Examination of Community Concerns about Water Contamination with Perfluorooctanoic Acid and Related Chemicals Using Population-based Cancer Registry Data

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SYNOPSIS

Objective. This study evaluated cancer incidence rates in two West Virginia counties whose water supplies have been contaminated with perfluorooctanoic acid (PFOA) and its ammonium salt, ammonium perfluorooctanoate (APFO) as well as the county between the counties with known contamination. Previous human and animal studies have raised but not fully answered the question of whether PFOA is associated with increased risk of certain cancers as well as other adverse health outcomes.

Methods. Data from the West Virginia Cancer Registry were used to compute age-adjusted (2000 standard) average annual (1993-2002) cancer incidence rates using US Bureau of the Census population-estimates as denominators and to evaluate differences in age at diagnosis for Wood, Jackson and Mason counties and for the state of West Virginia. The West Virginia Department of Environmental Protection provided information on PFOA and APFO contamination from a series of water sampling studies conducted between 2002 and 2005. US Bureau of the Census data were used to clarify observed differences. Data from the United States Department of Agriculture 2002 Census of Agriculture and the United States Environmental Protection Agency's Toxics Release Inventory (TRI) were used to evaluate the presence of other environmentally-based cancer risks.

Results. Elevated (in comparison to West Virginia as a whole) age-adjusted incidence rates of prostate cancer and non-Hodgkin lymphoma were observed in the northern two of the three counties of concern and elevated rates of leukemia and cutaneous melanoma were observed in the northern-most county, in which an identified source of

PFOA is located. Prostate cancer rates for the northern two counties have been diverging from those of West Virginia since 1999. These results are not accounted for by differences in population age or racial structure. However, exposures to other substances including agricultural chemicals and Occupational Safety and Health Administration carcinogens reported in the TRI have been documented and may play a role in the observed differences.

Conclusions. Some cancers previously hypothesized to be associated with PFOA exposure were found to be elevated in one of the two counties known to have PFOA water contamination as well as in the county between the two counties with known water contamination. Other cancers previously hypothesized to be associated with PFOA exposure were not elevated. This is an ecologic study, lacking quantitative data for any exposures, and does not permit causal attributions. It does, however, demonstrate the utility of cancer registry data and other secondary data sources in initial investigations of community cancer concerns and supports the need for further evaluation of the impact of PFOA and related chemicals in the target counties, including studies evaluating health outcomes in relation to measured exposure levels.

INTRODUCTION

Perfluorooctanoic acid (PFOA; sometimes called C8; molecular formula C8 H F15 O2; structural formula F-CF2-CF2-CF2-CF2-CF2-CF2-CF2-C(=O)-OH) is an environmentally persistent fully fluoridated organic acid used in making non-stick cookware coatings, stain resistant textile and paper coatings, fire retardants, and many other consumer products. PFOA has been found in the blood of occupationally-exposed workers (Alexander et al., 2003; Olsen et al., 2003a,b) as well as the general population (Guruge et al., 2005; Inoue et al., 2004; Kannan et al., 2004; Kubwabo et al., 2004), and has been increasing in the human population (Harada et al., 2004; Olsen et al., 2005). Because of its ubiquity and because of concerns about its association with adverse health outcomes (Federal Register, 2003), the US Environmental Protection Agency (EPA) is in the process of conducting a risk assessment of PFOA and has created a draft of that assessment. Both environmental (Giesy and Kannan, 2002) and human health concerns are pertinent.

Epidemiologic studies of exposed workers have yielded inconsistent results with respect to the carcinogenicity of PFOA. For example, in a retrospective cohort study of 3,537 workers employed for at least 6 months at a facility producing APFO, an ammonium salt of PFOA, reported elevated standardized mortality ratios (SMRs) for prostate cancer among men working in the chemical division of the plant (Gilliand and Mandel, 1993). When the study was updated to include subsequent mortality (Alexander, 2001), none of the SMRs was significantly elevated, and exposure categories and inclusion criteria (workers had to be employed at the plant for at least 1 year) were changed. Non-significant elevations were found for colon cancer, pancreatic

cancer and prostate cancer among persons categorized as definitely exposed to PFOA and for cancer of the testis, cancer of other male genital organs, pancreatic cancer and cutaneous melanoma in the probable exposure group.

Dupont (2003) evaluated cancer incidence among workers at their Washington Works plant in Parkersburg, WV and found significantly elevated rates of bladder and kidney cancer and non-significantly elevated rates of myeloid leukemia, cancer of the larynx, multiple myeloma, testicular cancer, cutaneous melanoma and brain cancer.

In a study of episodes of healthcare (Olsen et al., 2001), chemical plant workers with presumed long-term, high exposures were found to have elevated risk of episodes of care for male reproductive cancers including prostate cancer and for gastrointestinal neoplasms, although much of the latter was attributable to benign colon polyps. Workers in the long-term high exposure group were also significantly more likely to seek care for biliary tract disorders, disorders of the pancreas, and bladder and lower urinary tract infections.

Animal literature also suggests carcinogenic potential for PFOA (Kennedy et al., 2004). It has been found to increase the incidence of hepatocellular carcinoma (Abdellatif et al., 1991; Sibinski, 1987), Leydig cell adenomas (Cook et al., 1992; Sibinski, 1987) and pancreatic acinar cell tumors (Cook et al., 1994). Evidence for increased incidence of mammary fibroadenomas (Sibinski, 1987) is considered equivocal. While female rates receiving PFOA had significantly higher rates of mammary fibroadenomas than did female rates not receiving PFOA, the rates in female rats receiving PFOA did not differ from those in historical controls. However, the

relevance of the animal studies to human carcinogenesis has been questioned (Kennedy et al., 2004).

The issue of PFOA's health effects is of particular interest in Wood, Mason and Jackson counties in West Virginia and nearby counties in Ohio due to the finding that some of the drinking water supply in these counties has been contaminated with PFOA. The source of the PFOA is located in Wood County. Elevated levels of PFOA have been found in blood serum of area residents (Raloff, 2005; Ward, 2005), who had a mean serum concentration of 340 ppb PFOA, about 60 to 80 times that of the general US population (Ward, 2005). In addition, there are APFO emissions to the air and some direct contamination of the soil has occurred (West Virginia Department of Environmental Protection, 2002). Additional studies, resulting from a court settlement, are underway that will allow quantification of serum levels of affected water supply consumers and water well owners. As a result, the West Virginia Cancer Cluster Workgroup, headed by the West Virginia Cancer Registry, undertook this study of cancer incidence in affected West Virginia counties.

METHODS

Data Sources. Cancer incidence data were obtained from the West Virginia Cancer Registry (WVCR). WVCR began collecting all-site cancer data with the exception of cervical cancer in situ and basal and squamous cell carcinoma of the skin in 1993 and is certified for completeness, timeliness and data quality at the highest level by the North American Association of Central Cancer Registries (North American Association of Central Cancer Registries, Inc., 2005a). WVCR also meets the standards of the Centers for Disease Control and Prevention's National Program of Cancer Registries.

The West Virginia Department of Environmental Protection provided PFOA test results. Cancer mortality data were obtained from the West Virginia Bureau for Public Health, Health Statistics Center. Data on population characteristics were obtained from the US Bureau of the Census (US Bureau of the Census, 2005); Behavioral Risk Factor Surveillance System data were obtained from the West Virginia Bureau for Public Health, Health Statistics Center; data on agricultural practices were obtained from the United States Department of Agriculture 2002 Census on Agriculture (United States Department of Agriculture, 2005); and data on the release of carcinogens were obtained from the United States Environmental Protection Agency's Toxics Release Inventory (United States Department of Environmental Protection, 2005). The West Virginia Department of Environmental Protection (WVDEP) provided APOF and PFOA public water supply test results (West Virginia Department of Environmental Protection, 2005).

Data Analysis. Rocky Mountain Cancer Data Systems (Rocky Mountain Cancer Data Systems, 2005) supports the computation of age-adjusted average annual cancer incidence rates per 100,000, including 95% confidence intervals using US Census population estimates as the denominator.

Given the instability of Zip Code Tabulation Area (ZCTA) population counts and the limited availability of updated ZCTA population estimates (i.e., the most current for the target ZCTAs is 2000), ZCTA-level analyses were restricted to cancer incidence in 1998 through 2002. Due to the small population sizes of many ZCTAs in the area, adjacent ZCTAs were sometimes aggregated to yield an average annual number of observed cases of at least 4, in keeping with WVCR standards for data release. Because ZCTAs may cross county borders, persons who were residents of target

ZCTAs but not target counties were included in the analyses. However, only 5 of the 763 cases included in the ZCTA analyses were not residents of the target counties. The expected number of cases was computed by applying the West Virginia rate to the population from 2000 US Census data.

RESULTS

Demographic and health behaviors of the population. Table 1 summarizes the demographic characteristics of the West Virginia counties of interest and of West Virginia as a whole and Table 2 shows health behaviors as measured by the Behavioral Risk Factor Surveillance System. The age, sex, racial and ethnic distributions of the counties are similar to West Virginia as a whole, although income is higher and poverty is lower in Jackson and Wood counties than in West Virginia and income is slightly lower and poverty slightly higher in Mason County. Mason, Wood and Jackson County residents are somewhat less likely to report not having insurance than are West Virginians and Mason and Jackson County residents are somewhat less likely to report difficulty seeing a doctor due to costs.

Cancer Incidence. Table 3 summarizes the age-adjusted (2000 Standard) average annual (1993-2002) incidence rates and 95% confidence intervals for the specified cancers. In keeping with WVCR practice, incidence rates are suppressed when based on fewer than 4 cases during the entire time period. The prostate cancer and non-Hodgkin lymphoma rates were significantly elevated in Jackson and Wood counties, and the all-site, cutaneous melanoma, leukemia (all types) and chronic lymphocytic leukemia rates were significantly elevated in Wood County. No cancer rates were significantly elevated in Mason County. Although there is considerable year-to-year

variability in the prostate cancer rates prior to 1999, the rates for Jackson and Wood counties appear to be diverging from those for West Virginia since 1999 (see Figure 1).

Table 4 summarizes the expected and observed number of cases by Zip Code Tabulation Area (ZCTA). Although there were no significant differences, there was a tendency towards higher than expected numbers of prostate cancer cases. The only areas with fewer (although not significantly) than expected cases of prostate cancer were the Henderson, Apple Grove, Ashton, Glenwood and Gallipolis area in southern Mason County, the Liverpool, Sandyville, Rickport, Walker and Waverly area in eastern Jackson and Eastern Wood counties and the Belleville, Davisville and Mineral Wells area in Wood County. Although the 26133 ZCTA (Belleville) does abut the Ohio River, 85.3% of the male population in the combined ZCTA area lives in the 26142 and 26150 ZCTAs, which are in the eastern portion of Wood County.

Cancer Mortality. Age-adjusted cancer mortality rates for West Virginia and the three target counties are summarized in Table 5. Leukemia mortality appears elevated in all of the target counties, as does lymphoma mortality in Mason and Wood counties, cutaneous melanoma mortality in Jackson and Wood counties, pancreatic cancer mortality in Jackson County and lung and female breast cancer mortality in Mason County.

Presence of APFO and PFOA in Public Water Systems. Table 6 summarizes public water system results for APFO testing conducted by E. I. du Pont de Nemours and Company and reported to the West Virginia Department of Environmental Protection in accordance with Consent Order No. GWR-2001-019; results from samples collected after water had been treated are summarized in Table 7. Although APFO levels

declined from 2002 to 2003 for the Mason County Public Service District wells tested, they increased from 2003 to 2004. Levels increased throughout the period for the Washington Works wells but decreased for the wells at Racine Locks and Dam. Mean (median) after treatment levels for Lubeck were 0.65 (0.65) in 2002, 0.49 (0.49) in 2003 and 0.72 (0.66) ppb in 2004. PFOA testing conducted by also conducted by DuPont in 2004 found means (medians) of 1.00 (0.98) ppb for the Lubeck production wells and 18.82 (2.91) ppb for the Washington Works production wells and a result of 1.04 for the Lubeck after treatment sample.

Other Potential Environmental Exposures. As shown in Table 8, which summarizes the results of the United States Department of Agriculture's 2002 Agricultural Census, Jackson and Mason both have substantial agricultural activities, with both counties exceeding the 75th percentile of West Virginia counties for number of acres of cropland, number of acres on which fertilizer is used and head of cattle and calves and hogs and pigs. Mason County also exceeds the 75th percentile of West Virginia for number of acres on which manure, insecticide and herbicide as well as number of egg laying chickens and Jackson County also exceeds the West Virginia 75th percentile head of sheep and lambs. Wood County exceeds the West Virginia 75th percentile only for the number of acres on which herbicide is used.

Table 9 summarizes reports from the United States Environmental Protection Agency's Toxics Release Inventory (TRI). The on- and off-site release totals include both appropriate and potentially inappropriate disposal and releases of reportable substances characterized as carcinogens by the Occupational Safety and Health Administration (OSHA). Occupational exposure studies have found 1,3-butadiene

inhalation exposures to be associated with increased risk of lymphohematopoietic cancers (United States Environmental Protection Agency, 2002). Further examination of annual Wood County TRI data for 1,3-butadiene revealed that nearly all of the releases were air releases (see Figure 2).

DISCUSSION

Using population-based cancer registry data to evaluate cancer incidence rates in West Virginia counties impacted by contamination of the water supply with perfluorooctanoic acid, statistically significantly elevated age-adjusted rates of prostate cancer and non-Hodgkin lymphoma were found in the northern two of the three affected counties. Statistically significantly elevated age-adjusted rates of cutaneous melanoma and leukemia (all types) and chronic lymphocytic leukemia were found in the northern most of the affected counties, which is the county in which the identified source of the PFOA is located. These findings are consistent with previous occupational exposure studies that have reported associations of PFOA with prostate cancer and cutaneous melanoma. However, some of the cancers found to be elevated in this study, including non-Hodgkin lymphoma and chronic lymphocytic leukemia have not been reported elsewhere and some cancers found to be elevated in occupational exposure studies, such as bladder and kidney cancer, testicular cancer, cancer of the larynx, multiple myeloma, myeloid leukemia and gastrointestinal cancers were not found to be statistically significantly elevated in this population-based assessment. Although not statistically significant, the ZCTA analyses suggested the possibility that men in the southern-most area of the region of interest as well as men living on the eastern border

of the area of interest might not experience the same levels of excess prostate cancer as did men in other areas of the region of interest.

Review of other data sources, including the USDA Census of Agriculture and EPA's Toxics Release Inventory illustrated some of the complexities in evaluating community cancer concerns even in situations where there is documented evidence of a potentially carcinogenic contaminant in the water supply. For example, air releases of 1,3-butadiene, which has been associated with elevated rates of lymphohematopoietic cancers (United States Environmental Protection Agency, 2002) have been reported in Wood County, which had elevated rates of non-Hodgkin lymphoma and leukemia. The agricultural exposures described in the Census of Agriculture data may also play a role in rates of cancers such as leukemia and prostate cancer (Jaga and Dharmani, 2005).

West Virginia Cancer Registry data meet high standards for quality (e.g., 100% pass the edits required for certification by the North American Association of Central Cancer Registries (NAACCR) and for completeness of case ascertainment, with a 1998-2002 mean completeness estimate of 99.7% for West Virginia residents and a 1998-2002 mean of 1.7% of cases reported by death certificate only (North American Association of Central Cancer Registries, Inc., 2005b). However, these characteristics are on a statewide level. Data quality and completeness from individual counties may vary and data quality and completeness from border counties such as Wood, Jackson and Mason counties in West Virginia may be influenced by the quality and completeness of the data provided by the other state(s) on which the counties border. In this case, NAACCR evaluations indicate that 99.8% of Ohio cases pass mandatory edits, case ascertainment is 94.7% complete for Ohio residents and a 1998-2002 mean

of 2.8% of cases reported by death certificate only. Thus it is possible that there is some underestimation of rates for Wood, Jackson and Mason counties.

The analyses presented here establish only that the rates of certain cancers previously associated with occupational PFOA exposure are elevated in counties in which residents may have been exposed to PFOA via the water supply. They do not demonstrate a causal relationship between PFOA and individual cancer cases. There are other substances to which residents may have been exposed, such as agricultural chemicals or 1,3-butadiene, which also have carcinogenic potential. Individual exposure histories for PFOA and other potential carcinogens are unknown. These data do, however, establish the need for further examination of the impact of non-occupational exposures to PFOA on cancer incidence in communities.

REFERENCES

Abdellatif, A.G.; Preat, V.; Taper, H.S.; and Roberfroid, M. 1991. The modulation of rat liver carcinogenesis by perfluorooctanoic acid, a peroxisome proliferators. Toxicol Appl Pharmacol; 111;530-7.

Alexander, B.H. 2001. Mortality study of workers employed at the 3M Cottage Grove facility. Final Report. April 26, 2001. Division of Environmental and Occupational Medicine. School of Public Health, University of Minnesota. US EPA AR226-1030a018.

Alexander, B.H., Olsen, G.W., Burris, J.M., Burlew, M.M., and Mandel, J.H. 2002. Epidemiologic assessment of worker serum perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) concentrations and medical surveillance examinations. J Occup Environ Med; 45(3):260-70.

Alexander, B.H.; Olsen, G.W.; Burris, J.M.; Mandel, J.H.; and Mandel, J.S. 2003. Mortality of employees of a perfluorooctanesulphonyl fluoride manufacturing facility. Occup Environ Med; 60:722-9.

Cook, J.C.; Murray, S.M.; Frame, S.R.; and Hurtt, M.F. 1992. Induction of Leydig cell adenomas by ammonium perfluorooctanoate: a possible endocrine-related mechanism. Toxicol Appl Phramacol. 113:209-17.

Cook, J.C.; Hurtt, M.E.; Frame, S.R.; Beigel, L.B. 1994. Mechanisms of extrahepatic tumor induction by peroxisome proliferators in Crl:CD BR(CD) rate. Toxicologist. 14:301.

DuPont (Haskell Laboratory). 2003. Epidemiology Surveillance Report: Cancer incidence for Washington Works site 1959-2001. US EPA AR226-1307-6.

Federal Register. 2003. Perfluorooctanoic Acid (PFOA), Fluorinated Telomers; Request for Comment, Solicitation of Interested Parties for Enforceable Consent Agreement Development, and Notice of Public Meeting. 68(73):18626-18633.

Giesy, J.P., and Kannan, K. 2002. Perfluorochemical surfactants in the environment. Environ Sci Technol. 36:147A-152A.

Gilliand, F.D. and Mandel, J.S. 1993. Mortality among employees of a perfluorooctanoic acid production plant. J. Occup. Med. 35(9):950-954.

Guruge, K.S.; Taniyasu, S.; Yamashita, N.; Wijeratna, S.; Mohotti, K.M.; Seneviratne, H.R.; Kannan, K.; Yamanaka, N. and Miyazaki, S. 2005. Perfluorinated organic compounds in human blood serum and seminal plasma: a study of urban and rural tea worker populations in Sri Lanka. J Environ Monit. 7(4):371-7.

Harada, K.; Saito, N.; Inoue, K.; Yoshinaga, T.; Watanabe, T.; Sasaki, S.; Kamiyama, S.; and Koizumi, A. 2004. The influence of time, sex and geographic factors on levels of perfluorooctane sulfomate and perfluorooctanoate in human serum over the past 25 years. J Occup Helath. 46(2):141-7.

Inoue, K.; Okada, F.; Ito, R.; Kato, S.; Sasaki, S.; Nakajima, S.; Uno, A.; Saijo, Y.; Sata, F.; Yoshimura, Y.; Kishi, R.; and Nakazawa, H. 2004. Perfluorooctane sulfonate (PFOS) and related perfluorinated compounds in human maternal and cord blood samples: assessment of PFOS exposure in a susceptible population during pregnancy. Environ Health Perspec 112(11):1204-7.

Jaga, K., Dharmani, C. 2005. The epidemiology of cancer and pesticide exposure. Rev Environ Health. 20:15-38.

Kannan, K.; Corsolini, S.; Falandysz, J.; Fillmann, G.; Kumar, K.S.; Loganathan, B.G.; Mohd, M.A.; Olivero, J.; Van Wouwe, N.; Yang, J.H. and Aldoust, K.M.. 2004. Perfluorooctanesulfonate and related fluorochemicals in human blood from several countries. Environ Sci Technol. 38(17):4489-95.

Kennedy, G.L.; Buttenhoff, J.L.; Olsen, G.W.; O'Connor, J.C.; Seacat, A.M.; Perkins, R.G.; Biegel, L.B.; Murphy, S.R.; Farrar, D.G. 2004. The toxicology or perfluorooctonate. Crit Rev oxicol; 34:351-84.

Kubwabo, C.; Vais, N.; and Benoit, F.M. 2004. A pilot study on the determination of perfluorooctanesulfonate and other perfluorinated compounds in blood of Canadians. J Environ Monit. 6(6):540-5.

North American Association of Central Cancer Registries, Inc. 2005a. Registry Certification. Last accessed 10/13/05 from http://www.naaccr.org/index.asp?Col_SectionKey=12&Col_ContentID=54

North American Association of Central Cancer Registries, Inc. 2005b. Cancer in North America: 1998-2002. Chicago, IL.

Olsen, G.W.; Burlew, M.M.; Hocking, B.B.; Skratt, J.C.; Burris, J.M. and Mandel, J.H. 2001. An epidemiologic analysis of episodes of care of 3M Decatur chemical and film plant employees, 1993-1998. 3M Company. Final Report. May 18, 2001. US EPA AR226-1030a021.

Olsen, G.W.; Logan, P.W.; Hansen, K.J.; Simpson, C.A.; Burris, J.M.; Burlew, M.M.; Vorarath, P.P.; Venkateswarlu, P.; Schumpert, J.C. and Mandel, JH. 2003a. An occupational exposure assessment of a perfluorooctanesulfonyl fluoride production site: biomonitoring. AIHA J; 64(5):651-9.

Olsen, G.W.; Church, T.R.; Miller, J.P.; Burris, J.M.; Hansen, K.J.; Lundberg, J.K.; Armitage, J.B.; Herron, R.N.; Medhdizadehkashi, Z.; O'Neill, E.M.; Mandel, J.H.; and

Zobel, L.R. 2003b. Perfluorooctanesulfonate and other fluorochemicals in the serum of American Red Cross adult blood donors. Env Health Perspec; 111:1892-1901.

Olsen, G.W.; Huang, H.Y.; Helzlsouer, K.J.; Butenhoff, J.L.; and Mandel, J.H. 2005. Historical comparison of perfluorooctane sulfate, perfluorooctonoute, and other fluorochemicals in human blood. Environ Health Perspect; 113(5):539-45.

Raloff J. 2005. Nonstick pollution sticks in people. Science News, August 27, 2005.

Rocky Mountain Cancer Data Systems. 2005. Available functions. Last accessed 9/12/05 from http://rmcds1.med.utah.edu/.

Sibinski, L.J.. 1987. Final report of a two year oral (diet) toxicity and carcinogenicity study of fluorochemical FC-143 (perfluorooctanane ammonium carboxylate) in rats. Vol. 1-4, 3m Company/RIKER Exp. No.0281CR0012;8EHQ-1087-0394.

United States Bureau of the Census. United States Census 2000. Last accessed 9/12/05 from http://www.census.gov/

United States Department of Agriculture. 2002 Census of Agriculture. Last accessed 9/12/05 from http://www.nass.usda.gov/census/

United States Environmental Protection Agency. Toxics Release Inventory. Last accessed 9/12/05 from http://www.epa.gov/tri/

United States Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. 2002. Health Assessment of 1,3-Butadiene. Washington, DC.

Ward K. Charleston Gazette, August 21, 2005. Caution urged for contact with C8. ProQuest document 885376411. Last accessed Aug. 23, 2005.

West Virginia Department of Environmental Protection. 2002. Ammonium Perfluorooctonate (C8) Assessment of Toxicity Team (CATT) Report. Charleston, WV.

West Virginia Department of Environmental Protection. Groundwater Investigation Steering Team (GIST). Last accessed September 22, 2005 at http://www.ewg.org/issues_content/PFCs/20021113/pdf/WVDEP_GIST.pdf

Figure 1. Age-adjusted (2000 Standard) Average Annual Incidence Rates per 100,000 of Invasive Prostate Cancer

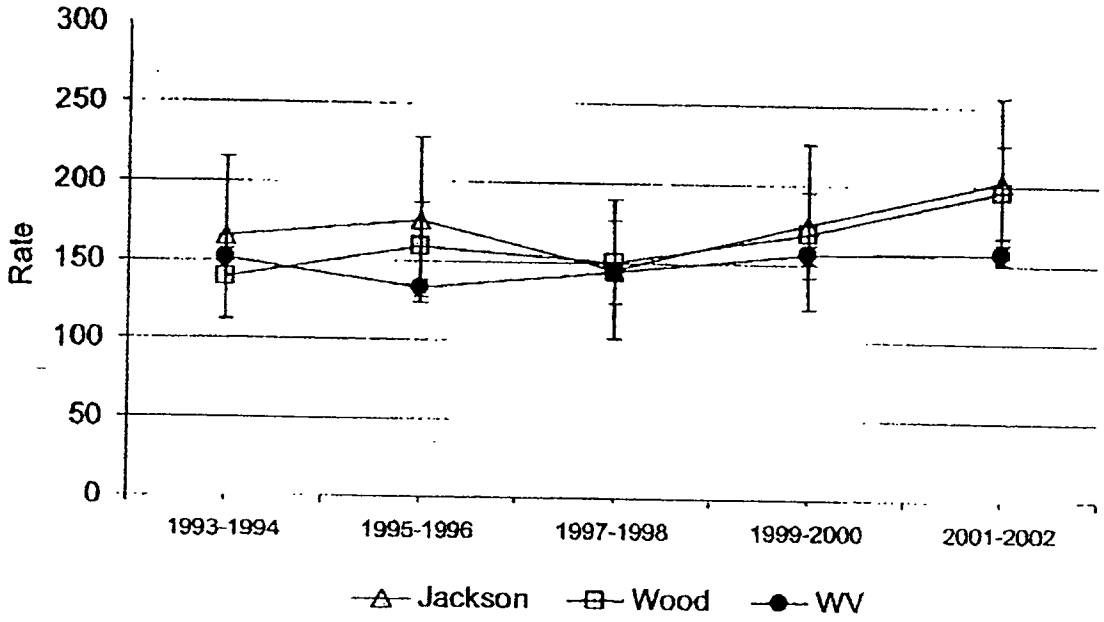

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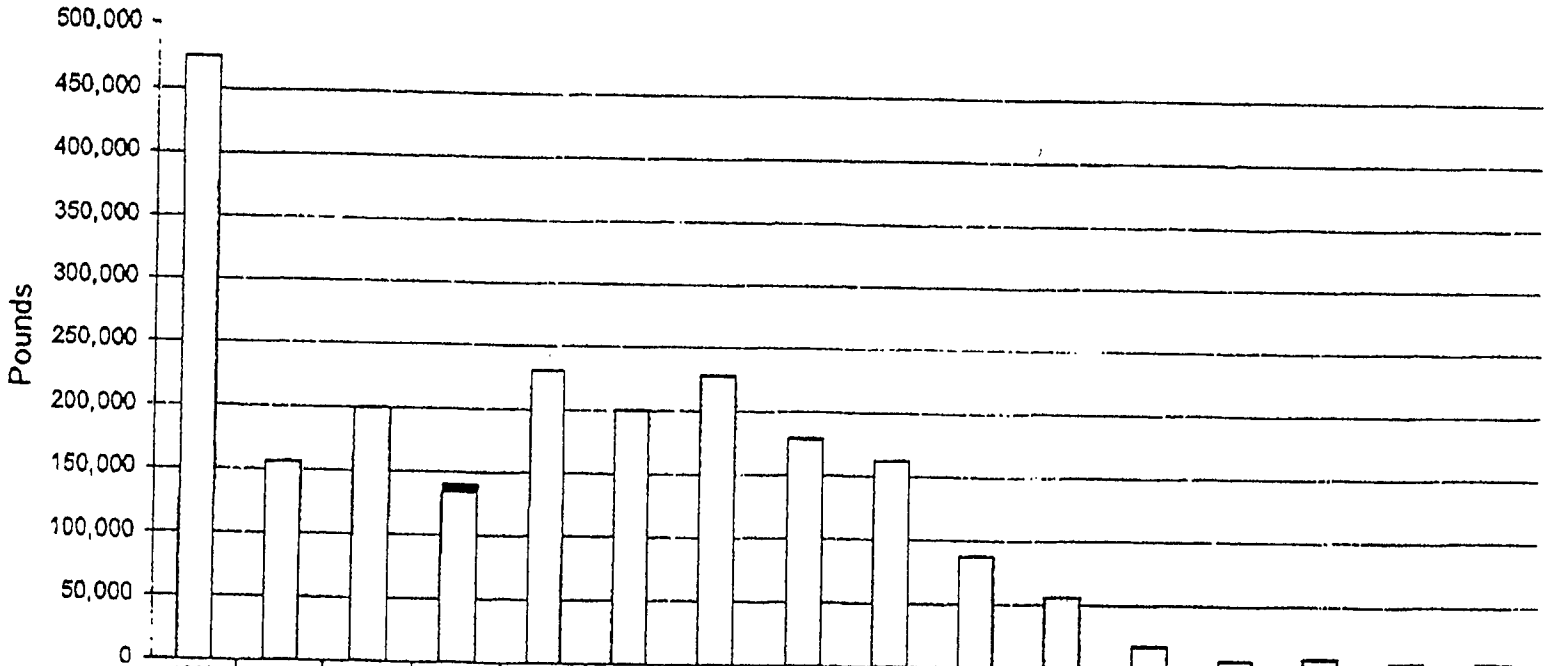
Figure 2. Wood County 1,3-Butadiene Release Reports from TRI



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
■ Other	0	0	0	6,100	0	0	0	0	0	0	0	0	5	88	69	57
□ Air	474000	156000	199000	134000	230000	200000	228000	178100	161500	87800	59861	17658	7456	8680	6180	5800

Table 1. 2000 US Census Data

CHARACTERISTIC	JACKSON	MASON	WOOD	WEST VIRGINIA
Median age	38.8	39.7	39.3	38.9
% aged 65 years and older	15.3	15.2	15.5	15.3
% male	48.7	49.0	48.0	48.6
% white	98.7	98.4	97.3	95.0
% black	0.1	0.5	1.0	3.2
% Hispanic	0.3	0.5	0.6	0.7
% high school diploma or higher	77.4	72.4	81.4	75.2
Median household income	$32,434	$27,134	$33,285	$29,696
% families below poverty	12.2	16.6	10.6	13.9

Table 2. 1997-2001 Behavioral Risk Factor Surveillance System Data

CHARACTERISTIC	JACKSON	MASON	WOOD	WV MEDIAN
% physically inactive	34.3	34.1	35.2	35.4
% obese by body mass index	22.1	22.2	22.2	23.5
% current cigarette smokers	27.4	27.0	26.6	27.2
% current smokeless tobacco users	10.5	8.5	6.9	9.3
% binge drinkers	5.9	6.2	9.8	8.4
% reported that diagnosed diabetic	7.2	7.8	7.2	7.3
% reported that diagnosed hypertensive	35.0	29.4	31.9	30.7
% not using seat belts	27.1	31.5	27.2	31.6
% with no health insurance	21.5	17.7	18.7	24.2
% with difficulty seeing doctor due to costs	12.6	9.3	14.6	15.9

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Table 3. 1993-2002 Average Annual Age-adjusted (2000 Standard)

Incidence Rates per 100,000 with 95% Confidence Intervals

TYPE OF CANCER	JACKSON	MASON	WOOD	WEST VIRGINIA
All sites	492.0	469.6	***504.8***	482.7
	(467.3-516.8)	(444.4-494.7)	***(491.0-518.6)***	(479.7-485.7)
Prostate	***171.9***	154.6	***161.5***	147.8
	(149.4-194.3)	(132.3-177.0)	***(149.4-173.6)***	(145.2-150.4)
Lung (men)	107.1	145.9	128.4	123.7
	(89.6-124.6)	(124.6-167.1)	(117.7-139.2)	(121.4-126.0)
Breast (women)	118.5	97.4	123.3	117.5
	(101.8-135.2)	(81.8-113.1)	(113.9-132.7)	(115.4-119.5)
Lung (women)	63.7	64.7	67.2	66.1
	(51.6-75.8)	(52.4-77.0)	(60.6-73.8)	(64.6-67.6)

~ fewer than 4 cases reported for entire period of 1993-2002

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Table 3. 1993-2002 Average Annual Age-adjusted (2000 Standard)

Incidence Rates per 100,000 with 95% Confidence Intervals, Continued

TYPE OF CANCER	JACKSON	MASON	WOOD	WEST VIRGINIA
Colorectal	56.6	55.8	61.5	59.5
	(48.1-65.0)	(47.0-64.6)	(56.7-66.3)	(58.4-60.5)
Uterus	25.8	24.5	26.4	26.3
	(18.1-33.6)	(16.7-32.2)	(22.1-30.7)	(25.4-27.3)
Bladder	26.0	18.4	24.6	23.3
	(20.4-31.7)	(13.5-23.4)	(21.6-27.7)	(22.7-24.0)
Non-Hodgkin lymphoma	***24.0***	19.8	***21.1***	17.9
	(18.5-29.5)	(14.6-25.0)	***(18.2-23.9)***	(17.3-18.5)
Mouth and pharynx (men)	17.0	21.7	17.5	16.4
	(10.1-23.9)	(13.3-30.1)	(13.6-21.4)	(15.5-17.2)

~ fewer than 4 cases reported for entire period of 1993-2002

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Table 3. 1993-2002 Average Annual Age-adjusted (2000 Standard)

Incidence Rates per 100,000 with 95% Confidence Intervals, Continued

TYPE OF CANCER	JACKSON	MASON	WOOD	WEST VIRGINIA
Ovary	10.2	10.5	17.5	15.9
	(5.3-15.0)	(5.3-15.7)	(13.9-21.1)	(15.2-16.7)
Cutaneous melanoma	17.4	14.2	***17.7***	13.9
	(12.6-22.2)	(9.7-18.7)	***(15.1-20.4)***	(13.4-14.4)
Cervix	15.7	7.9	10.7	13.1
	(9.2-22.2)	(3.2-12.6)	(7.7-13.6)	(12.3-13.8)
Leukemia (all)	13.8	9.4	***15.0***	12.1
	(9.6-18.0)	(5.8-13.1)	***(12.6-17.4)***	(11.7-12.6)
Chronic lymphocytic leukemia	4.5	3.7	***6.7***	3.8
	(2.2-6.7)	(1.4-6.0)	***(5.1-8.3)***	(3.5-4.1)

~ fewer than 4 cases reported for entire period of 1993-2002

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Table 3. 1993-2002 Average Annual Age-adjusted (2000 Standard)

Incidence Rates per 100,000 with 95% Confidence Intervals, Continued

TYPE OF CANCER	JACKSON	MASON	WOOD	WEST VIRGINIA
Acute myeloid leukemia	3.4	2.1	3.1	3.3
	(1.3-5.5)	(0.4-3.8)	(2.0-4.1)	(3.0-3.5)
Chronic myeloid leukemia	2.8	~	1.7	1.6
	(0.8-4.7)		(0.8-2.5)	(1.4-1.7)
Acute lymphocytic leukemia	~	~	1.0	1.2
			(0.3-1.6)	(1.1-1.4)
Kidney	11.2	12.2	12.9	12.4
	(7.5-14.9)	(8.2-16.2)	(10.7-15.1)	(11.9-12.9)
Pancreas	11.4	8.9	10.4	9.4
	(7.6-15.1)	(5.4-12.4)	(8.4-12.3)	(9.0-9.8)

~ fewer than 4 cases reported for entire period of 1993-2002

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Table 3. 1993-2002 Average Annual Age-adjusted (2000 Standard)

Incidence Rates per 100,000 with 95% Confidence Intervals, Continued

TYPE OF CANCER	JACKSON	MASON	WOOD	WEST VIRGINIA
Thyroid	5.0	5.2	4.8	5.9
	(2.4-7.7)	(2.5-7.9)	(3.4-6.2)	(5.6-6.2)
Brain	5.2	5.9	8.2	6.5
	(2.6-7.7)	(3.1-8.8)	(6.3-10.0)	(6.1-6.8)
Stomach	8.4	5.0	6.1	6.3
	(5.2-11.6)	(2.5-7.5)	(4.6-7.6)	(6.0-6.6)
Larynx	4.2	6.9	4.1	5.8
	(2.0-6.4)	(3.9-9.8)	(2.9-5.4)	(5.5-6.2)
Esophagus	2.4	7.1	3.9	4.8
	(0.7-4.1)	(3.0-10.1)	(2.7-5.1)	(4.5-5.1)

~ fewer than 4 cases reported for entire period of 1993-2002

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Table 3. 1993-2002 Average Annual Age-adjusted (2000 Standard)

Incidence Rates per 100,000 with 95% Confidence Intervals, Continued

TYPE OF CANCER	JACKSON	MASON	WOOD	WEST VIRGINIA
Multiple myeloma	6.0	5.9	6.1	5.3
	(3.3-8.7)	(3.2-8.7)	(4.6-7.6)	(4.9-5.6)
Testis	5.7	3.1	5.6	5.0
	(1.5-9.9)	(0.1-6.2)	(3.3-7.9)	(4.5-5.4)
Liver	3.9	2.2	3.0	3.7
	(1.7-6.2)	(0.6-3.9)	(1.9-4.1)	(3.5-4.0)
Hodgkin lymphoma	3.6	3.5	3.2	2.8
	(1.3-5.8)	(1.2-5.9)	(2.1-4.4)	(2.6-3.1)
Soft tissues	2.3	1.9	2.1	2.6
	(0.6-4.0)	(0.2-3.7)	(1.2-3.0)	(2.4-2.8)

~ fewer than 4 cases reported for entire period of 1993-2002

Table 3. 1993-2002 Average Annual Age-adjusted (2000 Standard)

Incidence Rates per 100,000 with 95% Confidence Intervals, Continued

TYPE OF CANCER	JACKSON	MASON	WOOD	WEST VIRGINIA
Eye	~	~	1.5	0.9
			(0.8-2.3)	(0.8-1.1)
Bones and joints	~	~	0.7	1.0
			(0.1-1.2)	(0.8-1.1)
Gallbladder	1.2	~	0.7	0.9
	(0.0-2.5)		(0.2-1.1)	(0.8-1.1)

~ fewer than 4 cases reported for entire period of 1993-2002

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Table 4. Average Annual (1998-2002) Number of Observed and Expected Invasive Prostate Cancers by Residential Zip Code at Diagnosis with 95% Confidence Intervals

ZIP CODE(S) AND DESCRIPTION	OBSERVED	EXPECTED
25106, 25502, 25503, 25520, 25515 (Henderson, Apple Grove, Ashton, Glenwood, and Gallipolis in Mason County)	4.6 (1.7-7.5)	4.8 (4.6-5.0)
25123, 25187, 25241 (Leon and Southside in Mason County and Evans in Jackson County)	5.0 (2.5-7.5)	4.3 (4.1-4.5)
25231, 25244, 25245, 25248, 25279 (Advent, Gay, Given, Kenna and Staats Mills in Jackson County)	5.0 (3.4-6.6)	3.8 (3.7-4.0)
25239, 25253, 25262, 25264 (Cottageville and Millwood in Jackson County and Letart and Mount Alto in Mason County)	7.0 (1.6-12.4)	3.9 (3.7-4.0)
25247, 25260, 25265, 25287 (Hartford, Clifton, New Haven and Lakin in Mason County)	5.0 (2.5-7.5)	3.5 (3.3-3.6)
25252, 25275, 26169, 26180, 26184 (Liverpool and Sandyville in Jackson County and Rockport, Walker and Waverly in Wood County)	6.2 (4.6-7.8)	6.6 (6.3-6.9)
26133, 26142, 26150 (Belleville, Davisville and Mineral Wells in Wood County)	5.6 (4.0-7.2)	7.1 (6.8-7.4)

Table 4. Average Annual (1998-2002) Number of Observed and Expected Invasive Prostate Cancers by Residential Zip Code at Diagnosis with 95% Confidence Intervals, Continued

ZIP CODE(S) AND DESCRIPTION	OBSERVED	EXPECTED
25271 (Ripley, Jackson County)	10.0	5.9
	(4.9-15.1)	(5.7-6.1)
25550 (Point Pleasant, Mason County)	8.2	6.5
	(4.8-11.6)	(6.3-6.7)
26101 (Parkersburg, Wood County)	48.4	29.7
	(28.6-68.2)	(28.5-30.9)
26104 (Parkersburg, Wood County)	8.0	5.9
	(4.1-11.9)	(5.7-6.1)
26105 (Parkersburg, Wood County)	13.0	8.6
	(8.5-17.5)	(8.3-8.9)
26164 (Ravenswood, Jackson County)	10.2	6.0
	(3.3-17.1)	(5.8-6.2)
26181 (Washington, Wood County)	8.2	5.1
	(4.8-11.6)	(4.9-5.3)
26187 (Williamston, Wood County)	6.0	4.3
	(3.6-8.4)	(4.1-4.5)

Table 5. Age-adjusted (2000 Standard) Cancer Mortality Rates per 100,000, 1998-2002

Site	Jackson	Mason	Wood	West Virginia
All site	229.5	232.0	202.1	221.6
Colon	15.7	21.7	17.2	22.6
Liver	~	3.8	2.4	4.1
Pancreas	11.4	4.7	9.0	9.2
Lung and bronchus	75.4	90.9	66.4	72.8
Cutaneous melanoma	6.8	2.8	3.4	2.9
Female Breast	25.8	30.1	19.2	25.7
Prostate	30.9	30.0	25.1	28.1
Bladder	7.3	3.9	6.1	4.9
Lymphoma	7.7	10.5	10.1	8.2
Testis	~	~	~	0.2
Leukemia	10.9	8.5	9.5	7.9

~ 4 deaths

Table 6. Public Water System APFO Status, Production Wells and Miscellaneous Use[a]

2002	Washington Works	Lubeck	Mason County	Racine Locks & Dam	Lakin Wellfield
# Wells tested	6	5	4	1	-
# Tests	41	29	9	1	-
# ND[b]	0	0	0	0	-
# NQ[c]	0	0	3	0	-
Mean	12.20 ppb	0.68 ppb	0.08 ppb	0.52 ppb	-
Median	3.06 ppb	0.61 ppb	0.07 ppb	0.52 ppb	-
2003	**Washington Works**	**Lubeck**	**Mason County**	**Racine Locks & Dam**	**Lakin Wellfield**
# Wells tested	6	5	-	-	-
# Tests	24	20	-	-	-
# ND	0	0	-	-	-
# NQ	1	0	-	-	-
Mean	14.02 ppb	0.52 ppb	-	-	-
Median	8.43 ppb	0.46 ppb	-	-	-

[a]WV Department of Environmental Protection, 2005; [b]Non-detect; [c]Not quantifiable

Table 6. Public Water System APFO Status, Production Wells and Miscellaneous Use[a], Continued

2004	Washington Works	Lubeck	Mason County	Racine Locks & Dam	Lakin Wellfield
# Wells tested	6	5	4	1	3
# Tests	25	21	4	1	3
# ND	0	0	0	0	3
# NQ	0	0	2	0	0
Mean	22.38 ppb	0.73 ppb	0.07 ppb	0.11 ppb	-
Median	9.41 ppb	0.60 ppb	0.07 ppb	0.11 ppb	-

[a]WV Department of Environmental Protection, 2005

Table 7. Public Water System APFO Status, After Treatment Samples[a]

2002	Washington Works	Lubeck	Mason County	Racine Locks & Dam	Lakin Wellfield
# Tests		4			
# ND[b]		0			
# NQ[c]		0			
Mean		0.65			
Median		0.65			
2003	**Washington Works**	**Lubeck**	**Mason County**	**Racine Locks & Dam**	**Lakin Wellfield**
# Tests		4			
# ND		0			
# NQ		0			
Mean		0.49			
Median		0.49			

[a]WV Department of Environmental Protection, 2005; [b]Non-detect; [c]Not quantifiable

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Table 7. Public Water System APFO Status, After Treatment Samples[a], Continued

2004	Washington Works	Lubeck	Mason County	Racine Locks & Dam	Lakin Wellfield
# Tests		4			1
# ND		0			1
# NQ		0			0
Mean		0.72			-
Median		0.66			-

[a]WV Department of Environmental Protection, 2005

Table 8. United States Department of Agriculture 2002 Agricultural Census

	JACKSON	MASON	WOOD	WV MEDIAN	WV 75TH PERCENTILE	# COUNTIES INCLUDED
# acres of cropland	**45,147**	**48,710**	30,419	18,802.0	31,381.0	55
# acres on which fertilizer used	**11,166**	**21,360**	5,153	4,473.0	7,764.0	55
# acres on which manure used	2,950	**3,505**	2,926	1,163.0	3,437.0	53
# acres on which insecticide used	212	**2,785**	357	170.0	433.0	45
# acres on which herbicide used	584	**10,818**	**3,331**	766.5	1913.0	52
# acres on which chemicals to prevent/treat crop disease used	35	209	80	78.0	219.0	25
# layers (chickens)	1,081	**1,781**	377	654.5	1354.0	52
# cattle and calves	**11,879**	**14,891**	8,292	5,633	10,794.0	55
# hogs and pigs	**441**	**614**	154	85.0	173.0	47
# sheep and lambs	**1,038**	270	183	378.0	597.0	45

Table 9. OSHA Carcinogen On- and Off-site Releases (in pounds except as noted),

Selected Years of Toxics Release Inventory Data

	JACKSON				MASON				WOOD			
	1988	1993	1998	2003	1988	1993	1998	2003	1988	1993	1998	2003
1,3-butadiene									474,000	200,000	56,861	5,857
Acetaldehyde					112,700	474,037	272,196	27,905				
Acrylonitrile									857,040	160,823	66,879	34,343
Arsenic compounds							95,216	101,117			81,725	
Asbestos (friable)	94,800											
Beryllium compounds							10,184	12,559				
Cadmium									2,231			
Cadmium compounds		782										
Chromium compounds			582	77			175,826	162,150	253	206	61,402	21
Cobalt	24											
Cobalt compounds						773	61,454	65,795				9
Creosote												7,200

* Data for dioxins and dioxin-like substances are reported in grams.

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Table 9. OSHA Carcinogen On- and Off-site Releases (in pounds except as noted),

Selected Years of Toxics Release Inventory Data, Continued

	JACKSON				MASON				WOOD			
	1988	1993	1998	2003	1988	1993	1998	2003	1988	1993	1998	2003
Dichloromethane									187,000	37,759	51,296	5,953
Dioxin and dioxin-like compounds*				0.95*				1.83*				0.7316*
Epichlorohydrin					3,167	849	3,316	2,009				
Ethyl acrylate									13,300	5,612	2,819	2,970
Ethylbenzene										10,562	11,485	
Ethylene oxide					31,125	950	280	470				
Formaldehyde					84	35	10	80	59,573	171,840	91,009	22,285
Lead									457	347	3,414	1,668
Lead compounds							85,250	84,239			36,285	1,028
Nickel									30	250	14,000	
Nickel compounds					252		162,560	142,894		173	81,203	26

* Data for dioxins and dioxin-like substances are reported in grams.

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Table 9. OSHA Carcinogen On- and Off-site Releases (in pounds except as noted),

Selected Years of Toxics Release Inventory Data, Continued

	JACKSON				MASON				WOOD			
	1988	1993	1998	2003	1988	1993	1998	2003	1988	1993	1998	2003
Polycyclic aromatic compounds			8,403	333				6				679
Propylene oxide					68,120	29,072	1,320	2,020				
Styrene									738,000	412,576	329,216	125,635
Trichloroethylene									13,600			

* Data for dioxins and dioxin-like substances are reported in grams.

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