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Contaminant Occurrence Support Document for Category 2 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.

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Executive Summary

This document provides occurrence-related background information on 47 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"). For the second Six-Year Review, these 47 regulated contaminants are referred to as the "Category 2" contaminants. The "Category 1" contaminants (discussed in a separate report) are those regulated contaminants with 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 Category 2 contaminants discussed in this report are the regulated contaminants that meet some, but not all, of the occurrence, health effects, or laboratory analytical factors defining the Category 1 contaminants. For example, some Category 2 contaminants might exhibit moderately high occurrence nationally, but research on their health effects is still in progress and has not yet concluded. A list of the 47 regulated contaminants assessed here is included in this document's Table of Contents.

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. Only the Stage 1 analyses were conducted for the 47 contaminants assessed in this report.

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 population-served by systems nationwide that reported at least one sample analytical result greater than a contaminant's Maximum Contaminant Level (MCL) concentration, the drinking water contaminant standard. This provides a preliminary estimate of potential exposure to a drinking water contaminant at concentrations of health concerns. Based on this measure, the range of occurrence (highest to lowest) and the top five occurring contaminants were estimated, grouped by chemical (i.e., inorganic chemicals [IOCs], synthetic organic chemicals [SOCs], volatile organic compounds [VOCs]), and are summarized below. The results for the four regulated radionuclides assessed are also summarized below.

IOC occurrence ranged from a high of nitrate with 7.310% (of the total population-served by systems reporting at least one detection greater than the nitrate MCL concentration) to a low of barium with 0.092% (relative to the barium MCL concentration). The top five occurring IOCs based on this Stage 1 measure are nitrate (7.310%), nitrite (4.840%), antimony (1.505%), beryllium (1.505%), and arsenic (1.240%). (Note: The percentage of arsenic is based on the former MCL concentration of 0.05 mg/L that was in effect when the compliance monitoring data, used for the second Six-Year Review analysis, were collected. Additional analyses were conducted relative to the current arsenic MCL concentration of 0.01 mg/L.) These detections represent single detections and are not representative of MCL violations.

SOC occurrence ranged from a high of di(2-ethylhexyl)phthalate with 6.397% (of the total population-served by PWSs reporting at least one detection greater than the MCL concentration) to a low of 0.000% for diquat, endrin, glyphosate, methoxychlor, picloram, and silvex. The top five occurring SOCs based on this Stage 1 measure are di(2-ethylhexyl)phthalate (6.397%), atrazine (1.551%), ethylene dibromide (1.201%), benzo(a)pyrene (0.117%), and polychlorinated biphenyls (0.101%). These detections represent single detections and are not representative of MCL violations. Note: The high occurrence of di(2-ethylhexyl)phthalate could be due, in part, to sample contamination from older generation laboratory and field sampling equipment made of plastics that contained (and sometimes released) phthalates.

VOC occurrence ranged from a high of 1,1-dichloroethylene with 2.517% (of the total population-served by PWSs reporting at least one detection greater than the 1,1-dichloroethylene MCL concentration) to a low of 0.000% for 1,2-dichlorobenzene, trans-1,2-dichloroethylene, ethylbenzene, monochlorobenzene, 1,2,4-trichlorobenzene, and 1,1,1-trichloroethane. The top four occurring VOCs based on this measure are 1,1-dichloroethylene (2.517%), cis-1,2-dichloroethylene (0.074%), 1,4-dichlorobenzene (0.044%), and styrene (0.001%). These detections represent single detections and are not representative of MCL violations.

The national occurrence of four radionuclides was also assessed using the same Stage 1 analysis that provides a preliminary estimate of exposure. Based on the measure of the percent of total population-served by PWSs reporting at least one detection greater than each contaminant's MCL concentration, the highest occurring radionuclide is uranium (11.884%). These detections represent single detections and are not representative of MCL violations.

These IOC, SOC, VOC, and radionuclide occurrence measures (based on the percentage of population-served) are quite similar to the findings for measures reflecting occurrence for PWSs. Additional occurrence details are presented in the report such as occurrence estimates by source water type and estimates for the actual numbers of PWSs and population-served numbers (in addition to the percentages presented above).

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Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CDD	Chlorinated Dibenzo-p-dioxins
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cr(0)	Chromium element
Cr(III)	Chromium valence state III
Cr(VI)	Chromium valence state VI or hexavalent Chromium
CWS	Community Water System
1,4-DCB	1,4,-Dichlorobenzene
DDT	Dichlorodiphenyltrichloroethane
1,2-DCE	1,2-Dichloroethylene
DEHA	Di(2-ethylhexyl)adipate
DEHP	Di(2-ethylhexyl)phthalate
DWEL	Drinking Water Equivalent Level
EDB	Ethylene Dibromide
EPA	Environmental Protection Agency (United States)
EPCRA	Emergency Planning and Community Right-to-Know Act
EXTOXNET	EXtension TOXicology NETwork
FR	Federal Register
HCH	Hexachlorocyclohexane
HSDB	Hazardous Substances Data Bank
ICR	Information Collection Request
IOC	Inorganic Chemical
IUR	Inventory Update Reporting
LCR	Lead and Copper Rule
LOAEL	Lowest Observed Adverse Effect Level
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MFL	million fibers per liter

mg	milligram
mg/kg/day	milligrams per kilogram per day
mg/L	milligrams per liter
MRL	Minimum Reporting Level
Mrem/yr	Millirems per year
NAWQA	National Water Quality Assessment
ND	Not Detected
NLM	National Library of Medicine
NPDWR	National Primary Drinking Water Regulation(s)
NTNCWS	Non-Transient Non-Community Water System
OGWDW	Office of Ground Water and Drinking Water
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
ppb	parts per billion
ppm	parts per million
PVC	Polyvinyl chloride
PWS	Public Water System
QA/QC	Quality Assurance / Quality Control
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RED	Reregistration Eligibility Decision
RL	Reporting Limit
RSC	Relative Source Contribution
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SOC	Synthetic Organic Chemical
SRP	Scientific Review Panel
1,2,4-TCB	1,2,4-Trichlorobenzene
TNCWS	Transient Non-Community Water Systems

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
USBR	United States Bureau of Reclamation

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 47 of those regulated contaminants. The remaining 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. This report’s focus is on the 47 contaminants 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, an 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 48 present information specific to each of the Category 2 regulated drinking water contaminants that EPA is reviewing under this second Six-Year Review. The Table of Contents provides a list of the Category 2 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 1 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 32 of the 47 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 six of the Category 2 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 Hazardous Substances Data Bank

The Hazardous Substances Data Bank (HSDB) is a toxicology data file on the National Library of Medicine’s (NLM) Toxicology Data Network (TOXNET®). It focuses on the toxicology of potentially hazardous chemicals and also includes information on human exposure, industrial hygiene, emergency handling procedures, environmental fate, regulatory requirements, and related areas. All data are referenced and derived from a core set of books, government documents, technical reports and selected primary journal literature. HSDB is peer-reviewed by the Scientific Review Panel (SRP), a committee of experts in the major subject areas within the data bank’s scope. HSDB is organized into individual chemical records for over 4,500 compounds, five of which are Category 2 contaminants discussed in this report (HSDB, 2006). These data were used to provide background information for some of the Category 2 contaminants.

1.3.4 United States Geological Survey Pesticide Use Maps

The USGS has produced maps of pesticide use for 244 compounds used in United States crop production, 6 of which are Category 2 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).

1.3.5 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 25 of the 47 contaminants discussed in this report (USEPA, 2003b).

1.3.6 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 33 of the 47 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).

1.3.7 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. Data are available from the NAWQA program for 29 of the Category 2 contaminants. 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.

1.3.8 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 public water systems 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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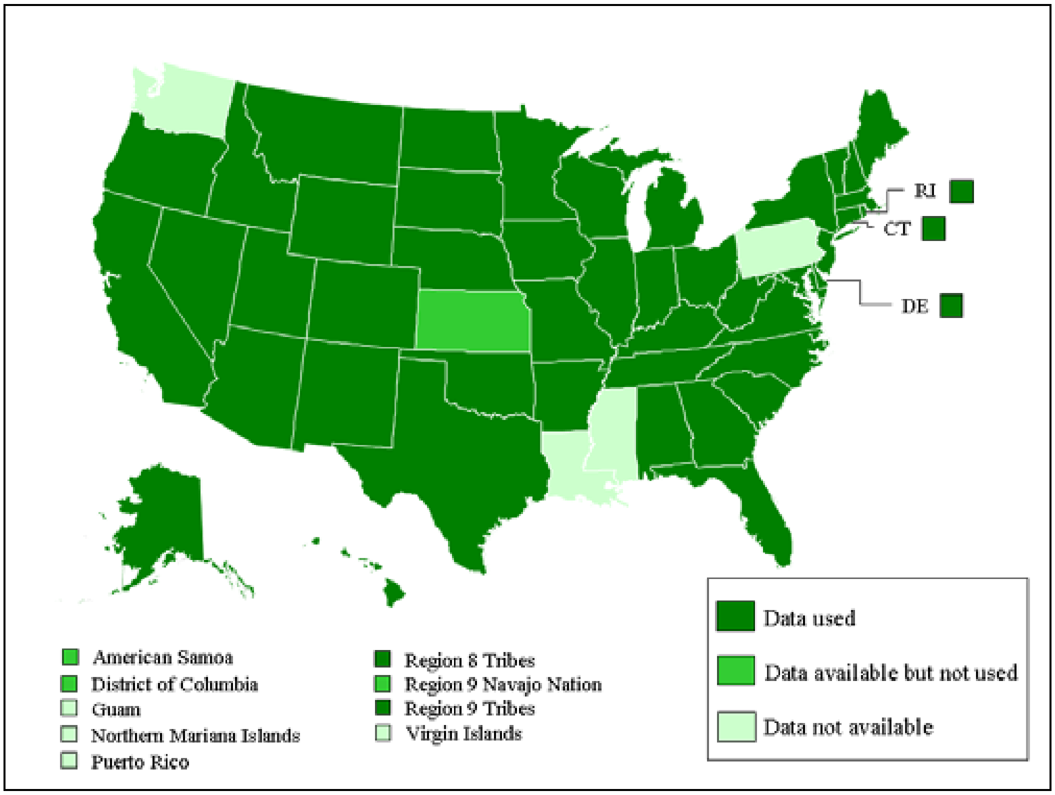
[1] Upon request, Regions 8 and 9 provided a crosswalk table that listed the state in which each tribal water system was located. All analyses conducted at the state-level (e.g., maps illustrating the geographic distribution of occurrence) present the tribal systems' data along with the state in which 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 public water systems. Approximately 254 million people are served by these public water systems 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 2 Contaminants

Contaminant (MCL)	Number of States with Data	Total Number of Records	Total Number of Systems	Total Population-Served by Systems	MRL
Inorganic Chemicals (IOCs)					
Antimony (0.006 mg/L)	45	185,986	49,016	223,251,662	0.001 mg/L
Arsenic[1] (0.05 mg/L)	45	224,035	49,473	230,393,228	0.005 mg/L
Asbestos (7 mf/L)	38	18,181	8,278	85,161,934	0.2 MFL
Barium (2 mg/L)	45	183,118	49,125	229,775,707	0.1 mg/L
Beryllium (0.004 mg/L)	45	183,575	48,021	221,383,819	0.001 mg/L
Cadmium (0.005 mg/L)	45	181,667	48,920	229,685,370	0.001 mg/L
Chromium (Total) (0.1 mg/L)	45	185,952	48,908	229,628,430	0.01 mg/L
Cyanide (0.2 mg/L)	44	120,368	32,067	162,458,600	0.005 mg/L
Fluoride (4 mg/L)	45	333,211	48,600	233,569,199	0.1 mg/L
Mercury (Inorganic) (0.002 mg/L)	45	181,629	48,859	229,853,379	0.0002 mg/L
Nitrate (as N) (10 mg/L)	44	1,052,487	119,537	229,508,036	0.1 mg/L
Nitrite (as N) (1 mg/L)	44	397,175	86,313	207,984,813	0.1 mg/L
Selenium (0.05 mg/L)	45	181,684	48,925	229,863,411	0.005 mg/L
Thallium (0.002 mg/L)	45	185,047	48,925	223,324,845	0.0005 mg/L
Synthetic Organic Chemicals (SOCs)[2]					
Alachlor (2 µg/L)	44	155,989	36,845	197,311,966	0.2 µg/L
Atrazine (3 µg/L)	44	161,690	37,215	200,372,590	0.1 µg/L
Benzo(a)pyrene (0.2 µg/L)	43	119,871	28,578	184,144,163	0.02 µg/L
Dalapon (200 µg/L)	42	112,423	28,387	178,186,111	1 µg/L
Di(2-ethylhexyl)adipate (DEHA) (400 µg/L)	43	121,792	28,902	184,134,674	0.02 µg/L
Di(2-ethylhexyl)phthalate (DEHP) (6 µg/L)	42	120,846	27,667	179,948,572	0.6 µg/L
Dinoseb (7 µg/L)	43	121,896	32,713	182,919,390	0.2 µg/L
Diquat (20 µg/L)	38	55,634	15,595	120,622,647	2 µg/L
Endrin (2 µg/L)	44	134,336	32,783	184,043,162	0.01 µg/L
Ethylene Dibromide (EDB) (0.05 µg/L)	43	218,797	36,215	188,153,915	0.01 µg/L
Glyphosate (700 µg/L)	42	58,174	16,351	116,276,011	6 µg/L

Contaminant (MCL)	**Number of States with Data**	**Total Number of Records**	**Total Number of Systems**	**Total Population-Served by Systems**	**MRL**
Lindane (gamma-Hexachlorocyclohexane) (0.2 µg/L)	44	135,585	33,265	187,258,935	0.02 µg/L
Methoxychlor (40 µg/L)	44	137,068	33,421	187,636,119	0.1 µg/L
Pentachlorophenol (1 µg/L)	43	136,475	34,339	190,507,709	0.04 µg/L
Picloram (500 µg/L)	43	121,920	32,910	186,386,430	0.1 µg/L
Polychlorinated Biphenyls (PCBs) (0.5 µg/L)	34	67,216	18,393	124,114,208	0.1 µg/L
Simazine (4 µg/L)	44	158,256	36,830	196,986,505	0.07 µg/L
2,3,7,8-TCDD (Dioxin) (0.00003 µg/L)	27	11,076	2,383	52,854,445	0.000005 µg/L
2,4,5-Trichlorophenoxypropionc Acid (Silvex) (50 µg/L)	43	122,713	32,887	183,000,768	0.2 µg/L
Volatile Organic Compounds (VOCs)					
1,2-Dichlorobenzene (600 µg/L)	45	372,946	50,422	226,929,816	0.5 µg/L
1,4-Dichlorobenzene (75 µg/L)	44	370,698	49,969	224,476,625	0.5 µg/L
1,1-Dichloroethylene (7 µg/L)	45	378,630	50,425	226,909,664	0.5 µg/L
cis-1,2-Dichloroethylene (70 µg/L)	44	373,316	50,314	225,615,734	0.5 µg/L
trans-1,2-Dichloroethylene (100 µg/L)	44	371,258	50,319	225,611,137	0.5 µg/L
Ethylbenzene (700 µg/L)	45	374,141	50,447	226,939,375	0.5 µg/L
Monochlorobenzene (Chlorobenzene) (100 µg/L)	44	370,519	50,311	225,627,782	0.5 µg/L
Styrene (100 µg/L)	45	372,269	50,421	226,933,636	0.5 µg/L
1,2,4-Trichlorobenzene (70 µg/L)	45	371,132	50,135	226,842,102	0.5 µg/L
1,1,1-Trichloroethane (200 µg/L)	45	374,950	50,440	226,931,546	0.5 µg/L
Radiological Contaminants					
Alpha Particles (15 pCi/L)	35	73,002	18,653	121,170,400	1 pCi/L
Beta Particles (screening level = 50 pCi/L)	34	59,983	14,231	120,274,924	4 pCi/L
Combined Radium-226 & -228 (original Radionuclides rule) (5 pCi/L) [3]	35	18,452	6,884	47,422,440	1 pCi/L
Combined Radium-226 & -228 (revised Radionuclides rule) (5 pCi/L) [3]	33	18,050	3,893	41,426,437	1 pCi/L
Uranium (30 µg/L)	33	41,581	5,921	70,631,392	0.001 µg/L

1. The MCL concentration for arsenic is now 0.01 mg/L. The Six-Year data were analyzed relative to the former MCL concentration of 0.05 mg/L because that was the MCL during the period of review for the Six-Year 2 analysis (1998 through 2005). However, additional analyses relative to the new arsenic MCL concentration are included in Chapter 5.

2. The reduced number of systems sampling for SOC data, as compared to IOCs and VOCs, likely relates to state waivers for pesticides and herbicides.

3. The revised Radionuclides Rule (published in 2000) went into effect on December 8, 2003 so combined radium-226 and -228 occurrence data collected before December 8, 2003 were analyzed and presented in the row labeled "original Radionuclides rule" and data collected after December 8, 2003 were analyzed and presented in the row labeled "revised Radionuclides rule."

1.4 Occurrence Analysis

A two-stage analytical approach is used to evaluate the Six-Year Review-ICR contaminant occurrence data. "Stage 1" and "Stage 2" analyses (described below) were conducted on the second Six-Year Review Category 1 contaminants, but only Stage 1 analyses were conducted on the Category 2 contaminants described in this report.

The Stage 1 analytical methodology is a conservative approach for estimating contaminant occurrence; estimates 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] (This Stage 1 analysis can be viewed roughly as a peak occurrence assessment.) Occurrence measures for each contaminant are estimated for systems and population-served by the 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. In contrast, Stage 2 analyses are based on counts of systems with estimated mean concentrations of a contaminant greater than some concentration threshold of interest. The Stage 1 analysis is more conservative than the Stage 2 analysis. Stage 1 analyses will therefore always result in occurrence estimates that are greater than (or occasionally equal to), but never less than Stage 2 analysis. Therefore, when very low occurrence is estimated for a particular contaminant using the Stage 1 analytical approach, the use of the Stage 2 analytical approach is generally not warranted. For a complete description of the Stage 1 (and Stage 2) methodology, refer to USEPA (2009b). These findings for either the Stage 1 or Stage 2 analyses are not representative of MCL violations.

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 one-half the MCL concentration (½ MCL concentration). Analyses were conducted at greater than the MCL concentration and greater than or equal to ½ the MCL concentration. Contaminant occurrence findings based on the Six-Year Review – ICR data are summarized in tables presented in the specific contaminant chapters that follow this introductory chapter. To review all the national occurrence estimates for all contaminants assessed for this second Six-Year Review, please refer to the document *The Analysis of the Contaminant Occurrence Data from Public*

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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).

Water Systems in Support of the Second Six-Year Review of National Primary Drinking Water Regulations (USEPA, 2009b).

1.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2001. *About the Agency for Toxic Substances and Disease Registry.* Available on the Internet at: http://www.atsdr.cdc.gov/about.html. Accessed June 28, 2001.

Extension Toxicology Network (EXTOXNET). 2008. “EXTOXNET - EXtension TOXicology NETwork.” Available on the Internet at: http://extoxnet.orst.edu/etn.txt.html.

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/.

Hamilton, P.A., T.L. Miller, and D.N. Myers. 2004. *Water Quality in the Nation's Streams and Aquifers: Overview of Selected Findings, 1991-2001*. USGS Circular 1265. Available on the Internet at: http://water.usgs.gov/pubs/circ/2004/1265/pdf/circular1265.pdf.

Hazardous Substance Data Bank (HSDB). 2006. “*Fact Sheet* Hazardous Substances Data Bank (HSDB®).” Last modified September 25, 2006. Available on the Internet at: http://www.nlm.nih.gov/pubs/factsheets/hsdbfs.html.

Leahy, P.P. and T.H. Thompson. 1994. *The National Water-Quality Assessment Program*. U.S. Geological Survey Open-File Report 94-70, 4 p. Available on the Internet at: http://water.usgs.gov/nawqa/NAWQA.OFR94-70.html. Accessed October 25, 2004.

National Research Council (NRC). 2002. *Opportunities to Improve the U.S. Geological Survey National Water Quality Assessment Program.* National Academy Press. 238 p. Available on the Internet at: http://www.nap.edu/catalog/10267.html.

United States Environmental Protection Agency (USEPA). 2002. *The Toxics Release Inventory (TRI) and Factors to Consider When Using TRI Data*. EPA-260-F-02-017. November 2002. Available on the Internet at: http://www.epa.gov/triinter/2002_tri_brochure.pdf.

USEPA. 2003a. *EPA Protocol for the Review of Existing National Primary Drinking Water Regulations*. EPA-815-R-03-002. June 2003. Available on the Internet at: http://www.epa.gov/safewater/standard/review/pdfs/support_6yr_protocal_final.pdf.

USEPA. 2003b. Non-confidential Inventory Update Reporting (IUR) Production Volume Information. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm.

USEPA. 2003c. *How are the Toxics Release Inventory Data Used? -- government, business,* *academic and citizen uses*. EPA-260-R-002-004. May 2003. Available on the Internet at: http://www.epa.gov/tri/guide_docs/pdf/2003/2003_datausepaper.pdf.

USEPA. 2009a. Contaminant Occurrence Support Document for Category 1 Contaminants for the Second Six-Year Review of National Primary Drinking Water Regulations. EPA Report 815-B-09-010. October 2009.

USEPA. 2009b. 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. EPA-815-B-09-006. October 2009.

USEPA. 2009c. *EPA Protocol for the Second Review of Existing National Primary Drinking Water Regulations (Updated).* EPA Report 815-B-09-002. October 2009.

United States Geological Survey (USGS). 2001. “Summary publications from 51 NAWQA study units sampled in 1991-2001.” Available on the Internet at: http://water.usgs.gov/nawqa/nawqasum/. Last updated May 19, 2004.

USGS. 2007. Pesticide National Synthesis Project, 2002 Pesticide Use Maps. Available on the Internet at: http://water.usgs.gov/nawqa/pnsp/usage/maps/compound_listing.php?year=02.

2 Alachlor

This chapter on alachlor 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 alachlor 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 alachlor 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.

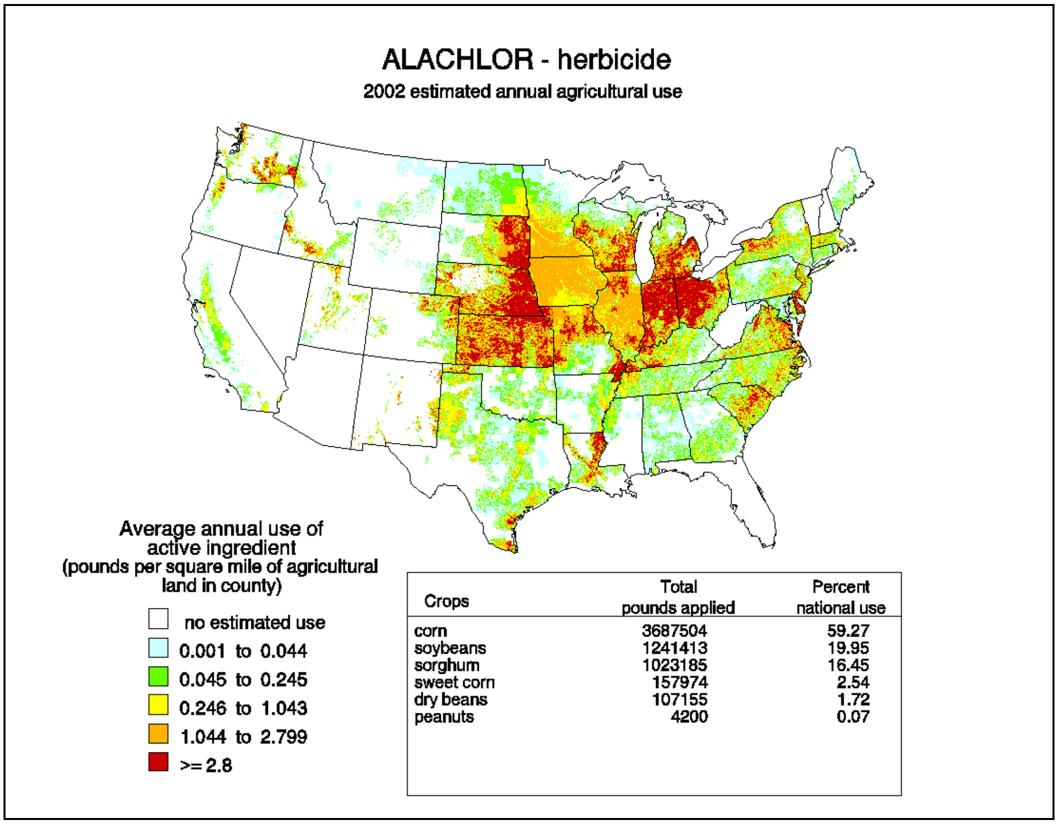
According to USEPA (1998), alachlor ($C_{14}H_{20}NO_2Cl$) is a colorless to white crystalline solid typically used as an herbicide to control cropland weeds and grasses. It generally has a high mobility and potential to leach, and the half life for its disappearance from soil ranges from 6 to 21 days. It is extremely persistent in ground water (USEPA, 1998). Trade names for alachlor include Lasso and Alanex (USEPA, 1998).

2.2 Use, Production, and Releases

Alachlor was first registered in 1969. It is used nationwide, with particularly heavy usage on corn, peanuts, sorghum, and soybeans (USEPA, 1998).

Exhibit 2-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual alachlor 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 6.2 million pounds of alachlor active ingredient were used on average each year between 1999 and 2004.

Exhibit 2-1: Estimated Annual Agricultural Use for Alachlor (c. 2002)



Crops	Total pounds applied	Percent national use
corn	3687504	59.27
soybeans	1241413	19.95
sorghum	1023185	16.45
sweet corn	157974	2.54
dry beans	107155	1.72
peanuts	4200	0.07

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 alachlor.

Alachlor is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of alachlor for the period 1998-2006 ranged from 274 pounds to about 11,000 pounds, with a general decrease over time (USEPA, 2008).

2.3 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 alachlor in ambient water are available from the NAWQA program.

2.3.1 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 alachlor between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for alachlor was 0.002 µg/L.

In NAWQA stream samples (Exhibit 2-2), alachlor was found at frequencies ranging from 5.34% of samples in undeveloped areas to 6.11% in urban areas, 20.26% in mixed land use settings, and 40.07% of samples in agricultural settings. The 95th percentile concentration was 0.002 µg/L in undeveloped areas, 0.004 µg/L in urban areas, 0.021 µg/L in mixed land use settings, and 0.110 µg/L in agricultural settings. The highest concentration, 6.7 µg/L, was found at an agricultural site.

Exhibit 2-2: USGS National Synthesis Summary of NAWQA Monitoring of Alachlor 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	1,996 (83)	40.07%	ND[1]	0.110	6.700
Mixed	1,378 (65)	20.26%	ND[1]	0.021	3.800
Undeveloped	144 (8)	5.34%	ND[1]	0.002	0.010
Urban	806 (30)	6.11%	ND[1]	0.004	0.092

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 2-3), alachlor was found at frequencies ranging from 0% of samples in undeveloped areas to 0.47% in urban areas, 0.77% of samples in mixed land use settings, and 2.78% 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 in a mixed land use setting.

Exhibit 2-3: USGS National Synthesis Summary of NAWQA Monitoring of Alachlor 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	1,401	2.78%	ND[1]	ND[1]	0.946
Mixed	2,729	0.77%	ND[1]	ND[1]	1.3

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	0.00%	ND[1]	ND[1]	ND[1]
Urban	854	0.47%	ND[1]	ND[1]	0.146

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)

2.3.2 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for alachlor. 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 2-4. Overall, alachlor was detected in 16.4% of samples and at 7.9% of sites. Alachlor was detected more frequently in surface water sites than in ground water sites. The median concentration based on detections from all sites was 0.015 µg/L. The 99th percentile concentration based on detections from all sites was 3.33 µg/L.

Exhibit 2-4: EPA Summary Analysis of Alachlor 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	6,108	1.9%	5,217	1.6%	0.0023	0.0246	3.8	9.8	10
surface water	15,641	22.0%	1,949	24.9%	0.0008	0.015	0.62	3.09	38.2
all sites	21,749	16.4%	7,166	7.9%	0.0008	0.015	0.65	3.33	38.2

1. RLs (Reporting Limits) for alachlor 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.

2.4 Occurrence in Drinking Water

Alachlor 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 alachlor 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 alachlor. (There were no alachlor data from Oklahoma.) These data consist of 155,989 analytical results from 36,845 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.

2.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 2-5 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For alachlor, 0.328% of 36,845 systems reported detections. Exhibit 2-6 lists the minimum, median, 90th percentile, and maximum alachlor concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of alachlor, based on detections from all systems, is 0.31 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 2-5: Alachlor Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	118,787	33,522	73,774,399
Surface Water	37,202	3,323	123,537,567
Combined Ground & Surface Water	155,989	36,845	197,311,966
Percent with Detections			
Ground Water	0.193%	0.206%	3.728%
Surface Water	0.204%	1.565%	4.247%
Combined Ground & Surface Water	0.196%	0.328%	4.053%

Exhibit 2-6: Alachlor Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.32	0.98	5
Surface Water	0.01	0.2	0.83	14
Combined Ground & Surface Water	0.01	0.31	0.92	14

The following maps illustrate the geographic distribution of alachlor occurrence in drinking water. Exhibit 2-7 shows the states with systems with at least one detection and Exhibit 2-8 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). Oklahoma submitted Six-Year data for most contaminants; however, there is a statewide waiver for alachlor in Oklahoma so no alachlor data were available from that state.

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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.

Detection rates were generally low; only four states reported detections in more than 1% of their systems. These states are all located in the eastern half of the United States. In six states, between 0.5% and 1% of systems reported detections. Six states reported detections greater than the MCL concentration of 2 μg/L.

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

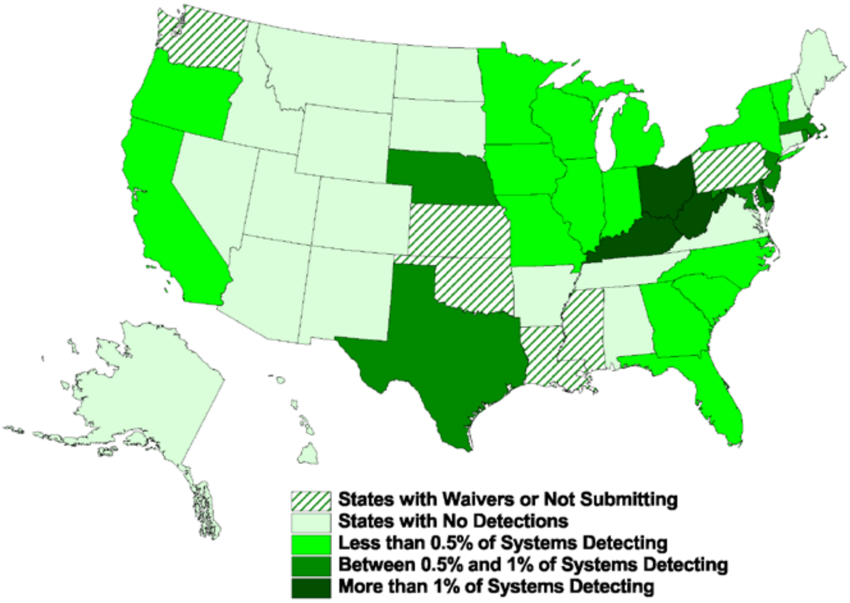

Exhibit 2-8: Percentage of Systems with at Least One Alachlor Detection Greater than the MCL Concentration (> 2 µg/L), by State

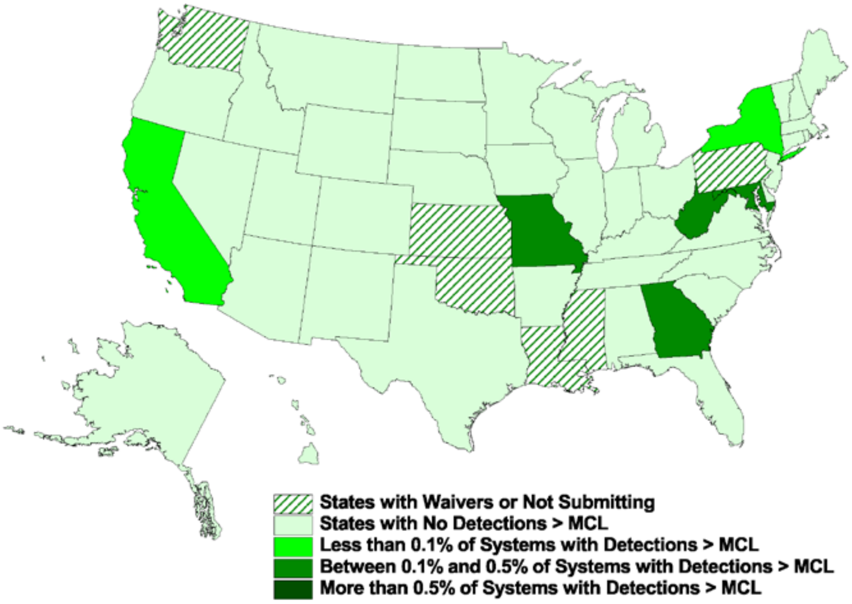

Exhibit 2-9 presents the Stage 1 analysis of alachlor occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 1 µg/L and 2 µg/L. Nineteen (0.052% of) systems, serving about 85,000 persons, reported at least one detection greater than or equal to 1 µg/L; and 8 (0.022% of) systems, serving about 25,000 persons, reported at least one detection greater than 2 µg/L.

Exhibit 2-9: Alachlor 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	5	0.015%	13,383	0.018%
	≥ 1 µg/L	14	0.042%	39,016	0.053%
Surface Water	> 2 µg/L	3	0.090%	12,036	0.010%
	≥ 1 µg/L	5	0.150%	46,473	0.038%

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	8	0.022%	25,419	0.013%
	≥ 1 µg/L	19	0.052%	85,489	0.043%

2.5 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/.

Thelin, G.P. and L.P. Gianessi. 2000. *Method for Estimating Pesticide Use for County Areas of the Conterminous United States.* U.S. Geological Survey Open-File Report 00-250, 62 p. Available on the Internet at: http://ca.water.usgs.gov/pnsp/rep/ofr00250/ofr00250.pdf.

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. 1998. *Reregistration Eligibility Decision (RED) Alachlor*. Washington, DC: Office of Prevention, Pesticides, and Toxic Substances. EPA-738-R-98-020. Available on the Internet at: http://www.epa.gov/oppsrrd1/REDs/0063.pdf.

USEPA. 2008. TRI Explorer: Trends – Alachlor. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for alachlor.] Accessed March 7, 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.

United States Geological Survey (USGS). 2007. 2002 Pesticide Use Maps. Available on the Internet at: http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1863. Accessed March 6, 2008.

3 Alpha Particles

This chapter on gross alpha particle activity (alpha particles) 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 alpha particle 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).

3.1 Background

EPA published an interim Drinking Water Regulation for gross alpha particle activity on July 9, 1976 (41 FR 28402 (USEPA, 1976)). The Maximum Contaminant Level (MCL) for gross alpha particle activity (including radium-226, but excluding uranium and radon) established on that date was 15 pCi/L. In 2000, EPA published the final National Primary Drinking Water Regulations (NPDWR) for radionuclides. The MCL for alpha particles remained at 15 pCi/L. The 2000 rule set a Maximum Contaminant Level Goal (MCLG) of zero for alpha particles, based on a cancer classification of A (known human carcinogen) (USEPA, 2000).

Radioactive elements (radionuclides) occur naturally in some drinking water sources (USEPA, 2006a). They result from the erosion of natural deposits of certain radioactive minerals (USEPA, 2008). Alpha radiation is a type of ionizing radiation; alpha particles consist of two protons and two neutrons. In fact, most of the naturally occurring radionuclides are alpha particle emitters (USEPA, 2006b). Water samples with elevated alpha particle levels are generally indicative of naturally occurring radioactive elements, including radium-224 and radium-226 (MDE, 2008).

3.2 Use, Production, and Releases

As alpha particles occur naturally in conjunction with radioactive elements, data for use, production, and release are not available.

3.3 Occurrence in Ambient Water

No National Water Quality Assessment (NAWQA) Program data are available on the occurrence of alpha particles in ambient waters.

3.4 Occurrence in Drinking Water

Under the original radionuclides rule, all community water systems (CWSs) must initially collect four consecutive quarterly samples in their distribution system. If the annual average concentration of the initial sampling is equal to or less than ½ the MCL (7.5 pCi/L), then a system may reduce to one sample every four years. If any alpha particle results are greater than 5 pCi/L (but is equal to or less than the MCL of 15 pCi/L), the system must analyze the same or an equivalent sample for Radium-226. If Radium-226 is greater than 3 pCi/L, the system must analyze for Radium-228. If the annual average alpha particle activity is greater than ½ the MCL (but is equal to or less than the MCL), the system must take four consecutive quarterly samples every four years. If the annual average of alpha particle activity is greater than the MCL, the system must take one sample each quarter until the annual average is below the MCL or until the state sets an alternate monitoring schedule.

Under the revised radionuclides rule, all CWSs must collect four consecutive quarterly samples for alpha particle measurement at each entry point to the distribution system between December 8, 2003 and December 31, 2007 unless the state grandfathered data collected between June 2000 and December 8, 2003. In addition, the state may waive the final two quarters of sampling if results from the first two quarters are below the detection limit. If the running annual average of initial quarterly samples is less than the detection limit, the system may reduce sampling to once every nine years. If the average is equal to or greater than the detection limit but equal to or less than ½ the MCL, the system may reduce sampling to once every six years. If the average is greater than ½ the MCL (but is equal to or less than the MCL), the system may reduce sampling to once every three years. If the average is greater than the MCL, the system must take one sample each quarter until the running annual average of results from consecutive quarters no longer exceeds the MCL, or until the state sets an alternate monitoring schedule. Quarterly monitoring is also triggered by one result that is more than four times the MCL or high enough to cause the running annual average to exceed the MCL.

The analysis of alpha particle 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.

Alpha particle data were provided by 35 of the Six-Year Review-ICR states. (No data were received from Arkansas, California, Delaware, Georgia, Hawaii, Illinois, Massachusetts, New Hampshire, Oklahoma, or Wisconsin.) The alpha particle data from the 35 states consist of 73,002 analytical results from 18,653 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.

3.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 3-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For alpha particles, 68.080% of 18,653 systems reported detections. Exhibit 3-2 lists the minimum, median, 90th percentile, and maximum alpha particle concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of alpha particles, based on detections from all systems, is 3.36 pCi/L.

Exhibit 3-1: Summary of Alpha Particles Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	61,653	16,467	40,744,045
Surface Water	11,349	2,186	80,426,355
Combined Ground & Surface Water	73,002	18,653	121,170,400
Percent with Detections			
Ground Water	58.993%	69.242%	78.754%
Surface Water	47.934%	59.332%	63.369%
Combined Ground & Surface Water	57.274%	68.080%	68.542%

Exhibit 3-2: Alpha Particles Summary Statistics

Source Water Type	Detection Value (pCi/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	8E-10	3.7	13.81	348.33
Surface Water	0.01	1.6	6.8	133.53
Combined Ground & Surface Water	8E-10	3.36	13	348.33

The following maps illustrate the geographic distribution of alpha particle occurrence in drinking water. Exhibit 3-3 shows the states with systems with at least one detection and Exhibit 3-4 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit any data for use in the Six-Year Review (Kansas[1], Louisiana, Mississippi, Pennsylvania, and Washington). Arkansas, California,

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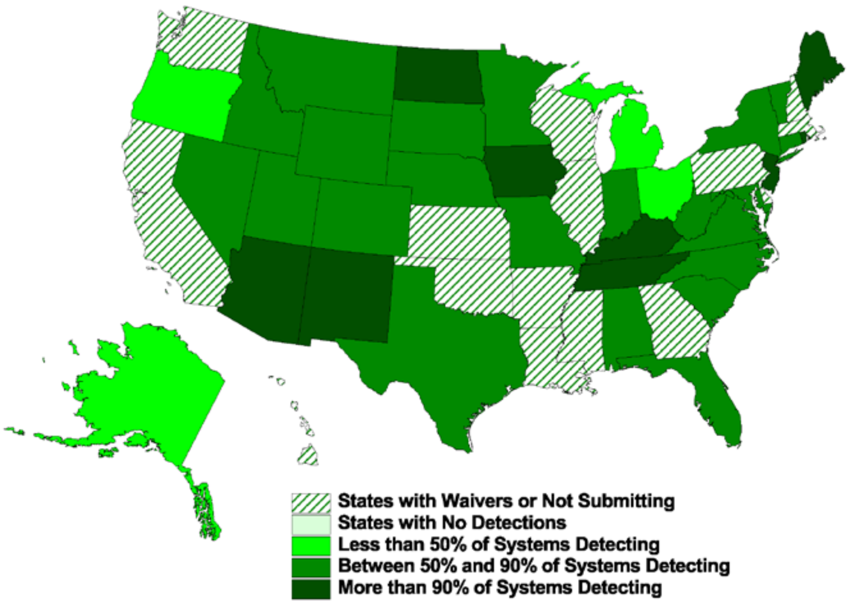
[1] Kansas submitted data after the data management and analyses had been conducted; data for Kansas are not

Delaware, Georgia, Hawaii, Illinois, Massachusetts, New Hampshire, Oklahoma, or Wisconsin submitted Six-Year data for most contaminants, but did not submit data for alpha particles.

The distribution of systems with detections of alpha particles is geographically dispersed and detection rates were relatively high. In 9 states, more than 90% of systems reported detections of alpha particles. In 26 states, more than 0.5% of systems reported at least one detection greater than the MCL concentration of 15 pCi/L.

Exhibit 3-3: Percentage of Systems with at Least One Alpha Particles Detection, by State



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included in the analyses

Exhibit 3-4: Percentage of Systems with at Least One Alpha Particles Detection Greater than the MCL Concentration (> 15 pCi/L), by State

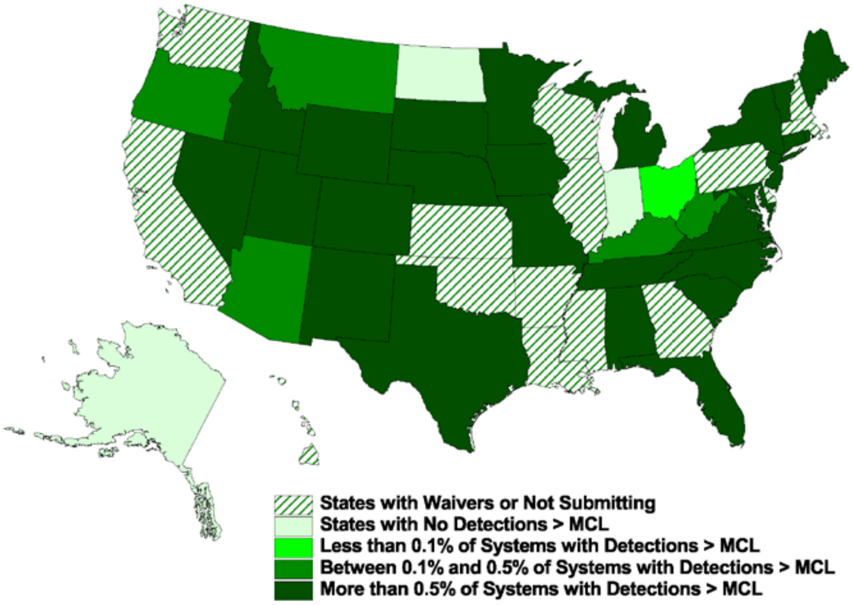

Exhibit 3-5 presents the Stage 1 analysis of alpha particle occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 7.5 pCi/L and 15 pCi/L. A total of 2,596 (13.917% of) systems, serving over 18.3 million persons, reported at least one detection greater than or equal to 7.5 pCi/L; and 854 (4.578% of) systems, serving more than 7.5 million persons, reported at least one detection greater than 15 pCi/L.

Exhibit 3-5: Alpha Particles 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	> 15 pCi/L	832	5.053%	2,891,759	7.097%
	≥ 7.5 pCi/L	2,511	15.249%	8,323,500	20.429%
Surface Water	> 15 pCi/L	22	1.006%	4,631,051	5.758%
	≥ 7.5 pCi/L	85	3.888%	10,037,894	12.481%

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	> 15 pCi/L	854	4.578%	7,522,810	6.208%
	≥ 7.5 pCi/L	2,596	13.917%	18,361,394	15.153%

3.5 References

MDE (Maryland Department of the Environment). 2008. Radium and Your Drinking Water (A Homeowner's Guide). Available on the Internet at: http://www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/radium.asp. Accessed March 25, 2008.

United States Environmental Protection Agency (USEPA). 1976. Title 40—Protection of Environment. Chapter 1--Environmental Protection Agency. Part 141—Interim Primary Drinking Water Regulations. Promulgation of Regulations on Radionuclides. Federal Register, Vol. 41, No. 133, p. 28402, July 9, 1976.

USEPA. 2000. National Primary Drinking Water Regulations; Radionuclides; Final Rule. Federal Register. Vol. 65, No. 236. p. 76707, December 7, 2000.

USEPA. 2006a. Basic Information about Radionuclides in Drinking Water. Last modified September 19, 2006. Available on the Internet at: http://www.epa.gov/safewater/radionuclides/basicinformation.html. Accessed March 18, 2008.

USEPA. 2006b. Technical Fact Sheet: Final Rule for (Non-Radon) Radionuclides in Drinking Water. Last modified September 19, 2006. Available on the Internet at: http://www.epa.gov/OGWDW/radionuclides/regulation_techfactsheet.html. Accessed March 25, 2008.

USEPA. 2008. Drinking Water Contaminants. Last modified February 15, 2008. Available on the Internet at: http://www.epa.gov/safewater/contaminants/index.html. Accessed March 17, 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.

4 Antimony

This chapter on antimony 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 antimony 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 National Primary Drinking Water Regulations (NPDWR) for antimony 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 0.006 mg/L. EPA based the maximum contaminant level goal on a reference dose (RfD) of 0.0004 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, 1992), in its native state (uncombined with other elements), antimony is a silvery white, brittle metal. However, native antimony is rare. It usually occurs in the mineral stibnite, and also in trace amounts in silver, copper, and lead ores. According to the United States Bureau of Reclamation (USBR, 2001), antimony is found in over 100 minerals. Little antimony is currently mined in the United States. Most is imported, but it is also produced as a by-product of smelting lead and other metals (ATSDR, 1995).

Most antimony ends up in soil, where it attaches strongly to particles that contain iron, manganese, or aluminum. Antimony is found at low levels in some rivers, lakes, and streams (ATSDR, 1995). Antimony compounds do not tend to accumulate in aquatic life (ATSDR, 1992).

4.2 Use, Production, and Releases

Because it is brittle, antimony is not used in its native state. In alloy form, it is used in lead storage batteries, solder, sheet and pipe metal, bearings, castings, and pewter. Antimony oxide is added to textiles and plastics to prevent them from catching fire. It is also used in paints, ceramics, and fireworks, and as enamels for plastics, metal, and glass (ATSDR, 1995). The most common end-use of antimony compounds is antimony trioxide for fire retardation (ATSDR, 1992).

The Toxic Substances Control Act (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 antimony in the United States from 1986 to 2002. Note that the production of antimony in the United States was not documented in the Chemical Update System until 1994 and has increased progressively since then.

Exhibit 4-1: Production of Antimony in the United States

Inventory Update Year	Production Volume
1986 Range	No reports
1990 Range	No reports
1994 Range	< 10,000 pounds
1998 Range	10,000 – 500,000 pounds
2002 Range	> 1 million – 10 million pounds

Source: USEPA, 2003

Antimony and antimony compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of antimony for the period 1998-2006 ranged from approximately 829,000 pounds to approximately 1.8 million pounds, with maximum releases occurring in 2003. On-site releases were greater than off-site releases (USEPA, 2008a). Total antimony compound releases ranged from approximately 10 million pounds to approximately 32 million pounds, with a general decrease over time. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

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 antimony 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for antimony. 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 4-2. Overall, antimony was detected in 13.4% of samples and at 11.0% of sites. Antimony was detected slightly more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.186 µg/L (0.000186 mg/L). The 99th percentile concentration based on detections from all sites was 8 µg/L (0.008 mg/L).

Exhibit 4-2: EPA Summary Analysis of Antimony 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	3,252	12.5%	2,904	9.9%	0.025	0.099	1.75	4	6.296
surface water	2,380	14.6%	394	19.3%	0.024	0.23	4.933	10.779	16.863
all sites	5,632	13.4%	3,298	11.0%	0.024	0.186	2.376	8	16.863

1. RLs (Reporting Limits) for antimony varied, but did not exceed 0.025 µg/L.

4.4 Occurrence in Drinking Water

Antimony is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[1] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[2] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

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[1] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[2] 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.

The analysis of antimony 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 antimony. These data consist of 185,986 analytical results from 49,016 systems 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.

4.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 4-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For antimony, 5.978% of 49,016 systems reported detections. Exhibit 4-4 lists the minimum, median, 90th percentile, and maximum antimony concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of antimony, based on detections from all systems, is 0.001 mg/L.

Exhibit 4-3: Antimony Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	145,441	44,971	85,727,750
Surface Water	40,545	4,045	137,523,912
Combined Ground & Surface Water	185,986	49,016	223,251,662
Percent with Detections			
Ground Water	2.673%	5.677%	15.708%
Surface Water	3.581%	9.320%	21.390%
Combined Ground & Surface Water	2.871%	5.978%	19.208%

Exhibit 4-4: Antimony Summary Statistics

Source Water Type	**Detection Value (mg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.000041	0.00079	0.006	0.06
Surface Water	0.000042	0.001545	0.0071	0.06
Combined Ground & Surface Water	0.000041	0.001	0.006	0.06

The following maps illustrate the geographic distribution of antimony occurrence in drinking water. Exhibit 4-5 shows the states with systems with at least one detection and Exhibit 4-6 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[3], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of antimony is geographically dispersed. In seven states, more than 10% of systems detected antimony. In 30 states, between 1% and 10% of systems reported detections. Nineteen states reported no detections greater than the MCL concentration. For six states, more than 0.5% of systems reported at least one detection greater than the MCL concentration of 0.006 mg/L.

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

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

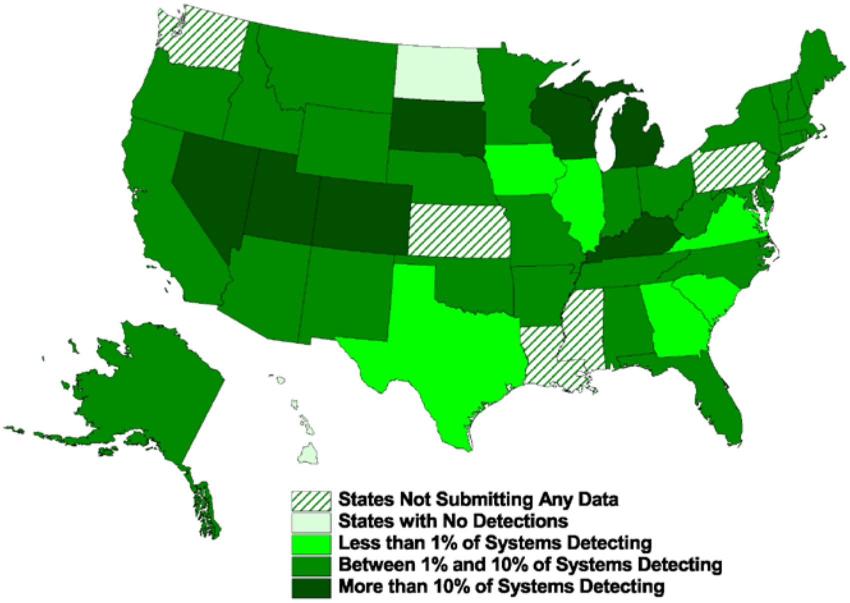

Exhibit 4-6: Percentage of Systems with at Least One Antimony Detection Greater than the MCL Concentration (> 0.006 mg/L), by State

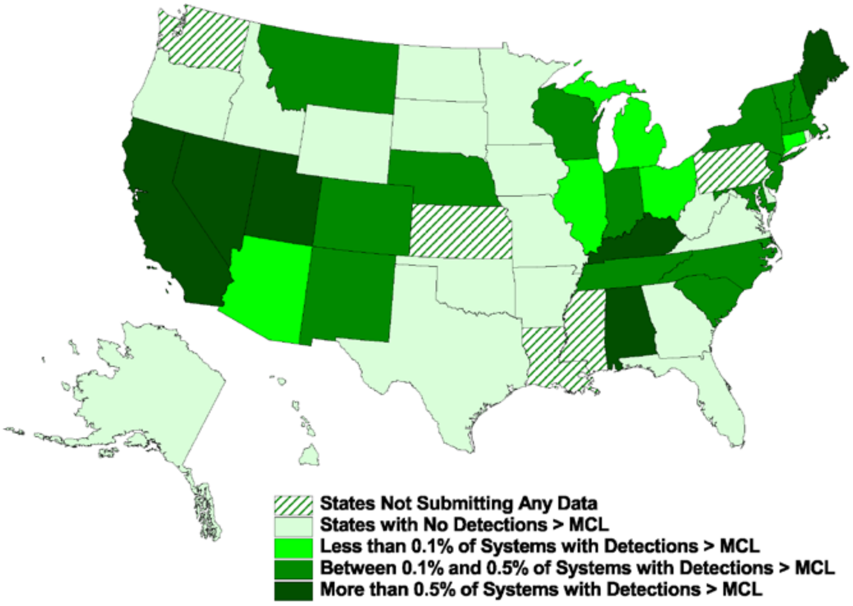

Exhibit 4-7 presents the Stage 1 analysis of antimony occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.003 mg/L and 0.006 mg/L. A total of 629 (1.283% of) systems, serving more than 12 million persons, reported at least one detection greater than or equal to 0.003 mg/L; and 130 (0.265% of) systems, serving almost 3.4 million persons, reported at least one detection greater than 0.006 mg/L.

Exhibit 4-7: Antimony 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	> 0.006 mg/L	97	0.216%	251,693	0.294%
	≥ 0.003 mg/L	512	1.139%	1,812,718	2.115%
Surface Water	> 0.006 mg/L	33	0.816%	3,108,813	2.261%
	≥ 0.003 mg/L	117	2.892%	10,308,814	7.496%
Combined Ground & Surface Water	> 0.006 mg/L	130	0.265%	3,360,506	1.505%
	≥ 0.003 mg/L	629	1.283%	12,121,532	5.430%

4.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological Profile for Antimony and Compounds.* September 1992. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp23.pdf.

ATSDR. 1995. *ToxFAQs for Antimony and Compounds.* September 1995. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts23.html.

United States Bureau of Reclamation (USBR). 2001. Antimony Fact Sheet. Last modified Sept. 21, 2001. Available on the Internet at: http://www.usbr.gov/pmts/water/publications/reportpdfs/Sb.pdf.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Antimony. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for antimony.] Accessed February 21, 2008.

USEPA. 2008a. TRI Explorer: Trends – Antimony. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for antimony.] Accessed March 6, 2008.

USEPA. 2008b. TRI Explorer: Trends – Antimony Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for antimony compounds.] Accessed March 6, 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.

5 Arsenic

This chapter on arsenic 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 arsenic 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

In 1976, the United States Environmental Protection Agency (EPA) issued a National Interim Primary Drinking Water Regulation for arsenic at 0.05 mg/L. Under the 1986 amendments to the Safe Drinking Water Act (SDWA), Congress directed EPA to publish Maximum Contaminant Level Goals (MCLGs) and promulgate National Primary Drinking Water Regulations (NPDWRs) for 83 contaminants, including arsenic. EPA failed to publish an arsenic NPDWR at that time (USEPA, 1998). On June 22, 2000, EPA proposed a Maximum Contaminant Level (MCL) of 0.005 mg/L (USEPA, 2000). The Final Rule, published on January 22, 2001, established an MCLG of zero (based on a cancer classification of A, known human carcinogen) and an MCL at 0.01 mg/L (USEPA, 2001). The date by which systems must comply with the new 0.01 mg/L standard was January 23, 2006. Until then, the MCL was 0.05 mg/L (USEPA, 2003a).

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2007), arsenic is a naturally occurring element widely distributed in the earth's crust. Its primary sources are its main ore mineral, arsenopyrite, and smelting of copper, gold, and lead (USGS, 2006). It is odorless and tasteless (USEPA, 2007) in its native (uncombined) state. In the environment, it combines with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Organic arsenic compounds are formed when arsenic in animals and plants combines with carbon and hydrogen (ATSDR, 2007).

5.2 Use, Production, and Releases

Inorganic arsenic compounds are mainly used to preserve wood. Chromated copper arsenate (CCA), no longer used in the United States for residential uses, was used to make "pressure-treated" lumber. It is, however, still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton fields and orchards (ATSDR, 2007).

The Toxic Substances Control Act (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 5-1 presents the production of arsenic in the United States from 1986 to 2002. Note that the production of arsenic in the United States was only documented in the Chemical Update System in 1998.

Exhibit 5-1: Production of Arsenic in the United States

Inventory Update Year	Production Volume
1986 Range	No reports
1990 Range	No reports
1994 Range	No reports
1998 Range	> 500,000 - 1 million pounds
2002 Range	No reports

Source: USEPA, 2003b

Arsenic and arsenic compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of arsenic for the period 1998-2006 ranged from approximately 824,000 pounds to approximately 76.8 million pounds, with an overall decrease over time. On-site releases were greater than off-site releases (USEPA, 2008a). Total arsenic compound releases ranged from approximately 111 million pounds to approximately 569 million pounds, with a general decrease over time. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

5.3 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 arsenic in ambient water are available from the NAWQA program.

5.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for arsenic. 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 5-2. Overall, arsenic was detected in 55.1% of samples and at 52.9% of sites. Arsenic was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was about 2.3 µg/L (0.0023 mg/L). The 99th percentile concentration based on detections from all sites was 79 µg/L (0.079 mg/L).

Exhibit 5-2: EPA Summary Analysis of Arsenic 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	3,725	53.7%	3,303	51.7%	0.091	2	24.06	57	550
surface water	2,460	57.1%	468	61.3%	0.09	3	16.406	104.15	284
all sites	6,185	55.1%	3,771	52.9%	0.09	2.27	22.728	79	550

1. RLs (Reporting Limits) for arsenic varied, but did not exceed 0.091 µg/L.

5.4 Occurrence in Drinking Water

Arsenic is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[1] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[2] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

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[1] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[2] 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.

The analysis of arsenic 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 arsenic. These data consist of 224,035 analytical results from 49,473 systems 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.

5.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 5-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For arsenic, 37.329% of 49,473 systems reported detections. Exhibit 5-4 lists the minimum, median, 90th percentile, and maximum arsenic concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of arsenic, based on detections from all systems, is 0.005 mg/L.

Exhibit 5-3: Arsenic Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	176,964	45,387	85,737,044
Surface Water	47,071	4,086	144,656,184
Combined Ground & Surface Water	224,035	49,473	230,393,228
Percent with Detections			
Ground Water	39.904%	37.788%	50.451%
Surface Water	25.627%	32.232%	48.633%
Combined Ground & Surface Water	36.904%	37.329%	49.309%

Exhibit 5-4: Arsenic Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.000058	0.00546	0.02	0.75
Surface Water	0.00006	0.0033	0.01	0.44
Combined Ground & Surface Water	0.000058	0.005	0.02	0.75

The following maps illustrate the geographic distribution of arsenic occurrence in drinking water. Exhibit 5-5 shows the states with systems with at least one detection, Exhibit 5-6 shows the states with systems with at least one detection greater than the new MCL concentration of 0.01 mg/L, and Exhibit 5-7 shows the states with systems with at least one detection greater than the former MCL concentration of 0.05 mg/L. Note that five states did not submit data for use in the Six-Year Review (Kansas[3], Louisiana, Mississippi, Pennsylvania, and Washington).

Detection rates were high for arsenic. In 12 states, more than 50% of systems detected arsenic. Most of these states are located in the Southwest, northern Midwest, or northern New England. In 19 states, more than 5% of systems reported at least one detection greater than the new MCL concentration of 0.01 mg/L. In 16 states, more than 0.5% of systems reported at least one detection greater than the former MCL concentration of 0.05 mg/L.

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

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

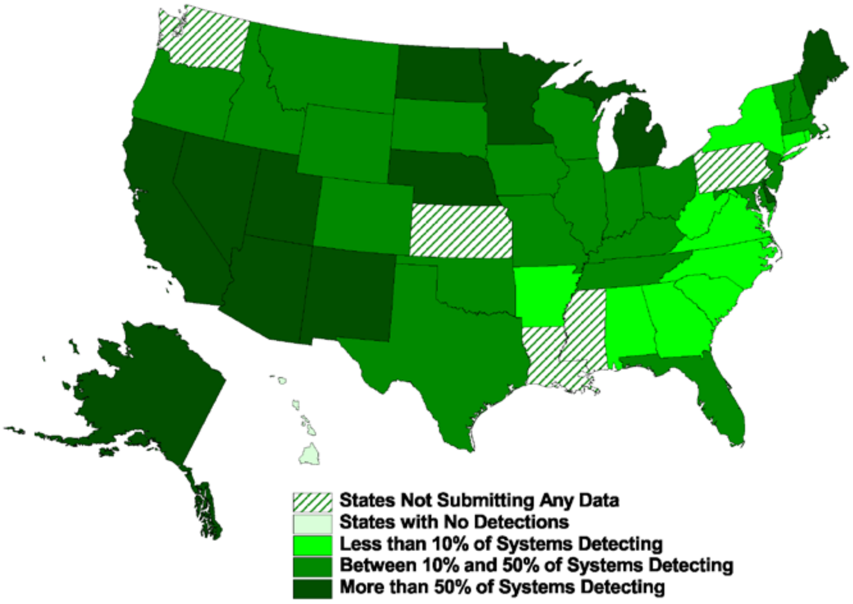

Exhibit 5-6: Percentage of Systems with at Least One Arsenic Detection Greater than the new MCL Concentration (> 0.01 mg/L), by State

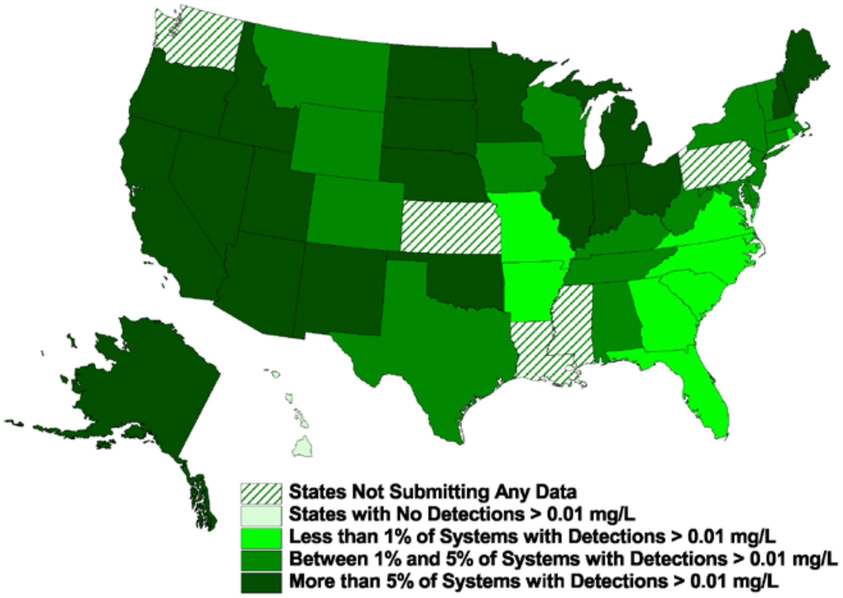

Exhibit 5-7: Percentage of Systems with at Least One Arsenic Detection Greater than the former MCL Concentration (> 0.05 mg/L), by State

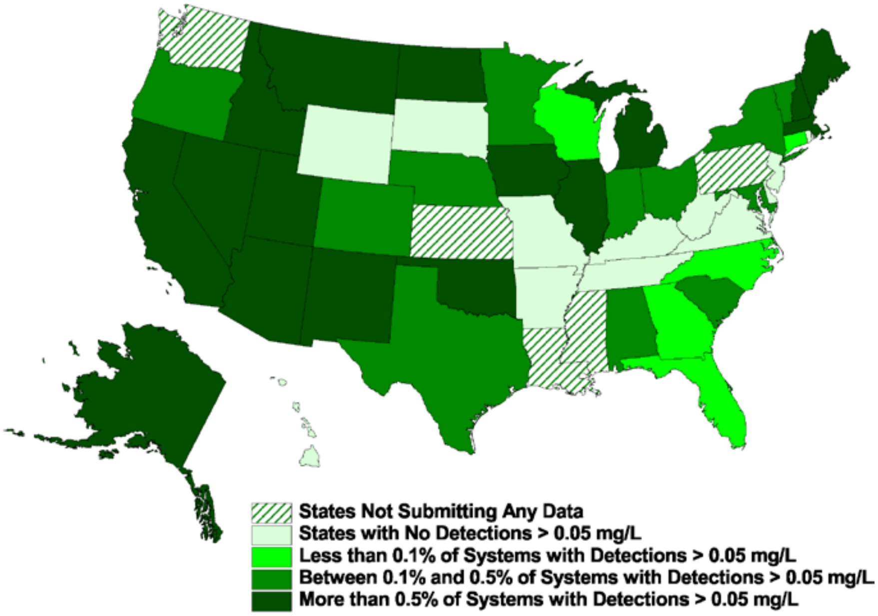

Exhibit 5-8 presents the Stage 1 analysis of arsenic occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to several thresholds: 0.005 mg/L, 0.01 mg/L, 0.025 mg/L, and 0.05 mg/L. Note that the MCL concentration for arsenic is currently 0.01 mg/L. The Six-Year data were also analyzed relative to the former MCL concentration of 0.05 mg/L because that was the MCL concentration during the period of review for the Six-Year 2 analysis (1998 through 2005).

More than 8,200 (16.631% of) systems, serving more than 47 million persons, reported at least one detection greater than or equal to 0.005 mg/L; and about 3,500 (7.107% of) systems, serving almost 24.4 million persons, reported at least one detection greater than 0.01 mg/L. Almost 1,300 (2.569% of) systems, serving more than 11 million persons, reported at least one detection greater than or equal to 0.025 mg/L; and 371 (0.750% of) systems, serving approximately 2.9 million persons, reported at least one detection greater than 0.05 mg/L.

**Exhibit 5-8: Arsenic 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	> 0.05 mg/L	346	0.762%	1,352,250	1.577%
	≥ 0.025 mg/L	1,216	2.679%	3,901,453	4.550%
	> 0.01 mg/L	3,364	7.412%	8,655,516	10.095%
	≥ 0.005 mg/L	7,859	17.316%	18,464,077	21.536%
Surface Water	> 0.05 mg/L	25	0.612%	1,503,598	1.039%
	≥ 0.025 mg/L	55	1.346%	7,158,650	4.949%
	> 0.01 mg/L	152	3.720%	15,741,605	10.882%
	≥ 0.005 mg/L	369	9.031%	28,990,530	20.041%
Combined Ground & Surface Water	> 0.05 mg/L	371	0.750%	2,855,848	1.240%
	≥ 0.025 mg/L	1,271	2.569%	11,060,103	4.801%
	> 0.01 mg/L	3,516	7.107%	24,397,121	10.589%
	≥ 0.005 mg/L	8,228	16.631%	47,454,607	20.597%

5.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. *ToxFAQs for Arsenic.* August 2007. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts2.html.

United States Environmental Protection Agency (USEPA). 1998. Announcement of Stakeholders Meeting on Arsenic in Drinking Water. Federal Register. Vol. 63, No. 17. p. 3890-3891, January 27, 1998.

USEPA. 2000. National Primary Drinking Water Regulations; Arsenic and Clarifications to Compliance and New Source Contaminants Monitoring. Federal Register. Vol. 65, No. 121. p. 38888, June 22, 2000.

USEPA. 2001. National Primary Drinking Water Regulations; Arsenic and Clarifications to Compliance and New Source Contaminants Monitoring. Federal Register. Vol. 66, No. 14. p. 6975-7066, January 22, 2001.

USEPA. 2003a. Minor Clarification of National Primary Drinking Water Regulation for Arsenic. Federal Register. Vol. 68, No. 57. p. 14507, March 25, 2003.

USEPA. 2003b. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Arsenic. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for arsenic.] Accessed February 21, 2008.

USEPA. 2007. Arsenic in Drinking Water: Basic Information. Last modified March 26, 2007. Available on the Internet at: http://www.epa.gov/safewater/arsenic/basicinformation.html. Accessed March 6, 2008.

USEPA. 2008a. TRI Explorer: Trends – Arsenic. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for arsenic.] Accessed March 6, 2008.

USEPA. 2008b. TRI Explorer: Trends – Arsenic Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for arsenic compounds.] Accessed March 6, 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.

United States Geological Survey (USGS). 2006. U.S. Geological Survey, Mineral Commodity Summaries (arsenic). Available on the internet at: http://minerals.usgs.gov/minerals/pubs/commodity/arsenic/arsenmcs06.pdf. Accessed March 15, 2008.

6 Asbestos

This chapter on asbestos 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 asbestos 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

EPA published the current National Primary Drinking Water Regulations (NPDWR) for asbestos 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 7 million fibers per liter (MFL) for asbestos fibers exceeding 10 micrometers in length. EPA evaluated asbestos as a Category II contaminant[1] (equivalent to Group C, possible human carcinogen) by the oral route of exposure.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2001), asbestos is the name given to a group of six different fibrous minerals (amosite, chrysotile, crocidolite, and the fibrous varieties of tremolite, actinolite, and anthophyllite) that occur naturally in the environment. Asbestos minerals have separable long fibers that are strong and flexible enough to be spun and woven and are heat resistant (ATSDR, 2001). The fibers can be released to air or water from the breakdown of natural deposits or manufactured products. Small fibers may remain airborne for a long time. Asbestos does not move through soil or decompose (ASTDR, 2001).

6.2 Use, Production, and Releases

Because its minerals are so strong, flexible, and heat resistant, asbestos has been used for a wide range of manufactured goods, mostly in building materials (roofing shingles, ceiling and floor tiles, paper products, and asbestos-cement products), friction products (automobile clutch,

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[1] Note that this “Category II” classification for asbestos is different than it being a part of the group of 47 Category 2 contaminants discussed in this report. “Category II” contaminants include those contaminants for which EPA has determined there is limited evidence of carcinogenicity from drinking water considering weight of evidence, pharmacokinetics, potency, and exposure. For Category II contaminants, EPA has used two approaches to set the MCLG: Either (1) setting the MCLG based upon non-carcinogenic endpoints of toxicity (the reference dose) then applying an additional risk management factor of 1 to 10; or (2) setting the MCLG based upon a theoretical lifetime excess cancer risk range of 10^{-5} to 10^{-6} using a conservative mathematical extrapolation model (USEPA, 2002).

brake, and transmission parts), heat-resistant fabrics, packaging, gaskets, and coatings. Some vermiculite or talc products may contain asbestos (ATSDR, 2001).

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 asbestos.

Asbestos (friable) is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of asbestos (friable) for the period 1998-2006 ranged from approximately 6.7 million pounds to approximately 24 million pounds, with a decrease over time. On-site releases were greater than off-site releases (USEPA, 2008).

6.3 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 asbestos in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

6.4 Occurrence in Drinking Water

Asbestos is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[2] The maximum waiver period for IOCs is nine years. Statewide waivers are often granted for asbestos.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[3] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of asbestos 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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[2] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[3] 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.

Asbestos data were provided by 38 of the Six-Year Review-ICR states. (There were no asbestos data from the following states: Arkansas, Hawaii, Michigan, Minnesota, Missouri, Oklahoma, and Texas.) The asbestos data from the 38 states consist of 18,181 analytical results from 8,278 systems 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.

6.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 6-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For asbestos, 3.237% of 8,278 systems reported detections. Exhibit 6-2 lists the minimum, median, 90th percentile, and maximum asbestos concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of asbestos, based on detections from all systems, is 0.2 MFL.

Exhibit 6-1: Asbestos Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	13,837	6,873	22,423,343
Surface Water	4,344	1,405	62,738,591
Combined Ground & Surface Water	18,181	8,278	85,161,934
Percent with Detections			
Ground Water	2.211%	2.663%	5.018%
Surface Water	3.016%	6.050%	20.393%
Combined Ground & Surface Water	2.404%	3.237%	16.345%

Exhibit 6-2: Asbestos Summary Statistics

Source Water Type	**Detection Value (MFL)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.02	0.26	4	143.9
Surface Water	0.008	0.2	1.07	2,494
Combined Ground & Surface Water	0.008	0.2	3.48	2,494

The following maps illustrate the geographic distribution of asbestos occurrence in drinking water. Exhibit 6-3 shows the states with systems with at least one detection and Exhibit 6-4 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[4], Louisiana, Mississippi, Pennsylvania, and Washington). Arkansas, Hawaii, Michigan, Minnesota, Missouri, Oklahoma, and Texas submitted Six-Year data for most contaminants but did not submit data for asbestos.

The distribution of systems with detections of asbestos is geographically dispersed. In nine states, more than 5% of systems detected asbestos. In 16 states, between 1% and 5% of systems reported detections. Twenty-eight states reported no detections of asbestos greater than the MCL concentration of 7 MFL. In three states, more than 0.5% of systems reported at least one detection greater than 7 MFL.

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

Exhibit 6-3: Percentage of Systems with at Least One Asbestos Detection, by State

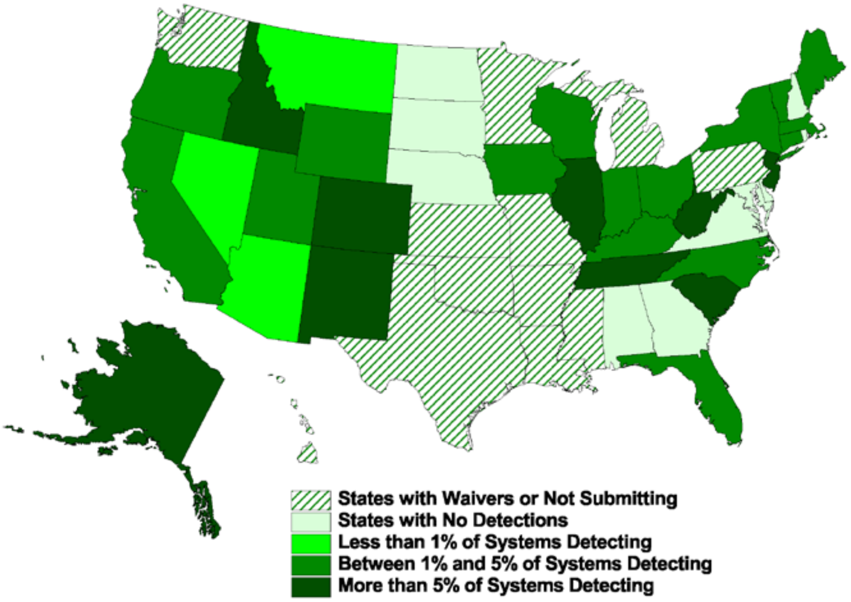


Exhibit 6-4: Percentage of Systems with at Least One Asbestos Detection Greater than the MCL Concentration (> 7 MFL), by State

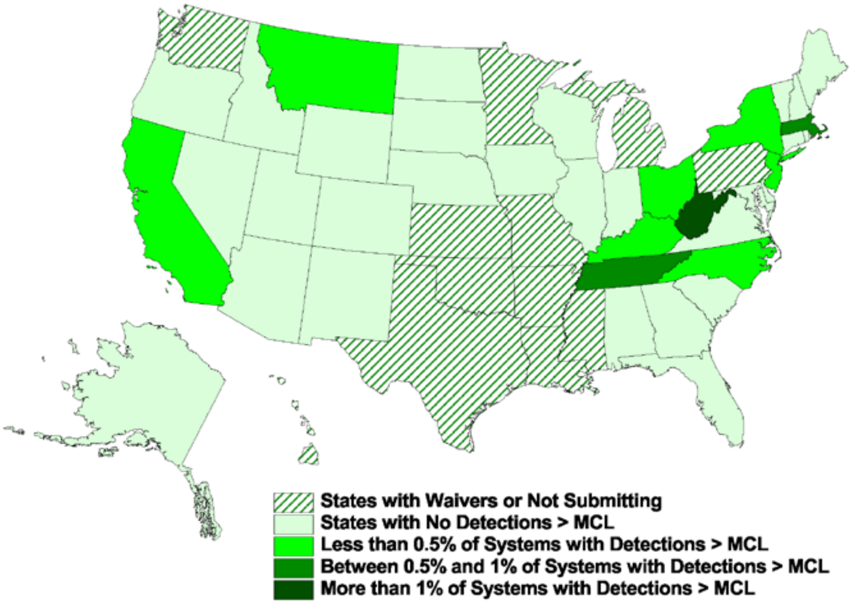


Exhibit 6-5 presents the Stage 1 analysis of asbestos occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative two thresholds: 3.5 MFL and 7 MFL. A total of 25 (0.302% of) systems, serving more than 400,000 persons, reported at least one detection greater than or equal to 3.5 MFL; and 14 (0.169% of) systems, serving approximately 254,000 persons, reported at least one detection greater than 7 MFL.

Exhibit 6-5: Asbestos 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	> 7 MFL	11	0.160%	57,015	0.254%
	≥ 3.5 MFL	19	0.276%	82,927	0.370%
Surface Water	> 7 MFL	3	0.214%	196,962	0.314%
	≥ 3.5 MFL	6	0.427%	322,738	0.514%
Combined Ground & Surface Water	> 7 MFL	14	0.169%	253,977	0.298%
	≥ 3.5 MFL	25	0.302%	405,665	0.476%

6.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2001. *ToxFAQs for Asbestos.* September 2001. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts61.html.

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/.

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. 2002. National Primary Drinking Water Regulations; Announcement of the Results of EPA's Review of Existing Drinking Water Standards and Request for Public Comment. Federal Register. Vol. 67, No. 74. p. 19051, April 17, 2002.

USEPA. 2008. TRI Explorer: Trends – Asbestos. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for asbestos (friable).] Accessed March 6, 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 Atrazine

This chapter on atrazine 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 atrazine 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 atrazine 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 3 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 Group C, possible human carcinogen, based on limited evidence of carcinogenicity in animals in the absence of human data. EPA published a Federal Register (FR) notice in February 1999, in which EPA responded to recommendations by the Children's Health Advisory Committee, by committing to re-evaluate the MCL for atrazine after the Agency has finalized its risk assessment (64 FR 5277 (USEPA, 1999)).

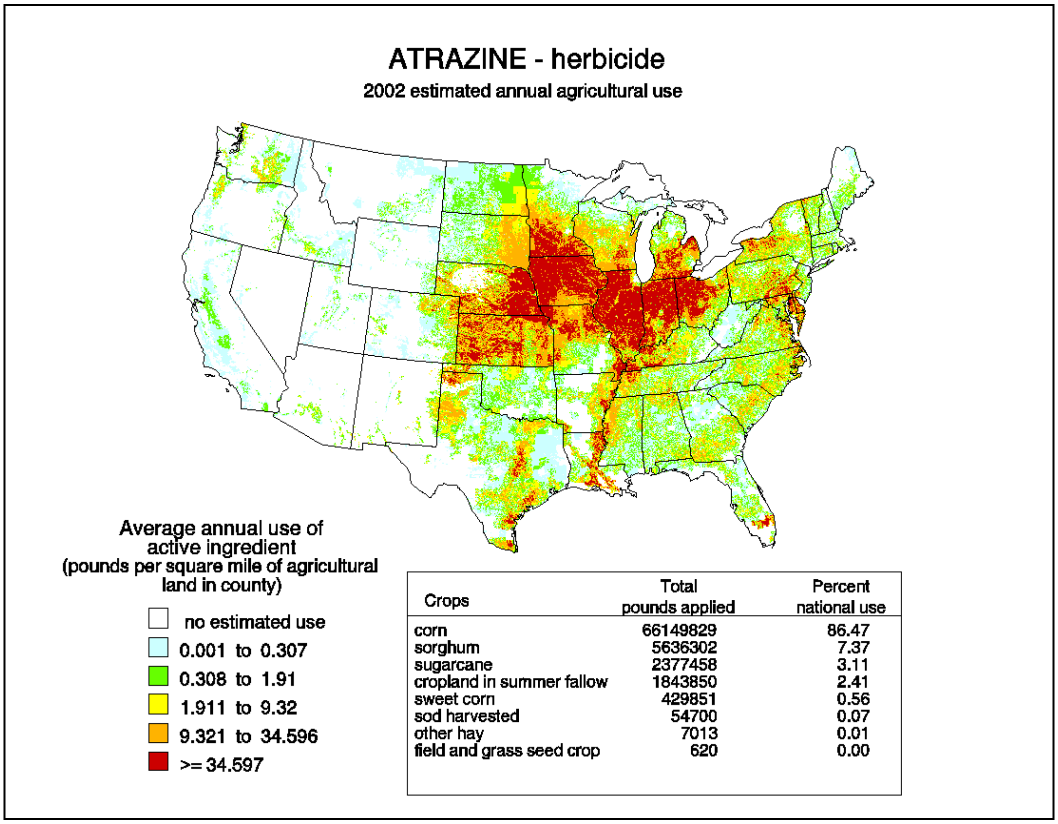
According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2003a), atrazine ($C_8H_{14}ClN_5$) is an herbicide that does not occur naturally. Pure atrazine is an odorless, white powder that is not very volatile, reactive, or flammable, and that will dissolve in water (ATSDR, 2003a). Atrazine has a high to medium mobility and is degraded slowly in most environments, whether by biological or chemical processes. In soils it may persist for days or months. In rare situations it may remain for years. Breakdown is especially slow in rivers and lakes. It will also persist for a long time in groundwater. Atrazine does not tend to accumulate in living organisms (ATSDR, 2003b).

7.2 Use, Production, and Releases

Although it is a restricted use pesticide, atrazine is the most heavily used pre- and post-emergence herbicide in the United States (ATSDR, 2003b). It is used to kill weeds, primarily on farms for crops such as corn, sorghum, and sugarcane; however, it has also been used on highway and railroad rights-of-way (ATSDR, 2003a). Only trained individuals are allowed to spray atrazine (ATSDR, 2003b).

Exhibit 7-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual atrazine 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 76.5 million pounds of atrazine active ingredient were used on average each year between 1999 and 2004.

Exhibit 7-1: Estimated Annual Agricultural Use for Atrazine (c. 2002)



Crops	Total pounds applied	Percent national use
corn	66149829	86.47
sorghum	5636302	7.37
sugarcane	2377458	3.11
cropland in summer fallow	1843850	2.41
sweet corn	429851	0.56
sod harvested	54700	0.07
other hay	7013	0.01
field and grass seed crop	620	0.00

Source: USGS, 2007

The Toxic Substances Control Act (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 7-2 presents the production of atrazine in the United States from 1986 to 2002. Note that the production of atrazine in the United States increased from 1986 to 1998 and was not reported in the Chemical Update System in 2002.

Exhibit 7-2: Production of Atrazine in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 million – 10 million pounds
1990 Range	> 1 million – 10 million pounds
1994 Range	> 10 million – 50 million pounds
1998 Range	> 10 million – 50 million pounds
2002 Range	No reports

Source: USEPA, 2003

Atrazine is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of atrazine for the period 1998-2006 ranged from about 504,000 pounds to about 700,000 pounds, with the maximum releases occurring in 2005. On-site releases were greater than off-site releases (USEPA, 2008).

7.3 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 atrazine in ambient water are available from the NAWQA program.

7.3.1 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 atrazine between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for atrazine was 0.004 µg/L.

In NAWQA stream samples (Exhibit 7-3), atrazine was found at frequencies ranging from 54.26% of samples in undeveloped areas to 70.73% in urban areas, 85.13% in mixed land use settings, and 89.93% of samples in agricultural settings. The 95th percentile concentration was 0.050 µg/L in undeveloped areas, 0.209 µg/L in urban areas, 0.678 µg/L in mixed land use settings, and 2.400 µg/L in agricultural settings. The highest concentration, 201 µg/L, was found at an agricultural site.

Exhibit 7-3: USGS National Synthesis Summary of NAWQA Monitoring of Atrazine 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	2,009 (83)	89.93%	0.073	2.400	201.000
Mixed	1,382 (65)	85.13%	0.016	0.678	41.300
Undeveloped	143 (8)	54.26%	0.003	0.050	2.000
Urban	801 (30)	70.73%	0.009	0.209	3.370

Source: Gilliom et al., 2007

In ground water NAWQA samples (Exhibit 7-4), atrazine was found at frequencies ranging from 11.76% of samples in undeveloped areas to 18.17% in mixed land use settings, 31.34% of samples in urban areas, and 42.18% of samples in agricultural settings. The 95th percentile concentration was 0.0082 µg/L in undeveloped areas, 0.033 µg/L in mixed land use settings, 0.089 µg/L in urban areas, and 0.358 µg/L in agricultural settings. The highest concentration, 4.78 µg/L, was found at an agricultural site.

Exhibit 7-4: USGS National Synthesis Summary of NAWQA Monitoring of Atrazine 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	1,406	42.18%	ND[1]	0.358	4.78
Mixed	2,730	18.17%	ND[1]	0.033	2.8
Undeveloped	34	11.76%	ND[1]	0.0082	0.0085
Urban	852	31.34%	ND[1]	0.089	4.2

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)

7.3.2 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for atrazine. 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 7-5. Overall, atrazine was detected in 65.8% of samples and at 44.2% of sites. Atrazine was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.0369 µg/L. The 99th percentile concentration based on detections from all sites was 13.4 µg/L.

Exhibit 7-5: EPA Summary Analysis of Atrazine 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	6,093	30.8%	5,203	29.7%	0.0004	0.017	0.53	1.71	5.01
surface water	15,604	79.4%	1,948	83.0%	0.0001	0.0412	2.57	14.8	201
all sites	21,697	65.8%	7,151	44.2%	0.0001	0.0369	2.21	13.4	201

1. RLs (Reporting Limits) for atrazine varied, but did not exceed 0.0004 µg/L. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible.

7.4 Occurrence in Drinking Water

Atrazine 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

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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.

quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of atrazine 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 atrazine. (There were no atrazine data from Oklahoma.) These data consist of 161,690 analytical results from 37,215 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.

7.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 7-6 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For atrazine, 2.386% of 37,215 systems reported detections. Exhibit 7-7 lists the minimum, median, 90th percentile, and maximum atrazine concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of atrazine, based on detections from all systems, is 0.4 µg/L.

Exhibit 7-6: Atrazine Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	121,515	33,752	74,386,872
Surface Water	40,175	3,463	125,985,718
Combined Ground & Surface Water	161,690	37,215	200,372,590
Percent with Detections			
Ground Water	1.725%	1.132%	7.923%
Surface Water	11.796%	14.612%	22.482%
Combined Ground & Surface Water	4.227%	2.386%	17.077%

Exhibit 7-7: Atrazine Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.003	0.19	0.69	10.9
Surface Water	0.00037	0.55	1.7	27
Combined Ground & Surface Water	0.00037	0.4	1.43	27

The following maps illustrate the geographic distribution of atrazine occurrence in drinking water. Exhibit 7-8 shows the states with systems with at least one detection and Exhibit 7-9 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 atrazine in Oklahoma so no atrazine data were available from that state.

Seven states reported detections in more than 5% of their systems. With the exception of Hawaii, these states were all located in the central part of the United States. In 14 states, between 1% and 5% of systems reported detections. Only four states reported no detections of atrazine. Fifteen states reported detections greater than the MCL concentration of 3 µg/L.

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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 7-8: Percentage of Systems with at Least One Atrazine Detection, by State

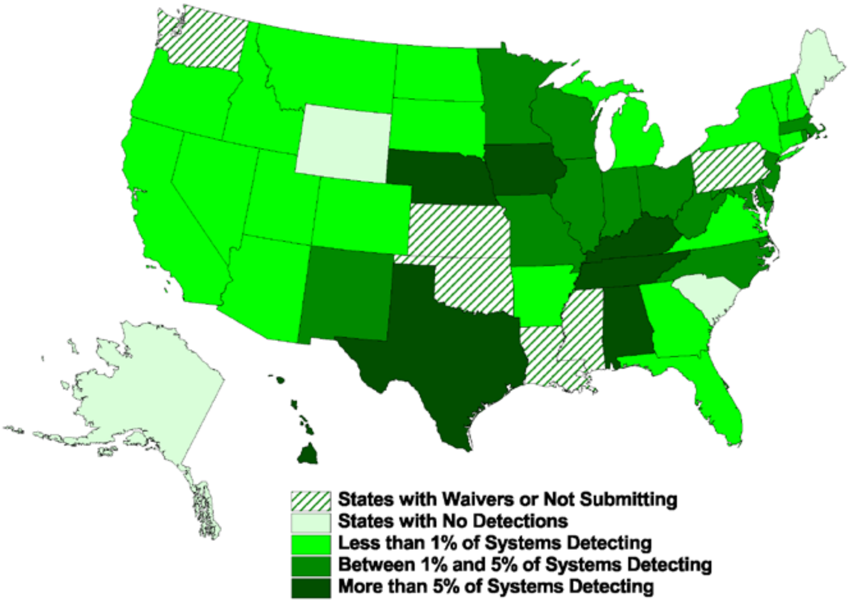

Exhibit 7-9: Percentage of Systems with at Least One Atrazine Detection Greater than the MCL Concentration (> 3 µg/L), by State

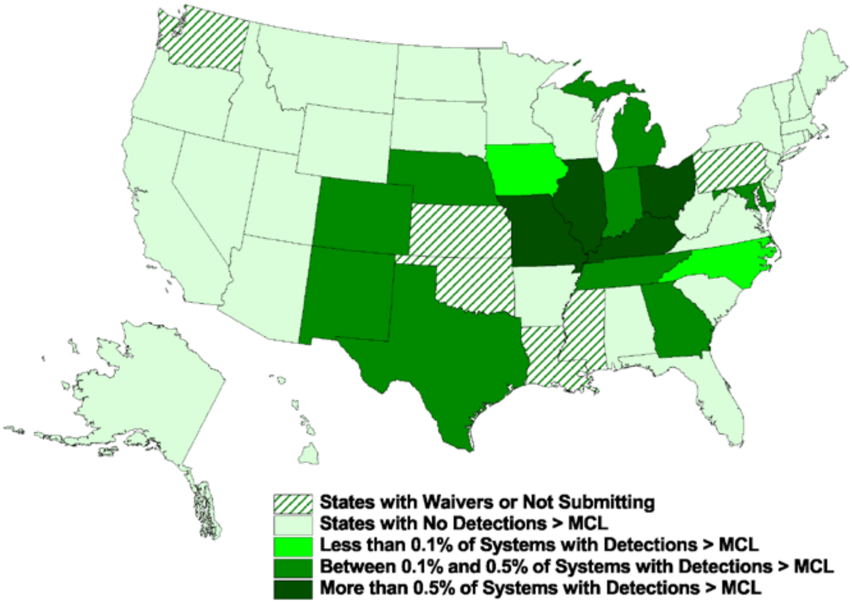

Exhibit 7-10 presents the Stage 1 analysis of atrazine occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 1.5 µg/L and 3 µg/L. More than 180 (0.494% of) systems, serving about 8.2

million persons, reported at least one detection greater than or equal to 1.5 µg/L; and 98 (0.263% of) systems, serving more than 3.1 million persons, reported at least one detection greater than 3 µg/L.

Exhibit 7-10: Atrazine 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	7	0.021%	93,709	0.126%
	≥ 1.5 µg/L	24	0.071%	220,526	0.296%
Surface Water	> 3 µg/L	91	2.628%	3,014,621	2.393%
	≥ 1.5 µg/L	160	4.620%	7,977,093	6.332%
Combined Ground & Surface Water	> 3 µg/L	98	0.263%	3,108,330	1.551%
	≥ 1.5 µg/L	184	0.494%	8,197,619	4.091%

7.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2003a. *ToxFAQs for Atrazine.* September 2003. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts153.html.

ATSDR. 2003b. *Toxicological Profile for Atrazine.* September 2003. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp153.pdf.

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/.

Thelin, G.P. and L.P. Gianessi. 2000. *Method for Estimating Pesticide Use for County Areas of the Conterminous United States.* U.S. Geological Survey Open-File Report 00-250, 62 p. Available on the Internet at: http://ca.water.usgs.gov/pnsp/rep/ofr00250/ofr00250.pdf.

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. 1999. Response to Recommendations from the Children's Health Protection Advisory Committee Regarding Evaluation of Existing Environmental Standards; Notice. Federal Register. Vol. 64, No. 22. p. 5277, February 3, 1999.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Atrazine. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for atrazine.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – Atrazine. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for atrazine.] Accessed March 6, 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.

United States Geological Survey (USGS). 2007. 2002 Pesticide Use Maps. Available on the Internet at: http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1980. Accessed March 6, 2008.

8 Barium

This chapter on barium 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 barium 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 State Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for barium on July 1, 1991 (56 FR 30266 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 2 mg/L. EPA based the MCLG on a reference dose (RfD) of 0.07 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), barium is a silvery-white metal. Its primary source in nature is the mineral barite (Klein and Hurlbut, 1993). Barium can be combined with nitrate, carbonate, or chloride to form barium compounds (ATSDR, 2007). The length of time that it will last in air, land, water, or sediments depends on the form of barium released. Some compounds, such as barium chloride, barium nitrate, or barium hydroxide, that dissolve easily in water usually do not last in these forms for a long time in the environment. However, the barium in these compounds that is dissolved in water quickly combines with sulfate or carbonate that are naturally found in water and become the longer lasting forms (barium sulfate and barium carbonate). Fish and aquatic organisms can accumulate barium (ATSDR, 2007).

8.2 Use, Production, and Releases

Barium compounds are used by the oil and gas industries to make drilling muds. (Drilling muds keep the drill bits lubricated, making it easier to drill through rock.) Barium compounds are also used to make paint, bricks, ceramics, glass, and rubber. In addition, barium sulfate can be used by doctors to perform medical tests and to take x-rays of the gastrointestinal tract (ATSDR, 2007).

The Toxic Substances Control Act (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 barium in the United States from 1986 to 2002. Note that the production of barium in the United States was only documented in the Chemical Update System in 1994.

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

Inventory Update Year	Production Volume
1986 Range	No reports
1990 Range	No reports
1994 Range	10,000 – 500,000 pounds
1998 Range	No reports
2002 Range	No reports

Source: USEPA, 2003

Barium and barium compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of barium for the period 1998-2006 ranged from approximately 6.6 million pounds to approximately 12.9 million pounds, with a decrease over time. On-site releases were greater than off-site releases (USEPA, 2008a). Total barium compound releases ranged from approximately 211 million pounds to approximately 306 million pounds, with a general decrease over time. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

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 barium 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for barium. 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 8-2. Overall, barium was detected in 99.3% of samples and at 98.8% of sites. Percentages of samples with detections were similarly high for surface water and ground water. The median concentration based on detections from all sites was approximately 38 µg/L (0.038 mg/L). The 99th percentile concentration based on detections from all sites was approximately 560 µg/L (0.560 mg/L).

Exhibit 8-2: EPA Summary Analysis of Barium 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	3,253	98.8%	2,905	98.7%	1	47	327	675	5,053
surface water	2,378	100.0%	393	100.0%	1	29.8	107	145.37	258.4
all sites	5,631	99.3%	3,298	98.8%	1	38.155	237.43	559.67	5,053

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

8.4 Occurrence in Drinking Water

Barium is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[1] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[2] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of barium 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

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[1] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[2] 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.

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 barium. These data consist of 183,118 analytical results from 49,125 systems 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.

8.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 8-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For barium, 72.020% of 49,125 systems reported detections. Exhibit 8-4 lists the minimum, median, 90th percentile, and maximum barium concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of barium, based on detections from all systems, is 0.05 mg/L.

Exhibit 8-3: Barium Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	142,438	45,118	85,388,860
Surface Water	40,680	4,007	144,386,847
Combined Ground & Surface Water	183,118	49,125	229,775,707
Percent with Detections			
Ground Water	62.814%	71.978%	82.897%
Surface Water	54.444%	72.498%	77.449%
Combined Ground & Surface Water	60.955%	72.020%	79.473%

Exhibit 8-4: Barium Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.000086	0.06	0.23	19
Surface Water	0.0001	0.04	0.15	19
Combined Ground & Surface Water	0.000086	0.05	0.21	19

The following maps illustrate the geographic distribution of barium occurrence in drinking water. Exhibit 8-5 shows the states with systems with at least one detection and Exhibit 8-6 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[3], Louisiana, Mississippi, Pennsylvania, and Washington).

Detection rates were high for barium and the distribution of systems with detections of barium is geographically dispersed. In 17 states, more than 90% of systems detected barium. In three states, more than 0.5% of systems reported at least one detection greater than the MCL concentration of 2 mg/L.

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

Exhibit 8-5: Percentage of Systems with at Least One Barium Detection, by State

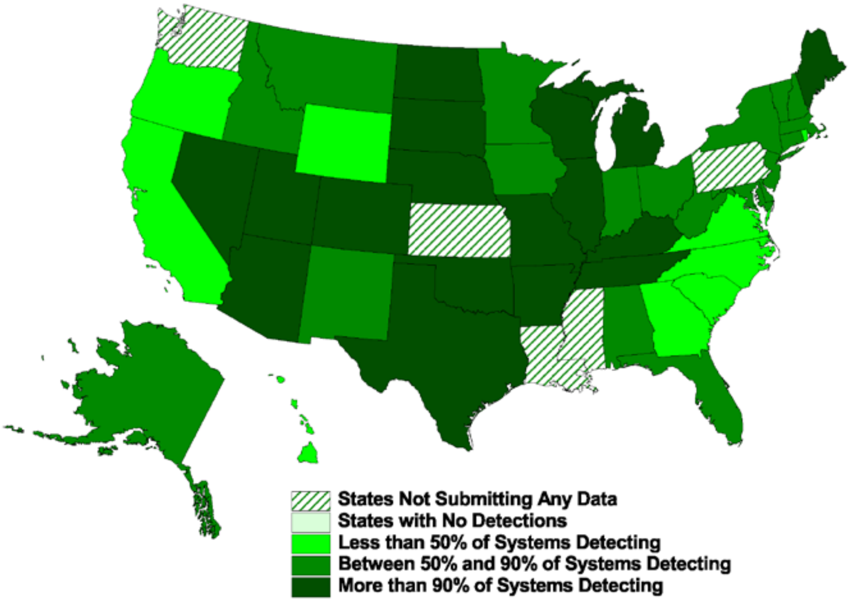

Exhibit 8-6: Percentage of Systems with at Least One Barium Detection Greater than the MCL Concentration (> 2 mg/L), by State

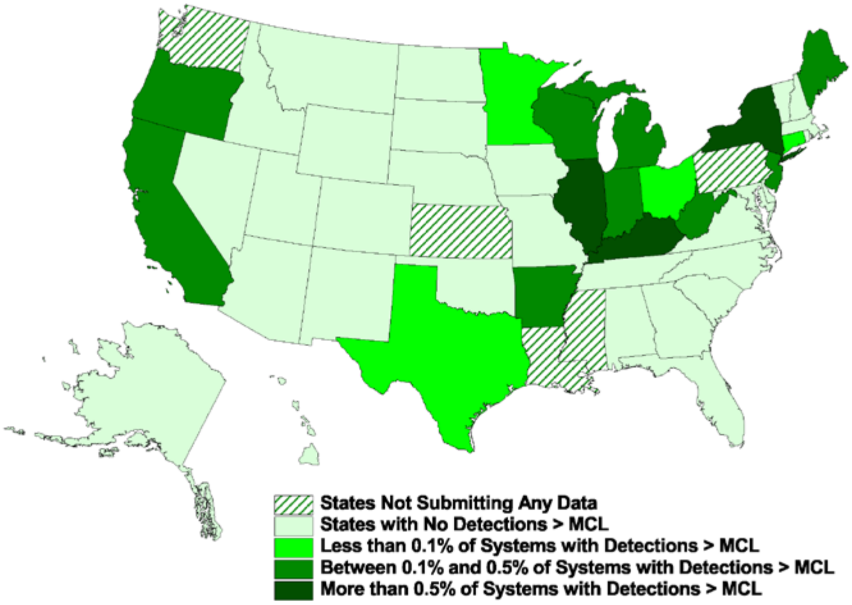

Exhibit 8-7 presents the Stage 1 analysis of barium occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 1 mg/L and 2 mg/L. A total of 240 (0.489% of) systems, serving more than 820,000 persons, reported at least one detection greater than or equal to 1 mg/L; and 66 (0.134% of) systems, serving more than 211,000 persons, reported at least one detection greater than 2 mg/L.

Exhibit 8-7: Barium 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 mg/L	61	0.135%	189,533	0.222%
	≥ 1 mg/L	225	0.499%	609,877	0.714%
Surface Water	> 2 mg/L	5	0.125%	21,575	0.015%
	≥ 1 mg/L	15	0.374%	211,283	0.146%
Combined Ground & Surface Water	> 2 mg/L	66	0.134%	211,108	0.092%
	≥ 1 mg/L	240	0.489%	821,160	0.357%

8.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. *ToxFAQs for Barium.* August 2007. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts24.html.

Klein, C. and C.S. Hurlbut (after J.D. Dana). 1993. *Manual of Mineralogy* (21st edition). John Wiley and Sons.

United States Environmental Protection Agency (USEPA). 1991. Drinking Water; National Primary Drinking Water Regulations; Monitoring for Volatile Organic Chemicals; MCLGs and MCLs for Aldicarb, Aldicarb Sulfoxide, Aldicarb Sulfone, Pentachlorophenol, and Barium; Final Rule. Federal Register. Vol. 56, No. 126. p. 30266, July 1, 1991.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Barium. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for barium.] Accessed February 21, 2008.

USEPA. 2008a. TRI Explorer: Trends – Barium. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for barium.] Accessed March 4, 2008.

USEPA. 2008b. TRI Explorer: Trends – Barium Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for barium compounds.] Accessed March 4, 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.

9 Benzo(a)pyrene

This chapter on benzo(a)pyrene 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 benzo(a)pyrene 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 current National Primary Drinking Water Regulations (NPDWR) for benzo(a)pyrene 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 0.2 µg/L based on analytical method feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1995), benzo(a)pyrene ($C_{20}H_{12}$) is one of a group of compounds called polycyclic aromatic hydrocarbons (PAHs). It is largely associated with soils, particulate matter, and sediments; it does not readily leach. In soils, degradation takes weeks to months and is caused primarily by microbial activity. In water, it is susceptible to degradation by sunlight (ATSDR, 1995).

9.2 Use, Production, and Releases

PAHs are very common because they are formed naturally as a result of incomplete combustion of organic materials. Although they can be manufactured as individual compounds for research purposes, they are not manufactured as the mixtures found in combustion products. There is no known use for benzo(a)pyrene except as a research chemical (ATSDR, 1995).

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 benzo(a)pyrene.

Benzo(a)pyrene is not listed as a Toxics Release Inventory (TRI) chemical; thus, no TRI release records are available.

9.3 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 benzo(a)pyrene in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

9.4 Occurrence in Drinking Water

Benzo(a)pyrene 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 benzo(a)pyrene 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 benzo(a)pyrene. (There were no benzo(a)pyrene data from Hawaii or Oklahoma.) These data consist of 119,871 analytical results from 28,578 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.

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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.

9.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 9-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For benzo(a)pyrene, 0.490% of 28,578 systems reported detections. Exhibit 9-2 lists the minimum, median, 90th percentile, and maximum benzo(a)pyrene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of benzo(a)pyrene, based on detections from all systems, is 0.07 µg/L.

Exhibit 9-1: Benzo(a)pyrene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	92,473	25,566	65,074,173
Surface Water	27,398	3,012	119,069,990
Combined Ground & Surface Water	119,871	28,578	184,144,163
Percent with Detections			
Ground Water	0.124%	0.399%	4.456%
Surface Water	0.201%	1.262%	5.385%
Combined Ground & Surface Water	0.142%	0.490%	5.057%

Exhibit 9-2: Benzo(a)pyrene Summary Statistics

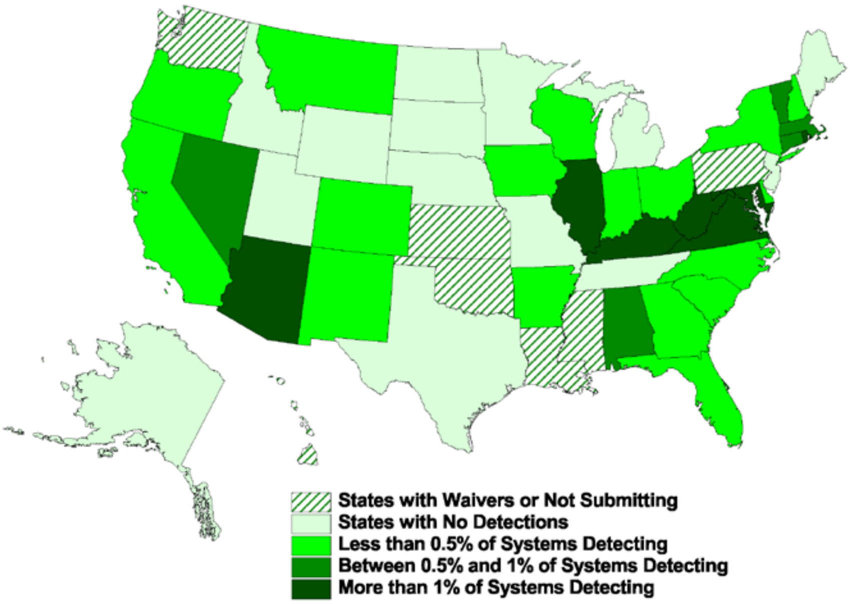
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.007	0.06	0.18	1
Surface Water	0.01	0.1	0.34	0.54

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Combined Ground & Surface Water	0.007	0.07	0.2	1

The following maps illustrate the geographic distribution of benzo(a)pyrene occurrence in drinking water. Exhibit 9-3 shows the states with systems with at least one detection and Exhibit 9-4 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). Hawaii and Oklahoma did submit Six-Year data for most contaminants, but did not submit data for benzo(a)pyrene.

Detection rates were generally low for benzo(a)pyrene. Seven states reported detections in more than 1% of their systems. With the exception of Arizona, these states are all located in the eastern part of the United States. In five states, between 0.5% and 1% of systems reported detections. Fourteen states reported no detections, and 12 states reported detections greater than the MCL concentration of 0.2 µg/L.

Exhibit 9-3: Percentage of Systems with at Least One Benzo(a)pyrene Detection, by State



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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 9-4: Percentage of Systems with at Least One Benzo(a)pyrene Detection Greater than the MCL Concentration (> 0.2 µg/L), by State

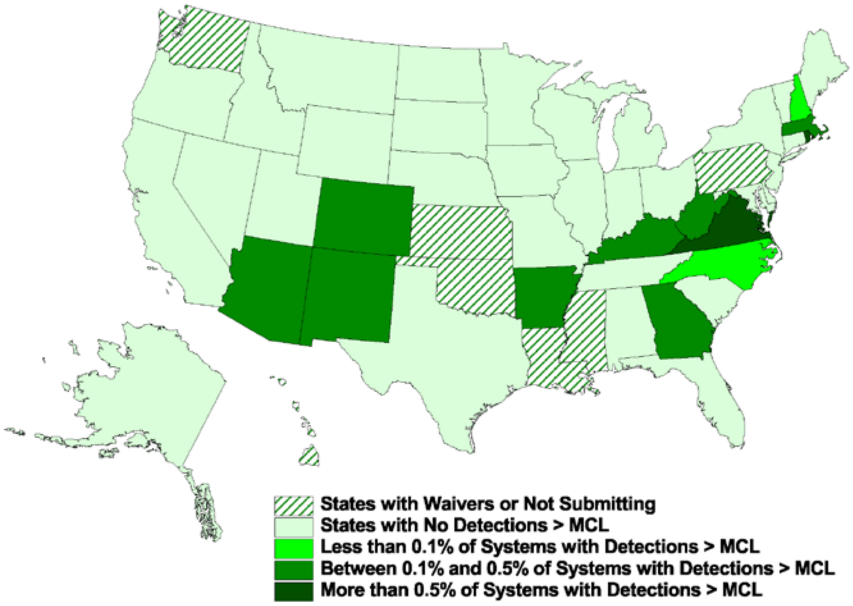

Exhibit 9-5 presents the Stage 1 analysis of benzo(a)pyrene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.1 µg/L and 0.2 µg/L. A total of 53 (0.185% of) systems, serving almost 3 million persons, reported at least one detection greater than or equal to 0.1 µg/L; and 14 (0.049% of) systems, serving almost 215,000 persons, reported at least one detection greater than 0.2 µg/L.

Exhibit 9-5: Benzo(a)pyrene 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	9	0.035%	12,087	0.019%
	≥ 0.1 µg/L	35	0.137%	69,321	0.107%
Surface Water	> 0.2 µg/L	5	0.166%	202,896	0.170%
	≥ 0.1 µg/L	18	0.598%	2,899,838	2.435%

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	> 0.2 µg/L	14	0.049%	214,983	0.117%
	≥ 0.1 µg/L	53	0.185%	2,969,159	1.612%

9.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Toxicological Profile for Polycyclic Aromatic Hydrocarbons.* August 1995. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp69.pdf.

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/.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

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.

10 Beryllium

This chapter on beryllium 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 beryllium 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 beryllium 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 0.004 mg/L. EPA classified beryllium in Group B2, probable human carcinogen, based on clear evidence of its carcinogenicity via inhalation or injection in several animal species. However, EPA also placed beryllium in drinking water Category II[1] for regulation, based on the weight of evidence for carcinogenicity via ingestion, and the potency, exposure and pharmacokinetics of this chemical. EPA derived the maximum contaminant level goal (MCLG) by applying an additional risk management factor of 10 to the RfD of 0.005 mg/kg-day (USEPA, 1992).

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2002), beryllium is a hard, grayish metal. In nature, it is found in minerals, coal, soil, and volcanic dust. Its primary ore mineral, beryl, is also known as the gemstones emerald (when green) and aquamarine (when blue) (Klein and Hurlbut, 1993). Beryllium can be released into the air by burning coal and soil. It poses a health risk from inhalation at high doses, although ambient levels are low enough that the general public is unlikely to develop beryllium disease (ATSDR, 2002).

10.2 Use, Production, and Releases

Beryllium ores are commercially mined. The beryllium is purified for use in nuclear weapons and reactors, aircraft and space vehicle structures, instruments, x-ray machines, and mirrors. Beryllium ores are used to make specialty ceramics for electrical and high-technology applications. Beryllium alloys are used in automobiles, computers, sports equipment (golf clubs and bicycle frames), and dental bridges (ATSDR, 2002).

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[1] Note that this “Category II” classification for beryllium is different than it being a part of the group of 47 Category 2 contaminants discussed in this report.

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 beryllium.

Beryllium and beryllium compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of beryllium for the period 1998-2006 ranged from approximately 74,000 pounds to approximately 458,000 pounds, with an increase over time. On-site releases were greater than off-site releases (USEPA, 2008a). Total beryllium compound releases ranged from approximately 641,000 pounds to approximately 972,000 pounds, with a general decrease over time. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

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 beryllium 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for beryllium. 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 10-1. Overall, beryllium was detected in 1.5% of samples and at 2.5% of sites. Beryllium was detected in similar percentages of surface water and ground water sites. The median concentration based on detections from all sites was 0.07 µg/L (0.00007 mg/L). The 99th percentile concentration based on detections from all sites was 18 µg/L (0.018 mg/L).

Exhibit 10-1: EPA Summary Analysis of Beryllium 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	3,252	2.2%	2,904	2.4%	0.03	0.0885	7.535	18	18

	Detection Frequency (detections are results ≥ RL[1])				**Concentration Values (of detections, in µg/L)**				
	Number of Samples	% Samples with Detections	Number of Sites	% Sites with Detections	Minimum	Median	95th Percen-tile	99th Percen-tile	Maximum
surface water	2,379	0.5%	394	2.8%	0.032	0.0445	11	11	11
all sites	5,631	1.5%	3,298	2.5%	0.03	0.07	7.535	18	18

1. RLs (Reporting Limits) for beryllium varied, but did not exceed 0.032 µg/L.

10.4 Occurrence in Drinking Water

Beryllium is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[2] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[3] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of beryllium 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 beryllium. These data consist of 183,575 analytical results from 48,021 systems 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.

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[2] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[3] 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.

10.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 10-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For beryllium, 3.117% of 48,021 systems reported detections. Exhibit 10-3 lists the minimum, median, 90th percentile, and maximum beryllium concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of beryllium, based on detections from all systems, is 0.0005 mg/L.

Exhibit 10-2: Beryllium Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	143,332	44,015	84,495,418
Surface Water	40,243	4,006	136,888,401
Combined Ground & Surface Water	183,575	48,021	221,383,819
Percent with Detections			
Ground Water	1.348%	2.992%	11.296%
Surface Water	0.825%	4.493%	15.313%
Combined Ground & Surface Water	1.233%	3.117%	13.780%

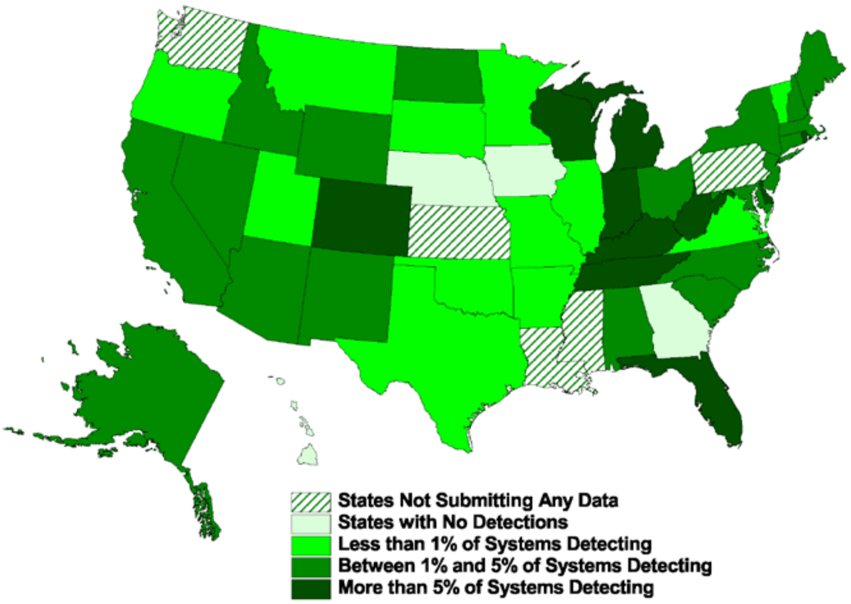
Exhibit 10-3: Beryllium Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.000021	0.0004	0.003	0.14
Surface Water	0.000021	0.001	0.002	0.05
Combined Ground & Surface Water	0.000021	0.0005	0.003	0.14

The following maps illustrate the geographic distribution of beryllium occurrence in drinking water. Exhibit 10-4 shows the states with systems with at least one detection and Exhibit 10-5 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[4], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of beryllium is geographically dispersed. In 10 states, more than 5% of systems detected beryllium. In 19 states, between 1% and 5% of systems reported detections. Twenty-five states reported no detections of beryllium greater than the MCL concentration of 0.004 mg/L. In four states, more than 0.5% of systems reported at least one detection greater than 0.004 mg/L.

Exhibit 10-4: Percentage of Systems with at Least One Beryllium Detection, by State



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

Exhibit 10-5: Percentage of Systems with at Least One Beryllium Detection Greater than the MCL Concentration (> 0.004 mg/L), by State

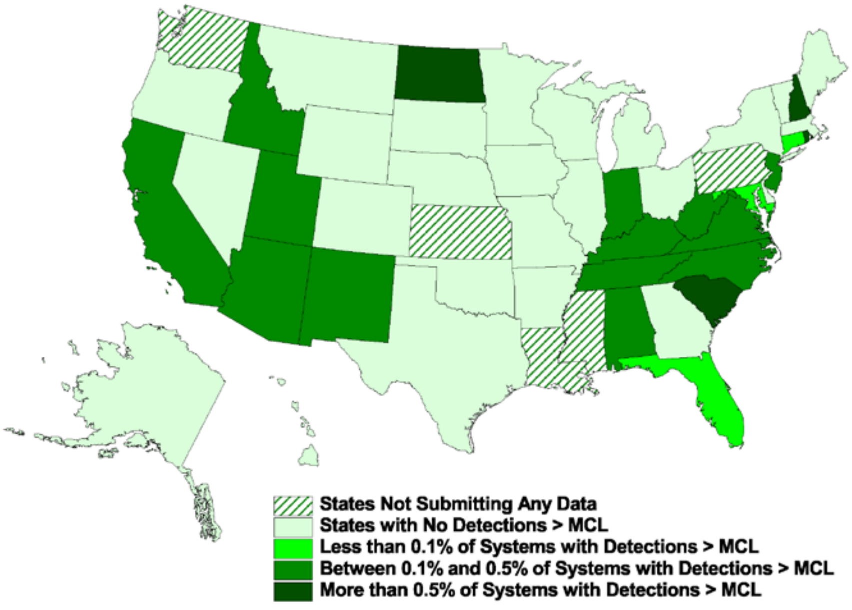

Exhibit 10-6 presents the Stage 1 analysis of beryllium occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.002 mg/L and 0.004 mg/L. A total of 250 (0.521% of) systems, serving about 5.8 million persons, reported at least one detection greater than or equal to 0.002 mg/L; and 53 (0.110% of) systems, serving almost 3.1 million persons, reported at least one detection greater than 0.004 mg/L.

Exhibit 10-6: Beryllium 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	> 0.004 mg/L	41	0.093%	148,433	0.176%
	≥ 0.002 mg/L	202	0.459%	1,453,696	1.720%
Surface Water	> 0.004 mg/L	12	0.300%	2,918,844	2.132%
	≥ 0.002 mg/L	48	1.198%	4,332,647	3.165%

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	> 0.004 mg/L	53	0.110%	3,067,277	1.386%
	≥ 0.002 mg/L	250	0.521%	5,786,343	2.614%

10.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2002. *ToxFAQs for Beryllium.* September 2002. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts4.html.

Klein, C. and C.S. Hurlbut (after J.D. Dana). 1993. *Manual of Mineralogy* (21st edition). John Wiley and Sons.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2008a. TRI Explorer: Trends – Beryllium. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for beryllium.] Accessed March 6, 2008.

USEPA. 2008b. TRI Explorer: Trends – Beryllium Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for beryllium compounds.] Accessed March 6, 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.

11 Beta Particles and Photon Emitters

This chapter on beta particles and photon emitters 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 beta particle 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

EPA published an interim Drinking Water Regulation for the sum of the doses from man-made beta particles and photon emitters on July 9, 1976 (41 FR 28402 (USEPA, 1976)). The Maximum Contaminant Level (MCL) that was established was a concentration that produces a dose equivalent of 50 pCi/L or less to the total body or any internal organ for the sum of the doses from man-made beta particles and photon emitters. A total of 168 individual beta particle and photon emitters may be used to calculate compliance with the MCL (USEPA, 2001). The beta particles and photon emitters include: cesium-137, cobalt-60, iodine-129 &-131, plutonium, strontium-90, technetium-99, and tritium, in addition to another 160 individual beta particle and photon emitters. In 2000, EPA published the final National Primary Drinking Water Regulations (NPDWR) for radionuclides. The MCL for beta particles and photon emitters remained at 4 mrem/yr.[1] The 2000 rule set a Maximum Contaminant Level Goal (MCLG) for beta particles at zero (USEPA, 2000).

Beta particle and photon radioactivity may occur due to contamination from facilities using or producing radioactive materials (USEPA, 2006). The decay of natural and man-made deposits of certain minerals that are radioactive may emit a form of radiation known as photons and beta radiation (USEPA, 2008a). Three regulated beta emitters – iodine-131, strontium-90, and tritium – are described in more detail below. Data for these three beta emitters are available in the Six Year Review-ICR Dataset but occurrence results were not included in this report.

Iodine-131

According to USEPA (2008b), iodine-131 is produced by the fission of uranium atoms during operation of nuclear reactors and by plutonium (or uranium) in the detonation of nuclear

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[1] Although the MCL for beta particles, 4 millirem per year (mrem/yr), is in the unit of measure of mrem/yr, the primary unit of analytical measure is picocuries per liter (pCi/L). This unit of measure relates to screening thresholds of 15 pCi/L and 50 pCi/L that are defined in the 2000 Radionuclides Rule.

weapons. It has a half-life of about eight days and emits beta particles upon radioactive decay (USEPA, 2008b).

Radioactive iodines have the same physical properties as stable iodine; yet, radioactive iodines decay with time. Iodine is a nonmetallic, purplish-black crystalline solid. It has the unusual property of sublimation. It sublimes to a deep violet vapor at room temperature. This vapor is irritating to the eyes, nose and throat. Iodine dissolves in alcohol and in water and melts at 236 °F (USEPA, 2008b).

Iodine reacts easily with other chemicals, and isotopes of iodine are found as compounds rather than as a pure elemental nuclide. Thus, iodine-131 found in nuclear facilities and waste treatment plants quickly forms compounds with the mixture of chemicals present. However, iodine released to the environment from nuclear power plants is usually a gas (USEPA, 2008b).

Strontium-90

According to USEPA (2007a), strontium-90 (Sr-90) is a by-product of the fission of uranium and plutonium in nuclear reactors, and in nuclear weapons. It is found in waste from nuclear reactors and can also contaminate reactor parts and fluids. Large amounts of Sr-90 were produced during atmospheric nuclear weapons tests conducted in the 1950's and 1960's and dispersed worldwide (USEPA, 2007a).

Non-radioactive strontium and its radioactive isotopes have the same physical properties. Strontium is a soft metal similar to lead. It is chemically very reactive, and is only found in compounds in nature. When freshly cut, it has a silvery luster, but rapidly reacts with air and turns yellow. Finely cut strontium will burst into flame in air. Because of these qualities, it is generally stored in kerosene (USEPA, 2007a).

Sr-90 emits a beta particle with no gamma radiation, as it decays to yttrium-90 (also a beta-emitter). Sr-90 has a half-life of about 29 years. It behaves chemically much like calcium, and therefore tends to concentrate in the bones and teeth (USEPA, 2007a).

Tritium

According to USEPA (2007b), tritium is produced naturally in the upper atmosphere when cosmic rays strike nitrogen molecules in the air. It is also produced during nuclear weapons explosions, as a byproduct in reactors producing electricity, and in special production reactors, where the isotope lithium-6 is bombarded to produce tritium (USEPA, 2007b).

Tritium is a hydrogen atom that has two neutrons in the nucleus, in addition to its single proton, giving it an atomic weight near three. Although tritium can be a gas, its most common form is in water, because, like non-radioactive hydrogen, radioactive tritium reacts with oxygen to form water. Tritium replaces one of the stable hydrogens in the water molecule, H_2O, and is called tritiated water. Like H_2O, tritiated water is colorless and odorless. Tritium has a half-life of about 12 years and emits a very weak beta particle (USEPA, 2007b).

11.2 Use, Production, and Releases

As beta particles occur naturally with decay of natural and man-made deposits of certain minerals that are radioactive, data for use, production, and release are not available. Use, production, and release data for three regulated beta emitters – iodine-131, strontium-90, and tritium – are described in more detail below.

Iodine-131

Iodines are among the most widely used radionuclides, used mostly in the medical field. Because of its short half-life and useful beta emission, iodine-131 is used extensively in nuclear medicine. Its tendency to collect in the thyroid gland makes iodine especially useful for diagnosing and treating thyroid problems. Iodine's chemical properties make it easy to attach to molecules for imaging studies. It is useful in tracking the metabolism of drugs or compounds, or for viewing structural defects in various organs, such as the heart (USEPA, 2008b).

Strontium-90

Strontium-90 is used as a radioactive tracer in medical and agricultural studies. The heat generated by Sr-90's radioactive decay can be converted to electricity for long-lived, portable power supplies. These are often used in remote locations, such as in navigational beacons, weather stations, and space vehicles (USEPA, 2007a).

Sr-90 is also used in electron tubes, as a radiation source in industrial thickness gauges, and for the treatment of eye diseases. Controlled amounts of Sr-90 have been used as a treatment for bone cancer (USEPA, 2007a).

Tritium

Tritium has several important uses. Its most significant use is as a component in the triggering mechanism in thermonuclear (fusion) weapons. Very large quantities of tritium are required for the maintenance of our nation's nuclear weapons capabilities (USEPA, 2007b).

Tritium is also produced commercially in reactors. It is used in various self-luminescent devices, such as exit signs in buildings, aircraft dials, gauges, luminous paints, and wristwatches. Tritium is also used in life science research, and in studies investigating the metabolism of potential new drugs (USEPA, 2007b).

11.3 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 beta particles in ambient water are available from the NAWQA program.

11.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for beta particles. 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 11-1. Overall, beta particles were detected in 53.0% of samples and at 52.3% of sites. Beta particles were detected in all 10 surface water samples and 51.9% of the 418 ground water samples. The median beta particle concentration based on detections from all sites was about 7.1 pCi/L. The 99th percentile concentration based on detections from all sites was about 82 pCi/L.

Exhibit 11-1: EPA Summary Analysis of Beta Particles Data from NAWQA Study Units, 1992-2001

	Detection Frequency (detections are results ≥ RL[1])				**Concentration Values (of detections, in pCi/L)**				
	Number of Samples	% Samples with Detections	Number of Sites	% Sites with Detections	Minimum	Median	95th Percen-tile	99th Percen-tile	Maximum
ground water	418	51.9%	414	51.7%	1.1	7.1	36.48	82.22	652.82
surface water	10	100.0%	5	100.0%	4.49	15.5	35	35	35
all sites	428	53.0%	419	52.3%	1.1	7.117	36	82.22	652.82

1. RLs (Reporting Limits) for beta particle activity varied, but did not exceed 4.5 pCi/L.

11.4 Occurrence in Drinking Water

Under the original radionuclides rule, all surface water community water systems (CWSs) serving more than 100,000 persons, as well as other CWSs as specified by the state, were required to sample for beta particle measurement. Initially, all CWSs must collect four consecutive quarterly samples or the composite of four consecutive quarterly samples. If the annual average particle activity of the initial sampling is less than 50 pCi/L, a system may reduce to one sample every four years. If the annual average is greater than 50 pCi/L, the sample must be analyzed to identify the major radioactive constituents present, and the appropriate internal organ and total body doses must be calculated. If the annual average beta particle activity is greater than the MCL, the system must take one sample each quarter until the annual average is below the MCL or until the state sets an alternate monitoring schedule.

If the average annual activity of tritium is greater than 20,000 pCi/L, and strontium-90 is greater than 8 pCi/L, or if both radionuclides are present and the sum of annual dose equivalents to total body or bone marrow is greater than 4 mrem/year, the system is out of compliance.

If a system is using water contaminated by effluents from a nuclear facility, and if beta particle activity is greater than 15 pCi/L, the system may be required to monitor quarterly for strontium-89 (limit is 80 pCi/L), cesium-134 (limit is 80 pCi/L), and iodine-131 (limit is 3 pCi/L). The average annual concentration of man-made radionuclides must not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year.

Under the new radionuclides rule, all CWSs designated by the state as vulnerable or contaminated (i.e., utilizing waters contaminated by effluents from nuclear facilities) are required to sample for beta particle activity.

CWSs designated by the state as vulnerable must collect four consecutive quarterly samples for beta emitters. “Quarterly” monitoring for gross beta is based on the analysis of monthly samples or the analysis of a three month composite of samples. Vulnerable CWSs must also collect annual samples for tritium and strontium-90. “Annual” samples must be collected quarterly and analyzed or composited and analyzed. Sampling must begin within one quarter after the quarter in which the CWS is notified by the state. If the beta particle activity minus the naturally occurring potassium-40 beta particle activity has a running annual average less than or equal to 50 pCi/L (screening level), the system may reduce sampling to once every three years.

CWSs utilizing waters contaminated by effluents from nuclear facilities must collect four consecutive quarterly samples for beta emitters and iodine-131 as well as annual samples for tritium and strontium-90 (the quarterly and annual monitoring requirements noted for vulnerable systems are also applicable to contaminated systems). Sampling must begin within one quarter after the quarter in which the system is notified by the state. If the beta particle activity minus the naturally occurring potassium-40 beta particle activity has a running annual average (computed quarterly) less than or equal to 15 pCi/L (screening level), the system may reduce sampling to once every three years.

For both vulnerable and contaminated systems, if a sample is greater than the screening level, the system must further analyze the sample for the major radioactive constituents and determine compliance with the MCLs for beta particle and photon radioactivity using the “sum of the fractions” calculation outlined in 40 CFR 141.66(d)(2). If the results show an MCL violation for any of the constituents, the system must conduct monthly monitoring at any sampling point that exceeds the MCL beginning the month after the exceedance occurs. A system can resume quarterly monitoring if the running annual of three months of samples is at or below the MCL.

The analysis of beta particle 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.

Beta particle data were provided by 34 of the Six-Year Review-ICR states. (No data were received from Florida, Georgia, Hawaii, Maine, Michigan, North Dakota, Nebraska, New

Hampshire, Oklahoma, and South Carolina.) The beta particle data from the 34 states consist of 59,983 analytical results from 14,231 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.

11.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 11-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For beta particles, 74.513% of 14,231 systems reported detections. Exhibit 11-3 lists the minimum, median, 90th percentile, and maximum beta particle concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of beta particles, based on detections from all systems, is 5.2 pCi/L.

Exhibit 11-2: Summary of Beta Particles Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	48,622	12,505	31,262,033
Surface Water	11,361	1,726	89,012,891
Combined Ground & Surface Water	59,983	14,231	120,274,924
Percent with Detections			
Ground Water	65.143%	72.971%	80.112%
Surface Water	61.685%	85.689%	89.231%
Combined Ground & Surface Water	64.488%	74.513%	86.861%

Exhibit 11-3: Beta Particles Summary Statistics

Source Water Type	Detection Value (pCi/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.00001	5.8	17.8	340.5

Source Water Type	**Detection Value (pCi/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Surface Water	0.003	4	9.06	488
Combined Ground & Surface Water	0.00001	5.2	16.09	488

The following maps illustrate the geographic distribution of beta particle 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 screening level of 50 pCi/L.[2] Note that five states did not submit any data for use in the Six-Year Review (Kansas[3], Louisiana, Mississippi, Pennsylvania, and Washington). Florida, Georgia, Hawaii, Maine, Michigan, North Dakota, Nebraska, New Hampshire, Oklahoma, and South Carolina submitted Six-Year data for most contaminants, but did not submit data for of beta particles.

The distribution of systems with detections of beta particles is geographically dispersed and detection rates were relatively high. In 15 states, more than 90% of systems reported detections of beta particles. In seven states, more than 1% of systems reported at least one detection greater than the screening level of 50 pCi/L.

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[2] Although the MCL for beta particles, 4 millirem per year (mrem/yr), is in the unit of measure of mrem/yr, the primary unit of analytical measure is picocuries per liter (pCi/L). This unit of measure relates to screening thresholds of 15 pCi/L and 50 pCi/L that are defined in the 2000 Radionuclides Rule. More than 95% of all compliance monitoring data for beta particles submitted by the states to EPA were in units of pCi/L. The analyses presented here are based on compliance monitoring data represented in units of pCi/L and are conducted relative to the screening threshold of 50 pCi/L.

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

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

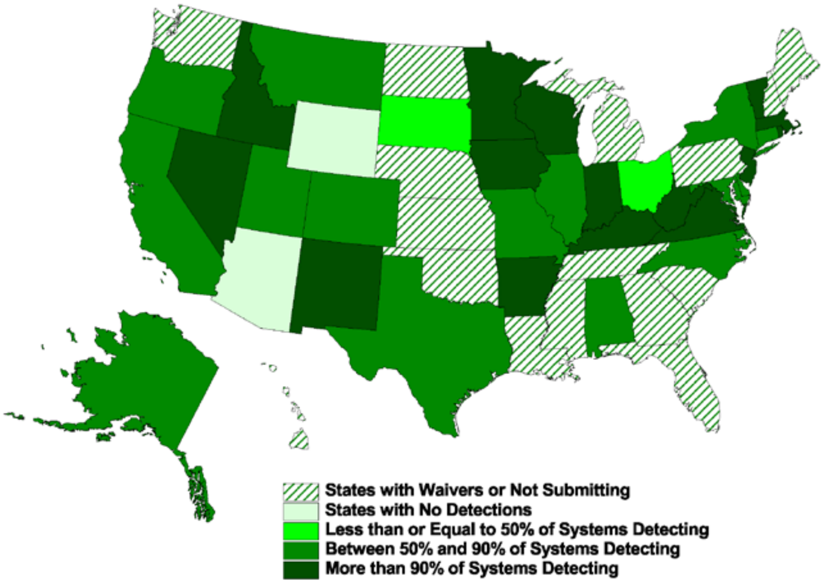

Exhibit 11-5: Percentage of Systems with at Least One Beta Particles Detection Greater than 50 pCi/L, by State

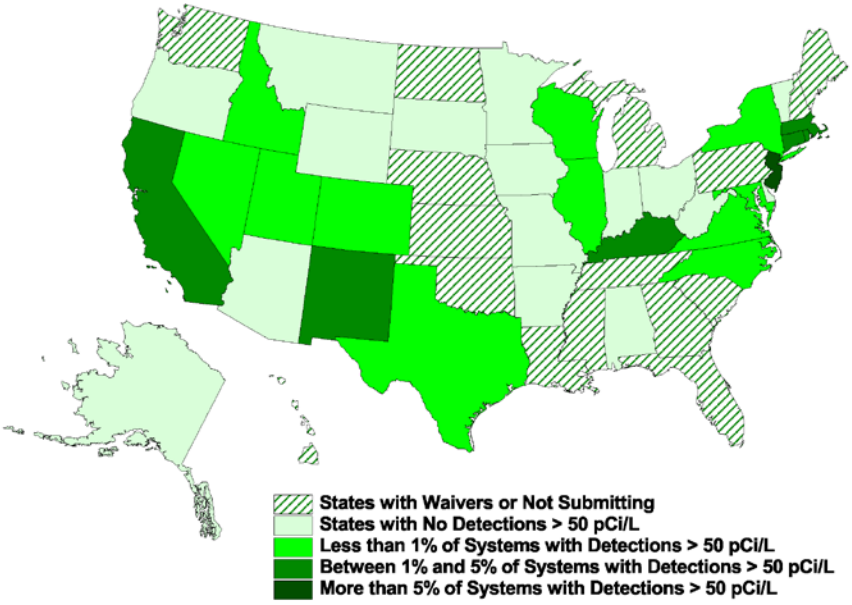

Exhibit 11-6 presents the Stage 1 analysis of beta particle occurrence in drinking water from systems and populations served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 25 pCi/L and 50 pCi/L. A total of 335 (2.354% of) systems, serving almost 9.7 million persons, reported at least one detection greater than or equal to 25 pCi/L; and 75 (0.527% of) systems, serving almost 1.5 million persons, reported at least one detection greater than 50 pCi/L.

Exhibit 11-6: Beta Particles 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 pCi/L	68	0.544%	540,849	1.730%
	≥ 25 pCi/L	302	2.415%	1,662,946	5.319%
Surface Water	> 50 pCi/L	7	0.406%	936,487	1.052%
	≥ 25 pCi/L	33	1.912%	7,998,101	8.985%
Combined Ground & Surface Water	> 50 pCi/L	75	0.527%	1,477,336	1.228%
	≥ 25 pCi/L	335	2.354%	9,661,047	8.032%

11.5 References

United States Environmental Protection Agency (USEPA). 1976. Title 40—Protection of Environment. Chapter 1--Environmental Protection Agency. Part 141—Interim Primary Drinking Water Regulations. Promulgation of Regulations on Radionuclides. Federal Register, Vol. 41, No. 133, p. 28402, July 9, 1976.

USEPA. 2000. National Primary Drinking Water Regulations; Radionuclides; Final Rule. Federal Register. Vol. 65, No. 236. p. 76707, December 7, 2000.

USEPA. 2001. Radionuclides Rule: A Quick Reference Guide. EPA-816-F-01-003, June 2001. Available on the Internet at: http://www.epa.gov/safewater/radionuclides/pdfs/qrg_radionuclides.pdf.

USEPA. 2006. Basic Information about Radionuclides in Drinking Water. Last modified September 19, 2006. Available on the Internet at: http://www.epa.gov/safewater/radionuclides/basicinformation.html. Accessed March 18, 2008.

USEPA. 2007a. Radiation Protection: *Strontium-90*. Last modified November 13, 2007. Available on the Internet at: http://www.epa.gov/radiation/radionuclides/strontium.html. Accessed March 18, 2008.

USEPA. 2007b. Radiation Protection: *Tritium*. Last modified November 15, 2007. Available on the Internet at: http://www.epa.gov/radiation/radionuclides/uranium.html. Accessed March 18, 2008.

USEPA. 2008a. Drinking Water Contaminants. Last modified February 15, 2008. Available on the Internet at: http://www.epa.gov/safewater/contaminants/index.html. Accessed March 17, 2008.

USEPA. 2008b. Radiation Protection: *Iodine*. Last modified February 20, 2008. Available on the Internet at: http://www.epa.gov/radiation/radionuclides/iodine.html. Accessed March 18, 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.

12 Cadmium

This chapter on cadmium 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 cadmium 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 cadmium 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 0.005 mg/L. Because of inadequate dose-response data to determine whether it poses a carcinogenic hazard from oral exposure, the Agency regulated cadmium as a Group D carcinogen, not classifiable as to human carcinogenicity by the oral route of exposure. Therefore, EPA developed the MCLG for cadmium based on the reference dose (RfD) of 0.0005 mg/kg-day.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1999), cadmium is a natural element in the earth’s crust. All soils and rocks, including coal and mineral fertilizers, contain some cadmium. It is usually found combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). Some cadmium compounds are able to leach through soils to ground water. Cadmium tends to accumulate in aquatic life (ATSDR, 1999).

12.2 Use, Production, and Releases

Cadmium is used for metal plating and coating operations, and plastics. It is also used in nickel-cadmium and solar batteries and in pigments. Most cadmium used in the United States is extracted during the production of other metals such as zinc, lead, and copper (ATSDR, 1999).

The Toxic Substances Control Act (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 12-1 presents the production of cadmium in the United States from 1986 to 2002. Note that the production of cadmium in the United States was only documented in the Chemical Update System in 1998.

Exhibit 12-1: Production of Cadmium in the United States

Inventory Update Year	Production Volume
1986 Range	No reports
1990 Range	No reports
1994 Range	No reports
1998 Range	> 1 million – 10 million pounds
2002 Range	No reports

Source: USEPA, 2003

Cadmium and cadmium compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of cadmium for the period 1998-2006 ranged from approximately 698,000 pounds to approximately 2.8 million pounds, with a decrease after 1999 and an increase after 2004. On-site releases were greater than off-site releases (USEPA, 2008a). Total cadmium compound releases ranged from approximately 2.6 million pounds to approximately 13.3 million pounds, with a general decrease over time. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

12.3 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 cadmium in ambient water are available from the NAWQA program.

12.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for cadmium. 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 12-2. Overall, cadmium was detected in 8.1% of samples and at 7.4% of sites. Cadmium was detected at a higher percentage of surface water sites than ground water sites. The median concentration based on detections from all sites was 0.135 µg/L (0.000135 mg/L). The 99th percentile concentration based on detections from all sites was about 13 µg/L (0.013 mg/L).

Exhibit 12-2: EPA Summary Analysis of Cadmium 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	3,399	7.3%	3,005	6.0%	0.018	0.087	4	7.43	9.363
surface water	3,345	8.9%	469	16.2%	0.018	0.205	9	18	18.244
all sites	6,744	8.1%	3,474	7.4%	0.018	0.135	8.375	13.179	18.244

1. RLs (Reporting Limits) for cadmium varied, but did not exceed 0.018 µg/L.

12.4 Occurrence in Drinking Water

Cadmium is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[1] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[2] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of cadmium 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] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[2] 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.

All of the Six-Year Review-ICR states provided occurrence data for cadmium. These data consist of 181,667 analytical results from 48,920 systems 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.

12.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 12-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For cadmium, 5.605% of 48,920 systems reported detections. Exhibit 12-4 lists the minimum, median, 90th percentile, and maximum cadmium concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of cadmium, based on detections from all systems, is 0.00054 mg/L.

Exhibit 12-3: Cadmium Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	141,170	44,928	85,335,776
Surface Water	40,497	3,992	144,349,594
Combined Ground & Surface Water	181,667	48,920	229,685,370
Percent with Detections			
Ground Water	2.360%	5.382%	14.395%
Surface Water	1.721%	8.116%	18.449%
Combined Ground & Surface Water	2.217%	5.605%	16.943%

Exhibit 12-4: Cadmium Summary Statistics

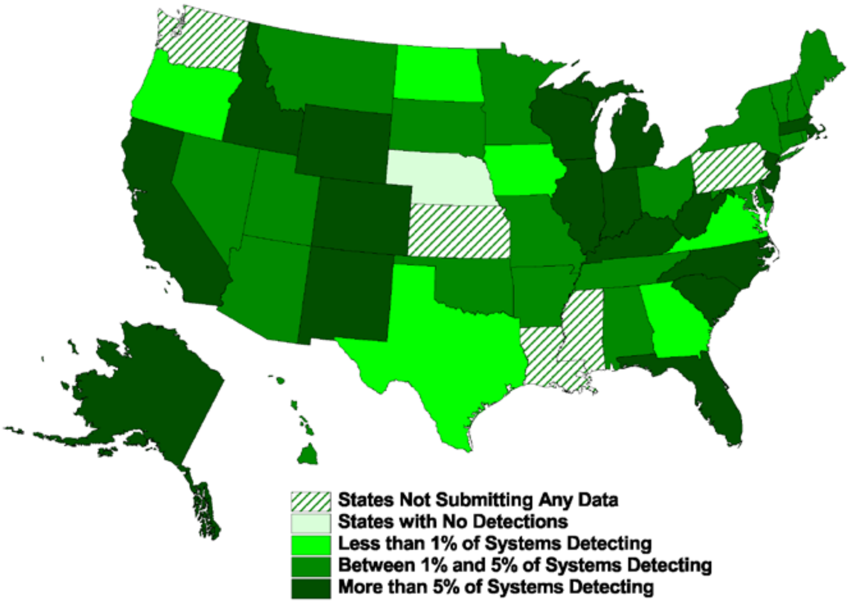
Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.000006	0.0005	0.004	0.08

Source Water Type	**Detection Value (mg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Surface Water	0.000007	0.000853	0.003	0.05
Combined Ground & Surface Water	0.000006	0.00054	0.0035	0.08

The following maps illustrate the geographic distribution of cadmium occurrence in drinking water. Exhibit 12-5 shows the states with systems with at least one detection and Exhibit 12-6 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[3], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of cadmium is geographically dispersed. In 18 states, more than 5% of systems detected cadmium. In seven states, more than 0.5% of systems reported at least one detection greater than the MCL concentration of 0.005 mg/L.

Exhibit 12-5: Percentage of Systems with at Least One Cadmium Detection, by State



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

Exhibit 12-6: Percentage of Systems with at Least One Cadmium Detection Greater than the MCL Concentration (> 0.005 mg/L), by State

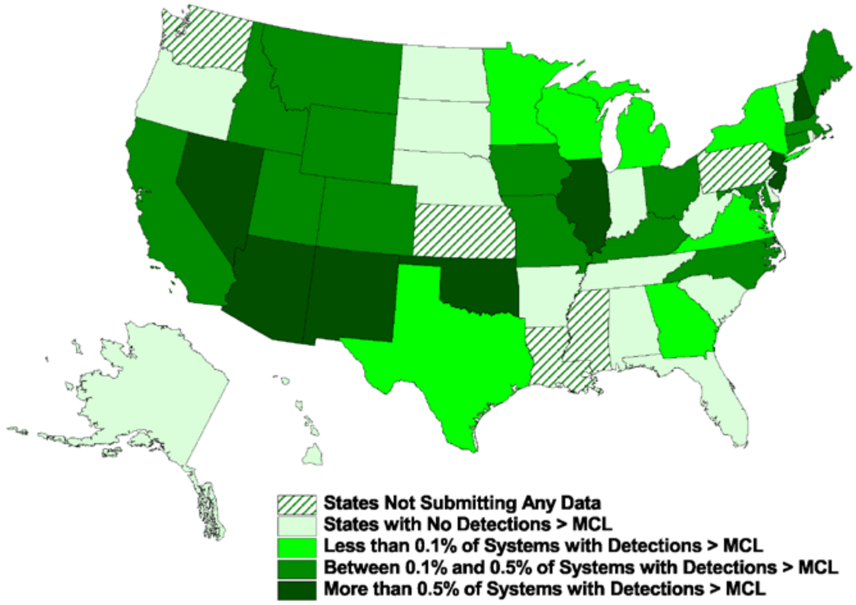

Exhibit 12-7 presents the Stage 1 analysis of cadmium occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.0025 mg/L and 0.005 mg/L. A total of 466 (0.953% of) systems, serving almost 6 million persons, reported at least one detection greater than or equal to 0.0025 mg/L; and 134 (0.274% of) systems, serving almost 2.4 million persons, reported at least one detection greater than 0.005 mg/L.

Exhibit 12-7: Cadmium 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	> 0.005 mg/L	121	0.269%	497,363	0.583%
	≥ 0.0025 mg/L	407	0.906%	1,710,771	2.005%
Surface Water	> 0.005 mg/L	13	0.326%	1,901,706	1.317%
	≥ 0.0025 mg/L	59	1.478%	4,288,872	2.971%

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	> 0.005 mg/L	134	0.274%	2,399,069	1.045%
	≥ 0.0025 mg/L	466	0.953%	5,999,643	2.612%

12.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. *ToxFAQs for Cadmium.* June 1999. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts5.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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Cadmium. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for cadmium.] Accessed February 21, 2008.

USEPA. 2008a. TRI Explorer: Trends – Cadmium. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for cadmium.] Accessed March 5, 2008.

USEPA. 2008b. TRI Explorer: Trends – Cadmium Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for cadmium compounds.] Accessed March 5, 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.

13 Chromium (Total)

This chapter on chromium (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 chromium 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

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for total chromium (Cr) on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) and maximum contaminant level (MCL) of 0.1 mg/L. Although the NPDWR regulates total chromium, the adverse health effects associated with hexavalent chromium (chromium VI) are the basis of the current MCLG because that is the more toxic species (USEPA, 1991). EPA based the MCLG on a reference dose (RfD) of 0.005 mg/kg-day and an assumed relative source contribution (RSC) from water of 70% for total chromium. EPA regulated chromium as a Group D carcinogen, not classifiable as to human carcinogenicity by the oral route of exposure.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2000), chromium exists in three common stable valence states. In order of generally increasing toxicity, these states are Cr (0), (III), and (VI). In its elemental form (Cr(0)), chromium is a hard, blue-white elemental metal. It is found in the earth’s crust in minerals as Cr(III). Chromium compounds have no taste or odor (ATSDR, 2000).

Chromium typically enters the environment in either the Cr(III) or Cr(VI) valence state. The major sources of chromium to ground water include leaching from rocks, mineral deposits, and mining and mill wastes. The two largest sources of chromium emission to the atmosphere are the chemical manufacturing industry and the combustion of natural gas, oil, and coal. Chromium tends to bind to soils strongly, though small amounts can dissolve in water and infiltrate into aquifers (ATSDR, 2000).

13.2 Use, Production, and Releases

The use of chromium to produce stainless steel and nonferrous alloys are two of its more important applications. Mixed with other metals, it can enhance hardenability and resistance to corrosion. Chromium is also used in bricks in furnaces, dyes and pigments, and for chrome plating, leather tanning, and wood preserving (ATSDR, 2000).

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 chromium.

Chromium and chromium compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of chromium for the period 1998-2006 ranged from approximately 10 million pounds to approximately 31 million pounds, with an overall decrease over time. Off-site releases were greater than on-site releases for all years except 1998 (USEPA, 2008a). Total chromium compound releases ranged from approximately 50 million pounds to approximately 140 million pounds, with a general decrease over time. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

13.3 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 chromium in ambient water are available from the NAWQA program.

13.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for chromium. 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 13-1. Overall, chromium was detected in 47.2% of samples and at 61.1% of sites. Chromium was detected more frequently in ground water than in surface water. The median concentration based on detections from all sites is 2 µg/L (0.002 mg/L). The 99th percentile concentration based on detections from all sites is about 17.5 µg/L (0.0175 mg/L).

Exhibit 13-1: EPA Summary Analysis of Chromium 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	3,341	62.3%	2,967	62.8%	0.402	2.58	9	19	148
surface water	2,610	28.0%	418	48.6%	0.4	1.7115	4.59	10	89
all sites	5,951	47.2%	3,385	61.1%	0.4	2	8	17.4741	148

1. RLs (Reporting Limits) for chromium varied, but did not exceed 0.4 µg/L.

13.4 Occurrence in Drinking Water

Chromium is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[1] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[2] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of chromium 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 chromium. These data consist of 185,952 analytical results from 48,908 systems 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.

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[1] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[2] 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.

13.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 13-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For chromium, 24.209% of 48,908 systems reported detections. Exhibit 13-3 lists the minimum, median, 90th percentile, and maximum chromium concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of chromium, based on detections from all systems, is 0.00415 mg/L.

Exhibit 13-2: Chromium Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	143,094	44,905	85,254,121
Surface Water	42,858	4,003	144,374,309
Combined Ground & Surface Water	185,952	48,908	229,628,430
Percent with Detections			
Ground Water	15.696%	24.044%	40.204%
Surface Water	14.098%	26.055%	41.829%
Combined Ground & Surface Water	15.328%	24.209%	41.226%

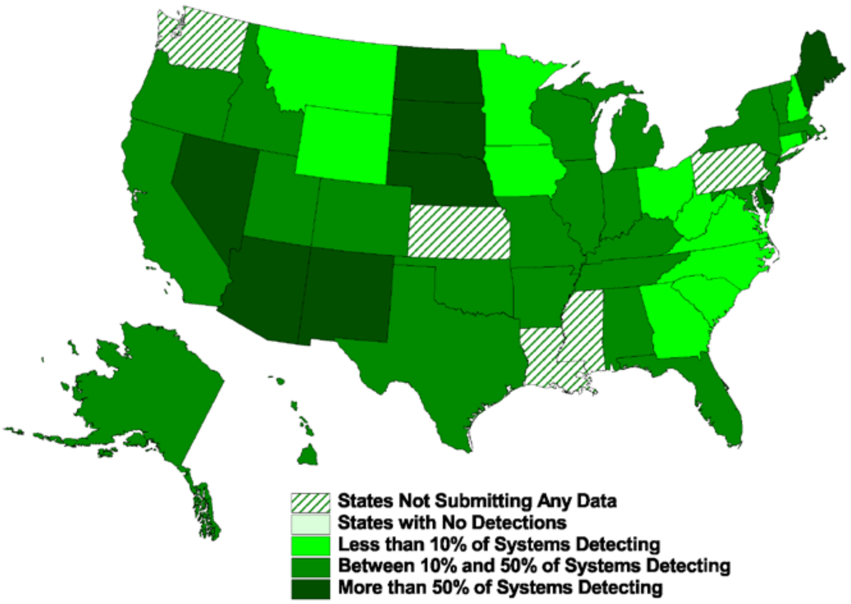
Exhibit 13-3: Chromium Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.000009	0.004	0.01	5.2
Surface Water	0.000009	0.006	0.02	0.32
Combined Ground & Surface Water	0.000009	0.00415	0.01	5.2

The following maps illustrate the geographic distribution of chromium occurrence in drinking water. Exhibit 13-4 shows the states with systems with at least one detection and Exhibit 13-5 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[3], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of chromium is geographically dispersed. Detection rates were high, with 8 states having greater than 50% of their systems detecting chromium and another 25 states between 10% and 50% of systems with detections of chromium. Only one state reported more than 0.5% of systems detecting chromium greater than the MCL concentration of 0.1 mg/L.

Exhibit 13-4: Percentage of Systems with at Least One Chromium Detection, by State



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

Exhibit 13-5: Percentage of Systems with at Least One Chromium Detection Greater than the MCL Concentration (> 0.1 mg/L), by State

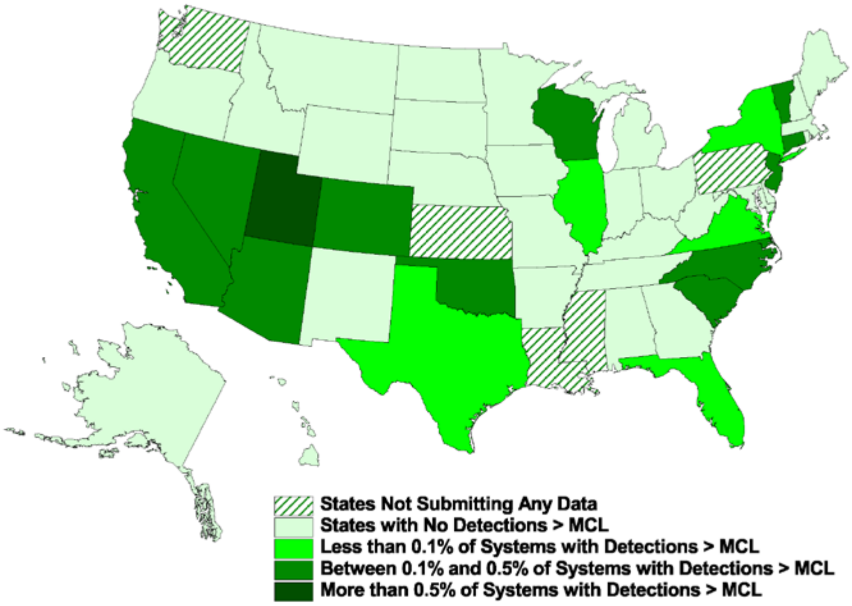

Exhibit 13-6 presents the Stage 1 analysis of chromium occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.05 mg/L and 0.1 mg/L. A total of 172 (0.352% of) systems, serving almost 9.5 million persons, reported at least one detection greater than or equal to 0.05 mg/L; and 43 (0.088% of) systems, serving about 717,000 persons, reported at least one detection greater than 0.1 mg/L.

Exhibit 13-6: Chromium 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	> 0.1 mg/L	37	0.082%	122,695	0.144%
	≥ 0.05 mg/L	144	0.321%	1,064,526	1.249%
Surface Water	> 0.1 mg/L	6	0.150%	593,922	0.411%
	≥ 0.05 mg/L	28	0.699%	8,424,108	5.835%

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	> 0.1 mg/L	43	0.088%	716,617	0.312%
	≥ 0.05 mg/L	172	0.352%	9,488,634	4.132%

13.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. *Toxicological Profile for Chromium.* September 2000. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp7.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. 2008a. TRI Explorer: Trends – Chromium. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for chromium.] Accessed February 29, 2008.

USEPA. 2008b. TRI Explorer: Trends – Chromium Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for chromium compounds.] 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.

14 Cyanide

This chapter on cyanide 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 cyanide 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 cyanide on July 17, 1992 (57 FR 31776 (USEPA, 1992)). The NPDWR established a maximum contaminant level goal (MCLG) and maximum contaminant level (MCL) of 0.2 mg/L. The MCLG was developed based on a reference dose (RfD) of 0.02 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, 2006a), cyanide is combined with other chemicals to form compounds. Some simple cyanide compounds are hydrogen cyanide, sodium cyanide and potassium cyanide. Certain bacteria, fungi, and algae can produce cyanide. In addition, cyanide is found in a number of foods and plants. In certain plant foods (e.g., almonds, millet sprouts, lima beans, soy, spinach, bamboo shoots, and cassava roots), cyanides occur naturally as part of sugars or other naturally-occurring compounds. Most cyanide in the soil or water will form hydrogen cyanide and evaporate. In the soil, some cyanide compounds will degraded by microorganisms. They do not bind to soils and may leach to ground water when concentrations are toxic to microorganisms (ATSDR, 2006a).

14.2 Use, Production, and Releases

Hydrogen cyanide and other cyanides are used in electroplating, metallurgy, organic chemicals production, photographic developing, manufacture of plastics, fumigation of ships, and some mining processes. In recent years, there has been strong demand for the use of hydrogen cyanide in nylon and other synthetic fibers. Other cyanides are used as herbicides (ATSDR, 2006b).

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 cyanide.

Cyanide compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of cyanide compounds for the period 1998-2006 ranged from approximately 5.1 million pounds to approximately 9.9 million pounds, with a decrease over time. On-site releases were greater than off-site releases (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 cyanide 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

Cyanide is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[1] The maximum waiver period for IOCs is nine years. (Statewide waivers for cyanide may be granted if all systems in the state are required to chlorinate. Cyanide waivers may also be granted if a state determines that a system is not vulnerable to cyanide contamination due to a lack of industrial cyanide sources.)

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[2] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of cyanide 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 cyanide. (There were no cyanide data from South Carolina.) These data consist of 120,368 analytical results from 32,067 systems during the period from 1998 to 2005. The number of sample results

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[1] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[2] 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.

and systems vary by state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness.

14.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 14-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For cyanide, 4.144% of 32,067 systems reported detections. Exhibit 14-2 lists the minimum, median, 90th percentile, and maximum cyanide concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of cyanide, based on detections from all systems, is 0.0089 mg/L.

Exhibit 14-1: Cyanide Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	93,931	29,277	66,122,477
Surface Water	26,437	2,790	96,336,123
Combined Ground & Surface Water	120,368	32,067	162,458,600
Percent with Detections			
Ground Water	1.559%	3.559%	14.736%
Surface Water	1.808%	10.287%	19.276%
Combined Ground & Surface Water	1.613%	4.144%	17.428%

Exhibit 14-2: Cyanide Summary Statistics

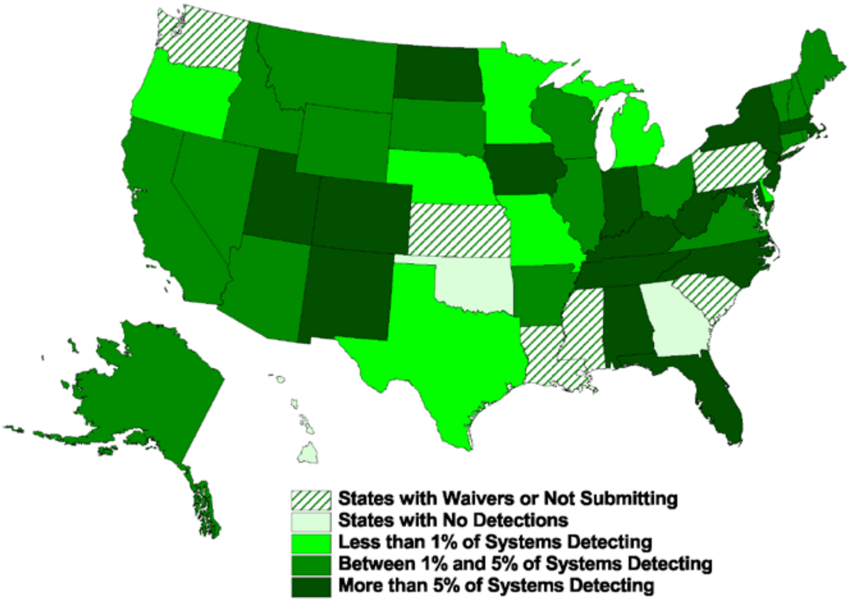
Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.0009	0.009	0.1	1.93
Surface Water	0.001	0.0085	0.05	1.88

Source Water Type	**Detection Value (mg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Combined Ground & Surface Water	0.0009	0.0089	0.08	1.93

The following maps illustrate the geographic distribution of cyanide occurrence in drinking water. Exhibit 14-3 shows the states with systems with at least one detection and Exhibit 14-4 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[3], Louisiana, Mississippi, Pennsylvania, and Washington). South Carolina did submit Six-Year data for most contaminants, but did not submit cyanide data.

The distribution of systems with cyanide detections is geographically dispersed. Sixteen states reported that more than 5% of systems detected cyanide. In three states, more than 0.5% of systems reported at least one detection greater than the MCL concentration of 0.2 mg/L.

Exhibit 14-3: Percentage of Systems with at Least One Cyanide Detection, by State



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

Exhibit 14-4: Percentage of Systems with at Least One Cyanide Detection Greater than the MCL Concentration (> 0.2 mg/L), by State

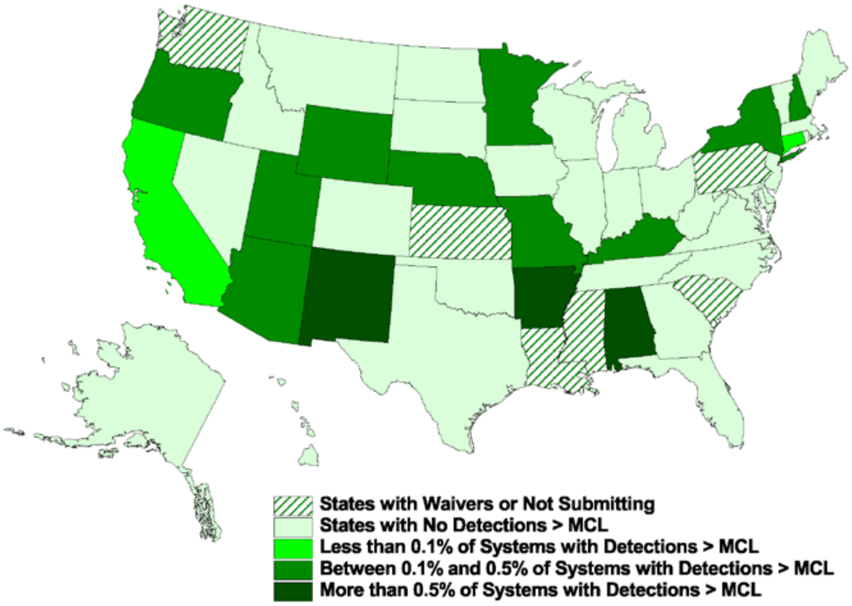

Exhibit 14-5 presents the Stage 1 analysis of cyanide occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.1 mg/L and 0.2 mg/L. A total of 117 (0.365% of) systems, serving more than 1.8 million persons, reported at least one detection greater than or equal to 0.1 mg/L; and 44 (0.137% of) systems, serving almost 257,000 persons, reported at least one detection greater than 0.2 mg/L.

Exhibit 14-5: Cyanide 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	39	0.133%	222,909	0.337%
	≥ 0.1 µg/L	91	0.311%	546,722	0.827%
Surface Water	> 0.2 µg/L	5	0.179%	33,999	0.035%
	≥ 0.1 µg/L	26	0.932%	1,304,404	1.354%

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	> 0.2 µg/L	44	0.137%	256,908	0.158%
	≥ 0.1 µg/L	117	0.365%	1,851,126	1.139%

14.5 References

Agency for Toxic Substances or Disease Registry (ATSDR). 2006a. *ToxFAQs for Cyanide.* July 2006. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts8.html.

ATSDR. 2006b. *Toxicological Profile for Cyanide.* July 2006. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp8.html.

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/.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2008. TRI Explorer: Trends – Cyanide Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for cyanide compounds.] Accessed March 5, 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.

15 Dalapon

This chapter on dalapon (2,2-dichloropropionic acid) 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 dalapon 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 dalapon 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 developed the MCLG based on a reference dose (RfD) of 30 µg/kg-day (0.03 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Extension Toxicology Network (EXTOXNET, 1996), in its pure acid form, dalapon ($C_3H_4Cl_2O_2$) is a colorless liquid with an acrid odor. As sodium-magnesium salts, it is a white to off-white powder. It will persist in soils for two to eight weeks. Dalapon leaches readily; its mobility is limited due to breakdown by soil microbes. It is also readily broken down by microbes in water. It tends not to accumulate in aquatic life (EXTOXNET, 1996).

15.2 Use, Production, and Releases

Dalapon is an herbicide used to control grasses in a wide variety of crops. The major crop use for dalapon is on sugarcane and sugar beets. It is also used on fruits, potatoes, carrots, asparagus, alfalfa and flax. It is also used in a number of non-crop applications such as lawns, drainage ditches, along railroad tracks, and in industrial areas (EXTOXNET, 1996).

The Toxic Substances Control Act (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 dalapon in the United States from 1986 to 2002. Note that the production of dalapon in the United States was only documented in the Chemical Update System in 1986 and 1990 and was lower in the 1990.

Exhibit 15-1: Production of Dalapon in the United States

Inventory Update Year	Production Volume
1986 Range	> 10 million – 50 million pounds
1990 Range	10,000 – 500,000 pounds
1994 Range	No reports
1998 Range	No reports
2002 Range	No reports

Source: USEPA, 2003

Dalapon is not listed as a Toxics Release Inventory (TRI) chemical. Therefore, no TRI release records are available.

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 dalapon 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

Dalapon 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

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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.

(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 dalapon 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.

Dalapon data were provided by 42 of the Six-Year Review-ICR states. (No dalapon data were received from Hawaii, New Hampshire, or Oklahoma.) The dalapon data from the 42 states consist of 112,423 analytical results from 28,387 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.

15.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 15-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For dalapon, 1.828% of 28,387 systems reported detections. Exhibit 15-3 lists the minimum, median, 90th percentile, and maximum dalapon concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of dalapon, based on detections from all systems, is 1.6 µg/L.

Exhibit 15-2: Dalapon Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	88,908	25,558	64,625,469
Surface Water	23,515	2,829	113,560,642
Combined Ground & Surface Water	112,423	28,387	178,186,111
Percent with Detections			
Ground Water	0.733%	1.471%	6.168%
Surface Water	1.905%	5.055%	8.451%

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Combined Ground & Surface Water	0.978%	1.828%	7.623%

Exhibit 15-3: Dalapon Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	1.7	6.6	1,210
Surface Water	0.04	1.4	3.2	83
Combined Ground & Surface Water	0.01	1.6	5	1,210

The following maps illustrate the geographic distribution of dalapon occurrence in drinking water. Exhibit 15-4 shows the states with systems with at least one detection and Exhibit 15-5 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, New Hampshire, and Oklahoma submitted Six-Year data for most contaminants, but did not submit data for dalapon.

Detection rates were generally low; 11 states reported detections in more than 1% of their systems. These states are all located in the eastern half of the United States, as well as the northern Midwest. In six states, between 0.5% and 1% of systems reported detections. Missouri was the only state that reported detections greater than the MCL concentration of 200 µg/L.

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

Exhibit 15-4: Percentage of Systems with at Least One Dalapon Detection, by State

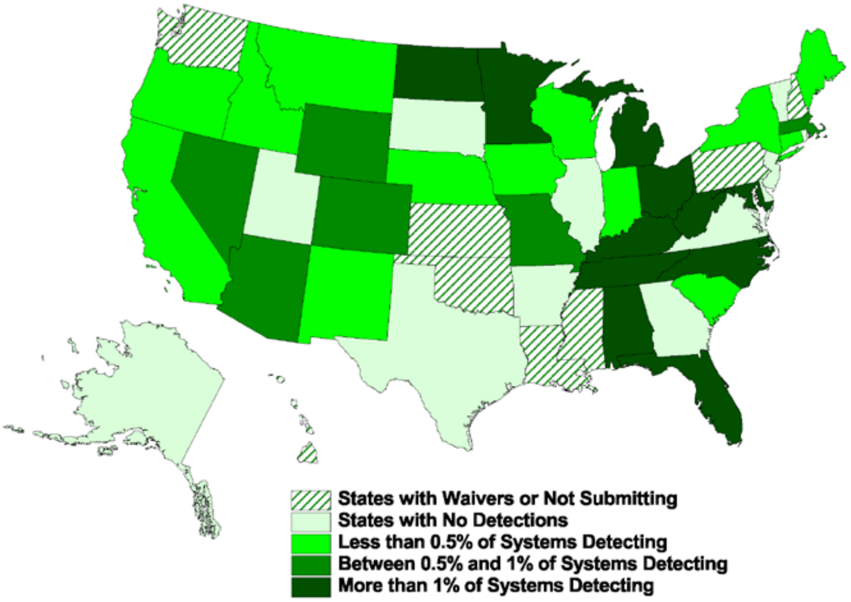

Exhibit 15-5: Percentage of Systems with at Least One Dalapon Detection Greater than the MCL Concentration (> 200 µg/L), by State

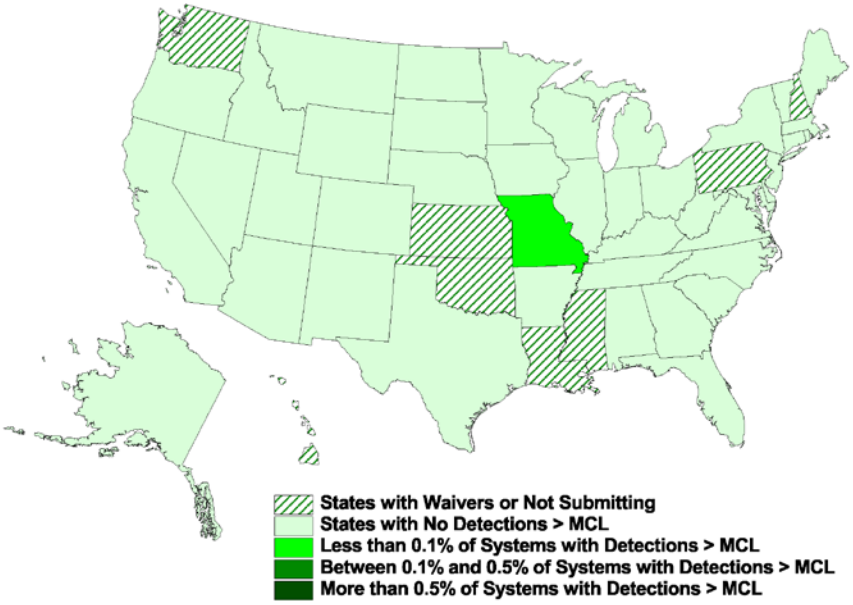

Exhibit 15-6 presents the Stage 1 analysis of dalapon occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 100 µg/L and 200 µg/L. One ground water system, serving about 20,000 persons, reported at least one detection greater than or equal to both thresholds. No surface water systems reported detections exceeding either threshold.

Exhibit 15-6: Dalapon 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	1	0.004%	20,114	0.031%
	≥ 100 µg/L	1	0.004%	20,114	0.031%
Surface Water	> 200 µg/L	0	0.000%	0	0.000%
	≥ 100 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 200 µg/L	1	0.004%	20,114	0.011%
	≥ 100 µg/L	1	0.004%	20,114	0.011%

15.5 References

Extension Toxicology Network (EXTOXNET). 1996. EXTOXNET Pesticide Information Profiles–Dalapon. Last modified June 1996. Available on the Internet at: http://extoxnet.orst.edu/pips/dalapon.htm. Accessed July 6, 2008.

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/.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Dalapon. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for dalapon.] Accessed February 21, 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.

16 Di(2-ethylhexyl)adipate (DEHA)

This chapter on di(2-ethylhexyl)adipate (DEHA) 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 di(2-ethylhexyl)adipate 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 National Primary Drinking Water Regulations (NPDWR) for di(2-ethylhexyl)adipate 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 400 µg/L. The Agency developed the MCLG based on a reference dose (RfD) of 600 µg/kg-day (0.6 mg/kg-day) and a cancer classification of C, possible human carcinogen.

According to the Hazardous Substance Data Bank (HSDB, 2008), di(2-ethylhexyl)adipate ($C_{22}H_{42}O_4$) is a light-colored, oily liquid with a slight aromatic odor. Other names for di(2-ethylhexyl)adipate include bis(2-ethylhexyl)adipate and DEHA. It tends to bind strongly to soils and does not readily leach. In soil or water, it breaks down quickly by microbial action (HSDB, 2008).

16.2 Use, Production, and Releases

Di(2-ethylhexyl)adipate is used in making plastics. It can also be used as a solvent, in aircraft lubricants, and as a hydraulic fluid. Furthermore, di(2-ethylhexyl)adipate is also used as a plasticizer or solvent in the following cosmetics: bath oils, eye shadow, cologne, foundations, rouge, blusher, nail-polish remover, moisturizers and indoor tanning preparations, and in meat wrapping operations (HSDB, 2008).

The Toxic Substances Control Act (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 16-1 presents the production of di(2-ethylhexyl)adipate in the United States from 1986 to 2002. Note that the production of di(2-ethylhexyl)adipate in the United States has fluctuated since 1986.

Exhibit 16-1: Production of Di(2-ethylhexyl)adipate 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	> 50 million – 100 million pounds
1998 Range	> 50 million – 100 million pounds
2002 Range	> 10 million – 50 million pounds

Source: USEPA, 2003

Di(2-ethylhexyl)adipate is not listed as a Toxics Release Inventory (TRI) chemical; thus, no TRI release records are available.

16.3 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 di(2-ethylhexyl)adipate in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

16.4 Occurrence in Drinking Water

Di(2-ethylhexyl)adipate 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

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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.

(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 di(2-ethylhexyl)adipate 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.

Di(2-ethylhexyl)adipate data were provided by 43 of the Six-Year Review-ICR states. (No di(2-ethylhexyl)adipate data were received from Hawaii or Oklahoma.) These data consist of 121,792 analytical results from 28,902 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.

16.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 16-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For di(2-ethylhexyl)adipate, 1.754% of 28,902 systems reported detections. Exhibit 16-3 lists the minimum, median, 90th percentile, and maximum di(2-ethylhexyl)adipate concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of di(2-ethylhexyl)adipate, based on detections from all systems, is 0.91 µg/L.

Exhibit 16-2: Di(2-ethylhexyl)adipate Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	94,351	25,891	65,031,810
Surface Water	27,441	3,011	119,102,864
Combined Ground & Surface Water	121,792	28,902	184,134,674
Percent with Detections			
Ground Water	0.627%	1.599%	6.686%
Surface Water	0.609%	3.089%	6.811%

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Combined Ground & Surface Water	0.623%	1.754%	6.767%

Exhibit 16-3: Di(2-ethylhexyl)adipate Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.935	15.13	1,300
Surface Water	0.02	0.8	4.1	43.7
Combined Ground & Surface Water	0.01	0.91	8.2	1,300

The following maps illustrate the geographic distribution of di(2-ethylhexyl)adipate occurrence in drinking water. Exhibit 16-4 shows the states with systems with at least one detection and Exhibit 16-5 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 and Oklahoma did submit Six-Year data for most contaminants, but did not submit data for di(2-ethylhexyl)adipate.

The distribution of systems with detections of di(2-ethylhexyl)adipate is geographically dispersed. Seven states reported detections in more than 5% of their systems. In 10 states, between 1% and 5% of systems reported detections. Only two states reported detections greater than the MCL concentration of 400 µg/L.

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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 16-4: Percentage of Systems with at Least One Di(2-ethylhexyl)adipate Detection, by State

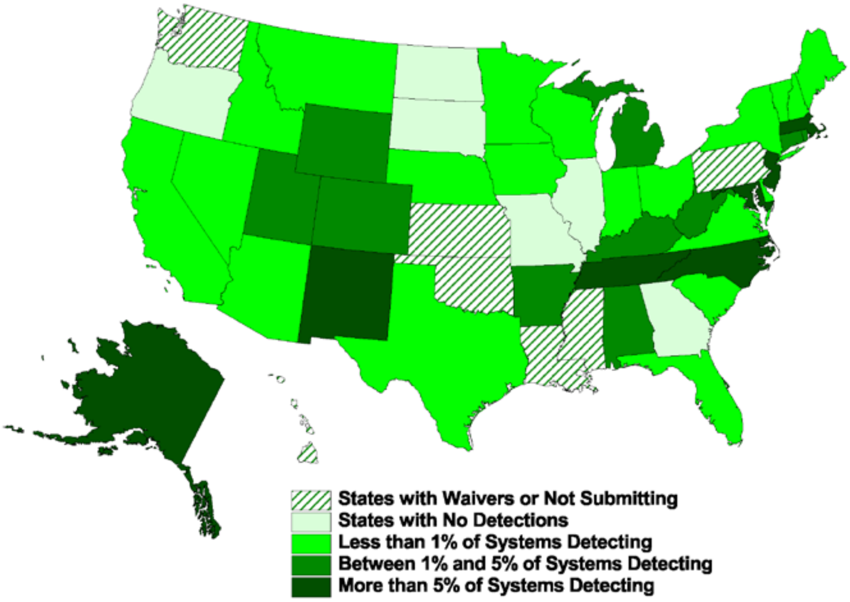

Exhibit 16-5: Percentage of Systems with at Least One Di(2-ethylhexyl)adipate Detection Greater than the MCL Concentration (> 400 µg/L), by State

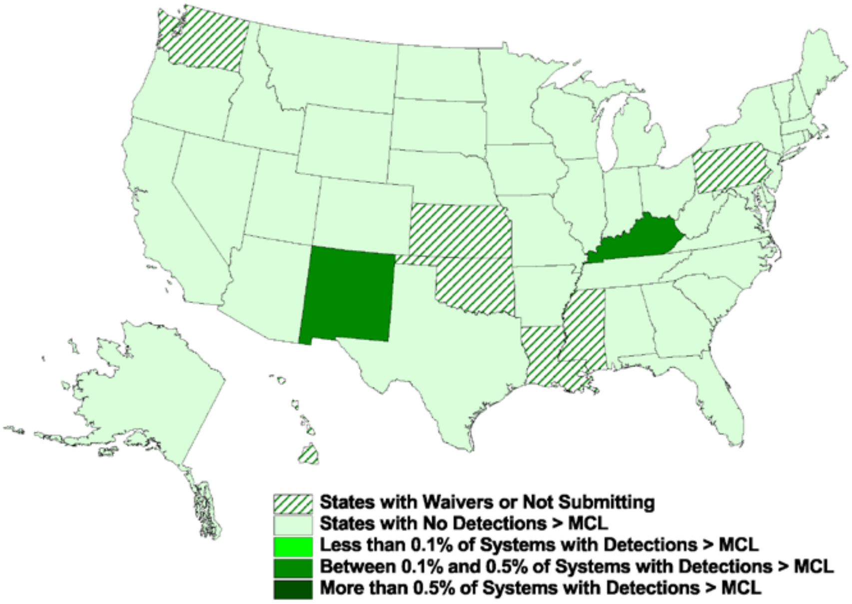

Exhibit 16-6 presents the Stage 1 analysis of di(2-ethylhexyl)adipate occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 200 µg/L and 400 µg/L. Seven ground water systems, serving about 25,000 persons, reported at least one detection greater than or equal to 200 µg/L; and 2 ground water systems, serving about 23,000 persons, reported at least one detection greater than 400 µg/L. No surface water systems reported detections greater than either threshold.

Exhibit 16-6: Di(2-ethylhexyl)adipate 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	> 400 µg/L	2	0.008%	22,913	0.035%
	≥ 200 µg/L	7	0.027%	24,953	0.038%
Surface Water	> 400 µg/L	0	0.000%	0	0.000%
	≥ 200 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 400 µg/L	2	0.007%	22,913	0.012%
	≥ 200 µg/L	7	0.024%	24,953	0.014%

16.5 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/.

Hazardous Substance Data Bank (HSDB). 2008. BIS(2-ETHYLHEXYL) ADIPATE. Available on the Internet at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Search for BIS(2-ETHYLHEXYL)ADIPATE.] Accessed: July 2, 2008.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Di(2-ethylhexyl)adipate. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for di(2-ethylhexyl)adipate.] Accessed February 21, 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.

17 Di(2-ethylhexyl)phthalate (DEHP)

This chapter on di(2-ethylhexyl)phthalate (DEHP) 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 di(2-ethylhexyl)phthalate 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 di(2-ethylhexyl)phthalate 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, and a maximum contaminant level (MCL) of 6 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2002), di(2-ethylhexyl)phthalate ($C_{24}H_{38}O_4$) is a member of the group of related chemicals called phthalates or phthalic acid esters. Di(2-ethylhexyl)phthalate (also known as bis(2-ethylhexyl)phthalate or DEHP) is a colorless liquid with almost no odor. It will bind to soil, limiting its ability to leach into ground water. In water it rapidly biodegrades unless oxygen is limited. It can accumulate in aquatic organisms; however tissue levels are usually low because it is metabolized by larger organisms (ATSDR, 2002).

17.2 Use, Production, and Releases

Di(2-ethylhexyl)phthalate is a manufactured chemical that is commonly added to plastics to make them flexible. Its greatest use is as a plasticizer for polyvinyl chloride (PVC). Because of concerns about health effects, di(2-ethylhexyl)phthalate is no longer used as a plasticizer in food wraps. It is present in plastic products such as wall coverings, tablecloths, floor tiles, furniture upholstery, shower curtains, garden hoses, swimming pool liners, rainwear, baby pants, dolls, some toys, shoes, automobile upholstery and tops, packaging film and sheets, sheathing for wire and cable, medical tubing, and blood storage bags (ATSDR, 2002).

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 di(2-ethylhexyl)phthalate.

Di(2-ethylhexyl)phthalate is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of di(2-ethylhexyl)phthalate for the period 1998-2006 ranged from 998,000 pounds to approximately 1.5 million pounds, with a general decrease over time. Off-site releases were greater than on-site releases (USEPA, 2008).

17.3 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 di(2-ethylhexyl)phthalate in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

17.4 Occurrence in Drinking Water

Di(2-ethylhexyl)phthalate 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 di(2-ethylhexyl)phthalate 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.

Di(2-ethylhexyl)phthalate data were provided by 42 of the Six-Year Review-ICR states. (There were no di(2-ethylhexyl)phthalate data from the following states: Hawaii, Oklahoma, and Wisconsin.) The di(2-ethylhexyl)phthalate data from the 42 states consist of 120,846 analytical results from 27,667 public water systems (PWSs) during the period from 1998 to 2005. The

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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.

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.

17.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 17-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For di(2-ethylhexyl)phthalate, 11.197% of 27,667 systems reported detections. (The high occurrence of di(2-ethylhexyl)phthalate could be due, in part, to sample contamination from older generation laboratory and field sampling equipment made of plastics that contained (and sometimes released) phthalates and may exaggerate the actual sample concentrations.) Exhibit 17-2 lists the minimum, median, 90th percentile, and maximum di(2-ethylhexyl)phthalate concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of di(2-ethylhexyl)phthalate, based on detections from all systems, is 1.2 µg/L.

Exhibit 17-1: Di(2-ethylhexyl)phthalate Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	92,944	24,677	62,976,862
Surface Water	27,902	2,990	116,971,710
Combined Ground & Surface Water	120,846	27,667	179,948,572
Percent with Detections			
Ground Water	4.864%	10.577%	19.240%
Surface Water	5.061%	16.321%	28.450%
Combined Ground & Surface Water	4.910%	11.197%	25.227%

Exhibit 17-2: Di(2-ethylhexyl)phthalate Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.05	1.3	6.26	250
Surface Water	0.06	1.1	4.4	49
Combined Ground & Surface Water	0.05	1.2	5.8	250

The following maps illustrate the geographic distribution of di(2-ethylhexyl)phthalate occurrence in drinking water. Exhibit 17-3 shows the states with systems with at least one detection and Exhibit 17-4 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). Hawaii, Oklahoma, and Wisconsin did submit Six-Year data for most contaminants, but did not submit di(2-ethylhexyl)phthalate data.

The distribution of systems with detections of di(2-ethylhexyl)phthalate is geographically dispersed. As stated earlier, the high occurrence of di(2-ethylhexyl)phthalate could be due, in part, to sample contamination from older generation laboratory and field sampling equipment made of plastics that contained (and sometimes released) phthalates and may exaggerate the actual sample concentrations. Seventeen states reported detections in more than 10% of their systems. In 12 states, between 5% and 10% of systems reported detections. Systems in 35 states reported at least one detection greater than the MCL concentration of 6 µg/L.

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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 17-3: Percentage of Systems with at Least One Di(2-ethylhexyl)phthalate Detection, by State

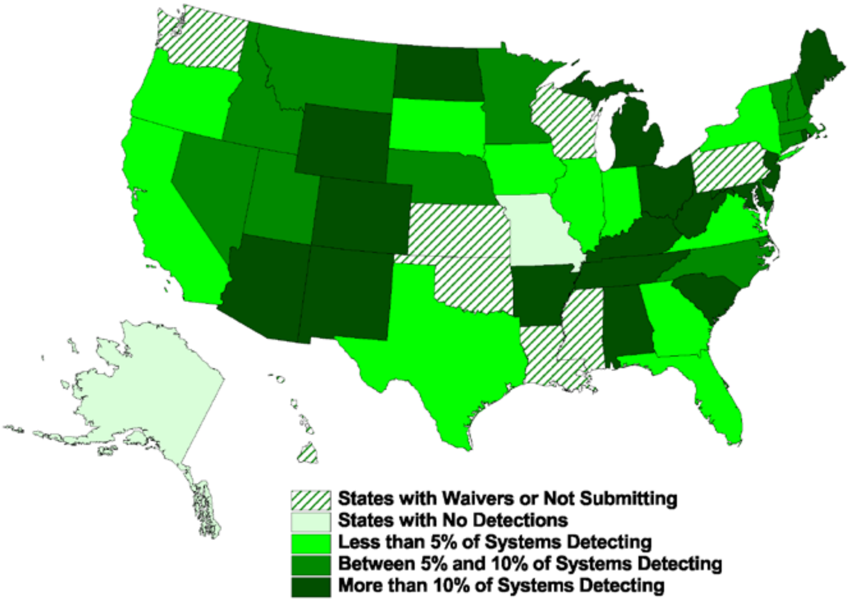

Exhibit 17-4: Percentage of Systems with at Least One Di(2-ethylhexyl)phthalate Detection Greater than the MCL Concentration (> 6 µg/L), by State

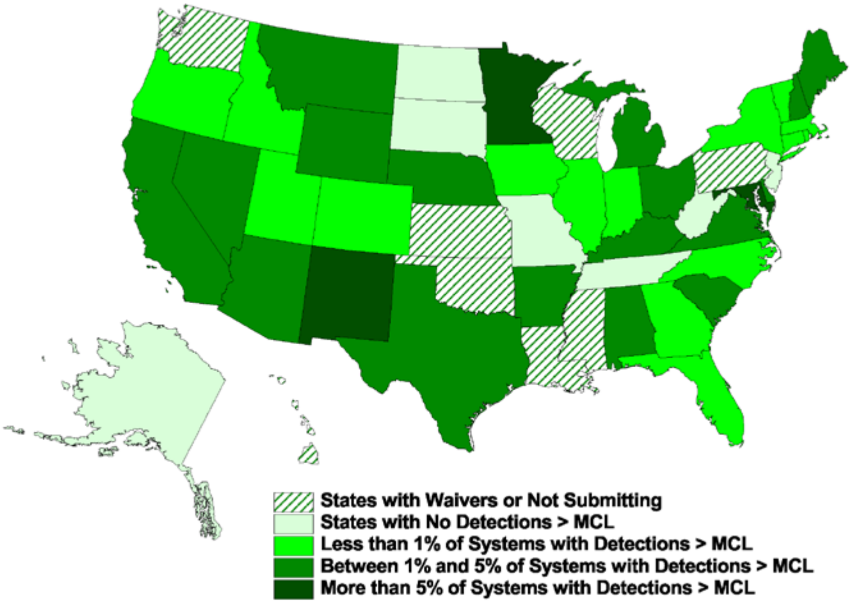

Exhibit 17-5 presents the Stage 1 analysis of di(2-ethylhexyl)phthalate occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 3 µg/L and 6 µg/L. A total of 955 (3.452% of) systems, serving more than 25 million persons, reported at least one detection greater than or equal to 3 µg/L; and 460 (1.663% of) systems, serving more than 11.5 million persons, reported at least one detection greater than 6 µg/L.

Exhibit 17-5: Di(2-ethylhexyl)phthalate 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	> 6 µg/L	390	1.580%	2,513,952	3.992%
	≥ 3 µg/L	786	3.185%	5,407,270	8.586%
Surface Water	> 6 µg/L	70	2.341%	8,996,752	7.691%
	≥ 3 µg/L	169	5.652%	19,734,540	16.871%
Combined Ground & Surface Water	> 6 µg/L	460	1.663%	11,510,704	6.397%
	≥ 3 µg/L	955	3.452%	25,141,810	13.972%

17.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2002. *Toxicological Profile for Di(2-ethylhexyl)phthalate (DEHP).* September 2002. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp9.pdf.

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/.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2008. TRI Explorer: Trends – Di(2-ethylhexyl)Phthalate. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for di(2-ethylhexyl)phthalate.] Accessed March 6, 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.

18 1,2-Dichlorobenzene (o-Dichlorobenzene)

This chapter on 1,2-dichlorobenzene (o-dichlorobenzene) 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-dichlorobenzene 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 1,2-dichlorobenzene 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 600 µg/L. EPA developed the MCLG based on a reference dose (RfD) of 90 µg/kg-day (0.09 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, 2006), 1,2-dichlorobenzene ($C_6H_4Cl_2$) is a colorless to pale yellow liquid. It is part of the dichlorobenzene family, which also includes 1,3-dichlorobenzene and 1,4-dichlorobenzene. It has a pleasant, aromatic odor, and is not very flammable or soluble in water. 1,2-Dichlorobenzene tends to bind moderately tightly to soil, although some leaching can occur. It is fairly resistant to various forms of degradation. Other names for 1,2-dichlorobenzene include o-dichlorobenzene and 1,2-DCB (ATSDR, 2006).

18.2 Use, Production, and Releases

1,2-Dichlorobenzene is used as a solvent for waxes, gums, resins, and wood preservatives and as an agent in the synthesis of dyes and odor-controlling products. It is also used as a precursor to 3,4-dichloroaniline in the production of herbicides (ATSDR, 2006).

The Toxic Substances Control Act (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 1,2-dichlorobenzene in the United States from 1986 to 2002. Note that the production of 1,2-dichlorobenzene in the United States has fluctuated from year to year since 1986.

Exhibit 18-1: Production of 1,2-Dichlorobenzene in the United States

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

Source: USEPA, 2003

1,2-Dichlorobenzene is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of 1,2-dichlorobenzene for the period 1998-2006 ranged from approximately 87,000 pounds to approximately 390,000 pounds, with a general decrease over time. On-site releases were greater than off-site releases (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 1,2-dichlorobenzene in ambient water are available from the NAWQA program.

18.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for 1,2-dichlorobenzene. 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 18-2. Overall, 1,2-dichlorobenzene was detected in 1.2% of samples and at 1.1% of sites. 1,2-Dichlorobenzene was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.04 µg/L. The 99th percentile concentration based on detections from all sites was 1.502 µg/L.

Exhibit 18-2: EPA Summary Analysis of 1,2-Dichlorobenzene 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	4,660	0.6%	4,159	0.7%	0.002	0.036	0.749	1.502	1.502
surface water	1,419	3.2%	191	9.4%	0.01	0.04	0.36	0.447	0.447
all sites	6,079	1.2%	4,350	1.1%	0.002	0.04	0.3653	1.502	1.502

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

18.4 Occurrence in Drinking Water

1,2-Dichlorobenzene 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-dichlorobenzene 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-dichlorobenzene. These data consist of 372,946 analytical results from 50,422 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.

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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.

18.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 18-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 1,2-dichlorobenzene, 0.230% of 50,422 systems reported detections. Exhibit 18-4 lists the minimum, median, 90th percentile, and maximum 1,2-dichlorobenzene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 1,2-dichlorobenzene, based on detections from all systems, is 0.8 µg/L.

Exhibit 18-3: 1,2-Dichlorobenzene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	288,648	46,166	86,389,766
Surface Water	84,298	4,256	140,540,050
Combined Ground & Surface Water	372,946	50,422	226,929,816
Percent with Detections			
Ground Water	0.081%	0.201%	0.539%
Surface Water	0.045%	0.540%	2.326%
Combined Ground & Surface Water	0.073%	0.230%	1.646%

Exhibit 18-4: 1,2-Dichlorobenzene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.9	3	110
Surface Water	0.004	0.5	1.3	6

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Combined Ground & Surface Water	0.004	0.8	2.74	110

Exhibit 18-5 illustrates the geographic distribution of 1,2-dichlorobenzene occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

Only three states reported detections in more than 1% of systems. In four states, between 0.5% and 1% of systems reported detections. No systems reported detections greater than the MCL concentration of 600 µg/L.

Exhibit 18-5: Percentage of Systems with at Least One 1,2-Dichlorobenzene Detection, by State

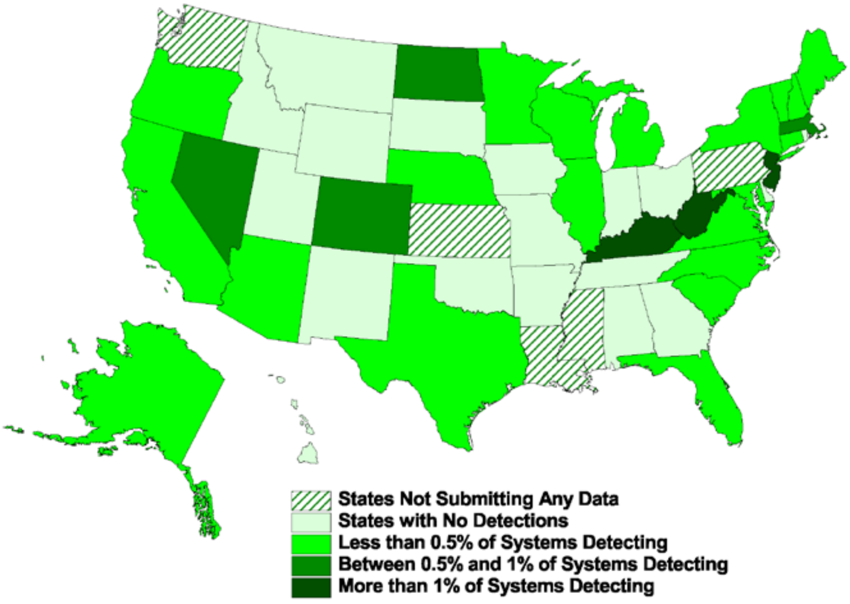

Exhibit 18-6 presents the Stage 1 analysis of 1,2-dichlorobenzene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset

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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.

relative to two thresholds: 300 µg/L and 600 µg/L. No systems reported detections greater than or equal to either threshold.

Exhibit 18-6: 1,2-Dichlorobenzene 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	> 600 µg/L	0	0.000%	0	0.000%
	≥ 300 µg/L	0	0.000%	0	0.000%
Surface Water	> 600 µg/L	0	0.000%	0	0.000%
	≥ 300 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 600 µg/L	0	0.000%	0	0.000%
	≥ 300 µg/L	0	0.000%	0	0.000%

18.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2006. *Toxicological Profile for Dichlorobenzenes*. August 2006. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp10.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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – 1,2-Dichlorobenzene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for 1,2-dichlorobenzene.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – 1,2-Dichlorobenzene. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for 1,2-dichlorobenzene.] Accessed March 5, 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 1,4-Dichlorobenzene (p-Dichlorobenzene)

This chapter on 1,4-dichlorobenzene (p-dichlorobenzene) 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 1,4-dichlorobenzene 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 1,4-dichlorobenzene on July 8, 1987 (52 FR 25690 (USEPA, 1987)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 75 µg/L. EPA developed the MCLG based on a reference dose (RfD) of 100 µg/kg-day (0.1 mg/kg-day) and a cancer classification of C, possible human carcinogen.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2006), 1,4-dichlorobenzene ($C_6H_4Cl_2$) is a colorless to white solid that smells like mothballs and is one of two chemicals commonly used to make mothballs. It is part of the dichlorobenzene family of chemicals, which also includes 1,2-dichlorobenzene and 1,3-dichlorobenzene. Commercially, 1,4-dichlorobenzene is the most important of the three dichlorobenzene isomers. 1,4-Dichlorobenzene is not very flammable or soluble in water. It can bind to soil and is not easily biodegraded. Other names for 1,4-dichlorobenzene include p-dichlorobenzene and 1,4-DCB (ATSDR, 2006).

19.2 Use, Production, and Releases

In addition to mothballs, 1,4-dichlorobenzene is used to make deodorant blocks for garbage cans, restrooms, and animal-holding facilities. Its usefulness in these applications arises from 1,4-dichlorobenzene’s low solubility in water and its relatively high volatility: it sublimes readily near room temperature. 1,4-Dichlorobenzene has been increasingly used in the synthesis of resins. It has also been used as an insecticide on fruit and as an agent to control mold and mildew growth on tobacco seeds, leather, and some fabrics (ATSDR, 2006).

The Toxic Substances Control Act (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 19-1 presents the production of 1,4-dichlorobenzene in the United States from 1986 to 2002. Note that the production of 1,4-dichlorobenzene in the United States has increased since 1986.

Exhibit 19-1: Production of 1,4-Dichlorobenzene in the United States

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

Source: USEPA, 2003

1,4-Dichlorobenzene is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of 1,4-dichlorobenzene for the period 1998-2006 ranged from approximately 98,000 pounds to approximately 189,000 pounds, with a general decrease over time. On-site releases were greater than off-site releases (USEPA, 2008).

19.3 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 1,4-dichlorobenzene in ambient water are available from the NAWQA program.

19.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for 1,4-dichlorobenzene. 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 19-2. Overall, 1,4-dichlorobenzene was detected in 4.3% of samples and at 3.1% of sites. It was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.015 µg/L. The 99th percentile concentration based on detections from all sites was 1.15 µg/L.

Exhibit 19-2: EPA Summary Analysis of 1,4-Dichlorobenzene 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	4,660	1.8%	4,159	1.9%	0.0029	0.0135	0.457	1.7	1.7
surface water	1,417	12.5%	191	29.3%	0.002	0.0155	0.2298	0.66	0.67
all sites	6,077	4.3%	4,350	3.1%	0.002	0.015	0.3	1.15	1.7

1. RLs (Reporting Limits) for 1,4-dichlorobenzene varied, but did not exceed 0.003 µg/L.

19.4 Occurrence in Drinking Water

1,4-Dichlorobenzene 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 1,4-dichlorobenzene 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 1,4-dichlorobenzene. (There were no 1,4-dichlorobenzene data from Arkansas.) These data consist of 370,698 analytical results from 49,969 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.

19.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 19-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 1,4-dichlorobenzene, 1.497% of 49,969 systems reported detections. Exhibit 19-4 lists the minimum, median, 90th percentile, and maximum 1,4-dichlorobenzene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 1,4-dichlorobenzene, based on detections from all systems, is 0.8 µg/L.

Exhibit 19-3: 1,4-Dichlorobenzene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	286,821	45,785	85,479,601
Surface Water	83,877	4,184	138,997,024
Combined Ground & Surface Water	370,698	49,969	224,476,625
Percent with Detections			
Ground Water	0.417%	1.424%	2.374%
Surface Water	0.217%	2.294%	3.910%
Combined Ground & Surface Water	0.371%	1.497%	3.325%

Exhibit 19-4: 1,4-Dichlorobenzene Summary Statistics

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.0052	0.8	2.5	700
Surface Water	0.002	0.6	1.4	13.6
Combined Ground & Surface Water	0.002	0.8	2.4	700

The following maps illustrate the geographic distribution of 1,4-dichlorobenzene occurrence in drinking water. Exhibit 19-5 shows the states with systems with at least one detection and Exhibit 19-6 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). Arkansas did submit Six-Year data for most contaminants, but did not submit data for 1,4-dichlorobenzene.

In eight states, more than 2% of systems detected 1,4-dichlorobenzene. These states are mostly located in the eastern half of the United States, as well as the upper Midwest. Sixteen states reported that 1% to 2% of systems reported detections. Only three states reported detections greater than the MCL concentration of 75 µg/L, but the exceedances occurred in less than 0.1% of systems.

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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 19-5: Percentage of Systems with at Least One 1,4-Dichlorobenzene Detection, by State

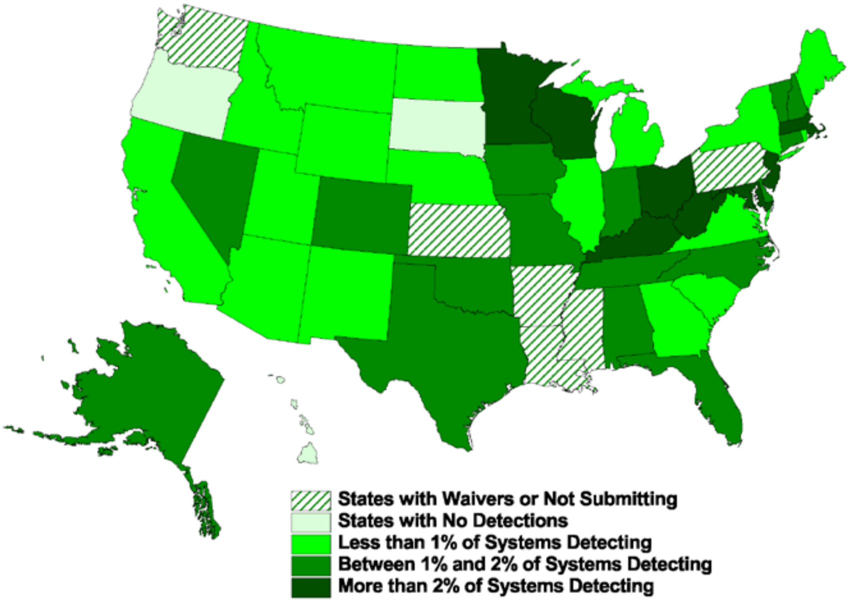

Exhibit 19-6: Percentage of Systems with at Least One 1,4-Dichlorobenzene Detection Greater than the MCL Concentration (> 75 µg/L), by State

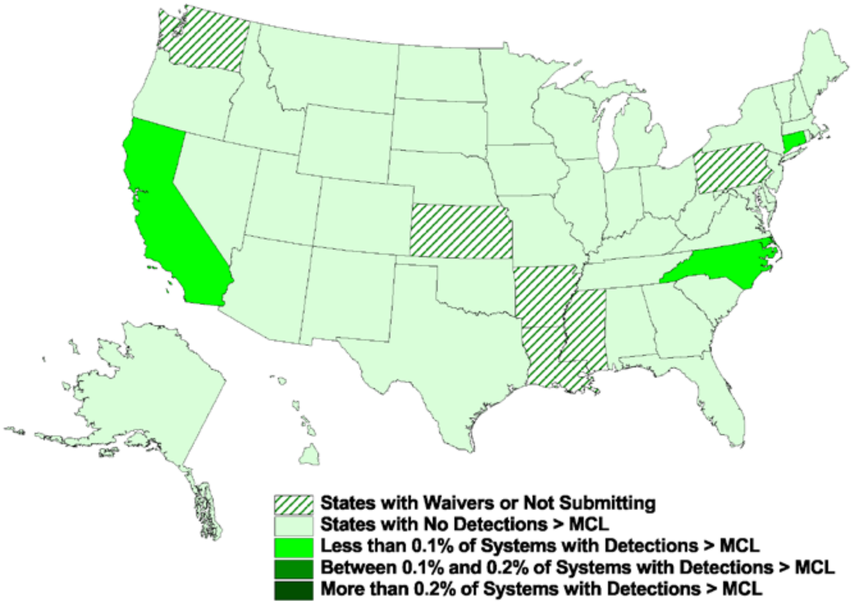

Exhibit 19-7 presents the Stage 1 analysis of 1,4-dichlorobenzene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 37.5 µg/L and 75 µg/L. Six ground water systems, serving about 103,500 persons, reported at least one detection greater than or equal to 37.5 µg/L; and 3 ground water systems, serving approximately 99,000 persons, reported at least one detection greater than 75 µg/L. No surface water systems reported detections exceeding either threshold.

Exhibit 19-7: 1,4-Dichlorobenzene 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	> 75 µg/L	3	0.007%	99,019	0.116%
	≥ 37.5 µg/L	6	0.013%	103,510	0.121%
Surface Water	> 75 µg/L	0	0.000%	0	0.000%
	≥ 37.5 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 75 µg/L	3	0.006%	99,019	0.044%
	≥ 37.5 µg/L	6	0.012%	103,510	0.046%

19.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2006. *Toxicological Profile for Dichlorobenzenes.* August 2006. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp10.html.

United States Environmental Protection Agency (USEPA). 1987. National Primary Drinking Water Regulations—Synthetic Organic Chemicals; Monitoring for Unregulated Contaminants; Final Rule. Federal Register. Vol. 52, No. 130. p. 25690, July 8, 1987.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – 1,4-Dichlorobenzene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for 1,4-dichlorobenzene.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – 1,4-Dichlorobenzene. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for 1,4-dichlorobenzene.] Accessed March 5, 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.

20 1,1-Dichloroethylene

This chapter on 1,1-dichloroethylene 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-dichloroethylene 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-dichloroethylene on July 8, 1987 (52 FR 25690 (USEPA, 1987)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 7 µg/L. The Agency developed the MCLG based on a reference dose (RfD) of 10 µg/kg-day (0.01 mg/kg-day) and a cancer classification of C, possible human carcinogen.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1995), 1,1-dichloroethylene ($C_2H_2Cl_2$) is an industrial chemical that is not found naturally in the environment. It is a colorless liquid with a mild, sweet smell. If released to water or soil, it readily evaporates and is degraded by sunlight. When it does not evaporate, degradation is slow. 1,1-Dichloroethylene is also called vinylidene chloride (ATSDR, 1995).

20.2 Use, Production, and Releases

1,1-Dichloroethylene is used to make certain plastics, including flexible films such as food wrap, and packaging materials. It is also used to make flame retardant coatings for fiber and carpet backings, in piping, coating for steel pipes, and in adhesive applications (ATSDR, 1995).

The Toxic Substances Control Act (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-dichloroethylene in the United States from 1986 to 2002. Note that the production of 1,1-dichloroethylene in the United States has fluctuated since 1986.

Exhibit 20-1: Production of 1,1-Dichloroethylene in the United States

Inventory Update Year	Production Volume
1986 Range	> 100 million – 500 million pounds
1990 Range	> 100 million – 500 million pounds
1994 Range	> 10 million – 50 million pounds
1998 Range	> 100 million – 500 million pounds
2002 Range	> 10 million – 50 million pounds

Source: USEPA, 2003

1,1-Dichloroethylene is listed as a Toxics Release Inventory (TRI) chemical. (It is listed under the synonym vinylidene chloride.) TRI data indicate that total off-site and on-site releases for the period 1998-2006 ranged from approximately 42,000 pounds to approximately 478,000 pounds, with a general decrease over time. On-site releases were greater than off-site releases (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-dichloroethylene 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for 1,1-dichloroethylene. 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 20-2. Overall, 1,1-dichloroethylene was detected in 2.4% of samples and at 2.0% of sites. It was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.0217 µg/L. The 99th percentile concentration based on detections from all sites was 5.317 µg/L.

Exhibit 20-2: EPA Summary Analysis of 1,1-Dichloroethylene 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	1.6%	4,159	1.5%	0.004	0.0295	0.8491	5.317	5.317
surface water	1,414	5.0%	191	13.1%	0.005	0.0193	0.34	34	34
all sites	6,072	2.4%	4,350	2.0%	0.004	0.0217	0.51	5.317	34

1. RLs (Reporting Limits) for 1,1-dichloroethylene varied, but did not exceed 0.005 µg/L.

20.4 Occurrence in Drinking Water

1,1-Dichloroethylene 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-dichloroethylene 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-dichloroethylene. These data consist of 378,630 analytical results from 50,425 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.

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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.

20.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 20-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 1,1-dichloroethylene, 0.688% of 50,425 systems reported detections. Exhibit 20-4 lists the minimum, median, 90th percentile, and maximum 1,1-dichloroethylene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 1,1-dichloroethylene, based on detections from all systems, is 1.7 µg/L.

Exhibit 20-3: 1,1-Dichloroethylene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	290,587	46,171	86,395,257
Surface Water	88,043	4,254	140,514,407
Combined Ground & Surface Water	378,630	50,425	226,909,664
Percent with Detections			
Ground Water	0.804%	0.643%	4.623%
Surface Water	3.832%	1.175%	6.713%
Combined Ground & Surface Water	1.508%	0.688%	5.917%

Exhibit 20-4: 1,1-Dichloroethylene Summary Statistics

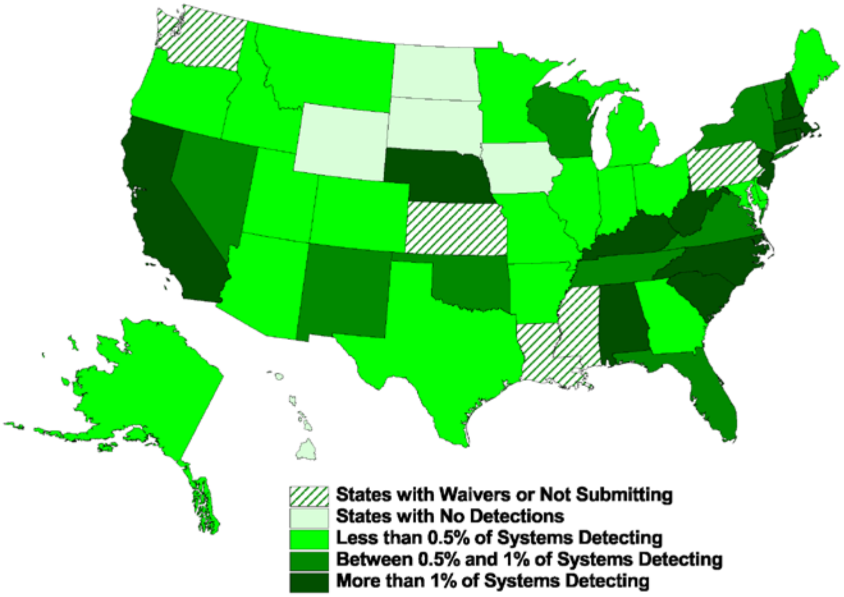
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.054	1.1	8.4	214
Surface Water	0.12	2.145	7.9	67

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Combined Ground & Surface Water	0.054	1.7	8	214

The following maps illustrate the geographic distribution of 1,1-dichloroethylene occurrence in drinking water. Exhibit 20-5 shows the states with systems with at least one detection and Exhibit 20-6 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).

The distribution of systems with detections of 1,1-dichloroethylene is geographically dispersed and detection rates were generally low. Twelve states reported detections in more than 1% of their systems. Nine states reported detections in 0.5% to 1% of systems. Five states reported no detections. Thirteen states reported detections greater than the MCL concentration of 7 µg/L.

Exhibit 20-5: Percentage of Systems with at Least One 1,1-Dichloroethylene Detection, by State



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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 20-6: Percentage of Systems with at Least One 1,1-Dichloroethylene Detection Greater than the MCL Concentration (> 7 µg/L), by State

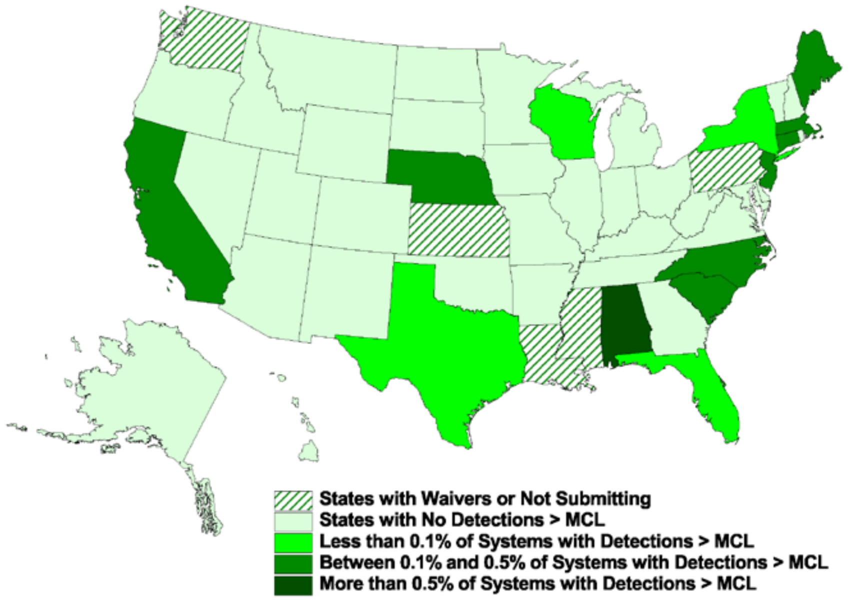

Exhibit 20-7 presents the Stage 1 analysis of 1,1-dichloroethylene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 3.5 µg/L and 7 µg/L. A total of 68 (0.135% of) systems, serving almost 7.8 million persons, reported at least one detection greater than or equal to 3.5 µg/L; and 33 (0.065% of) systems, serving approximately 5.7 million persons, reported at least one detection greater than 7 µg/L.

Exhibit 20-7: 1,1-Dichloroethylene 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	> 7 µg/L	24	0.052%	261,170	0.302%
	≥ 3.5 µg/L	52	0.113%	922,641	1.068%
Surface Water	> 7 µg/L	9	0.212%	5,451,023	3.879%
	≥ 3.5 µg/L	16	0.376%	6,853,605	4.878%

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	> 7 µg/L	33	0.065%	5,712,193	2.517%
	≥ 3.5 µg/L	68	0.135%	7,776,246	3.427%

20.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *ToxFAQs for 1,1-Dichloroethene.* September 1995. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts39.html.

United States Environmental Protection Agency (USEPA). 1987. National Primary Drinking Water Regulations—Synthetic Organic Chemicals; Monitoring for Unregulated Contaminants; Final Rule. Federal Register. Vol. 52, No. 130. p. 25690, July 8, 1987.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – 1,1-Dichloroethylene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for 1,1-dichloroethylene.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – Vinylidene Chloride. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for vinylidene chloride.] Accessed March 9, 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.

21 cis-1,2-Dichloroethylene

This chapter on cis-1,2-dichloroethylene 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 cis-1,2-dichloroethylene 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 cis-1,2-dichloroethylene on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) and maximum contaminant level (MCL) of 70 µg/L. The Agency 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.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1996), 1,2-dichloroethylene ($C_2H_2Cl_2$) is a highly flammable, colorless liquid with a sharp, harsh odor that can be smelled in very small amounts. Two slightly different forms exist, a “cis” form and a “trans” form. When 1,2-dichloroethylene is released to land or water, most of it evaporates into the air. 1,2-Dichloroethylene below soil surfaces in landfills or hazardous waste sites may dissolve in water and possibly contaminate groundwater (ATSDR, 1996). 1,2-Dichloroethylene is also known as 1,2-dichloroethene and 1,2-DCE.

21.2 Use, Production, and Releases

1,2-Dichloroethylene is used most often to produce solvents and in chemical mixtures. Specifically, it is used as a solvent for waxes and resins; in the extraction of rubber; as a refrigerant; in the manufacture of pharmaceuticals and artificial pearls; in the extraction of oils and fats from fish and meat; and in making other organic compounds (ATSDR, 1996).

The Toxic Substances Control Act (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 cis-1,2-dichloroethylene in the United States from 1986 to 2002. Note that the production of cis-1,2-dichloroethylene in the United States decreased from 1990 to 1994 and was not reported in the Chemical Update System in 1986, 1998, and 2002.

Exhibit 21-1: Production of cis-1,2-Dichloroethylene in the United States

Inventory Update Year	Production Volume
1986 Range	No reports
1990 Range	> 500,000 – 1 million pounds
1994 Range	10,000 – 500,000 pounds
1998 Range	No reports
2002 Range	No reports

Source: USEPA, 2003

cis-1,2-Dichloroethylene is not listed as a Toxics Release Inventory (TRI) chemical; thus, no TRI release records are available.

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 cis-1,2-dichloroethylene 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for cis-1,2-dichloroethylene. 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 21-2. Overall, cis-1,2-dichloroethylene was detected in 9.9% of samples and at 3.8% of sites. cis-1,2-Dichloroethylene was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.049 µg/L. The 99th percentile concentration based on detections from all sites was 9.4 µg/L.

Exhibit 21-2: EPA Summary Analysis of cis-1,2-Dichloroethylene 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	3.1%	4,159	2.5%	0.003	0.2	6.2	71	82
surface water	1,402	32.4%	182	35.7%	0.005	0.04	0.5707	4.67	7.62
all sites	6,060	9.9%	4,341	3.8%	0.003	0.049	1.2	9.4	82

1. RLs (Reporting Limits) for cis-1,2-dichloroethylene varied, but did not exceed 0.005 µg/L.

21.4 Occurrence in Drinking Water

cis-1,2-Dichloroethylene 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 cis-1,2-dichloroethylene 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 cis-1,2-dichloroethylene. (There were no cis-1,2-dichloroethylene data from Hawaii.) These data consist of 373,316 analytical results from 50,314 public water systems (PWSs) during the period from

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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.

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.

21.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 21-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For cis-1,2-dichloroethylene, 0.964% of 50,314 systems reported detections. Exhibit 21-4 lists the minimum, median, 90th percentile, and maximum cis-1,2-dichloroethylene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of cis-1,2-dichloroethylene, based on detections from all systems, is 1.1 µg/L.

Exhibit 21-3: cis-1,2-Dichloroethylene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	287,606	46,072	85,155,955
Surface Water	85,710	4,242	140,459,779
Combined Ground & Surface Water	373,316	50,314	225,615,734
Percent with Detections			
Ground Water	1.506%	0.914%	7.828%
Surface Water	3.046%	1.509%	8.808%
Combined Ground & Surface Water	1.860%	0.964%	8.438%

Exhibit 21-4: cis-1,2-Dichloroethylene Summary Statistics

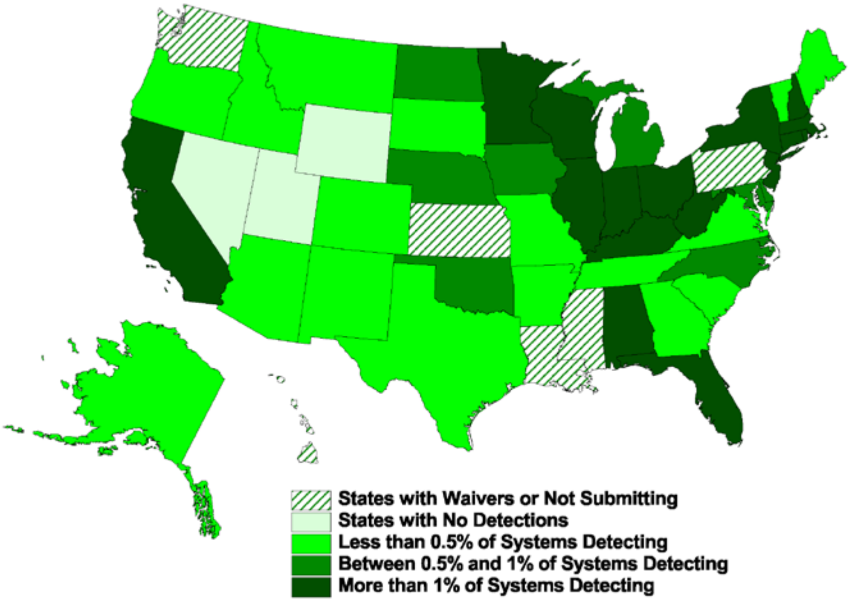
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	1	5	220

Source Water Type	**Detection Value (μg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Surface Water	0.008	1.2	5	160
Combined Ground & Surface Water	0.008	1.1	5	220

The following maps illustrate the geographic distribution of cis-1,2-dichloroethylene occurrence in drinking water. Exhibit 21-5 shows the states with systems with at least one detection and Exhibit 21-6 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). Hawaii did submit Six-Year data for most contaminants, but did not submit data for cis-1,2-dichloroethylene.

The distribution of systems with detections of cis-1,2-dichloroethylene is geographically dispersed and detection rates were generally low. Sixteen states reported detections in more than 1% of their systems. In eight states, between 0.5% and 1% of systems reported detections. Seventeen states reported detections in less than 0.5% of systems. Four states reported detections greater than the MCL concentration of 70 μg/L.

Exhibit 21-5: Percentage of Systems with at Least One cis-1,2-Dichloroethylene Detection, by State



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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 21-6: Percentage of Systems with at Least One cis-1,2-Dichloroethylene Detection Greater than the MCL Concentration (> 70 μg/L), by State

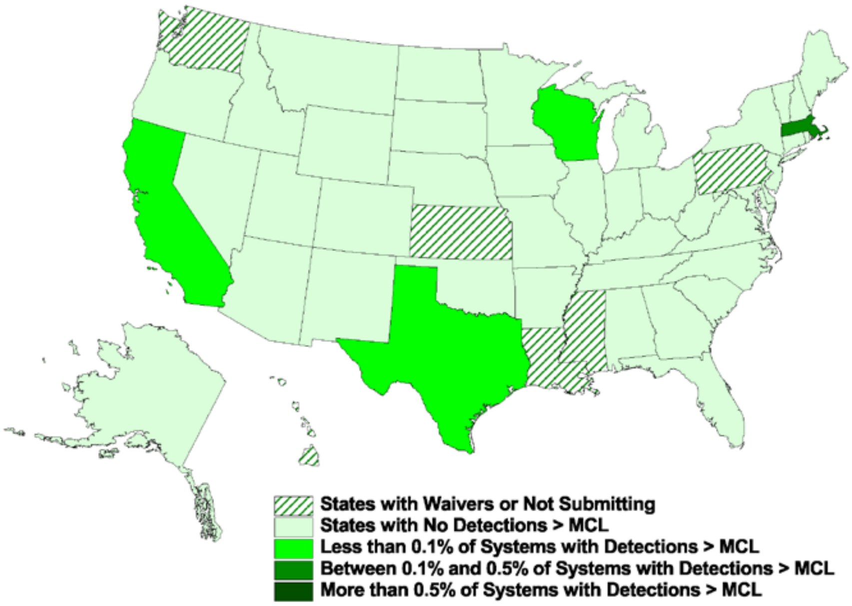

Exhibit 21-7 presents the Stage 1 analysis of cis-1,2-dichloroethylene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 35 µg/L and 70 µg/L. Thirteen (0.026% of) systems, serving almost 550,000 persons, reported at least one detection greater than or equal to 35 µg/L; and 5 (0.010% of) systems, serving almost 167,000 persons, reported at least one detection greater than 70 µg/L.

Exhibit 21-7: cis-1,2-Dichloroethylene 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	3	0.007%	37,997	0.045%
	≥ 35 μg/L	10	0.022%	218,371	0.256%
Surface Water	> 70 μg/L	2	0.047%	128,756	0.092%
	≥ 35 μg/L	3	0.071%	328,756	0.234%

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	> 70 µg/L	5	0.010%	166,753	0.074%
	≥ 35 µg/L	13	0.026%	547,127	0.243%

21.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. *Toxicological Profile for 1,2-Dichloroethene.* August 1996. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp87.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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – cis-1,2-Dichloroethylene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for cis-1,2-dichloroethylene.] Accessed February 21, 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.

22 trans-1,2-Dichloroethylene

This chapter on trans-1,2-dichloroethylene 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 trans-1,2-dichloroethylene 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 trans-1,2-dichloroethylene 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 100 µg/L. The Agency 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 the Agency for Toxic Substances and Disease Registry (ATSDR, 1996), 1,2-dichloroethylene ($C_2H_2Cl_2$) is a highly flammable, colorless liquid with a sharp, harsh odor that can be smelled in very small amounts. Two slightly different forms exist, a “cis” form and a “trans” form. When 1,2-dichloroethylene is released to land or water, most of it evaporates into the air. 1,2-Dichloroethylene below soil surfaces in landfills or hazardous waste sites may dissolve in water and possibly contaminate groundwater (ATSDR, 1996). 1,2-Dichloroethylene is also known as 1,2-dichloroethene and 1,2-DCE.

22.2 Use, Production, and Releases

1,2-Dichloroethylene is used most often to produce solvents and in chemical mixtures. Specifically, it is used as a solvent for waxes and resins; in the extraction of rubber; as a refrigerant; in the manufacture of pharmaceuticals and artificial pearls; in the extraction of oils and fats from fish and meat; and in making other organic compounds. The trans isomer is more widely used in industry than either the cis isomer or the commercial mixture (ATSDR, 1996).

The Toxic Substances Control Act (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 trans-1,2-dichloroethylene in the United States from 1986 to 2002. Note that the production of trans-1,2-dichloroethylene in the United States has fluctuated since 1986.

Exhibit 22-1: Production of trans-1,2-Dichloroethylene 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	10,000 – 500,000 pounds
2002 Range	> 1 million – 10 million pounds

Source: USEPA, 2003

trans-1,2-Dichloroethylene is not listed as a Toxics Release Inventory (TRI) chemical; thus, no TRI release records are available.

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 trans-1,2-dichloroethylene 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for trans-1,2-dichloroethylene. 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 22-2. Overall, trans-1,2-dichloroethylene was detected in 0.9% of samples and at 0.8% of sites. trans-1,2-Dichloroethylene was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.029 µg/L. The 99th percentile concentration based on detections from all sites was 5.6 µg/L.

Exhibit 22-2: EPA Summary Analysis of trans-1,2-Dichloroethylene 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	0.6%	4,159	0.6%	0.0038	0.3	5.3	5.6	5.6
surface water	1,413	1.6%	190	5.3%	0.0053	0.01595	2.83	3.52	3.52
all sites	6,071	0.9%	4,349	0.8%	0.0038	0.029	4.5	5.6	5.6

1. RLs (Reporting Limits) for trans-1,2-dichloroethylene varied, but did not exceed 0.0053 µg/L.

22.4 Occurrence in Drinking Water

trans-1,2-Dichloroethylene 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 trans-1,2-dichloroethylene 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 trans-1,2-dichloroethylene. (There were no trans-1,2-dichloroethylene data from Hawaii.) These data consist of 371,258 analytical results from 50,319 public water system (PWSs) during the period

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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.

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.

22.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 22-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For trans-1,2-dichloroethylene, 0.189% of 50,319 systems reported detections. Exhibit 22-4 lists the minimum, median, 90th percentile, and maximum trans-1,2-dichloroethylene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of trans-1,2-dichloroethylene, based on detections from all systems, is 1 µg/L.

Exhibit 22-3: trans-1,2-Dichloroethylene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	286,957	46,078	85,155,343
Surface Water	84,301	4,241	140,455,794
Combined Ground & Surface Water	371,258	50,319	225,611,137
Percent with Detections			
Ground Water	0.089%	0.171%	1.908%
Surface Water	0.300%	0.377%	1.048%
Combined Ground & Surface Water	0.137%	0.189%	1.372%

Exhibit 22-4: trans-1,2-Dichloroethylene Summary Statistics

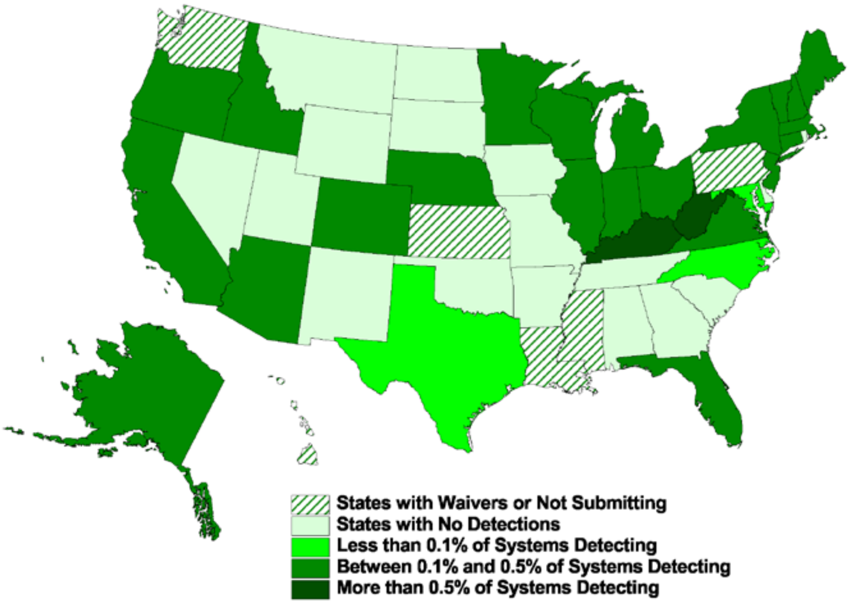
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.02	0.6	1.5	24

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Surface Water	0.2	1.2	6.9	17
Combined Ground & Surface Water	0.02	1	6.1	24

Exhibit 22-5 illustrates the geographic distribution of trans-1,2-dichloroethylene occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) 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 data for trans-1,2-dichloroethylene.

Detection rates were generally low for trans-1,2-dichloroethylene; only two states reported detections in more than 0.5% of their systems. In 22 states, between 0.1% and 0.5% of systems reported detections. Seventeen states reported no detections. Furthermore, no states reported detections greater than the MCL concentration of 100 µg/L.

Exhibit 22-5: Percentage of Systems with at Least One trans-1,2-Dichloroethylene Detection, by State



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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 22-6 presents the Stage 1 analysis of trans-1,2-dichloroethylene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 50 µg/L and 100 µg/L. No systems reported detections greater than or equal to either threshold.

Exhibit 22-6: trans-1,2-Dichloroethylene 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	0	0.000%	0	0.000%
	≥ 50 µg/L	0	0.000%	0	0.000%
Surface Water	> 100 µg/L	0	0.000%	0	0.000%
	≥ 50 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 100 µg/L	0	0.000%	0	0.000%
	≥ 50 µg/L	0	0.000%	0	0.000%

22.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. *Toxicological Profile for 1,2-Dichloroethene.* August 1996. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp87.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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – trans-1,2-Dichloroethylene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for trans-1,2-dichloroethylene.] Accessed February 21, 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.

23 Dinoseb

This chapter on dinoseb 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 dinoseb 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 dinoseb 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 7 µg/L. The Agency developed the MCLG based on a reference dose (RfD) of 1 µg/kg-day (0.001 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Extension Toxicology Network (EXTOXNET, 1996), dinoseb ($C_{10}H_{12}N_2O_5$) is a dark reddish-brown solid or dark orange viscous liquid (depending on the temperature). The use of dinoseb was cancelled in the United States in 1986. Dinoseb is not commercially available in the United States. Because dinoseb binds weakly to soil and is degraded slowly by soil bacteria, it can leach into ground water. In surface water, it is mainly broken down by sunlight. It is not likely to accumulate in aquatic life (EXTOXNET, 1996).

23.2 Use, Production, and Releases

The greatest use of dinoseb is as an herbicide for post-emergence weed control in soybeans, vegetables, fruits, nuts, citrus, and other field crops. Dinoseb is also used as an insecticide in grapes, and as a seed crop drying agent (EXTOXNET, 1996).

The Toxic Substances Control Act (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 dinoseb in the United States from 1986 to 2002. Note that the production of dinoseb in the United States has remained constant since 1986.

Exhibit 23-1: Production of Dinoseb in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 million – 10 million 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, 2003

Dinoseb is not listed as a Toxics Release Inventory (TRI) chemical; thus, no TRI release records are available.

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 dinoseb in ambient water are available from the NAWQA program.

23.3.1 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 dinoseb between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for dinoseb was 0.040 µg/L.

In NAWQA stream samples (Exhibit 23-2), dinoseb was found at frequencies ranging from 0% of samples in undeveloped and urban areas to 0.02% of samples in mixed land use settings, and 0.27% of samples in agricultural settings. The 95th percentile concentrations were less than the method detection limit in all land use settings. The highest concentration, 1 µg/L, was found at an agricultural site.

Exhibit 23-2: USGS National Synthesis Summary of NAWQA Monitoring of Dinoseb 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	1,466 (62)	0.27%	ND[1]	ND[1]	1.000
Mixed	800 (36)	0.02%	ND[1]	ND[1]	0.270
Undeveloped	101 (5)	0.00%	ND[1]	ND[1]	ND[1]
Urban	521 (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 23-3), dinoseb was found at frequencies ranging from 0% of samples in undeveloped and urban areas to 0.32% in mixed land use settings, and 0.76% of samples in agricultural settings. The 95th percentile concentrations were less than the method detection limit in all settings. The highest concentration, 40 µg/L, was found at an agricultural site.

Exhibit 23-3: USGS National Synthesis Summary of NAWQA Monitoring of Dinoseb in Ground Water, 1991-2001

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	1,187	0.76%	ND[1]	ND[1]	40
Mixed	1,569	0.32%	ND[1]	ND[1]	19.2
Undeveloped	23	0.00%	ND[1]	ND[1]	ND[1]
Urban	666	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)

23.3.2 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for dinoseb. 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 23-4. Overall, dinoseb was detected in 0.5% of samples and at 0.8% of sites. Dinoseb was detected more frequently in surface water sites than in ground water sites. The median concentration based on detections from all sites was 0.07 µg/L. The 99th percentile concentration based on detections from all sites was 40 µg/L.

Exhibit 23-4: EPA Summary Analysis of Dinoseb 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	4,028	0.8%	3,651	0.8%	0.0058	0.06	19.2	40	40
surface water	5,545	0.3%	895	0.9%	0.02	0.13	1	1	1
all sites	9,573	0.5%	4,546	0.8%	0.0058	0.07	8	40	40

1. RLs (Reporting Limits) for dinoseb 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.

23.4 Occurrence in Drinking Water

Dinoseb 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

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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.

quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of dinoseb 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 dinoseb. (There were no dinoseb data from Hawaii or Oklahoma.) These data consist of 121,896 analytical results from 32,713 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.

23.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 23-5 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For dinoseb, 0.266% of 32,713 systems reported detections. Exhibit 23-6 lists the minimum, median, 90th percentile, and maximum dinoseb concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of dinoseb, based on detections from all systems, is 0.32 µg/L.

Exhibit 23-5: Dinoseb Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	99,807	29,785	66,425,963
Surface Water	22,089	2,928	116,493,427
Combined Ground & Surface Water	121,896	32,713	182,919,390
Percent with Detections			
Ground Water	0.120%	0.235%	4.513%
Surface Water	0.118%	0.581%	2.274%
Combined Ground & Surface Water	0.120%	0.266%	3.087%

Exhibit 23-6: Dinoseb Summary Statistics

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.03	0.385	10.55	45
Surface Water	0.07	0.3	3	3
Combined Ground & Surface Water	0.03	0.32	9.2	45

The following maps illustrate the geographic distribution of dinoseb occurrence in drinking water. Exhibit 23-7 shows the states with systems with at least one detection and Exhibit 23-8 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). Hawaii and Oklahoma did submit Six-Year data for most contaminants, but did not submit data for dinoseb.

Detection rates were generally low for dinoseb. Only five states reported detections in more than 1% of their systems. These states are all located in the eastern half of the United States. In four states, between 0.5% and 1% of systems reported detections. Twenty-two states reported no detections. Three states reported detections greater than the MCL concentration of 7 µg/L.

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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 23-7: Percentage of Systems with at Least One Dinoseb Detection, by State

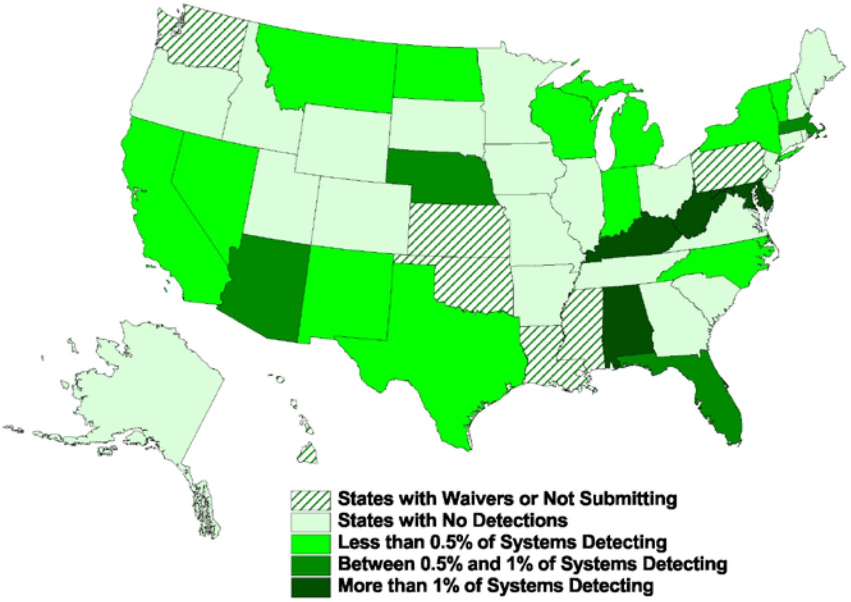


Exhibit 23-8: Percentage of Systems with at Least One Dinoseb Detection Greater than the MCL Concentration (> 7 µg/L), by State

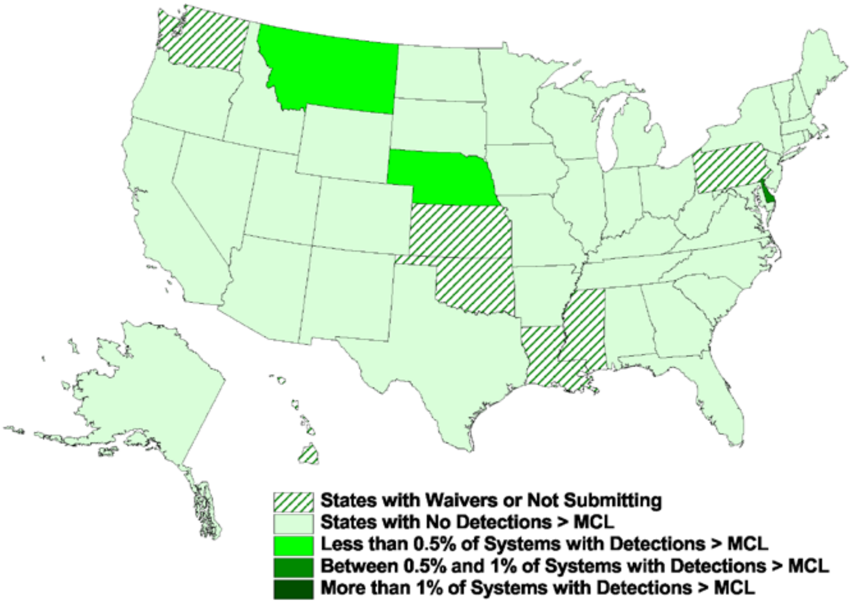


Exhibit 23-9 presents the Stage 1 analysis of dinoseb occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 3.5 µg/L and 7 µg/L. Six ground water systems, serving about 26,000 persons, reported at least one detection greater than or equal to 3.5 µg/L; and 5 ground water systems, serving about 26,000 persons, reported at least one detection greater than 7 µg/L. No surface water systems reported detections greater than or equal to either threshold.

Exhibit 23-9: Dinoseb 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	> 7 µg/L	5	0.017%	26,212	0.039%
	≥ 3.5 µg/L	6	0.020%	26,292	0.040%
Surface Water	> 7 µg/L	0	0.000%	0	0.000%
	≥ 3.5 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 7 µg/L	5	0.015%	26,212	0.014%
	≥ 3.5 µg/L	6	0.018%	26,292	0.014%

23.5 References

Extension Toxicology Network (EXTOXNET). 1996. EXTOXNET Pesticide Information Profiles–Dinoseb. Last modified June 1996. Available on the Internet at: http://extoxnet.orst.edu/pips/dinoseb.htm. Accessed July 6, 2008.

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/.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Dinoseb. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for dinoseb.] Accessed February 21, 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.

24 Diquat

This chapter on diquat 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 diquat 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).

24.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for diquat 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 20 µg/L. The Agency developed the MCLG based on a reference dose (RfD) of 2.2 µg/kg-day (0.0022 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Extension Toxicology Network (EXTOXNET, 1996), diquat ($C_{12}H_{12}N_2^{2+}$) is an organic solid of white or yellow crystals. Diquat is a non-selective herbicide that acts quickly to damage only the parts of the plant to which it is applied. It is persistent in soils, adhering strongly to particles, and does not readily leach into water. If applied to water, a portion will become associated with particles in the water, and the rest will break down quickly due to sunlight and microbes (EXTOXNET, 1996).

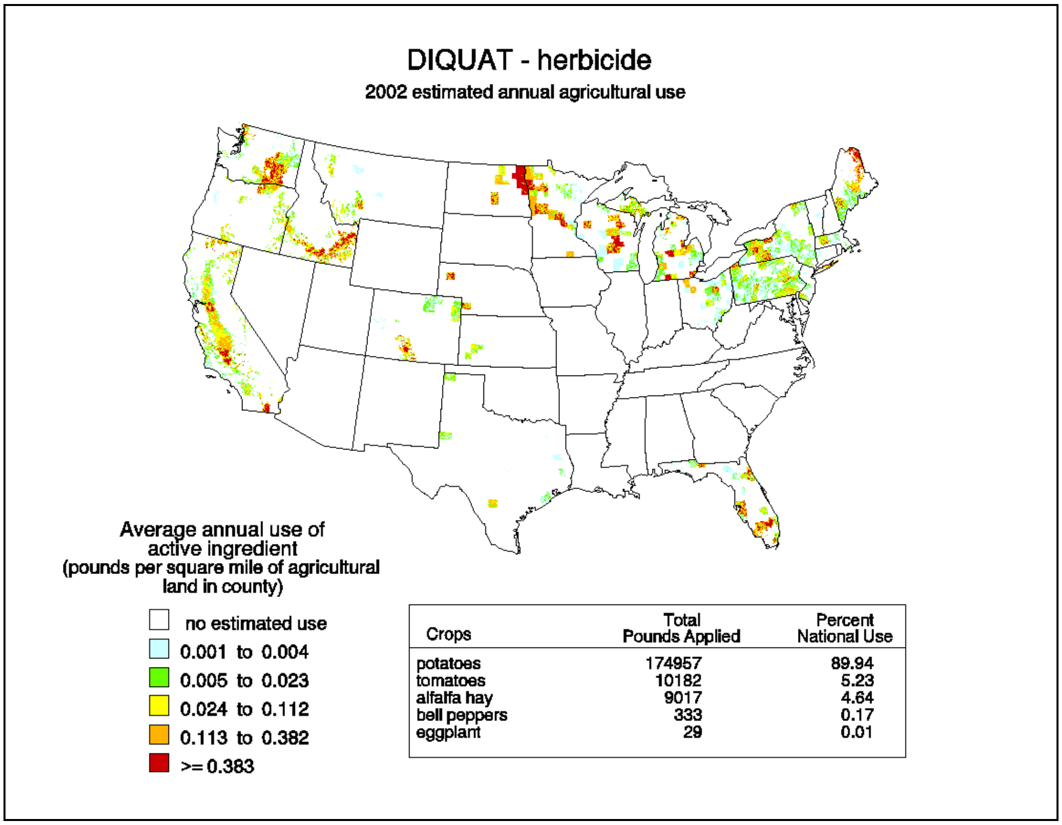
24.2 Use, Production, and Releases

Diquat is a quick-acting contact herbicide that is used to control both crop and aquatic weeds. It is used to desiccate potato vines and seed crops, and as a sugar cane-flowering suppressant (EXTOXNET, 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 diquat.

Exhibit 24-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual diquat 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 195,000 pounds of diquat active ingredient were used on average each year between 1999 and 2004.

Exhibit 24-1: Estimated Annual Agricultural Use for Diquat (c. 2002)



Crops	Total Pounds Applied	Percent National Use
potatoes	174957	89.94
tomatoes	10182	5.23
alfalfa hay	9017	4.64
bell peppers	333	0.17
eggplant	29	0.01

Source: USGS, 2007

Diquat is not listed as a Toxics Release Inventory (TRI) chemical; thus, no TRI release records are available.

24.3 Occurrence in Ambient Water

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

24.4 Occurrence in Drinking Water

Diquat 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 diquat.

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 diquat 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.

Diquat data were provided by 38 of the Six-Year Review-ICR states. (There were no diquat data from the following states: Hawaii, Minnesota, Missouri, North Carolina, New Hampshire, Oklahoma, and Texas.) These data consist of 55,634 analytical results from 15,595 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.

24.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 24-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For diquat, 0.442% of 15,595 systems reported detections. Exhibit 24-3 lists the minimum, median, 90th percentile, and maximum diquat concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of diquat, based on detections from all systems, is 0.8 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 24-2: Diquat Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	43,185	14,021	45,472,880
Surface Water	12,449	1,574	75,149,767
Combined Ground & Surface Water	55,634	15,595	120,622,647
Percent with Detections			
Ground Water	0.171%	0.357%	6.430%
Surface Water	0.185%	1.207%	7.498%
Combined Ground & Surface Water	0.174%	0.442%	7.095%

Exhibit 24-3: Diquat Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.17	0.75	6.5	9
Surface Water	0.08	2	6.9	13
Combined Ground & Surface Water	0.08	0.8	6.5	13

Exhibit 24-4 illustrates the geographic distribution of diquat occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) 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 but did not submit data for diquat.

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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.

Detection rates were generally low for diquat; only 2 states reported detections in more than 5% of their systems. In seven states, between 1% and 5% of systems reported detections. Twenty-one states reported no detections. Furthermore, no states reported detections greater than the MCL concentration of 20 µg/L.

Exhibit 24-4: Percentage of Systems with at Least One Diquat Detection, by State

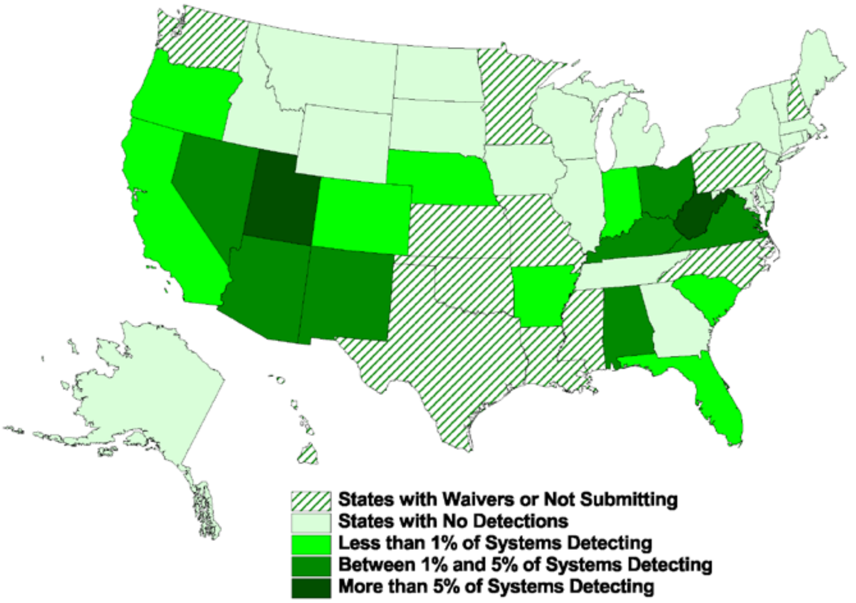

Exhibit 24-5 presents the Stage 1 analysis of diquat occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 10 µg/L and 20 µg/L. Two surface water systems, serving about 68,000 persons, reported at least one detection greater than or equal to 10 µg/L. No systems reported detections greater than 20 µg/L.

Exhibit 24-5: Diquat 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	> 20 µg/L	0	0.000%	0	0.000%
	≥ 10 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**
Surface Water	> 20 µg/L	0	0.000%	0	0.000%
	≥ 10 µg/L	2	0.127%	68,095	0.091%
Combined Ground & Surface Water	> 20 µg/L	0	0.000%	0	0.000%
	≥ 10 µg/L	2	0.013%	68,095	0.056%

24.5 References

Extension Toxicology Network (EXTOXNET). 1996. EXTOXNET Pesticide Information Profiles– Diquat Dibromide. Last modified June 1996. Available on the Internet at: http://extoxnet.orst.edu/pips/diquatdi.htm. Accessed July 7, 2008.

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/.

Thelin, G.P. and L.P. Gianessi. 2000. *Method for Estimating Pesticide Use for County Areas of the Conterminous United States.* U.S. Geological Survey Open-File Report 00-250, 62 p. Available on the Internet at: http://ca.water.usgs.gov/pnsp/rep/ofr00250/ofr00250.pdf.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

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.

United States Geological Survey (USGS). 2007. 2002 Pesticide Use Maps. Available on the Internet at: http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1950. Accessed March 6, 2008.

25 Endrin

This chapter on endrin 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 endrin 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).

25.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for endrin 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 2 µg/L. The Agency developed the MCLG based on a reference dose (RfD) of 0.3 µg/kg-day (0.0003 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, 1996), endrin ($C_{12}H_8Cl_6O$) is a solid, white, almost odorless substance that was used as a pesticide to control insects, rodents, and birds. Since 1986, however, it has not been produced or sold for general use in the United States. Endrin binds strongly to soil and does not easily leach into ground water. It is very persistent in soil (lasting over 10 years). If released to water, it will become associated with sediments, where it can last for a long time (ATSDR, 1996).

25.2 Use, Production, and Releases

Beginning in 1951, endrin was first used as an insecticide, rodenticide, and avicide to control cutworms, voles, grasshoppers, borers, and other pests on cotton, sugarcane, tobacco, apple orchards, and grain. It was also used as an insecticide on bird perches. Except for its use as a toxicant on bird perches, which was canceled in 1991, all other uses of endrin in the United States were voluntarily canceled by the manufacturer in 1986 (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 endrin.

Endrin is not listed as a Toxics Release Inventory (TRI) chemical; no TRI release records are available.

25.3 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 endrin in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

25.4 Occurrence in Drinking Water

Endrin 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 endrin 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 endrin. (There were no endrin data from Oklahoma.) These data consist of 134,336 analytical results from 32,783 public water system (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.

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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.

25.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 25-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For endrin, 0.143% of 32,783 systems reported detections. Exhibit 25-2 lists the minimum, median, 90th percentile, and maximum endrin concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of endrin, based on detections from all systems, is 0.02 µg/L.

Exhibit 25-1: Endrin Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	105,777	29,734	67,885,419
Surface Water	28,559	3,049	116,157,743
Combined Ground & Surface Water	134,336	32,783	184,043,162
Percent with Detections			
Ground Water	0.039%	0.101%	3.927%
Surface Water	0.105%	0.558%	3.690%
Combined Ground & Surface Water	0.053%	0.143%	3.777%

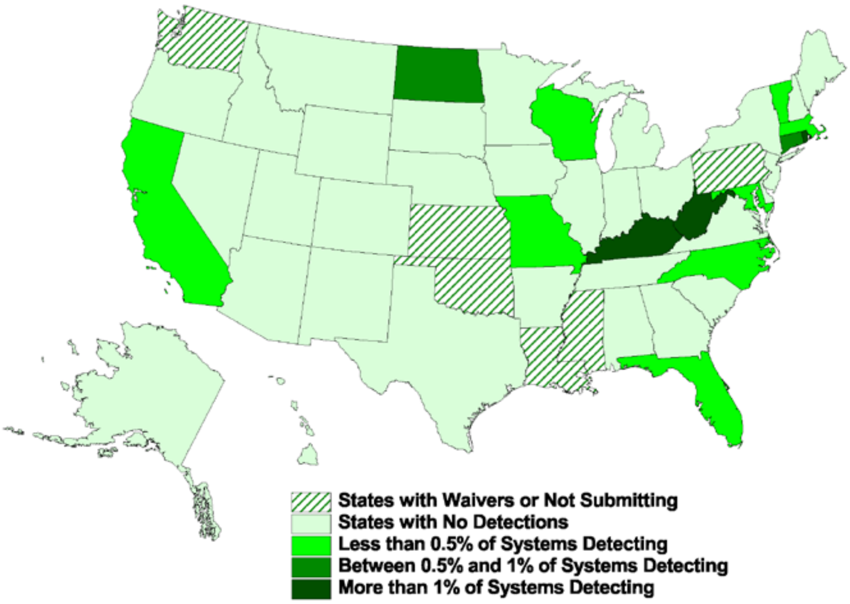
Exhibit 25-2: Endrin Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.0025	0.008	0.14	3.3
Surface Water	0.001	0.07	0.5	0.52
Combined Ground & Surface Water	0.001	0.02	0.5	3.3

The following maps illustrate the geographic distribution of endrin occurrence in drinking water. Exhibit 25-3 shows the states with systems with at least one detection and Exhibit 25-4 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 submitted Six-Year data for most contaminants; however, there is a statewide waiver for endrin in Oklahoma so no endrin data were available from that state.

Detection rates were generally low; only 3 states reported detections in more than 1% of their systems. These states are all located in the eastern half of the United States. In two states, between 0.5% and 1% of systems reported detections. California was the only state that reported detections greater than the MCL concentration of 2 µg/L.

Exhibit 25-3: Percentage of Systems with at Least One Endrin 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 25-4: Percentage of Systems with at Least One Endrin Detection Greater than the MCL Concentration (> 2 µg/L), by State

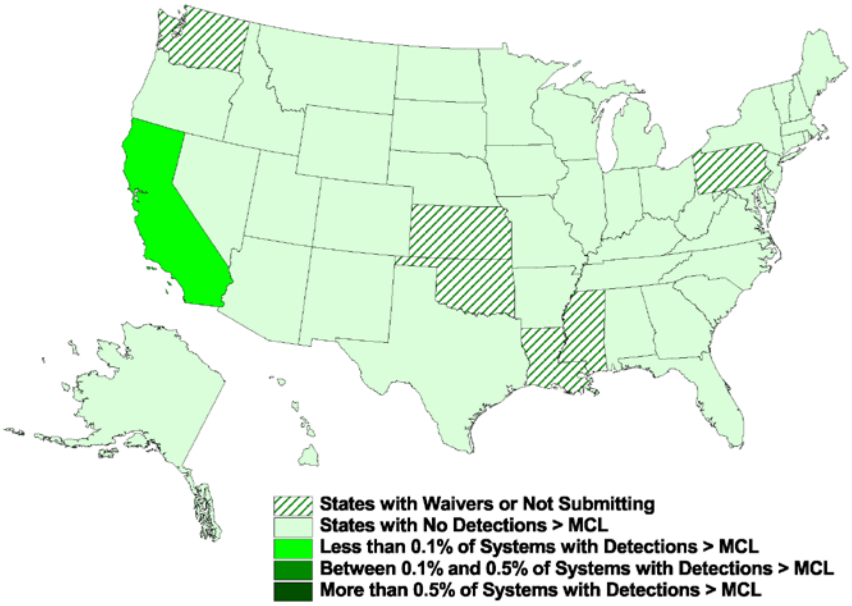

Exhibit 25-5 presents the Stage 1 analysis of endrin occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 1 µg/L and 2 µg/L. Two (0.006% of) systems, serving 2,800 persons, reported at least one detection greater than or equal to 1 µg/L; and 1 (0.003% of) systems, serving about 300 persons, reported at least one detection greater than 2 µg/L. No surface water systems reported detections greater than either threshold.

Exhibit 25-5: Endrin 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	1	0.003%	300	0.000%
	≥ 1 µg/L	2	0.007%	2,800	0.004%
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	1	0.003%	300	0.000%
	≥ 1 µg/L	2	0.006%	2,800	0.002%

25.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. *Toxicological Profile for Endrin.* August 1996. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp89.html.

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/.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

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.

26 Ethylbenzene

This chapter on ethylbenzene 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 ethylbenzene 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).

26.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for ethylbenzene 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 700 µg/L. The Agency developed the MCLG based on a reference dose (RfD) of 100 µg/kg-day (0.1 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), ethylbenzene (C_8H_{10}) is a colorless, flammable liquid that smells like gasoline. If released to water, it will evaporate rapidly. It does not bind strongly to sediments and soils and can, therefore, leach into ground water if released to land. It is susceptible to biodegradation. Ethylbenzene does not accumulate significantly in aquatic organisms (ATSDR, 2007).

26.2 Use, Production, and Releases

The greatest use (more than 99%) of ethylbenzene is to make styrene. Consumer products containing ethylbenzene include: gasoline; paints and inks; pesticides; carpet glues; varnishes and paints; and tobacco products. It is also naturally found in coal tar and petroleum (ATSDR, 2007).

The Toxic Substances Control Act (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 26-1 presents the production of ethylbenzene in the United States from 1986 to 2002. Note that the production of ethylbenzene in the United States has remained constant since 1986.

Exhibit 26-1: Production of Ethylbenzene 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, 2003

Ethylbenzene is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of ethylbenzene for the period 1998-2006 ranged from approximately 5.7 million pounds to approximately 10 million pounds, with a general decrease over time. On-site releases were greater than off-site releases (USEPA, 2008).

26.3 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 ethylbenzene in ambient water are available from the NAWQA program.

26.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for ethylbenzene. 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 26-2. Overall, ethylbenzene was detected in 5.7% of samples and at 3.6% of sites. Ethylbenzene was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.012 µg/L. The 99th percentile concentration based on detections from all sites was 51 µg/L.

Exhibit 26-2: EPA Summary Analysis of Ethylbenzene 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	4,653	2.3%	4,153	2.3%	0.002	0.01	8.714	270	2100
surface water	1,402	17.3%	182	31.3%	0.002	0.0132	1.8	1.9	3
all sites	6,055	5.7%	4,335	3.6%	0.002	0.012	1.9	51	2100

1. RLs (Reporting Limits) for ethylbenzene varied, but did not exceed 0.002 µg/L.

26.4 Occurrence in Drinking Water

Ethylbenzene 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 ethylbenzene 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 ethylbenzene. These data consist of 374,141 analytical results from 50,447 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.

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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.

26.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 26-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For ethylbenzene, 3.909% of 50,447 systems reported detections. Exhibit 26-4 lists the minimum, median, 90th percentile, and maximum ethylbenzene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of ethylbenzene, based on detections from all systems, is 0.9 µg/L.

Exhibit 26-3: Ethylbenzene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	289,622	46,190	86,398,177
Surface Water	84,519	4,257	140,541,198
Combined Ground & Surface Water	374,141	50,447	226,939,375
Percent with Detections			
Ground Water	1.146%	3.750%	10.518%
Surface Water	0.629%	5.638%	12.681%
Combined Ground & Surface Water	1.030%	3.909%	11.857%

Exhibit 26-4: Ethylbenzene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.02	0.9	4.4	557
Surface Water	0.002	0.9	6	97.5

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Combined Ground & Surface Water	0.002	0.9	4.6	557

Exhibit 26-5 illustrates the geographic distribution of ethylbenzene occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) 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 ethylbenzene is geographically dispersed. Eleven states reported detections in more than 5% of systems. In 24 states, between 1% and 5% of systems reported detections. Nine states reported detections in less than 1% of systems. No states reported detections greater than the MCL concentration of 700 µg/L.

Exhibit 26-5: Percentage of Systems with at Least One Ethylbenzene Detection, by State

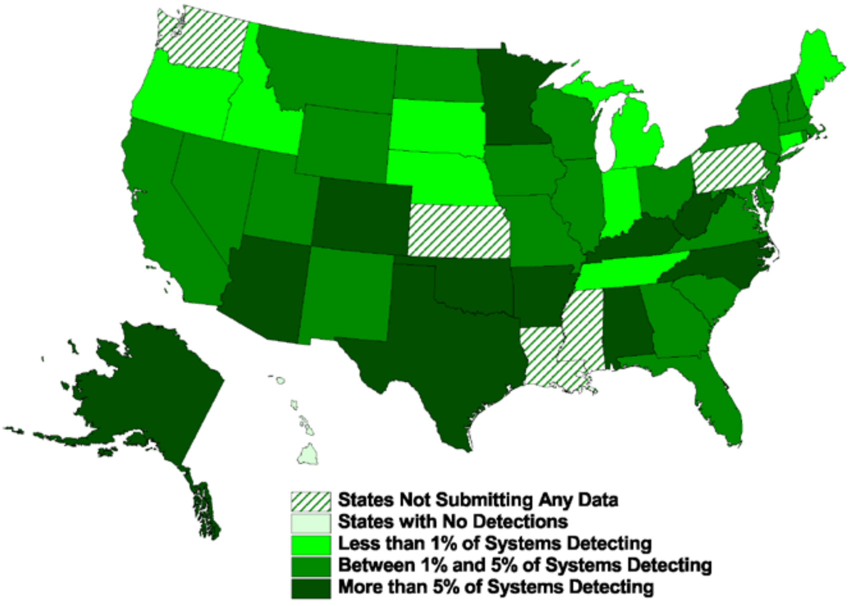

Exhibit 26-6 presents the Stage 1 analysis of ethylbenzene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 350 µg/L and 700 µg/L. Two ground water systems, serving almost

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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.

6,000 persons, reported at least one detection greater than or equal to 350 µg/L. No systems reported detections greater than 700 µg/L.

Exhibit 26-6: Ethylbenzene 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	> 700 µg/L	0	0.000%	0	0.000%
	≥ 350 µg/L	2	0.004%	5,961	0.007%
Surface Water	> 700 µg/L	0	0.000%	0	0.000%
	≥ 350 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 700 µg/L	0	0.000%	0	0.000%
	≥ 350 µg/L	2	0.004%	5,961	0.003%

26.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. *Draft Toxicological Profile for Ethylbenzene.* September 2007. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp110.pdf.

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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Ethylbenzene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for ethylbenzene.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – Ethylbenzene. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for ethylbenzene.] Accessed March 8, 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.

27 Ethylene Dibromide (EDB)

This chapter on ethylene dibromide (EDB) 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 ethylene dibromide 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).

27.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for ethylene dibromide 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 0.05 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1995), ethylene dibromide ($C_2H_4Br_2$) is a manufactured chemical that also occurs naturally in small amounts in the ocean, where it is likely formed by algae and kelp. It is a colorless, heavy organic liquid with a mild, sweet odor. It generally does not bind strongly to soil and will move through soil into the groundwater where it hardly breaks down. If applied to surface water, it will volatilize, and be broken down in the atmosphere. Other names for ethylene dibromide include 1,2-dibromoethane, EDB, and glycol bromide (ATSDR, 1995).

27.2 Use, Production, and Releases

Ethylene dibromide has been used as a pesticide in soil, and on citrus, vegetable, and grain crops. Most of these uses were stopped by EPA in 1984. Another major use of ethylene dibromide was as an additive in leaded gasoline. Uses today include treatment of logs for termites and beetles, control of moths in beehives, and as a preparation for dyes and waxes (ATSDR, 1995).

The Toxic Substances Control Act (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 27-1 presents the production of ethylene dibromide in the United States from 1986 to 2002. Note that the production of ethylene dibromide in the United States decreased from 1986 to 1998 and remained constant thereafter.

Exhibit 27-1: Production of Ethylene Dibromide 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	> 10 million – 50 million pounds
1998 Range	> 1 million – 10 million pounds
2002 Range	> 1 million – 10 million pounds

Source: USEPA, 2003

Ethylene dibromide is listed as a Toxics Release Inventory (TRI) chemical. (It is listed under the synonym 1,2-dibromoethane.) TRI data indicate that total off-site and on-site releases of ethylene dibromide for the period 1998-2006 ranged from approximately 5,600 pounds to approximately 48,000 pounds, with maximum releases occurring in 1999. With the exception of 1999, on-site releases were greater than off-site releases (USEPA, 2008).

27.3 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 ethylene dibromide in ambient water are available from the NAWQA program.

27.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for ethylene dibromide. 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 27-2. Overall, ethylene dibromide was detected in 0.3% of samples and at 0.2% of sites. Ethylene dibromide was only detected in ground water. The median concentration based on detections in ground water was 0.098 µg/L. The 99th percentile concentration based on detections from all sites was 1.4 µg/L.

Exhibit 27-2: EPA Summary Analysis of Ethylene Dibromide 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	4,958	0.4%	4,147	0.2%	0.015	0.098	1.4	1.4	1.4
surface water	1,393	0.0%	185	0.0%					
all sites	6,351	0.3%	4,332	0.2%	0.015	0.098	1.4	1.4	1.4

1. RLs (Reporting Limits) for ethylene dibromide varied, but did not exceed 0.036 µg/L.

27.4 Occurrence in Drinking Water

Ethylene dibromide 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 ethylene dibromide.

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 ethylene dibromide occurrence presented in the following section is based on state compliance monitoring data from the Six-Year Review-ICR Dataset. This is the largest

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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.

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 ethylene dibromide. (There were no ethylene dibromide data from Maryland or Oklahoma.) These data consist of 218,797 analytical results from 36,215 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.

27.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 27-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For ethylene dibromide, 0.538% of 36,215 systems reported detections. Exhibit 27-4 lists the minimum, median, 90th percentile, and maximum ethylene dibromide concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of ethylene dibromide, based on detections from all systems, is 0.04 µg/L.

Exhibit 27-3: Ethylene Dibromide Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	173,371	33,245	72,299,607
Surface Water	45,426	2,970	115,854,308
Combined Ground & Surface Water	218,797	36,215	188,153,915
Percent with Detections			
Ground Water	0.433%	0.442%	5.930%
Surface Water	1.228%	1.616%	7.544%
Combined Ground & Surface Water	0.598%	0.538%	6.924%

Exhibit 27-4: Ethylene Dibromide Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.001387	0.04	0.33	1.6
Surface Water	0.01	0.04	0.16	0.5
Combined Ground & Surface Water	0.001387	0.04	0.23	1.6

The following maps illustrate the geographic distribution of ethylene dibromide occurrence in drinking water. Exhibit 27-5 shows the states with systems with at least one detection and Exhibit 27-6 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). Maryland and Oklahoma did submit Six-Year data for most contaminants, but did not submit data for ethylene dibromide.

The distribution of systems with detections of ethylene dibromide is geographically dispersed, and detection rates were generally low. Seven states reported detections in more than 1% of their systems. Eight states reported detections in 0.5% to 1% of systems. Seventeen states reported no detections. Seventeen states reported detections greater than the MCL concentration of 0.05 µg/L.

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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 27-5: Percentage of Systems with at Least One Ethylene Dibromide Detection, by State

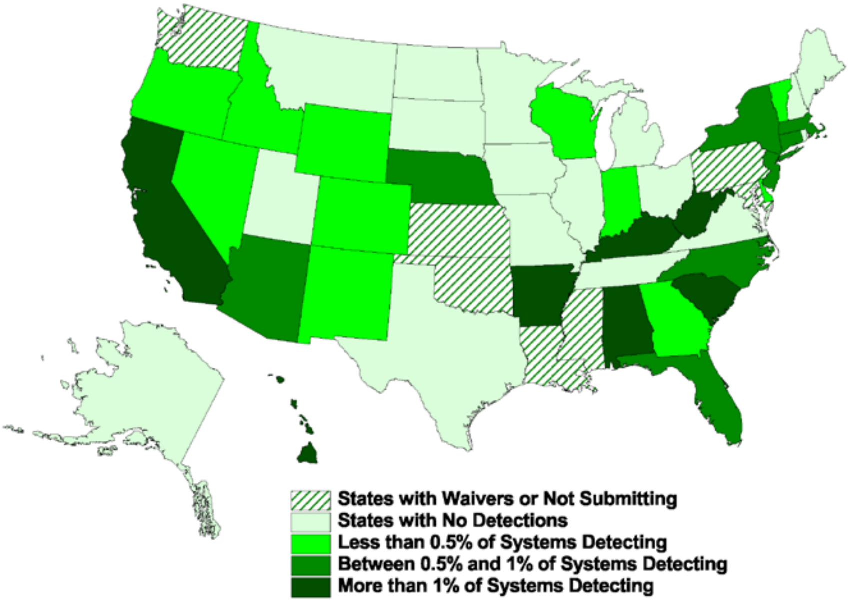

Exhibit 27-6: Percentage of Systems with at Least One Ethylene Dibromide Detection Greater than the MCL Concentration (> 0.05 µg/L), by State

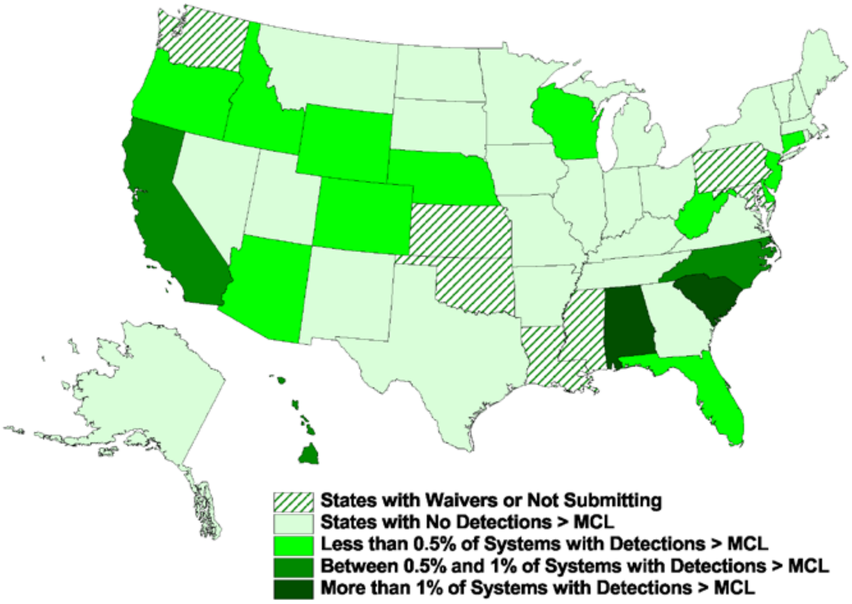

Exhibit 27-7 presents the Stage 1 analysis of ethylene dibromide occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.025 µg/L and 0.05 µg/L. More than 120 (0.337% of) systems, serving more than 3.0 million persons, reported at least one detection greater than or equal to 0.025 µg/L; and 88 (0.243% of) systems, serving almost 2.3 million persons, reported at least one detection greater than 0.05 µg/L.

Exhibit 27-7: Ethylene Dibromide 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	> 0.05 µg/L	67	0.202%	449,648	0.622%
	≥ 0.025 µg/L	96	0.289%	1,143,149	1.581%
Surface Water	> 0.05 µg/L	21	0.707%	1,810,412	1.563%
	≥ 0.025 µg/L	26	0.875%	1,894,232	1.635%
Combined Ground & Surface Water	> 0.05 µg/L	88	0.243%	2,260,060	1.201%
	≥ 0.025 µg/L	122	0.337%	3,037,381	1.614%

27.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *ToxFAQs for 1,2-Dibromoethane.* September 1995. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts37.html.

United State 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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Ethylene Dibromide. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for ethylene dibromide.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – 1,2-Dibromoethane. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for 1,2-dibromoethane.] Accessed March 9, 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.

28 Fluoride

This chapter on fluoride 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 fluoride 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).

28.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for fluoride on April 2, 1986 (51 FR 11396 (USEPA, 1986)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 4 mg/L. At the same time, EPA published a secondary maximum contaminant level (SMCL) for fluoride of 2 mg/L to protect against dental fluorosis, which is considered to be an adverse cosmetic effect.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2003), the term "fluorides" is used to refer to the common salts of the element fluorine, with the most common salts being sodium fluoride and calcium fluoride. Both salts are white solids, but sodium fluoride readily dissolves in water while calcium fluoride does not. Fluorine, the element, is a pale, yellow-green, irritating gas that has a strong, sharp odor. It is so chemically reactive that it is almost always found naturally combined with metals as a salt. Because health effects are due to the fluoride ion, the term "fluoride" is most commonly used in discussing health effects and regulations (ATSDR, 2003).

Fluorides occur naturally in a variety of geologic settings (e.g., in sedimentary and volcanic rocks) in coal, clay, and certain minerals, and also are found in sea water. Fluoride concentrations are typically higher in ground water than surface water because fluoride is leached from rocks through which the ground water flows (ATSDR, 2003). Fluoride may be released to the air by volcanic activity, the burning of coal, and the aerosolization of soil particles (ATSDR, 2003).

Fluoride is unique as a drinking water contaminant because of its beneficial effects at low level exposures, and because it is voluntarily added to some drinking water systems as a public health measure for reducing the incidence of cavities among the treated population. The amount of fluoride added to drinking water for fluoridation ranges from 0.7 to 1.2 mg/L, depending on ambient air temperatures. The decision to fluoridate a water supply is made by the state or local municipality, and is not mandated by EPA or any other Federal entity (USEPA, 2002).

28.2 Use, Production, and Releases

The main use of sodium fluoride is as a drinking water additive for prevention of tooth decay. It is also used as a component of laundry sours (for removal of iron stains), in wood preservation compounds, and in rimmed steel manufacturing (ATSDR, 2003). The most important use of hydrogen fluoride is in the production of fluorocarbon chemicals (ATSDR, 2003). Demand for hydrogen fluoride to make fluorocarbons is increasing; fluorocarbon refrigerants are an alternative to ozone-depleting chlorofluorocarbons. The next most important uses of hydrogen fluoride are: chemical derivatives, 18%; aluminum manufacturing, 6%; stainless steel pickling, 5%; petroleum alkylation catalysts, 4%; and uranium chemicals production, 3% (ATSDR, 2003). Miscellaneous other uses include glass etching, herbicides, and rare metals (ATSDR, 2003).

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 fluoride.

Fluorine and hydrogen fluoride are both listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of hydrogen fluoride for the period 1998-2006 ranged from approximately 72.7 million pounds to about 83.2 million pounds, with a general decrease over time. On-site releases were greater than off-site releases (USEPA, 2008a). TRI data for fluorine indicate that total releases ranged from about 60,000 pounds to more than 261,000 pounds, with a decrease over time. On-site releases were greater than off-site releases (USEPA, 2008b).

28.3 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 fluoride in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

28.4 Occurrence in Drinking Water

Fluoride is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) are required to sample for fluoride.[1] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year

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[1] Data for both CWSs and non-transient non-community water systems (NTNCWSs) were analyzed for the Second Six-Year Review.

compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[2] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule. PWSs exceeding the fluoride SMCL of 2 mg/L must provide public notification to their customers.

The analysis of fluoride 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 fluoride. These data consist of 333,211 analytical results from 48,600 systems 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.

28.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 28-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For fluoride, 79.276% of 48,600 systems reported detections (which is expected since, as previously mentioned, it is voluntarily added to some drinking water systems as a public health measure). Exhibit 28-2 lists the minimum, median, 90th percentile, and maximum fluoride concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of fluoride, based on detections from all systems, is 0.79 mg/L.

Exhibit 28-1: Fluoride Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	249,831	44,577	85,996,458
Surface Water	83,380	4,023	147,572,741

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[2] 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.

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Combined Ground & Surface Water	333,211	48,600	233,569,199
Percent with Detections			
Ground Water	80.310%	78.991%	90.508%
Surface Water	85.166%	82.426%	96.708%
Combined Ground & Surface Water	81.525%	79.276%	94.425%

Exhibit 28-2: Fluoride Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.0001	0.73	1.5	38
Surface Water	0.00006	0.86	1.27	29.2
Combined Ground & Surface Water	0.00006	0.79	1.4	38

The following maps illustrate the geographic distribution of fluoride occurrence in drinking water. Exhibit 28-3 shows the states with systems with at least one detection and Exhibit 28-4 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[3], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of fluoride is geographically dispersed. Detection rates were high; all states reported detections of fluoride. Eleven states reported that more than 95% of systems reported detections, and another 6 states reported detections in 90 to 95% of systems. Thirty-eight states reported detections greater than the MCL concentration of 4 mg/L, although only 5 of the 38 states reported that more than 2% of their systems exceeded 4 mg/L.

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

Exhibit 28-3: Percentage of Systems with at Least One Fluoride Detection, by State

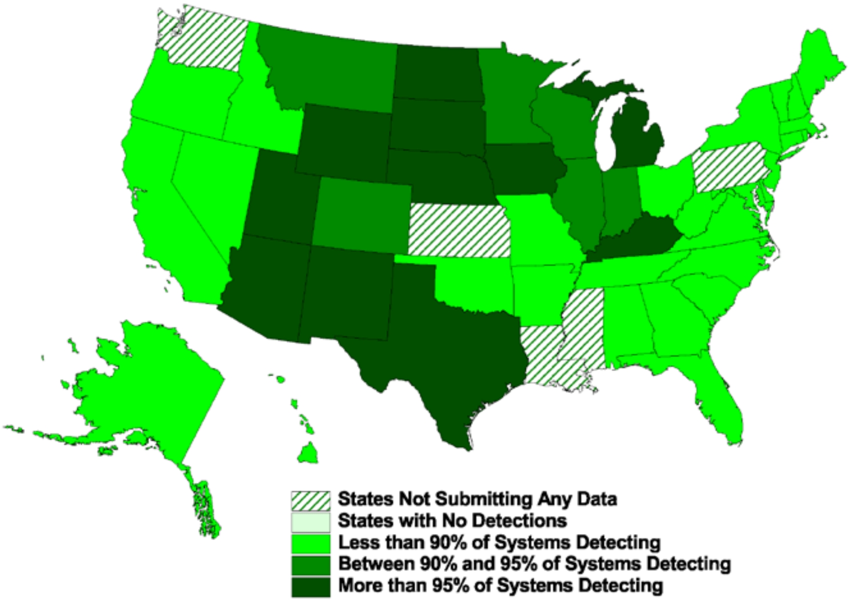


Exhibit 28-4: Percentage of Systems with at Least One Fluoride Detection Greater than the MCL Concentration (> 4 mg/L), by State

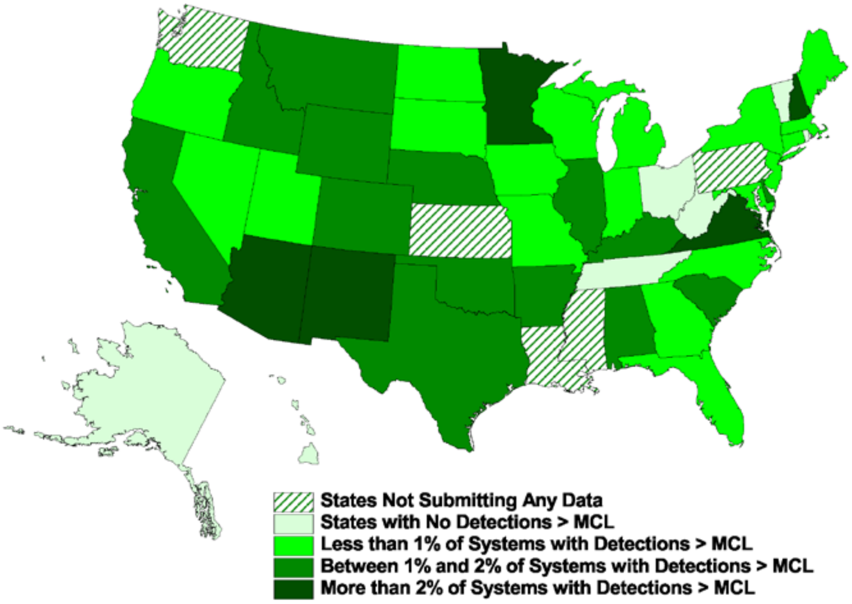


Exhibit 28-5 presents the Stage 1 analysis of fluoride occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 2 mg/L and 4 mg/L. About 2,400 (5.029% of) systems, serving about 11.5

million persons, reported at least one detection greater than or equal to 2 mg/L; and 519 (1.068% of) systems, serving 2.8 million persons, reported at least one detection exceeding 4 mg/L.

Exhibit 28-5: Fluoride Stage 1 Analysis –
Systems and Populations 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	> 4 mg/L	493	1.106%	1,341,331	1.560%
	≥ 2 mg/L	2,298	5.155%	6,344,789	7.378%
Surface Water	> 4 mg/L	26	0.646%	1,481,883	1.004%
	≥ 2 mg/L	146	3.629%	5,108,236	3.462%
Combined Ground & Surface Water	> 4 mg/L	519	1.068%	2,823,214	1.209%
	≥ 2 mg/L	2,444	5.029%	11,453,025	4.903%

28.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2003. *Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine*. September 2003. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp11.html.

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/.

United States Environmental Protection Agency (USEPA). 1986. National Primary and Secondary Drinking Water Regulations; Fluoride; Final Rule. Federal Register. Vol. 51, No. 63. p. 11396, April 2, 1986.

USEPA. 2002. National Primary Drinking Water Regulations; Announcement of the Results of EPA's Review of Existing Drinking Water Standards and Request for Public Comment; Proposed Rule. Federal Register. Vol. 67, No. 74, p. 19030, April 17, 2002.

USEPA. 2008a. TRI Explorer: Trends – Hydrogen Fluoride. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for hydrogen fluoride.] Accessed February 29, 2008.

USEPA. 2008b. TRI Explorer: Trends – Fluorine. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for fluorine.] 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.

29 Glyphosate

This chapter on glyphosate 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 glyphosate 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).

29.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for glyphosate 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 700 µg/L. The Agency developed the MCLG based on a reference dose (RfD) of 100 µg/kg-day (0.1 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

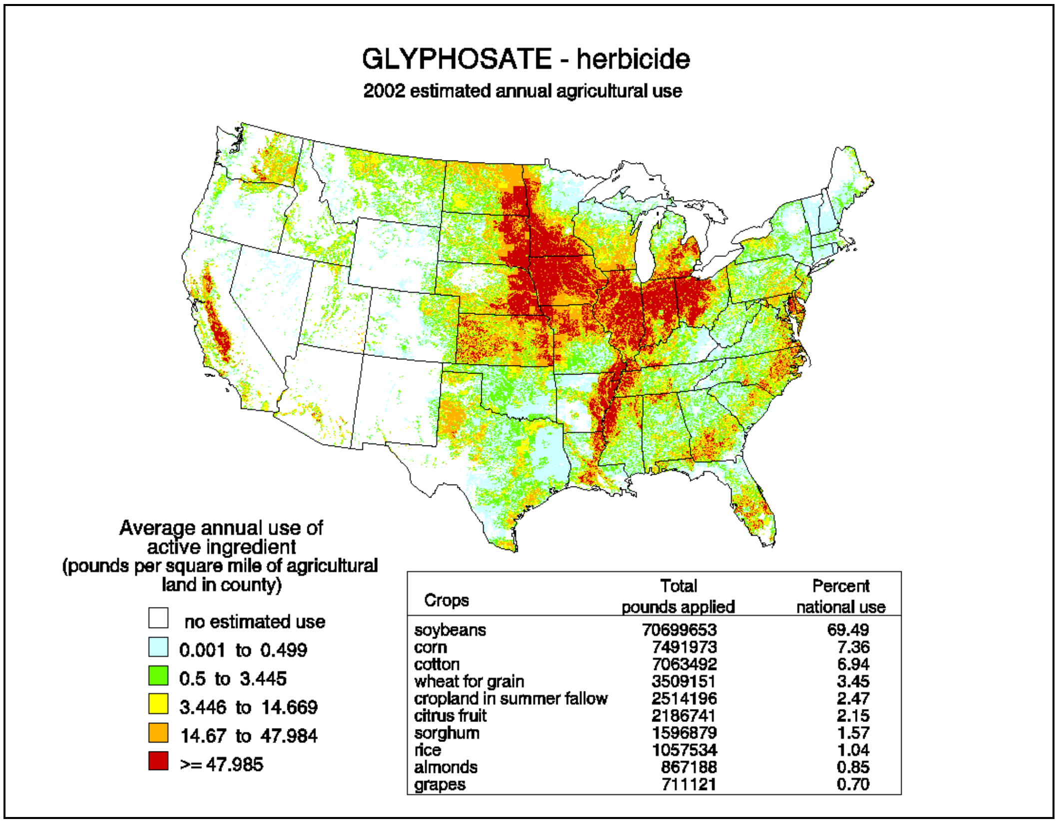
According to the Extension Toxicology Network (EXTOXNET, 1996), glyphosate ($C_3H_8NO_5P$) is an organic solid of colorless crystals. Glyphosate itself is an acid, but it is commonly used in salt form. It is generally distributed as water-soluble concentrates and powders. Glyphosate binds strongly to most soils and does not leach easily. It breaks down primarily by the action of microbes. The time required to degrade varies greatly; field studies have reported half lives in soil of 1 to 174 days (EXTOXNET, 1996).

29.2 Use, Production, and Releases

Glyphosate is a non-selective herbicide used on many food and non-food crops as well as non-crop areas such as roadsides. The most common uses include control of annual and perennial plants including grasses, sedges, broad-leaved weeds, and woody plants (EXTOXNET, 1996).

Exhibit 29-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual glyphosate 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 approximately 102 million pounds of glyphosate active ingredient were used on average each year between 1999 and 2004. The greatest use of glyphosate is in the Midwest.

Exhibit 29-1: Estimated Annual Agricultural Use for Glyphosate (c. 2002)



Crops	Total pounds applied	Percent national use
soybeans	70699653	69.49
corn	7491973	7.36
cotton	7063492	6.94
wheat for grain	3509151	3.45
cropland in summer fallow	2514196	2.47
citrus fruit	2186741	2.15
sorghum	1596879	1.57
rice	1057534	1.04
almonds	867188	0.85
grapes	711121	0.70

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 glyphosate.

Glyphosate is not listed as a Toxics Release Inventory (TRI) chemical; thus, no TRI release records are available.

29.3 Occurrence in Ambient Water

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

29.4 Occurrence in Drinking Water

Glyphosate 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 glyphosate.

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 glyphosate 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.

Glyphosate data were provided by 42 of the Six-Year Review-ICR states. (No glyphosate data were received from Missouri, North Carolina, or Texas.) The glyphosate data from the 42 states consist of 58,174 analytical results from 16,351 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.

29.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 29-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For glyphosate, 0.177% of 16,351 systems reported detections. Exhibit 29-3 lists the minimum, median, 90th percentile, and maximum glyphosate

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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.

concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of glyphosate, based on detections from all systems, is 10 µg/L.

Exhibit 29-2: Glyphosate Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	46,591	14,974	46,311,603
Surface Water	11,583	1,377	69,964,408
Combined Ground & Surface Water	58,174	16,351	116,276,011
Percent with Detections			
Ground Water	0.064%	0.140%	6.074%
Surface Water	0.095%	0.581%	1.043%
Combined Ground & Surface Water	0.070%	0.177%	3.047%

Exhibit 29-3: Glyphosate Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	5.5	10	97.5	700
Surface Water	2.6	10	66	500
Combined Ground & Surface Water	2.6	10	95	700

Exhibit 29-4 illustrates the geographic distribution of glyphosate occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) Note that five states did not submit data for use in the Six-Year Review (Kansas[2],

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[2] Kansas submitted data after the data management and analyses had been conducted; data for Kansas data included in the analyses.

Louisiana, Mississippi, Pennsylvania, and Washington). Missouri, North Carolina, and Texas submitted Six-Year data for most contaminants, but did not submit data for glyphosate.

Detection rates were generally low for glyphosate; only 2 states reported detections in more than 1% of their systems. In two states, between 0.5% and 1% of systems reported detections. Thirty-three states reported no detections of glyphosate. Furthermore, no states reported detections greater than the MCL concentration of 700 µg/L.

Exhibit 29-4: Percentage of Systems with at Least One Glyphosate Detection, by State

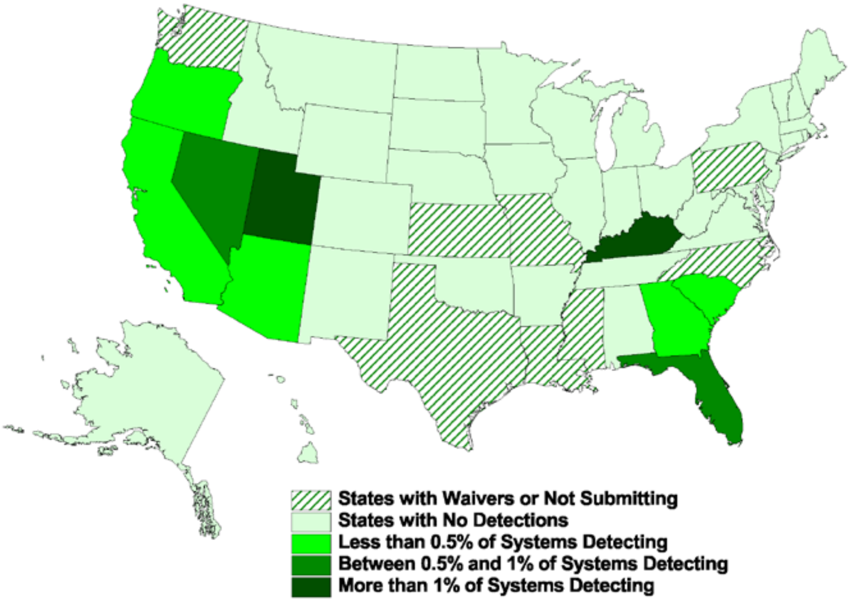

Exhibit 29-5 presents the Stage 1 analysis of glyphosate occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 350 µg/L and 700 µg/L. Two (0.012% of) systems, serving almost 49,000 persons, reported at least one detection greater than or equal to 350 µg/L. No systems reported detections greater than 700 µg/L.

Exhibit 29-5: Glyphosate 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	> 700 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
	≥ 350 µg/L	1	0.007%	40	0.000%
Surface Water	> 700 µg/L	0	0.000%	0	0.000%
	≥ 350 µg/L	1	0.073%	48,800	0.070%
Combined Ground & Surface Water	> 700 µg/L	0	0.000%	0	0.000%
	≥ 350 µg/L	2	0.012%	48,840	0.042%

29.5 References

Extension Toxicology Network (EXTOXNET). 1996. EXTOXNET Pesticide Information Profiles–Glyphosate. Last modified June 1996. Available on the Internet at: http://extoxnet.orst.edu/pips/glyphosa.htm. Accessed March 6, 2008.

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/.

Thelin, G.P. and L.P. Gianessi. 2000. *Method for Estimating Pesticide Use for County Areas of the Conterminous United States.* U.S. Geological Survey Open-File Report 00-250, 62 p. Available on the Internet at: http://ca.water.usgs.gov/pnsp/rep/ofr00250/ofr00250.pdf.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

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.

United States Geological Survey (USGS). 2007. 2002 Pesticide Use Maps. Available on the Internet at: http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1099. Accessed March 6, 2008.

30 Lindane (Gamma-Hexachlorocyclohexane)

This chapter on lindane (gamma-hexachlorocyclohexane) 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 lindane 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).

30.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for lindane 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 0.2 µg/L. The Agency based the MCLG on a reference dose (RfD) of 0.3 µg/kg-day (0.0003 mg/kg-day) and a cancer classification of C, possible human carcinogen.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2005), lindane ($C_6H_6Cl_6$) is one of eight isomers of the manufactured chemical hexachlorocyclohexane (HCH). Lindane is a white solid that may evaporate into the air as a colorless vapor with a slightly musty odor. In the air, the different forms of HCH can exist as a vapor or attached to small particles such as soil and dust. The particles may be removed from the air by rain or degraded by other compounds in the atmosphere. In soil, sediments, and water, HCH is broken down to less toxic substances by algae, fungi, and bacteria, but this process can take a long time. Other names for lindane include gamma-hexachlorocyclohexane, gamma-HCH, and γ-HCH (ATSDR, 2005).

30.2 Use, Production, and Releases

Lindane has not been produced in the United States since 1976, but is imported for insecticide use (ATSDR, 2005). Between 1998 and 1999, lindane registrants voluntarily cancelled all registered uses of lindane, except for seed treatment uses on 19 agricultural crops and a dog mange treatment. Use for dog mange was voluntarily cancelled in 2001. In 2001 and 2002 registrants voluntarily cancelled all but six lindane seed treatment uses. In 2006, EPA called for the voluntary cancellation of all agricultural uses of lindane (USEPA, 2006).

The Toxic Substances Control Act (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 30-1 presents the production of lindane in the United States from 1986 to 2002. Note that the production of lindane in the United States was only documented in the Chemical Update System in 1986 and 1998 and was the same for both those years.

Exhibit 30-1: Production of Lindane in the United States

Inventory Update Year	Production Volume
1986 Range	10,000 – 500,000 pounds
1990 Range	No reports
1994 Range	No reports
1998 Range	10,000 – 500,000 pounds
2002 Range	No reports

Source: USEPA, 2003

Lindane is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of lindane for the period 1998-2006 ranged from 10 pounds to approximately 26,000 pounds, with a decrease over time (USEPA, 2008).

30.3 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 lindane in ambient water are available from the NAWQA program.

30.3.1 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 lindane (gamma-HCH) between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for lindane was 0.002 µg/L.

In NAWQA stream samples (Exhibit 30-2), lindane was found at frequencies ranging from 0.48% of samples in undeveloped areas to 1.02% in agricultural settings, 1.91% in mixed land use settings, and 3.11% of samples in urban areas. The 95th percentile concentration was less than the method detection limit in all land use settings. The highest concentration, 0.130 µg/L, was found in an undeveloped setting.

Exhibit 30-2: USGS National Synthesis Summary of NAWQA Monitoring of Lindane 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	2,001 (83)	1.02%	ND[1]	ND[1]	0.053
Mixed	1,355 (65)	1.91%	ND[1]	ND[1]	0.043
Undeveloped	144 (8)	0.48%	ND[1]	ND[1]	0.130
Urban	803 (30)	3.11%	ND[1]	ND[1]	0.048

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 30-3), lindane was only detected in mixed land use settings (at a frequency of 0.07%). The highest concentration at a mixed land use setting was 0.152 µg/L.

Exhibit 30-3: USGS National Synthesis Summary of NAWQA Monitoring of Lindane 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	1,397	0.00%	ND[1]	ND[1]	ND[1]
Mixed	2,728	0.07%	ND[1]	ND[1]	0.152
Undeveloped	33	0.00%	ND[1]	ND[1]	ND[1]
Urban	843	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)

30.3.2 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for lindane. 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 30-4. Overall, lindane was detected in 1.7% of samples and at 1.5% of sites. Lindane was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.0102 µg/L. The 99th percentile concentration based on detections from all sites was 0.11 µg/L.

Exhibit 30-4: EPA Summary Analysis of Lindane 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	6,060	0.0%	5,193	0.0%	0.009	0.0109	0.0128	0.0128	0.0128
surface water	14,870	2.3%	1,907	5.7%	0.0009	0.0102	0.075	0.11	0.219
all sites	20,930	1.7%	7,100	1.5%	0.0009	0.0102	0.075	0.11	0.219

1. RLs (Reporting Limits) for lindane varied, but did not exceed 0.004 µg/L. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible.

30.4 Occurrence in Drinking Water

Lindane 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

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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.

quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of lindane 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 lindane. (There were no lindane data from Oklahoma.) These data consist of 135,585 analytical results from more than 33,265 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.

30.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 30-5 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For lindane, 0.253% of 33,265 systems reported detections. Exhibit 30-6 lists the minimum, median, 90th percentile, and maximum lindane concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of lindane, based on detections from all systems, is 0.04 µg/L.

Exhibit 30-5: Lindane Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	106,917	30,143	68,277,043
Surface Water	28,668	3,122	118,981,892
Combined Ground & Surface Water	135,585	33,265	187,258,935
Percent with Detections			
Ground Water	0.109%	0.219%	4.169%
Surface Water	0.105%	0.577%	3.978%
Combined Ground & Surface Water	0.108%	0.253%	4.048%

Exhibit 30-6: Lindane Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.002	0.04	0.11	0.69
Surface Water	0.001	0.03	0.2	0.5
Combined Ground & Surface Water	0.001	0.04	0.11	0.69

The following maps illustrate the geographic distribution of lindane occurrence in drinking water. Exhibit 30-7 shows the states with systems with at least one detection and Exhibit 30-8 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). Oklahoma submitted Six-Year data for most contaminants; however, there is a statewide waiver for lindane in Oklahoma so no lindane data were available from that state.

Detection rates were generally low; only six states reported detections in more than 1% of their systems. These states are all located in the eastern half of the United States. In three states, between 0.5% and 1% of systems reported detections. Two 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 for Kansas are not included in the analyses.

Exhibit 30-7: Percentage of Systems with at Least One Lindane Detection, by State

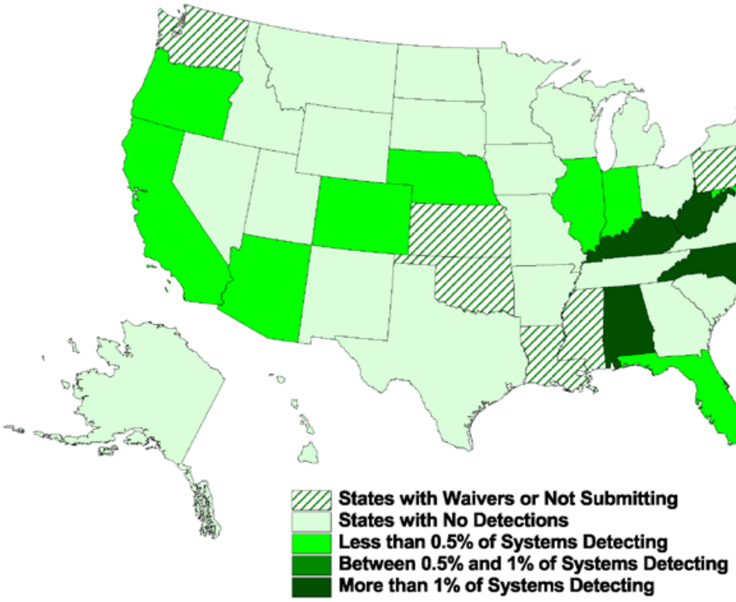

Exhibit 30-8: Percentage of Systems with at Least One Lindane Detection Greater than the MCL Concentration (> 0.2 µg/L), by State

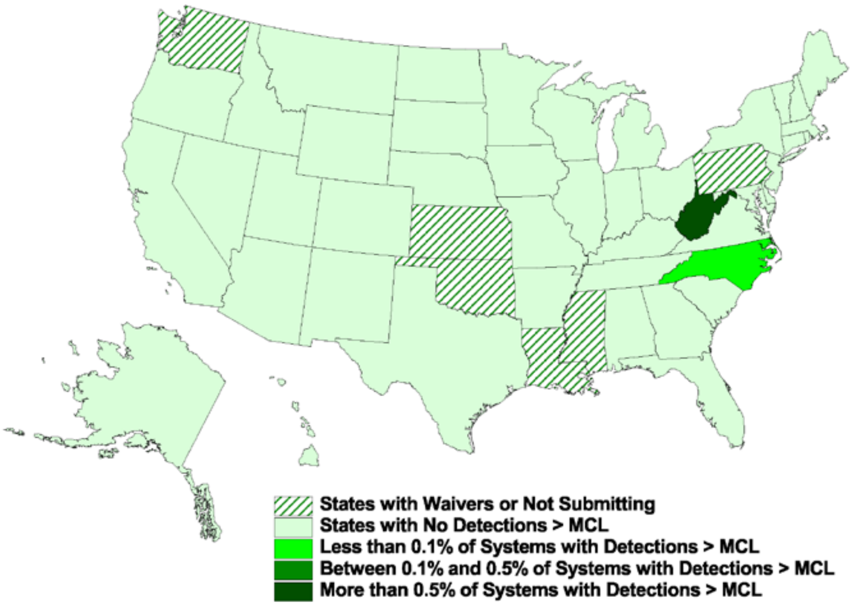

Exhibit 30-9 presents the Stage 1 analysis of lindane occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.1 µg/L and 0.2 µg/L. Fifteen (0.045% of) systems, serving almost 550,000 persons, reported at least one detection greater than or equal to 0.1 µg/L; and 3 (0.009% of) systems, serving more than 4,800 persons, reported at least one detection greater than 0.2 µg/L.

Exhibit 30-9: Lindane 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	2	0.007%	462	0.001%
	≥ 0.1 µg/L	11	0.036%	36,143	0.053%
Surface Water	> 0.2 µg/L	1	0.032%	4,374	0.004%
	≥ 0.1 µg/L	4	0.128%	512,063	0.430%
Combined Ground & Surface Water	> 0.2 µg/L	3	0.009%	4,836	0.003%
	≥ 0.1 µg/L	15	0.045%	548,206	0.293%

30.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2005. *ToxFAQs for Hexachlorocyclohexane.* August 2005. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts43.html.

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/.

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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Lindane. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for lindane.] Accessed February 21, 2008.

USEPA. 2006. Addendum to the 2002 Lindane Reregistration Eligibility Decision (RED). July 2006. Available on the Internet at:
http://www.epa.gov/oppsrrd1/REDs/lindane_red_addendum.pdf

USEPA. 2008. TRI Explorer: Trends – Lindane. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for lindane.] Accessed March 6, 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 Regulationsi.* Office of Water. EPA-815-B-09-006. October 2009.

31 Mercury (Inorganic)

This chapter on mercury (inorganic) 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 mercury 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).

31.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for inorganic mercury 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 0.002 mg/L. The Agency based the MCLG on a Drinking Water Equivalent Level (DWEL) of 0.01 mg/L[1] and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1999), mercury is a metal that has several forms. Metallic mercury is a shiny, silver-white, odorless liquid; it is very rare in nature. Mercury in nature is generally combined with sulfur in the ore mineral cinnabar. It also is emitted into the atmosphere from volcanoes and from the incineration of coal (USGS, 2000). It can be combined with other elements, such as chlorine or oxygen, to form inorganic mercury compounds. These are usually white powders or crystals. Mercury also combines with carbon to make organic mercury compounds. The most common organic compound, methylmercury, is produced mainly by microscopic organisms in the water and soil. Increased mercury in the environment can increase the production of methylmercury (ATSDR, 1999), which is the most toxic form (USGS, 2000).

31.2 Use, Production, and Releases

Metallic mercury is used to produce chlorine gas and caustic soda. It can also be used in thermometers, dental fillings, and batteries. Mercury is used to produce chlorine gas and caustic soda, and is also used in thermometers, dental fillings, and batteries. Mercury salts are sometimes used in skin lightening creams and as antiseptic creams and ointments (ATSDR, 1999).

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[1] The DWEL was recommended by a panel of experts on mercury, and was derived using the weight of evidence from the entire inorganic mercury database. The DWEL was later back-calculated to a reference dose (RfD) of 0.0003 mg/kg-day (USEPA, 1995).

The Toxic Substances Control Act (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 31-1 presents the production of mercury in the United States from 1986 to 2002. Note that the production of mercury in the United States was only documented in the Chemical Update System in 1986 and 1990 and remained constant in those years.

Exhibit 31-1: Production of Mercury in the United States

Inventory Update Year	Production Volume
1986 Range	10,000 – 500,000 pounds
1990 Range	10,000 – 500,000 pounds
1994 Range	No reports
1998 Range	No reports
2002 Range	No reports

Source: USEPA, 2003

Mercury and mercury compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of mercury for the period 1998-2006 ranged from about 72,000 pounds to approximately 291,000 pounds, with a general increase over time. In most years, off-site releases were greater than on-site releases (USEPA, 2008a). Total mercury compound releases ranged from approximately 3.1 million pounds to approximately 9.1 million pounds, with a decrease until 1999. After 1999, total amounts released leveled off. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

31.3 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 mercury in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

31.4 Occurrence in Drinking Water

Mercury is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[2] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[3] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of mercury 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 mercury. These data consist of 181,629 analytical results from 48,859 systems 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.

31.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 31-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For mercury, 3.964% of 48,859 systems reported detections. Exhibit 31-3 lists the minimum, median, 90th percentile, and maximum mercury concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of mercury, based on detections from all systems, is 0.0002 mg/L.

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[2] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[3] 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 31-2: Mercury Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	141,104	44,863	85,514,854
Surface Water	40,525	3,996	144,338,525
Combined Ground & Surface Water	181,629	48,859	229,853,379
Percent with Detections			
Ground Water	1.894%	3.669%	17.131%
Surface Water	1.426%	7.282%	21.783%
Combined Ground & Surface Water	1.789%	3.964%	20.052%

Exhibit 31-3: Mercury Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.000021	0.0002	0.001	0.06
Surface Water	0.000022	0.0002	0.001	0.1
Combined Ground & Surface Water	0.000021	0.0002	0.001	0.1

The following maps illustrate the geographic distribution of mercury occurrence in drinking water. Exhibit 31-4 shows the states with systems with at least one detection and Exhibit 31-5 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[4], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with mercury detections is geographically dispersed. In 12 states, more than 5% of systems detected mercury. In five states, more than 0.5% of systems

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

reported at least one detection greater than the MCL concentration of 0.002 mg/L. Twenty states reported no detections of mercury greater than 0.002 mg/L.

Exhibit 31-4: Percentage of Systems with at Least One Mercury Detection, by State

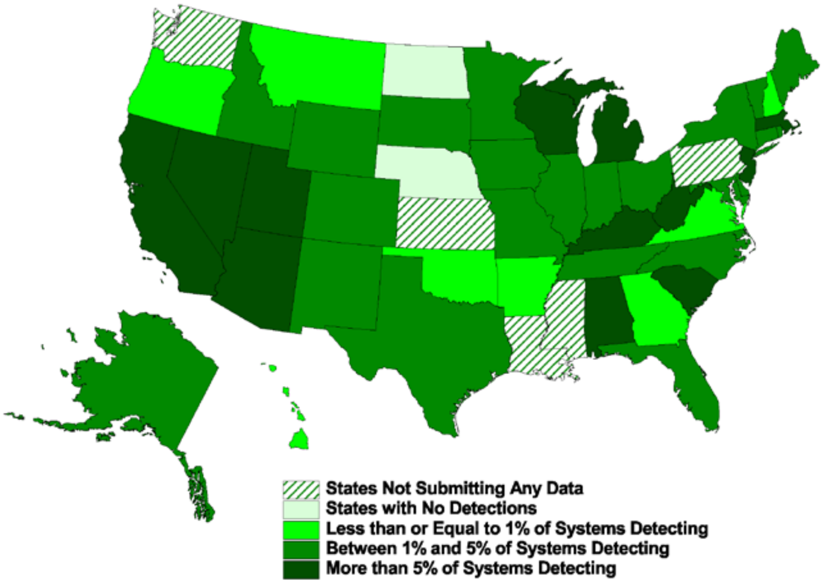

Exhibit 31-5: Percentage of Systems with at Least One Mercury Detection Greater than the MCL Concentration (> 0.002 mg/L), by State

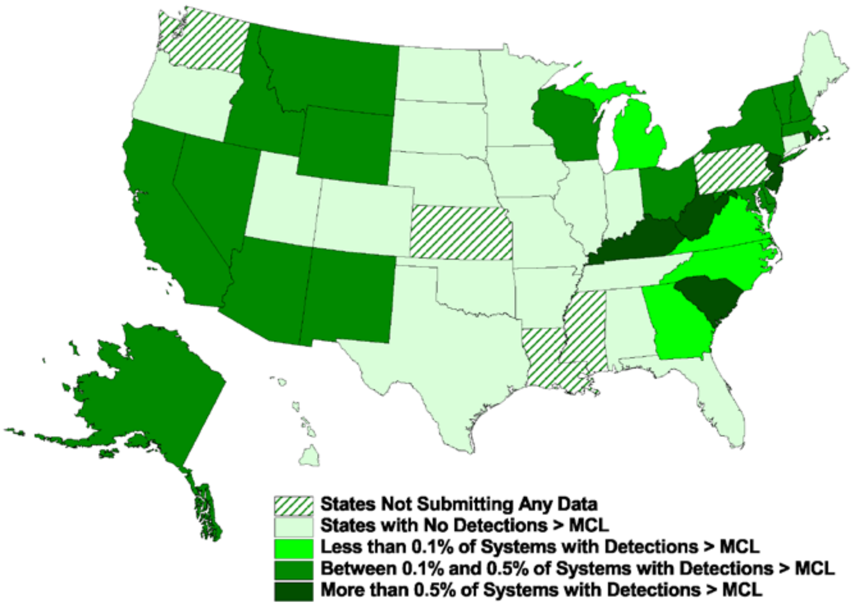

Exhibit 31-6 presents the Stage 1 analysis of mercury occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.001 mg/L and 0.002 mg/L. A total of 274 (0.561% of) systems, serving more than 12.8 million persons, reported at least one detection greater than or equal to 0.001 mg/L; and 82 (0.168% of) systems, serving almost 2.6 million persons, reported at least one detection greater than 0.002 mg/L.

Exhibit 31-6: Mercury 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	> 0.002 mg/L	64	0.143%	617,666	0.722%
	≥ 0.001 mg/L	223	0.497%	2,282,255	2.669%
Surface Water	> 0.002 mg/L	18	0.450%	1,973,654	1.367%
	≥ 0.001 mg/L	51	1.276%	10,552,870	7.311%
Combined Ground & Surface Water	> 0.002 mg/L	82	0.168%	2,591,320	1.127%
	≥ 0.001 mg/L	274	0.561%	12,835,125	5.584%

31.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. *ToxFAQs for Mercury*. April 1999. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts46.html.

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/.

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. 1995. Integrated Risk Information System (IRIS), Mercuric Chloride. File First On-line May 1, 1995. Available on the Internet at: http://www.epa.gov/iris/subst/0692.htm. Accessed March 10, 2008.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Mercury. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for mercury.] Accessed February 21, 2008.

USEPA. 2008a. TRI Explorer: Trends – Mercury. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for mercury.] Accessed March 6, 2008.

USEPA. 2008b. TRI Explorer: Trends – Mercury Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for mercury compounds.] Accessed March 6, 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.

United States Geological Survey (USGS). 2000. Mercury in the Environment, Fact Sheet 146-00 (October 2000). Available on the Internet at: http://www.usgs.gov/themes/factsheet/146-00 . Accessed March 15, 2008.

32 Methoxychlor

This chapter on methoxychlor 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 methoxychlor 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).

32.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for methoxychlor 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. The Agency based the MCLG on a reference dose (RfD) of 5 µg/kg-day (0.005 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, 2002), methoxychlor ($C_{16}H_{15}Cl_3O_2$) is a manufactured chemical that does not occur naturally in the environment. Pure methoxychlor is a pale-yellow powder with a slight fruity or musty odor. This chemical does not dissolve easily in water and binds strongly to particles. It may take months to break down. It does not generally accumulate in the food chain. Other names for methoxychlor include DMDT, Marlate®, or Metox® (ATSDR, 2002).

32.2 Use, Production, and Releases

Methoxychlor is used as an insecticide against flies, mosquitoes, cockroaches, chiggers, and a wide variety of other insects. Methoxychlor is also used on agricultural crops and livestock, and in animal feed, barns, grain storage bins, home garden, and on pets. It is preferred to dichlorodiphenyltrichloroethane (DDT) for use on animals, in animal feed, and on DDT-sensitive crops such as squash, melons, etc. because it is more unstable than DDT and has less residual effect (ATSDR, 2002).

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 methoxychlor.

Methoxychlor is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of methoxychlor for the period 1998-2006 ranged from 43 pounds to approximately 25,000 pounds, with the maximum releases occurring in 1998. On-site releases were greater than off-site releases (USEPA, 2008).

32.3 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 methoxychlor in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

32.4 Occurrence in Drinking Water

Methoxychlor 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 methoxychlor 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 methoxychlor. (There were no methoxychlor data from Oklahoma.) These data consist of 137,068 analytical results from 33,421 public water systems (PWSs) during the period from 1998

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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.

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.

32.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 32-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For methoxychlor, 0.159% of 33,421 systems reported detections. Exhibit 32-2 lists the minimum, median, 90th percentile, and maximum methoxychlor concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of methoxychlor, based on detections from all systems, is 0.1 µg/L.

Exhibit 32-1: Methoxychlor Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	108,078	30,291	68,501,754
Surface Water	28,990	3,130	119,134,365
Combined Ground & Surface Water	137,068	33,421	187,636,119
Percent with Detections			
Ground Water	0.031%	0.089%	3.912%
Surface Water	0.128%	0.831%	2.406%
Combined Ground & Surface Water	0.052%	0.159%	2.956%

Exhibit 32-2: Methoxychlor Summary Statistics

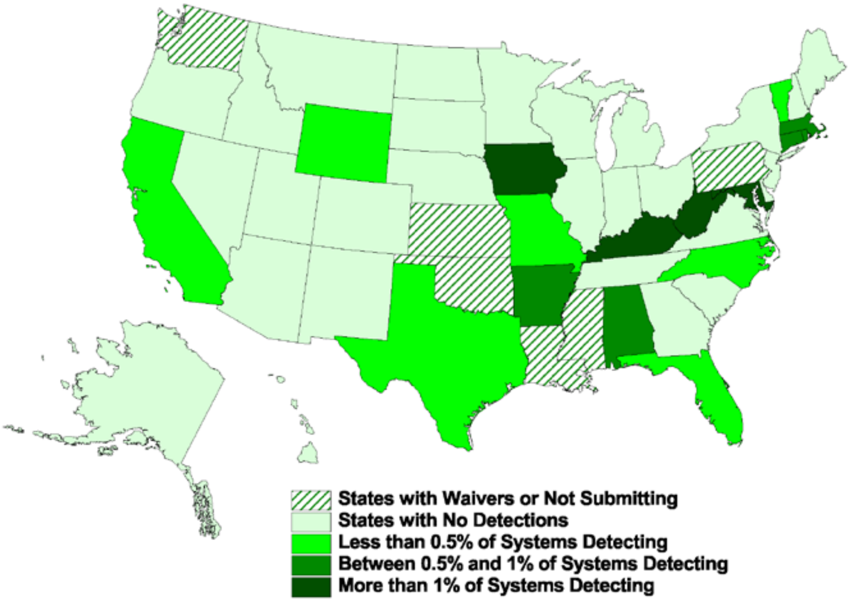
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.009	0.04	0.62	0.8
Surface Water	0.0073	0.2	0.6	1.1

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Combined Ground & Surface Water	0.0073	0.1	0.6	1.1

Exhibit 32-3 illustrates the geographic distribution of methoxychlor occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) 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 methoxychlor in Oklahoma so no methoxychlor data were available from that state.

Detection rates were generally low for methoxychlor; only four states reported detections in more than 1% of their systems. In five states, between 0.5% and 1% of systems reported detections. Twenty-eight states reported no detections of methoxychlor. Furthermore, no states reported detections greater than the MCL concentration of 40 µg/L.

Exhibit 32-3: Percentage of Systems with at Least One Methoxychlor Detection, by State



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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 32-4 presents the Stage 1 analysis of methoxychlor occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 20 µg/L and 40 µg/L. No systems reported detections greater than or equal to either threshold.

Exhibit 32-4: Methoxychlor 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%
Surface Water	> 40 µg/L	0	0.000%	0	0.000%
	≥ 20 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 40 µg/L	0	0.000%	0	0.000%
	≥ 20 µg/L	0	0.000%	0	0.000%

32.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2002. *Toxicological Profile for Methoxychlor.* September 2002. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp47.pdf.

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/.

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. 2008. TRI Explorer: Trends – Methoxychlor. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for methoxychlor.] Accessed March 6, 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.

33 Monochlorobenzene (Chlorobenzene)

This chapter on monochlorobenzene (chlorobenzene) 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 monochlorobenzene 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).

33.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for monochlorobenzene 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 100 µg/L. The Agency based the MCLG 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 the Agency for Toxic Substances and Disease Registry (ATSDR, 1999), monochlorobenzene (C_6H_5Cl) does not occur naturally in the environment. It is a colorless, flammable liquid with an aromatic, almond-like odor. Monochlorobenzene does not bind to soils and can leach into ground water. If released to water or land, it will either evaporate or rapidly biodegrade. However, some may filter into the groundwater. It does not accumulate significantly in the food chain (ATSDR, 1999). Monochlorobenzene is also known as chlorobenzene.

33.2 Use, Production, and Releases

The production of monochlorobenzene in the United States has declined by more than 60% from its peak in 1960. It was used in the past to make other chemicals, such as phenol and dichlorodiphenyltrichloroethane (DDT). Now it is used as a solvent for some pesticide formulations, to degrease automobile parts, and as a chemical intermediate to make several other chemicals (ATSDR, 1999).

The Toxic Substances Control Act (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 33-1 presents the production of monochlorobenzene in the United States from 1986 to 2002. Note that the production of monochlorobenzene in the United States remained constant from 1986 to 1998 and decreased thereafter.

Exhibit 33-1: Production of Monochlorobenzene in the United States

Inventory Update Year	Production Volume
1986 Range	> 100 million – 500 million pounds
1990 Range	> 100 million – 500 million pounds
1994 Range	> 100 million – 500 million pounds
1998 Range	> 100 million – 500 million pounds
2002 Range	> 50 million – 100 million pounds

Source: USEPA, 2003

Monochlorobenzene is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of monochlorobenzene for the period 1998-2006 ranged from approximately 639,000 pounds to approximately 982,000 pounds, with a general decrease over time. On-site releases were greater than off-site releases (USEPA, 2008).

33.3 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 monochlorobenzene in ambient water are available from the NAWQA program.

33.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for monochlorobenzene. 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 33-2. Overall, monochlorobenzene was detected in 1.9% of samples and at 1.5% of sites. It was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.01 µg/L. The 99th percentile concentration based on detections from all sites was 1.3 µg/L.

Exhibit 33-2: EPA Summary Analysis of Monochlorobenzene 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	4,659	0.9%	4,159	0.9%	0.001	0.00805	1.1	3.51	3.51
surface water	1,413	5.4%	190	13.2%	0.002	0.01325	0.06	0.43	0.43
all sites	6,072	1.9%	4,349	1.5%	0.001	0.01	0.3	1.3	3.51

1. RLs (Reporting Limits) for monochlorobenzene varied, but did not exceed 0.002 µg/L.

33.4 Occurrence in Drinking Water

Monochlorobenzene 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 monochlorobenzene 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 monochlorobenzene. (There were no monochlorobenzene data from Hawaii.) These data consist of 370,519 analytical results from 50,311 public water systems (PWSs) during the period from

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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.

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.

33.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 33-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For monochlorobenzene, 0.268% of 50,311 systems reported detections. Exhibit 33-4 lists the minimum, median, 90th percentile, and maximum monochlorobenzene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of monochlorobenzene, based on detections from all systems, is 0.7 µg/L.

Exhibit 33-3: Monochlorobenzene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	286,477	46,069	85,149,817
Surface Water	84,042	4,242	140,477,965
Combined Ground & Surface Water	370,519	50,311	225,627,782
Percent with Detections			
Ground Water	0.111%	0.228%	1.205%
Surface Water	0.067%	0.707%	1.782%
Combined Ground & Surface Water	0.101%	0.268%	1.564%

Exhibit 33-4: Monochlorobenzene Summary Statistics

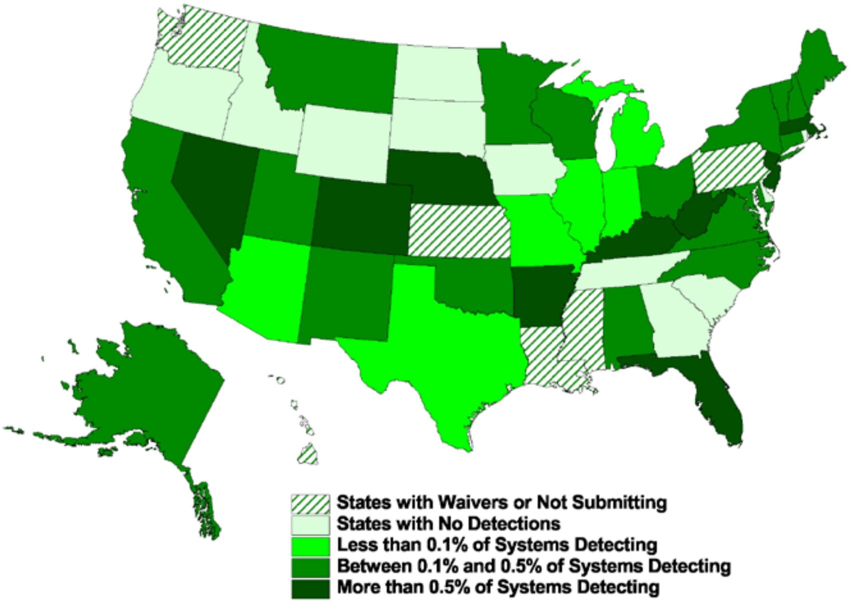
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.02	0.7	2	42

Source Water Type	Detection Value (µg/L)			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Surface Water	0.003	0.8	1.9	19.7
Combined Ground & Surface Water	0.003	0.7	1.94	42

Exhibit 33-5 illustrates the geographic distribution of monochlorobenzene occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Hawaii submitted Six-Year data for most contaminants, but did not submit data for monochlorobenzene.

Detection rates were generally low for monochlorobenzene. Nine states reported detections in more than 0.5% of their systems. In 18 states, between 0.1% and 0.5% of systems reported detections. Eleven states reported no detections. Furthermore, no states reported detections greater than the MCL concentration of 100 µg/L.

Exhibit 33-5: Percentage of Systems with at Least One Monochlorobenzene Detection, by State



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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 33-6 presents the Stage 1 analysis of monochlorobenzene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 50 µg/L and 100 µg/L. No systems reported detections greater than or equal to either threshold.

Exhibit 33-6: Monochlorobenzene 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	0	0.000%	0	0.000%
	≥ 50 µg/L	0	0.000%	0	0.000%
Surface Water	> 100 µg/L	0	0.000%	0	0.000%
	≥ 50 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 100 µg/L	0	0.000%	0	0.000%
	≥ 50 µg/L	0	0.000%	0	0.000%

33.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. *ToxFAQs for Chlorobenzene.* July 1999. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts131.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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Monochlorobenzene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for monochlorobenzene.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – Chlorobenzene. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for monochlorobenzene.] Accessed March 5, 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.

34 Nitrate (as N)

This chapter on nitrate (as N) 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 nitrate 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).

34.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for nitrate on January 30, 1991 (56 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) and maximum contaminant level (MCL) of 10 mg/L (as nitrogen (N)).[1] EPA based the MCLG on a survey of epidemiologic studies of infant methemoglobinemia in populations exposed to nitrate contaminated water. No cancer classification is currently available for nitrate (USEPA, 2009b).

Nitrate is a water soluble nitrogen-oxygen chemical unit that is formed when nitrogen from ammonia or other sources combines with oxygenated water (Wisconsin DNR, 2003). Nitrate occurs naturally in soil and water and is the primary source of nitrogen for plants. Excessively high nitrate in drinking water, however, poses a health risk, especially to infants and to pregnant or nursing women (Oregon DEQ, 2002). High concentrations occur in fertilizers, manure, and discharges from septic tanks and because it dissolves easily in water, nitrate can move easily from these sources into surface water or ground water (CDPHE, undated).

34.2 Use, Production, and Releases

According to the Hazardous Substance Data Bank (HSDB, 2008), a common source of nitrates is from their use in fertilizer. Ammonium nitrate is also used in explosives, in instant cold packs, and to make nitrous oxide.

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 nitrate.

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[1] If nitrate is analyzed as NO_3, the MCL is greater than or equal to 45 mg/L.

Nitrate compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of nitrate compounds for the period 1998-2006 ranged from about 275 million pounds to approximately 332 million pounds. On-site releases were greater than off-site releases (USEPA, 2008).

34.3 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 nitrate in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

34.4 Occurrence in Drinking Water

Community water systems (CWSs), non-transient non-community water systems (NTNCWSs), and transient non-community water systems (TNCWSs) are all required to sample for nitrate. Waivers are not permitted.

Initially, ground water CWSs and NTNCWSs and all TNCWSs must collect one sample each year. Surface water CWSs and NTNCWSs must collect four quarterly samples. If all results are less than ½ the MCL, then ground water systems and TNCWSs may continue monitoring annually and surface water systems may reduce to annual monitoring. If a result is greater than or equal to ½ the MCL (but less than the MCL), CWSs and NTNCWSs must collect four consecutive quarterly samples that are all less than the MCL (for ground water systems) or less than ½ the MCL (for surface water systems). TNCWSs may continue with annual monitoring. Once the four quarterly samples are all below the MCL (or ½ the MCL for surface water systems), the system may continue to monitor routinely. If a result is greater than or equal to the MCL, the system must collect a confirmation sample and average it with the original sample to determine compliance with the MCL. The system must monitor quarterly until four consecutive quarterly samples are less than the MCL (unless the state or EPA allows reduced monitoring under an enforcement action). After that, the system may continue to monitor routinely.

The analysis of nitrate 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 nitrate. (No nitrate data from Arkansas were analyzed for the Six-Year Review. Arkansas did submit data for nitrate plus nitrite, but only individual nitrate and nitrite results were analyzed.) These data consist of 1,052,487 analytical results from 119,537 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.

34.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 34-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For nitrate, 69.942% of 119,537 systems reported detections. Exhibit 34-2 lists the minimum, median, 90th percentile, and maximum nitrate concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of nitrate, based on detections from all systems, is 1.8 mg/L.

Exhibit 34-1: Nitrate Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	899,945	114,764	92,900,757
Surface Water	152,542	4,773	136,607,279
Combined Ground & Surface Water	1,052,487	119,537	229,508,036
Percent with Detections			
Ground Water	57.670%	69.466%	85.648%
Surface Water	83.304%	81.374%	94.559%
Combined Ground & Surface Water	61.385%	69.942%	90.952%

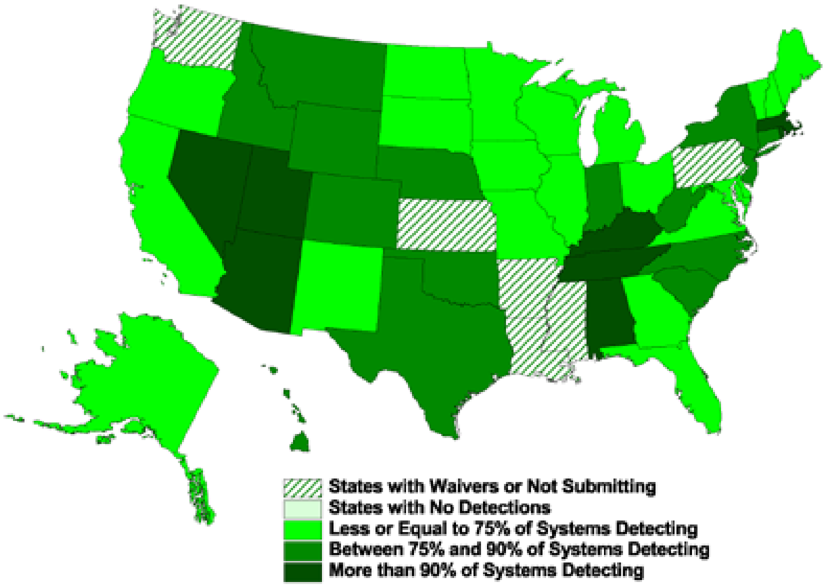
Exhibit 34-2: Nitrate Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	1.04E-06	1.6	7.53	99
Surface Water	7.34E-05	2.71	9.04	48.5
Combined Ground & Surface Water	1.04E-06	1.8	7.91	99

The following maps illustrate the geographic distribution of nitrate occurrence in drinking water. Exhibit 34-3 shows the states with systems with at least one detection and Exhibit 34-4 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). Arkansas did submit Six-Year data for most contaminants (including nitrate plus nitrite) but did not submit individual nitrate data.

Detection rates were high for nitrate. In eight states, more than 90% of systems detected nitrate. In 16 states, between 75% and 90% of systems detected nitrate. For seven states, more than 5% of systems reported at least one detection greater than the MCL concentration of 10 mg/L.

Exhibit 34-3: Percentage of Systems with at Least One Nitrate Detection, by State



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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 34-4: Percentage of Systems with at Least One Nitrate Detection Greater than the MCL Concentration (> 10 mg/L), by State

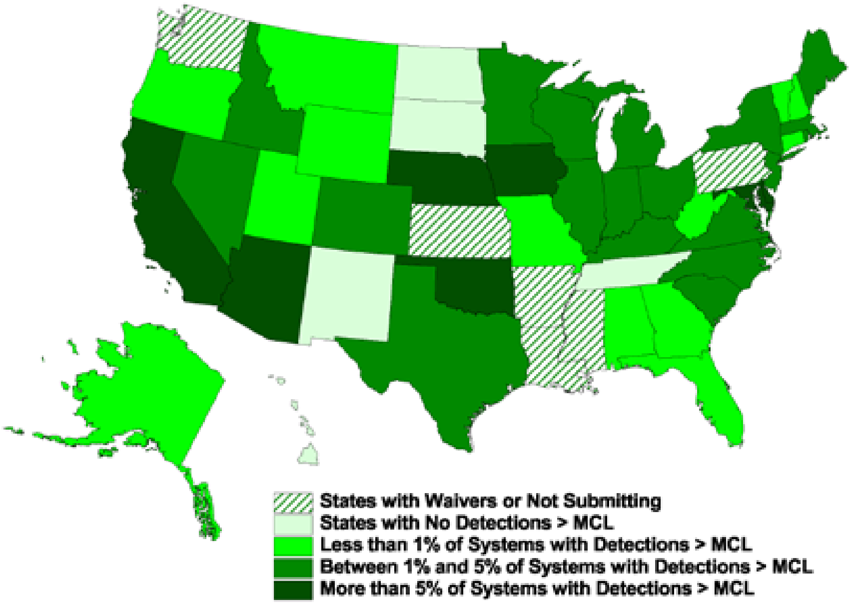

Exhibit 34-5 presents the Stage 1 analysis of nitrate occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 5 mg/L and 10 mg/L. More than 11,100 (9.294% of) systems, serving more than 44 million persons, reported at least one detection greater than or equal to 5 mg/L; and almost 3,000 (2.487% of) systems, serving almost 16.8 million persons, reported at least one detection greater than 10 mg/L.

Exhibit 34-5: Nitrate 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 mg/L	2,855	2.488%	5,278,260	5.682%
	≥ 5 mg/L	10,742	9.360%	19,289,360	20.763%
Surface Water	> 10 mg/L	118	2.472%	11,498,833	8.417%
	≥ 5 mg/L	368	7.710%	24,830,964	18.177%

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	> 10 mg/L	2,973	2.487%	16,777,093	7.310%
	≥ 5 mg/L	11,110	9.294%	44,120,324	19.224%

34.5 References

Colorado Department of Public Health and the Environment (CDPHE). Undated. Fact Sheet - Nitrate in Drinking Water. Available on the Internet at: http://www.cdphe.state.co.us/wq/drinkingwater/pdf/FactSheets/NitrateInDrinkingWater.pdf. Accessed March 15, 2008.

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/.

Hazardous Substance Data Bank (HSDB). 2008. AMMONIUM NITRATE. Available on the Internet at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Search for AMMONIUM NITRATE.] Accessed: July 8, 2008.

Oregon Department of Environmental Quality (DEQ). 2002. Nitrate in Drinking Water. Available on the Internet at: http://www.deq.state.or.us/wq/pubs/factsheets/groundwater/nitratedw.pdf . Accessed March 15, 2008.

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. 2008. TRI Explorer: Trends – Nitrate Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for nitrate compounds.] Accessed March 6, 2008.

USEPA. 2009a. *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.

USEPA. 2009b. *Six-Year Review 2 – Health Effects Assessment - Summary Report.* Office of Water. EPA-822-R-09-006. October 2009.

Wisconsin Department of Natural Resources (DNR). 2003. Nitrate. Available on the Internet at: http://www.dnr.state.wi.us/org/water/dwg/nitrate.htm. Accessed: July 3, 2008.

35 Nitrite (as N)

This chapter on nitrite (as N) 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 nitrite 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).

35.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for nitrite 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 1.0 mg/L (as N). EPA based the MCLG on extrapolation from nitrate, assuming the conversion of 10 percent of nitrate-nitrogen to nitrite-nitrogen. No cancer classification is currently available for nitrite (USEPA, 2009b).

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2007), nitrites are naturally occurring inorganic ions that are part of the nitrogen cycle. Microbial action in soil or water decomposes wastes containing organic nitrogen into ammonia, which is then oxidized to nitrite and nitrate. Like nitrate, nitrite is highly soluble in water and will move through soil and into ground water (ATSDR, 2007). It will remain in water until consumed by plants or other organisms (HSDB, 2008).

35.2 Use, Production, and Releases

Sodium nitrite is used in the chemical and pharmaceutical industries for making dyes and in the synthesis of pharmaceuticals and agricultural pesticides. It is also used to form nitrous acid, as a rubber accelerator, as a preservative for meats and fish, and as a photographic and analytical reagent. A minor use is as a fertilizer (HSDB, 2008).

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 nitrite.

Nitrite is not listed as a Toxics Release Inventory (TRI) chemical; no TRI release records are available.

35.3 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 nitrite in ambient water are available from the NAWQA program.

35.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for nitrite. 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 35-1. Overall, nitrite was detected in 51.6% of samples and at 38.5% of sites. Nitrite was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.02 mg/L. The 99th percentile concentration based on detections from all sites was 0.383 mg/L.

Exhibit 35-1: EPA Summary Analysis of Nitrite (as N) Data from NAWQA Study Units, 1992-2001

	Detection Frequency (detections are results ≥ RL[1])				Concentration Values (of detections, in mg/L)				
	Number of Samples	% Samples with Detections	Number of Sites	% Sites with Detections	Minimum	Median	95th Percen-tile	99th Percen-tile	Maximum
ground water	6,972	19.6%	5,470	22.4%	0.001	0.02	0.14	0.428	1.617
surface water	28,889	59.3%	2,754	70.7%	0.001	0.02	0.13	0.38	1.9
all sites	35,861	51.6%	8,224	38.5%	0.001	0.02	0.13	0.383	1.9

1. RLs (Reporting Limits) for nitrite (as N) varied, but did not exceed 0.001 mg/L.

35.4 Occurrence in Drinking Water

Community water systems (CWSs), non-transient non-community water systems (NTNCWSs), and transient non-community water systems (TNCWSs) are all required to sample for nitrite. Waivers are not permitted.

All public water systems (PWSs) must collect one sample during their initial compliance period. If a result is less than ½ the MCL, then the system must monitor at the frequency specified by the state. If a result is greater than or equal to ½ the MCL (but less than the MCL), the system must take one sample per quarter for at least a year until they obtain four consecutive samples below the MCL. After that, the system may continue to monitor routinely. If a result is greater than or equal to the MCL, the system must collect a confirmation sample and average it with the original sample to determine compliance with the MCL. The system must then monitor quarterly until they obtain four consecutive samples below the MCL (unless the state or EPA allows reduced monitoring under an enforcement action). After that, the system may continue to monitor routinely.

The analysis of nitrite 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 nitrite. (No nitrite data from Arkansas were analyzed for the Six-Year Review. Arkansas did submit data for nitrate plus nitrite, but only individual nitrate and nitrite results were analyzed.) These data consist of 397,175 analytical results from 86,313 systems 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.

35.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 35-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For nitrite, 22.318% of 86,313 systems reported detections. Exhibit 35-3 lists the minimum, median, 90th percentile, and maximum nitrite concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of nitrite, based on detections from all systems, is 0.02 mg/L.

Exhibit 35-2: Nitrite Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	345,206	82,738	81,271,403
Surface Water	51,969	3,575	126,713,410
Combined Ground & Surface Water	397,175	86,313	207,984,813

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Percent with Detections			
Ground Water	13.251%	22.285%	36.640%
Surface Water	6.477%	23.077%	49.731%
Combined Ground & Surface Water	12.365%	22.318%	44.615%

Exhibit 35-3: Nitrite Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.000001	0.02	0.4	13
Surface Water	0.000002	0.03	0.45	8.68
Combined Ground & Surface Water	0.000001	0.02	0.4	13

The following maps illustrate the geographic distribution of nitrite occurrence in drinking water. Exhibit 35-4 shows the states with systems with at least one detection and Exhibit 35-5 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[1], Louisiana, Mississippi, Pennsylvania, and Washington). Arkansas did submit Six-Year data for most contaminants (including nitrate plus nitrite) but did not submit individual nitrite data.

Detection rates were high for nitrite. In four states, more than 50% of systems detected nitrite. In 19 states, between 10% and 50% of systems detected nitrite. For four states, more than 1% of systems reported at least one detection greater than the MCL concentration of 1 mg/L.

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

Exhibit 35-4: Percentage of Systems with at Least One Nitrite Detection, by State

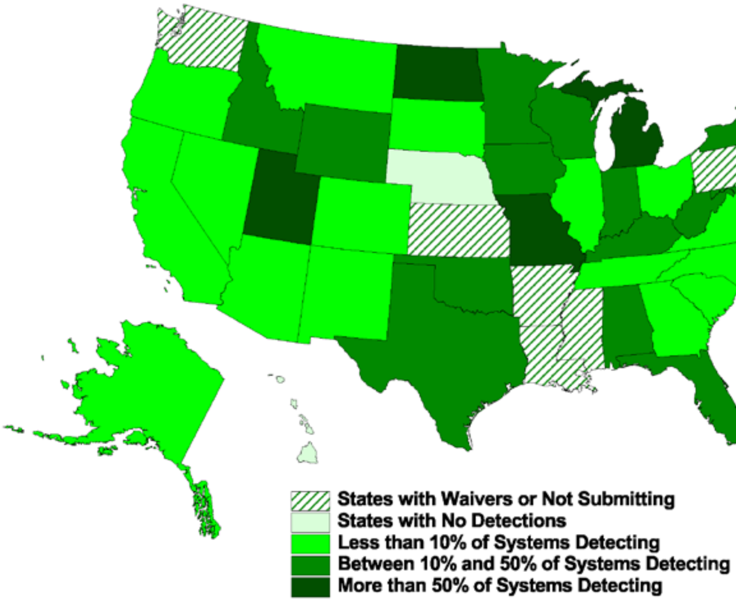

Exhibit 35-5: Percentage of Systems with at Least One Nitrite Detection Greater than the MCL Concentration (>1 mg/L), by State

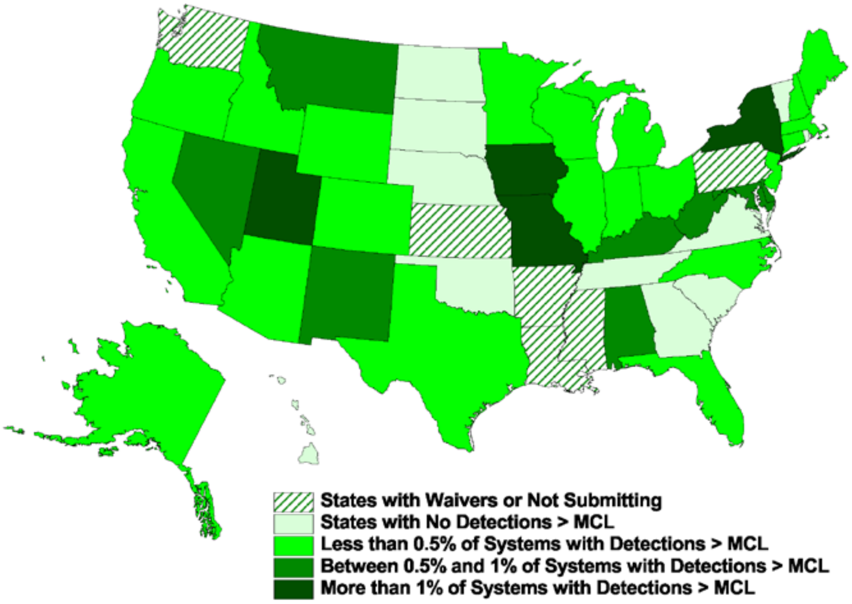

Exhibit 35-6 presents the Stage 1 analysis of nitrite occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.5 mg/L and 1 mg/L. Nearly 1,400 (1.568% of) systems, serving almost 26.5

million persons, reported at least one detection greater than or equal to 0.5 mg/L; and 635 (0.736% of) systems, serving more than 10 million persons, reported at least one detection greater than 1 mg/L.

Exhibit 35-6: Nitrite 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 mg/L	584	0.706%	729,751	0.898%
	≥ 0.5 mg/L	1,241	1.500%	4,915,364	6.048%
Surface Water	> 1 mg/L	51	1.427%	9,337,280	7.369%
	≥ 0.5 mg/L	112	3.133%	21,530,847	16.992%
Combined Ground & Surface Water	> 1 mg/L	635	0.736%	10,067,031	4.840%
	≥ 0.5 mg/L	1,353	1.568%	26,446,211	12.715%

35.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. “Nitrate/Nitrite Toxicity: What Are Nitrate and Nitrite?” Last updated September 24, 2007. Available on the Internet at: http://www.atsdr.cdc.gov/csem/nitrate/nitrate.html. Accessed March 21, 2008.

Hazardous Substance Data Bank (HSDB). 2008. SODIUM NITRITE. Available on the Internet at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Search for Sodium Nitrite.] Accessed: July 8, 2008.

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. 2009a. *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.

USEPA. 2009b. *Six-Year Review 2 – Health Effects Assessment - Summary Report.* Office of Water. EPA-822-R-09-006. October 2009.

36 Pentachlorophenol

This chapter on pentachlorophenol 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 pentachlorophenol 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).

36.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for pentachlorophenol on July 1, 1991 (56 FR 30266 (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 1 µg/L, based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2001), pentachlorophenol (C_6HCl_5O) is a colorless crystalline synthetic chemical. It has very little odor at room temperature but takes on a sharp characteristic phenolic smell when heated. It can be found in two forms: as pure pentachlorophenol and as a highly water-soluble sodium salt. At hazardous waste sites, impure pentachlorophenol is dark gray to brown and exists as dust, beads, or flakes. Impurities typically include polychlorinated dibenzo-p-dioxins and dibenzofurans. Pentachlorophenol tends to adhere to soils and sediment, and adhere to particulates in water. It will degrade in soil and surface waters due to sunlight and microorganisms (ATSDR, 2001).

36.2 Use, Production, and Releases

Once a widely used biocide and wood preservative, pentachlorophenol has been restricted to use by certified applicators since 1984. It is still used industrially as a wood preservative for utility poles, railroad ties, and wharf pilings (ATSDR, 2001).

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 pentachlorophenol.

Pentachlorophenol is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases for the period 1998-2006 ranged from approximately 2,600 pounds to approximately 272,000 pounds, with a general decrease over time (USEPA, 2008).

36.3 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 pentachlorophenol in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

36.4 Occurrence in Drinking Water

Pentachlorophenol 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 pentachlorophenol 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 pentachlorophenol. (There were no pentachlorophenol data from Hawaii or Oklahoma.) These data consist of 136,475 analytical results from 34,339 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.

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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.

36.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 36-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For pentachlorophenol, 0.731% of 34,339 systems reported detections. Exhibit 36-2 lists the minimum, median, 90th percentile, and maximum pentachlorophenol concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of pentachlorophenol, based on detections from all systems, is 0.08 µg/L.

Exhibit 36-1: Pentachlorophenol Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	107,551	31,142	68,667,605
Surface Water	28,924	3,197	121,840,104
Combined Ground & Surface Water	136,475	34,339	190,507,709
Percent with Detections			
Ground Water	0.243%	0.639%	5.996%
Surface Water	0.270%	1.627%	4.585%
Combined Ground & Surface Water	0.248%	0.731%	5.094%

Exhibit 36-2: Pentachlorophenol Summary Statistics

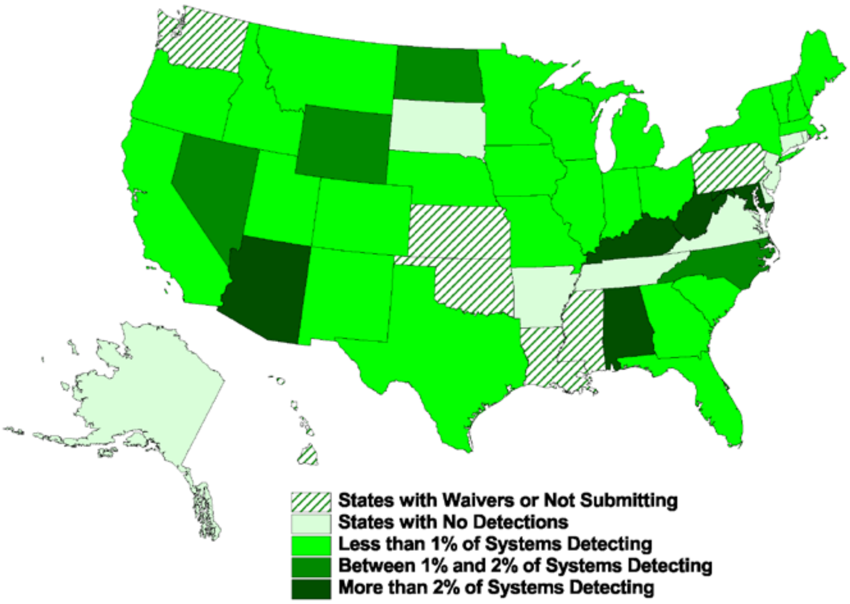
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.08	0.6	10
Surface Water	0.01	0.09	0.51	4

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Combined Ground & Surface Water	0.01	0.08	0.6	10

The following maps illustrate the geographic distribution of pentachlorophenol occurrence in drinking water. Exhibit 36-3 shows the states with systems with at least one detection and Exhibit 36-4 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). Hawaii and Oklahoma did submit Six-Year data for most contaminants, but did not submit data for pentachlorophenol.

In five states, greater than 2% of the systems detected pentachlorophenol. Four out of five of these states are located in the eastern half of the United States. In four states, between 1% and 2% of systems reported detections. Seven states reported at least one detection greater than the MCL concentration of 1 µg/L. In two states, more than 0.2% of systems reported detections greater than 1 µg/L.

Exhibit 36-3: Percentage of Systems with at Least One Pentachlorophenol Detection, by State



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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 36-4: Percentage of Systems with at Least One Pentachlorophenol Detection Greater than the MCL Concentration (> 1 µg/L), by State

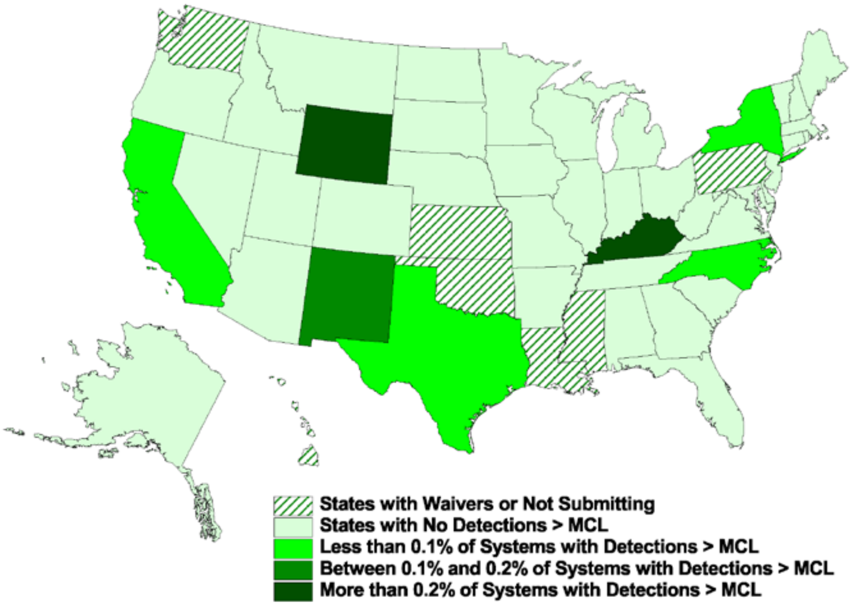


Exhibit 36-5 presents the Stage 1 analysis of pentachlorophenol occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.5 µg/L and 1 µg/L. A total of 29 (0.084% of) systems, serving almost 750,000 persons, reported at least one detection greater than or equal to 0.5 µg/L; and 8 (0.023% of) systems, serving almost 12,000 persons, reported at least one detection greater than 1 µg/L.

Exhibit 36-5: Pentachlorophenol 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	7	0.022%	11,376	0.017%
	≥ 0.5 µg/L	21	0.067%	434,892	0.633%
Surface Water	> 1 µg/L	1	0.031%	429	0.000%
	≥ 0.5 µg/L	8	0.250%	310,346	0.255%

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	> 1 µg/L	8	0.023%	11,805	0.006%
	≥ 0.5 µg/L	29	0.084%	745,238	0.391%

36.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2001. *Toxicological Profile for Pentachlorophenol.* September 2001. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp51.html.

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/.

United States Environmental Protection Agency (USEPA). 1991. Drinking Water; National Primary Drinking Water Regulations; Monitoring for Volatile Organic Chemicals; MCLGs and MCLs for Aldicarb, Aldicarb Sulfoxide, Aldicarb Sulfone, Pentachlorophenol, and Barium; Final Rule. Federal Register. Vol. 56, No. 126. p. 30266, July 1, 1991.

USEPA. 2008. TRI Explorer: Trends – Pentachlorophenol. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for pentachlorophenol.] Accessed March 5, 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.

37 Picloram

This chapter on picloram 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 picloram 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).

37.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for picloram 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 500 µg/L. The Agency based the MCLG on a reference dose (RfD) of 70 µg/kg-day (0.07 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

Picloram ($C_6H_3Cl_3N_2O_2$) is a colorless crystalline organic solid. It is moderately to highly persistent in the soil environment (EXTOXNET, 1996). Furthermore, picloram is extremely soluble in water and, therefore, is highly mobile. It will leach easily and, given the slow rate at which it breaks down, will remain in water for an extended period. It generally does not pose a threat to humans at the levels detected, but there are concerns about its effects on non-target plants (USEPA, 1995).

37.2 Use, Production, and Releases

Picloram is a systemic herbicide used for control of woody plants and a wide range of broad-leaved weeds. Most grasses are resistant to picloram, so it is used in range management programs (EXTOXNET, 1996). It is applied in the greatest amounts to pasture and rangeland, followed by forestry (USEPA, 1995).

The Toxic Substances Control Act (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 37-1 presents the production of picloram in the United States from 1986 to 2002. Note that the production of picloram in the United States has remained constant since 1986.

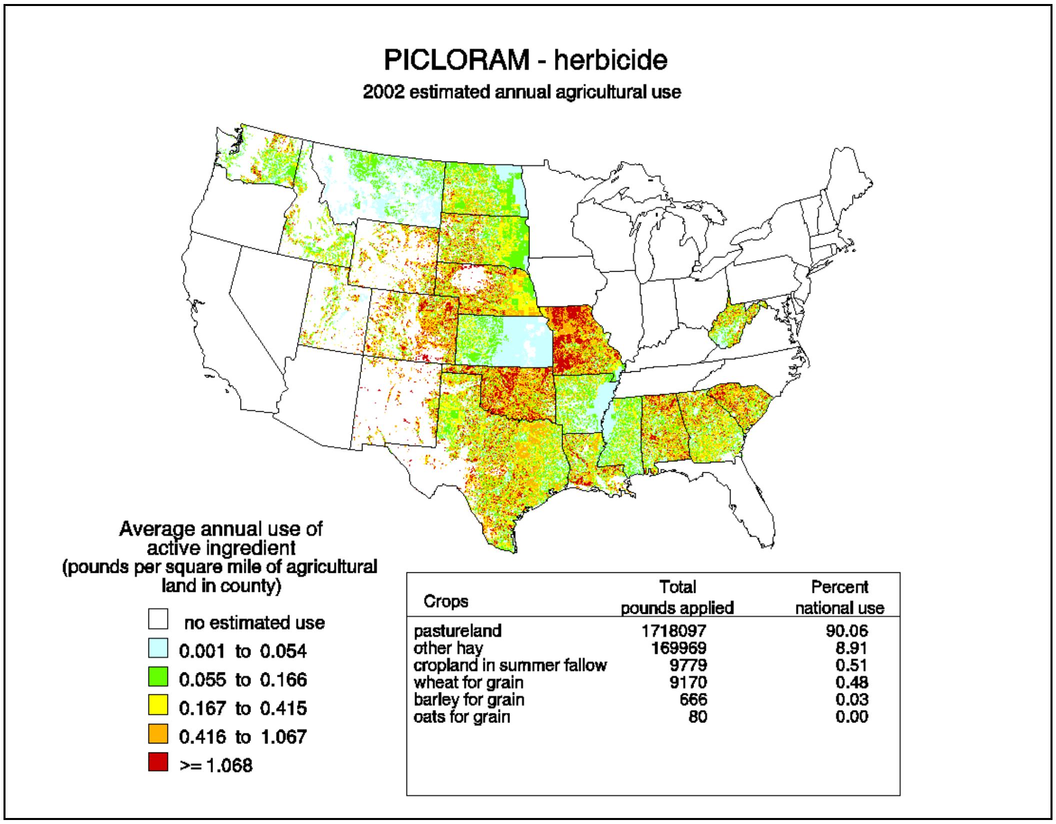
Exhibit 37-1: Production of Picloram in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 million – 10 million 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, 2003

Exhibit 37-2, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual picloram 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 1.9 million pounds of picloram active ingredient were used on average each year between 1999 and 2004.

Exhibit 37-2: Estimated Annual Agricultural Use for Picloram (c. 2002)



Crops	Total pounds applied	Percent national use
pastureland	1718097	90.06
other hay	169969	8.91
cropland in summer fallow	9779	0.51
wheat for grain	9170	0.48
barley for grain	666	0.03
oats for grain	80	0.00

Source: USGS, 2007

Picloram is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of picloram for the period 1998-2006 ranged from about 52,000 pounds to about 380,000 pounds, with a general decrease over time. Only on-site releases were reported (USEPA, 2008).

37.3 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 picloram in ambient water are available from the NAWQA program.

37.3.1 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 picloram between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for picloram was 0.040 µg/L.

In NAWQA stream samples (Exhibit 37-3), picloram was only detected in mixed land use settings (at a frequency of 0.08%). The highest concentration at a mixed land use setting was 0.010 µg/L.

Exhibit 37-3: USGS National Synthesis Summary of NAWQA Monitoring of Picloram 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)	0.00%	ND[1]	ND[1]	ND[1]
Mixed	800 (36)	0.08%	ND[1]	ND[1]	0.010
Undeveloped	101 (5)	0.00%	ND[1]	ND[1]	ND[1]
Urban	520 (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 37-4), picloram was found at frequencies ranging from 0% of samples in undeveloped areas to 0.13% in mixed land use settings, 0.17% in agricultural settings, and 0.61% in urban areas. The 95th percentile concentrations were less than the method detection limit in all settings. The highest concentration, 3.91 µg/L, was found in an urban area.

Exhibit 37-4: USGS National Synthesis Summary of NAWQA Monitoring of Picloram 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	1,168	0.17%	ND[1]	ND[1]	2.2
Mixed	1,545	0.13%	ND[1]	ND[1]	0.17
Undeveloped	22	0%	ND[1]	ND[1]	ND[1]
Urban	659	0.61%	ND[1]	ND[1]	3.91

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)

37.3.2 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for picloram. 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 37-5. Overall, picloram was detected in 0.2% of samples and at 0.4% of sites. Picloram detection rates were similarly low at both surface water and ground water sites. The median concentration based on detections from all sites was 0.17 µg/L. The 99th percentile concentration based on detections from all sites was 3.91 µg/L.

Exhibit 37-5: EPA Summary Analysis of Picloram 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	3,966	0.3%	3,607	0.3%	0.05	0.255	3.91	3.91	3.91
surface water	5,519	0.1%	891	0.8%	0.004	0.1	2.7	2.7	2.7
all sites	9,485	0.2%	4,498	0.4%	0.004	0.17	3.305	3.91	3.91

1. RLs (Reporting Limits) for picloram varied, but did not exceed 0.02 µg/L. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible.

37.4 Occurrence in Drinking Water

Picloram 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 picloram 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 picloram. (There were no picloram data from Hawaii or Oklahoma.) These data consist of 121,920 analytical results from 32,910 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.

37.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 37-6 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For picloram, 0.413% of 32,910 systems reported detections. Exhibit 37-7 lists the minimum, median, 90th percentile, and maximum picloram concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of picloram, based on detections from all systems, is 0.24 µg/L.

Exhibit 37-6: Picloram Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	99,734	29,914	66,798,378

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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.

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Surface Water	22,186	2,996	119,588,052
Combined Ground & Surface Water	121,920	32,910	186,386,430
Percent with Detections			
Ground Water	0.159%	0.351%	4.486%
Surface Water	0.180%	1.035%	4.624%
Combined Ground & Surface Water	0.163%	0.413%	4.575%

Exhibit 37-7: Picloram Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.25	2.48	190
Surface Water	0.01	0.2	3.235	100
Combined Ground & Surface Water	0.01	0.24	3	190

Exhibit 37-8 illustrates the geographic distribution of picloram occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) 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 did not submit data for picloram.

Detection rates were generally low for picloram; only seven states reported detections in more than 1% of their systems. In five states, between 0.5% and 1% of systems reported detections. Fourteen states reported no detections. Furthermore, no states reported detections greater than the MCL concentration of 500 µg/L.

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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 37-8: Percentage of Systems with at Least One Picloram Detection, by State

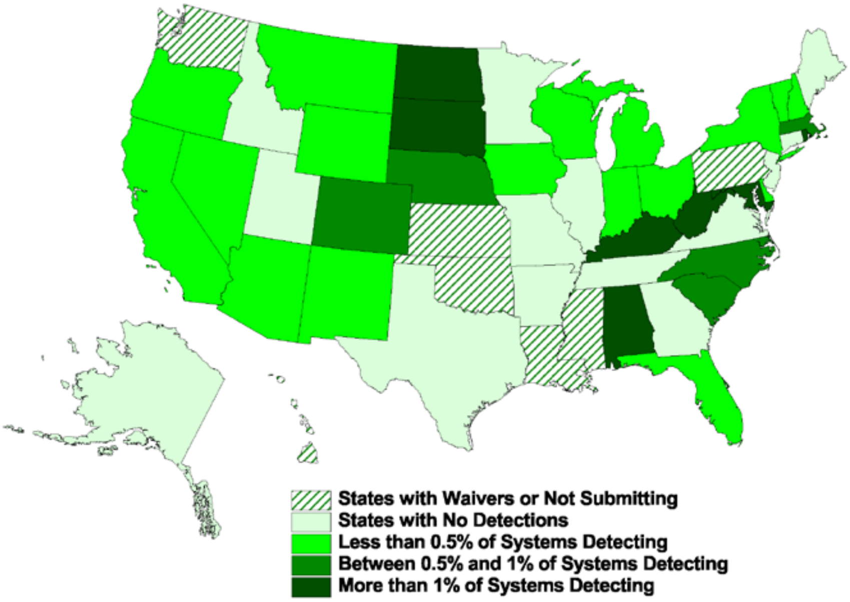

Exhibit 37-9 presents the Stage 1 analysis of picloram occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 250 µg/L and 500 µg/L. No systems reported detections greater than or equal to either threshold.

Exhibit 37-9: Picloram 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	> 500 µg/L	0	0.000%	0	0.000%
	≥ 250 µg/L	0	0.000%	0	0.000%
Surface Water	> 500 µg/L	0	0.000%	0	0.000%
	≥ 250 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 500 µg/L	0	0.000%	0	0.000%
	≥ 250 µg/L	0	0.000%	0	0.000%

37.5 References

Extension Toxicology Network (EXTOXNET). 1996. EXTOXNET Pesticide Information Profiles–Picloram. Last modified June 1996. Available on the Internet at: http://extoxnet.orst.edu/pips/picloram.htm. Accessed July 3, 2008.

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/.

Thelin, G.P. and L.P. Gianessi. 2000. *Method for Estimating Pesticide Use for County Areas of the Conterminous United States.* U.S. Geological Survey Open-File Report 00-250, 62 p. Available on the Internet at: http://ca.water.usgs.gov/pnsp/rep/ofr00250/ofr00250.pdf.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 1995. *R.E.D. FACTS: Picloram.* August 1995. Available on the Internet at: http://www.epa.gov/oppsrrd1/REDs/factsheets/0096fact.pdf.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Picloram. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for picloram.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – Picloram. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for picloram.] Accessed March 7, 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.

United States Geological Survey (USGS). 2007. 2002 Pesticide Use Maps. Available on the Internet at: http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1051. Accessed March 6, 2008.

38 Polychlorinated Biphenyls (PCBs)

This chapter on polychlorinated biphenyls (PCBs) 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 PCBs 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).

38.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for PCBs 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 0.5 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2001), there are no known natural sources of PCBs. PCBs are mixtures of up to 209 individual chlorinated compounds. (The chemical formula for all PCBs is $C_{12}H_{10-x}Cl_x$.) PCBs are either oily liquids or solids that are colorless to light yellow and have no known smell or taste. Some PCBs can exist as a vapor in air. PCBs are very persistent and stable; they do not readily biodegrade. They tend to remain with soil and do not leach significantly. If applied to water, PCBs tend to become associated with particles in the water and become part of the sediments. They accumulate significantly in aquatic organisms. Many commercial PCB mixtures are known in the United States by the trade name Aroclor (ATSDR, 2001).

38.2 Use, Production, and Releases

PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they are good insulators and do not burn easily. The manufacture of PCBs was stopped in the United States in 1977 because of evidence that they build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures, electrical devices containing PCB capacitors, and old microscope and hydraulic oils (ATSDR, 2001).

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 PCBs.

PCBs are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of PCBs for the period 1998-2006 ranged from approximately 1.2 million pounds to approximately 22 million pounds, with maximum releases occurring in 2003. On-site releases were greater than off-site releases (USEPA, 2008).

38.3 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 PCBs in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

38.4 Occurrence in Drinking Water

PCBs 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 the occurrence of PCBs 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-four of the Six-Year Review-ICR states provided occurrence data for PCBs. These data consist of almost 67,216 analytical results from approximately 18,393 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by

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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.

state, although the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness.

38.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 38-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For PCBs, 0.158% of 18,393 systems reported detections. Exhibit 38-2 lists the minimum, median, 90th percentile, and maximum PCB concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of PCBs, based on detections from all systems, is 0.1 µg/L.

Exhibit 38-1: PCBs Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	53,365	16,249	45,009,798
Surface Water	13,851	2,144	79,104,410
Combined Ground & Surface Water	67,216	18,393	124,114,208
Percent with Detections			
Ground Water	0.071%	0.135%	6.179%
Surface Water	0.087%	0.326%	1.135%
Combined Ground & Surface Water	0.074%	0.158%	2.964%

Exhibit 38-2: PCBs Summary Statistics

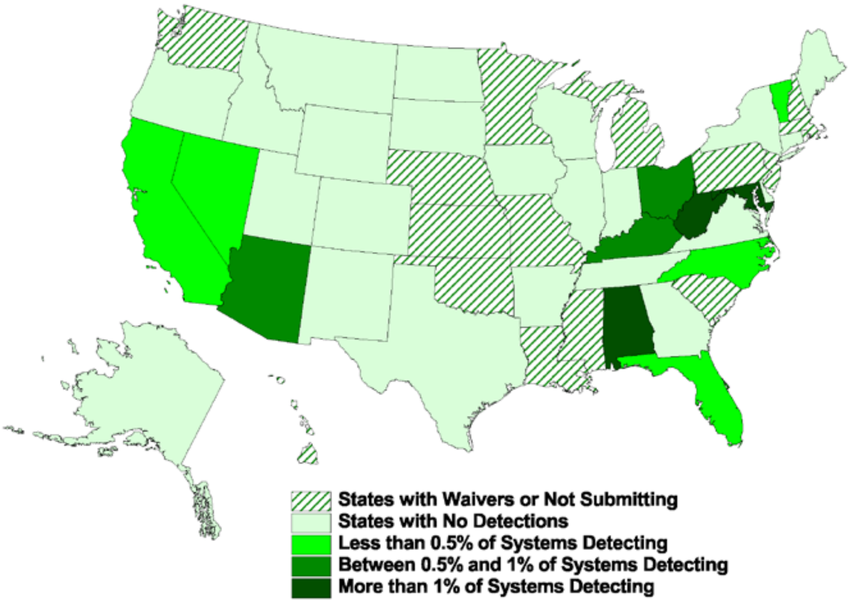
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.1	0.1	0.6	1.44
Surface Water	0.05	0.17	0.5	0.5

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Combined Ground & Surface Water	0.05	0.1	0.54	1.44

The following maps illustrate the geographic distribution of PCB occurrence in drinking water. Exhibit 38-3 shows the states with systems with at least one detection and Exhibit 38-4 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). The following states did submit Six-Year data for most contaminants, but did not submit data for PCBs: Hawaii, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, Oklahoma, Rhode Island, and South Carolina.

The distribution of systems with detections of PCBs is geographically dispersed, and detection rates were generally low. Three states reported detections in more than 1% of their systems. Three states reported detections in 0.5% to 1% of systems. Twenty-three states reported no detections. Two states reported detections greater than the MCL concentration of 0.5 µg/L.

Exhibit 38-3: Percentage of Systems with at Least One PCB Detection, by State



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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 38-4: Percentage of Systems with at Least One PCB Detection Greater than the MCL Concentration (> 0.5 µg/L), by State

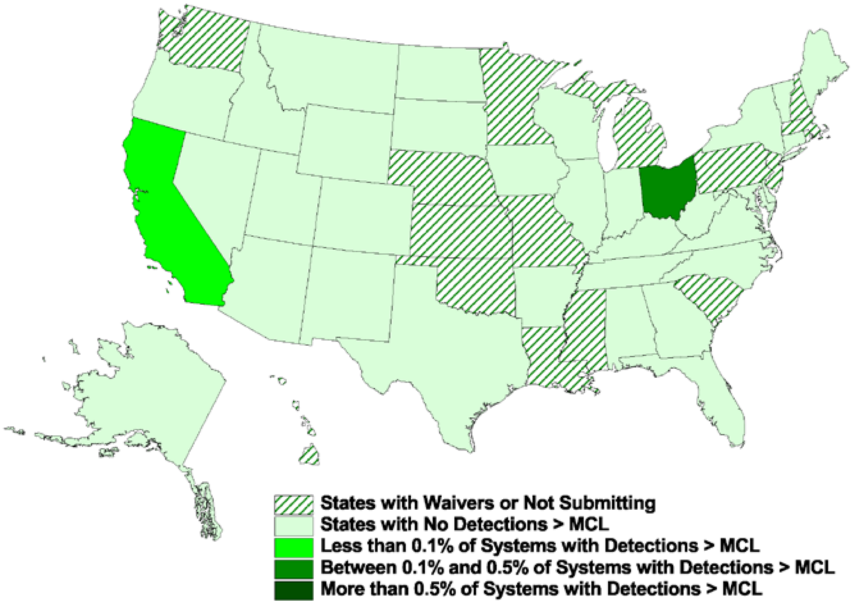

Exhibit 38-5 presents the Stage 1 analysis of PCB occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.25 µg/L and 0.5 µg/L. Seven (0.038% of) systems, serving more than 721,000 persons, reported at least one detection greater than or equal to 0.25 µg/L; and 2 (0.011% of) systems, serving about 125,000 persons, reported at least one detection greater than 0.5 µg/L.

Exhibit 38-5: PCBs 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	> 0.5 µg/L	2	0.012%	125,046	0.278%
	≥ 0.25 µg/L	4	0.025%	128,040	0.284%
Surface Water	> 0.5 µg/L	0	0.000%	0	0.000%
	≥ 0.25 µg/L	3	0.140%	593,206	0.750%

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	> 0.5 µg/L	2	0.011%	125,046	0.101%
	≥ 0.25 µg/L	7	0.038%	721,246	0.581%

38.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2001. *ToxFAQs for Polychlorinated Biphenyls (PCBs).* February 2001. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts17.html.

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/.

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. 2008. TRI Explorer: Trends – Polychlorinated Biphenyls. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for polychlorinated biphenyls.] Accessed March 8, 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.

39 Combined Radium-226 and Radium-228

This chapter on radium (as combined radium-226 and -228) 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 combined radium 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).

39.1 Background

The United States Environmental Protection Agency (EPA) published an interim Drinking Water Regulation for combined radium-226 and radium-228 on July 9, 1976 (41 FR 28402 (USEPA, 1976)). The Maximum Contaminant Level (MCL) established on that date was 5 pCi/L. In 2000, EPA published the final National Primary Drinking Water Regulations (NPDWRs) for radionuclides. The MCL for combined radium remained the same; however, monitoring requirements changed. In the original 1976 rule, radium-228 was only measured if radium-226 was found at levels greater than 3 pCi/L. The revised Radionuclides rule in 2000 requires four consecutive quarterly samples for radium-228 and radium-226 unless samples have been grandfathered. Furthermore, the 2000 rule set a Maximum Contaminant Level Goal (MCLG) of zero for combined radium (USEPA, 2000). Under the revised rule, gross alpha results may be substituted for radium-226 samples only if gross alpha samples are equal to or less than 5 pCi/L. Radium-228 must still be monitored, and gross alpha samples may not be used to substitute for radium-228. However, EPA is recommending that systems substitute gross alpha for radium-226 only if previous gross alpha results are less than the gross alpha detection limit of 3 pCi/L, to avoid exceeding the combined radium MCL of 5 pCi/L.

According to USEPA (2007), radium forms when isotopes of uranium or thorium decay in the environment. In the natural environment, radium occurs at very low levels in virtually all rock, soil, water, plants, and animals. When uranium (or thorium) occurs in high levels in rock, radium is often also found at high levels (USEPA, 2007).

Radium is a naturally radioactive, silvery-white metal when freshly cut. It blackens on exposure to air. Purified radium and some radium compounds glow in the dark (luminesce). The radiation emitted by radium can also cause certain materials to emit light. Metallic radium is highly chemically reactive. It forms compounds that are very similar to barium compounds, making separation of the two elements difficult (USEPA, 2007).

Radium-226, the most common isotope, originates from the decay of the plentiful uranium-238. It is an alpha emitter, with accompanying gamma radiation, and has a half-life of about 1,600 years. Radium-228, found in the thorium-232 decay series, is principally a beta emitter and has a half-life of 5.76 years. Radium decays to form isotopes of the radioactive gas radon, which is not chemically reactive. Stable lead is the final product of this lengthy radioactive decay series (USEPA, 2007).

39.2 Use, Production, and Releases

When radium was first discovered in the early 1900's, no one understood its danger. People were fascinated with the mysterious properties of radium, especially the luminescence produced when it is mixed with a phosphor. Industries sprang up to manufacture hundreds of consumer products containing radium. Advertisements proclaimed its special powers and unique effects in such products such as hair tonic, toothpaste, ointments, and elixirs. Mixtures of radium salts and appropriate phosphors were widely used for clock dials and gauges before the risks of radium exposure were understood (USEPA, 2007).

Most of its original uses have been halted for health and safety reasons. However, its wide use in luminescent paints continued through World War II, because the soft glow of radium's luminescence made aircraft dials, gauges and other instruments visible to their operators at night. Radium was also an early radiation source for cancer treatment. Small seeds were implanted in tumors to kill cancerous cells. Safer, more effective radiation sources, such as cobalt-60 have mostly replaced it (USEPA, 2007).

Radium is a radiation source in some industrial radiography devices, a technology similar to x-ray imaging used in industry to inspect for flaws in metal parts. When radium is mixed with beryllium it becomes a good source of neutrons, useful in well logging devices and research. Radium also has been added to the tips of lightning rods, improving their effectiveness by ionizing the air around it (USEPA, 2007).

As radium is naturally occurring, data for production and release are not available.

39.3 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. Combined radium in ambient surface water and ground water are not available from the NAWQA Program. However, separate radium-226 and radium-228 data are available.

39.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for radium-226 and radium-228 separately. 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 for radium-226 are presented in Exhibit 39-1. Overall, radium-226 was detected in 94.2% of samples and at 96.6% of sites. Radium-226 was detected more frequently in ground water samples than in surface water samples, but it was detected in all surface water sites. The median radium-226 concentration based on detections from all sites was 0.16 pCi/L. The 99th percentile concentration based on detections from all sites was 0.915 pCi/L.

Exhibit 39-1: EPA Summary Analysis of Radium-226 Data from NAWQA Study Units, 1992-2001

	Detection Frequency (detections are results ≥ RL[1])				**Concentration Values (of detections, in pCi/L)**				
	Number of Samples	% Samples with Detections	Number of Sites	% Sites with Detections	Minimum	Median	95th Percen-tile	99th Percen-tile	Maximum
ground water	98	95.9%	98	95.9%	0.0202	0.286	0.804	1.11	1.11
surface water	74	91.9%	20	100.0%	0.02	0.055	0.22	0.35	0.35
all sites	172	94.2%	118	96.6%	0.02	0.16	0.727	0.915	1.11

1. RLs (Reporting Limits) for radium-226 varied, but did not exceed 0.02 pCi/L.

The results of the EPA analysis for radium-228 are presented in Exhibit 39-2. Radium-228 was only sampled in ground water sites. It was detected in 82.6% of ground water samples and at 82.9% of ground water sites. Radium-228 was not sampled in any surface water sites. The median radium-228 concentration based on detections from ground water sites was 0.578 pCi/L. The 99th percentile concentration based on detections from ground water sites was 2.53 pCi/L.

Exhibit 39-2: EPA Summary Analysis of Radium-228 Data from NAWQA Study Units, 1992-2001

	Detection Frequency (detections are results ≥ RL[1])				**Concentration Values (of detections, in pCi/L)**				
	Number of Samples	% Samples with Detections	Number of Sites	% Sites with Detections	Minimum	Median	95th Percen-tile	99th Percen-tile	Maximum
ground water	459	82.6%	457	82.9%	0.0244	0.578	1.36	2.53	5.89
surface water	0		0						
all sites	459	82.6%	457	82.9%	0.0244	0.578	1.36	2.53	5.89

1. RLs (Reporting Limits) for radium-228 varied, but did not exceed 0.025 pCi/L.

39.4 Occurrence in Drinking Water

Under the original Radionuclides rule (prior to December 8, 2003), all community water systems (CWSs) must initially collect four consecutive quarterly samples for gross alpha measurement. The gross alpha sample may be substituted for the required combined radium analysis provided that the measured gross alpha particle activity does not exceed 5 pCi/L. If any gross alpha result is greater than 5 pCi/L, the system must analyze the same or an equivalent sample for radium-226. If radium-226 is greater than 3 pCi/L, the system must analyze for radium-228.

Under the revised Radionuclides rule (after December 8, 2003), all CWSs must collect four consecutive quarterly samples at all sampling points between December 8, 2003 and December 31, 2007 unless data have been grandfathered. If the average of combined radium is less than the detection limit, the system may reduce sampling to once every nine years. (However, systems that only submit gross alpha particle activity analytical results and do not sample for radium-226 individually may not be allowed to move to a reduced monitoring frequency of one sample every nine years. The detection limit for gross alpha (3 pCi/L) does not allow systems to confirm that radium-226 is below its respective detection limit as measured individually (1 pCi/L)). If the average is equal to or greater than the detection limit but equal to or less than ½ the MCL, the system may reduce sampling to once every six years. If the average is greater than ½ the MCL (but is equal to or less than the MCL), the system may reduce sampling to once every three years. If the average is greater than the MCL, the system must take one sample each quarter until the annual average is below the MCL. Quarterly monitoring is also triggered by one result that is more than four times the MCL or high enough to cause the running annual average to exceed the MCL.

Gross alpha particle activity analytical results can still be substituted for radium-226, if the gross alpha particle activity result is less than the detection limit of 3 pCi/L. In these instances, one-half the detection limit (i.e., 1.5 pCi/L) is used for radium-226 and is added to the radium-228 activity.

The analysis of combined radium 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.

Combined radium data were provided by 35 of the Six-Year Review-ICR states for the original Radionuclides Rule (the period prior to December 8, 2003). (No data were received from Arkansas, Delaware, Florida, Hawaii, Massachusetts, Michigan, Minnesota, New Hampshire, Oklahoma, or Tennessee.) The combined radium data from the 35 states consist of 18,452 analytical results from 6,884 public water systems (PWSs) during the period from 1998 to December 8, 2003.

Combined radium data were provided by 33 of the Six-Year Review-ICR states for the revised Radionuclides Rule (the period after December 8, 2003). (No data were received from Arkansas, Florida, Georgia, Hawaii, Indiana, Massachusetts, Michigan, Minnesota, New Hampshire, Oklahoma, Tennessee, or Texas.) The combined radium data from the 33 states consist of 18,050 analytical results from 3,893 PWSs during the period from December 9, 2003 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.

39.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 39-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections, for combined radium data collected under the original Radionuclides rule (before December 8, 2003). Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For combined radium (original rule), 62.188% of 6,884 systems reported detections. Exhibit 39-4 lists the minimum, median, 90th percentile, and maximum combined radium (original rule) concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of combined radium (original rule), based on detections from all systems, is 1.9 pCi/L.

Exhibit 39-3: Summary of Combined Radium Occurrence Data from the Six-Year Review-ICR Dataset (data collected for original radionuclides rule)

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	15,920	6,190	15,006,355
Surface Water	2,532	694	32,416,085
Combined Ground & Surface Water	18,452	6,884	47,422,440
Percent with Detections			
Ground Water	67.079%	63.231%	79.462%
Surface Water	40.600%	52.882%	68.248%
Combined Ground & Surface Water	63.446%	62.188%	71.796%

Exhibit 39-4: Combined Radium Summary Statistics (data collected for original radionuclides rule)

Source Water Type	Detection Value (pCi/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	2.1	9.3	47
Surface Water	0.02	0.785	2.4	142
Combined Ground & Surface Water	0.01	1.9	9	142

Exhibit 39-5 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by systems with detections, for combined radium data collected under the revised Radionuclides rule (after December 8, 2003). For combined radium (revised rule), 69.972% of 3,893 systems reported detections. Exhibit 39-6 lists the minimum, median, 90th percentile, and maximum combined radium (revised rule) concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of combined radium (revised rule), based on detections from all systems, is 2 pCi/L.

Exhibit 39-5: Summary of Combined Radium Occurrence Data from the Six-Year Review-ICR Dataset (data collected for revised radionuclides rule)

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	15,895	3,472	11,709,681
Surface Water	2,155	421	29,716,756
Combined Ground & Surface Water	18,050	3,893	41,426,437
Percent with Detections			
Ground Water	67.732%	71.083%	68.876%
Surface Water	43.016%	60.808%	51.978%
Combined Ground & Surface Water	64.781%	69.972%	56.754%

Exhibit 39-6: Combined Radium Summary Statistics (data collected for revised radionuclides rule)

Source Water Type	**Detection Value (pCi/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.0008	2.3	8.1	56.66
Surface Water	0.01	1	3	27.789
Combined Ground & Surface Water	0.0008	2	7.8	56.66

The following maps illustrate the geographic distribution of combined radium occurrence in drinking water. Exhibits 39-7 and 39-8 show the states with systems with at least one detection for the original and revised radionuclide rules, respectively. Exhibits 39-9 and 39-10 show the states with systems with at least one detection greater than the MCL concentration for the original and revised radionuclide rules, respectively. Note that five states did not submit any data for use in the Six-Year Review (Kansas[1], Louisiana, Mississippi, Pennsylvania, and Washington).

The distribution of systems with detections of combined radium is geographically dispersed. Based on the data collected for the original radionuclides rule, 13 states had more than 90% of systems reporting detections. Based on the data collected for the revised radionuclides rule, 11 states had more than 90% of systems reporting detections. In 14 states, more than 10% of systems reported at least one detection greater than the MCL concentration of 5 pCi/L (based on the data collected for the original radionuclides rule. In 11 states, more than 10% of systems reported at least one detection greater than the MCL concentration of 5 pCi/L (based on the data collected for the revised radionuclides rule.

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

Exhibit 39-7: Percentage of Systems with at Least One Combined Radium Detection, by State (data collected for original radionuclides rule)

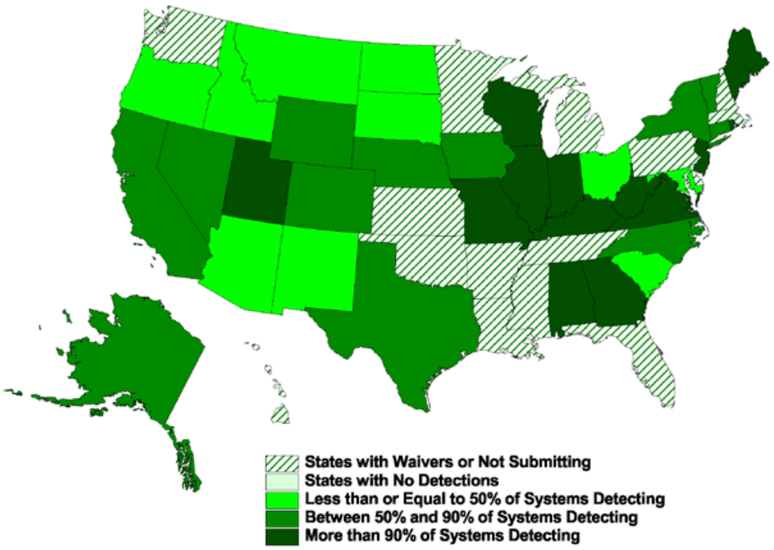

Exhibit 39-8: Percentage of Systems with at Least One Combined Radium Detection, by State (data collected for revised radionuclides rule)

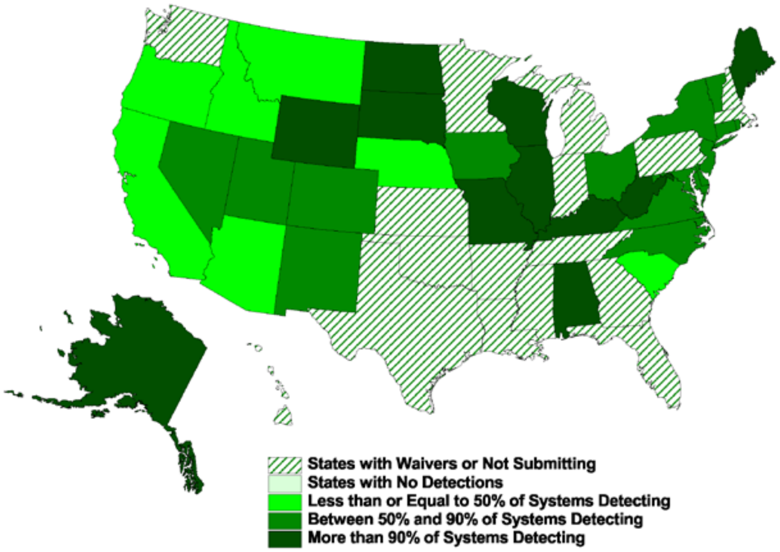

Exhibit 39-9: Percentage of Systems with at Least One Combined Radium Detection Greater than the MCL Concentration (> 5 pCi/L), by State (data collected for original radionuclides rule)

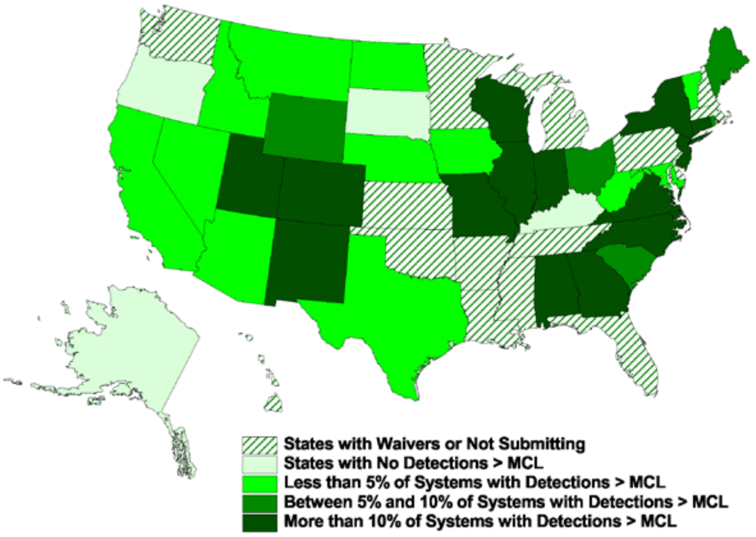

Exhibit 39-10: Percentage of Systems with at Least One Combined Radium Detection Greater than the MCL Concentration (> 5 pCi/L), by State (data collected for revised radionuclides rule)

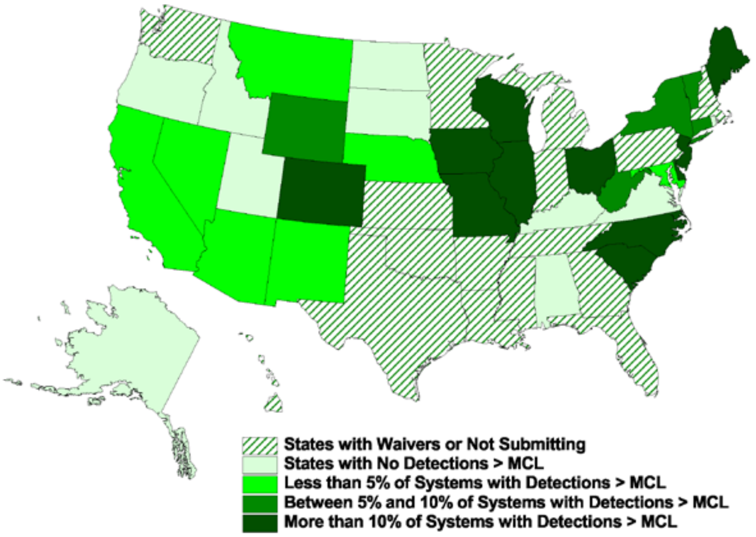

Exhibit 39-11 presents the Stage 1 analysis for the original Radionuclides Rule. These exhibits summarize combined radium occurrence in drinking water from systems and populations served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 2.5 pCi/L and 5 pCi/L. For systems sampling under the original Radionuclides Rule, a total of 1,222 (17.751% of) PWSs, serving almost 9.2 million persons, reported at least one detection greater than or equal to 2.5 pCi/L; and 502 (7.292% of) PWSs, serving almost 4.6 million persons, reported at least one detection greater than 5 pCi/L

Exhibit 39-11: Combined Radium Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance (data collected under the original radionuclides rule)

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 pCi/L	488	7.884%	2,143,386	14.283%
	≥ 2.5 pCi/L	1,185	19.144%	4,652,946	31.007%
Surface Water	> 5 pCi/L	14	2.017%	2,418,615	7.461%
	≥ 2.5 pCi/L	37	5.331%	4,510,400	13.914%
Combined Ground & Surface Water	> 5 pCi/L	502	7.292%	4,562,001	9.620%
	≥ 2.5 pCi/L	1,222	17.751%	9,163,346	19.323%

Exhibit 39-12 presents the Stage 1 analysis for the systems sampling under the revised Radionuclides Rule. For systems sampling under the revised Radionuclides Rule, a total of 1,055 (27.100% of) PWSs, serving almost 7.4 million persons, reported at least one detection greater than or equal to 2.5 pCi/L; and 446 (11.456% of) PWSs, serving more than 3.8 million persons, reported at least one detection greater than 5 pCi/L.

Exhibit 39-12: Combined Radium Stage 1 Analysis – Systems and Population with at Least One Threshold Exceedance (data collected under the revised radionuclides rule)

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 pCi/L	432	12.442%	2,438,570	20.825%
	≥ 2.5 pCi/L	1,008	29.032%	4,280,726	36.557%

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 pCi/L	14	3.325%	1,372,884	4.620%
	≥ 2.5 pCi/L	47	11.164%	3,100,164	10.432%
Combined Ground & Surface Water	> 5 pCi/L	446	11.456%	3,811,454	9.201%
	≥ 2.5 pCi/L	1,055	27.100%	7,380,890	17.817%

39.5 References

United States Environmental Protection Agency (USEPA). 1976. Title 40—Protection of Environment. Chapter 1--Environmental Protection Agency. Part 141—Interim Primary Drinking Water Regulations. Promulgation of Regulations on Radionuclides. Federal Register, Vol. 41, No. 133, p. 28402, July 9, 1976.

USEPA. 2000. National Primary Drinking Water Regulations; Radionuclides; Final Rule. Federal Register. Vol. 65, No. 236. p. 76707, December 7, 2000. http://www.epa.gov/fedrgstr/EPA-WATER/2000/December/Day-07/w30421.htm

USEPA. 2007. Radiation Protection: *Radium*. Last modified November 13, 2007. Available on the Internet at: http://www.epa.gov/radiation/radionuclides/radium.html. Accessed March 18, 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.

40 Selenium

This chapter on selenium 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 selenium 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).

40.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for selenium on January 30, 1991 (56 FR 3526 (USEPA, 1991a)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 0.05 mg/L. EPA based the MCLG on a maximum safe intake[1] of 0.4 mg/person/day and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2003), selenium is a naturally occurring element that is distributed widely in nature in most rocks and soils. In its pure form, selenium exists as metallic gray to black hexagonal crystals, but in nature it is usually combined with sulfide or with silver, copper, lead, and nickel minerals. In the environment, the oxidized form, which occurs in alkaline soils, is more toxic. Plants can take it up, and it may accumulate up the food chain (ATSDR, 2003).

40.2 Use, Production, and Releases

Most processed selenium is used in the electronics industry. Selenium is also used: as a nutritional supplement; in the glass industry; as a component of pigments in plastics, paints, enamels, inks, and rubber; in the preparation of pharmaceuticals; as a nutritional feed additive for poultry and livestock; in pesticide formulations; in rubber production; as an ingredient in antidandruff shampoos; and as a constituent of fungicides. Radioactive selenium is used in diagnostic medicine (ATSDR, 2003).

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[1] The 0.4 mg/day safe level was based on data (Yang *et al.*, 1989a and 1989b) that extrapolated from blood selenium levels to estimated dietary intake in the studied population. As described in USEPA (1991a), EPA partially considered selenium's status as a nutrient and did not use the typical procedure for deriving the MCLG. Hence, there is no specific reference to an RfD for selenium in the 1991 FR notice. After the publication of the regulation, IRIS (USEPA, 1991b) posted an RfD of 0.005 mg/kg-day for selenium using the same data that are the basis of the regulation.

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 selenium.

Selenium and selenium compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of selenium for the period 1998-2006 ranged from approximately 267,000 pounds to approximately 4.4 million pounds, with maximum releases in 2001 and 2006. On-site releases were greater than off-site releases (USEPA, 2008a). Total selenium compound releases ranged from approximately 2.5 million pounds to approximately 8.5 million pounds, with a general decrease over time. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

40.3 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 selenium in ambient water are available from the NAWQA program.

40.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for selenium. 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 40-1. Overall, selenium was detected in 27.0% of samples and at 26.7% of sites. The median concentration based on detections from all sites was 2 µg/L (0.002 mg/L). The 99th percentile concentration based on detections from all sites was about 48 µg/L (0.048 mg/L).

Exhibit 40-1: EPA Summary Analysis of Selenium 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	3,464	25.8%	3,065	27.2%	0.17	2	14.11	37.97	92.461
surface water	3,269	28.2%	462	23.4%	0.201	2.155	17	78	150

	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
all sites	6,733	27.0%	3,527	26.7%	0.17	2	16.28	47.564	150

1. RLs (Reporting Limits) for selenium varied, but did not exceed 0.2 µg/L.

40.4 Occurrence in Drinking Water

Selenium is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[2] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[3] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of selenium 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 selenium. These data consist of 181,684 analytical results from 48,925 systems 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.

40.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 40-2 presents the number of samples and systems, as well as the population-served by the systems,

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[2] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[3] 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.

and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For selenium, 17.284% of 48,925 systems reported detections. Exhibit 40-3 lists the minimum, median, 90th percentile, and maximum selenium concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of selenium, based on detections from all systems, is 0.003 mg/L.

Exhibit 40-2: Selenium Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	141,387	44,924	85,462,006
Surface Water	40,297	4,001	144,401,405
Combined Ground & Surface Water	181,684	48,925	229,863,411
Percent with Detections			
Ground Water	12.790%	16.715%	34.217%
Surface Water	10.016%	23.669%	38.724%
Combined Ground & Surface Water	12.175%	17.284%	37.048%

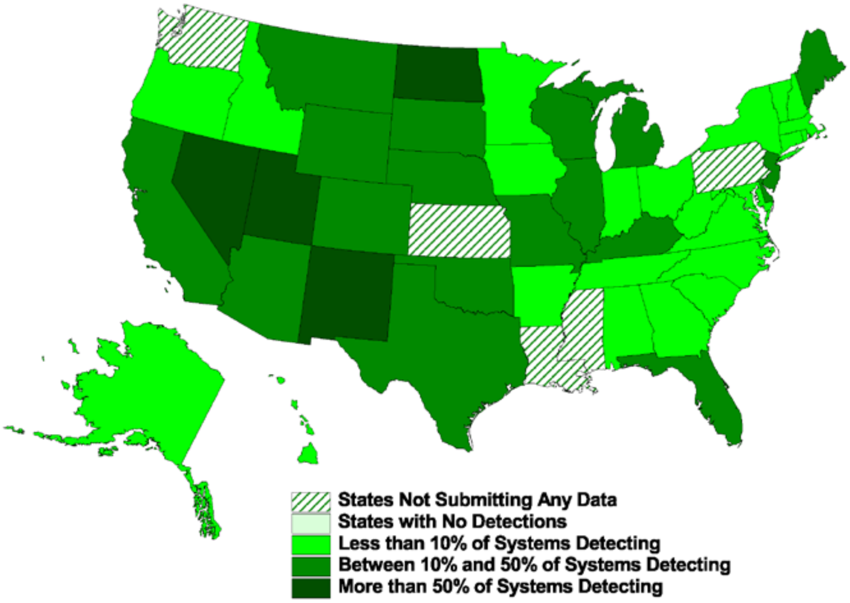
Exhibit 40-3: Selenium Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.000076	0.003	0.01	0.49
Surface Water	0.00006	0.003	0.0087	0.2
Combined Ground & Surface Water	0.00006	0.003	0.01	0.49

The following maps illustrate the geographic distribution of selenium occurrence in drinking water. Exhibit 40-4 shows the states with systems with at least one detection and Exhibit 40-5 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[4], Louisiana, Mississippi, Pennsylvania, and Washington).

Detection rates were high for selenium. In four states, more than 50% of systems detected selenium. In 18 states, between 10% and 50% of systems reported detections. Twenty-eight states reported no detections of selenium greater than the MCL concentration. For five states, more than 0.5% of systems reported at least one detection greater than the MCL concentration of 0.05 mg/L.

Exhibit 40-4: Percentage of Systems with at Least One Selenium Detection, by State



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

Exhibit 40-5: Percentage of Systems with at Least One Selenium Detection Greater than the MCL Concentration (> 0.05 mg/L), by State

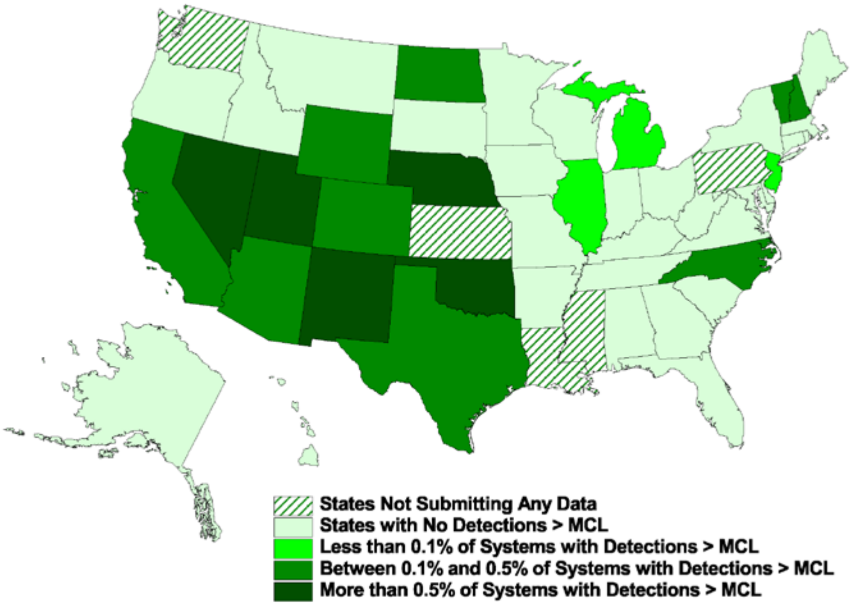


Exhibit 40-6 presents the Stage 1 analysis of selenium occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.025 mg/L and 0.05 mg/L. A total of 280 (0.572% of) systems, serving almost 4.8 million persons, reported at least one detection greater than or equal to 0.025 mg/L; and 65 (0.133% of) systems, serving almost 225,000 persons, reported at least one detection greater than 0.05 mg/L.

Exhibit 40-6: Selenium 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	> 0.05 mg/L	63	0.140%	123,164	0.144%
	≥ 0.025 mg/L	252	0.561%	750,440	0.878%
Surface Water	> 0.05 mg/L	2	0.050%	101,652	0.070%
	≥ 0.025 mg/L	28	0.700%	4,034,609	2.794%

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	> 0.05 mg/L	65	0.133%	224,816	0.098%
	≥ 0.025 mg/L	280	0.572%	4,785,049	2.082%

40.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2003. *ToxFAQs for Selenium.* September 2003. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts92.html.

United States Environmental Protection Agency (USEPA). 1991a. 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. 1991b. Integrated Risk Information System (IRIS) – Selenium. Oral RfD. Available on the Internet at: http://www.epa.gov/iris/subst/0472.htm

USEPA. 2008a. TRI Explorer: Trends – Selenium. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for selenium.] Accessed March 6, 2008.

USEPA. 2008b. TRI Explorer: Trends – Selenium Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for selenium compounds.] Accessed March 6, 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.

Yang, G., R. Zhou, S. Yin, et al. 1989a. Studies of safe maximal daily dietary selenium intake in a seleniferous area in China. I. Selenium intake and tissue levels of the inhabitants. *Journal of Trace Elements and Electrolytes in Health and Disease*. 3(2):77-87.

Yang, G., S. Yin, R. Zhou, et al. 1989b. Studies of safe maximal daily dietary Se-intake in a seleniferous area in China. II. Relation between Se- intake and the manifestation of clinical signs and certain biochemical alterations in blood and urine. *Journal of Trace Elements and Electrolytes in Health and Disease*. 3(2):123-130.

41 Simazine

This chapter on simazine 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 simazine 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).

41.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for simazine 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 4 µg/L. The Agency based the MCLG on a reference dose (RfD) of 5 µg/kg-day (0.005 mg/kg-day) and a cancer classification of C, possible human carcinogen.

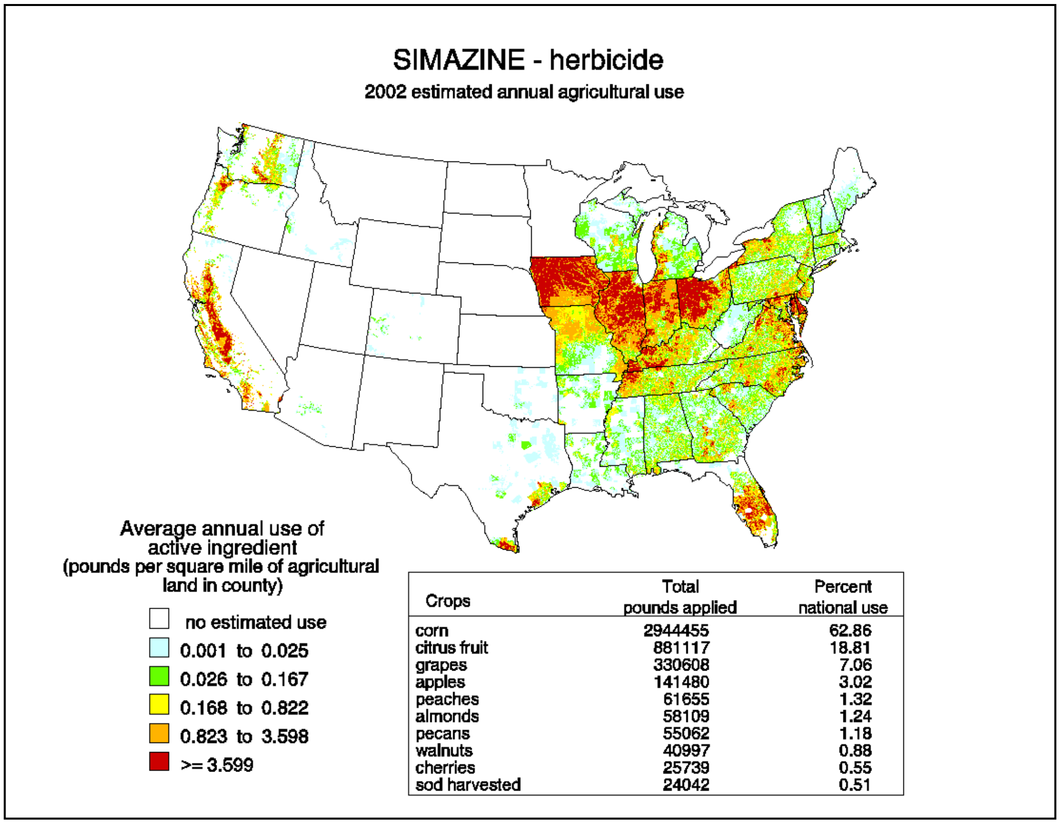
According to the Extension Toxicology Network (EXTOXNET, 1996), simazine ($C_7H_{12}ClN_5$), a selective triazine herbicide, is an organic white solid. It acts by inhibiting photosynthesis. The ability of simazine to bind to soil is highly dependent on soil type; it will bind more strongly to soils high in clay and organic matter. Persistence in soils is also highly variable, and there is a wide range of reported half lives. Persistence of simazine in water is similarly variable. Biodegradation is believed to be slow and depends on the level of algae or the degree of weed infestation (EXTOXNET, 1996).

41.2 Use, Production, and Releases

Simazine is a pre-emergence herbicide used for control of broad-leaved and grassy weeds in field, berry fruit, nuts, vegetable and ornamental crops, turfgrass, orchards, and vineyards. At higher rates, it is used for nonselective weed control in industrial areas. Before 1992, simazine was used to control submerged weeds and algae in large aquariums, farm ponds, fish hatcheries, swimming pools, ornamental ponds, and cooling towers (EXTOXNET, 1996).

Exhibit 41-1, compiled by the United States Geological Survey (USGS, 2007), shows the geographic distribution of estimated average annual simazine 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 4.7 million pounds of simazine active ingredient were used on average each year between 1999 and 2004.

Exhibit 41-1: Estimated Annual Agricultural Use for Simazine (c. 2002)



Crops	Total pounds applied	Percent national use
corn	2944455	62.86
citrus fruit	881117	18.81
grapes	330608	7.06
apples	141480	3.02
peaches	61655	1.32
almonds	58109	1.24
pecans	55062	1.18
walnuts	40997	0.88
cherries	25739	0.55
sod harvested	24042	0.51

Source: USGS, 2007

The Toxic Substances Control Act (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 41-2 presents the production of simazine in the United States from 1986 to 2002. Note that the production of simazine in the United States increased from 1986 to 1994 but has not been reported in the Chemical Update System thereafter.

Exhibit 41-2: Production of Simazine in the United States

Inventory Update Year	Production Volume
1986 Range	> 1 million – 10 million pounds

Inventory Update Year	Production Volume
1990 Range	> 1 million – 10 million pounds
1994 Range	> 10 million – 50 million pounds
1998 Range	No reports
2002 Range	No reports

Source: USEPA, 2003

Simazine is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of simazine for the period 1998-2006 ranged from about 2,700 pounds to about 37,000 pounds, with the maximum releases occurring in 2004 (USEPA, 2008).

41.3 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 simazine in ambient water are available from the NAWQA program.

41.3.1 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 simazine between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for simazine was 0.006 µg/L.

In NAWQA stream samples (Exhibit 41-3), simazine was found at frequencies ranging from 23.92% of samples in undeveloped areas to 58.16% in agricultural settings, 63.42% of samples in mixed land use settings, and 64.72% in urban areas. The 95th percentile concentration was 0.013 µg/L in undeveloped areas, 0.159 µg/L in mixed land use settings, 0.175 µg/L in agricultural settings, and 0.340 µg/L in urban areas. The highest concentration, 9.030 µg/L, was found at an urban site.

Exhibit 41-3: USGS National Synthesis Summary of NAWQA Monitoring of Simazine 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	2,009 (83)	58.16%	0.006	0.175	5.760
Mixed	1,385 (65)	63.42%	0.007	0.159	1.620
Undeveloped	144 (8)	23.92%	ND[1]	0.013	0.140
Urban	812 (30)	64.72%	0.008	0.340	9.030

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 41-4), simazine was found at frequencies ranging from 2.94% of samples in undeveloped areas to 5.75% in mixed land use settings, 18.22% of samples in urban areas, and 18.38% of samples in agricultural settings. The 95th percentile concentration was less than the maximum method detection limit in undeveloped settings, 0.0028 µg/L in mixed land use settings, 0.0273 µg/L in agricultural settings, and 0.034 µg/L in urban areas. The highest concentration, 1.38 µg/L, was found in an agricultural setting.

Exhibit 41-4: USGS National Synthesis Summary of NAWQA Monitoring of Simazine 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	18.38%	ND[1]	0.0273	1.38
Mixed	2,732	5.75%	ND[1]	0.0028	0.315
Undeveloped	34	2.94%	ND[1]	ND[1]	0.0031
Urban	856	18.22%	ND[1]	0.034	1.1

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)

41.3.2 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for simazine. 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 41-5. Overall, simazine was detected in 47.2% of samples and at 26.1% of sites. Simazine was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.0218 µg/L. The 99th percentile concentration based on detections from all sites was 2.67 µg/L.

Exhibit 41-5: EPA Summary Analysis of Simazine 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	6,107	13.9%	5,216	13.5%	0.0009	0.0112	0.194	0.605	1.38
surface water	15,637	60.3%	1,949	60.0%	0.0003	0.023	0.513	3.04	38.8
all sites	21,744	47.2%	7,165	26.1%	0.0003	0.0218	0.49	2.67	38.8

1. RLs (Reporting Limits) for simazine varied, but did not exceed 0.0009 µg/L. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible.

41.4 Occurrence in Drinking Water

Simazine 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

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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.

quarters are below the MCL. If all quarterly samples are below the MCL, the system may return to annual sampling.

The analysis of simazine 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 simazine. (There were no simazine data from Oklahoma.) These data consist of 158,256 analytical results from 36,830 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.

41.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 41-6 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For simazine, 0.725% of 36,830 systems reported detections. Exhibit 41-7 lists the minimum, median, 90th percentile, and maximum simazine concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of simazine, based on detections from all systems, is 0.27 µg/L.

Exhibit 41-6: Simazine Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	119,755	33,478	73,412,761
Surface Water	38,501	3,352	123,573,744
Combined Ground & Surface Water	158,256	36,830	196,986,505
Percent with Detections			
Ground Water	0.106%	0.221%	3.869%
Surface Water	2.639%	5.758%	14.665%
Combined Ground & Surface Water	0.722%	0.725%	10.641%

Exhibit 41-7: Simazine Summary Statistics

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Ground Water	0.01	0.3	2.46	6.2
Surface Water	0.01	0.26	1	12.4
Combined Ground & Surface Water	0.01	0.27	1.1	12.4

The following maps illustrate the geographic distribution of simazine occurrence in drinking water. Exhibit 41-8 shows the states with systems with at least one detection and Exhibit 41-9 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 simazine in Oklahoma so no simazine data were available from that state.

The distribution of systems with detections of simazine is geographically dispersed and detection rates were generally low. Nine states reported detections in more than 1% of their systems. In eight states, between 0.5% and 1% of systems reported detections. Fifteen states did not report detections. Eight states reported detections greater than the MCL concentration of 4 µg/L.

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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 41-8: Percentage of Systems with at Least One Simazine Detection, by State

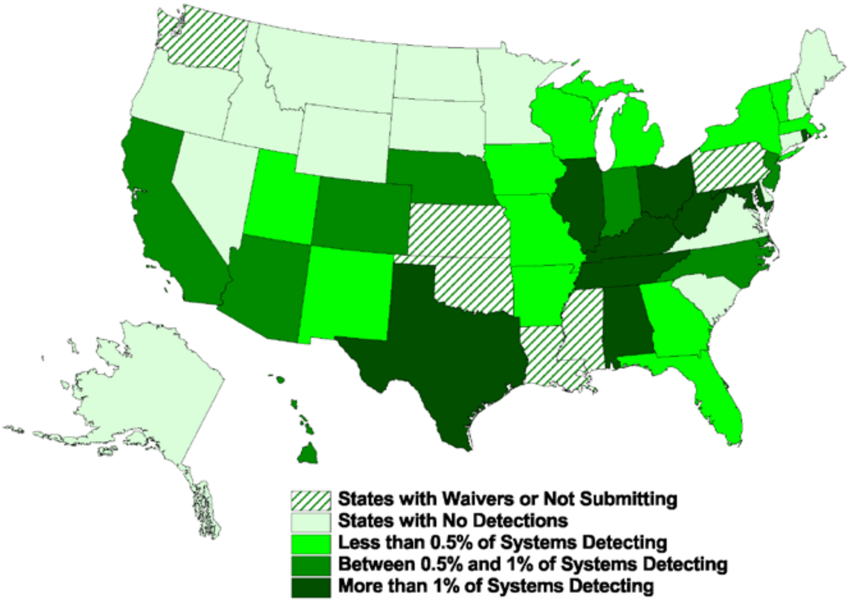

Exhibit 41-9: Percentage of Systems with at Least One Simazine Detection Greater than the MCL Concentration (> 4 µg/L), by State

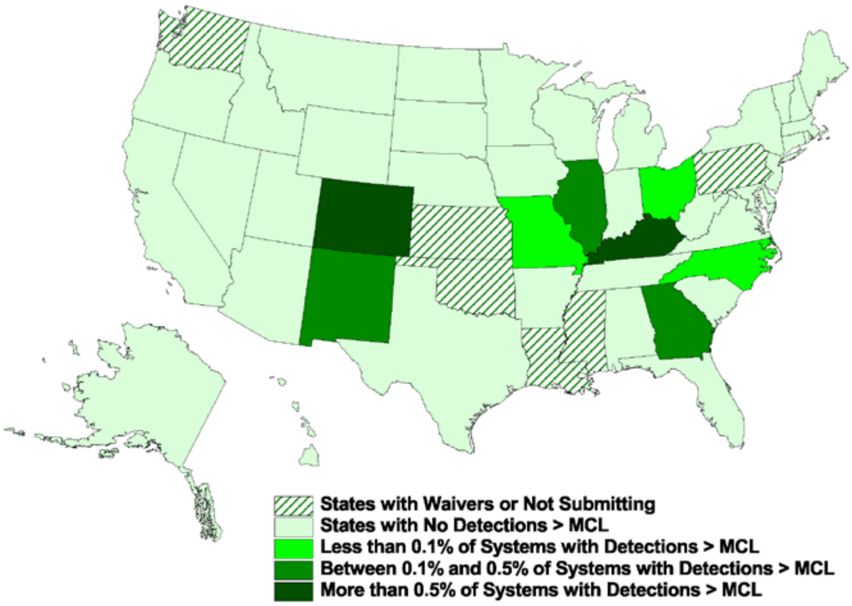

Exhibit 41-10 presents the Stage 1 analysis of simazine occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 2 µg/L and 4 µg/L. A total of 34 (0.092% of) systems, serving about 729,000 persons, reported at least one detection greater than or equal to 2 µg/L; and 16 (0.043% of) systems, serving more than 123,000 persons, reported at least one detection greater than 4 µg/L.

Exhibit 41-10: Simazine 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	> 4 µg/L	4	0.012%	2,408	0.003%
	≥ 2 µg/L	5	0.015%	3,108	0.004%
Surface Water	> 4 µg/L	12	0.358%	120,751	0.098%
	≥ 2 µg/L	29	0.865%	725,922	0.587%
Combined Ground & Surface Water	> 4 µg/L	16	0.043%	123,159	0.063%
	≥ 2 µg/L	34	0.092%	729,030	0.370%

41.5 References

Extension Toxicology Network (EXTOXNET). 1996. EXTOXNET Pesticide Information Profiles–Simazine. Last modified June 1996. Available on the Internet at: http://extoxnet.orst.edu/pips/simazine.htm. Accessed July 6, 2008.

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/.

Thelin, G.P. and L.P. Gianessi. 2000. *Method for Estimating Pesticide Use for County Areas of the Conterminous United States.* U.S. Geological Survey Open-File Report 00-250, 62 p. Available on the Internet at: http://ca.water.usgs.gov/pnsp/rep/ofr00250/ofr00250.pdf.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations—Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Simazine. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for simazine.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – Simazine. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for simazine.] Accessed March 6, 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.

United States Geological Survey (USGS). 2007. 2002 Pesticide Use Maps. Available on the Internet at: http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1981. Accessed March 6, 2008.

42 Styrene

This chapter on styrene 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 styrene 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).

42.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for styrene 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 100 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 C, possible human carcinogen.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2007), styrene is a colorless liquid that evaporates easily and has a sweet smell. It often contains other chemicals that give it a sharp, unpleasant smell. Low levels of styrene can occur naturally in a variety of foods such as fruits, vegetables, nuts, beverages, and meats. In addition, small amounts of styrene can be transferred to food from styrene-based packaging material. Styrene evaporates from shallow soils and surface water and is quickly broken down in the air. Styrene that remains in soil or water may be broken down by bacteria or other microorganisms, thereby acting to minimize ground water concentrations. It is not expected to build up in animals (ATSDR, 2007).

42.2 Use, Production, and Releases

Styrene is widely used to make plastics and rubber. Most products contain styrene linked together in a long chain (polystyrene) as well as unlinked styrene. Products containing styrene include insulation, fiberglass, plastic pipes, automobile parts, shoes, drinking cups and other food containers, and carpet backing (ATSDR, 2007).

The Toxic Substances Control Act (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 42-1 presents the production of styrene in the United States from 1986 to 2002. Note that the production of styrene in the United States has remained constant since 1986.

Exhibit 42-1: Production of Styrene 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, 2003

Styrene is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of styrene for the period 1998-2006 ranged from approximately 50 million pounds to approximately 62 million pounds, with a general decrease over time. On-site releases were greater than off-site releases (USEPA, 2008).

42.3 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 styrene in ambient water are available from the NAWQA program.

42.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for styrene. 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 42-2. Overall, styrene was detected in 3.5% of samples and at 2.2% of sites. Styrene was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.0116 µg/L. The 99th percentile concentration based on detections from all sites was 0.3 µg/L.

Exhibit 42-2: EPA Summary Analysis of Styrene 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	4,639	1.1%	4,139	1.2%	0.003	0.0139	0.0969	0.3	0.3
surface water	1,401	11.4%	182	23.1%	0.001	0.01095	0.05185	0.3424	0.4764
all sites	6,040	3.5%	4,321	2.2%	0.001	0.0116	0.06	0.3	0.4764

1. RLs (Reporting Limits) for styrene varied, but did not exceed 0.003 µg/L.

42.4 Occurrence in Drinking Water

Styrene 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 styrene 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 styrene. These data consist of 372,269 analytical results from 50,421 systems 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.

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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.

42.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 42-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For styrene, 1.047% of 50,421 systems reported detections. Exhibit 42-4 lists the minimum, median, 90th percentile, and maximum styrene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of styrene, based on detections from all systems, is 0.885 µg/L.

Exhibit 42-3: Styrene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	288,205	46,165	86,392,838
Surface Water	84,064	4,256	140,540,798
Combined Ground & Surface Water	372,269	50,421	226,933,636
Percent with Detections			
Ground Water	0.242%	1.003%	3.038%
Surface Water	0.109%	1.527%	2.179%
Combined Ground & Surface Water	0.212%	1.047%	2.506%

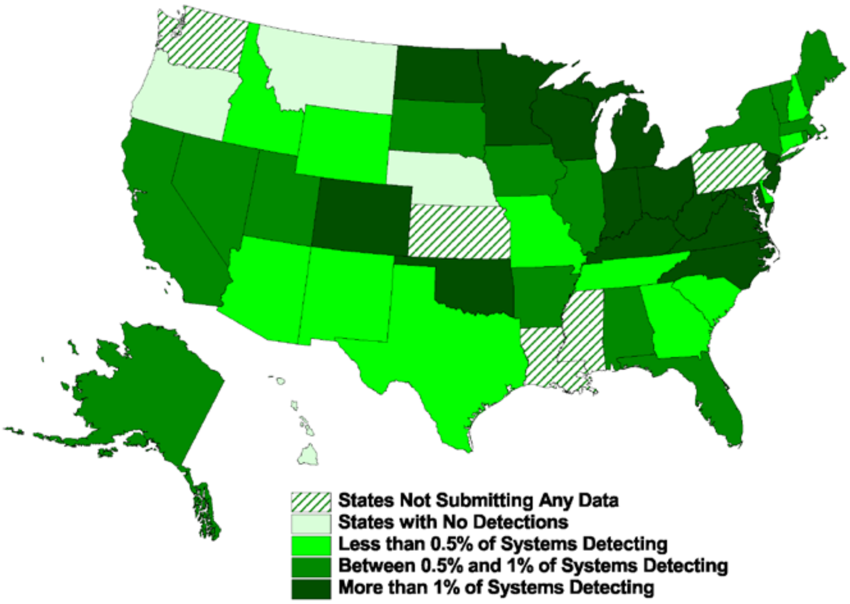
Exhibit 42-4: Styrene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.02	0.9	8.1	710
Surface Water	0.002	0.69	2.6	18.8
Combined Ground & Surface Water	0.002	0.885	7.5	710

The following maps illustrate the geographic distribution of styrene occurrence in drinking water. Exhibit 42-5 shows the states with systems with at least one detection and Exhibit 42-6 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).

The distribution of systems with detections of styrene is geographically dispersed, and detection rates were generally low. Fourteen states reported detections in more than 1% of their systems. In 15 states, between 0.5% and 1% of systems reported detections. Twelve states reported detections in less than 0.5% of systems. Four states reported detections greater than the MCL concentration of 100 µg/L.

Exhibit 42-5: Percentage of Systems with at Least One Styrene Detection, by State



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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 42-6: Percentage of Systems with at Least One Styrene Detection Greater than the MCL Concentration (> 100 µg/L), by State

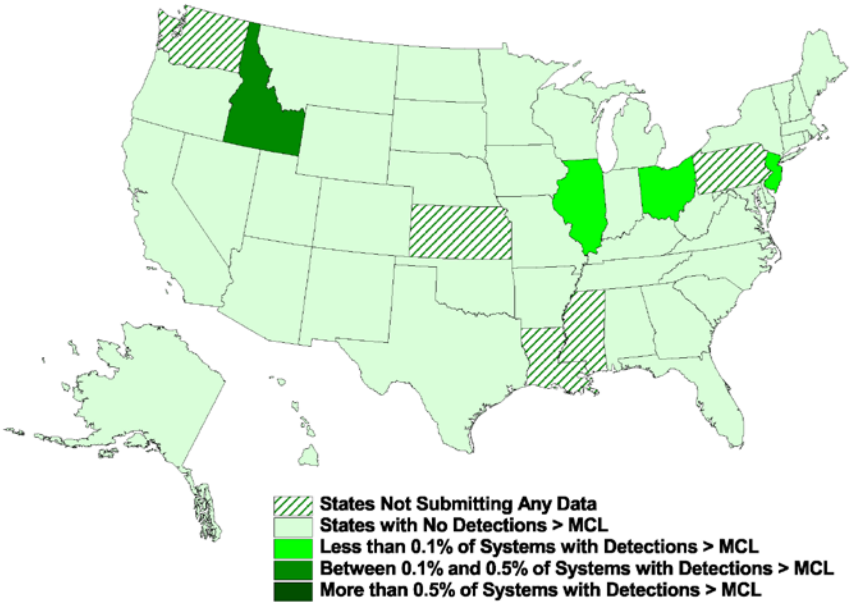

Exhibit 42-7 presents the Stage 1 analysis of styrene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 50 µg/L and 100 µg/L. Seven ground water systems, serving almost 1,700 persons, reported at least one detection greater than or equal to 50 µg/L; and 4 ground water systems, serving more than 1,300 persons, reported at least one detection greater than 100 µg/L. No surface water systems reported any detections greater than or equal to either threshold.

Exhibit 42-7: Styrene 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	4	0.009%	1,310	0.002%
	≥ 50 µg/L	7	0.015%	1,651	0.002%
Surface Water	> 100 µg/L	0	0.000%	0	0.000%
	≥ 50 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	> 100 µg/L	4	0.008%	1,310	0.001%
	≥ 50 µg/L	7	0.014%	1,651	0.001%

42.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. *ToxFAQs for Styrene.* September 2007. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts53.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. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – Styrene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for styrene.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – Styrene. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for styrene.] Accessed March 8, 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.

43 2,3,7,8-TCDD (Dioxin)

This chapter on 2,3,7,8-TCDD (dioxin) 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 dioxin 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).

43.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for dioxin 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 0.00003 µg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1999), chlorinated dibenzo-p-dioxins (CDDs) are a family of 75 chemically related compounds commonly known as chlorinated dioxins. Dioxin ($C_4H_4O_2$) is one of the most toxic and the most studied of the CDDs. In their pure form, CDDs are crystals or colorless solids. They can enter the environment as mixtures containing a number of individual components. In water, dioxin will remain associated with soil or sediments rather than leach. It is subject to breakdown by sunlight at the surface, but is resistant to biodegradation. Dioxin may accumulate in aquatic organisms (ATSDR, 1999).

43.2 Use, Production, and Releases

Dioxin is not produced or used commercially in the U.S. except for research purposes. It is a contaminant formed during the production of some chlorinated organic compounds. It may also be formed during combustion of a variety of chlorinated organic compounds, during the chlorine bleaching process at pulp and paper mills, or during chlorination by drinking water and wastewater treatment plants (ATSDR, 1999).

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 dioxin.

Dioxin and dioxin-like compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of dioxin and dioxin-like compounds for the period 2000-2006 ranged from approximately 86,000 pounds to approximately 149,000 pounds, with maximum releases occurring in 2001 (USEPA, 2008). (No TRI data were available for dioxin and dioxin-like compounds for 1998 or 1999.)

43.3 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 dioxin in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

43.4 Occurrence in Drinking Water

Dioxin 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 dioxin.

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 dioxin 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.

Twenty-seven of the Six-Year Review-ICR states provided occurrence data for dioxin. These data consist of 11,076 analytical results from 2,383 public water systems (PWSs) during the period from 1998 to 2005. The number of sample results and systems vary by state, although

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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.

the state data sets have been reviewed and checked to ensure adequacy of coverage and completeness.

43.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 43-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For dioxin, 0.713% of 2,383 systems reported detections. Exhibit 43-2 lists the minimum, median, 90th percentile, and maximum dioxin concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of dioxin, based on detections from all systems, is 0.000005 µg/L.

Exhibit 43-1: Dioxin Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	6,445	1,956	16,399,032
Surface Water	4,631	427	36,455,413
Combined Ground & Surface Water	11,076	2,383	52,854,445
Percent with Detections			
Ground Water	0.155%	0.460%	0.211%
Surface Water	0.216%	1.874%	0.749%
Combined Ground & Surface Water	0.181%	0.713%	0.582%

Exhibit 43-2: Dioxin Summary Statistics

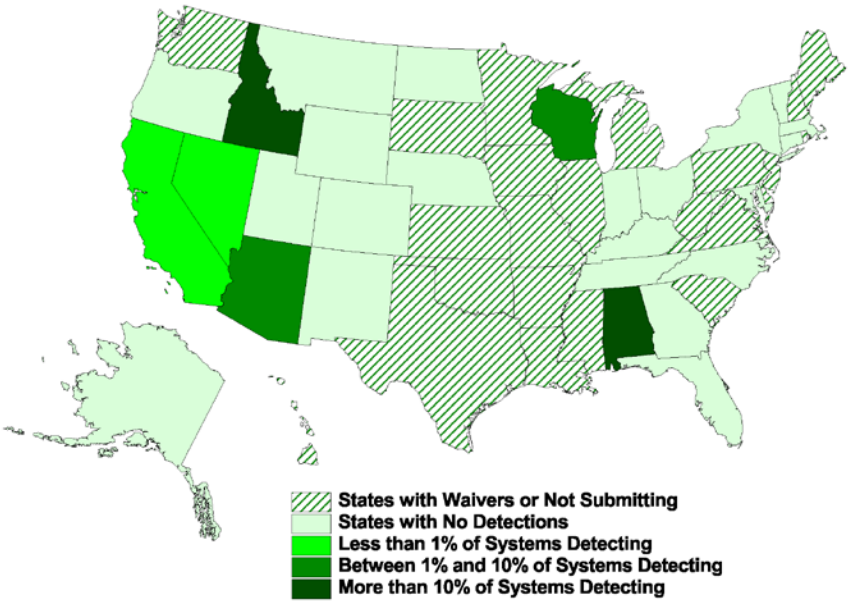
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.000002	0.000005	0.000102	0.000178
Surface Water	0.000001	3.5E-06	1.75E-05	0.00003

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Combined Ground & Surface Water	0.000001	0.000005	2.75E-05	0.000178

The following maps illustrate the geographic distribution of dioxin occurrence in drinking water. Exhibit 43-3 shows the states with systems with at least one detection and Exhibit 43-4 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). The following states did provide Six-Year data for most contaminants, but did not provide data for dioxin: Arkansas, Delaware, Hawaii, Iowa, Illinois, Maine, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, Oklahoma, Rhode Island, South Carolina, South Dakota, Texas, Virginia, and West Virginia.

Only six states reported detections of dioxin. Two states reported detections in more than 10% of their systems. Two states detected dioxin in 1% to 10% of their systems. Twenty-one states reported no detections. One state reported detections greater than the MCL concentration of 0.00003 µg/L.

Exhibit 43-3: Percentage of Systems with at Least One Dioxin Detection, by State



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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 43-4: Percentage of Systems with at Least One Dioxin Detection Greater than the MCL Concentration (> 0.00003 µg/L), by State

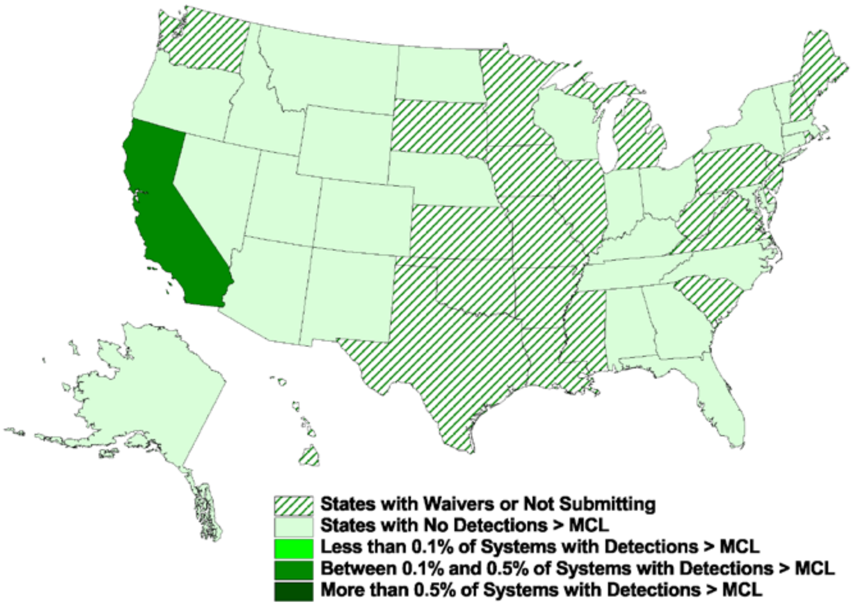

Exhibit 43-5 presents the Stage 1 analysis of dioxin occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.000015 µg/L and 0.00003 µg/L. Three (0.126% of) systems, serving more than 9,600 persons, reported at least one detection greater than or equal to 0.000015 µg/L; and 1 (0.042% of) systems, serving about 7,100 persons, reported at least one detection greater than 0.00003 µg/L.

Exhibit 43-5: Dioxin 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	> 0.00003 µg/L	1	0.051%	7,100	0.043%
	≥ 0.000015 µg/L	2	0.102%	7,226	0.044%
Surface Water	> 0.00003 µg/L	0	0.000%	0	0.000%
	≥ 0.000015 µg/L	1	0.234%	2,400	0.007%

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	> 0.00003 µg/L	1	0.042%	7,100	0.013%
	≥ 0.000015 µg/L	3	0.126%	9,626	0.018%

43.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. *ToxFAQs for Chlorinated Dibenzo-p-dioxins (CDDs).* February 1999. Available on the Internet at: http://www.atsdr.cdc.gov/tfacts104.html.

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/.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations – Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2008. TRI Explorer: Trends – Dioxin and dioxin-like compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for dioxin and dioxin-like compounds.] Accessed March 8, 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.

44 Thallium

This chapter on thallium 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 thallium 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).

44.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for thallium on July 17, 1992 (57 FR 3526 (USEPA, 1991)). The NPDWR established a maximum contaminant level goal (MCLG) of 0.0005 mg/L based on a reference dose (RfD) of 0.00007 mg/kg-day and a cancer classification of D, not classifiable as to human carcinogenicity. The NPDWR also established a maximum contaminant level (MCL) of 0.002 mg/L based on analytical feasibility.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1992), pure thallium is a bluish-white elemental metal. In nature, it is found in clays, soils, and in copper, lead, and zinc ores (USGS, 2008). In its pure form, it is odorless and tasteless. Thallium can also be found in alloys with other metals and as a bromine, chlorine, fluorine, or iodine salt. Thallium exists in two chemical states, thallous and thallic. Thallous, the more common and stable form, is the form that humans are more likely to come into contact with in the environment (ATSDR, 1992).

44.2 Use, Production, and Releases

Thallium is most commonly used in electronic devices, switches, and closures by the semiconductor industry. It also has limited use in the manufacture of special glasses and for medical procedures that evaluate heart disease. Thallium was also once used as a pesticide for control of rodents and insects, but that use was banned in 1972 (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 thallium.

Thallium and thallium compounds are listed as Toxics Release Inventory (TRI) chemicals. TRI data indicate that total off-site and on-site releases of thallium for the period

1998-2006 ranged from approximately 96,000 pounds to approximately 304,000 pounds, with an increase over time (USEPA, 2008a). Total thallium compound releases ranged from approximately 1.9 million pounds to approximately 11 million pounds, with a general decrease over time. Amounts released on-site were greater than amounts released off-site (USEPA, 2008b).

44.3 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 thallium in ambient waters from the Pesticide National Synthesis Project (Gilliom *et al.*, 2007) or the EPA Summary Analysis of Cycle 1 data.

44.4 Occurrence in Drinking Water

Thallium is regulated as an inorganic chemical (IOC) in drinking water. All community water systems (CWSs) and non-transient non-community water systems (NTNCWSs) are required to sample for the IOCs.[1] The maximum waiver period for IOCs is nine years.

Ground water systems must sample once during the initial three-year compliance period. After three compliance periods without a detection, a ground water system may be granted a nine-year waiver. Surface water systems must sample annually during the initial three-year compliance period. After three annual samples without a detection, a surface water system may be granted a nine-year waiver. If the results are greater than the MCL, the public water system (PWS) 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).[2] If all quarterly samples are below the MCL, the system may continue at initial monitoring indefinitely until the state or EPA establishes an alternate schedule.

The analysis of thallium 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 thallium. These data consist of 185,047 analytical results from 48,925 systems 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.

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[1] Nitrate and nitrite have their own monitoring requirements. See the nitrate and nitrite chapters for details of those requirements.

[2] 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.

44.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 44-1 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For thallium, 3.493% of 48,925 systems reported detections. Exhibit 44-2 lists the minimum, median, 90th percentile, and maximum thallium concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of thallium, based on detections from all systems, is 0.000665 mg/L.

Exhibit 44-1: Thallium Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	144,990	44,898	85,832,905
Surface Water	40,057	4,027	137,491,940
Combined Ground & Surface Water	185,047	48,925	223,324,845
Percent with Detections			
Ground Water	1.728%	3.285%	11.410%
Surface Water	1.473%	5.811%	13.385%
Combined Ground & Surface Water	1.673%	3.493%	12.626%

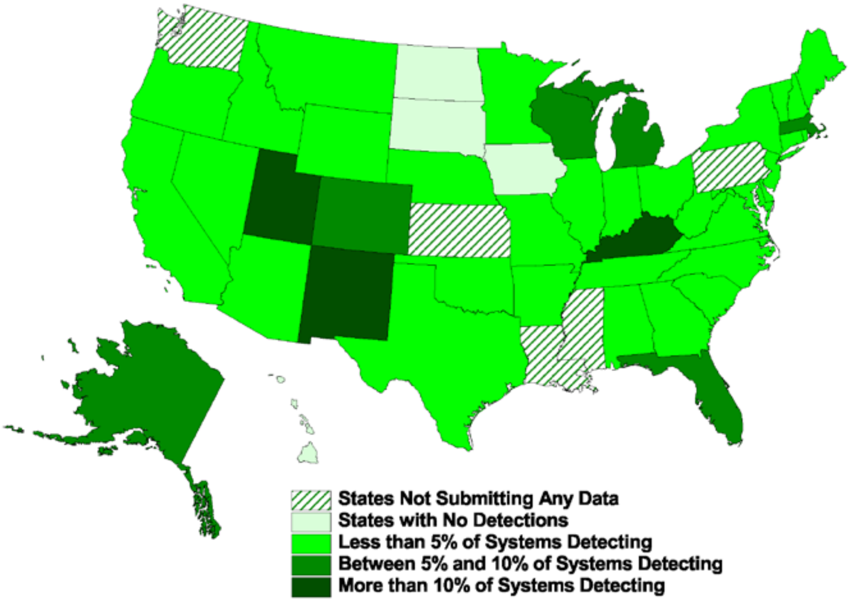
Exhibit 44-2: Thallium Summary Statistics

Source Water Type	Detection Value (mg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.00003	0.00046	0.002	0.09
Surface Water	0.00003	0.001	0.002	0.01
Combined Ground & Surface Water	0.00003	0.000665	0.002	0.09

The following maps illustrate the geographic distribution of thallium occurrence in drinking water. Exhibit 44-3 shows the states with systems with at least one detection and Exhibit 44-4 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[3], Louisiana, Mississippi, Pennsylvania, and Washington).

In three states, greater than 10% of systems detected thallium. In six states, between 5% and 10% of systems reported detections. For four states, more than 1% of systems reported at least one detection greater than the MCL concentration of 0.002 mg/L.

Exhibit 44-3: Percentage of Systems with at Least One Thallium Detection, by State



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

Exhibit 44-4: Percentage of Systems with at Least One Thallium Detection Greater than the MCL Concentration (> 0.002 mg/L), by State

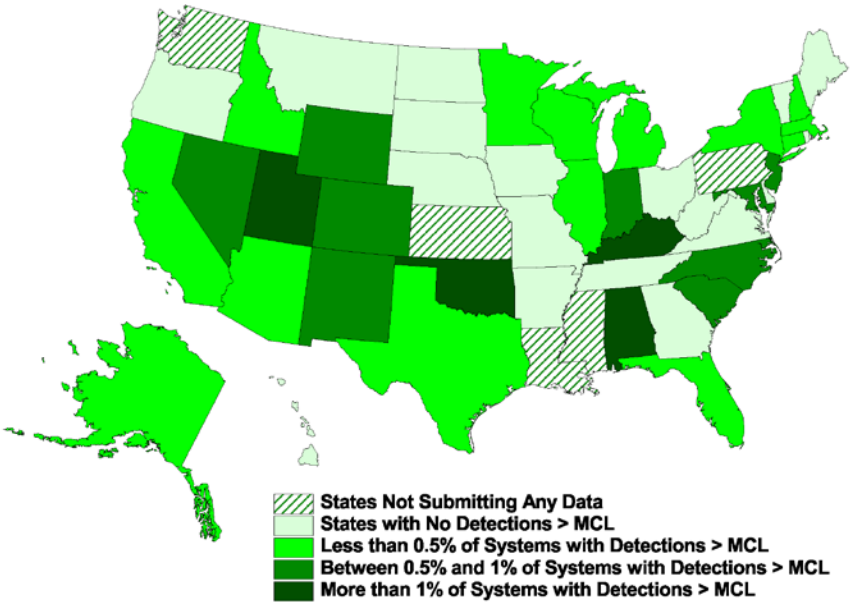

Exhibit 44-5 presents the Stage 1 analysis of thallium occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 0.001 mg/L and 0.002 mg/L. More than 850 (1.752% of) systems, serving almost 20 million persons, reported at least one detection greater than or equal to 0.001 mg/L; and 125 (0.255% of) systems, serving more than 1.8 million persons, reported at least one detection greater than 0.002 mg/L.

Exhibit 44-5: Thallium 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	> 0.002 mg/L	101	0.225%	281,729	0.328%
	≥ 0.001 mg/L	703	1.566%	5,653,247	6.586%
Surface Water	> 0.002 mg/L	24	0.596%	1,550,072	1.127%
	≥ 0.001 mg/L	154	3.824%	14,008,014	10.188%

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	> 0.002 mg/L	125	0.255%	1,831,801	0.820%
	≥ 0.001 mg/L	857	1.752%	19,661,261	8.804%

44.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. *Toxicological Profile for Thallium.* July 1992. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp54.html.

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/.

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. 2008a. TRI Explorer: Trends – Thallium. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for thallium.] Accessed March 6, 2008.

USEPA. 2008b. TRI Explorer: Trends – Thallium Compounds. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for thallium compounds.] Accessed March 6, 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.

United States Geological Survey (USGS). 2008. Thallium Statistics and Information. Available on the Internet at: http://minerals.usgs.gov/minerals/pubs/commodity/thallium. Accessed March 16, 2008.

45 1,2,4-Trichlorobenzene

This chapter on 1,2,4-trichlorobenzene 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 1,2,4-trichlorobenzene 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).

45.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for 1,2,4-trichlorobenzene 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 70 µg/L. The Agency based the MCLG 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.

According to the Hazardous Substance Data Bank (HSDB, 2008), 1,2,4-trichlorobenzene ($C_6H_3Cl_3$) is an aromatic, colorless organic liquid. It tends to adhere to soil, minimizing leaching into ground water. It is expected to biodegrade slowly in soils and water. It has been reported to accumulate in aquatic organisms. 1,2,4-Trichlorobenzene is also known as 1,2,4-TCB (Kenneth Barbalace, 2010).

45.2 Use, Production, and Releases

The greatest uses of 1,2,4-trichlorobenzene are in chemical manufacturing, dyes and intermediates, dielectric fluid, synthetic transformer oils, lubricants, and as a heat-transfer medium. 1,2,4-Trichlorobenzene was once used as a soil treatment for termite control (HSDB, 2008).

The Toxic Substances Control Act (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 45-1 presents the production of 1,2,4-trichlorobenzene in the United States from 1986 to 2002. Note that the production of 1,2,4-trichlorobenzene in the United States remained constant from 1986 to 1998 and then decreased in 2002.

Exhibit 45-1: Production of 1,2,4-Trichlorobenzene 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	> 1 million – 10 million pounds

Source: USEPA, 2003

1,2,4- Trichlorobenzene is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of 1,2,4-trichlorobenzene for the period 1998-2006 ranged from approximately 40,000 pounds to approximately 183,000 pounds, with a general decrease over time. On-site releases were greater than off-site releases (USEPA, 2008).

45.3 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 1,2,4-trichlorobenzene in ambient water are available from the NAWQA program.

45.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for 1,2,4-trichlorobenzene. 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 45-2. Overall, 1,2,4-trichlorobenzene was detected in 0.3% of samples and at 0.1% of sites. 1,2,4-Trichlorobenzene was only detected in surface water. The median concentration based on detections in surface water was 0.036 µg/L. The 99th percentile concentration based on detections from all sites was 0.2604 µg/L.

Exhibit 45-2: EPA Summary Analysis of 1,2,4-Trichlorobenzene 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	4,545	0.0%	4,127	0.0%					
surface water	1,403	1.4%	183	3.3%	0.008	0.036	0.1802	0.2604	0.2604
all sites	5,948	0.3%	4,310	0.1%	0.008	0.036	0.1802	0.2604	0.2604

1. RLs (Reporting Limits) for 1,2,4-trichlorobenzene varied, but did not exceed 0.07 µg/L.

45.4 Occurrence in Drinking Water

1,2,4-Trichlorobenzene 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 1,2,4-trichlorobenzene 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 1,2,4-trichlorobenzene. These data consist of almost 371,132 analytical results from 50,135 systems 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.

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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.

45.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 45-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 1,2,4-trichlorobenzene, 0.321% of 50,135 systems reported detections. Exhibit 45-4 lists the minimum, median, 90th percentile, and maximum 1,2,4-trichlorobenzene concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 1,2,4-trichlorobenzene, based on detections from all systems, is 0.6 µg/L.

Exhibit 45-3: 1,2,4-Trichlorobenzene Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	287,446	45,887	86,306,318
Surface Water	83,686	4,248	140,535,784
Combined Ground & Surface Water	371,132	50,135	226,842,102
Percent with Detections			
Ground Water	0.053%	0.292%	0.903%
Surface Water	0.045%	0.636%	0.880%
Combined Ground & Surface Water	0.051%	0.321%	0.889%

Exhibit 45-4: 1,2,4-Trichlorobenzene Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.02	0.6	2.74	70
Surface Water	0.003	0.5	1.2	10

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Combined Ground & Surface Water	0.003	0.6	2.2	70

Exhibit 45-5 illustrates the geographic distribution of 1,2,4-trichlorobenzene occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) Note that five states did not submit data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington).

Detection rates were generally low for 1,2,4-trichlorobenzene; only five states reported detections in more than 1% of their systems. In four states, between 0.5% and 1% of systems reported detections. Sixteen states reported no detections. Furthermore, no states reported detections greater than the MCL concentration of 70 µg/L.

Exhibit 45-5: Percentage of Systems with at Least One 1,2,4-Trichlorobenzene Detection, by State

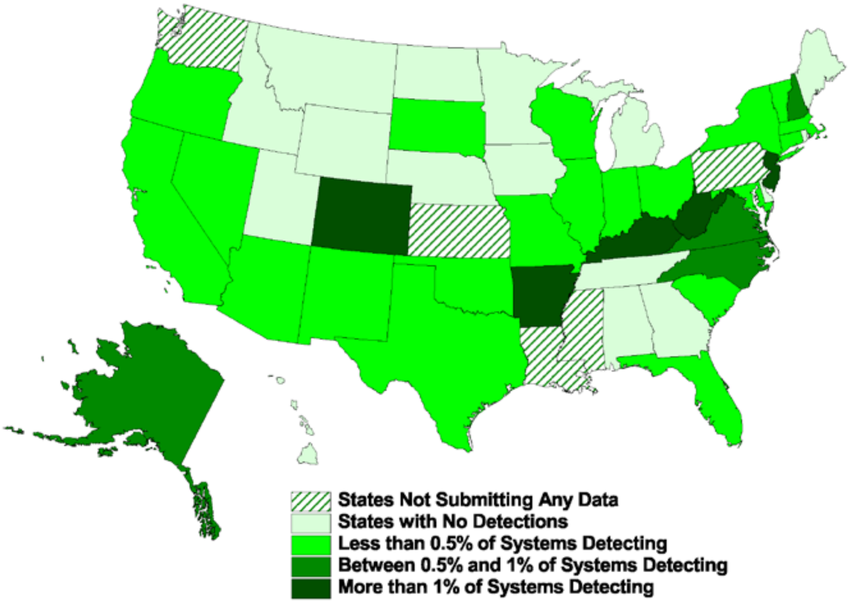

Exhibit 45-6 presents the Stage 1 analysis of 1,2,4-trichlorobenzene occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-

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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.

ICR Dataset relative to two thresholds: 35 µg/L and 70 µg/L. Two (0.004% of) ground water systems, serving about 2,100 persons, reported at least one detection greater than or equal to 35 µg/L. No systems reported detections greater than 70 µg/L.

Exhibit 45-6: 1,2,4-Trichlorobenzene 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%
	≥ 35 µg/L	2	0.004%	2,131	0.002%
Surface Water	> 70 µg/L	0	0.000%	0	0.000%
	≥ 35 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 70 µg/L	0	0.000%	0	0.000%
	≥ 35 µg/L	2	0.004%	2,131	0.001%

45.5 References

Hazardous Substance Data Bank (HSDB). 2008. 1,2,4-TRICHLOROBENZENE. Available on the Internet at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Search for 1,2,4-TRICHLOROBENZENE.] Accessed: July 7, 2008.

Kenneth Barbalace. 2010. Chemical Database – 1,2,4-Trichlorobenzene. EnvironmentalChemistry.com. 1995 - 2010. http://EnvironmentalChemistry.com/yogi/chemicals/cn/1,2,4-Trichlorobenzene.html. Accessed March 16, 2010.

United States Environmental Protection Agency (USEPA). 1992. Drinking Water; National Primary Drinking Water Regulations–Synthetic Organic Chemicals and Inorganic Chemicals; National Primary Drinking Water Regulations Implementation; Final Rule. Federal Register. Vol. 57, No. 138. p. 31776, July 17, 1992.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – 1,2,4-Trichlorobenzene. Last modified September 10, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for 1,2,4-trichlorobenzene.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – 1,2,4-Trichlorobenzene. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for 1,2,4-trichlorobenzene.] Accessed March 8, 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.

46 1,1,1-Trichloroethane

This chapter on 1,1,1-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 1,1,1-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).

46.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for 1,1,1-trichloroethane on July 8, 1987 (52 FR 25690 (USEPA, 1987)). The NPDWR established a maximum contaminant level goal (MCLG) and a maximum contaminant level (MCL) of 200 µg/L. The Agency developed the MCLG based on a reference dose (RfD) of 35 µg/kg-day (0.035 mg/kg-day) derived from an inhalation study and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 2006), 1,1,1-trichloroethane is a colorless liquid with a sweet, sharp odor. It volatilizes very quickly, and at high concentrations (between 80,000 and 105,000 ppm), the gas may ignite in the presence of a spark. In surface waters, such as lakes and rivers, where it partially mixes with water, much of the chemical evaporates quickly. 1,1,1-Trichloroethane also evaporates from soil surfaces. Water can easily carry it through soil into ground water where organisms may break it down. 1,1,1-Trichloroethane does not accumulate readily in aquatic organisms (ATSDR, 2006).

46.2 Use, Production, and Releases

1,1,1-Trichloroethane was once commonly used as an industrial solvent and as the active ingredient in household products such as spot cleaners, glues, and aerosol sprays. However, domestic use of the chemical has been banned in the United States since 2002 because its vapors are detrimental to the ozone layer. Production of 1,1,1-trichloroethane for export is allowed until 2012 (ATSDR, 2006).

The Toxic Substances Control Act (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 46-1 presents the production of 1,1,1-trichloroethane in the United States from 1986 to 2002. Note that the production of 1,1,1-trichloroethane in the United States has decreased since 1990.

Exhibit 46-1: Production of 1,1,1-Trichloroethane 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, 2003

1,1,1-Trichloroethane is listed as a Toxics Release Inventory (TRI) chemical. TRI data indicate that total off-site and on-site releases of 1,1,1-trichloroethane for the period 1998-2006 ranged from approximately 76,000 pounds to approximately 888,000 pounds, with a general decrease over time. On-site releases were greater than off-site releases (USEPA, 2008).

46.3 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 1,1,1-trichloroethane in ambient water are available from the NAWQA program.

46.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for 1,1,1-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 46-2. Overall, 1,1,1-trichloroethane was detected in 9.4% of samples and at 8.3% of sites. It was detected more frequently in surface water than in ground water. The median concentration based on detections from all sites was 0.024 µg/L. The 99th percentile concentration based on detections from all sites was 3 µg/L.

Exhibit 46-2: EPA Summary Analysis of 1,1,1-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 Percentile	99th Percentile	Maximum
ground water	4,659	7.4%	4,159	7.2%	0.002	0.0296	0.72	3.524	5.7
surface water	1,413	15.9%	190	31.1%	0.002	0.02	0.15	0.92	2.3
all sites	6,072	9.4%	4,349	8.3%	0.002	0.024	0.5882	3	5.7

1. RLs (Reporting Limits) for 1,1,1-trichloroethane varied, but did not exceed 0.002 µg/L.

46.4 Occurrence in Drinking Water

1,1,1-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 1,1,1-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 1,1,1-trichloroethane. These data consist of approximately 374,950 analytical results from about 50,440 systems 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.

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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.

46.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 46-3 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For 1,1,1-trichloroethane, 1.075% of 50,440 systems reported detections. Exhibit 46-4 lists the minimum, median, 90th percentile, and maximum 1,1,1-trichloroethane concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of 1,1,1-trichloroethane, based on detections from all systems, is 1 µg/L.

Exhibit 46-3: 1,1,1-Trichloroethane Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	289,053	46,183	86,390,348
Surface Water	85,897	4,257	140,541,198
Combined Ground & Surface Water	374,950	50,440	226,931,546
Percent with Detections			
Ground Water	0.967%	1.052%	4.369%
Surface Water	0.950%	1.315%	7.905%
Combined Ground & Surface Water	0.963%	1.075%	6.559%

Exhibit 46-4: 1,1,1-Trichloroethane Summary Statistics

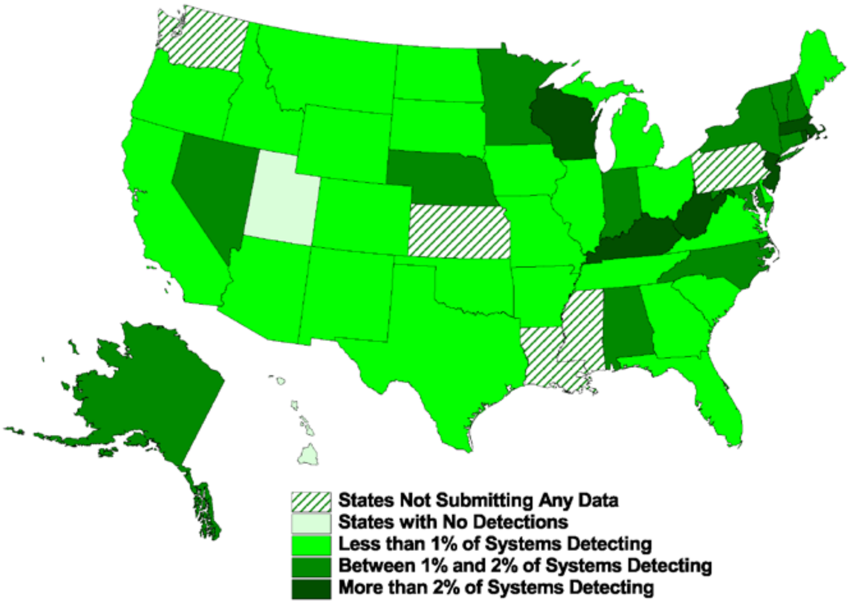
Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.009	1	5.6	1,400
Surface Water	0.2	0.97	4.3	92

Source Water Type	**Detection Value (µg/L)**			
	Minimum	**Median**	**90th Percentile**	**Maximum**
Combined Ground & Surface Water	0.009	1	5.2	1,400

The following maps illustrate the geographic distribution of 1,1,1-trichloroethane occurrence in drinking water. Exhibit 46-5 shows the states with systems with at least one detection and Exhibit 46-6 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).

Six states reported detections in more than 2% of systems. Five out of these six states are located in the eastern half of the United States. In 12 states, between 1% and 2% of systems reported detections. Only two states reported at least one detection greater than the MCL concentration of 200 µg/L.

Exhibit 46-5: Percentage of Systems with at Least One 1,1,1-Trichloroethane Detection, by State



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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 46-6: Percentage of Systems with at Least One 1,1,1-Trichloroethane Detection Greater than the MCL Concentration (> 200 µg/L), by State

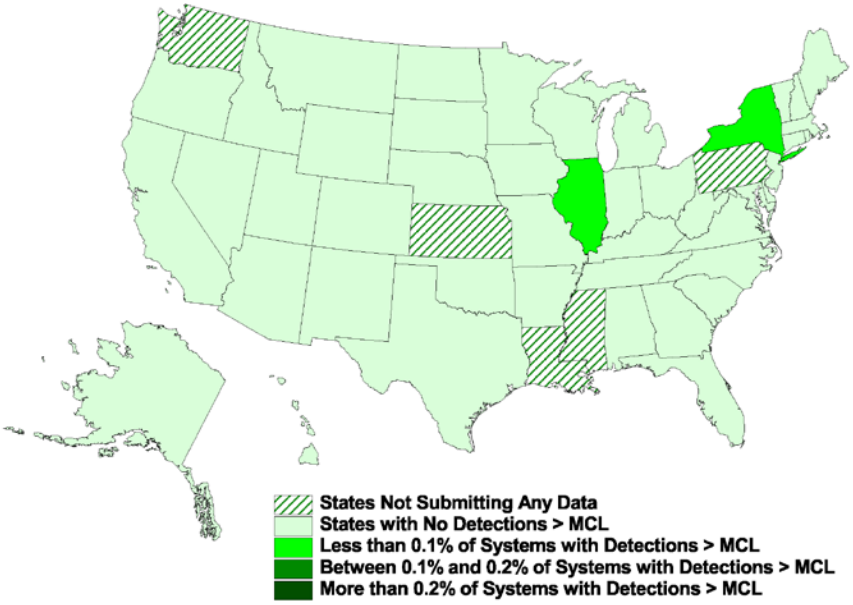

Exhibit 46-7 presents the Stage 1 analysis of 1,1,1-trichloroethane occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 100 µg/L and 200 µg/L. Two (0.004% of) ground water systems, serving 226 persons, reported at least one detection greater than or equal to 100 µg/L and greater than 200 µg/L. No surface water systems reported detections exceeding either threshold.

Exhibit 46-7: 1,1,1-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	> 200 µg/L	2	0.004%	226	0.000%
	≥ 100 µg/L	2	0.004%	226	0.000%
Surface Water	> 200 µg/L	0	0.000%	0	0.000%
	≥ 100 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	> 200 µg/L	2	0.004%	226	0.000%
	≥ 100 µg/L	2	0.004%	226	0.000%

46.5 References

Agency for Toxic Substances and Disease Registry (ATSDR). 2006. *Toxicological Profile for 1,1,1-Trichloroethane.* July 2006. Available on the Internet at: http://www.atsdr.cdc.gov/toxprofiles/tp70.html.

United States Environmental Protection Agency (USEPA). 1987. National Primary Drinking Water Regulations—Synthetic Organic Chemicals; Monitoring for Unregulated Contaminants; Final Rule. Federal Register. Vol. 52, No. 130. p. 25690, July 8, 1987.

USEPA. 2003. Non-confidential Inventory Update Reporting (IUR) Production Volume Information – 1,1,1-Trichloroethane. Last modified September 10th, 2007. Available on the Internet at: http://www.epa.gov/oppt/iur/tools/data/2002-vol.htm. [Search for 1,1,1-trichloroethane.] Accessed February 21, 2008.

USEPA. 2008. TRI Explorer: Trends – 1,1,1-Trichloroethane. Released February 21, 2008. Available on the Internet at: http://www.epa.gov/triexplorer/trends.htm. [Search for 1,1,1-trichloroethane.] Accessed March 5, 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.

47 2,4,5-Trichlorophenoxypropionic Acid (Silvex)

This chapter on 2,4,5-Trichlorophenoxypropionic Acid (2,4,5-TP or silvex) 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 silvex 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).

47.1 Background

The United States Environmental Protection Agency (EPA) published the current National Primary Drinking Water Regulations (NPDWR) for silvex 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 50 µg/L. The Agency based the MCLG on a reference dose (RfD) of 8 µg/kg-day (0.008 mg/kg-day) and a cancer classification of D, not classifiable as to human carcinogenicity.

According to the Hazardous Substance Data Bank (HSDB, 2008), silvex ($C_9H_7Cl_3O_3$) is a white organic powder with little odor. It adheres strongly to soils, where it is degraded by microbial activity. If released to water, silvex will adhere to particles in the water and become part of the sediment. It biodegrades slowly in water and sediments (HSDB, 2008).

47.2 Use, Production, and Releases

Since 1985, the use of silvex has been banned. The greatest use of silvex was as a post-emergence herbicide for control of woody plants, and broadleaf herbaceous weeds in rice and bluegrass turf, sugarcane, rangeland improvement programs, and on lawns. Aquatic uses included control of weeds in ditches and riverbanks, on floodways, along canals, reservoirs, streams, and along southern waterways (HSDB, 2008).

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 silvex.

Silvex is not listed as a Toxics Release Inventory (TRI) chemical; thus, no TRI release records are available.

47.3 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 silvex in ambient water are available from the NAWQA program.

47.3.1 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 silvex between 1992 and 2001 in streams and wells across the country (Gilliom *et al.*, 2007). The maximum long-term method detection limit for silvex was 0.030 µg/L.

In NAWQA stream samples (Exhibit 47-1), silvex was never detected in any agricultural, mixed land use, undeveloped or urban areas.

Exhibit 47-1: USGS National Synthesis Summary of NAWQA Monitoring of Silvex 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)	0.00%	ND[1]	ND[1]	ND[1]
Mixed	800 (36)	0.00%	ND[1]	ND[1]	ND[1]
Undeveloped	101 (5)	0.00%	ND[1]	ND[1]	ND[1]
Urban	521 (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 47-2), silvex was found at frequencies ranging from 0% of samples in undeveloped and urban areas to 0.07% in mixed land use settings, and 0.09% of samples in agricultural settings. The 95th percentile concentrations were less than the method detection limit in all settings. The highest concentration, 0.06 µg/L, was found at an agricultural and a mixed land use site.

Exhibit 47-2: USGS National Synthesis Summary of NAWQA Monitoring of Silvex in Ground Water, 1991-2001

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	1,160	0.09%	ND[1]	ND[1]	0.06
Mixed	1,446	0.07%	ND[1]	ND[1]	0.06
Undeveloped	23	0.00%	ND[1]	ND[1]	ND[1]
Urban	607	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)

47.3.2 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, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for silvex. 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 47-3. Silvex was detected in 0.1% of ground water samples and 0.1% of ground water sites. Silvex was never detected in surface water. The median and 99th percentile concentrations based on detections in ground water were both 0.06 µg/L.

Exhibit 47-3: EPA Summary Analysis of Silvex 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	3,733	0.1%	3,377	0.1%	0.06	0.06	0.06	0.06	0.06
surface water	5,478	0.0%	882	0.0%					
all sites	9,211	0.0%	4,259	0.0%	0.06	0.06	0.06	0.06	0.06

1. RLs (Reporting Limits) for silvex varied, but did not exceed 0.021 µg/L. Note that because this EPA analysis involves more data points than the USGS analyses presented above, a direct comparison is not possible.

47.4 Occurrence in Drinking Water

Silvex 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 silvex 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 silvex. (There were no silvex data from Hawaii or Oklahoma.) These data consist of 122,713 analytical results from 32,887 systems 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.

47.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 47-4 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For silvex, 0.237% of 32,887 systems reported detections. Exhibit 47-5 lists the minimum, median, 90th percentile, and maximum silvex concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of silvex, based on detections from all systems, is 0.2 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 47-4: Silvex Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	100,329	29,954	66,468,861
Surface Water	22,384	2,933	116,531,907
Combined Ground & Surface Water	122,713	32,887	183,000,768
Percent with Detections			
Ground Water	0.071%	0.177%	4.241%
Surface Water	0.147%	0.852%	1.662%
Combined Ground & Surface Water	0.085%	0.237%	2.599%

Exhibit 47-5: Silvex Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	0.01	0.2	1	28
Surface Water	0.01	0.2	0.5	5
Combined Ground & Surface Water	0.01	0.2	1	28

Exhibit 47-6 illustrates the geographic distribution of silvex occurrence in drinking water, identifying the states with systems with at least one detection. (No systems reported detections greater than the MCL concentration; thus, no map is included for MCL concentration exceedances.) 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 did not submit data for silvex.

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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.

Detection rates were generally low; five states reported detections in more than 1% of their systems. Three states reported detections in 0.5% to 1% of systems. Twenty-six states reported no detections. Furthermore, no states reported detections greater than the MCL concentration of 50 µg/L.

Exhibit 47-6: Percentage of Systems with at Least One Silvex Detection, by State

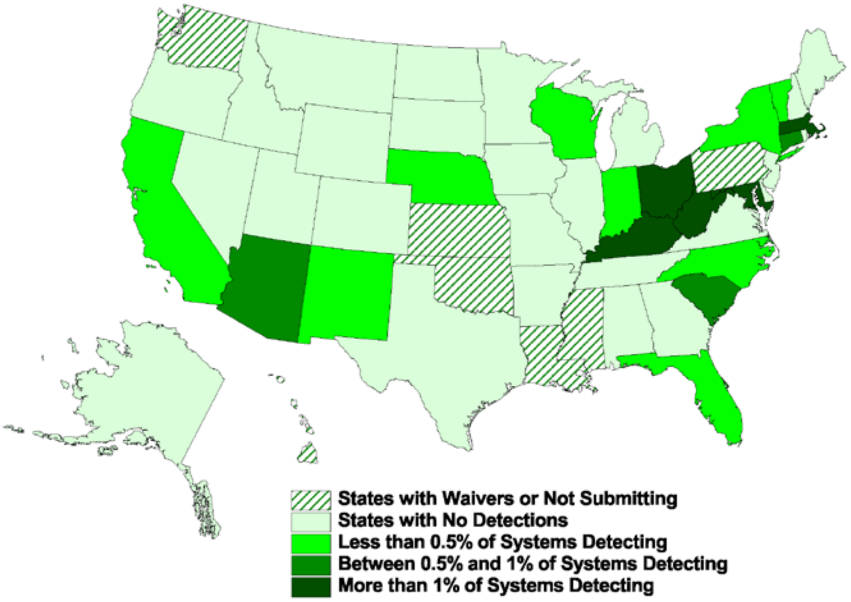

Exhibit 47-7 presents the Stage 1 analysis of silvex occurrence in drinking water from systems and population-served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 25 µg/L and 50 µg/L. One (0.003% of) ground water system, serving 240 persons, reported at least one detection greater than or equal to 25 µg/L. No systems reported detections greater than 50 µg/L.

Exhibit 47-7: Silvex 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%
	≥ 25 µg/L	1	0.003%	240	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
Surface Water	> 50 µg/L	0	0.000%	0	0.000%
	≥ 25 µg/L	0	0.000%	0	0.000%
Combined Ground & Surface Water	> 50 µg/L	0	0.000%	0	0.000%
	≥ 25 µg/L	1	0.003%	240	0.000%

47.5 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/.

Hazardous Substance Data Bank (HSDB). 2008. SILVEX. Available on the Internet at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB. [Search for Silvex.] Accessed: July 7, 2008.

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. 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.

48 Uranium

This chapter on uranium 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 uranium 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).

48.1 Background

EPA published the current National Primary Drinking Water Regulations (NPDWR) for uranium on December 7, 2000 (65 FR 76707 (USEPA, 2000)). The NPDWR established a maximum contaminant level goal (MCLG) of zero (based on a cancer classification of A, known human carcinogen) and a maximum contaminant level (MCL) of 30 µg/L. This regulation became effective on December 8, 2003.

USEPA (2001) explains that for the MCL rulemaking, EPA assumed a typical conversion factor of 0.9 pCi/µg for the mix of uranium isotopes found at public water systems (PWSs), which means that an MCL of 30 µg/L will typically correspond to 27 pCi/L. EPA considered the 30 µg/L level (which corresponds to a 27 pCi/L level) to be appropriate because it is protective for both kidney toxicity and cancer. However, the relationship between mass concentration (µg/L) and activity (pCi/L) is dependent upon the relative mix of the radioactive isotopes (e.g., uranium-234, uranium-235, uranium- 238) that comprise the uranium at a particular drinking water source.[1] In circumstances with more extreme conversion factors (> 1.5 pCi/µg), uranium activity levels may exceed 40 pCi/L. In these circumstances, EPA recommends that drinking water systems mitigate uranium levels to 30 pCi/L or less, to provide greater assurance that adequate protection from cancer health effects is being afforded (USEPA, 2001).

According to USEPA (2007), uranium is a naturally-occurring element found at low levels in virtually all rock, soil, and water. Significant concentrations of uranium occur in some substances such as phosphate rock deposits, and minerals such as uraninite in uranium-rich ores. Because uranium has such a long radioactive half-life (4.47×10^9 years for U-238), the total global quantity remains relatively constant (USEPA, 2007).

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[1] For further discussion of mass and activity, including the formula to convert between the two measurement units, see USEPA (1999).

48.2 Use, Production, and Releases

Uranium metal is very dense and heavy. When depleted, uranium is used by the military as shielding to protect Army tanks, and also in parts of bullets and missiles. The military also uses enriched uranium to power nuclear propelled Navy ships and submarines, and in nuclear weapons. Fuel used for naval reactors is typically highly enriched in U-235. In nuclear weapons, uranium is also highly enriched (USEPA, 2007)

The main use of uranium in the civilian sector is to fuel commercial nuclear power plants, where fuel is typically enriched in U-235 to 2-3%. Depleted uranium is used in helicopters and airplanes as counter weights on certain wing parts. Other uses include ceramic glazes where small amounts of natural uranium (i.e., not having gone through the enrichment process) may be added for color. Some lighting fixtures utilize uranium, as do some photographic chemicals. Phosphate fertilizers often contain high amounts of natural uranium because the mineral material from which they are made is typically high in uranium. Also, people who collect rocks and minerals may have specimens of uranium minerals in their collection such as pitchblende, uraninite, autunite, uranophane, or coffinite (USEPA, 2007).

48.3 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 uranium in ambient water are available from the NAWQA program.

48.3.1 EPA Summary Analysis of NAWQA Data

EPA, with the cooperation of the USGS, has performed a summary analysis of all Cycle 1 water monitoring data from all study units (1992-2001) for uranium. 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 48-1. Overall, uranium was detected in 45.6% of samples and at 50.6% of sites. Uranium was detected more frequently in surface water sites than in ground water sites, although ground water sites are generally more likely to have detections of uranium. The median uranium concentration based on detections from all sites was about 3.4 µg/L. The 99th percentile concentration based on detections from all sites was 115 µg/L.

Exhibit 48-1: EPA Summary Analysis of Uranium 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	7,522	49.1%	3,373	50.2%	0.009	3.274	54	153.45	553
surface water	4,978	40.2%	430	53.7%	0.009	3.607	22	42	74
all sites	12,500	45.6%	3,803	50.6%	0.009	3.434	42.22	115	553

1. RLs (Reporting Limits) for uranium varied, but did not exceed 0.009 µg/L.

48.4 Occurrence in Drinking Water

Initially, all community water systems (CWSs) must collect four consecutive quarterly samples at all entry points to the distribution system between December 8, 2003 and December 31, 2007, unless data have been grandfathered. If the average is less than the detection limit, the system may reduce sampling to once every nine years. If the average is equal to or greater than the detection limit but equal to or less than ½ the MCL, the system may reduce sampling to once every six years. If the average is greater than ½ the MCL (but is equal to or less than the MCL), the system may reduce sampling to once every three years. If the average is greater than the MCL, the system must take one sample each quarter until the annual average is below the MCL. Quarterly monitoring is also triggered by one result that is more than four times the MCL or high enough to cause the running annual average to exceed the MCL. Gross alpha samples may also be used as a substitute for uranium samples, as long as gross alpha activity is equal to or less than 15 pCi/L.

The analysis of uranium 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.

Uranium data were provided by 33 of the Six-Year Review-ICR states. (No data were received from Alabama, Arkansas, Delaware, Georgia, Hawaii, Indiana, Kentucky, Michigan, New Hampshire, Oklahoma, Tennessee, or Utah.) The uranium data from the 33 states consist of 41,581 analytical results from 5,921 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.

48.4.1 Stage 1 Analysis of Occurrence Data

Stage 1 analyses have been performed at the sample and system levels. Exhibit 48-2 presents the number of samples and systems, as well as the population-served by the systems, and the percentage of detections and the percentage of the population-served by the systems with detections. Detections in systems provide a fundamental indication of national occurrence, but are not representative of MCL violations. For uranium, 69.262% of 5,921 systems reported detections. Exhibit 48-3 lists the minimum, median, 90th percentile, and maximum uranium concentrations based on detections from all systems in the Six-Year Review-ICR Dataset. The median concentration of uranium, based on detections from all systems, is 6.8 µg/L.

Exhibit 48-2: Summary of Uranium Occurrence Data from the Six-Year Review-ICR Dataset

Source Water Type	Number of Samples	Number of Systems	Population-Served by Systems
Total Number			
Ground Water	31,461	5,191	23,338,623
Surface Water	10,120	730	47,292,769
Combined Ground & Surface Water	41,581	5,921	70,631,392
Percent with Detections			
Ground Water	70.227%	71.528%	81.666%
Surface Water	71.522%	53.151%	75.079%
Combined Ground & Surface Water	70.542%	69.262%	77.256%

Exhibit 48-3: Uranium Summary Statistics

Source Water Type	Detection Value (µg/L)			
	Minimum	Median	90th Percentile	Maximum
Ground Water	1.49E-06	6.57	35	469
Surface Water	0.001493	7.31	25.07	244.77
Combined Ground & Surface Water	1.49E-06	6.8	32.83	469

The following maps illustrate the geographic distribution of uranium occurrence in drinking water. Exhibit 48-4 shows the states with systems with at least one detection and Exhibit 48-5 shows the states with systems with at least one detection greater than the MCL concentration. Note that five states did not submit any data for use in the Six-Year Review (Kansas[2], Louisiana, Mississippi, Pennsylvania, and Washington). Alabama, Arkansas,

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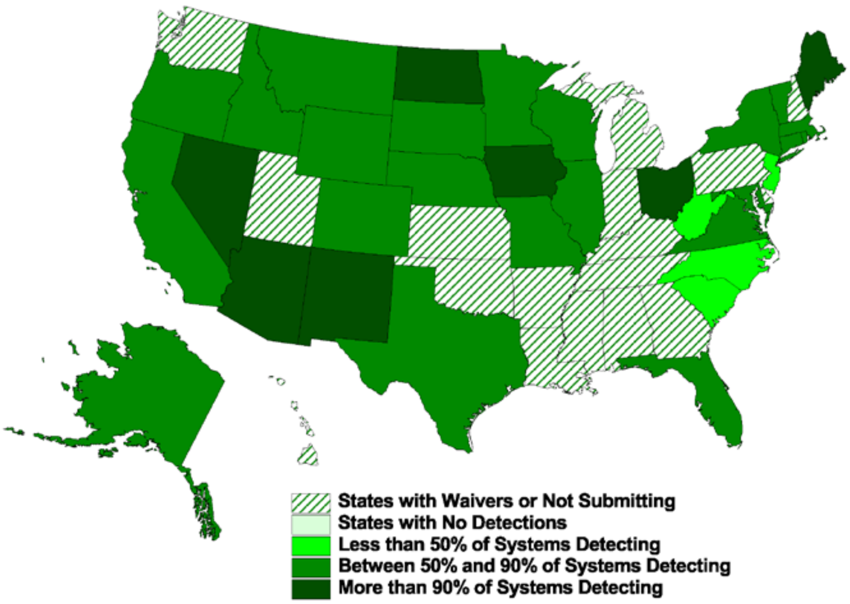
[2] Kansas submitted data after the data management and analyses had been conducted; data for Kansas are not

Delaware, Georgia, Hawaii, Indiana, Kentucky, Michigan, New Hampshire, Oklahoma, or Tennessee submitted Six-Year data for most contaminants, but did not submit data for uranium.

The distribution of systems with detections of uranium is geographically dispersed and detection rates were generally low. In seven states, more than 90% of systems reported detections of uranium. In 11 states, more than 10% of systems reported at least one detection greater than the MCL concentration of 30 µg/L.

Exhibit 48-4: Percentage of Systems with at Least One Uranium Detection, by State



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included in the analyses.

Exhibit 48-5: Percentage of Systems with at Least One Uranium Detection Greater than the MCL Concentration (> 30 µg/L), by State

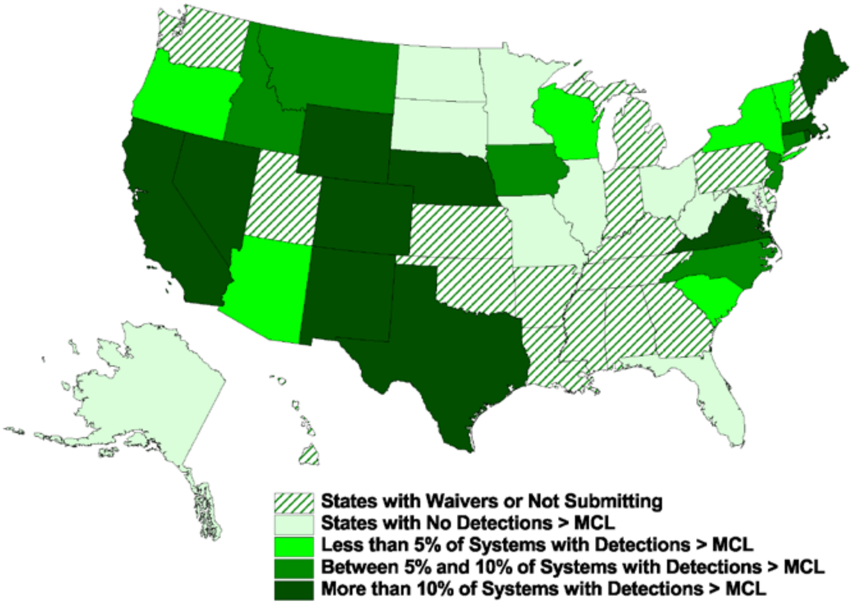

Exhibit 48-6 presents the Stage 1 analysis of uranium occurrence in drinking water from systems and populations served by those systems in the Six-Year Review-ICR Dataset relative to two thresholds: 15 µg/L and 30 µg/L. A total of 923 (15.589% of) PWSs, serving more than 19.5 million persons, reported at least one detection greater than or equal to 15 µg/L; and 448 (7.566% of) PWSs, serving almost 8.4 million persons, reported at least one detection greater than 30 µg/L.

Exhibit 48-6: Uranium 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	> 30 µg/L	413	7.956%	1,240,188	5.314%
	≥ 15 µg/L	846	16.297%	5,684,077	24.355%
Surface Water	> 30 µg/L	35	4.795%	7,153,925	15.127%
	≥ 15 µg/L	77	10.548%	13,809,436	29.200%

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	> 30 µg/L	448	7.566%	8,394,113	11.884%
	≥ 15 µg/L	923	15.589%	19,493,513	27.599%

48.5 References

United States Environmental Protection Agency (USEPA). 1999. Radiation Risk Assessment at CERCLA Sites: Q & A. EPA Report 540/R/99/006, December 1999, pp. 5-6.

USEPA. 2000. National Primary Drinking Water Regulations; Radionuclides; Final Rule. Federal Register. Vol. 65, No. 236. p. 76707, December 7, 2000.

USEPA. 2001. “Use of Uranium Drinking Water Standards under 40 CFR 141 and 40 CFR 192 as Remediation Goals for Groundwater at CERCLA sites.” Memorandum from Elaine F. Davies, Acting Director. Directive no. 9283.1-14. November 6, 2001. Available on the Internet at: http://www.epa.gov/swerffrr/documents/uranium_drinking_water_standards.htm

USEPA. 2007. Radiation Protection: *Uranium*. Last modified November 15, 2007. Available on the Internet at: http://www.epa.gov/radiation/radionuclides/uranium.html. Accessed March 17, 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.