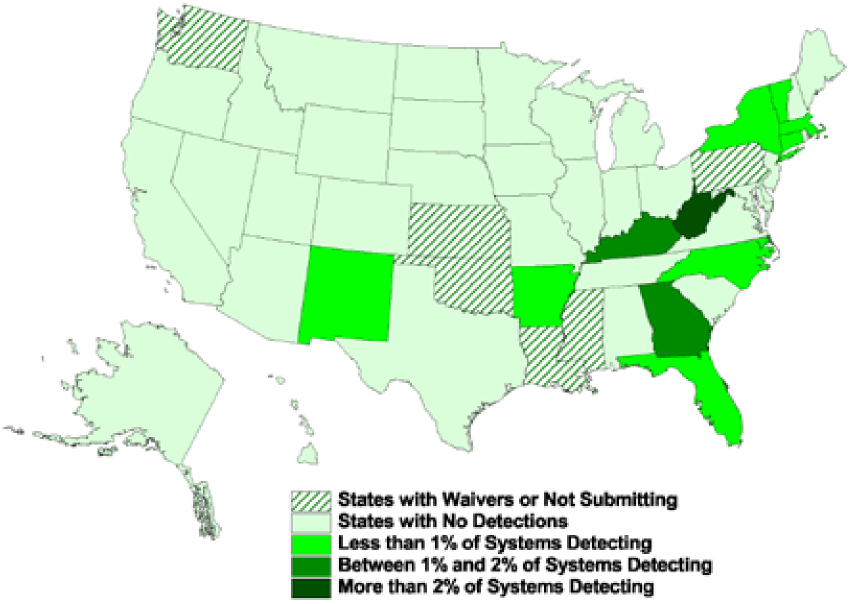

Exhibit 19-5: Percentage of Systems with at Least One Toxaphene Detection Greater than the MCL Concentration (> 3 µg/L), by State

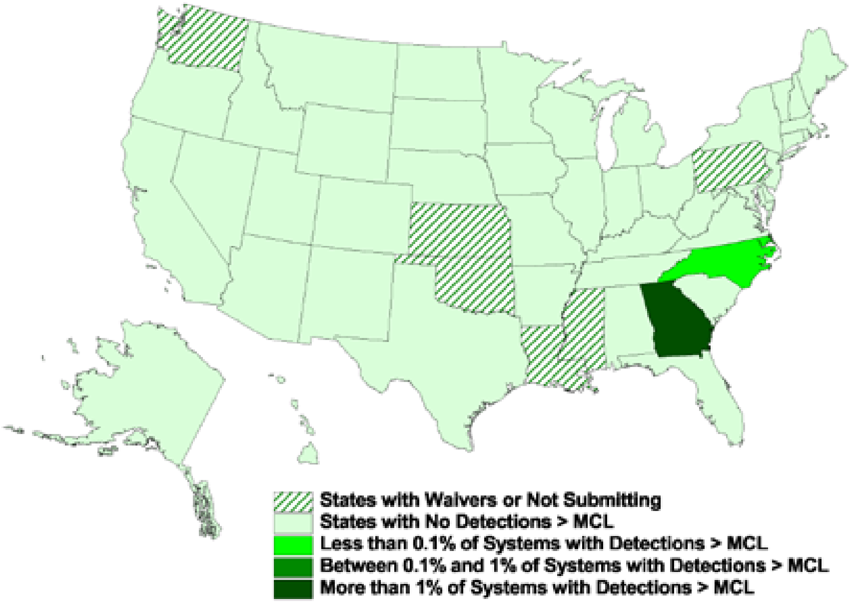

Exhibit 19-6 presents the Stage 1 analysis of toxaphene occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 3 µg/L, 1.5 µg/L, and 1 µg/L. Nine systems (0.030% of all systems), serving approximately 285,000 persons, reported at least one detection greater than or equal to 1.5 µg/L; and five systems (0.016% of all systems), serving about 27,000 persons, reported at least one detection greater than the MCL concentration of 3 µg/L. All of the systems reporting at least on detection greater than 3 µg/L were ground water systems.

Exhibit 19-6: Toxaphene Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	**> 3 µg/L**	5	0.018%	27,063	0.044%
	≥ 1.5 µg/L	7	0.025%	27,713	0.046%
	> 1 µg/L	7	0.025%	27,713	0.046%

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Surface Water	**> 3 µg/L**	0	0.000%	0	0.000%
	≥ 1	2	0.075%	257,737	0.260%
	> 1 µg/L	2	0.075%	257,737	0.260%
Combined Ground & Surface Water	**> 3 µg/L**	5	0.016%	27,063	0.017%
	≥ 1.5 µg/L	9	0.030%	285,450	0.178%
	> 1 µg/L	9	0.030%	285,450	0.178%

The occurrence estimates presented above (in Exhibit 19-6) are based on the conservative assumption that if a toxaphene detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to toxaphene (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of toxaphene). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of toxaphene because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of toxaphene (rather than the entire population-served by the system).

Exhibit 19-7 presents the Stage 1 analysis of toxaphene occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Eleven (0.022% of) sample points, serving an estimated 283,000 persons, reported at least one detection greater than or equal to 1.5 µg/L; and 5 (0.010% of) sample points, serving an estimated 24,000 persons, reported at least one detection greater than 3 µg/L.

Exhibit 19-7: Toxaphene Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	**> 3 µg/L**	5	0.011%	24,198	0.040%
	≥ 1	7	0.016%	24,848	0.041%
	> 1 µg/L	7	0.016%	24,848	0.041%

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Surface Water	**> 3 µg/L**	0	0.000%	0	0.000%
	≥ 1	4	0.067%	257,737	0.260%
	> 1 µg/L	4	0.067%	257,737	0.260%
Combined Ground & Surface Water	**> 3 µg/L**	5	0.010%	24,198	0.015%
	≥ 1	11	0.022%	282,585	0.177%
	> 1 µg/L	11	0.022%	282,585	0.177%

19.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean toxaphene concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 19-8 presents the Stage 2 analysis of estimated system mean concentrations for toxaphene occurrence in drinking water relative to several thresholds. The thresholds are: 3 µg/L, 1.5 µg/L, and 1 µg/L. Exhibit 19-9 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, five ground water systems (approximately 0.016% of all systems) had an estimated system mean greater than or equal to 1.5 µg/L. These five systems serve 23,429 persons. No more than 4 systems (0.013% of all systems), serving 22,989 persons, had an estimated system mean greater than the MCL concentration of 3 µg/L.

Exhibit 19-8: Toxaphene Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	**½ MRL**	**Zero**	**Full MRL**	**½ MRL**	**Zero**
Ground	> 3 µg/L	4	3	3	0.014%	0.011%	0.011%

	≥ 1	5	5	5	0.018%	0.018%	0.018%
	> 1 µg/L	7	5	5	0.025%	0.018%	0.018%
Surface Water	> 3 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
	> 1 µg/L	2	0	0	0.075%	0.000%	0.000%
Combined Ground & Surface Water	> 3 µg/L	4	3	3	0.013%	0.010%	0.010%
	≥ 1	5	5	5	0.016%	0.016%	0.016%
	> 1 µg/L	9	5	5	0.030%	0.016%	0.016%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 19-9: Toxaphene Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	**Threshold**	**Population-Served by Systems with Mean Exceeding Threshold[1]**			**Percent of Population-Served by Systems with Mean Exceeding Threshold[1]**		
		Full MRL	**½ MRL**	**Zero**	**Full MRL**	**½ MRL**	**Zero**
Ground Water	> 3 µg/L	22,989	22,691	22,691	0.038%	0.037%	0.037%
	≥ 1	23,429	23,429	23,429	0.038%	0.038%	0.038%
	> 1 µg/L	27,713	23,429	23,429	0.046%	0.038%	0.038%
Surface Water	> 3 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
	> 1 µg/L	257,737	0	0	0.260%	0.000%	0.000%
Combined Ground & Surface Water	> 3 µg/L	22,989	22,691	22,691	0.014%	0.014%	0.014%
	≥ 1	23,429	23,429	23,429	0.015%	0.015%	0.015%
	> 1 µg/L	285,450	23,429	23,429	0.178%	0.015%	0.015%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

19.5 Additional Occurrence Data

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003), 11 systems (approximately 0.08% of about 14,000 systems), reported at least one detection of toxaphene. One system (approximately 0.01% of all systems), reported at least one detection greater than the MCL concentration.

19.6 Summary of Data

TRI data indicate that total off-site and on-site releases of toxaphene for the period 1998-2006 were typically on the order of several thousand pounds. Releases to land constituted almost all releases, except in 1999, when no such releases were reported.

No data are available from the NAWQA program for toxaphene in ambient waters.

The Stage 1 analysis of occurrence in drinking water indicates that toxaphene was detected in 0.132% of 30,387 surface water and ground water systems. The median concentration, based on detections from all systems, was 1 µg/L. In total, 0.016% of systems (serving about 27,000 persons) reported at least one detection greater than the MCL concentration of 3 µg/L. All of the systems reporting at least one detection greater than the MCL concentration were ground water systems. A small number of surface water systems reported at least one detection greater than the other thresholds (1 µg/L and 1.5 µg/L).

In the Stage 2 analysis, approximately 0.013% of all systems (serving 0.014% of the population) had an estimated system mean concentration of toxaphene greater than the MCL concentration.

19.7 References

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USEPA. 2008. TRI Explorer: Trends – Toxaphene. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for toxaphene.] Accessed February 29, 2008.

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20 1,1,2-Trichloroethane

This chapter on 1,1,2-trichloroethane is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and 1,1,2-trichloroethane occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the “Six Year Review-ICR Dataset”). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

20.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for 1,1,2-trichloroethane on July 17, 1992 (57 FR 31776 (USEPA, 1992)). The NPDWR established a maximum contaminant level goal (MCLG) of 3 µg/L based on a reference dose (RfD) of 4 µg/kg-day (0.004 mg/kg-day) and a cancer classification of C, possible human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1989), 1,1,2-trichloroethane ($C_2H_3Cl_3$) is a colorless, sweet-smelling liquid. It does not burn easily and boils at a higher temperature than water. 1,1,2-Trichloroethane is also known as ethane trichloride, β-trichloroethane, vinyl trichloride, and 1,2,2-trichloroethane (ATSDR, 1989).

It is difficult to determine precisely how 1,1,2-trichloroethane enters the environment; however, surveys of industrial wastewater show 1,1,2-trichloroethane in discharges from the timber products industry, plastics and synthetics industries, and laundries. Studies of 1,1,2-trichloroethane below the soil surface and in ground water indicate that it may take months to years to break down. Low levels of 1,1,2-trichloroethane may be found in outdoor air, most likely related to its use as a solvent. Limited data show that 1,1,2-trichloroethane is present in a quarter to a half of city air samples. Where 1,1,2-trichloroethane is found, the samples usually contain 10 to 50 parts per trillion (ppt). In the air, 1,1,2-trichloroethane has a half-life of 49 days, providing enough time for it to spread far and re-deposit before breaking down. It may also be formed in landfills when 1,1,2,2-tetrachloroethane degrades (ATSDR, 1989).

20.2 Use, Production, and Releases

The principal use of 1,1,2-trichloroethane is as a chemical intermediate in the production of 1,1-dichloroethylene. Industries that discharge 1,1,2-trichloroethane include the timber products industry, plastics and synthetics industries, and laundries. (ATSDR, 1989). 1,1,2-Trichloroethane also has limited use as a solvent for fats, oils, waxes, and resins. Information indicates that 1,1,2-trichloroethane has been sold for use in consumer products, but it is not known for which products, nor how extensive the use (ATSDR, 1989).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 20-1 presents the production of 1,1,2-trichloroethane in the United States from 1986 to 2002. Note that except for a decrease for the 1994 data, the production of 1,1,2-trichloroethane in the United States has remained within the range of 100 million to 500 million since 1986.

Exhibit 20-1: Production of 1,1,2-Trichloroethane in the United States

Inventory Update Year	Production Volume
1986 Range	> 100 million - 500 million
1990 Range	> 100 million - 500 million
1994 Range	> 10 million - 50 million
1998 Range	> 100 million - 500 million
2002 Range	> 100 million - 500 million

Source: USEPA, 2003a

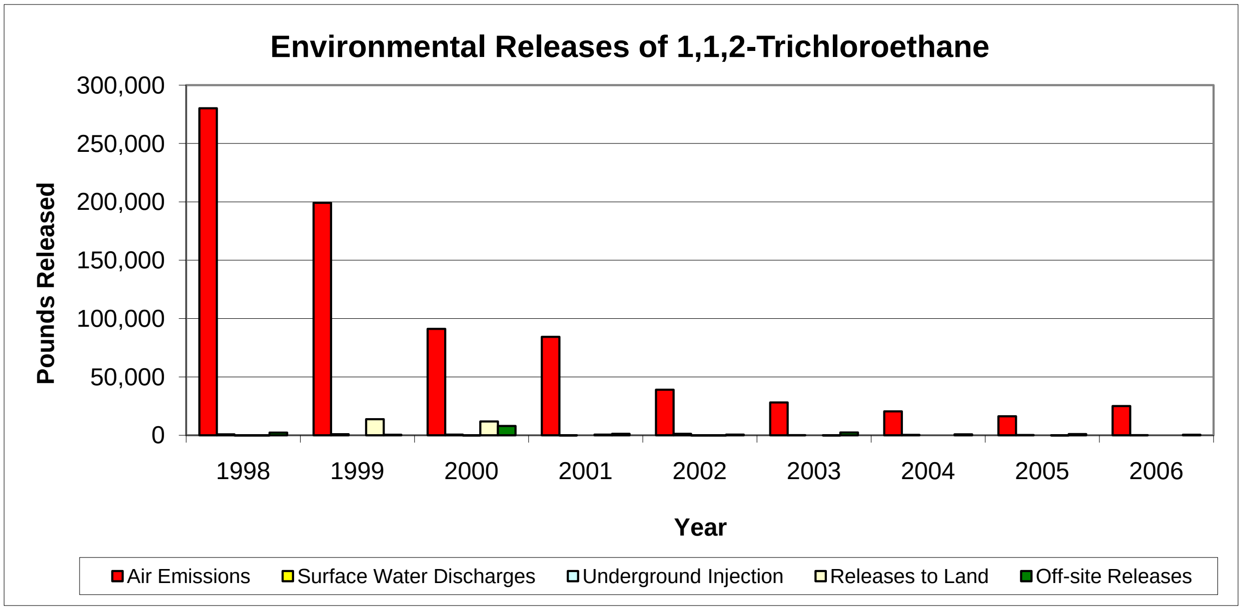
1,1,2-Trichloroethane is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 20-2a lists the environmental releases of 1,1,2-trichloroethane between 1998 and 2006. (Exhibit 20-2b provides a graphical presentation of the environmental releases.) Total releases were highest in 1998 and declined steadily with time. Air emissions generally constituted over 90% of the total material released. Land releases were negligible except for sharp increases in 1999, 2000, and 2001. Surface water discharges and off-site releases contributed only a few percent of the total, and underground injection was essentially nonexistent. The TRI data for 1,1,2-trichloroethane were reported from 20 states, with 6 states (Arkansas, Iowa, Kentucky, Louisiana, Ohio, and Texas) reporting releases in all 9 years.

Exhibit 20-2a: Table of Toxics Release Inventory (TRI) Data for 1,1,2-Trichloroethane

Year	**On-Site Releases (pounds)**				**Off-site Releases (pounds)**	**Total On- & Off-site Releases (pounds)**
	Total Air Emissions	**Surface Water Discharges**	**Underground Injection**	**Releases to Land**		
1998	280,213	790	5	1	2,326	283,335
1999	199,121	926	0	13,788	484	214,319
2000	91,189	572	5	11,813	7,967	111,546
2001	84,383	15	0	554	1,274	86,226
2002	39,046	1,256	0	16	570	40,888
2003	28,101	84	0	19	2,423	30,627
2004	20,492	412	0	0	796	21,701
2005	16,268	239	0	15	1,062	17,584
2006	24,989	92	0	0	433	25,514

Source: USEPA, 2008

Exhibit 20-2b: Graph of Toxics Release Inventory (TRI) Data for 1,1,2-Trichloroethane



Source: USEPA, 2008

20.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of 1,1,2-trichloroethane in ambient water are available from the NAWQA program.

20.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for 1,1,2-trichloroethane. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 20-3. Overall, 1,1,2-trichloroethane was detected in ground water at 0.1% of samples and at 0.1% of sites. 1,1,2-Trichloroethane was never detected in surface water. The median concentration, based on detections from ground water sites, was 0.0399 µg/L. The 99th percentile concentration, based on detections from ground water sites, was 0.0785 µg/L.

Exhibit 20-3: EPA Summary Analysis of 1,1,2-Trichloroethane 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
ground water	4,544	0.1%	4,127	0.1%	0.028	0.0399	0.0785	0.0785	0.0785
surface water	1,408	0.0%	190	0.0%					
all sites	5,952	0.1%	4,317	0.1%	0.028	0.0399	0.0785	0.0785	0.0785

1. RLs (Reporting Limits) for 1,1,2-trichloroethane varied, but did not exceed 0.06 µg/L.

20.4 Occurrence in Drinking Water

1,1,2-Trichloroethane is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of 1,1,2-trichloroethane occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for 1,1,2-trichloroethane. These data consist of 372,386 analytical results from 50,195 public water systems (PWSs) during the period from 1998 to 2005. The numbers of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for 1,1,2-trichloroethane in the dataset is 0.5 µg/L.

20.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 20-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 1,1,2-trichloroethane, 0.179% of 50,195 systems reported detections. Exhibit 20-5 lists the minimum, median, 90th percentile, and maximum 1,1,2-trichloroethane concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 1,1,2-trichloroethane, based on detections from all systems, was 0.6 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 20-4: 1,1,2-Trichloroethane Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	288,218	45,942	80,274	86,314,890	86,314,890
Surface Water	84,168	4,253	10,845	140,536,579	140,536,579
Combined Ground & Surface Water	372,386	50,195	91,119	226,851,469	226,851,469
Percent with Detections					
Ground Water	0.033%	0.128%	0.077%	1.016%	0.579%
Surface Water	0.169%	0.729%	0.424%	0.842%	0.268%
Combined Ground & Surface Water	0.064%	0.179%	0.119%	0.908%	0.386%

Exhibit 20-5: 1,1,2-Trichloroethane Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.54	2.3	36
Surface Water	0.04	0.7	2.4	40
Combined Ground & Surface Water	0.01	0.6	2.4	40

The following maps illustrate the geographic distribution of 1,1,2-trichloroethane occurrence in drinking water. Exhibit 20-6 shows the states with systems with at least one detection and Exhibit 20-7 shows the states with systems with at least one detection greater than the MCL concentration for 1,1,2-trichloroethane. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

The distribution of systems with detections of 1,1,2-trichloroethane is geographically dispersed. Detection rates were generally low; only two states reported detections in more 1% of their systems. Only five states reported detections greater than the MCL concentration of 5 µg/L.

Exhibit 20-6: Percentage of Systems with at Least One 1,1,2-Trichloroethane Detection, by State

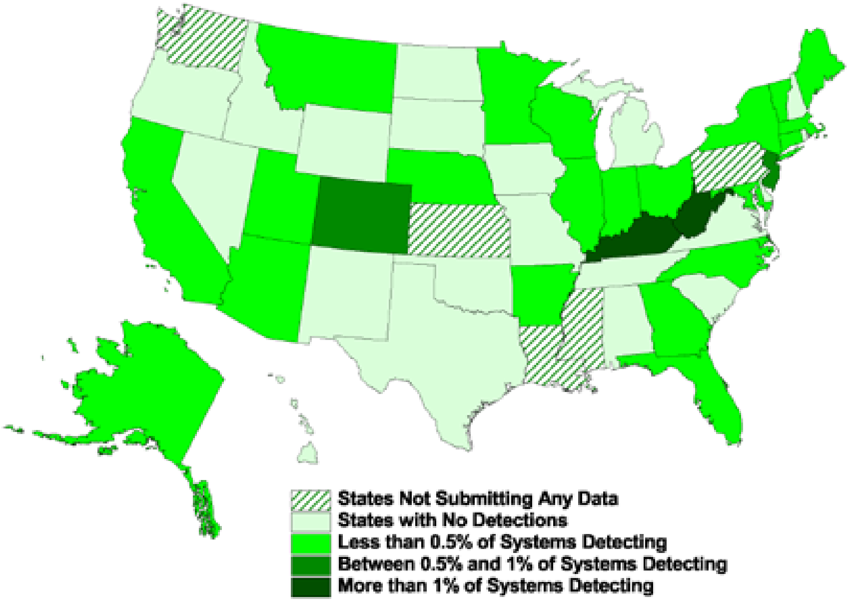

Exhibit 20-7: Percentage of Systems with at Least One 1,1,2-Trichloroethane Detection Greater than the MCL Concentration (> 5 µg/L), by State

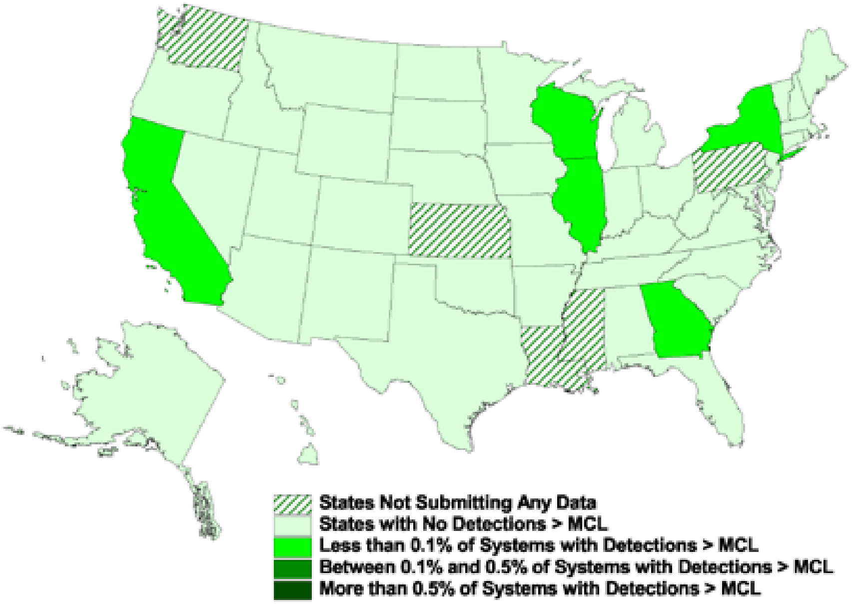

Exhibit 20-8 presents the Stage 1 analysis of 1,1,2-trichloroethane occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 5 µg/L, 3 µg/L, and 2.5 µg/L. Thirteen systems (0.026% of all systems), serving about 353,000 persons, reported at least one detection greater than or equal to 2.5 µg/L; and seven systems (0.014% of all systems), serving about 126,000 persons, reported at least one detection greater than the MCL concentration of 5 µg/L. Similar numbers of surface water and ground water systems reported at least one detection greater than the thresholds. However, because surface water systems tend to be larger, a greater population was served by surface water systems reporting at least one detection greater than the thresholds.

Exhibit 20-8: 1,1,2-Trichloroethane Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 5 µg/L	5	0.011%	20,910	0.024%
	≥	7	0.015%	31,838	0.037%
	≥	8	0.017%	31,882	0.037%
Surface Water	> 5 µg/L	2	0.047%	105,441	0.075%
	≥	5	0.118%	320,808	0.228%
	≥	5	0.118%	320,808	0.228%
Combined Ground & Surface Water	> 5 µg/L	7	0.014%	126,351	0.056%
	≥	12	0.024%	352,646	0.155%
	≥	13	0.026%	352,690	0.155%

The occurrence estimates presented above (in Exhibit 20-8) are based on the conservative assumption that if a 1,1,2-trichloroethane detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to 1,1,2-trichloroethane (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of 1,1,2-trichloroethane). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of 1,1,2-trichloroethane because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of 1,1,2-trichloroethane (rather than the entire population-served by the system).

Exhibit 20-9 presents the Stage 1 analysis of 1,1,2-trichloroethane occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Nineteen (0.021% of) sample points, serving an estimated 32,000 persons, reported at least one detection greater than or equal to 2.5 µg/L; and 11 (0.012% of) sample points, serving an estimated 15,000 persons, reported at least one detection exceeding 5 µg/L. As with the system-level analysis, a larger population was served by surface water systems with exceedances.

Exhibit 20-9: 1,1,2-Trichloroethane Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 5 µg/L	5	0.006%	5,774	0.007%
	≥	7	0.009%	8,273	0.010%
	≥	8	0.010%	8,295	0.010%
Surface Water	> 5 µg/L	6	0.055%	9,630	0.007%
	≥ 3 µg/L	9	0.083%	19,462	0.014%
	≥	11	0.101%	23,292	0.017%
Combined Ground & Surface Water	> 5 µg/L	11	0.012%	15,404	0.007%
	≥	16	0.018%	27,735	0.012%
	≥	19	0.021%	31,587	0.014%

20.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean 1,1,2-trichloroethane concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 20-10 presents the Stage 2 analysis of estimated system mean concentrations for 1,1,2-trichloroethane occurrence in drinking water relative to several thresholds. The thresholds are: 5 µg/L, 3 µg/L, and 2.5 µg/L. Exhibit 20-11 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, one ground water system (approximately 0.002% of all systems) had an estimated system mean greater than or equal to 2.5 µg/L. This system serves about 700 persons. None of the ground water systems had an estimated system mean greater than the MCL concentration of 5 µg/L. None of the surface water systems had a mean greater than or equal to any of the thresholds.

Exhibit 20-10: 1,1,2-Trichloroethane Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	1	1	1	0.002%	0.002%	0.002%
	≥	1	1	1	0.002%	0.002%	0.002%
Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	1	1	1	0.002%	0.002%	0.002%
	≥	1	1	1	0.002%	0.002%	0.002%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 20-11: 1,1,2-Trichloroethane Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 3 µg/L	700	700	700	0.001%	0.001%	0.001%
	≥ µg/L	700	700	700	0.001%	0.001%	0.001%
Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 5 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	700	700	700	0.0003%	0.0003%	0.0003%
	≥	700	700	700	0.0003%	0.0003%	0.0003%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

20.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including 1,1,2-trichloroethane, in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, 1,1,2-trichloroethane was not detected at an assessment level of 0.2 µg/L (based on 2,156 samples). The median concentration of detections was 0.028 µg/L. No detections were greater than or within one order of magnitude of the MCL concentration (5 µg/L).

In public wells, 1,1,2-trichloroethane was not detected at an assessment level of 0.2 µg/L (based on 1,078 samples). The median concentration of detections was 0.018 µg/L. No detections were greater than, or within one order of magnitude of, the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 138 systems (approximately 0.62% of about 22,000 systems), reported at least one detection of 1,1,2-trichloroethane. Nine systems (approximately 0.04% of all systems), reported at least one detection greater than the MCL concentration.

20.6 Summary of Data

TRI data indicate that the total off-site and on-site releases of 1,1,2-trichloroethane ranged from about 17,600 pounds to approximately 283,000 pounds. Nearly all of the material released was in the form of air emissions. Surface water and off-site discharges contributed a few percent to the total. Releases to land and underground injections were minor.

Ambient water data from the NAWQA program indicate that 1,1,2-trichloroethane was detected in 0.1% of 5,952 ground and surface water samples and at 0.1% of 4,317 sites. The median concentration, based on detections from all sites, was 0.04 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that 1,1,2-trichloroethane was detected in 0.179% of 50,195 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.6 µg/L. In total, 0.014% of systems (serving 0.056% of the population) reported at least one detection greater than the MCL concentration of 5 µg/L. 1,1,2-Trichloroethane was detected in similar numbers of ground water and surface water systems. However, because surface water systems are generally larger, a greater population was served by surface water systems at least one detection greater than the MCL concentration.

In the Stage 2 analysis, no systems had an estimated mean concentration of 1,1,2-trichloroethane greater than MCL concentration.

20.7 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. *Toxicological Profile for 1,1,2-Trichloroethane.* December 1989. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp148.html.

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Zogorski, J.S., J.M. Carter, T. Ivahnenko, W.W. Lapham, M.J. Moran, B.L. Rowe, P.J. Squillace, and P.L. Toccalino. 2006. Volatile organic compounds in the nation's ground water and drinking water supply wells. U.S. Geological Survey Circular 1292, 101 p. Available on the Internet at: http://pubs.er.usgs.gov/pubs/cir/cir1292.

21 Trichloroethylene (TCE)

This chapter on trichloroethylene (TCE) is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and trichloroethylene occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

21.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for trichloroethylene on July 8, 1987 (52 FR 25690 (USEPA, 1987)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of B2, probable human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1997), trichloroethylene (C_2HCl_3) is a nonflammable, colorless liquid at room temperature that has a somewhat sweet odor, and a sweet, burning taste. Other names for trichloroethylene include TCE and trichloroethene (ATSDR, 1997).

By far, the largest source of trichloroethylene in the environment is evaporation from factories that use it to remove grease from metals. In the air, trichloroethylene has a half-life of approximately one week, breaking down into a lung irritant called phosgene. Chemical waste sites may leak trichloroethylene to surface water, which slows break down to days or weeks. In ground water and soils, degradation is much slower than that (ATSDR, 1997).

Exposure to trichloroethylene may occur through contact with household products such as typewriter correction fluids, paints and paint removers, glues, spot removers, rug cleaning fluids, and metal cleaners. Factory workers, those living near factories, and those living near hazardous waste sites may also be exposed. Trichloroethylene is found in the air, but typically at concentrations much lower than 1 ppm. Trichloroethylene in foods is believed to come from contamination of the water used in food processing or from food processing equipment cleaned with trichloroethylene (ATSDR, 1997).

21.2 Use, Production, and Releases

According to ATSDR (1997), the primary use of trichloroethylene in the United States is as a vapor degreasing agent for fabricated metal parts. It is an excellent extraction solvent for greases, oils, fats, waxes, and tars and is used by the textile processing industry to scour cotton, wool, and other fabrics. As a general solvent, or as a component of solvent blends, trichloroethylene is used with adhesives, lubricants, paints, varnishes, paint strippers, pesticides, and cold metal cleaners. Before 1977, it was used as a surgical disinfectant, as a pet food additive, and as an agent to decaffeinate coffee; however, these uses were banned by the Food and Drug Administration (ATSDR, 1997).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 21-1 presents the production of trichloroethylene in the United States from 1986 to 2002. Aside from a decrease in the 1994 data, the production of trichloroethylene in the United States has remained within the range of 100 million to 500 million since 1986.

Exhibit 21-1: Production of Trichloroethylene in the United States

Inventory Update Year	Production Volume
1986 Range	> 100 million - 500 million
1990 Range	> 100 million - 500 million
1994 Range	> 50 million - 100 million
1998 Range	> 100 million - 500 million
2002 Range	> 100 million - 500 million

Source: USEPA, 2003a

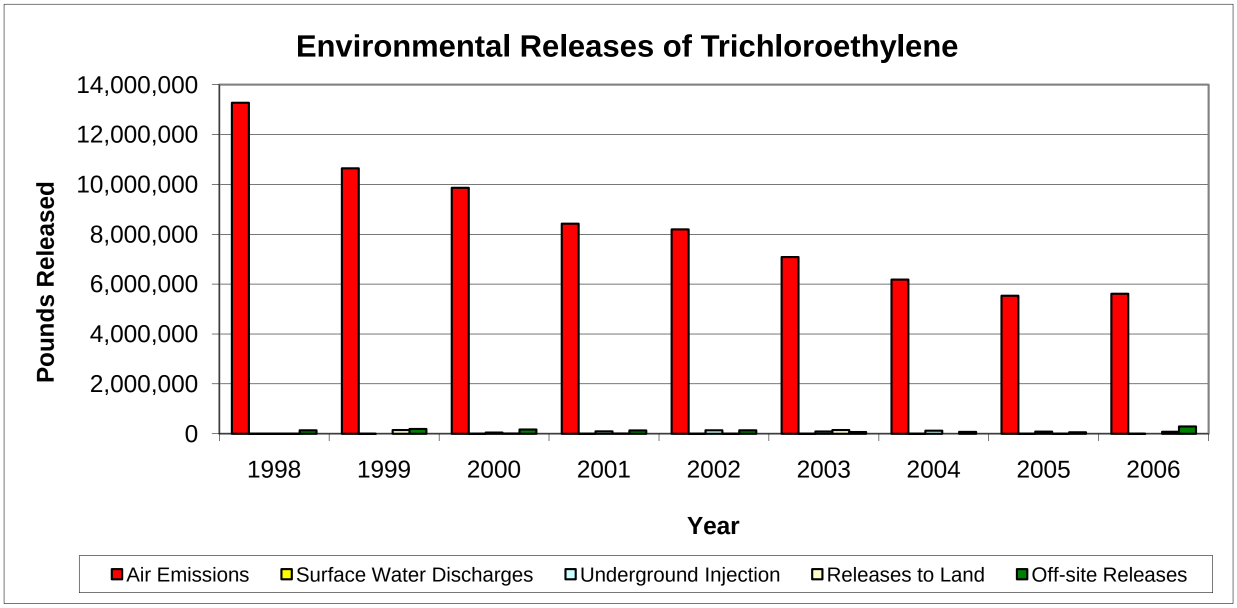
Trichloroethylene is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 21-2a lists the environmental releases of trichloroethylene between 1998 and 2006. (Exhibit 21-2b provides a graphical presentation of the environmental releases.) Trichloroethylene releases declined steadily during the period of review. Air emissions constituted more than 95% of all releases. Off-site releases were generally the second largest fraction and surface water discharges generally contributed the smallest amounts. The TRI data for trichloroethylene were reported from 45 states, with 40 states reporting releases in all 9 years. No releases were reported from Alaska, Hawaii, Idaho, North Dakota or West Virginia.

Exhibit 21-2a: Table of Toxics Release Inventory (TRI) Data for Trichloroethylene

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	13,274,099	882	593	800	136,766	13,413,140
1999	10,645,692	1,034	0	148,867	192,385	10,987,978
2000	9,861,009	593	47,877	9,607	171,952	10,091,038
2001	8,421,733	406	98,220	12,609	133,531	8,666,499
2002	8,197,393	579	140,190	230	139,398	8,477,790
2003	7,084,772	595	90,971	150,642	66,894	7,393,873
2004	6,181,340	216	123,637	2	71,780	6,376,975
2005	5,535,452	533	86,817	4,711	60,074	5,687,587
2006	5,612,675	482	0	77,339	294,071	5,984,567

Source: USEPA, 2008

Exhibit 21-2b: Graph of Toxics Release Inventory (TRI) Data for Trichloroethylene



Source: USEPA, 2008

21.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of trichloroethylene in ambient water are available from the NAWQA program.

21.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for trichloroethylene. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 21-3. Overall, trichloroethylene was detected in 12.8% of samples and at 6.2% of sites. Trichloroethylene was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.058 µg/L. The 99th percentile concentration, based on detections from all sites, was 17.33 µg/L.

Exhibit 21-3: EPA Summary Analysis of Trichloroethylene 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
ground water	4,655	5.4%	4,159	4.6%	0.002	0.177	7.9	103.5	230
surface water	1,413	37.2%	190	41.6%	0.003	0.0409	1.1	2.2	17.33
all sites	6,068	12.8%	4,349	6.2%	0.002	0.058	2.2	17.33	230

1. RLs (Reporting Limits) for trichloroethylene varied, but did not exceed 0.003 µg/L.

21.4 Occurrence in Drinking Water

Trichloroethylene is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of trichloroethylene occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for trichloroethylene. These data consist of 403,609 analytical results from 50,432 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for trichloroethylene in the dataset is 0.5 µg/L.

21.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 21-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For trichloroethylene, 2.009% of 50,432 systems reported detections. Exhibit 21-5 lists the minimum, median, 90th percentile, and maximum trichloroethylene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of trichloroethylene, based on detections from all systems, was 1.5 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 21-4: Trichloroethylene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	304,776	46,177	80,631	86,393,209	86,393,209
Surface Water	98,833	4,255	10,904	140,514,477	140,514,477
Combined Ground & Surface Water	403,609	50,432	91,535	226,907,686	226,907,686
Percent with Detections					
Ground Water	4.855%	1.867%	1.969%	12.214%	4.333%
Surface Water	14.934%	3.549%	5.805%	13.512%	4.748%
Combined Ground & Surface Water	7.323%	2.009%	2.426%	13.018%	4.590%

Exhibit 21-5: Trichloroethylene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.0018	1.3	7.5	159
Surface Water	0.001	1.8	14.2	50
Combined Ground & Surface Water	0.001	1.5	10.5	159

The following maps illustrate the geographic distribution of trichloroethylene occurrence in drinking water. Exhibit 21-6 shows the states with systems with at least one detection and Exhibit 21-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of trichloroethylene is geographically dispersed. Detection rates were high; systems in all states except Hawaii reported detections of

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

trichloroethylene, although only 6 states reported detections in more 5% of their systems. Thirty-two states reported at least one detection greater than the MCL concentration of 5 µg/L, although only 8 of these states had more than 0.5% of systems with at least one detection greater than 5 µg/L.

Exhibit 21-6: Percentage of Systems with at Least One Trichloroethylene Detection, by State

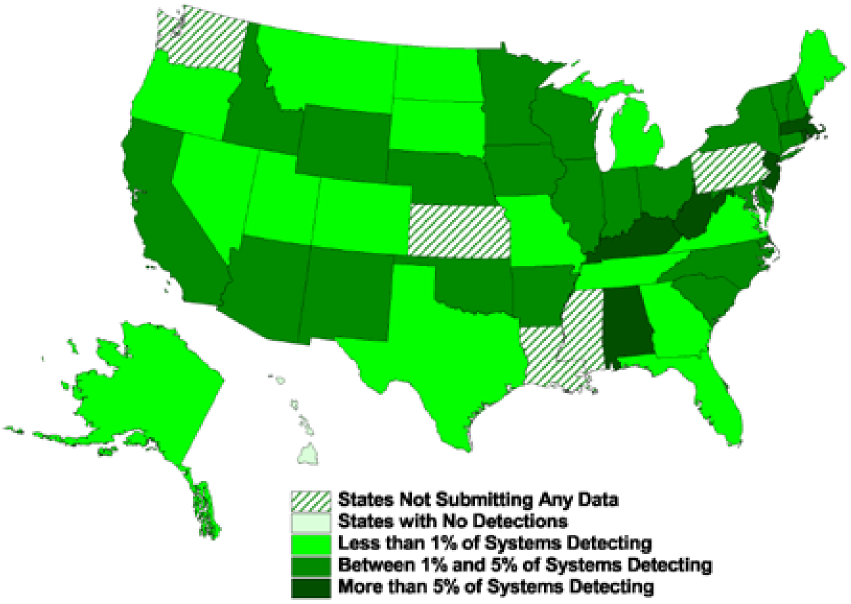

Exhibit 21-7: Percentage of Systems with at Least One Trichloroethylene Detection Greater than the MCL Concentration (> 5 µg/L), by State

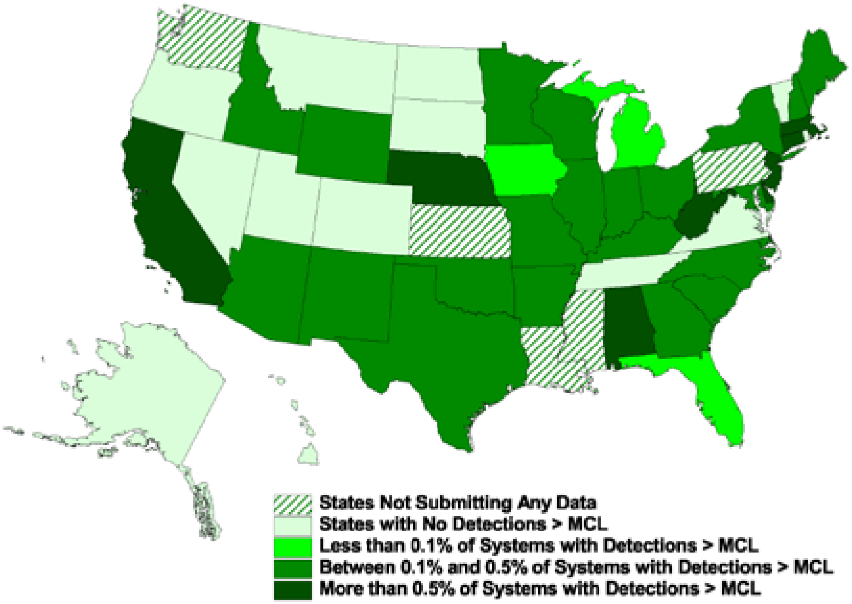

Exhibit 21-8 presents the Stage 1 analysis of trichloroethylene occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. A total of 338 systems (0.670% of all systems), serving almost 16 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 195 systems (0.387% of all systems), serving about 12 million persons, reported at least one detection greater than 5 µg/L. Trichloroethylene was detected in more ground water systems than surface water systems at levels greater than all thresholds. However, because surface water systems tend to be larger, a greater population was served by surface water systems reporting at least one detection greater than all thresholds.

Exhibit 21-8: Trichloroethylene Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 5 µg/L	157	0.340%	2,241,272	2.594%
	≥ 2.5 µg/L	283	0.613%	4,817,431	5.576%
	≥ 1 µg/L	490	1.061%	7,008,143	8.112%
	> 0.5 µg/L	682	1.477%	8,714,465	10.087%
Surface Water	> 5 µg/L	38	0.893%	9,703,812	6.906%
	≥ 2.5 µg/L	55	1.293%	11,131,487	7.922%
	≥ 1 µg/L	93	2.186%	16,021,388	11.402%
	> 0.5 µg/L	122	2.867%	17,384,229	12.372%
Combined Ground & Surface Water	> 5 µg/L	195	0.387%	11,945,084	5.264%
	≥ 2.5 µg/L	338	0.670%	15,948,918	7.029%
	≥ 1 µg/L	583	1.156%	23,029,531	10.149%
	> 0.5 µg/L	804	1.594%	26,098,694	11.502%

The occurrence estimates presented above (in Exhibit 21-8) are based on the conservative assumption that if a trichloroethylene detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to trichloroethylene (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of trichloroethylene). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of trichloroethylene because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of trichloroethylene (rather than the entire population-served by the system).

Exhibit 21-9 presents the Stage 1 analysis of trichloroethylene occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. A total of 769 (0.840% of) sample points, serving an estimated 4.5 million persons, reported at least one detection greater than or equal to 2.5 µg/L; and 433 (0.473% of) sample points, serving an estimated 3.3 million persons, reported at least one detection exceeding 5 µg/L. Similar to the system-level occurrence analysis, thresholds were exceeded in more ground water than surface water sample points. However, because surface water systems tend to be larger, a greater population was served by sample points with threshold exceedances.

Exhibit 21-9: Trichloroethylene Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 5 µg/L	245	0.304%	436,582	0.505%
	≥ 2.5 µg/L	478	0.593%	855,067	0.990%
	≥ 1 µg/L	910	1.129%	1,987,709	2.301%
	> 0.5 µg/L	1,301	1.614%	2,800,442	3.242%
Surface Water	> 5 µg/L	188	1.724%	2,858,740	2.034%
	≥ 2.5 µg/L	291	2.669%	3,692,244	2.628%
	≥ 1 µg/L	459	4.209%	5,214,082	3.711%
	> 0.5 µg/L	582	5.337%	6,059,333	4.312%
Combined Ground & Surface Water	> 5 µg/L	433	0.473%	3,295,321	1.452%
	≥ 2.5 µg/L	769	0.840%	4,547,311	2.004%
	≥ 1 µg/L	1,369	1.496%	7,201,791	3.174%
	> 0.5 µg/L	1,883	2.057%	8,859,775	3.905%

21.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean trichloroethylene concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 21-10 presents the Stage 2 analysis of estimated system mean concentrations for trichloroethylene occurrence in drinking water relative to several thresholds. The thresholds are: 5 µg/L, 2.5 µg/L, 1 µg/L, and 0.5 µg/L. Exhibit 21-11 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than 70 ground water and surface water systems (approximately 0.139% of all systems) had an estimated system mean greater than or equal to 2.5 µg/L. These 70 systems serve almost 4.8 million persons. Twenty-five systems (0.050% of all systems), serving about 410,000 persons, had an estimated system mean greater than 5 µg/L. More ground water systems than surface water systems had an estimated system mean greater than the MCL concentration, although a larger population was served by surface water systems with means exceeding the MCL concentration.

Exhibit 21-10: Trichloroethylene Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	18	18	18	0.039%	0.039%	0.039%
	≥ 2.5 µg/L	60	58	54	0.130%	0.126%	0.117%
	≥ 1 µg/L	209	181	160	0.453%	0.392%	0.346%
	> 0.5 µg/L	624	334	267	1.351%	0.723%	0.578%
Surface Water	> 5 µg/L	7	7	7	0.165%	0.165%	0.165%
	≥ 2.5 µg/L	10	10	10	0.235%	0.235%	0.235%
	≥ 1 µg/L	31	27	22	0.729%	0.635%	0.517%
	> 0.5 µg/L	115	54	43	2.703%	1.269%	1.011%
Combined Ground & Surface Water	> 5 µg/L	25	25	25	0.050%	0.050%	0.050%
	≥ 2.5 µg/L	70	68	64	0.139%	0.135%	0.127%
	≥ 1 µg/L	240	208	182	0.476%	0.412%	0.361%
	> 0.5 µg/L	739	388	310	1.465%	0.769%	0.615%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 21-11: Trichloroethylene Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 5 µg/L	50,410	50,410	50,410	0.058%	0.058%	0.058%
	≥ 2.5 µg/L	307,930	234,229	140,973	0.356%	0.271%	0.163%
	≥ 1 µg/L	1,911,987	1,686,897	1,347,211	2.213%	1.953%	1.559%
	> 0.5 µg/L	8,000,226	2,929,896	2,411,718	9.260%	3.391%	2.792%

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Surface Water	> 5 µg/L	359,713	359,713	359,713	0.256%	0.256%	0.256%
	≥ 2.5 µg/L	4,456,573	4,456,573	4,456,573	3.172%	3.172%	3.172%
	≥ 1 µg/L	8,458,791	6,594,945	6,051,956	6.020%	4.693%	4.307%
	> 0.5 µg/L	16,251,310	9,936,227	9,472,157	11.566%	7.071%	6.741%
Combined Ground & Surface Water	> 5 µg/L	410,123	410,123	410,123	0.181%	0.181%	0.181%
	≥ 2.5 µg/L	4,764,503	4,690,802	4,597,546	2.100%	2.067%	2.026%
	≥ 1 µg/L	10,370,778	8,281,842	7,399,167	4.570%	3.650%	3.261%
	> 0.5 µg/L	24,251,536	12,866,123	11,883,875	10.688%	5.670%	5.237%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

21.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including trichloroethylene, in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, trichloroethylene had a detection frequency of 0.92% at an assessment level of 0.2 µg/L (based on 2,400 samples). The median concentration of detections was 0.14 µg/L. Nine detections were within one order of magnitude of the MCL concentration (5 µg/L) and six detections were greater than the MCL concentration.

In public wells, trichloroethylene had a detection frequency of 4.3% at an assessment level of 0.2 µg/L (based on 1,093 samples). The median concentration of detections was 0.52 µg/L. Twenty-seven detections were within one order of magnitude of the MCL concentration and nine detections were greater than the MCL concentration.

Occurrence of Water-Quality Constituents in Domestic Wells across the United States

The USGS, in collaboration with the Centers for Disease Control and Prevention (CDC), released an online report on the occurrence of 11 priority water-quality constituents of possible health concern in domestic wells located in 16 states across the United States (Bartholomay *et al.*, 2007). Two water-quality data sets were used to define the water quality of domestic-water supplies: (1) data from the NAWQA Program, and (2) USGS state data. The common assessment level used to quantify the detection frequency of trichloroethylene was 0.2 µg/L.

A total of 1,041 wells were sampled for trichloroethylene (referred to as trichloroethene (TCE) in the study). The detection frequency for trichloroethylene was 0.8%. Less than 0.5% of samples had concentrations of trichloroethylene less than, but within one order of magnitude of, the MCL concentration (5 µg/L); 0.1% of samples had concentrations greater than the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 602 systems (approximately 2.61% of about 23,000 systems), reported at least one detection of trichloroethylene. One hundred and fifty systems (approximately 0.65% of all systems), reported at least one detection greater than the MCL concentration.

21.6 Summary of Data

TRI data indicate that the total off-site and on-site releases of trichloroethylene for the period 1998-2006 ranged from approximately 5.7 million pounds to about 13.4 million pounds. The maximum releases of trichloroethylene were in 1998, and amounts declined steadily with time. Air emissions constituted over 95% of the total releases.

Ambient water data from the NAWQA program indicate that trichloroethylene was detected in 12.8% of 6,068 ground and surface water samples and at 6.2% of 4,349 sites. The median concentration, based on detections from all sites, was 0.06 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that trichloroethylene was detected in 2.009% of 50,432 surface water and ground water systems. The median concentration, based on detections from all systems, was 1.5 µg/L. In total, 0.387% of systems (serving 5.264% of the population) reported at least one detection greater than the MCL concentration of 5 µg/L. Detections greater than the MCL concentration were more common in ground water than surface water systems. However, because surface water systems tend to be larger, a greater population was served by surface water systems reporting at least one detection greater than the MCL concentration. A similar pattern was seen for sample points.

In the Stage 2 analysis, 0.050% of all systems (serving 0.181% of the population) had an estimated system mean concentration of trichloroethylene greater than the MCL concentration. The number of systems with threshold exceedances was greater for ground water systems, but larger population were served by surface water systems with mean exceedances.

21.7 References

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22 Vinyl Chloride

This chapter on vinyl chloride is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and vinyl chloride occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

22.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for vinyl chloride on July 8, 1987 (52 FR 25690 (USEPA, 1987)). The NPDWR established a maximum contaminant level goal (MCLG) of zero based on a cancer classification of A, known human carcinogen. The NPDWR also established a maximum contaminant level (MCL) of 2 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2006), vinyl chloride (C_2H_3Cl) is a colorless, flammable gas. It has a mild, sweet odor, and can be tasted in water at concentrations greater than 3.4 parts per million. Other names for vinyl chloride include chloroethene, chloroethylene, ethylene monochloride, and monochloroethylene (ATSDR, 2006).

Most vinyl chloride enters the environment from manufacturing plants that release it into the air and water according to regulatory limits. Once in the air, vinyl chloride breaks down into simple carbon compounds within a few days. Vinyl chloride evaporates easily, so contaminated surface soils rapidly release it to the air. The presence of vinyl chloride in ground water is frequently the result of subsurface reactions among other chemicals. Vinyl chloride is not thought to accumulate in plant and animal tissues (ATSDR, 2006).

Inhalation of vinyl chloride is typical only in the vicinity of manufacturing plants, waste sites, and landfills. Tobacco smoke also contains vinyl chloride, but only at trace levels. Surveys of the presence of vinyl chloride in ground water have found it in less than 1% of wells. No current data are available on whether vinyl chloride might leach from polyvinyl chloride (PVC) pipes (ATSDR, 2006).

22.2 Use, Production, and Releases

According to ATSDR (2006), vinyl chloride once enjoyed a wide variety of uses. However, since the 1970s it has been used primarily for the production of PVC, a common plastic product. Vinyl chloride is also produced in the natural environment when other manufactured chemicals are degraded by microorganisms (ATSDR, 2006).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 22-1 presents the production of vinyl chloride in the United States from 1986 to 2002. Note that the production of vinyl chloride in the United States has exceeded 1 billion pounds since 1986.

Exhibit 22-1: Production of Vinyl Chloride in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 billion pounds
1990 Range	> 1 billion pounds
1994 Range	> 1 billion pounds
1998 Range	> 1 billion pounds
2002 Range	> 1 billion pounds

Source: USEPA, 2003a

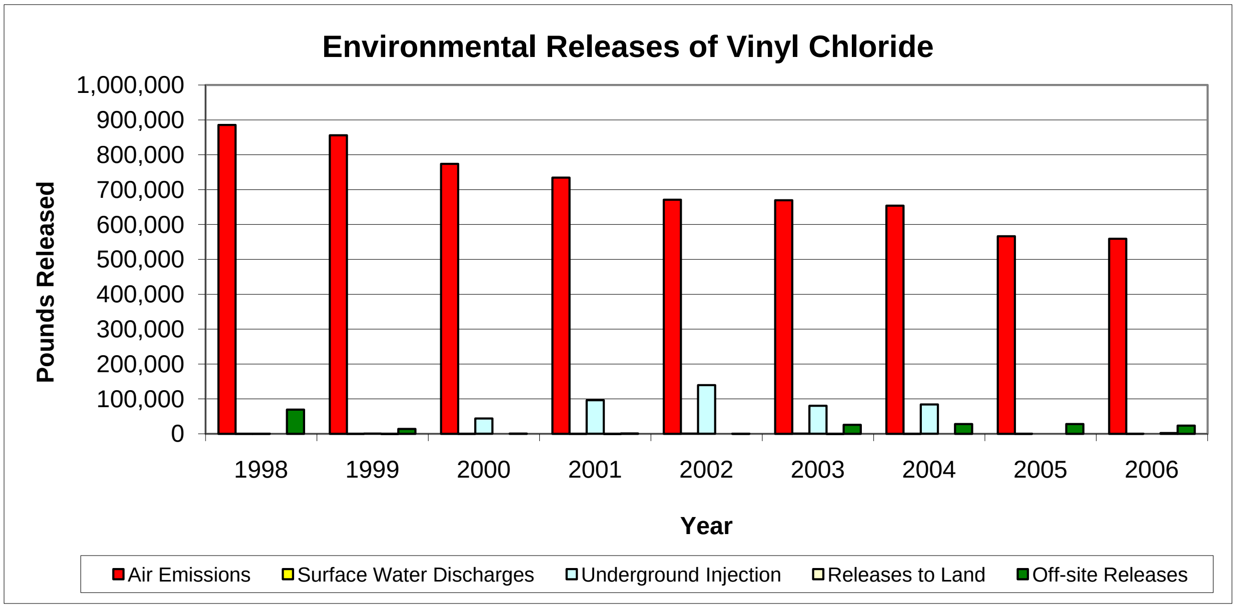
Vinyl chloride is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 22-2a lists the environmental releases of vinyl chloride between 1998 and 2006. (Exhibit 22-2b provides a graphical presentation of the environmental releases.) Total releases declined steadily during the period of review. Most releases were due to air emissions (ranging from approximately 82% to 98%). Off-site releases and underground injection provided most of the remainder of releases; both were highly variable. Surface water discharges and releases to land comprised less than 1% of the total. The TRI data for vinyl chloride were reported from 26 states, with 10 states (Delaware, Illinois, Kentucky, Louisiana, Michigan, Mississippi, Missouri, New Jersey, Ohio and Texas) reporting releases in all 9 years.

Exhibit 22-2a: Table of Toxics Release Inventory (TRI) Data for Vinyl Chloride

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	885,387	78	154	0	69,214	954,833
1999	855,691	103	405	1	14,015	870,215
2000	773,826	177	43,650	0	623	818,276
2001	734,259	102	96,042	1	1,002	831,406
2002	670,992	543	139,462	0	349	811,346
2003	669,404	389	80,154	10	25,777	775,734
2004	653,837	228	84,114	0	27,918	766,097
2005	566,475	156	0	0	28,018	594,648
2006	559,292	111	0	2,400	23,587	585,390

Source: USEPA, 2008

Exhibit 22-2b: Graph of Toxics Release Inventory (TRI) Data for Vinyl Chloride



Source: USEPA, 2008

22.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of vinyl chloride in ambient water are available from the NAWQA program.

22.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for vinyl chloride. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 22-3. Overall, vinyl chloride was detected in 1.1% of samples and at 0.8% of sites. Vinyl chloride was detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.2 µg/L. The 99th percentile concentration, based on detections from all sites, was 34 µg/L.

Exhibit 22-3: EPA Summary Analysis of Vinyl Chloride 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 Percentile	99th Percentile	Maximum
ground water	4,659	0.8%	4,159	0.6%	0.01	0.45	29	32	32
surface water	1,414	1.8%	191	4.7%	0.01	0.043	1.6	34	34
all sites	6,073	1.1%	4,350	0.8%	0.01	0.2	8.13	34	34

1. RLs (Reporting Limits) for vinyl chloride varied, but did not exceed 0.01 µg/L.

22.4 Occurrence in Drinking Water

Vinyl chloride is regulated as a volatile organic compound (VOC) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of vinyl chloride occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA's Drinking Water program to date.

All of the Six-Year Review-ICR states provided occurrence data for vinyl chloride. These data consist of 373,161 analytical results from 50,411 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for vinyl chloride in the dataset is 0.5 µg/L.

22.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 22-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For vinyl chloride, 0.411% of 50,411 systems reported detections. Exhibit 22-5 lists the minimum, median, 90th percentile, and maximum vinyl chloride concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of vinyl chloride, based on detections from all systems, was 0.89 µg/L.

Exhibit 22-4: Vinyl Chloride Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	288,671	46,158	80,487	86,057,502	86,057,502
Surface Water	84,490	4,253	10,861	140,406,921	140,406,921

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Combined Ground & Surface Water	373,161	50,411	91,348	226,464,423	226,464,423
Percent with Detections					
Ground Water	0.137%	0.349%	0.245%	1.388%	0.783%
Surface Water	0.183%	1.082%	0.552%	1.663%	0.669%
Combined Ground & Surface Water	0.147%	0.411%	0.281%	1.558%	0.712%

Exhibit 22-5: Vinyl Chloride Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.8	4.6	46.5
Surface Water	0.3	1	2.48	37.7
Combined Ground & Surface Water	0.01	0.89	3.545	46.5

The following maps illustrate the geographic distribution of vinyl chloride occurrence in drinking water. Exhibit 22-6 shows the states with systems with at least one detection and Exhibit 22-7 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of vinyl chloride is geographically dispersed. Detection rates were generally low; although 36 states reported detections of vinyl chloride, only 4 states reported detections in more than 1% of their systems. Twenty-two states reported detections greater than the MCL concentration of 2 µg/L, but none of these states reported more than 0.5% of systems with detections greater than 2 µg/L.

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Exhibit 22-6: Percentage of Systems with at Least One Vinyl Chloride Detection, by State

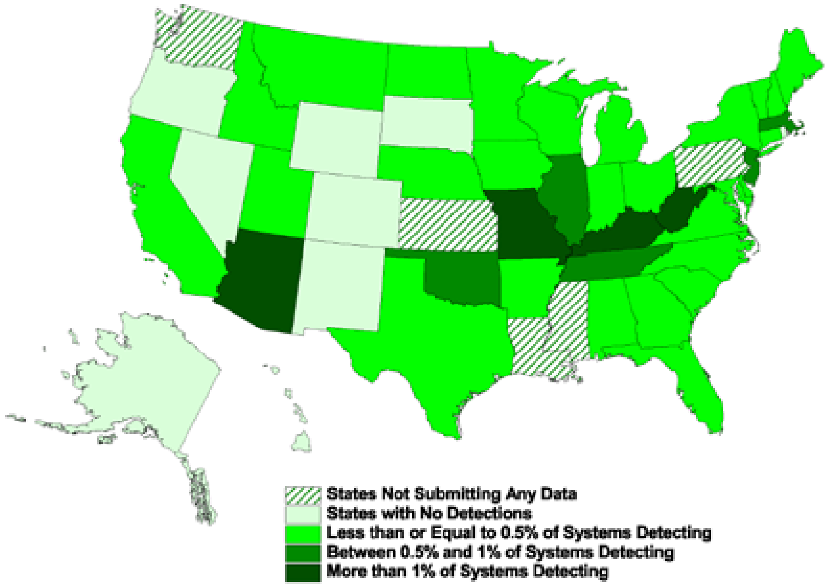

Exhibit 22-7: Percentage of Systems with at Least One Vinyl Chloride Detection Greater than the MCL Concentration (> 2 μg/L), by State

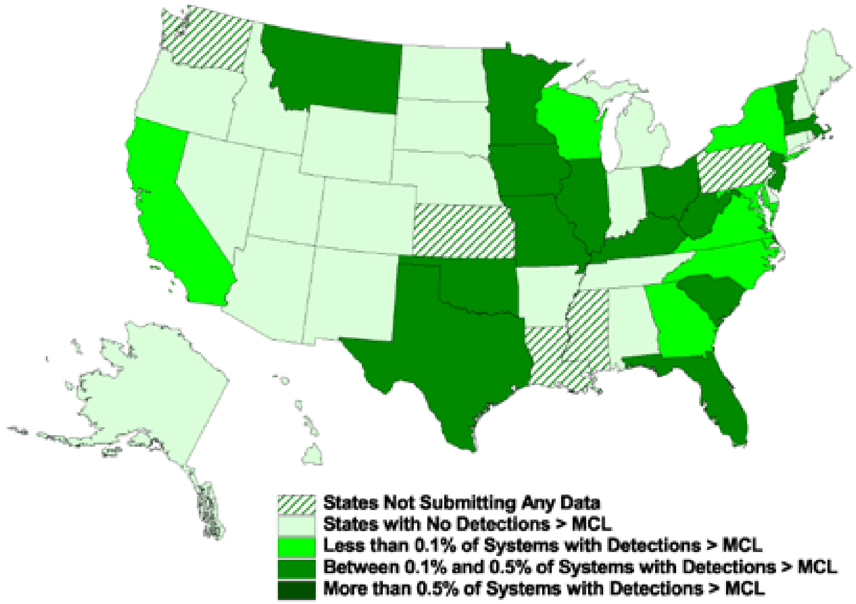

Exhibit 22-8 presents the Stage 1 analysis of vinyl chloride occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 2 µg/L, 1 µg/L, and 0.5 µg/L. A total of 84 systems (0.167% of all systems), serving about 896,000 persons, reported at least one detection greater than or equal to 1 µg/L; and 41 systems (0.081% of all systems), serving approximately 482,000 persons, reported at least one detection greater than the MCL concentration of 2 µg/L.

Exhibit 22-8: Vinyl Chloride Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 2 µg/L	31	0.067%	334,543	0.389%
	≥ 1	63	0.136%	427,229	0.496%
	> 0.5 µg/L	113	0.245%	825,343	0.959%
Surface Water	> 2 µg/L	10	0.235%	147,536	0.105%
	≥ 1	21	0.494%	468,912	0.334%
	> 0.5 µg/L	33	0.776%	1,621,211	1.155%
Combined Ground & Surface Water	> 2 µg/L	41	0.081%	482,079	0.213%
	≥ 1	84	0.167%	896,141	0.396%
	> 0.5 µg/L	146	0.290%	2,446,554	1.080%

The occurrence estimates presented above (in Exhibit 22-8) are based on the conservative assumption that if a vinyl chloride detection is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to vinyl chloride (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of vinyl chloride). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of vinyl chloride because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of vinyl chloride (rather than the entire population-served by the system).

Exhibit 22-9 presents the Stage 1 analysis of vinyl chloride occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. A total of 93 (0.102% of) sample points, serving an estimated 432,000 persons, reported at least one detection greater than or equal to 1 µg/L; and 44 (0.048% of) sample points, serving an estimated 281,000 persons, reported at least one detection exceeding the MCL concentration of 2 µg/L.

Exhibit 22-9: Vinyl Chloride Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 2 µg/L	33	0.041%	220,102	0.256%
	≥ 1	70	0.087%	280,092	0.325%
	> 0.5 µg/L	137	0.170%	416,459	0.484%
Surface Water	> 2 µg/L	11	0.101%	60,566	0.043%
	≥ 1	23	0.212%	151,515	0.108%
	> 0.5 µg/L	38	0.350%	757,509	0.540%
Combined Ground & Surface Water	> 2 µg/L	44	0.048%	280,669	0.124%
	≥ 1	93	0.102%	431,607	0.191%
	> 0.5 µg/L	175	0.192%	1,173,969	0.518%

22.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean vinyl chloride concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 22-10 presents the Stage 2 analysis of estimated system mean concentrations for vinyl chloride occurrence in drinking water relative to several thresholds. The thresholds are: 2 µg/L, 1 µg/L, and 0.5 µg/L. Exhibit 22-11 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no more than 21 ground water and surface water systems (approximately 0.042% of all systems) had an estimated system mean greater than or equal to 1 µg/L. These 21 systems serve 56,161 persons. Eleven systems (0.022% of all systems), serving 13,843 persons, had an estimated system mean greater than the MCL concentration of 2 µg/L.

Exhibit 22-10: Vinyl Chloride Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 2 µg/L	10	9	7	0.022%	0.019%	0.015%
	≥ 1	20	17	14	0.043%	0.037%	0.030%
	> 0.5 µg/L	104	41	28	0.225%	0.089%	0.061%
Surface Water	> 2 µg/L	1	1	1	0.024%	0.024%	0.024%
	≥ 1	1	1	1	0.024%	0.024%	0.024%
	> 0.5 µg/L	32	8	4	0.752%	0.188%	0.094%
Combined Ground & Surface Water	> 2 µg/L	11	10	8	0.022%	0.020%	0.016%
	≥ 1	21	18	15	0.042%	0.036%	0.030%
	> 0.5 µg/L	136	49	32	0.270%	0.097%	0.063%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 22-11: Vinyl Chloride Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 2 µg/L	12,478	10,793	4,688	0.014%	0.013%	0.005%
	≥ 1 µg/L	54,796	21,736	16,526	0.064%	0.025%	0.019%
	> 0.5 µg/L	712,162	338,964	71,559	0.828%	0.394%	0.083%
Surface Water	> 2 µg/L	1,365	1,365	1,365	0.001%	0.001%	0.001%
	≥ 1	1,365	1,365	1,365	0.001%	0.001%	0.001%
	> 0.5 µg/L	1,363,671	426,745	411,827	0.971%	0.304%	0.293%
Combined Ground & Surface Water	> 2 µg/L	13,843	12,158	6,053	0.006%	0.005%	0.003%
	≥ 1	56,161	23,101	17,891	0.025%	0.010%	0.008%
	> 0.5 µg/L	2,075,833	765,709	483,386	0.917%	0.338%	0.213%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

22.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including vinyl chloride, in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, vinyl chloride had a detection frequency of 0.083% at an assessment level of 0.2 µg/L (based on 2,401 samples). The median concentration of detections was 0.74 µg/L. Two detections were within one order of magnitude of the MCL concentration (2 µg/L). No detections were greater than the MCL concentration.

In public wells, vinyl chloride had a detection frequency of 0.18% at an assessment level of 0.2 µg/L (based on 1,096 samples). The median concentration of detections was 3.2 µg/L. No detections were within one order of magnitude of the MCL concentration; however, two detections were greater than the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 149 systems (approximately 0.61% of about 25,000 systems), reported at least one detection of vinyl chloride. Twenty-seven systems (approximately 0.11% of all systems), reported at least one detection greater than the MCL concentration.

22.6 Summary of Data

TRI data indicate that the total off-site and on-site releases of vinyl chloride for the period 1998 to 2006 ranged from about 585,000 pounds to about 955,000 pounds, declining steadily with time. Air emissions constituted nearly all of the releases; off-site releases and underground injection contributed a few percent to the total. Releases to land and surface water discharges were a minimal fraction of the total releases.

Ambient water data from the NAWQA program indicate that vinyl chloride was detected in 1.1% of 6,073 ground and surface water samples and at 0.8% of 4,350 sites. The median concentration, based on detections from all sites, was 0.2 µg/L.

The Stage 1 analysis of occurrence in drinking water indicates that vinyl chloride was detected in 0.411% of 50,411 surface water and ground water systems. The median concentration, based on detections from all systems, was 0.89 µg/L. In total, 0.081% of systems (serving 0.213% of the population) reported at least one detection greater than the MCL concentration of 2 µg/L.

In the Stage 2 analysis, 0.022% of all systems (serving 0.006% of the population) had an estimated system mean concentration of vinyl chloride greater than the MCL concentration. These included 10 ground water systems and one surface water system, serving about 12,478 persons and 1,365 persons, respectively.

22.7 References

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Zogorski, J.S., J.M. Carter, T. Ivahnenko, W.W. Lapham, M.J. Moran, B.L. Rowe, P.J. Squillace, and P.L. Toccalino. 2006. Volatile organic compounds in the nation's ground water and drinking water supply wells. U.S. Geological Survey Circular 1292, 101 p. Available on the Internet at: http://pubs.er.usgs.gov/pubs/cir/cir1292.

23 Xylenes (Total)

This chapter on xylenes (total) is part of a report that is organized so that each chapter presents information on one specific contaminant. Chapter 1 of this report, Introduction, presents background information on all sources of data used as well as the analytical approach used to estimate contaminant occurrence in drinking water. This contaminant chapter includes background information (such as regulatory history, general chemical information, and environmental fate and behavior), use and environmental release information, and total xylenes occurrence estimates in ambient water and drinking water. All drinking water occurrence estimates were based on data from the National Compliance Monitoring Information Collection Request (ICR) Dataset for the Second Six-Year Review (the "Six Year Review-ICR Dataset"). For detailed information regarding this dataset, data management, data quality assessments, and the analytical approach used to generate all contaminant occurrence estimates presented in this chapter, please refer to USEPA (2009).

23.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for total xylenes on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 10,000 µg/L. The Agency based the MCLG on a reference dose (RfD) of 2,000 µg/kg-day (2 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2007), xylene is a colorless, flammable liquid with a sweet odor. There are three isomers of xylene: meta-xylene, ortho-xylene, and para-xylene (m-, o-, and p-xylene, respectively). The term "total xylenes" refers to all three isomers of xylene. Commercial or mixed xylene typically contains about 40-65% m-xylene and up to 20% each of o-xylene, p-xylene, and ethylbenzene (ATSDR, 2007). Xylene is a synthetic chemical primarily produced from petroleum. Xylene also occurs naturally in petroleum and coal tar and, to a small extent, is formed during forest fires (ATSDR, 2007).

Xylene can enter the environment when it is manufactured, packaged, shipped, or used. Because xylene evaporates easily, most xylene that gets into soil and water will enter the air, where it is broken down by sunlight within a couple of days. Xylene below the soil surface may travel down through the soil and enter ground water, where it may remain for several months before being broken down by microorganisms (ATSDR, 2007).

Humans may come into contact with xylene when using a variety of consumer products, including gasoline, paint, varnish, shellac, rust preventatives, and cigarette smoke. Workers who routinely come into contact with xylene-containing solvents are at the highest risk. Xylene has also been detected in many types of food at levels ranging from 1 to 100 parts per billion (ppb). Typical levels of xylene measured in outdoor air in the United States range from 1 to 30 ppb (ATSDR, 2007).

23.2 Use, Production, and Releases

Xylene is primarily used as a solvent in the printing, rubber, and leather industries. Along with other solvents, xylene is widely used as a cleaning agent and paint thinner. It is also found in small amounts in airplane fuel and gasoline (ATSDR, 2007).

The Toxic Substances Control Act (TSCA) Inventory contains confidential data reported by industry as a partial update of the Chemical Substance Inventory Update System. The data are reported under the Inventory Update Reporting regulation. Manufacturers and importers are required to report company information and chemical information, including production volumes for chemicals they manufactured or imported in excess of 10,000 pounds in the immediately preceding fiscal year.

The TSCA Chemical Substance Inventory does not provide actual production volumes; instead, it indicates at which of five production volume ranges a chemical was manufactured or imported. The TSCA Inventory is updated every four years. Exhibit 23-1 presents the production of total xylenes in the United States from 1986 to 2002. Note that the production of total xylenes in the United States has remained greater than 1 billion pounds since 1986.

Exhibit 23-1: Production of Xylenes (Total) in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 billion pounds
1990 Range	> 1 billion pounds
1994 Range	> 1 billion pounds
1998 Range	> 1 billion pounds
2002 Range	> 1 billion pounds

Source: USEPA, 2003a

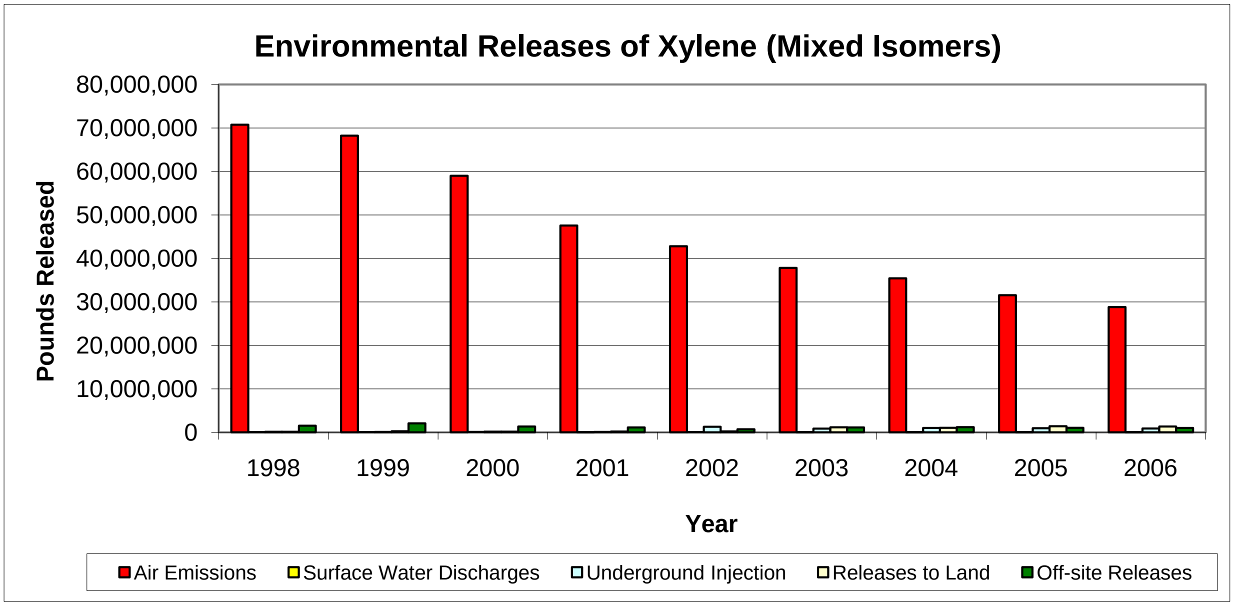
Xylenes (mixed isomers) is listed as a Toxics Release Inventory (TRI) chemical. Exhibit 23-2a lists the environmental releases of xylenes from 1998 to 2006. (Exhibit 23-2b provides a graphical presentation of the environmental releases.) Total releases declined steadily during the period of record. Air emissions comprised more than 90% of the total. Off-site releases were generally the second most important component. Land releases and underground injection abruptly increased in 2002 and 2003. Surface water discharges and underground injection were generally less than 1% of the total. The TRI data for xylenes (mixed isomers) were reported from all 50 states, plus American Samoa, Guam, the Northern Mariana Islands, Puerto Rico, and the Virgin Islands. All states/entities except for American Samoa reported xylene (mixed isomers) releases in all nine years.

Exhibit 23-2a: Table of Toxics Release Inventory (TRI) Data for Xylene (Mixed Isomers)

Year	On-Site Releases (pounds)				Off-site Releases (pounds)	Total On- & Off-site Releases (pounds)
	Total Air Emissions	Surface Water Discharges	Underground Injection	Releases to Land		
1998	70,752,076	57,504	124,285	110,051	1,510,412	72,554,328
1999	68,221,056	30,098	87,440	252,417	2,072,728	70,663,739
2000	58,994,999	82,264	151,148	142,558	1,338,504	60,709,473
2001	47,569,339	21,732	80,941	177,289	1,137,209	48,986,510
2002	42,797,703	42,840	1,274,919	220,451	690,481	45,026,395
2003	37,826,840	27,383	850,266	1,149,247	1,112,708	40,966,443
2004	35,408,702	28,551	991,687	1,034,448	1,186,781	38,650,169
2005	31,527,622	20,812	943,046	1,404,603	1,036,594	34,932,677
2006	28,806,761	14,075	866,934	1,322,519	1,000,118	32,010,408

Source: USEPA, 2008

Exhibit 23-2b: Graph of Toxics Release Inventory (TRI) Data for Xylene (Mixed Isomers)



Source: USEPA, 2008

23.3 Occurrence in Ambient Water

Lakes, rivers, and aquifers are the sources of most drinking water. The United States Geological Survey (USGS) National Water Quality Assessment (NAWQA) program is a national-scale assessment of the occurrence of contaminants in ambient surface and ground water. Contaminant occurrence in ambient water provides information on the potential for contaminants to adversely affect drinking water supplies. Data on the occurrence of total xylenes in ambient water are available from the NAWQA program.

23.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 (1992-2001) water monitoring data from all study units for total xylenes. Detection frequencies were computed as the percentage of samples and sites with detections (i.e., with at least one result equal to or greater than the reporting limit). 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.

The results of the EPA analysis are presented in Exhibit 23-3. Overall, xylenes (total) were detected in 1.4% of samples and at 1.4% of sites. Xylenes were detected more frequently in surface water than in ground water. The median concentration, based on detections from all sites, was 0.7 µg/L. The 99th percentile concentration, based on detections from all sites, was 300 µg/L.

Exhibit 23-3: EPA Summary Analysis of Xylenes (Total) 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
ground water	1,840	1.3%	1,731	1.2%	0.2	0.8	42	300	300
surface water	36	11.1%	19	15.8%	0.2	0.25	5.2	5.2	5.2
all sites	1,876	1.4%	1,750	1.4%	0.2	0.7	42	300	300

1. RLs (Reporting Limits) for xylenes (total) varied, but did not exceed 0.2 µg/L.

23.4 Occurrence in Drinking Water

Xylenes are regulated as volatile organic compounds (VOCs) in drinking water. All non-purchased community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for VOCs. The maximum waiver period for VOCs is six years for ground water systems and three years for surface water systems.

All CWSs and NTNCWSs must collect four consecutive quarterly samples during the initial three-year compliance period.[1] If all four samples are non-detections, then the system may reduce to annual sampling. After three annual samples without a detection, a system may be granted a waiver. If a compound is detected (but at less than the MCL), the system must take one sample per quarter until results are below the MCL (minimum of two quarterly samples for ground water systems and four quarterly samples for surface water systems). If all quarterly samples are below the MCL, the system may return to annual sampling. If a compound is detected at a level greater than the MCL, the system (whether ground water or surface water) must take four consecutive quarterly samples until all are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of xylenes occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest and most comprehensive compliance monitoring data set compiled by EPA to date.

Forty-four of the Six-Year Review-ICR states provided occurrence data for xylenes. (There were no data for xylenes from Hawaii.) These data consist of 363,466 analytical results from 47,698 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness. The national modal minimum reporting level (MRL) for xylenes in the dataset is 0.5 µg/L.

23.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample, sample point, and system levels. Note that some systems have multiple sample points, such as source water sample points or entry points to the distribution system. Exhibit 23-4 presents the number of samples, systems, and sample points in the data set, as well as the population-served by the systems and sample points, and the percentage of detections and the percentage of the population-served by the systems and sample points with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For xylenes, 7.592% of 47,698 systems reported detections. Exhibit 23-5 lists the minimum, median, 90th percentile, and maximum xylenes concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of xylenes, based on detections from all systems, was 1.1 µg/L.

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[1] All new systems or systems using a new water source that began operation after January 22, 2004 must demonstrate compliance with the MCL within a period of time specified by the State. The system must also comply with the initial sampling frequencies specified by the State to ensure that a system can demonstrate compliance with the MCL.

Exhibit 23-4: Xylenes (Total) Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Number of Sample Points	Pop. Served by Systems	Pop. Served by Sample Points
Total Number					
Ground Water	281,787	43,726	76,361	83,748,512	83,748,512
Surface Water	81,679	3,972	10,162	134,323,023	134,323,023
Combined Ground & Surface Water	363,466	47,698	86,523	218,071,535	218,071,535
Percent with Detections					
Ground Water	2.811%	7.275%	5.336%	13.222%	4.896%
Surface Water	1.654%	11.078%	5.757%	20.134%	5.806%
Combined Ground & Surface Water	2.551%	7.592%	5.386%	17.480%	5.457%

Exhibit 23-5: Xylenes (Total) Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	1.1	8.1	4,000
Surface Water	0.002	1	8.3	1,860
Combined Ground & Surface Water	0.002	1.1	8.1	4,000

Exhibit 23-6 illustrates the geographic distribution of xylenes occurrence in drinking water, identifying the states with systems having at least one detection. Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Hawaii did submit Six-Year data for most contaminants, but did not submit any data for xylenes.

The distribution of systems with detections of xylenes is geographically dispersed. Detection rates were generally high; all states reported detections in at least one of their systems.

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[2] Kansas submitted data after the data management and analyses had been conducted; data from Kansas are not included in the analyses.

Five states reported detections in more than 20% of their systems. No states reported detections greater than the MCL concentration of 10,000 µg/L.

Exhibit 23-6: Percentage of Systems with at Least One Xylenes Detection, by State

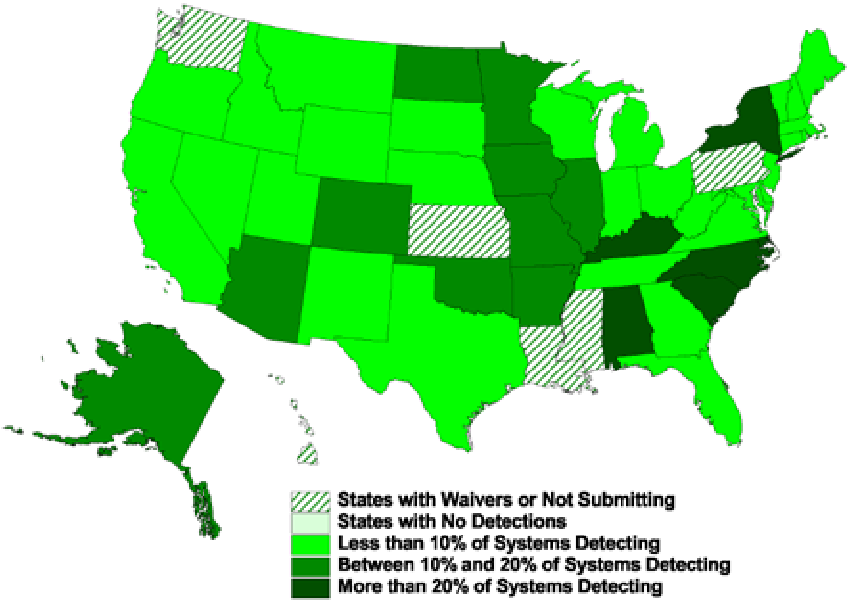

Exhibit 23-7 presents the Stage 1 analysis of xylenes occurrence in drinking water from systems and the population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds. The thresholds are: 10,000 µg/L, 5,000 µg/L, and 1,000 µg/L. Xylenes occurred in more ground water systems than surface water systems, which reported at least one detection greater than 1,000 µg/L. No ground or surface water systems reported detections of xylenes greater than or equal to 5,000 µg/L or 10,000 µg/L.

Exhibit 23-7: Xylenes (Total) Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Ground Water	> 10,000 µg/L	0	0.000%	0	0.000%
	≥ 5,000 µg/L	0	0.000%	0	0.000%
	≥ 1 µg/L	9	0.021%	2,344	0.003%

Source Water Type	Threshold	Number of Systems Exceeding Threshold	Percent of Systems Exceeding Threshold	Total Population-Served by Systems Exceeding Threshold	Percent of Population-Served by Systems Exceeding Threshold
Surface Water	> 10,000 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥ 1	1	0.025%	1,785	0.001%
Combined Ground & Surface Water	> 10,000 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥ 1	10	0.021%	4,129	0.002%

The occurrence estimates presented above (in Exhibit 23-7) are based on the conservative assumption that if a detection of xylenes is found in a single entry point/sample point in a system, then the entire population-served by the system is assumed to potentially be exposed to xylenes (even though other entry points/sampling points at the system, and the population-served by those entry/sample points, may exhibit no occurrence of xylenes). The sample point analysis is a less conservative estimate of the population-served by a system with a detection of xylenes because it estimates the potentially exposed population-served based only on the proportion of the population-served by entry points/sample points with detections of xylenes (rather than the entire population-served by the system).

Exhibit 23-8 presents the Stage 1 analysis of xylenes occurrence in drinking water from sample points and population-served by those sample points in the Six-Year Review-ICR Dataset. Similar to the system-level occurrence analysis, xylenes were detected in more ground water than surface water sample points at levels greater than 1,000 µg/L. Xylenes were never detected at levels greater than or equal to 5,000 µg/L or 10,000 µg/L.

Exhibit 23-8: Xylenes (Total) Stage 1 Analysis – Sample Points and Population with at Least One Threshold Exceedance

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Ground Water	> 10,000 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥ 1	9	0.012%	1,525	0.002%

Source Water Type	Threshold	Number of Sample Points Exceeding Threshold	Percent of Sample Points Exceeding Threshold	Total Population-Served by Sample Points Exceeding Threshold	Percent of Population-Served by Sample Points Exceeding Threshold
Surface Water	> 10,000 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥ 1	1	0.010%	1,785	0.001%
Combined Ground & Surface Water	> 10,000 µg/L	0	0.000%	0	0.000%
	≥	0	0.000%	0	0.000%
	≥ 1	10	0.012%	3,310	0.002%

23.4.2 Stage 2 Analysis of Occurrence Data

For the Stage 2 analyses, three different substitution values –zero, one-half the MRL value, and the full MRL value– were used to replace each non-detection record. Three arithmetic mean xylene concentrations were calculated at each system using the zero, one-half MRL and full MRL substitution values. These mean calculations were done for all systems with data in the Six-Year Review-ICR dataset. Then the percentages of all systems with a mean concentration greater than each threshold were calculated.

Exhibit 23-9 presents the Stage 2 analysis of estimated system mean concentrations for xylenes occurrence in drinking water relative to several thresholds. The thresholds are: 10,000 µg/L, 5,000 µg/L, and 1,000 µg/L. Exhibit 23-10 presents similar information based on population-served by the systems. Based on the Stage 2 analyses, no ground water or surface water systems had estimated system means greater than or equal to any of the thresholds.

Exhibit 23-9: Xylenes (Total) Stage 2 Analysis – Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 10,000 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
Surface Water	> 10,000 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%

Source Water Type	Threshold	Number of Systems with Mean Exceeding Threshold[1]			Percent of Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Combined Ground & Surface Water	> 10,000 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ µg/L	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

Exhibit 23-10: Xylenes (Total) Stage 2 Analysis – Population-Served by Systems with a System Mean Threshold Exceedance

Source Water Type	Threshold	Population-Served by Systems with Mean Exceeding Threshold[1]			Percent of Population-Served by Systems with Mean Exceeding Threshold[1]		
		Full MRL	½ MRL	Zero	Full MRL	½ MRL	Zero
Ground Water	> 10,000 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
Surface Water	> 10,000 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%
Combined Ground & Surface Water	> 10,000 µg/L	0	0	0	0.000%	0.000%	0.000%
	≥	0	0	0	0.000%	0.000%	0.000%
	≥ 1	0	0	0	0.000%	0.000%	0.000%

1. The results shown in this table are based on system arithmetic means that were calculated using all sample detection records and all non-detection records, with the non-detection records replaced (substituted) with concentration values equal to the full MRL, ½ MRL, and zero.

23.5 Additional Occurrence Data

Volatile Organic Compounds in the Nation's Ground Water and Drinking Water Supply Wells

The USGS conducted a national assessment of 55 VOCs, including *o*-, *m*- and *p*-xylenes, in samples collected from drinking water supply wells, specifically domestic and public wells (Zogorski *et al.*, 2006). This occurrence assessment was based on analyses of samples collected at the well head, and before any treatment or blending, from about 2,400 domestic wells and about 1,100 public wells.

In domestic wells, total xylenes had a detection frequency of 0.21% at an assessment level of 0.2 µg/L (based on 2,388 samples). The median concentration of detections was 0.020 µg/L. No detections were greater than or within one order of magnitude of the MCL concentration (10,000 µg/L).

In public wells, total xylenes had a detection frequency of 0.56% at an assessment level of 0.2 µg/L (based on 1,069 samples). The median concentration of detections was 0.44 µg/L. No detections were greater than or within one order of magnitude of the MCL concentration.

First Six-Year Review of NPDWRs

Similar types of Stage 1 contaminant occurrence analyses were conducted for the first Six-Year Review. The first Six-Year Review assessed regulated contaminant occurrence data collected from 1993 to 1997. The first Six-Year Review data set consisted of data from 16 states that were assembled into a “national cross-section” that was qualitatively indicative (though not statistically representative) of national occurrence. For the first Six-Year Review (USEPA, 2003b), 919 systems (approximately 4.16% of about 22,000 systems), reported at least one detection of xylenes. No systems reported a detection greater than the MCL concentration.

23.6 Summary of Data

TRI data indicate that the total off-site and on-site releases of xylenes for the period 1998-2006 ranged from about 32 million pounds to about 72.5 million pounds. Releases were greatest in 1998 and decreased steadily with time. Air emissions comprised more than 90% of the total releases. Off-site releases and releases to land were the second and third most important contributors. Surface water discharges and underground injection were a very small fraction of the total releases.

Ambient water data from the NAWQA program indicate that xylenes were detected in 1.4% of 1,876 ground and surface water samples and at 1.4% of 1,750 sites. The median concentration, based on detections from all sites, was 0.7 µg/L.

The Stage 1 analysis of occurrence in drinking water indicate that xylenes were detected in 7.592% of 47,698 surface water and ground water systems. The median concentration, based on detections from all systems, was 1.1 µg/L. No systems reported detections greater than 5,000 µg/L or the MCL concentration of 10,000 µg/L. Nine ground water systems and one surface water system reported at least one detection greater than 1,000 µg/L. The pattern was the same for sample points.

In the Stage 2 analysis, no systems had an estimated system mean concentration of xylenes greater than any of the thresholds.

23.7 References

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