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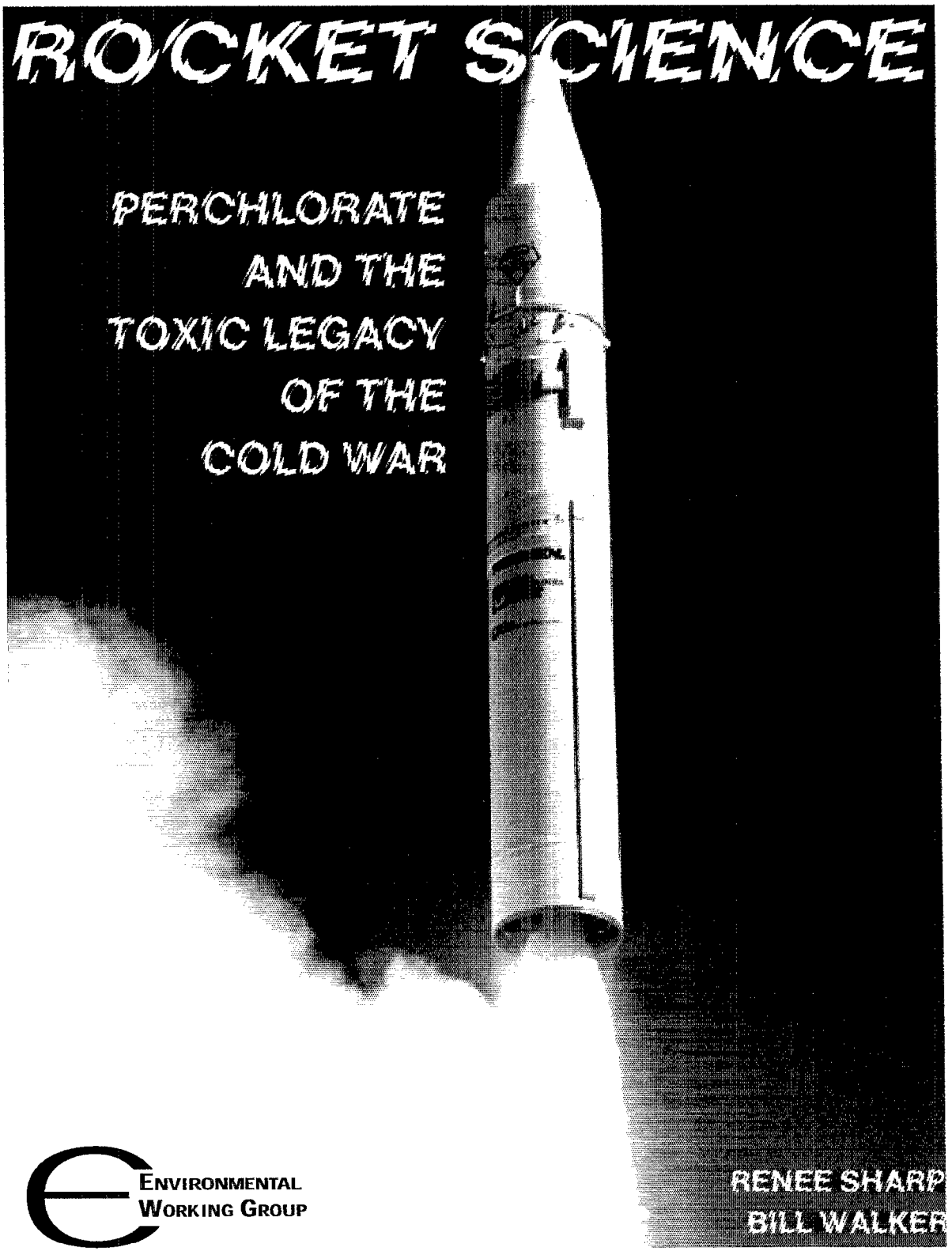
PERCHLORATE AND THE TOXIC LEGACY OF THE COLD WAR



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Executive Summary

Sources of drinking water for almost 7 million Californians and unknown millions of other Americans are contaminated with a toxic legacy of the Cold War: A chemical that interferes with normal thyroid function, may cause thyroid cancer and persists indefinitely in the environment, but is unregulated by the state or federal government.

Perchlorate, the main ingredient of missile and rocket fuel, has been detected in 58 California public water systems so far, but fewer than 15 percent of the state's drinking water sources have been sampled. Perchlorate has also been found in Lake Mead, Nev., and the Colorado River, which supply drinking water to more than half of Southern California as well as being a major source of water for Arizona and Nevada. The U.S. Environmental Protection Agency has found perchlorate-tainted water in 18 states and believes it exists wherever rocket fuel or rockets were made or tested – 39 states in all.

The EPA has found perchlorate-tainted water in 18 states and believes that contamination exists wherever rockets were made or tested.

Too much perchlorate can impair proper functioning of the thyroid gland, which controls growth, development and metabolism. Developing fetuses, infants and children with thyroid impairment may suffer mental retardation, loss of hearing and speech, or deficits in motor skills. In fact, improper regulation of thyroid function is the leading known cause of neurological impairment world-wide. At higher levels of exposure, perchlorate may also cause thyroid cancer and harm the immune system.

Perchlorate contamination of water and its effect on the thyroid have been known for decades, but neither California nor the federal government has established any enforceable health standard for perchlorate in drinking water. This year the EPA was scheduled to begin nationwide water sampling and issue its fourth provisional standard, but it will be years before there is an official state or federal drinking water standard.

These standards, however, will not be adequate to protect the public, particularly children. EWG calculates that the EPA's proposed standards would leave formula-fed infants exposed to between 7.5 and 2,000 times the safe level of perchlorate in drinking water.

Medical researchers are finding that even very low levels of perchlorate may affect the thyroid. But concerted pressure to set a looser standard is coming from a powerful alliance of chemical companies, aerospace contractors and

To fully protect children and other sensitive populations, safety standards for perchlorate in drinking water should be no higher than 4.3 parts per billion.

the U.S. Air Force. In a now-infamous experiment that has prompted a federal ethics investigation, defense contractors and the Air Force have sponsored tests in which human subjects were paid to swallow daily doses of perchlorate far exceeding the amount California health officials say is safe.

If a less protective standard is set, perchlorate polluters such as Lockheed Martin and Aerojet will save millions of dollars in cleanup costs. But no matter how strict the standards are, contractors have cut deals that will stick U.S. taxpayers with almost 90 percent of the cleanup bill. With cleanup of some sites estimated to take more than 200 years, the cost to taxpayers could reach billions of dollars.

EWG urges California and the EPA to set safety standards for perchlorate in drinking water that are fully protective of public health. The standard should be no higher than 4.3 ppb.

All human testing of perchlorate should be stopped. The U.S. military should be prohibited from lobbying to weaken environmental laws or regulations, and the corporations responsible for perchlorate contamination should pay for their fair share of cleanup.

A Toxic Legacy

Sources of drinking water for almost 7 million Californians and unknown millions of other Americans are contaminated with perchlorate, a chemical that disrupts normal thyroid function, may cause thyroid cancer and persists indefinitely in the environment, but is unregulated by the state or federal government.

State and federal regulators are dragging their feet on safety standards for a thyroid toxin that contaminates hundreds of water supplies nationwide.

An Environmental Working Group investigation found that the state has known about contamination of California groundwater by perchlorate, the main ingredient in rocket and missile fuel, for almost 50 years. Groundwater is an important source of drinking water in California, contributing about one-sixth of the state's drinking water during an average year, and almost one-third in drought years. (CADWR 1998.) Yet today, state and federal regulators are still dragging their feet on setting safety standards for perchlorate in drinking water, in part because of concerted pressure from the U.S. military, the space program and major defense contractors. As a result, standards that emerge are unlikely to provide adequate protection for developing fetuses, infants or children.

The human thyroid gland controls growth, development and metabolism. Perchlorate affects the thyroid because it is taken up preferentially by the gland in place of iodide, a necessary nutrient. This, in turn, can affect thyroid hormone levels. An underactive thyroid gland in adults can lead to fatigue, depression, anxiety, unexplained weight gain, hair loss, and low libido. More serious, however, are the effects of thyroid hormone disruption in the developing fetus and child. Small changes in maternal thyroid hormone levels during pregnancy have been associated with reduced IQs and attention deficit in children. Fetuses, infants and children who experience bigger changes in hormone levels may suffer mental retardation, loss of hearing and speech, or deficits in motor skills.

There are many scientific unknowns surrounding the health effects of perchlorate. To date, none of the scientific studies performed on the effects of perchlorate have adequately addressed how perchlorate might affect neurological development of children whose mothers were exposed to perchlorate while pregnant. Nor has there been any research conducted to determine whether perhclorate is concentrated in breast milk, which is considered a distinct possibility, if not likely. (EPA 1999c.)

What has been documented through animal research, however, is that perchlorate can disrupt the thyroid hormone system at low levels of exposure,

and that this may also lead to thyroid cancer, the disruption of female menstrual cycles, and the weakening of the immune system at higher levels. (EPA 1998.)

As of June 2001, perchlorate has been detected in 197 water sources in 58 different public water systems in California, in some cases at levels far above the state considers safe to drink. These systems serve almost 7 million people, mostly in the San Gabriel Valley and Inland Empire regions of Southern California and the Rancho Cordova area of Sacramento County. (Fig. 1, Table 1.) In addition, perchlorate was detected in 56 other water sources that have only been tested once, so the state does not consider the contamination to be confirmed. The state has so far sampled only about 15 percent of California's drinking water sources, raising the strong likelihood of undetected contamination (CADHS 2001).

The state's "action level" doesn't require suppliers to shut down contaminated wells, or even to tell customers they've been drinking perchlorate.

Significant concentrations of perchlorate are also found in the Colorado River and in Lake Mead. The lower Colorado supplies drinking water to more than half of Southern California, and both the river and Lake Mead are major sources of drinking water for Arizona and Nevada, including Phoenix and Las Vegas. The Colorado also irrigates almost one million acres of some of the nation's most productive farmland in California and Arizona, raising concerns about the toxicity of lettuce and other crops that may absorb perchlorate.

Nationwide, the U.S. Environmental Protection Agency (EPA) has found perchlorate-tainted water in 18 states and believes it poses a threat to drinking water wherever rocket fuel or rockets were made, tested, or disposed, and wherever other large scale uses of perchlorate are found - as many as 39 states in all. (Fig. 2, Table 2.) So far, only a small percentage of these sites have been tested for contamination. According to the EPA, however, soil and/or groundwater contamination have been found at essentially all such locations where an effort to test has been made. (EPA 2001a.) According to the EPA, "[A]t essentially every listed facility where an effort has been made to test for perchlorate, perchlorate has been found in the soil or groundwater."

In 1999 the EPA listed perchlorate under the federal Unregulated Contaminant Monitoring Rule, with monitoring beginning in January of 2001. As a result, all large public water systems and a sample of small systems nationwide are required to conduct a one-year, one-time monitoring program for perchlorate before the end of 2003.

Perchlorate contamination of California's water was first detected almost 50 years ago, and perchlorate's damaging effect on the thyroid has been known for just as long. But neither the California Department of Health Services (DHS) nor the EPA has established any enforceable health standard for safe levels of perchlorate in drinking water.

The state has set a so-called action level for perchlorate in drinking water, above which it recommends that water suppliers shut down the contaminated source. But "action level" is a misnomer. Although many drinking water sources where perchlorate has been detected above the action level have been voluntarily closed, there is no enforceable requirement that suppliers close the source, or even that they inform people who have been drinking the water. The EPA was expected to issue its latest "provisional" national standard for perchlorate in drinking water this year but delays in the submittal of data have "postpone[d] the assessment indefinitely." (EPA 2001a.) It is predicted to be several more years before there is an official state or federal drinking water standard.

EPA's proposed standard would leave formula-fed infants exposed to between 7.5 times to more than 2,000 times the safe level of perchlorate.

It is already clear that the EPA's new provisional standard not only will lack teeth, but will be set at a level that will not protect the public, particularly children, from harmful levels of perchlorate in drinking water. EWG calculated that the EPA's most likely proposed standard would leave infants who are fed formula mixed with tap water - about 40 percent of all babies - exposed to between 7.5 times to more than 2000 times the safe level of perchlorate, depending on the margin of safety applied. EWG's calculations show that current levels of perchlorate found in Lake Mead and the Colorado River are not safe for drinking water.

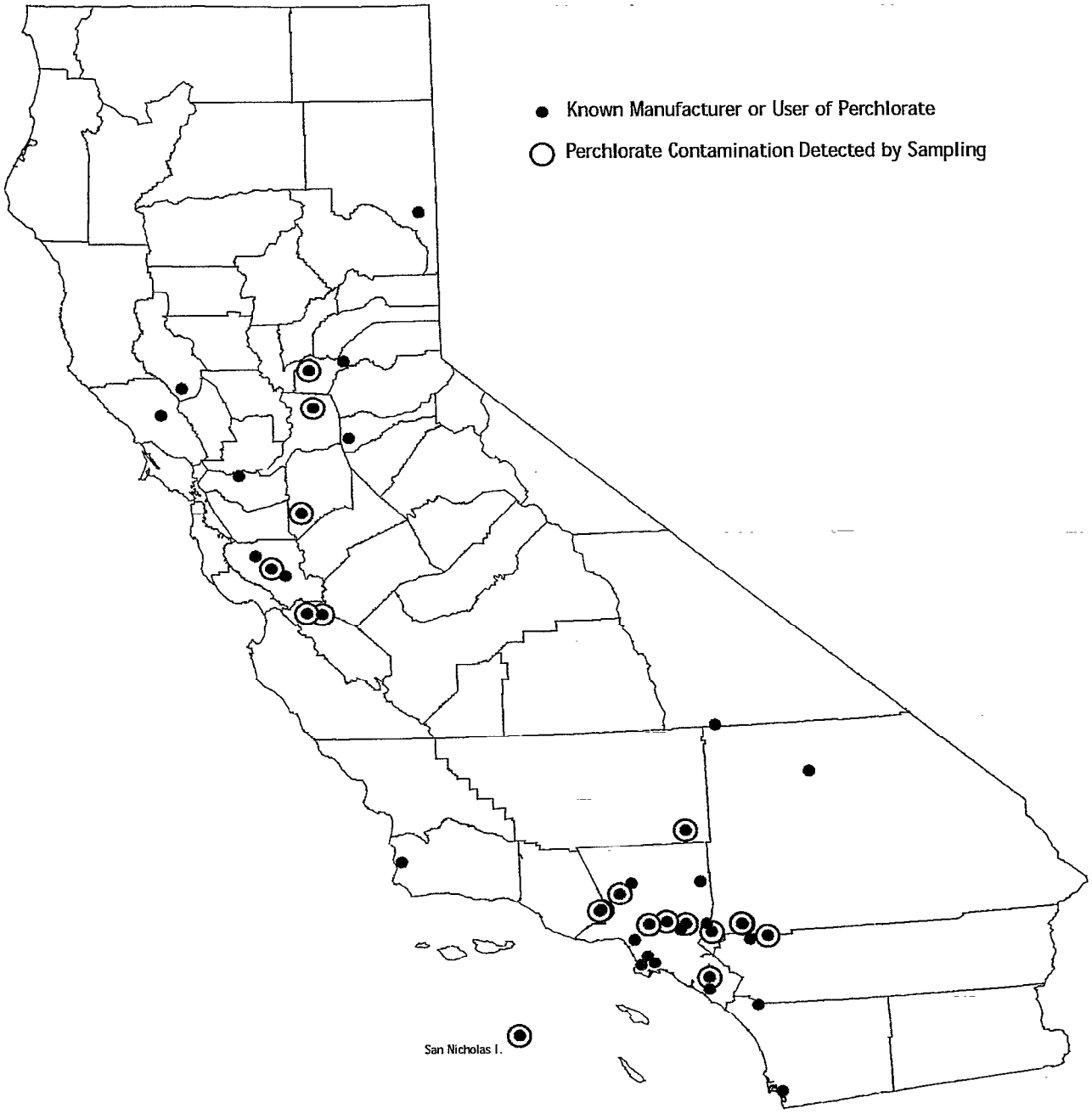
EWG analysis shows that bottle-fed infants who consume water in formula contaminated with perchlorate at the EPA's current proposed level (32 ppb) would be getting a dose of perchlorate only nominally lower than may affect thyroid hormone levels (40 ppb). Breastfed infants are also at risk because small changes in maternal thyroid hormones during pregnancy can have adverse effects on the fetus and because perchlorate may be passed on or concentrated in breast milk. (Escobar et al. 2000; EPA 1999c)

Each time the federal government has set a new provisional perchlorate safety standard, the recommended "safe" levels have been raised. The EPA's first provisional standard, set in 1992, was 4 parts per billion (ppb) of perchlorate in drinking water. In 1995, the provisional standard was revised as a "safe" range of 4 ppb to 18 ppb. In 1998, the EPA's provisional standard was raised to 32 ppb. The California action level, set in 1997, is 18 ppb, and the level at which the state recommends, but does not require, shutting off the contaminated source of water is 40 ppb. (Figure 3.)

But in calculating the previous provisional standards, which the state relied on in setting its action level, the EPA ignored critical data, neglected the needs of sensitive populations, and significantly underestimated the scientific uncertainties surrounding perchlorate's health effects.

Continued on page 12

Figure 1. Known and suspected perchlorate contamination in California.



SOURCE: EWG, from CA DHS and US EPA.

Figure 2. Known and suspected perchlorate contamination in the U.S.

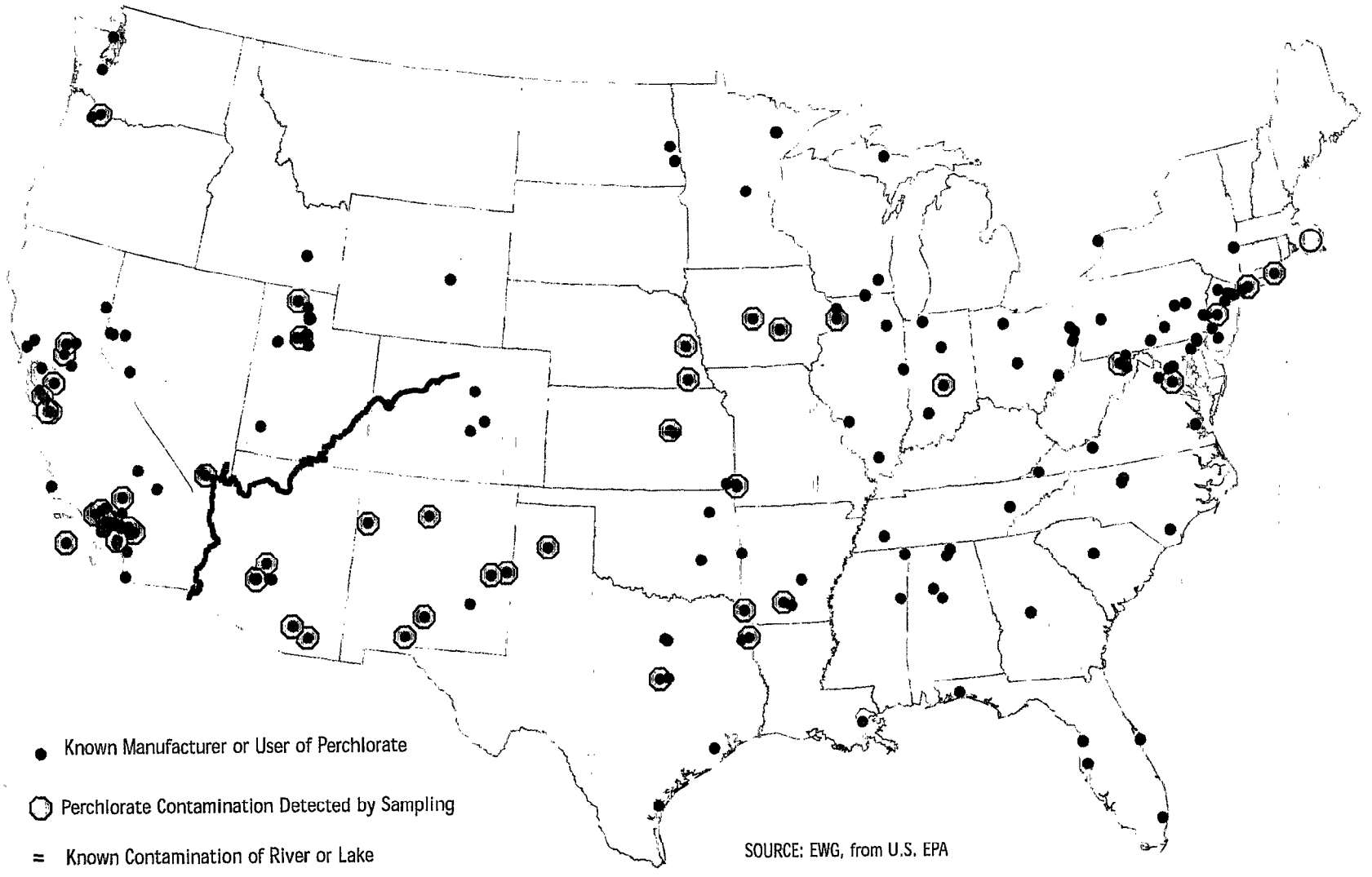


Table 1. Perchlorate contamination detected in California water systems.

County	Water System	Contam. Wells	Avg. Level Perchlorate (ppb)	Max. Level Perchlorate (ppb)	Population Served
Los Angeles	Azusa Light and Water	1	8.1	12.0	103,616
	Bellflower - Somerset MWC	1	6.4	6.7	25,000
	Cal. American Water Co.- San Marino	5	6.2	20.0	47,656
	California Domestic Water Company	1	5.3	5.6	619
	California Water Service Co.- East Los Angeles	1	7.2	7.6	153,280
	Covina City Water Dept.	1	21.4	23.0	47,988
	Glendale City Water Dept.	1	5.2	5.2	200,000
	Industry Waterworks System	3	9.2	14.0	5,000
	La Canada Irrigation Dist.	1	5.4	6.0	9,500
	La Puente Valley City Water Dept.	3	93.5	159.0	7,500
	La Verne City Water Dept.	6	13.9	22.0	34,009
	Las Flores Water Co.	1	5.8	8.0	4,854
	Los Angeles City Dept. of Water & Power	3	NA	20.1	3,600,000
	Lincoln Avenue Water Company	2	6.3	16.0	16,000
	Monrovia City Water Dept.	1	6.6	7.3	40,050
	Monterey Park City Water Dept.	2	8.7	14.0	57,000
	Newhall City Water Dept.	1	15.7	19.0	11,219
	Park WC – Bellflower-Norwalk	1	5.6	7.1	64,608
	Pasadena City Water Dept.	12	9.0	54.0	142,500
	Pomona City Water Dept.	18	10.7	19.0	131,723
	Rubio Canon Land & Water Assoc.	1	5.1	6.0	9,619
	San Gabriel Valley Water Co. - El Monte	4	25.3	74.0	153,657
	Santa Clarita Water Company	2	23.3	47.0	69,000
	Southern Cal. Water Company - Claremont	1	6.8	7.4	34,168
	Southern California Water Company - San Dimas	3	6.4	9.0	51,282
	South Pasadena City Water Dept.	1	5.7	6.0	24,000
	Suburban Water Systems	8	11.5	39.0	91,102
	Valencia Heights Water Company	4	10.9	33.0	4,600
	Valencia Water Company	1	10.0	14.0	60,000
	Valley County Water District	3	42.9	94.0	55,000
	Valley Water Company	4	5.9	8.0	9,477
	Whittier City Water Dept.	1	4.0	4.0	48,000

SOURCE: EWG, from CA DHS

Table 1. Perchlorate contamination detected in California water systems.

County	Water System	Contam. Wells	Avg. Level Perchlorate (ppb)	Max. Level Perchlorate (ppb)	Population Served
Orange	City of Tustin	4	7.5	10.7	52,100
	City of Anaheim	4	6.0	7.2	292,900
	City of Fullerton	1	5.4	5.5	117,420
	City of Santa Ana	1	5.3	5.5	293,700
	Page Avenue Mutual Water Company	1	7.3	7.7	185
	Southern California Water Company – W. Orange	2	6.1	7.2	84,737
	Tract 1322 Water System Inc.	1	7.2	7.2	NA
	Villa Capri Mobile Estates	1	5.5	5.6	616
Riverside	City of Corona	5	8.3	10.2	104,000
	Gage Canal Company	1	NA	23.0	354
	City of Riverside	20	10.4	55.0	245,000
	Rubidoux Community SD	3	9.5	12.0	22,800
Sacramento	Mather Field Water System	3	70.2	130.0	5,100
	Cordova Water Service	10	87.3	400.0	41,840
	Sacramento County MWD	2	NA	280.0	150,000
San Bernardino	City of Chino	5	11.6	21.0	52,130
	City of Loma Linda	4	15.6	35.0	20,000
	Cucamonga CWD	1	6.5	6.5	128,000
	East Valley WD	4	NA	13.0	61,000
	Redlands City MUD	8	29.6	130.0	69,300
	Rialto City	3	26.4	80.0	48,418
	San Bernardino City	1	NA	6.4	40,000
	San Gabriel Valley WC – Fontana	6	8.9	17.3	102,599
	Victoria Farms MWC	2	35.4	63.0	1,000
	West San Bernardino CWD	3	190.7	820.0	41,454
Ventura	USN San Nicholas Island	2	8.6	11.6	163

SOURCE: EWG, from CA DHS

Table 2. U.S. sites where perchlorate contamination has been detected.

Location		Facility	Source of Contamination	Type of Contamination	Maximum Perchlorate Level (ppb)
	Colorado River				9
	Lake Mead				24
AZ	Benson	Apache Nitrogen Products	Explosives manufacturing	Monitoring well	670
	Gila R. Indian Res.	Aerodyne	Propellant testing	Monitoring well	18
	Goodyear Airport	Unidynamics Phoenix, Inc.	Explosives/ordnance mfg	Monitoring well	80
	Maricopa County	Unidynamics Phoenix, Inc.	Explosives/ordnance disposal	Public water supply	(4)
				Soil	NA
	Phoenix	Universal Propulsion	Rocket manufacturing	Soil	NA
	Tucson	Davis Monthan Air Force Base	Explosives/propellant disposal	Soil	NA
AR	East Camden	Atlantic Research	Rocket manufacturing	Monitoring well	1,500
				Surface water	480,000
				Soil	NA
CA	Baldwin Park	Aerojet General	Rocket manufacturing	Public water supply	159
				Monitoring well	2,180
	Edwards	Edwards AFB	Rocket research	Monitoring well	300
	Glen Avon	Grand Central Rocket	Dumping at Stringfellow pits	Private well	81
	Glendale	Grand Central Rocket	Rocket manufacturing	Monitoring well	84
	Hollister	Whittaker Ordnance	Ordnance manufacturing	Private well	810
				Monitoring well	88
	Lincoln	Alpha Explosives	Explosives manufacturing	Monitoring well	67,000
				Surface water	NA
	Orange County	El Toro Marine Corps Air Station	Explosives disposal	Monitoring well	380
	Pasadena	NASA Jet Propulsion Lab	Rocket research	Public water supply	54
	Rancho Cordova	Aerojet General	Rocket manufacturing	Public water supply	260
				Monitoring well	640,000
	Redlands	Lockheed Propulsion	Rocket manufacturing	Public water supply	87
	Rialto	B.F. Goodrich	Rocket research & mfg	Public water supply	811
	San Jose	United Technologies	Rocket testing	Monitoring well	180,000
	San Nicholas I.	US Navy Firing Range	Explosives	Public water supply	12
	Santa Clarita	Whittaker-Bermite Ordnance	Ordnance manufacturing	Public water supply	47
	Santa Susana	Boeing/Rocketdyne, NASA, DOE	Rocket research, testing, prod.	Monitoring well	750
	Tracy	Lawrence Livermore Laboratory	DOE explosives research	Monitoring well	84
IN	Greenwood	American Water Works Service	Unknown	Public water supply	(4)
IA	Clinton	American Water Works Service	Unknown	Public water supply	(6)
	Ewart	Unknown	Unknown	Monitoring well	29
	Napier	Unknown	Unknown	Monitoring well	10
KS	Herington	Ammunition facility	Ammunition	Monitoring well	9

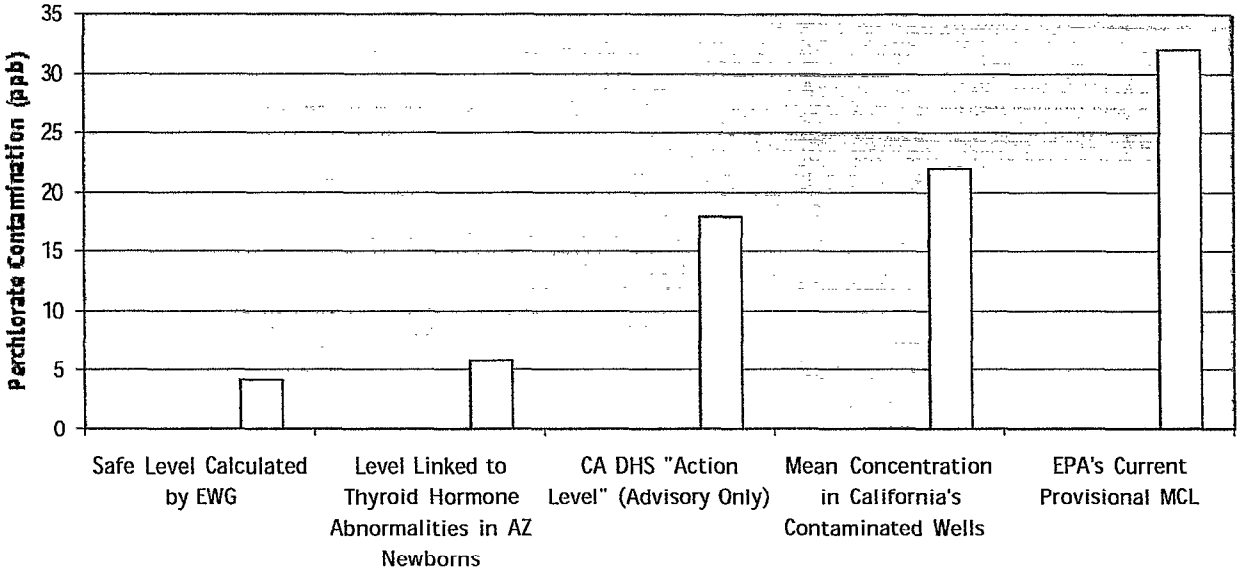
SOURCE: EWG, from EPA 2001b. All reports have been confirmed by federal, state or county agencies except (levels in parentheses).

Table 2. U.S. sites where perchlorate contamination has been detected.

Location		Facility	Source of Contamination	Type of Contamination	Maximum Perchlorate Level (ppb)
MA	Barnstable Co.	Mass. Military Reservation	Rocket disposal	Monitoring well	100
MD	Indian Head	Naval Surface Warfare Center	Propellant handling	Surface water	>1,000
MO	Joplin	ICI Explosives	Explosives facility	Monitoring well	107,000
NE	Lewiston	Unknown	Agricultural chemicals	Private well	5
	Mead	Unknown	Fireworks facility	Monitoring well	24
NV	Henderson	American Pacific Corp/PEPCON	Perchlorate mfg	Monitoring well	600,000
	Henderson	Kerr-McGee/BMI	Perchlorate mfg	Public water supply	16
				Monitoring well	3,700,000
				Surface water	120,000
NM	Alamogordo	Hollomon Air Force Base	Rocket testing	Monitoring well	40
				Seasonal surface water	16,000
				Soil	NA
	Clovis	American Water Works Service	Unknown	Public water supply	(4)
	Gallup	Fort Windgate Depot Activity	Explosives disposal	Monitoring well	2,860
	Los Alamos	Los Alamos National Lab	DOE chemical lab	Public water supply	3
				Monitoring well	220
				Deep borehole water	1,662
	Melrose	Melrose Air Force Range	Explosives	Public water supply	25
	White Sands	White Sands Missile Range	Rocket testing	Monitoring well	21,000
				Soil	NA
NY	Westhampton	Unknown	Unknown	Public water supply	16
				Monitoring well	3370
	Yaphank	Unknown	Unknown	Private well	24
				Monitoring well	122
PA	Yardley	American Water Works Service	Unknown	Public water supply	(5)
TX	Amarillo	PANTEX (DOE)	Explosives	Monitoring well	5
	Karnak	Longhorn Army Depot	Propellant handling	Monitoring well	169,000
				Surface water	NA
				Soil	NA
	McGregor	McGregor Naval Weapons Plant	Propellant handling	Monitoring well	91,000
				Surface water	NA
				Soil	NA
	Texarkana	Red River Army Depot	Propellant handling	Monitoring well	80
UT	Magna	Alliant Tech Systems	Rocket manufacturing	Public water supply	16
	Promontory	Thiokol	Rocket manufacturing	Public water supply	42
WA	Vancouver	Camp Bonneville	Explosives/propellant disposal	Soil	NA
WV	Rocket Center	Allegheny Ballistics Lab	Rocket research production	Groundwater discharge	400

SOURCE: EWG, from EPA 2001b. All reports have been confirmed by federal, state or county agencies except (levels in parentheses).

Figure 3. EPA's provisional perchlorate standard is at least 7.5 times too high.



SOURCE: EWG, from U.S. EPA, CA DHS and Brechner et al. 2000

Continued from page 5

The EPA ignored a study that found perchlorate to significantly affect thyroid hormones at a level ten times lower than the study on which it based the 1998 provisional standard. Most significantly, the agency based the provisional standards on adult rather than infant or child body weights, despite recognizing that perchlorate "may pose a serious threat to developmental processes in children." (EPA 2001a.)

While regulators have been steadily relaxing standards, medical research has been continually lowering the threshold at which perchlorate is known to have harmful effects.

Last year, a study by researchers with the Arizona state health department, of newborn infants whose mothers drank water from Lake Mead, found abnormal levels of a thyroid hormone in babies whose mothers were exposed to levels of perchlorate that were less than one-fifth the current EPA provisional standard and only one-third of the California action level. EWG calculates that to adequately protect infants and children, perchlorate standards should be at least four times, and as much as 1,000 times, more stringent than California's current action level. (Table 3.)

Many sites of perchlorate pollution are contaminated far above levels that are known to have negative health effects. In California, concentrations of perchlorate in groundwater at Superfund cleanup sites have been detected at

Table 3. Seventy percent of contaminated wells in California have not been shut down.

County	Contaminated Water Sources	Contaminated Water Systems	Max. Perchlorate Level Detected (ppb)	Contaminated Sources Still Active	Avg. ppb in Contaminated Active Sources	Pop. Served by Contaminated Active Sources
Los Angeles	99	32	159	77	9.1	5,098,371
San Bernardino	37	10	820	20	8.5	462,901
Riverside	29	4	55	25	10.2	473,154
Orange	15	8	10.7	13	6.4	841,658
Sacramento	15	3	400	3	4.9	41,840
Ventura	2	1	11.6	0		163
Total	**197**	**58**		**138**		**6,918,087**

SOURCE: EWG, from CA DHS.

hundreds of thousands of parts per billion. According to the most recent data from the Department of Health Services, the average concentration in contaminated sources is 83 ppb in Sacramento County, 36 ppb in San Bernardino County and 14 ppb in Los Angeles County.

Some contaminated wells have been shut down, but many are still in service. In Sacramento County, three of the 15 known contaminated sources are still delivering tap water to homes. In San Bernardino County, 20 of 37 contaminated wells are active, and in Los Angeles County, 77 of 99 contaminated sources are active. Statewide, 70 percent of known contaminated sources are still delivering water to customers. And sources that are listed as "inactive" may not be permanently closed, just not used for 12 consecutive months. (Table 3.)

In November 2000, concentrations of perchlorate in already treated drinking water drawn from Lake Mead reached a high of 24 ppb, prompting the Las Vegas water utility to temporarily shut off intake from the lake. Since monitoring of Lake Mead began in 1997, perchlorate levels in treated water from the lake have averaged 9 ppb, about the same level currently found in the lower Colorado River. Perchlorate levels as high as 1,700 ppb have been detected in the Lake Mead drainage basin.

Concerted pressure to set a looser, less protective drinking water standard is being applied at both the state and federal regulatory levels by a powerful alliance of opponents: the sole remaining U.S. manufacturer of perchlorate; giant aerospace contractors, whose rocket-making and -testing sites, and the communities surrounding them, are contaminated with the chemical; and the U.S. Air Force, which commissioned the contractors' work with perchlorate.

In California the defense contractors responsible for most perchlorate contamination are Lockheed Martin of Bethesda, Md., in the San Gabriel Valley and Inland Empire, and Aerojet, a division of Sacramento-based GenCorp, in

Sacramento County and the San Gabriel Valley. They are also major players in the Perchlorate Study Group, a chemical industry task force that, in conjunction with the Air Force, sponsors perchlorate research and meetings with regulators for the explicit purpose of delaying or weakening proposed standards.

In a scientifically invalid and morally unethical attempt to prove that perchlorate isn't so dangerous, Lockheed Martin, other companies in the Perchlorate Study Group and the Air Force have sponsored tests in Southern California, Oregon and other locations in which human subjects were paid to ingest daily doses of perchlorate. In one study, which began in August 2000 at Loma Linda University Medical School near San Bernardino, so-called "volunteers" were paid $1,000 to ingest, every day for six months, doses of perchlorate up to 83 times higher than the safe daily intake recommended by the State of California.

In November 2000, EWG obtained and published Loma Linda documents that showed these human guinea pigs were not fully informed of the dangers of perchlorate or the tests' true purposes: To help the Perchlorate Study Group resist stricter regulations and help Lockheed fight lawsuits from San Bernardino County residents whose drinking water was contaminated by perchlorate. (EWG 2000.) A month later, the U.S. Office for Human Research Protections launched an investigation, still ongoing, to determine whether the Loma Linda tests violate the ethical standards required for research facilities with federal contracts.

Big defense contractors who made millions from government-funded perchlorate work are cutting deals with the Defense Department that will stick taxpayers with most of the costs of cleanup.

Perchlorate contamination is not removed by conventional water treatment processes, nor by technologies that remove other common groundwater pollutants. Cleaning up the perchlorate mess, therefore, is expected to be lengthy and expensive. Groundwater cleanup at just one part of the Aerojet Superfund site in Sacramento County is predicted to cost at least $55 million and, incredibly, take 240 years to complete. If a less protective state or federal drinking water standard is set, Aerojet and the parties responsible for perchlorate contamination will save millions of dollars in cleanup costs.

But no matter how strict or lax the eventual standards are, the defense contractors - who for decades have pocketed big profits from their government-funded perchlorate work - have cut deals with the Defense Department that will stick taxpayers with most of the costs of cleanup. Two years ago, Aerojet negotiated an extraordinarily favorable deal with the government in which 88 percent of cleanup costs are recoverable from future military contracts. (Aerojet 2000.) The exact percentage negotiated by Lockheed Martin is secret, but knowledgeable sources say Lockheed's deal is equal to or better than Aerojet's. (EWG 2001.) The eventual cost to U.S. taxpayers of cleaning up the mistakes of the military and its contractors will reach billions of dollars.

Recommendations

- The State of California and the EPA should act promptly to set and enforce health-based safety standards for perchlorate in drinking water.

- State and federal standards for perchlorate in drinking water should be fully protective of public health, especially the health of developing fetuses, infants and children. The standard should also take into consideration all relevant scientific data, the needs of hypothyroid individuals, and the significant uncertainties. The drinking water standard should be no higher than 4.3 ppb.

- All human testing of perchlorate should be stopped immediately and tests on humans of any pollutant, pesticide or other toxic chemical should be banned.

- The Air Force, or any other branch of the U.S. military, should be prohibited from lobbying to weaken existing or proposed environmental laws or regulations.

The military should be prohibited from lobbying to weaken environmental laws or regulations.

- The corporations responsible for perchlorate contamination, and who have profited immensely from government contracts, should pay their share of cleanup. The U.S. military clearly shares responsibility, but making taxpayers pay for 90 percent of the cleanup of operations that made aerospace giants millions in profits is an egregious example of the "double-dipping" defense contractors are notorious for.

- Perchlorate polluters and the government should invest significantly more money into research on new cleanup technologies, and cleanup schedules must be greatly accelerated.

A Perchlorate Primer

Perchlorate consists of an atom of chlorine surrounded by four atoms of oxygen. It occurs as ammonium, potassium, magnesium or sodium salts. These perchlorate salts bind weakly to soil particles and are not significantly broken down in the environment. (EPA 1998.) In water, however, perchlorate salts are extremely soluble and highly mobile, migrating faster and farther than many other water contaminants. Together, these properties make perchlorate a particularly persistent and problematic pollutant once it contaminates groundwater.

Perchlorate salts are used in a variety of products as diverse as electronic tubes, car air bags, leather tanning and fireworks. Perchlorate was once used as a medical treatment for patients with severe hyperthyroidism, before serious side effects all but discontinued its use in the 1960s. (EPA 1998.) It is still used on a very limited scale in medicine for diagnosis and imaging. But perchlorate's main use is as an explosive propellant: Ninety percent of the perchlorate produced goes into solid rocket fuel for Air Force missiles and the NASA space shuttle. (EPA 1998.)

Ninety percent of the 20 million pounds of perchlorate produced each year goes into solid rocket fuel for Air Force missiles and the NASA space shuttle.

Large-scale production of perchlorate began in the 1940s and expanded along with the growth of the postwar military-industrial complex. In recent years perchlorate production reached almost 20 million pounds annually, but it fluctuates depending on demand by the military and the space program. For decades the two major perchlorate manufacturers have been American Pacific Corp. of Las Vegas and Kerr-McGee Corp. of Oklahoma City. American Pacific gained sole control of the industry in 1998 when Kerr-McGee sold its perchlorate operations to its rival for $39 million. In fiscal 2000, American Pacific reported income of $4.25 million on sales of $67.4 million, with about 70 percent coming from sales of perchlorate to aerospace and defense contractors.

Since the early 1950s, manufacture of perchlorate was centered at the American Pacific and Kerr-McGee plants outside Las Vegas, both in areas that drain into Lake Mead. In 1988, a series of explosions destroyed the American Pacific plant, leaving two people dead, more than 300 injured and a 400-foot crater in the desert. American Pacific built a new facility near Cedar City, Utah; in 1997 an explosion there killed one worker and critically injured another.

Perchlorate impairs normal thyroid function because it is taken up preferentially by the thyroid gland in place of idiode. The thyroid gland is therefore deprived of iodide, a necessary nutrient which it is designed to concentrate; and without idione, thyroid hormone is inactive. As a result,

perchlorate can disrupt the delicate balance of hormone levels in the body which are crucial for healthy metabolism, growth and development.

This effect has been known for decades, but recent research has found that perchlorate can affect human thyroid hormone levels at extremely low concentrations. Furthermore, studies have shown that perchlorate's effect on the thyroid may extend to thyroid cancer. Yet despite the numerous studies that have been conducted on the health effects of perchlorate, critical gaps in scientific understanding remain – most critically, studies that address the neurological development of fetuses and infants and studies that examine the possible concentration and transfer of perchlorate in breastmilk.

Perchlorate's effect on thyroid function was discovered in 1952 and has been confirmed by a series of studies since then. (Stanbury and Wyngaarden 1952; Kessler and Krunkemper 1966; Lampe et al. 1967; Brown-Grant and Sherwood 1971; Gauss 1972; Mannisto 1979.) Scientists also discovered perchlorate's pronounced effects on developing animals very early on. Studies in the 1950s showed that perchlorate could pass through the placenta and affected fetuses more seriously than adults. (Postel 1957; Brown-Grant and Sherwood 1971.)

Last year the Arizona health department found a significant increase in abnormal levels of a thyroid hormone in infants whose mothers drank perchlorate-tainted water from the Colorado River while pregnant.

Until the mid-1960s, perchlorate was used to treat a severe hyperthyroidism condition known as Graves' disease. Reports of adverse effects of perchlorate treatment began to appear in the medical literature in the early 1960s. Although some of these reactions were minor, such as skin rashes and nausea, there were also numerous reports of patients suffering from fatal reactions or severe side effects where blood cell production was seriously compromised or failed outright. (Southwell and Randall 1960; Hobson 1961; Johnson and Moore 1961; Fawcett and Clarke 1961; Krevans et al. 1962; Gjemdal 1963; Sunar 1963.) One study found that eleven of 76 severely ill Graves' disease patients treated with perchlorate suffered at least moderate and sometimes fatal hematological side effects. (Barzilai and Sheinfeld, 1966.)

Scientists did not begin to examine the potential health effects of perchlorate at low doses until recently. In 1995 the EPA found that laboratory animals developed thyroid disorders after two weeks of drinking perchlorate-laced water. (Caldwell et al. 1995; EPA 1998.) In a 90-day drinking water study, researchers found significant reductions of thyroid hormone levels from perchlorate doses more than 10 times lower than those consumed in the two-week test, but no lower dose was tested. (Springborn 1998.) The most recent study to suggest health effects from low-level exposure comes from Arizona, where last year the state health department found a significant increase in abnormal levels of a thyroid hormone in infants whose mothers drank perchlorate-tainted water from the Colorado River while pregnant. (Brechner et al. 2000.) The study

compared newborns in Yuma and Flagstaff. Levels of perchlorate are undetectable in the drinking water in Flagstaff. But at the time the data was collected, Yuma's water, drawn from the Colorado, had perchlorate concentrations more than three times lower than the California action level and more than five times lower than the EPA's current provisional standard.

There have been a few studies which have shown no association between perchlorate exposure in humans and thyroid hormone levels (e.g. Li et al. 2000a, Li et al. 2000b, Lamm et al. 1999, and Crump et al 2000), but these studies were all sponsored by various industry groups with a stake in the outcome of EPA's scientific review of perchlorate, including the perchlorate manufacturer American Pacific and the aerospace giant Kerr-McGee. Researchers from the California Department of Health Services and a University of Massachussetts scientist on the EPA's peer review panel have pointed out serious if not fatal weaknesses in all but one (Crump et al.) of these studies (Hill et al. 2000, Zoeller 2001.), but at this point the EPA is still using them in its evaluation of perchlorate.

Even modest abnormalities in a pregnant woman's thyroid hormone levels can cause serious damage to her child's IQ and development.

Perchlorate's risks are by far greatest to children. In adults, hypothyroidism causes a variety of adverse symptoms including fatigue, depression, anxiety, unexplained weight gain, hair loss and low libido. Although these symptoms can be serious, especially if left untreated, the consequences of depressed thyroid hormone levels on developing fetuses and infants can be devastating: In a developing fetus or infant, even temporary disruption of thyroid hormones can lead to permanent defects in the developing organism. (EPA 1998.)

Thyroid hormones are crucial to proper development of many organ systems, including the nervous and reproductive systems. (Porterfield 1994, Jannini 1995.) The possible developmental effects of hypothyroidism include mental retardation, vision, speech and hearing impairment, deaf-mutism, spasticity, abnormal gait, delayed reflex development, impaired fine motor skills, and abnormal testicular development in males. (EPA 1998; Brechner 2000.) In older children, depressed thyroid levels have been associated with lower motivation to learn and attention deficit disorder. (Porter et al. 1999.)

Probably the most important issue when considering the potential effects of perchlorate is the relationship between maternal and fetal thyroid hormone levels and neurolgical development. It has been known for decades that mild maternal hypothyroidism can cause reduced IQ in children (Man and Jones 1969). Recently, however, scientists have begun to recognize how sensitive neurological development is to maternal thyroid hormone levels. In fact, one study found that women whose levels of a particular thyroid hormone measured in the lowest 10 percent of the population during the first trimester of pregnancy were more than 2.5 times as likely to have a child with an IQ of less than 85 and five times as likely to have a child with an IQ of less than 70. This was true

Hundreds of Southern California residents claim they got cancer from drinking water contaminated by perchlorate from a Lockheed Martin missile plant.

whether or not these women were clinically hypothyroid, and many of the women in this group had thyroid hormone levels considered to be in the normal range (Pop et al. 1999.) This is important because it means that perchlorate does not have to alter women's thyroid hormone levels dramatically to have critical effects.

Despite the well established connection between maternal thyroid hormone levels and neurological development of offspring, none of the studies performed to date have been designed to address this critical issue. (EPA 1999c.) Furthermore, the studies that have been done have been interpreted using a cancer model of risk assessment rather than a brain development model. Another critical question which has been so far overlooked is whether perchlorate is concentrated and passed on to an infant through breastmilk. Although this issue is always a concern when talking about drinking water contamination, it is of particular importance in the case of perchlorate because the same molecule which moves iodide into the thyroid gland is also present in breast tissue. (Tazebay et al 2000, Welcsh et al. 2000.) Since perchlorate interferes with this molecule, being taken up preferentially at the expense of iodide, it is likely that perchlorate would be concentrated in milk, while iodide would be present at lower than normal concentrations. (EPA 1999c.)

Perchlorate was suspected as a carcinogen as far back as 1966, when the first long term study on the effects of perchlorate in drinking water was performed. After two years of perchlorate consumption, more than a third of perchlorate-fed lab animals developed benign thyroid tumors, compared with none of the control animals. (Kessler and Krunkemper 1966.) Perchlorate does not directly cause cancer, but perchlorate-induced tumors result from changes in the thyroid caused by hormone interference. (Similar effects are seen with other thyroid hormone disruptors.) The severity of these precursor lesions have been shown to be related to high doses of perchlorate and therefore the EPA considers the chemical to be a probable carcinogen. (EPA 1998.)

In 1996, about 800 residents of Redlands, Calif., in San Bernardino County near a now-closed Lockheed Martin plant, filed lawsuits against the company. They claim that the water they have been drinking for decades, today known to be contaminated with perchlorate and other toxins associated with the aerospace industry, has caused cancer and other health problems. Three of the plaintiffs have already died of leukemia and other cancers. Trial is set for 2002.

Rocket Science

About 90 percent of the perchlorate manufactured each year goes to the Air Force, NASA and defense contractors to make rocket fuel. Ammonium perchlorate is the main component of solid rocket fuel, typically constituting 60 percent to 75 percent of missile propellant and about 70 percent of space shuttle rocket motors. (EPA 1998.) Perchlorate makes up the bulk of the 55 million pounds of fuel from decommissioned Cold War missiles that are currently awaiting disposal, an amount projected to increase to 164 million pounds by 2005. (Siddiqui et al. 1998.)

At dozens of sites across the nation, millions of pounds of perchlorate waste were allowed for decades to drain directly into groundwater.

Perchlorate contamination of groundwater is the result of a combination of processes: manufacturing, rocket and fuel development, testing and maintenance. In each process, for more than 50 years the chemical industry, defense contractors or the military disposed of millions of pounds of perchlorate waste by simply flushing it with high-pressure water jets. The waste stream was enormous, because if a launch-ready rocket sits idle for too long, the fuel can go "flat" and hundreds of thousands of pounds of perchlorate must be replaced with a fresh supply. A space shuttle rocket motor, for instance, contains about 700,000 pounds of perchlorate. (NASA 1989.) Flushing generates large volumes of wastewater contaminated with perchlorate at levels up to 1 percent of the total volume. (EPA 1998; EPA 2001c.) For decades, the wastewater was either allowed to drain directly into the ground or, as in Sacramento County, pumped into abandoned gold-mining pits. (JAWA 1957.)

Following the fatal explosion in 1997 at American Pacific's Utah plant, a former employee at the old Nevada plant told the Las Vegas Review-Journal that in the early 1970s perchlorate tanks and pipelines, and spoiled batches of the chemical, were routinely dumped directly onto the desert floor. "Whenever they drained the 'chlorate plant, they just drained it on the blacktop and it drained into the desert. . . . They would [also] take 55-gallon containers of contaminated product and they would take them out and just leave them in the desert," said the former employee.

Only recently, and in only a few places, was technology installed to reclaim perchlorate from the wastewater stream. Even after reclamation, perchlorate concentrations in the wastewater stream remain hundreds of times higher than the EPA's most likely drinking water standards. No one can say for certain how many millions of pounds of perchlorate have been heedlessly flushed into the environment during the last half-century. Considering the amount of the

chemical necessary to be detectable in Lake Mead and the Colorado River, the volume of perchlorate waste must be vast.

Perchlorate contamination of soil, as well as surface water and groundwater is being increasingly discovered at rocket testing and disposal sites (both military and private) where open detonation of rockets occurred. (EPA 2001a.) Surface water at one such site in Arkansas has been contaminated with levels of perchlorate reaching as high as 480,000 ppb.

The first public record of perchlorate contamination in California dates back more than forty years. In 1957, a report in the Journal of the American Water Works Association describes how "several California municipalities have experienced pollution of ground water supplies as a result of local underground disposal practices [of rocket fuel waste]." The article says potassium and ammonium perchlorate wastes flushed into groundwater in eastern Sacramento County had spread over several square miles, with perchlorate concentrations of 3.5 million to 5 million parts per billion in water. (JAWA 1957.) It wasn't until seven years later, though, that the first official state report of perchlorate contamination was released.

The state of California first tested for perchlorate contamination in Sacramento County as early as 1953 – but regulators took no action until 1997.

In 1964 the California Department of Water Resources tested groundwater in Folsom and eastern Sacramento. Among many other toxins detected, the state found perchlorate in 34 wells at levels of up to 18,000 ppb, with the highest concentrations on the property of the company then known as Aerojet General. (CADWR 1964.) However, the water department's report lists the results of perchlorate tests conducted as early as 1953, so the state has known of the potential for contamination at least that long. Despite these findings, the state declared the water supplies safe, and Aerojet's pollution continued.

In 1979, the California Central Valley Regional Water Quality Control Board found that perchlorate could be used to trace other chemical contaminants such as trichloroethylene (TCE) and perchloroethylene (PCE) as having come from Aerojet. At the time, tests of drinking water wells in Rancho Cordova found perchlorate at 220 to 300 ppb. Yet the cleanup of other toxins did not even attempt to address perchlorate. This was a major blunder, because the cleanup process for the other chemicals involved extracting toxic groundwater, partially cleaning it, and then reinjecting the water - still contaminated with perchlorate at concentrations of up to 8,000 ppb - into layers of groundwater which were previously clean.

Arden Cordova Water Service, the company that supplies drinking water to Rancho Cordova, later sued Aerojet for negligence and fraudlent concealment over this practice, alleging that the company "knowingly reinjected water still containing high levels of perchlorate," contaminating dozens of wells. The water

supplier also sued the Central Valley water board and the state Department of Toxic Substances Control, saying both agencies had rejected its attempt to stop the reinjection. The suit alleges that the water board "willfully allowed" Aerojet to reinject the contaminated water into previously untainted wells, and that the Department of Toxic Substances Control kept from the public the extent of the contamination. Aerojet denies knowing that the reinjected water was contaminated.

A lawsuit contends that the state deliberately hid the truth about the extent of perchlorate contamination in Sacramento County from the public.

In 1985 perchlorate reared its head again. This time the problem was at the Aerojet facility in Azusa, Los Angeles County, which had been designated a federal Superfund site in 1984 because of trichloroethylene (TCE), perchloroethylene (PCE) and carbon tetrachloride (CTC) contamination. Aware that Aerojet had handled millions of pounds of perchlorate on the site, the EPA's San Francisco regional office tested groundwater in the area and found perchlorate concentrations of up to 2,600 ppb in 14 wells. (EPA 1998.) According to sources in the Superfund program, EPA then notified local, state and federal authorities, but the U.S Agency for Toxic Substances and Disease Registry (ATSDR) felt that the method used to analyze perchlorate's toxicity was inadequate. EPA requested further guidance from ATSDR, but when none was forthcoming, turned its attention to other chemicals at the site.

By 1997, the California Department of Health Services (DHS) had developed a new analytical method that could reliably detect perchlorate concentrations in water as low as four parts per billion. New tests showed the extent and level of contamination at Rancho Cordova to be far greater than previously known - then found to be up to 6,000 ppb and later found to exceed 600,000 ppb. Other Superfund sites associated with Aerojet and Lockheed Martin were tested, and health officials realized they had a statewide problem. The other companies identified by the EPA as being responsible for perchlorate contamination of California's groundwater are Alpha Explosives, Bermite Powder Company, B.F. Goodrich, Grand Central Rocket, Boeing/Rocketdyne, United Technologies and Whittaker Corporation.

Perchlorate is not removed by conventional water treatment processes or those that remove chemicals such as TCE or PCE. The "cleanup" method most widely used today is to blend contaminated water supplies with uncontaminated sources - in other words, the discredited idea that "dilution is the solution to pollution." (EPA 2001c.) Nanofiltration and osmosis, which force water through membranes with extremely small pores, can remove perchlorate from water, but these technologies are extremely expensive, especially with such large areas of contamination involved. Biological treatment (using bacteria to convert perchlorate into a less toxic or innocuous compound) and ion exchange systems (replacing the perchlorate molecules with chloride) have been tested, but it is still somewhat unclear if they will work on a large scale. Ion exchange also

produces its own toxic waste, a concentrated perchlorate brine which must be either disposed of or treated.

No matter which cleanup technology is used, the costs will be tremendous. Cleaning one part of the Aerojet Superfund site in Rancho Cordova, for example, is expected to cost $55 million. In documents filed with the federal Securities & Exchange Commission (SEC) in 2000, Lockheed Martin estimated the cost of complying with existing cleanup orders from the state and EPA as $140 million in San Bernardino County and $100 million in the San Gabriel Valley. (Lockheed 2000.) Even more startling is the estimated time frame for perchlorate cleanup. When the EPA recently unveiled its cleanup plans for the Rancho Cordova site, residents were stunned to learn that the agency's preferred plan would take an estimated 240 years. Aerojet, however, wants to take even longer - 348 years. SEC documents indicate that Aerojet doesn't expect to even determine the best cleanup technology for another 15 years. (SEC 2000.)

The public will pay for almost 90 percent of the cost of cleaning up perchlorate contamination in California.

Over two to three centuries, and considering that an unknown amount of contamination has yet to be detected, costs for cleaning up perchlorate pollution in the nation's groundwater could easily reach billions of dollars. The final cost is unknown; what is known is that Aerojet, Lockheed Martin and other responsible parties won't be paying most of it.

When a company is liable for environmental contamination of a site where work was done under government contract, federal law allows the contractor to "recover" the cleanup costs from future government contracts - in other words, to pass a big chunk of the cost on to the American taxpayer. Aerojet's SEC filings report that of the company's current estimated liability of $353 million for cleanup of all contaminants at all U.S. sites, it will recover $213 million, or 60 percent, from the government and other parties who share responsibility. But its deal on perchlorate in California is even sweeter: In January 1999, Aerojet and the government reached a cleanup settlement covering both the Sacramento and Azusa sites whereby "the Government/Aerojet environmental cost sharing ratio was raised to 88 percent/12 percent from the previous 65 percent/35 percent." (SEC 2000.) Aerojet also stands to benefit even further from the government-financed c leanup: Once the water supplies meet health standards, the company plans to sell part of the site for commercial development. (Bowman 2001.)

Lockheed Martin, the contractor responsible in Southern California, has negotitated a similar deal, but the exact percentage of reimbursement is unknown. (EWG 2001.) According to the company's most recent SEC filings, "A portion of our business is classified by the government and cannot be specifically described," but:

> Under an agreement with the U.S. Government in 1990, the . . . groundwater treatment and soil remediation expenditures referenced above are being allocated to our operations as general and administrative costs and, under existing government regulations, these and other environmental expenditures related to U.S. Government business . . . are allowable in establishing the prices of our products and services. As a result, a substantial portion of the expenditures is being reflected in our sales and cost of sales pursuant to U.S. Government agreement or regulation. (SEC 2001.)

In addition, as a party that shares responsibility for Lockheed's San Gabriel Valley contamination, the Air Force has agreed to directly pay 50 percent of cleanup costs there. This is in addition to the costs that will be borne up front by Lockheed but later reimbursed by the government. Lockheed also states that as a contractor it runs a number of government-owned facilities where unspecified groundwater contamination has been discovered. Under the usual provisions of Superfund law, a company that shares responsibility at a site owned by another entity also shares the cost of cleanup, but Lockheed says: "At [government-owned] facilities, environmental compliance and remediation costs have historically been the [sole] responsibility of the government." (SEC 2000.)

The bottom line: At Lockheed-owned sites where the government shares responsibility, the public is paying half; at government-owned sites where Lockheed shares cleanup responsibility, the taxpayers are footing the entire bill; and of the cost that remains, the government will reimburse Lockheed for a large part.

From 1991 to 1998, Lockheed and Aerojet contributed almost $2 million to lobbying efforts to repeal a polluter tax that funds cleanup of toxic sites.

Apparently those arrangements aren't good enough for the contractors. Both Lockheed Martin and Aerojet have been major contributors to a group of 188 political action committees which lobby Congress to repeal the federal Superfund tax on polluting industries. The tax generated $4 million a day to pay for toxic cleanups, including sites of perchlorate contamination, until 1995 when industry's influence won out and the tax was repealed. From 1991 to 1998, Lockheed contributed more than $1.5 million to get (and keep) the tax repealed; GenCorp, the parent company of Aerojet, also contributed more than $300,000 to these anti-Superfund PACs. (USPIRG 1998.)

Polluting the Regulatory Process

Although a number of provisional standards for perchlorate have been issued since 1992, there is still no enforceable state or federal drinking water standard. Unfortunately, perchlorate is a prime example of the cumbersome and politically charged process of regulating chemicals in the United States today - especially when the lobbying efforts of private industry are coupled with the influence of the Air Force.

Perchlorate is a prime example of the politically charged process of chemical regulation – especially when private industry and the Air Force team up to influence the outcome.

To set a drinking water standard, the EPA first derives a reference dose (RfD), the amount of a compound that is believed to pose minimal risk to all sectors of the population when consumed daily. This number is then converted into maximum contaminant level (MCL) allowed in drinking water.

The EPA issued its first provisional reference dose for perchlorate in 1992 at 0.0001 mg/kg-day, which translates into an MCL of 4 ppb based on an adult body weight. (EPA 1998; Jarabek 1998.) In 1995 the EPA reduced the uncertainty factors used in their calculations and the provisional MCL was raised to 18 ppb. (Jarabek 1998.)

In 1998 perchlorate was placed on the Contaminant Candidate List for National Primary Drinking Water Regulation. However, it was classified as a contaminant of secondary priority - one for which more data was needed before a standard could be set.

In late 1998 the EPA issued yet another revised RfD, based on new research that found effects at lower perchlorate doses. The RfD and corresponding MCL, however, were actually almost two times higher: 0.0009 mg/kg-day or 32 ppb. (EPA 1998.) This was due in part to the reduction of the uncertainty factors used in the calculation. An external peer review of the EPA's RfD held in early 1999, however, concluded that more research was needed before an official level could be set.

The EPA is now again in the process of revising the provisional RfD. A new one had been expected sometime in 2001, but the assessment has been postponed "indefinitely" because of delays in the submittal of data. (EPA 2001a.) This is far from the end of the process: The new RfD must pass through an external peer review, be converted into a goal MCL, and then an enforceable MCL, which takes health risks, treatment technology and cost into consideration.

In California, perchlorate is classified as an unregulated chemical for which

monitoring is required. In 1988, the California Legislature passed a bill to establish a state drinking water standard for perchlorate by the end of 2000, but it was vetoed by former Gov. Pete Wilson. The Department of Health Services did adopt an action level of 18 ppb for perchlorate in 1997 after discovering that the chemical was contaminating groundwater all over California. DHS recommends public notification if the action level has been exceeded, and recommends drinking water source removal if the level of contamination exceeds 40 ppb.

Most California water suppliers have either taken wells that exceed 18 ppb out of service or blended them with uncontaminated water - another application of the "dilution is the solution to pollution" fallacy. Yet because the so-called action levels only triggers recommendations, water customers may not be aware that they've been drinking rocket fuel, unless they know where to look in the Consumer Confidence Reports water suppliers must now provide. If water suppliers continue serving water above the action level they are required to inform customers, but the requirement doesn't extend to informing customers that they were previously drinking contaminated water, or for how long. A state water engineer acknowledges that for most suppliers, "It [is] simply easier to shut down the wells rather than notify all the customers and deal with the public relations problem." (DC 1997.)

Defense contractors and chemical companies, who stand to lose millions of dollars if a stringent standard is set for perchlorate in drinking water, have been fighting tougher standards for almost 40 years.

Misinformation is also not uncommon: A 1999 water quality report of the Arden Cordova Water Service in the Rancho Cordova area, for example, listed perchlorate as a water contaminant, but in the column stating the "potential sources of contamination," the source listed is "naturally present in the environment." (ACWS 1999.)

As of spring 2001, about 2,500 of the 16,000 public drinking water sources in California have been tested for perchlorate. The deadline for completion of statewide testing is December 2003. That data will guide the Department of Health Services in developing a Public Health Goal (PHG). Once a PHG is set, it typically takes two years before a final MCL is set. The entire state process, however, is being held up by the EPA's delay in setting a new provisional RfD.

Aerospace contractors and perchlorate makers, who stand to lose millions of dollars if a stringent standard is set for perchlorate in drinking water, have been fighting tougher standards for almost 40 years. As far back as 1962, the Manufacturing Chemists Association (now the American Chemistry Council) formed a committee on chemical propellant safety with a toxicity "task group", which included representatives from four companies in the solid propellant industry. Members of this committee participated in a Department of Defense working group called the Inter-Agency Chemical Rocket Propulsion Group (ICRPG), which was, according to the MCA memos, "the first time that a

government agency has asked representatives of industry to participate in this type of committee activity." The MCA says "our active participation in the ICRPG program should be of great help in establishing safe but realistic rules and regulations without unnecessary and excessive restrictions to industrial operations." (MCA 1962, 1965.)

Thirty years later, as accumulating evidence of contamination and potential health effects raised the spectre of tight drinking water standards, industry formed the Perchlorate Study Group (PSG), consisting of Aerojet, Alliant Techsystems, American Pacific/Western Electrochemical Company, Atlantic Research Corporation, Kerr-McGee Chemical Corporation, Lockheed Martin, Thiokol Propulsion Group, and United Technologies Chemical Systems. In 1992, in cooperation with the Air Force, the PSG began a high-stakes campaign to block or weaken proposed standards.

The Air Force and a coalition of big aerospace and chemical companies are working together to prevent tougher perchlorate standards.

In 1992 the EPA issued its first provisional RfD for perchlorate, 4 ppb. The calculations used a conservative uncertainty factor of 1,000. The PSG realized that the easiest way to raise the RfD was to reduce the uncertainty factor; it could easily get the RfD raised if the data deficiency value was reduced. The group paid an unknown amount for a more thorough literature review to be conducted and submitted enough additional data to the EPA for the agency to reassess the RfD. In 1995 the EPA reduced the uncertainty factors to 300, and issued a new provisional RfD of 18 ppb.

For the PSG and the Air Force, however, this was still not high enough. In 1996 the PSG and the Air Force hired a private firm named Toxicology Excellence for Risk Assessment, or TERA, to derive an "analogous" reference dose. In 1997, TERA sponsored a peer review of their RfD which concluded that there still wasn't enough toxicology information on perchlorate to do a credible risk analysis.

Soon after that, the review panel outlined a series of studies to be conducted by the Air Force and the PSG. According to a 1997 Air Force memo, the goal of the studies was clear: "[C]omplete the necessary studies to fill in the missing data gaps in order to see if the provisional reference dose can be raised." (Rogers 1997.) The reference dose subsequently recommended by Aerojet, McDonnell-Douglas and other PSG members was 20 to 100 times greater than the EPA's provisional reference dose. (Aerojet/McDonnell-Douglas 1997.)

A June 1997 Defense Contract Management Agency (an agency of the Department of Defense) situation report on the perchlorate contamination near Lockheed Martin's former site in Redlands, explained the high stakes for the U.S. military:

"There may be far-reaching ramifications when the public learns of this situation. Adverse media attention and congressional interest may occur." (1997 memo)

"Significant Political, Legislative, Military or Diplomatic Impacts: There may be far reaching ramifications when the public learns of this situation. Adverse media attention and congressional interest similar to/greater than Aerojet Rancho Cordova situation may occur. The government will have to deal with legal liability issues.... This discovery is likely to increase Lockheed Martin's environmental tort litigation case load and their environmental cost claims against the government. ... Future procurement programs could be adversely affected due to increased environmental related costs." (DCMDW, 1997.)

The report acknowledges that people most at risk "are those with existing thyroid gland problems, pregnant women and children," but urges: "This information has not been released to the public by environmental and public health regulators. Please keep this information close hold. Failure to do so will adversely affect... proactive environmental efforts." Just what those proactive efforts might be are not identified.

In 1998, after Native Americans living along the Colorado River raised concerns about the accumulation of perchlorate in their irrigated cash crops, the Defense Department financed an EPA study on the uptake of perchlorate by lettuce. Lettuce was chosen in part because 80 percent of the nation's winter lettuce crop is irrigated by the lower Colorado River. The Defense Department at first declined to give the scientists conducting the research permission to share their results with EPA scientists. After activists complained about the secrecy, preliminary results were released in a 1999 conference that showed relatively high levels of perchlorate uptake in young lettuce plants, but low levels of perchlorate in mature plants. But the full results have still not been released, and the Air Force has denied EWG's repeated requests for the data.

The Air Force has also declined to release information in response to a Freedom of Information Act inquiry by a law firm regarding military research on the health effects of perchlorate, the extent and causes of contamination, and studies which involved giving perchlorate to human subjects. The Air Force responded that this information was "fully exempt from disclosure" until the EPA peer review had been completed because this would expose the AF's "deliberative process." (RLG 2001.)The denial has been appealed.

In August 2000, Lockheed Martin launched a $1.75 million study at Loma Linda University near San Bernardino, Calif., in which "volunteers" were paid $1,000 to take a daily dose of perchlorate for 6 months. The doses ranged from 0.5 mg to 3 mg of perchlorate a day; the highest amount corresponds to a dose 83 times higher than California's current action level. Three other studies where "healthy male volunteers" are being fed perchlorate-laced drinking water were

also underway at that time. Two of these, being conducted at Harvard and Oregon State universities, are being funded by the PSG, and the other, being conducted by a scientist in Germany, is apparently being sponsored by the Air Force. (TERA 2001.)

In November 2000, when EWG broke the news of the Southern California tests, Loma Linda researchers acknowledged only that they were sponsored by Lockheed Martin. However, in its latest SEC filing, Lockheed discloses: "We also are coordinating with the U.S. Air Force, which is conducting preliminary studies of the potential health effects of exposure to perchlorates in connection with several sites across the country." (SEC 2001.)

Almost all of the recent toxicology research on perchlorate has been conducted or funded (or both) by the Air Force, the PSG, or a specific company. The EPA's 1998 report offering a revised RfD describes a number of occasions when it analyzed test data submitted by the Air Force or the PSG and found that significant results had been ignored.

For example, the EPA criticized a PSG-sponsored study by Argus Laboratory which overlooked the significance of a perchlorate-induced increase in the size of one brain region by almost 30 percent and of unexpectedly high increases in motor activity. The report stated that EPA disagreed with the argument "that these effects are 'not suggestive of a nuerotoxic effect' because of an 'unknown biological significance.' The EPA considers increase in the size of any brain region to be a potentially adverse effect." (EPA 1998.) Moreover, the EPA noted that "Argus Laboratory and the sponsor (PSG) have failed to respond adequately to the request for an explanation." (EPA 1998.) Similarly, when the EPA analyzed thyroid data provided by the Air Force, they found significant physiological changes at lower doses than had been reported and said the Air Force "did not provide a reason for discounting the significance" of changes at lower doses. (EPA 1998.)

Although children are at far more risk for the effects of thyroid hormone disruption than adults, the EPA based its standard on "safe" levels for a 154-pound adult.

Although children are at far more risk for the effects of thyroid hormone disruption than adults, federal and state regulators have consistently ignored children in their calculations. Children not only drink more water relative to their body weight, but their developing brains and bodies are more susceptible to hormone disruption. Studies on rats, guinea pigs and rabbits have consistently found perchlorate-induced effects in the thyroids of pups to be greater than the effects on those of the mothers. (EPA 1998.)

When it comes to the standard assumptions of body weight and water consumption used to convert the RfD to an MCL, however, the EPA uses an adult body weight of 154 pounds (70 kg) and drinking water consumption of two liters of water a day. (Jarabek 1998; EPA 1999b) These faulty assumptions

were used in all of the EPA's MCL calculations (1992, 1995 and 1998), as well in the DHS' derivation of the current action level. (EPA 1998; CADHS 2001.) DHS has indicated, however, that the California drinking water standard now in development will take children's health into account, and have stated that it is concerned about "the ability of perchlorate to interfere with the production of hormones by the thyroid gland, and the need for thyroid hormones for normal prenatal and postnatal development." (EPA 2001a; CADHS 2001.)

The EPA's proposed standard fails to account for the fact that infants who are fed formula mixed with tap water consume more than seven times as much water, relative to their weight, as the typical adult.

Although all children consume significantly more water than adults relative to their body weight, this is especially true for the almost 40 percent of infants who, in their first four months of life, drink formula made with tap water. (EWG 1999.) These bottle-fed infants consume more than seven times as much water as adults relative to their weight. If just this one error is accounted for, both the EPA's MCL and the California action level would be 7.5 times lower than their present values.

Despite weighty evidence to the contrary, the EPA apparently doesn't consider significant changes in thyroid hormone levels to be a problem for developing children. The EPA ignored critical data showing effects at concentrations ten times lower than the study on which the agency based the most recent provisional RfD.

In its 1998 report, the EPA emphasizes how devastating and permanent developmental effects are "caused by a lack of thyroid hormones" rather than by tumor development or thyroid structure change. The agency notes that "the earliest biological effect, changes in thyroid and pituitary hormones, is the precursor lesion for both the potential carcinogenic and neurodevelopmental effects." However, this seems to have been forgotten when it came to developing an RfD: The principal study used by the EPA to derive the 1998 RfD was one which showed changes in thyroid structure at perchlorate concentrations of 0.1 mg/kg/day. Yet, this level of perchlorate is ten times higher than was shown to affect thyroid hormones. (EPA 1998.) The explanation given by the EPA is that it was unclear what "degree of change to designate as adverse."

The EPA is on a slippery slope: Assuming that some degree of change in thyroid hormone levels might not do much harm, but admitting that we don't really know. The EPA's solution: Ignore the hormone data entirely and hope that no one would notice. If the RfD were based on changes in hormone levels rather than on changes in thyroid structure, it would be ten times lower than the current value.

These two errors in EPA's calculations - ignoring the effects on children and ignoring critical data - have resulted in a provisional MCL which is only nominally below the perchlorate concentration likely to have an effect on a

child's thyroid hormone levels. For an 11.5-lb. bottle-fed infant drinking 1.1 liters of water a day, water with a perchlorate concentration of only 40 ppb would likely have an effect on the child's thyroid hormone levels which are critical for proper development. It is possible that lower levels of perchlorate may also have an effect since no lower doses of perchlorate were tested. The EPA's provisional reference dose of 32 ppb is clearly not low enough to protect the health of infants and children.

Uncertainty factors are used to make standards conservative in order to account for more susceptible portions of the population, differences between the physiology of study animals and humans, data deficiencies and other unknowns. In 1998, the EPA reduced the uncertainty factor used in deriving its RfD to 100, radically underestimating the uncertainty surrounding perchlorate and failing to provide sufficient protection for sensitive human populations. Just some of the unknowns surrounding perchlorate's effects: whether it is being concentrated in breast milk; whether rats are more or less sensitive to thyroid hormone disruption than humans; whether the studies that have been done can detect subtle nuerodevelopmental effects stemming from perchlorate exposure; whether perchlorate is concentrated in the tissues of food crops grown with tainted water.

Perchlorate is only one of a number of the anti-thyroid compounds we are exposed during our everyday lives, including pesticides, dioxins and PCBs.

Considering the large percentage of the population who are already hypothyroid, the EPA's RfD also fails to adequately protect this sensitive subpopulation. The EPA typically builds in an extra tenfold margin of safety to account for people who might be more susceptible to the harmful effects of a certain compound than others. In the case of perchlorate, however, the safety margin was only threefold. This is a serious error in light of the fact that hypothyroidism is becoming increasingly common in America. A recent study found that, on top of the 10 million Americans already diagnosed with a thyroid problem, an additional 13 million (or almost 10 percent of the population in total) may have an undiagnosed thyroid condition. Furthermore, 90 percent of these people are likely to be hypothyroid rather than hyperthyroid. (Canaris et al. 2000.)

The RfD also overlooks the fact that perchlorate is only one of a number of anti-thyroid compounds to which we are exposed during our everyday lives, including pesticides, dioxins and PCBs. (EPA 1997.) Furthermore, recent research has shown that mixtures of pesticides and nitrates in drinking water have synergistic affects, and concentrations of these chemicals at the same order of magnitude as current MCLs have been found to have significant effects on thyroid hormone levels. (Porter et al 1999.) It is likely that perchlorate would compound these effects, yet no such consideration is addressed by the EPA or figured into the RfD calculations. Moreover, a reviewer of the EPA 1998 provisional RfD noted that the EPA has not adequately addressed the subtle

EWG's analysis shows that a safe level for perchlorate in drinking water should be 7.5 to more than 2,000 times lower than the standards proposed by the EPA.

adverse effects of altered thyroid hormone levels in fetuses and children, nor have they addressed the possibility that perchlorate blocks the uptake of iodine into milk and that perchlorate itself may be concentrated in breast milk. (EPA 1999c.)

Several internal EPA reviewers argued for an uncertainty factor of at least 300, which would decrease the current provisional RfD by a factor of three. (EPA, 1998.) In light of the major scientific uncertainties, the significant proportion of the population who would be highly susceptible to perchlorate's effects, and the many other anti-thyroid compounds we are already being exposed to, EWG believes that a UF of 1,000 is the minimum necessary to safeguard public health.

EWG's analysis shows that the MCL should be 7.5 to more than 2,000 times lower than the standards proposed by the EPA. While the EPA has been citing a proposed value of 32 ppb, its RfD and MCL calculations neglect many considerations critical to public health.

Following the EPA's guidelines of RfD and MCL derivation, but using assumptions, appropriate to protect children, EWG's calculations show that the MCL for perchlorate should be between 0.04 and 4.3 ppb. The highest value in this range (4.3 ppb) is the result of changing only the EPA's "standard assumptions" of adult body weight and drinking water consumption, to those of bottle-fed infants. The lower values in the range also take into consideration other key isues, such as the thyroid hormone data the EPA ignored and a more realistic estimation of the uncertainties.

Methodology

The EPA calculates a reference dose (RfD) by first identifying a research study on which it is going to base its calculations. Next a No Observed Adverse Effect Level (NOAEL) is determined for that study which is the dose of a chemical at which no adverse affect was seen. This NOAEL is then divided by a set of uncertainty factors which take into consideration data deficiencies, subpopulations who might be more sensitive to the effects than the average adult, extrapolations between animals and humans (if the study in question was conducted on animals), and additional factors, if necessary.

In the case of perchlorate, EPA's RfD was calculated by the following formula:

NOAEL x 0.85/ UF = RfD (in mg/kg-day)

where the NOAEL equals 0.1 mg/kg-day, and the uncertainty factor equals 100. The 0.85 value was used to adjust for the fact that the reported doses concerned ammonium perchlorate and not the perchlorate anion itself. Since ammonium is 15 percent of the molecular weight of the compound, the NOAEL is multiplied by 85 percent. The resulting RfD value determined by the EPA (1998) was 0.0009 mg/kg-day (rounded from 0.00085 mg/kg-day).

The EPA then uses assumptions of body weight and daily water consumption to convert this RfD (which is a safe dose of a chemical consumed over the entire lifespan) into a Maximum Contaminant Level (which is the safe level of a chemical in drinking water). The EPA has never designated an official provisional MCL (this comes after the adoption of an RfD), but the EPA and DHS have widely used the same formula for calculating the provisional MCL (EPA 1999b; CADHS 2001):

((RfD * standard body weight) / daily water consumption) * 1000 = MCL (in ppb)

where the standard body weight is 70 kg and standard water consumption is 2 liters/day. The resulting MCL value is 32 ppb.

EWG's Methodology

Levels protective of children's health were calculated by EWG using the same formulas used by the EPA, but entering revised values for body weight/ drinking water consumption, NOAEL, and/or UF which take into account children's lower body weight and higher relative drinking water consumption, data that was ignored by the EPA, and/or the significant scientific uncertainties which were not addressed in the EPA's calculations. (Table 4.)

Table 4. EPA's RfD ignores many critical assumptions.

Assumptions	RfD (ppb)
EPA's proposed safe levels : NOAEL = 0.1 mg/kg-day (adjusted to 0.085 due to ammonium perchlorate being 85% perchlorate by weight); UF = 100; adult body weight = 70 kg; adult drinking water consumption = 2 L/day.	32
Safe level calculated using the EPA's NOAEL and UF values, but using infant body weight and drinking water consumption values (5.2 kg, 1.1 L/day) rather than adult values.	4.3
Safe level using EPA's UF, but using a lower NOAEL (0.01 mg/kg-day adjusted to 0.0085) which was a LOAEL ignored by the EPA, as well as infant body weight and drinking water consumption values rather than adult values.	0.43
Safe level using a lower NOAEL (0.01 mg/kg-day adjusted to 0.0085), infant body weight and drinking water consumption values, and a higher UF figure (= 300) as was argued for by several internal EPA reviewers.	0.13
Safe level using a lower NOAEL (0.01 mg/kg-day adjusted to 0.0085), infant body weight and drinking water consumption, and a higher UF value (= 1000) which EWG believes more accurately reflects the scientific uncertainties.	0.043

SOURCE: EWG

- Infants have lower body weight and higher relative drinking water consumption.

The EPA, many other federal agencies and the World Health Organization use a default of 2 liters per day for adult drinking water consumption, which is about the 90 percent value. The 90th percentile value for water consumption for infants is therefore used: 1.1 liters/day for infants under 4 months of age. (USDA, 1996.) Note that this value is for infants who are exclusively bottle-fed. While the standard adult body weight is 70 kg, the average weight for infants less than 4 months old is 5.2 kg (EPA, 1996). Using these values, the resulting MCL is:

$$((0.0009 \text{ mg/kg-day} * 5.2 \text{ kg}) / 1.1 \text{ L}) * 1000 = 4.3 \text{ ppb}$$

- The EPA overlooked critical data showing hormone effects at lower perchlorate doses.

The NOAEL used in the EPA's calculations was 0.1 mg/kg-day (Caldwell, 1995). However, this value was not actually determined to be a NOAEL by the EPA, but rather a LOAEL (Lowest Observed Adverse Effect Level); that is, adverse effects were still seen at this dose of perchlorate. (EPA, 1998.) Moreover, significant changes in thyroid hormones levels found at perchlorate concentrations 10 times lower. Note that this still a LOAEL, and no smaller doses were tested so it is unclear whether lower concentrations might also yield effects. Entering a more appropriate value for the NOAEL into the equation (0.01 mg/kg-day; Springborn Laboratories, 1998), and retaining the EPA's UF of 100, the resulting RfD is:

$$(0.01 \text{ mg/kg-day} * 0.85)/100 = 0.00009 \text{ mg/kg-day}$$

Note that the 0.85 value is still used because the Springborn (1998) study used the ammonium perchlorate salt as did the Caldwell (1995) study on which the EPA based its RfD. And using a bottle-fed infant body weight and water consumption, the MCL would be:

((0.00009 mg/kg-day * 5.2 kg) / 1.1 L) * 1000 = 0.43 ppb

- The EPA underestimated the scientific uncertainty surrounding effects of perchlorate.

The uncertainty factor of 100 the EPA used is also inappropriate considering the significant percentage of the population that is already hypothyroid, the many unresolved scientific questions, the use of a LOAEL rather than a NOAEL in RfD derivation, interspecies differences, and the possible interactions between perchlorate and other common anti-thyroid agents. Using a somewhat more conservative uncertainty factor of 300 which several internal reviewers at the EPA argued for, and a more appropriate NOAEL (0.01 mg/kg-day, see above), the resulting RfD is:

(0.01 mg/kg-day * 0.85)/ 300 = 0.000028 mg/kg-day

Using bottle-fed infant weight and water consumption values, the corresponding MCL is:

((0.000028 mg/kg-day * 5.2 kg) / 1.1 L) * 1000 = 0.13 ppb

EWG believes, however, that given the significant uncertainties surrounding the health effects of perchlorate and the profound importance of proper thyroid hormone levels on development, an even more conservative uncertainty factor of 1,000 should be used. In this case, the RfD would be:

(0.01 mg/kg-day * 0.85)/ 1000 = 0.000009 mg/kg-day

Using bottle-fed infant weight and water consumption values, the corresponding MCL is:

((0.000009 mg/kg-day * 5.2 kg)/ 1.1 L) * 1000 = 0.043 ppb

In summary, when the MCL takes into consideration the high water intake of bottle-fed infants relative to their body weight, the much lower level of perchlorate known to significantly affect thyroid hormones, and an more appropriate picture of the uncertainties and risks involved to sensitive subpopulations, the EPA's proposed MCL values are from 7.5 times to more than 2,000 times too high.

Calculating perchlorate's effects on the infant thyroid

The lowest dose of ammonium perchlorate found to have a statistically significant effect on thyroid hormone levels is 0.01 mg/kg-day. The ammonium ion is 15 percent of the weight of ammonium perchlorate. Therefore, the amount of the perchlorate known to have an effect on thyroid hormone levels is 0.0085 mg/kg-day. The average weight for infants less than 4 months old is 5.2 kg (EPA 1996). The 90th percentile level for water consumption for bottle-fed infants is 1.1 L/day (USDA 1994). The drinking water concentration of perchlorate likely to have an effect on infant thyroid hormone levels is: 0.0085 mg/kg-day x 5.2 kg x 1000 ug/mg x 1/1.1 L = 40.2 ug/L = 40.2 ppb.

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