WATER TREATMENT CONTAMINANTS:

TOXIC TRASH IN DRINKING WATER

ENVIRONMENTAL WORKING GROUP

FEBRUARY 2013

www.ewg.org

1436 U Street. NW, Suite 100
Washington, DC 20009

Contents

ENVIRONMENTAL WORKING GROUP

www.ewg.org

Researchers
Renee Sharp
J. Paul Pestano

Editor
Elaine Shannon

Designers
Aman Anderson
Ty Yalniz

HEADQUARTERS
1436 U Street. NW, Suite 100
Washington, DC 20009
(202) 667-6982

CALIFORNIA OFFICE
2201 Broadway, Suite 308
Oakland, CA 94612

MIDWEST OFFICE
103 E. 6th Street, Suite 201
Ames, IA 50010

SACRAMENTO OFFICE
1107 9th Street, Suite 625
Sacramento, CA 95814

About EWG
The mission of the Environmental Working Group (EWG) is to use the power of public information to protect public health and the environment. EWG is a 501(c)(3) non-profit organization, founded in 1993 by Ken Cook and Richard Wiles.

WATER TREATMENT CONTAMINANTS:

Too Much Toxic Trash in American Water

BY RENEE SHARP, EWG SENIOR SCIENTIST
AND J. PAUL PESTANO, EWG RESEARCH ANALYST

WATER TREATMENT PLANTS ALONG THE EAST COAST ARE STRUGGLING TO RECOVER FROM SUPERSTORM SANDY, WHOSE TORRENTIAL RAINS WASHED TENS OF MILLIONS OF GALLONS OF RAW OR PARTIALLY TREATED SEWAGE INTO WATERWAYS.

The less dramatic but equally urgent story: inside those waterworks, and others across the nation, chlorine, added as a disinfectant to kill disease-causing microganisms in dirty source water, is reacting with rotting organic matter like sewage, manure from livestock, dead animals and fallen leaves to form toxic chemicals that are potentially harmful to people.

This unintended side effect of chlorinating water to meet federal drinking water regulations creates a family of chemicals known as **trihalomethanes**. The Environmental Protection Agency lumps them under the euphemism "disinfection byproducts" but we call them what they are: toxic trash.

The EPA regulates four members of the trihalomethane family, the best known of which is **chloroform**, once used as an anesthetic and, in pulp detective stories, to knock out victims. Today, the U.S. government classifies chloroform as a "probable" human carcinogen. California officials consider it a "known" carcinogen. Three other regulated trihalomethanes are bromodichloromethane, bromoform, and dibromochloromethane. Hundreds more types of toxic trash are unregulated.

Scientists suspect that trihalomethanes in drinking water may cause thousands of cases of bladder cancer every year. These chemicals have also been linked to colon and rectal cancer, birth defects, low birth weight and miscarriage (NHDES 2006).

WHEN DOES WATER TREATMENT CONTAMINATION REACH THE DANGER POINT?

An Environmental Working Group analysis of water quality tests conducted in 2011 and made public last year by 201 large American municipal water systems in 43 states has determined that each of these systems detected thihalomethane contamination. In short, more than 100 million Americans served by these large waterworks were exposed to toxic trash.

Only one of the systems studied by EWG – Davenport, Iowa – exceeded the EPA rule barring more than 80 parts per billion of trihalomethanes in drinking water (see Appendix). This legal limit was set in 1998, based on the potential for trihalomethanes to cause bladder cancer. The 80-parts-per-billion standard was part of a major Clinton administration initiative to improve federal drinking water protections under the federal Safe Drinking Water Act.

Yet the significant toxicity of trihalomethanes and other water contaminants generated by water treatment chemicals, documented by large numbers of scientists around the world, makes a compelling case for lowering the federal legal limit to well below 80 parts per billion. Since 1998, the evidence implicating trihalomethanes in serious disorders has mounted:

In 2011 a French research team, pooling data from studies in France, Finland and Spain, found that men exposed to more than 50 parts per billion of trihalomethanes had significantly increased bladder cancer risks (Costet 2011).

In 2007, a scientific team in Spain associated exposure to trihalomethanes greater than 35 parts per billion with increased bladder cancer risks (Villanueva 2007).

In 2007, researchers from four Taiwanese universities reported that people faced twice the odds of dying from bladder cancer if they drank water with trihalomethane contamination greater than 21 parts per billion. This study was cited in the 2011 National Report on Carcinogens, a Congressionally-mandated report produced by the National Toxicology Program, a federal interagency scientific body (Chang 2007, NTP 2011).

A 2010 study by the National Cancer Institute found that about a quarter of the human population may have a genetic susceptibility that raises its risk of bladder cancer from trihalomethanes (Cantor 2010).

Some 168 of the systems studied by EWG, or 84 percent, reported average annual trihalomethane contamination greater than 21 parts per billion – the level at which Taiwanese researchers detected a heightened risk of bladder cancer. Concentrations greater than 35 parts per billion were found in 107, or 53 percent of these systems. In 2005, the EPA considered lowering the legal limit for trihalomethanes to 40 parts per billion, calculating that this move would prevent nearly 1,300 bladder cancer cases each year and save the U.S. between $2.9 and $7.1 billion (EPA 2005). The agency did not attempt to establish this lower standard as a regulation with the force of law. Instead it made marginal improvements in the way it would measure trihalomethanes for compliance with existing regulations and gave water treatment facilities until 2016 to comply with these modest changes.

CONTAMINATION SPIKES PRESENT SPECIAL RISKS DURING PREGNANCY

EWG's analysis suggests that many people are likely exposed to far higher concentrations of trihalomethanes than anyone knows. The EPA regulation for these toxic chemicals is based on the system-wide annual average. But in most water systems, trihalomethane contamination fluctuates from month to month, sometimes rising well beyond the 80 parts-per-billion federal cap. Contamination spikes are offset by low readings that keep the systems in legal compliance.

The EPA standard for trihalomethanes is based on preventing bladder cancer, but the agency has noted that that these chemicals may present reproductive and developmental risks as well (EPA 2012a). A spike that lasts three months exposes a pregnant woman and her fetus to excessive trihalomethane for an entire trimester, a critical window of development. Scientific research has shown that such intensive exposure can have serious consequences for the child. Three studies published last year:

Australian scientists found that when women in their third trimester of pregnancy consumed water with 25 parts per billion of chloroform, their newborns were small for their gestational age, meaning that they typically had birth weights in the lowest ten percent of newborns and were at higher risk for a various health problems (Summerhayes 2012).

Canadian researchers found that exposure to more than 100 parts per billion of trihalomethanes during the last trimester of pregnancy was associated with newborns small for their gestational age (Levallois 2012).

Taiwanese researchers linked stillbirth risks to trihalomethane levels as low as 20 parts per billion (Hwang 2012).

Numerous other studies have associated reproductive and developmental problems with trihalomethanes. Among them:

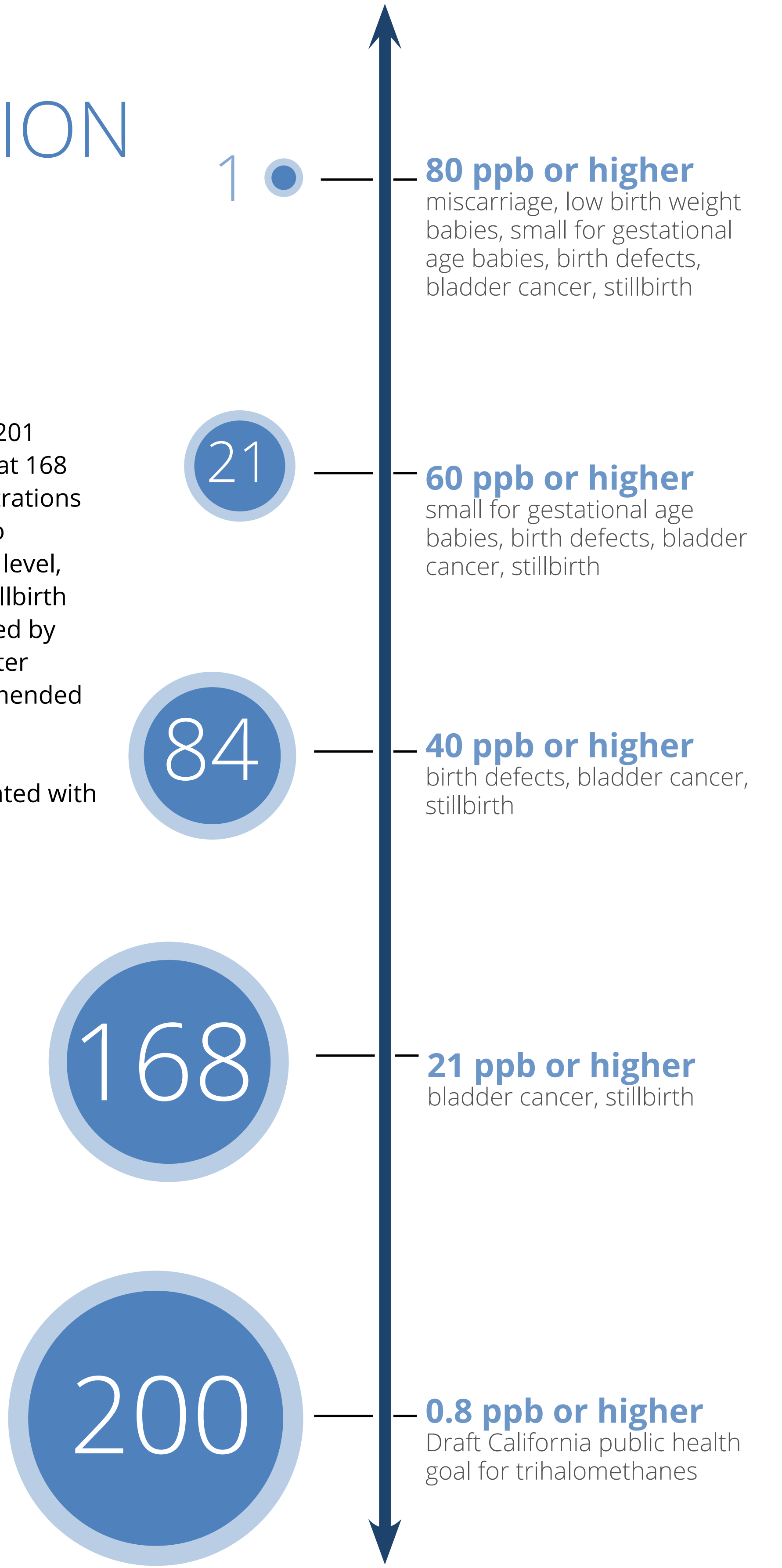
In 2008, scientists from the University of North

WATER CONTAMINATION BY THE NUMBERS

Water quality tests conducted in 2011 by 201 large water suppliers in 43 states show that 168 of them reported trihalomethane concentrations greater than 21 parts per billion level. Two Taiwanese studies have found that at this level, cancer risk doubles and the chances of stillbirth rise. All but one of the 201 utilities reviewed by EWG reported trihalomethane levels greater than 0.8 parts per billion, the goal recommended by California public health officials.

Shown at right are the health risks associated with each concentration of trihalomethanes.

NUMBER OF UTILITIES (OUT OF 201)



References: Bove 2002, Chang 2007, Hoffman 2008, Hwang 2012, Wright 2003

Carolina found that women exposed to more than 80 parts per billion of trihalomethanes during their third trimester of pregnancy faced twice the risk of delivering a child small for gestational age (Hoffman 2008).

British scientists found a link between 60 parts per billion of trihalomethane exposure and stillbirths (Toledano 2005).

In 2003, a team from the Harvard School of Public Health linked exposures to more than 80 parts per billion of trihalomethanes during the second trimester of pregnancy to low birth weight and small-for-gestational-age newborns (Wright 2003).

In 2002 researchers at the federal Agency for Toxic Substances and Disease Registry reviewed the findings of 14 major studies and concluded that there was "moderate evidence" for an association between trihalomethane exposure, small-for-gestational-age newborns, neural tube defects and miscarriage (Bove 2002). The neural tube is the structure in the fetus that develops into the brain and spinal cord.

TRIHALOMETHANES ARE JUST THE TIP OF THE ICEBERG

Studies have shown that there are more than 600 unwanted chemicals created by the interaction of water treatment disinfectants and pollutants in source water (Barlow 2004, Richardson 1998, 1999a, 1999b, 2003). Most of these water treatment contaminants have not been studied in depth. Among them: haloacetonitriles, haloaldehydes, haloketones, halohydroxyfuranones, haloquinones, aldehydes, haloacetamides, halonitriles, halonitromethanes, nitrosamines, organic N-chloramines, iodoacids, ketones and carboxylic acids (Bond 2011, Bull 2011, EWG 2001, Plewa 2004, Yang 2012). Some of these compounds are suspected carcinogens (Bull 2011). Notably, scientists believe that hundreds more water treatment contaminants are present in drinking water but have not yet been identified (Barlow 2004).

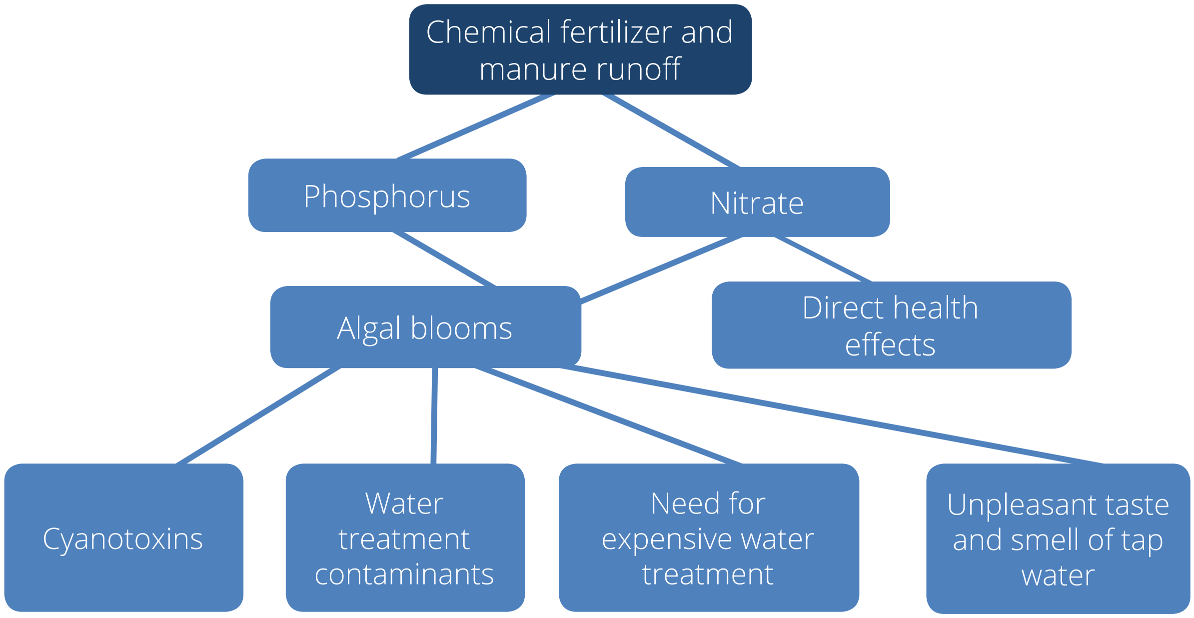
Besides the four regulated trihalomethanes, the EPA regulates five other contaminants in a family of chemicals known as **haloacetic acids** -- monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid and dibromoacetic acid (EPA 2012b). The current EPA legal limit for these five chemicals is 60 parts per billion.

While there have been relatively few epidemiological studies on the potential health effects of haloacetic acids, there is evidence suggesting that exposure to these chemicals during the second and third trimesters of pregnancy may be linked to intrauterine growth retardation and low birth weight (Levallois 2012, Hinckley 2005; Porter 2005).

Haloacetic acids have been classified by the EPA as possibly carcinogenic to humans because of evidence of carcinogenicity in animals. According to the EPA, long-term consumption of water that contains haloacetic acid concentrations in excess the legal limit of 60 parts per billion is associated with an increased risk of cancer (EPA 2002). A technical bulletin released by the Oregon Department of Human Services in 2004 warned that long-term exposure to haloacetic acids at or above 60 parts per billion may cause injury to the brain, nerves, liver, kidneys, eyes and reproductive systems.

Some studies point to concerns with specific haloacetic acids. Dibromoacetic acid has been shown to disturb the balance of the intestinal tract and to cause disease, especially in people with weakened immune systems (Rusin 1997). This particular haloacetic acid compound is toxic to the sperm of adult rats at concentrations as low as 10 parts per billion. At high doses, it has caused a range of neurological problems in test animals, including awkward gait, tremors and immovable hind limbs (Linder 1995). Two members of the haloacetic acid family -- dichloroacetic acid and trichloroacetic acid -- have been shown to cause severe skin and eye irritations in humans (NTP 2005).

WATER POLLUTION CASCADE FROM AGRICULTURAL RUNOFF



A CHLORINE SUBSTITUTE THAT DOESN'T SOLVE THE PROBLEM – AND MAY MAKE IT WORSE

In recent years, many water utilities have tried to reduce contamination caused by water treatment by switching from free chlorine to chloramines, compounds made from chlorine and ammonia gases.

Chloramines are more stable than chlorine and do not produce as many trihalomethanes and haloacetic acids. The EPA has reported that when Washington Aqueduct, a U.S. Corps of Engineers facility that treats drinking water for Washington D.C., switched to chloramines, the estimated average of the regulated water treatment contaminants in theses two families dropped by 47 percent (EPA 2006).

Yet switching to chloramines has not solved the problem but rather moved the problem – and may have complicated it.

Chloramines are toxic to kidney dialysis patients and extremely toxic to fish (EPA 2012b).

A nationwide study on water treatment contaminants conducted by the EPA reported that chloraminated drinking water had the highest levels of an unregulated chemical family known as **iodoacids** (EPA 2002). Some researchers consider iodoacids to be potentially the most toxic group of water treatment contaminants found to date, but there is still relatively little research on them (Barlow 2004, Plewa 2004).

Other dangerous compounds formed by chloramine are nitrosamines. In 2010, then-EPA Administrator Lisa Jackson launched a new "drinking water strategy." During these deliberations, the agency is addressing, among other things, nitrosamine contamination. Nitrosamines, which are currently unregulated, form when water is disinfected with chloramine. The U.S. government says some chemicals in the nitrosamine family are "reasonably anticipated" to be human carcinogens.

In a 2011 report called "The Chlorine Dilemma," David Sedlak, a professor of civil and environmental engineering at the University of California-Berkeley, detailed the "dark side" of water treatment and the new and unanticipated hazards of water treatment plants' shift from chlorine to chloramine. "Nitrosamines are the compounds that people warned you about when they told you you shouldn't be eating those nitrite-cured hot dogs," Sedlak told National Public Radio in 2011. "They're about a thousand times more carcinogenic than the disinfection byproducts that we'd been worried about with regular old chlorine."

The bottom line is that switching to chloramination may have achieved the desired effect of reducing trihalomethane and haloacetic acid levels, but it may have inadvertently exposed the population to additional unregulated byproducts that are more harmful in the long run.

Chloramines present other potential problems. Utilities observed that chloramines were not as effective at disinfection as free chlorine, so, according to the EPA, many treatment plants began to alternate between chloramines and chlorine to "dislodge biofilms and sediment in water mains" (EPA 2007). When chlorine was reintroduced to a system for a month-long "chlorine flush" (EWG 2007), the result was "chlorine burn," which removed sludge and sediment from pipes but also temporarily raised the level of chlorine-generated contaminants. Customers of utilities that used both types of chemicals were exposed to varying amounts of multiple water treatment contaminants.

There were more severe and long-lasting complications. In 2000, the Washington Aqueduct switched to chloramine without realizing that chlorine prevented corrosion of old lead pipes but chloramine did not (Brown 2010). The switch caused D.C.'s old lead pipes to discharge quantities of lead into the city's drinking water, triggering a public health crisis when the problem was detected in 2004. The belated discovery of high lead levels triggered warnings, broad distribution of water filters, firings, Congressional hearings and extensive replacement of lead water lines.

In a study published in January 2009 in the journal of Environmental Science and Technology, scientists Marc Edwards and Simoni Triantafyllidou of Virginia Tech and Dana Best of the Children's National Medical Center in Washington wrote that during the D.C. lead crisis, the number of babies and toddlers with elevated lead levels in their blood increased by more than four times, compared to the pre-2001 period (Edwards 2009). The authors warned that many of the youngest could suffer irreversible IQ loss or other developmental difficulties.

CLEANING UP SOURCE WATER

Cleaner source water is critical to breaking this cycle. By failing to protect source water, Congress, EPA and polluters leave Americans with no choice but to treat it with chemical disinfectants and then consume the residual chemicals generated by the treatment process.

For most utilities with chronically high readings of treatment pollutants, cleaning up source water will require aggressive action to reduce agricultural pollution, runoff from suburban sprawl and upstream sewage discharges.

Superstorm Sandy exerted unprecedented pressure on sources of drinking water along the East Coast. In the storm's wake, tens of millions of gallons of sewage washed into waterways and the Chesapeake Bay. The Federal Emergency Management Agency advised people in areas slammed by the storm to boil tap water. New York Gov. Andrew Cuomo estimated that the costs of repairing damaged sewage pumping stations and treatment plants in his state alone could surpass $1.1 billion. The fragile Chesapeake, already the site of a long-running environmental cleanup, was deluged with sewage from water treatment systems swamped by pounding rains. In Virginia, most of the lower Chesapeake Bay suffered widespread sewage contamination and was closed to shell-fishing for a period.

These are serious issues that must be addressed. The smart choice will be to make infrastructure improvements that help protect source water. It doesn't take a perfect storm for sewage to pollute the Potomac River. The Washington D.C. area's aging sewage pipes do that regularly. To remedy the problem, Washington authorities have embarked on a complex, long-term sewage control plan called the Clean Rivers project, estimated to cost $2.6 billion and wind up in 2025.

Other urban areas are long overdue for upgrades to their sewage and storm water management systems. In 2009, the American Society of Civil Engineers gave the nation a D-minus for inattention to its wastewater systems. "Clean and safe water is no less a national priority than are national defense, an adequate system of interstate highways, and a safe and efficient aviation system," the organization said. "Many other highly important infrastructure programs enjoy sustainable, long-term sources of federal backing, often through the use of dedicated trust funds; under current policy, water and wastewater infrastructure do not."

Treating fouled water with chemicals can be more expensive than reducing pollution before it gets to the treatment plant. Research has shown that the long-term economic benefits of keeping source water clean often far outweigh the costs. The EPA has found that every dollar spent to protect source water reduced water treatment costs by an average of $27 (CBF 2012). Philadelphia officials have estimated that every dollar they invest in green infrastructure to reduce storm water flows will create more than double the economic benefits (PWD 2009).

In much of the country, farming is a major source of organic pollution in drinking water and a contributor to water treatment contamination. Farming communities need common sense standards to reduce soil erosion and polluted runoff from agricultural operations. Farm operators and

Recommendations for consumers

Anyone drinking tap water should use some form of carbon filtration designed to reduce exposures to trihalomethanes, haloacetic acids and other water treatment contaminants.

Carbon filtration systems come in various forms, including pitchers, faucet-mounted attachments and larger systems installed on or under countertops. Prices vary. They may be deceiving, because different systems require filter replacement periodically.

EWG research shows that pitcher and faucet-mounted systems are typically the most economical, costing about $100 a year. Countertop and under-counter systems are more expensive to install, with yearly maintenance costs roughly equal to pitcher and faucet-mounted systems.

The prices for all of these systems pale in comparison to the expense of purchasing bottled water for a family of four, which EWG estimates to range between $950 and $1,800 a year.

Before purchasing any filtration system, it is important to research them. Not all activated carbon systems remove water treatment contaminants. Click here to see a list of some filters that reduce the concentrations of at least one of these chemical families. (http://www.ewg.org/report/ewgs-water-filter-buying-guide)

Consumers who are serious about avoiding water treatment contaminants should consider installing a whole-house filtration system. Numerous studies have shown that showering and bathing are important routes of exposure for trihalomethanes and may actually contribute more to total exposure than drinking water (OEHHA 2004, Xu and Weisel 2003).

It is critical, however, that consumers research their choices carefully. Many whole-house systems do not remove water treatment contaminants. In fact, when EWG was assembling the latest edition of its filter guide, we could not find a single whole-house system that was certified by the state of California or NSF International, an independent, non-profit certification body, to reduce trihalomethanes. Those that do may cost several hundred or even thousands of dollars and incur yearly maintenance costs of hundreds of dollars more.

Whichever system you choose, remember to change the filter according to the manufacturer's guidelines, or it will become clogged and cease to function effectively. (http://www.ewg.org/report/water-filter-maintenance) landowners should be expected to implement a basic standard of care involving simple and often conventional practices that improve soil and water quality. These should be a condition of eligibility for receiving the generous federal benefits accorded agricultural operations. States should take action to enact narrowly-targeted standards that restrict farming practices that inflict a disproportionally large amount of natural resource damage.

About 1 billion tons of topsoil erode from American cropland each year, much of it deposited in streams and rivers. Soil mixed with manure washed from pasture and rangelands contains even more fecal matter and other organic substances (USDA 2001, EWG 2012a).

Studies by the U.S. Geological Survey have found that fertilizer used in agriculture accounted for 17 percent of total phosphorus in major U.S. river basins (CSP 2007). Most phosphorus from fertilizer is absorbed into soil in fields and is carried to streams and rivers during soil erosion. USGS studies show that three-quarters of all American streams and rivers are polluted with enough phosphorus to support uncontrolled algae growth (USGS 1999, Cooke 1989). In bodies of water, algae blooms die, decompose and, like other organic matter, give off fulvic and humic acids that react with chlorine during treatment to form trihalomethanes.

With the exception of large animal feeding operations, farm businesses are exempt from the pollution control requirements of the federal Clean Water Act. Few states have authority to compel farms to adopt practices that would reduce agricultural pollution reaching rivers, lakes and bays.

For example, according to the Iowa Department of Natural Resources, 92 percent of the nitrogen and 80 percent of the phosphorus – the two pollutants most responsible for the poor condition of the waterways that it monitors – come mainly from agricultural runoff. Only 8 percent of the nitrogen and 20 percent of the phosphorus come from "municipal and industrial discharges." Yet Iowa's water quality regulation almost exclusively targets municipal and industrial discharges. Agricultural runoff remains largely unregulated (EWG 2012b).

The federal farm bill, reauthorized every five years, sets national policy for source water protection. The current debate over renewing the farm bill can be viewed as a referendum on the nation's commitment to protect drinking water supplies at the source. This legislation affects the nation's waters in two opposing ways. On one hand it authorizes subsidies that encourage all-out production of feed grains and oilseeds, spurring increased pollution and habitat destruction. On the other, it offers incentives to farmers who protect the environment.

In exchange for federal subsidies, farmers since 1985 have agreed to adopt soil conservation measures to minimize erosion and protect wetlands. As a result of this "conservation compact" between farmers and taxpayers, soil erosion on highly erodible land was reduced by 40 percent in recent decades. The nation met the long-sought goal of no net loss of wetlands.

Now, however, some lobbyists and legislators want to end this compact, opposing proposals to restore the link between "conservation compliance" and crop insurance subsidies, which are the government's chief form of income support for farm businesses. To finance those subsidies, many of the same lobbyists and legislators have proposed cutting programs managed by the U.S. Department of Agriculture to help farmers pay for conservation measures. These cuts would reverse a gradual trend in recent decades that has seen annual spending on conservation increase from $2 billion to more than $4 billion, with greater incentives for farmers who take steps to reduce water pollution (EWG 2012a).

If conservation funding is slashed, the U.S. will give up important gains that have constrained agricultural pollution. The problem of water treatment contaminants is likely to become more pronounced.

THE TROUBLE WITH EPA

The EPA's rules for water treatment contaminants date back to 1974, when scientists discovered that chlorine was reacting with dissolved pollution in the water supply to create more contaminants. Five years later, the EPA set the nation's first standards for trihalomethanes at 100 parts per billion, calculated as the running annual average of total concentration of the chemicals.

In 1998, the Clinton EPA lowered the trihalomethane cap to a running annual average of 80 parts per billion and set a new legal limit for haloacetic acids at a running annual average of 60 parts per billion.

But the agency's regulatory scheme succeeded in conveying a false sense of security to the public.

As noted earlier, the EPA regulates just nine pollutants generated by chlorine or chloramine--four trihalomethanes and five haloacetic acids (EPA 2012a). These nine regulated chemicals represent less than 2 percent of the more than 600 unwanted chemicals created by the interaction of water treatment disinfectants and pollutants in source water (Barlow 2004).

The legal limits for the nine regulated chemicals are not what either the agency or many independent scientists believe is truly safe. Rather, the regulations represent political compromises that take into account the costs and feasibility of treatment.

In 2010, California's Office of Environmental Health Hazard Assessment proposed a "public health goal" for trihalomethanes of 0.8 parts per billion. A "goal" is not a binding legal limit, but setting a goal is the first step in the process that establishes such a limit. California regulators estimated that if the goal of 0.8 parts per billion were attained, bladder cancer risks would be reduced to no more than 1 in a million (OEHHA 2010). The state is still in the process of publishing its final goal. Still, the 2010 proposal represents what California's public health and environmental experts believe should be done to protect the public from carcinogenic trihalomethanes. It is significant that that this proposed goal is one-hundredth of the EPA cap.

Yet another problem is of the EPA's own making. The agency established an unusual monitoring method that all but guaranteed that many Americans would be overexposed periodically to spikes in water treatment contamination. For most toxic chemicals in drinking water, the agency set a simple limit on the maximum level of the contaminant that could be measured at any time. But for water treatment contaminants, the agency permitted utilities to average the pollution throughout their systems and over the previous four quarters. This method made it legal for utilities to distribute excessively contaminated water from chronically problematic sections and use readings from other sections that were below average to remain in compliance with federal law and regulations.

This flaw is not theoretical. EWG's analysis of 201 utilities' water quality reports for 2012, known as "consumer confidence reports," uncovered several utilities in which annual trihalomethane and/or haloaceticacid levels for some sampling locations spiked to between 2 and 8 times higher than other sampling locations within the same systems. The entire systems escaped penalties because their water averaged out with a passing grade from EPA. But at certain times and in certain places, the water was excessively tainted, sometimes severely so. Pregnant women and their unborn children could be affected by these spikes.

In 2005, responding to critics of this complicated and flawed method, the EPA proposed new rules to go into effect between 2012 and 2016, depending on the size of the water system. These would require water utilities to find spots within their systems that had markedly high concentrations of water treatment contaminants and designate these locations as monitoring sites for compliance with federal drinking water standards. The EPA asserted that these new rules would prevent an estimated 280 cases of bladder cancer each year.

But EPA's plan represented only a partial solution. It retained the system-wide averaging method and would not solve the problem of recurrent contaminant spikes at particular locations.

To examine this issue further. EWG created a case study, analyzing detailed water treatment contaminant data for all 936 water utilities in Florida. We found that fully nine percent of all the tests exceeded the EPA maximum for trihalomethanes. The most contaminated water measured an astonishing 595 parts per billion. In four percent of the tests, haloacetic acids exceeded the EPA maximum, with some levels as high as 260 parts per billion. Spikes typically appeared in early spring and late summer.

POLICY RECOMMENDATIONS

If source water were less polluted as it flowed into a water utility's intake pipes, less disinfection with chlorine and chloramines would be needed, and these treatment chemicals would produce less contamination. But government policies do little to advance this goal.

Instead, taxpayers pour billions of dollars into federal programs like farm subsidy payments that exacerbate pollution and then pile on additional billions of dollars for water treatment facilities. Not enough federal money and effort are being devoted to finding more effective and efficient measures to protect rivers and streams from pollution in the first place.

Until such measures are in place and contaminant levels are dramatically reduced, EWG makes these recommendations for national policy:

- The EPA should reevaluate its legal limits for water treatment contaminants in light of the latest scientific research indicating that lower limits are well justified to protect human health.
- Congress should reform farm policies to provide more funds to programs designed to keep agricultural pollutants such as manure, fertilizer, pesticides and soil out of tap water.
- Congress should renew the "conservation compliance" provisions of the 1985 farm bill by tying wetland and soil protection requirements to crop insurance programs, by requiring farm businesses that receive subsidies to update their conservation plans and by strengthening the government's enforcement tools.
- Congress should strengthen and adequately fund conservation programs that reward farmers who take steps to protect sources of drinking water. Congress should expand "collaborative conservation" tools that award funds to groups of farmers who work together to protect drinking water sources.
- The USDA and other federal agencies involved in federal agriculture policy should place greater emphasis on restoring buffers and wetlands that filter runoff contaminated with farm pollutants.
- The federal government should fund more research on the identity of and toxicological profiles for the hundreds of water treatment contaminants in drinking water.
- The EPA must reevaluate the way it measures water treatment contaminants so that consumers cannot be legally exposed to spikes of toxic chemicals.
- Congress must allocate significant money to help repair and upgrade the nation's water infrastructure.
- Source water protection programs should be significantly expanded, including efforts to prevent or reduce pollution of source waters and to conserve land in buffer zones around public water supplies. Financial support for these projects is crucial.

APPENDIX

WATER TREATMENT CONTAMINANTS IN 201 LARGE WATER UTILITIES

Running annual average levels of trihalomethanes and haloacetic acids for the year 2011 as reported in the 2012 Consumer Confidence Reports of 201 large U.S. water utilities.

State	Water Supplier	Locations Served (in whole or part)	Total Trihalomethane Running Annual Average (in parts per billion)	Haloacetic Acids Running Annual Average (in parts per billion)
AK	Anchorage Water & Wastewater Utility	Anchorage	4.9	5.0
AL	Huntsville Utilities Water Department	Huntsville	34.4	23.9
AL	Montgomery Water Works & Sanitary Sewer Board	Montgomery	22.0	15.0
AR	Beaver Water District	Fayetteville, Springdale, Rogers, and Bentonville	63.6	37.3
AR	Central Arkansas Water	Little Rock	53.0	25.0
AZ	City of Chandler Municipal Utilities Department	Chandler	46.2	16.6
AZ	City of Glendale Water Services	Glendale	50.0	14.7
AZ	City of Mesa Water Resources Department	Mesa	59.1	17.7
AZ	City of Phoenix Water Services Department	Phoenix	58.0	22.0
AZ	City of Scottsdale Water Resources	Scottsdale	54.0	17.5
AZ	City of Tempe Water Utilities Division	Tempe	62.0	24.0
AZ	Town of Gilbert Public Works	Gilbert	43.9	16.1
CA	Alameda County Water District	Fremont, Newark, and Union City	26.0	17.0
CA	Anaheim Public Utilities	Anaheim	33.0	14.0
CA	Azusa Light and Water	Azusa	23.6	16.8
CA	California Water Service Company-Bakersfield	Bakersfield	41.0	39.0
CA	Castaic Lake Water Agency	Santa Clarita, Canyon Country and Newhall	25.6	8.0
CA	Chino Hills Water and Sewer	Chino Hills	32.5	3.6
CA	City of Antioch	Antioch	47.7	5.4
CA	City of Fresno Water Division	Fresno	0.8	2.5
CA	City of Glendale Water and Power	Glendale	38.4	11.0
CA	City of Huntington Beach	Huntington Beach	31.0	18.0
CA	City of Modesto	Modesto	28.7	18.8

CA	City of Oceanside	Oceanside	37.0	11.0
CA	City of Orange	Orange	24.0	13.0
CA	City of Riverside Public Utilities	Riverside	4.1	not listed
CA	City of Sacramento Department of Utilities	Sacramento	44.0	23.0
CA	City of Santa Ana Public Works	Santa Ana	52.0	23.0
CA	City of Torrance Water Department	Torrance	41.2	13.9
CA	Contra Costa Water District	Contra Costa County	47.7	5.4
CA	Cucamonga Valley Water District	Rancho Cucamonga, Upland, Ontario, and Fontana	46.0	18.0
CA	East Bay Municipal Utility District	Alameda and Contra Costa Counties	44.0	25.0
CA	East Orange County Water District-Wz	Orange	48.0	29.0
CA	Eastern Municipal Water District	Riverside County	59.0	24.0
CA	Helix Water District	San Diego County	48.1	11.8
CA	Irvine Ranch Water District	Irvine	39.0	25.0
CA	Joint Regional Water Supply System	Orange County	48.0	16.0
CA	Los Angeles Department of Water and Power	Los Angeles	45.0	28.0
CA	Marin Municipal Water District	Marin County	28.0	16.0
CA	Metropolitan Water District of Southern California	Los Angeles, Orange, San Diego, Riverside, San Bernardino, and Ventura counties	43.0	18.0
CA	San Diego Water Department	San Diego	63.8	15.1
CA	San Francisco Public Utilities Commission	San Francisco, San Mateo, Alameda and Santa Clara counties	42.0	34.0
CA	San Jose Water Company	San Jose	32.7	15.7
CA	Ventura Water Department	Ventura	30.0	25.0
CO	Aurora Water	Aurora	14.2	16.4
CO	City of Fort Collins Utilities	Fort Collins	32.1	19.0
CO	Colorado Springs Utilities	Colorado Springs	38.0	45.0
CO	Denver Water	Denver	29.0	18.0
CT	Aquarion Water Company	Bridgeport	38.0	33.0
CT	Metropolitan District Commission	Hartford	68.7	28.4
CT	South Central Connecticut Regional Water Authority	New Haven	29.0	22.0
CT	Waterbury Bureau of Water	Waterbury	45.0	43.0
DC	D.C. Water and Sewer Authority	Washington, D.C.	41.0	27.0
DE	Artesian Water Company	Newark	16.6	13.4
FL	Charlotte County Utilities	Charlotte, DeSoto, and Sarasota counties and the city of North Port	33.9	27.6
FL	City of Cocoa Claude H. Dyal Water Treatment Plant	Cocoa	38.3	40.3

FL	City of Hialeah - Department of Water and Sewers	Hialeah	30.0	28.0
FL	City of Lakeland, Department of Water Utilities	Lakeland	36.7	17.0
FL	City of North Miami Beach Public Services Department	North Miami Beach	13.8	6.9
FL	City of Port St Lucie Utility Systems Department	Port St Lucie	26.4	14.4
FL	Collier County Water Department	Naples	35.0	14.2
FL	Emerald Coast Utilities Authority	Pensacola	3.8	1.3
FL	Hillsborough County Water Resource Services-South Hillsborough	Lithia	24.0	7.7
FL	JEA	Jacksonville	37.9	16.8
FL	Lee County Utilities	Fort Myers	8.7	9.0
FL	Manatee County Utilities Department	Bradenton	40.7	30.6
FL	Melbourne Public Works & Utilities Department	Melbourne	44.6	11.8
FL	Miami-Dade Water and Sewer Department	Miami	30.0	28.0
FL	Orange County Utilities Deparment	Orange County	61.8	36.3
FL	Orlando Utilities Commission	Orlando	49.0	18.0
FL	Palm Bay Utilities	Palm Bay	22.8	7.1
FL	Palm Beach County Water Utilities Department	Palm Beach County	27.7	22.3
FL	Pasco County Utilities-Pasco County Regional Water System	Pasco County	17.7	9.4
FL	Pinellas County Utilities	Clearwater	36.5	21.4
FL	Tampa Water Department	Tampa	35.1	10.8
GA	Atlanta Department of Watershed Management	Atlanta	44.0	40.0
GA	Cherokee County Water and Sewerage Authority	Cherokee County	55.9	53.7
GA	Clayton County Water Authority	Clayton County	48.4	23.9
GA	Cobb County Water System	Cobb County and the cities of Acworth and Kennesaw	37.0	21.0
GA	Columbus Water Works	Columbus	30.3	18.5
GA	Dekalb County Watershed Management	DeKalb County	22.0	7.0
GA	Douglasville-Douglas County Water and Sewer Authority	Douglasville	52.4	31.0
GA	Gwinnett County Department of Water Resources	Buford	18.6	12.0
IA	Cedar Rapids Water Department	Cedar Rapids	1.4	0.4
IA	Des Moines Water Works	Des Moines	36.0	7.0

IA	Iowa American Water Company-Davenport	Davenport	92.0	27.0
ID	United Water Idaho Inc	Boise	17.6	13.0
IL	Chicago Department of Water Management	Chicago	19.6	10.5
IL	IL-American Water East St Louis	East St Louis	18.5	22.1
IL	IL-American Water Peoria	Peoria	32.5	11.5
IN	Citizens Water	Indianapolis	46.0	42.0
IN	Evansville Water and Sewer Utilities	Evansville	37.0	22.7
IN	Fort Wayne City Utilities-Three Rivers Filtration Plant	Fort Wayne	47.1	45.1
IN	Indiana American Water-Northwest	Gary	25.5	13.5
KS	Water District 1 of Johnson County	Johnson County	24.0	22.0
KS	Wichita Water Utilities	Wichita	25.0	11.0
KY	Kentucky-American Water	Lexington	47.0	31.0
KY	Louisville Water Company	Louisville	26.6	16.7
KY	Northern Kentucky Water District	Fort Thomas	72.0	58.0
LA	Jefferson Parish	Jefferson Parish	62.0	33.0
LA	Sewerage and Water Board of New Orleans	New Orleans	36.0	21.0
LA	Shreveport Department of Water and Sewerage	Shreveport	23.4	18.5
MA	Lowell Regional Water Utility	Lowell	49.2	14.9
MA	Massachusetts Water Resources Authority	Boston	8.7	8.7
MA	Springfield Water and Sewer Commission	Springfield	63.0	33.0
MA	Worcester DPW, Water Supply Division	Worcester	48.0	46.0
MD	Baltimore City Department of Public Works	Baltimore	52.0	54.0
MD	Washington Suburban Sanitary Commission	Potomac	41.9	34.7
MI	Detroit Water and Sewerage Department	Detroit	33.1	17.8
MI	Grand Rapids	Grand Rapids	37.6	26.0
MI	Lansing Board of Water and Light	Lansing	4.6	3.0
MN	City of Minneaplis Water Department	Minneapolis	32.1	26.3
MN	Saint Paul Regional Water Services	Saint Paul	44.6	27.1
MO	City of St Louis Water Division	St Louis	19.5	17.2
MO	City Utilities	Springfield	17.8	15.2

MO	Kansas City Water Services Department	Kansas City	8.4	17.1
MO	Missouri American Water-St Louis/St Charles County	St Louis	31.1	20.1
MT	City of Billings	Billings	39.5	35.5
NC	Cape Fear Public Utility Authority	Wilmington	61.0	13.1
NC	City of Asheville	Asheville	27.4	22.6
NC	City of Durham	Durham	44.6	28.0
NC	City of Greensboro Department of Water Resources	Greensboro	60.3	46.1
NC	City of Raleigh Public Utilities Department	Raleigh	33.7	15.2
NC	Onslow Water and Sewer Authority	Jacksonville	53.0	19.0
NC	Winston-Salem/Forsyth County Utility Commission	Clemmons	46.1	32.4
NE	Metropolitan Utilities District	Omaha	50.0	22.3
NJ	American Water Company-Coastal North	Shrewsbury	63.5	51.3
NJ	American Water Company-Ocean City	Ocean City	19.0	6.0
NJ	American Water Company-Short Hills	Short Hills	3.0	1.0
NJ	Middlesex Water Company	Woodbridge Township	45.0	28.6
NJ	New Jersey American Water-Delaware	Palmyra	37.0	10.0
NJ	New Jersey American Water-Elizabeth	Elizabeth	60.0	31.0
NJ	New Jersey District Water Supply Commission-Wanaque North	Wanaque	62.0	24.0
NJ	Passaic Valley Water Commission	Totowa Borough	27.0	44.0
NJ	United Water Bergen County	Bergen County	32.3	13.7
NM	Albuquerque Bernalillo County Water Utility Authority	Albuquerque	19.0	7.0
NV	City of Henderson	Henderson	61.0	21.0
NV	City of North Las Vegas Utilities Department	North Las Vegas	56.0	24.0
NV	Las Vegas Valley Water District	Las Vegas	62.0	27.0
NV	Truckee Meadows Water Authority	Reno, Sparks and Washoe County	30.9	30.4
NY	Buffalo Water Authority	Portions of the City of Buffalo	29.9	16.0
NY	City of Syracuse Water Department	Syracuse	46.0	22.0
NY	Erie County Water Authority	Portions of the City of Buffalo	39.0	17.0
NY	Mohawk Valley Water Authority	Utica	52.0	26.0
NY	Monroe County Water Authority	Greece	39.0	19.0

NY	New York City Department of Environmental Protection	New York	57.0	51.0
NY	Onondaga County Water Authority (OCWA)	Syracuse	64.6	37.9
NY	Rochester City	Rochester	46.0	32.0
NY	Suffolk County Water Authority	Portions of Suffolk County	7.4	0.9
NY	United Water New York	Clarkstown	23.9	13.9
NY	Yonkers City	Yonkers	40.0	47.1
OH	Akron Public Utilities Bureau	Akron	55.3	48.4
OH	City of Columbus Department of Public Utilities	Columbus	54.4	37.1
OH	City of Toledo Division of Water	Toledo	48.2	16.2
OH	Cleveland Division of Water	Cleveland	33.7	24.1
OH	Greater Cincinnati Water Works	Cincinnati	46.6	11.8
OK	City of Tulsa Water Supply System	Tulsa	52.0	16.0
OR	Eugene Water and Electric Board	Eugene	22.6	23.2
OR	Portland Water Bureau	Portland	22.0	26.0
PA	Allentown City Bureau of Water	Allentown	29.0	14.4
PA	Aqua Pennsylvania Inc Main Division	Bucks, Montgomery, Delaware, Philadelphia, and Chester counties	33.0	24.0
PA	City of Bethlehem	Bethlehem	34.7	31.7
PA	Pennsylvania American Water Company-Lake Scranton	Area of Scranton	34.0	18.0
PA	Pennsylvania American Water Company-Pittsburgh	Pittsburgh	60.1	14.9
PA	Philadelphia Water Department	Philadelphia	42.0	24.0
PA	Pittsburgh Water and Sewer Authority	Pittsburgh City	66.0	17.0
PA	West View Water Authority	West View Borough	48.0	16.4
RI	Providence Water	Providence	75.8	20.9
SC	Charleston Water System	Charleston	26.5	23.3
SC	City of Columbia	Columbia	29.0	24.0
SC	Greenville Water System	Greenville	14.0	11.9
SD	Sioux Falls	Sioux Falls	34.7	10.7
TN	Clarksville Water Department	Clarksville	42.0	30.0
TN	Knoxville Utilities Board	Knoxville	64.0	29.0
TN	Nashville Water Department #1	Nashville	38.4	31.9
TX	Arlington Water Utilities	Arlington	13.9	5.8
TX	Austin Water Utility	Austin	34.6	13.7
TX	City of Carrollton	Carrollton	13.5	13.0
TX	City of Garland	Garland	36.2	16.5
TX	City of Houston Public Works	Houston	17.0	9.0
TX	City of Irving	Irving	12.5	16.7
TX	City of Plano Utilities Operation Department	Plano	36.5	16.2

TX	Corpus Christi Water Department	Corpus Christi	58.4	18.7
TX	Dallas Water Utilities	Dallas	10.8	12.0
TX	El Paso Public Utilities Board Water Service	El Paso	29.3	5.6
TX	Lubbock Public Water System	Lubbock	15.0	4.1
UT	Weber Basin Water Conservancy District	Davis and Weber counties	27.6	25.2
VA	Arlington County	Arlington	49.0	35.0
VA	Chesterfield County Central Water System	Chesterfield	26.8	18.1
VA	City of Richmond	Richmond	24.0	27.0
VA	City of Virginia Beach Water Department	Virginia Beach	43.0	27.0
VA	Fairfax County Water Authority	Fairfax, Alexandria, Prince William, and Loudoun counties	27.0	15.0
VA	Henrico County Public Utilities	Henrico County	25.0	30.0
VA	Newport News Water Works	Newport News	19.0	17.0
VA	Norfolk Department of Utilities	Norfolk	47.0	32.0
VA	Western Virginia Water Authority	Roanoke	32.0	31.0
WA	City of Tacoma Water Division	Tacoma	29.7	38.7
WA	Seattle Public Utilities	Seattle	38.0	27.0
WI	Madison Water Utility	Madison	4.3	0.4
WI	Milwaukee Water Works	Milwaukee	10.0	2.4
WV	West Virginia American Water-Elk River Regional System	Kanawha, Boone, Putnam, Lincoln, Logan and Cabell counties	49.0	21.0

REFERENCES

1. Barlow J. 2004. Byproduct of water-disinfection process found to be highly toxic. University of Illinois News Bureau. Available: http://www.news.illinois.edu/news/04/0914water.html [accessed November 2012]
2. Bove F, Shim Y, Zeitz P. 2002. Drinking water contaminants and adverse pregnancy outcomes: a review. Environmental Health Perspectives 110 (Suppl 1): 61-74.
3. Brown 2010. D.C. water study sharpens view of lead threat. Washington Post. December 12, 2010. Available: http://www.washingtonpost.com/wp-dyn/content/article/2010/12/11/AR2010121102875.html [accessed November 2012]
4. Bond T, Huang J, Templeton MR, Graham N. 2011. Occurrence and control of nitrogenous disinfection by-products in drinking water--a review. Water Res. 45(15): 4341-54.
5. Bull RJ, Reckhow DA, Li X, Humpage AR, Joll C, Hrudey SE. 2011. Potential carcinogenic hazards of non-regulated disinfection by-products: haloquinones, halo-cyclopentene and cyclohexene derivatives, N-halamines, halonitriles, and heterocyclic amines. Toxicology 286(1-3): 1-19.
6. Cantor K, Villanueva CM, Silverman DT, Figueroa JD, Real FX, Garcia-Closas M, et al. 2010. Polymorphisms in GSTT1, GSTZ1, and CYP2E1, Disinfection Byproducts, and Risk of Bladder Cancer in Spain. Environmental Health Perspectives 118(11): 1545-50.
7. Chang C, Ho S, Wang L and Yang C. 2007. Bladder Cancer in Taiwan: Relationship to Trihalomethane Concentrations Present in Drinking- Water Supplies. Journal of Toxicology and Environmental Health Part A 70(20): 1752-7.
8. CBF. 2012. The Economic Argument for Cleaning Up the Chesapeake Bay and its Rivers. Chesapeake Bay Foundation. May 2012. Available: www.cbf.org/economicreport [accessed December 2012]
9. Cooke G, Carlson R. 1989. Reservoir Management for Water Quality and THM Precursor Control. AWWA Research Foundation and American Water Works Association.
10. Costet N, Villanueva CM, Jaakkola JJ, Kogevinas M, Cantor KP, King WD, Lynch CF, Nieuwenhuijsen MJ, Cordier S. 2011. Water disinfection by-products and bladder cancer: is there a European specificity? A pooled and meta-analysis of European case-control studies. Occup Environ Med. 68(5): 379-85.
11. CSP. 2007. Conservation Security Program (CSP) Program Assessment: A report from the Soil and Water Conservation Society and Environmental Defense. Conservation Security Program. Available: http://apps.edf.org/documents/7812_CSP%20Assessment%20-%2002.07.pdf [accessed November 2012]
12. DeAngelo AB, Daniel FB, Most BM, Olson GR. 1997. Failure of monochloroacetic acid and trichloroacetic acid administered in the drinking water to produce liver cancer in male F344/N rats. Journal of toxicology and environmental health 52(5): 425-45.
13. Edwards M, Triantafyllidou S, Best D. 2009. Elevated Blood Lead in Young Children Due to Lead-Contaminated Drinking Water: Washington, DC, 2001−2004. Environmental Science and Technology 43 (5): 1618–1623.
14. EPA. 2002. The Occurrence of Disinfection By-Products (DBPs) of Health Concern in Drinking Water: Results of a Nationwide DBP Occurrence Study. Available: www.epa.gov/athens/publications/reports/EPA_600_R02_068.pdf [accessed January 2012]
15. EPA. 2005. Economic Analysis for the Final Stage 2 Disinfectants and Disinfection Byproducts Rule. Available: http://water.epa.gov/lawsregs/rulesregs/sdwa/stage2/regulations.cfm [accessed December 2012]
16. EPA. 2006. Lead in DC Drinking Water: Changes in Lead Levels during Annual Switch to Free Chlorine. Available: http://www.epa.gov/dclead/chlorine.htm [accessed November 2012]
17. EPA. 2007. Lead in DC Drinking Water: Water Treatment News. Available: http://www.epa.gov/dclead/treatment_news.htm#disinfectant [accessed November 2012]
18. EPA. 2012a. Water: Stage 2 DBP Rule: Basic Information. Available: http://water.epa.gov/lawsregs/rulesregs/sdwa/stage2/basicinformation.cfm [accessed November 2012]
19. EPA. 2012b. Chloramines in Drinking Water. Available: http://water.epa.gov/lawsregs/rulesregs/sdwa/mdbp/chloramines_index.cfm [accessed November 2012]
20. EWG. 2012a. Troubled Waters. Farm pollution threatens drinking water. Environmental Working Group. Available: http://www.ewg.org/report/troubledwaters [accessed December 2012]
21. EWG. 2012b. Murky Waters. Forty years after the Clean Water Act became law, the data are clear: Iowa's rivers and streams are still polluted. Environmental Working Group. Available: http://www.ewg.org/research/murky-

waters [accessed December 2012]

22. EWG. 2007. Chlorine Pollutants at High Levels in D.C. Tapwater: New tests find high levels of hazardous chlorination byproducts in D.C. tap water. Environmental Working Group. Available: http://www.ewg.org/reports/dctapwater [accessed November 2012]
23. Hinckley AF, Bachand AM, Reif JS. 2005. Late pregnancy exposures to disinfection by-products and growth-related birth outcomes. Environmental health perspectives 113(12): 1808-13.
24. Hoffman CS, Mendola P, Savitz DA, Herring AH, Loomis D, Hartmann KE, Singer PC, Weinberg HS, Olshan AF. 2008. Drinking water disinfection by-product exposure and fetal growth. Epidemiology 19(5): 729-37.
25. Hwang BF, Jaakkola JJ. 2012. Risk of stillbirth in the relation to water disinfection by-products: a population-based case-control study in Taiwan. PLoS One. 7(3):e33949.
26. Levallois P, Gingras S, Marcoux S, Legay C, Catto C, Rodriguez M, Tardif R. 2012. Maternal exposure to drinking-water chlorination by-products and small-for-gestational-age neonates. Epidemiology. 23(2): 267-76.
27. Linder RE, Klinefelter GR, Strader LF, Narotsky MG, Suarez JD, Roberts NL, et al. 1995. Dibromoacetic acid affects reproductive competence and sperm quality in the male rat. Fundam Appl Toxicol 28(1): 9-17.
28. NHDES. 2006. Trihalomethanes: Health Information Summary. New Hampshire Department of Environmental Services. Available: www.des.nh.gov [accessed January 2013]
29. NTP 2011. Report on Carcinogens. National Toxicology Program, National Institutes of Health. Available: http://ntp.niehs.nih.gov/?objectid=03C9AF75-E1BF-FF40-DBA9EC0928DF8B15 [accessed November 2012]
30. NTP. 2007. NTP Report on the Toxicology Studies of Bromodichloromethane (CAS NO. 75-27-4) in Genetically Modified (FVB Tg.AC Hemizygous) Mice (Dermal, Drinking Water, and Gavage Studies) and Carcinogenicity Studies of Bromodichloromethane in Genetically Modified [B6.129-Trp53tm1Brd (N5) Haploinsufficient] Mice (Drinking Water and Gavage Studies). 07-4422: National Institutes of Health. ODHS. 2004. Haloacetic Acids. Technical Bulletin.: Oregon Department of Human Services; Environmental Toxicology Section.
31. ODHS. 2004. Haloacetic Acids. Technical Bulletin.: Oregon Department of Human Services; Environmental Toxicology Section.
32. OEHHA. 2010. Draft Public Health Goal for Trihalomethanes in Drinking Water. California Office of Environmental Health Hazard Assessment. Available: oehha.ca.gov/water/phg/pdf/THMPHG090910.pdf [accessed November 2012]
33. OEHHA. 2004. Evidence on the Developmental and reproductive Toxicity of Chloroform. California Office of Environmental Health Hazard Assessment.
34. Available: http://www.oehha.ca.gov/prop65/hazard_ident/pdf_zip/ChloroformHID.pdf [accessed November 2012]
35. Porter CK, Putnam SD, Hunting KL, Riddle MR. 2005. The effect of trihalomethane and haloacetic acid exposure on fetal growth in a Maryland county. American journal of epidemiology 162(4): 334-44.
36. PWD. 2009. Green City, Clean Waters: The City of Philadelphia's Program for Combined Sewer Overflow Control—A Long Term Control Plan Update. Summary Report. Philadelphia Water Department. Available: http://www.phillywatersheds.org/ltcpu/LTCPU_Summary_LoRes.pdf [accessed December 2012]
37. Plewa MJ, Wagner ED, Richardson SD, Thruston AD, Jr., Woo YT, McKague AB. 2004. Chemical and biological characterization of newly discovered iodoacid drinking water disinfection byproducts. Environmental Science and Technology 38(18): 4713-22.
38. Rusin PA, Rose JB, Haas CN, Gerba CP. 1997. Risk assessment of opportunistic bacterial pathogens in drinking water. Reviews of environmental contamination and toxicology 152: 57-83.
39. Summerhayes RJ, Morgan GG, Edwards HP, Lincoln D, Earnest A, Rahman B, Beard JR. 2012. Exposure to trihalomethanes in drinking water and small-for-gestational-age births. Epidemiology 23(1):15-22.
40. Toledano MB, Nieuwenhuijsen MJ, Best N, Whitaker H, Hambly P, de Hoogh C, Fawell J, Jarup L, Elliott P. 2005. Relation of trihalomethane concentrations in public water supplies to stillbirth and birth weight in three water regions in England. Environ Health Perspect. 113(2):225-32.
41. USDA. 2001. National Resources Inventory 2001: Annual NRI. United States Department of Agriculture.
42. USGS. 1999. The quality of our Nation's Waters-Nutrients and Pesticides: US Geological Survey Circular 1225. Available: http://pubs.usgs.gov/circ/circ1225/pdf/index.html
43. Villanueva C, Cantor K, Grimalt J, Malats N, Silverman D, Tardon A, et al. 2007. Bladder cancer and exposure to water disinfection by-products through ingestion, bathing, showering, and swimming in pools. American Journal of Epidemiology 165(2): 148-56.

44. Wright JM, Schwartz J, Dockery DW. 2003. Effect of trihalomethane exposure on fetal development. Occup Environ Med. 60(3): 173-80.

45. Xu X, Weisel CP. 2003. Inhalation exposure to haloacetic acids and haloketones during showering. Environmental Science and Technology 37(3): 569-76.

46. Yang X, Shang C, Shen Q, Chen B, Westerhoff P, Peng J, Guo W. 2012. Nitrogen origins and the role of ozonation in the formation of haloacetonitriles and halonitromethanes in chlorine water treatment. Environ Sci Technol. 46(23): 12832-8.