ANALYSIS OF POTENTIAL CANCER CLUSTER AND ENVIRONMENTAL CONTAMINATION SELINSGROVE, PENNSYLVANIA

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Executive Summary

Early in 2007, there were reports in the media that a cancer cluster had occurred among former or current Susquehanna University students who resided in or frequented a privately owned off-campus apartment complex. The publication of the Pennsylvania Department of Health report "Susquehanna University Cancer Study" represents the culmination of almost two years of investigation of the purported cancer cluster reported in the news media in 2007. Analysis of the alleged cluster using commonly accepted scientific methods failed to present evidence that an actual cluster or an atypical occurrence of cancer existed. A comprehensive environmental sampling study undertaken by the Pennsylvania Department of Environmental Protection and supplemented by additional investigation undertaken by Susquehanna failed to find any evidence of environmental contamination. The epidemiologic study undertaken by the DOH also failed to find evidence that there was an excess of cancer related to environmental contamination. The excess of melanoma and testicular cancer found by the DOH may be an artifact of study methodology or related to non-chemical causes. Overall these results when evaluated using generally recognized criteria for disease causation failed to support the hypothesis that environmental contamination in Selinsgrove caused cancer in the student or resident population. These studies are sufficient to conclude that the environment in Selinsgrove and on the Susquehanna campus is healthy and that no further investigation is necessary.

Introduction

In March of 2007, an article in the Harrisburg, PA, *Patriot-News* reported that there was an unusual cluster of cancer cases among young adults associated with an apartment complex in Selinsgrove, PA[1]. The privately owned apartment building, known locally as the "warehouse," was primarily used for independent off-campus housing by students of nearby Susquehanna University. Following this initial report, a series of investigations was undertaken by the State of Pennsylvania to determine if there was evidence to suggest that environmental factors, particularly chemical contamination, associated with the warehouse or the University could be related to the reported cases of cancer. The State Department of Environmental Protection (DEP) undertook a wide-ranging environmental investigation and the Department of Health (DOH) undertook an epidemiological public health study. Additional environmental investigation was undertaken by Susquehanna University.

[1] "Cancer, Contamination and a Mother's Quest: Fears of a Deadly Cluster in Selinsgrove." Harrisburg Patriot-News, Page A01, March 4, 2007.

Susquehanna University requested CPF Associates, Inc., an independent scientific research and consulting organization located near Washington, DC, to perform a comprehensive review of the issue and all of the studies that have been conducted. This report documents the results of this review which critically examines existing studies and places their results in the context of current environmental health practice. The review was conducted by Dr. Paul C. Chrostowski, an environmental health scientist with over 30 years experience in evaluating the potential impact of environmental chemicals on human health and the environment. Dr. Chrostowski's qualifications are attached at the end of this report.

Methodology

A critical element in evaluating the relationship between the presence of a chemical substance to a disease is whether exposure to the chemical caused the disease. Causation may be thought of as a chain of events that links an injury to toxic substance exposure. This chain must not be broken for causation to be demonstrated. In evaluating a chain of causation for a specific injury or illness, analysts usually start by evaluating the illness and then determining whether the subject was actually exposed to the agent of concern. The exposure analysis is based on biomonitoring, dosimetry, environmental monitoring[2], mathematical modeling, questionnaires, or a combination of these methods. Once it has been determined that exposure has occurred, a toxicology/epidemiology review is conducted to determine if a health hazard exists. The existence of a health hazard is then linked to the exposure through risk assessment concepts such as dose-response quantification. Finally, confounding causes of the illness are investigated. Only when exposure has occurred at a level sufficient to elicit an adverse health effect that is not explainable by other causes can the exposure be causally linked to the disease.

In 1965, Sir Austin Bradford Hill developed the first general criteria for evaluating causation in epidemiologic studies. Since then consensus criteria have evolved in the scientific literature for evaluating claims of causation. These criteria may be distilled into a few general principles for assessing causation in individuals[3]:

Hazard identification/qualitative toxicology. Is the chemical capable of causing the alleged disease in the person claiming damage?
Exposure and Dose Response. Did the person claiming the disease contact the hazardous chemical at a sufficient level (duration, frequency, intensity) to result in an injury?
Time course of disease. Was exposure temporally related to the injury given appropriate considerations of disease latency?
Confounders/differential diagnosis. Are there possible alternative causes for the disease?
Analysis of scientific plausibility. Do toxicologic, epidemiologic, chemical, and clinical data present an internally consistent and coherent view of the disease?

[2] Biomonitoring involves analysis of samples taken from an individual – usually blood or urine. Dosimetry involves measurements made using a detector that is attached to an individual. Environmental monitoring involves measurements made in the space in which an individual may be present.
[3] For more information, see Chrostowski, PC 2007. Hill's Postulated in Jorgensen, SE & Fath, BD. Ecotoxicology. Vol 3. Encyclopedia of Ecology 1858-1863. Oxford:Elsevier.

Epidemiologic studies deal with populations rather than individuals; for example, a population consisting of all people potentially exposed to a commonly applied pesticide. Epidemiologic studies typically involve a comparison of the incidence of an effect in an exposed group to the incidence in a control group. In addition to the individual criteria mentioned above, epidemiological criteria for causation include the numerical strength of association between exposure and health effect, consistency of human associations among populations, and agreement with experimental evidence (e.g. from animal studies). Epidemiologic studies are often used to support what is known as general causation – is the exposure capable of eliciting a response in the general population. They cannot be used to evaluate the exposure of specific individuals such as the students who resided in the "warehouse" housing complex. These principles of causation will be used in evaluating the studies performed in Selinsgrove to investigate the potential association between environmental contaminants and cancer.

Initial Cluster Analysis

The newspaper report revealed four cases of cancer-related death associated with students who either lived at or visited the privately owned apartment complex known as the "warehouse" (121 David St.) in addition to another, apparently unrelated student death. The story also listed 21 other cases of cancer among people who lived in Selinsgrove. Cancer is not the definition of a specific disease or health effect but is a broad class of diseases that can have many manifestations. Each of these students had contracted different types of cancer-- osteosarcoma (bone cancer), adrenal cancer, melanoma, colon cancer and testicular cancer. These diseases are all certainly tragic, especially in young people, but the diversity of cancers suggests that there is not a common cause. The cases reported from the community were also extremely diverse and included colon, thyroid, ovarian, breast, lung, bone, testicular, brain, and colorectal cancers plus leukemia and lymphoma. There are many causes of cancer including chemical exposure, radiation, nutritional factors, medicine use, occupational factors, smoking, socioeconomic factors, sexual and reproductive behavior, and genetics. According to the National Cancer Institute[4], between 25-40% of all cancers are caused by tobacco use, between 10-70% are caused by diet, and another 10% are caused by infections. Pollution of air, water, or food with toxic chemicals is associated with between less than 1% to 5% of all US cancers.

All of the cancers diagnosed in the students are caused by factors other than exposure to toxic chemicals. For example, the association between exposure to sunlight and melanoma is well known; genetics, trauma and radiation exposure have been associated with bone cancers. All of the cancers that were reported have been observed in this age group elsewhere in the United States. Some of them are quite common in this age group. For example, 45.8% of all testicular cancer, 16.4% of bone/joint cancer, and 8.5% of melanoma has historically occurred in the 20-34 year old age group.

At the time of the initial publication, there was little information about the existence of toxic chemicals in the nearby environment. The *Patriot-News* identified benzene associated with a previously remediated underground fuel tank leak and a chemical known as benzo(a)pyrene in soil. Benzene has been associated with human cancer, particularly some forms of

[4] Nancy Nelson, NCI Benchmarks, Volume 4, Issue 3. June 17, 2004.

leukemia, however, the scientific literature has not identified benzene as a causative agent for any of the cancers contracted by the four students. Benzo(a)pyrene has been identified as a carcinogen in laboratory animals for stomach, skin[5], and possibly lung cancers; none of these are cancers contracted by the four students. Also, the level of benzo(a)pyrene found in soil of 1.24 mg/kg is a common amount in urban areas, usually resulting from vehicular traffic, home heating, or use of wood preservatives. Thus, there is no information to suggest that the presence of these chemicals potentially could have caused the students' cancers.

There is no evidence that any of the four students who contracted cancer were exposed to any potentially toxic chemical at levels sufficient to have an effect. Exposure is defined as contact with the chemical agent, whether by ingestion, by inhalation, or by dermal contact. If exposure has not occurred, it is not possible for a potentially toxic agent to cause a health problem. There are several ways in which exposure may be demonstrated. Typically exposure is demonstrated through chemical measurements in the air, food, water or another medium that a potentially exposed person could contact. In other cases, exposure is demonstrated by taking measurements from the individuals who feel that they have been exposed. Blood tests for lead exposure are an example of this type of test. In rare cases where exposure measurements are not available, estimates of exposure may be made through the application of complex mathematical models, although this technique is uncertain at best. Mere proximity to a hazardous substance is not evidence that exposure has or may occur. At the time of the initial press reports, there was no evidence that any of the residents of the “warehouse” had been actually exposed to any toxic or hazardous chemicals.

A few additional points should be kept in mind when evaluating the potential of chemicals to cause cancer. First, in cases where causation has been demonstrated, the duration of exposure has been long, often many years. Second, many cancers have a long latency period which is the time between exposure and the onset of the disease. Exposure to ionizing radiation may result in bone cancer twenty years after the exposure has stopped. Finally, it must be recognized that disease clusters occur all the time. The Agency for Toxic Substances and Disease Registry (ATSDR)[6] notes that "from a statistical perspective, it is almost inevitable that some schools, church groups, friendship circles, and neighborhoods will be associated with clusters of chronic diseases. When first noticed, such clusters are often regarded as resulting from some specific, predictable process, rather than as events with independent causes that happened to have occurred by chance in one particular place (such as a coin toss)." ATSDR further notes that “All clusters appear unusual; yet most are due to chance…In some cases, it might be discovered that an apparent cluster is actually an assortment of unrelated diseases and disease processes. For example, a “brain cancer cluster” might actually be found to include patients with metastases from distant sites, patients with nonneoplastic infiltrative diseases, and even patients who suffered strokes. Other clusters might eventually be found to represent nothing but a random pattern of incorrectly reported laboratory results or clinical findings.”

DEP Environmental Investigations

[5] The type of skin cancers found in laboratory animals exposed to high doses of benzo(a)pyrene are known as papillomas. They are distinctly different from melanomas.
[6] ATSDR. 2002. Case Studies in Environmental Medicine. Disease Clusters: An Overview.

Over a three month period in the spring of 2007, the DEP undertook a comprehensive environmental sampling program in air, surface water, ground water, and soils around Selinsgrove. The objective of this program was to identify any environmental chemicals that could be associated with the cases of human cancer that were reported in the March 4, 2007 *Patriot-News.*

The DEP used state-of-the-art sampling and analytical equipment to detect a broad range of chemicals of potential concern in the various environmental media. In addition to general environmental sampling, the DEP focused on several locations that had been associated with contamination in the past or locations that had been associated in the media with cancer cases. The sampling results of this program were compared to Pennsylvania Act 2 residential standards and background levels. Act 2 standards are environmental concentrations of chemicals that are designed to be protective of public health by serving as remediation guidelines; background levels are concentrations that occur naturally or as a result of normal human activities. Act 2 provides for both residential and non-residential statewide health standards. The residential standards are more conservative from the standpoint of health protectiveness. For example, many of the residential standards are based on the assumption that a young child inadvertently eats 100 mg of contaminated soil for 250 days each year for a total of six years. The DEP has opted to use the residential standards in their analysis; however, the non-residential standards are fully protective of public health for situations not involving long-term residential exposure.

The sampling program undertaken by DEP in Selinsgrove is virtually unprecedented in the United States with respect to both number of samples and the sophisticated analytical equipment employed. Typically this level of detail is reserved for communities adjacent to federal Superfund sites where there is a long history of known contamination, which is not the case with Selinsgrove.

The DEP concluded that there was no evidence of environmental contamination that could cause an imminent health risk to the public and also no evidence that a significant unknown source of exposure was present in the past that could have resulted in an unacceptable level of risk. A detailed discussion of the DEP's results follows. The full DEP report is available at http://www.depweb.state.pa.us/ncregion/cwp/view.asp?a=3&Q=519676

Ambient Air and Soil Vapor Sampling for Volatile Organic Compounds

This analysis found sporadic detections of a group of airborne chemicals including carbon monoxide, ethanol, methanol, methyl mercaptan and sulfur dioxide. The levels were all below those of health concern. Some of these chemicals are often found in indoor air from burning of fuels including natural gas, propane, or heating oil. Others such as ethanol and methanol are found in consumer products.

The DEP found evidence of benzene, toluene, xylenes, trichloroethylene, and perchloroethylene in some soil vapor samples. These materials were also present at levels below those of health concern. Benzene, toluene, and xylenes are found in gasoline. Perchloroethylene and trichloroethylene are used by drycleaners and machine shops in

addition to being present in consumer products.

None of the chemicals found in ambient air or soil vapor samples has been associated with the cancers reported in the *Patriot-News.*

Geoprobe Borings/Wells

DEP detected acetone in water, which is a very common lab contaminant and component of household products, at a level below that of health concern.

DEP also found elevated levels of manganese, iron, and aluminum in groundwater. Selinsgrove obtains its drinking water from a different groundwater zone (aquifer) that is physically isolated from the zone where these contaminants were found. Selinsgrove drinking water meets all federal and state standards for health protection and water quality.

Rhoads Mills Wells

These wells contained several contaminants. Trace levels of chloromethane and bromomethane as well as chlorine are suggestive of the introduction of treated tap water into one of these wells or the use of chlorine (sodium or calcium hypochlorite) as a well disinfectant. In rural areas, privately owned drinking water wells are often disinfected with chlorine and contain these chemicals.

Additional contaminants found in the Rhoads Mill site wells include iron, manganese, nitrate, nitrite, chloride, sulfate, metolachlor, and alachlor. These contaminants may be associated with former operations at this site. Alachlor is the most widely used herbicide in the United States. There is no evidence linking either alachlor or metolachlor with human cancer, although some studies in laboratory animals have shown tumors at high doses.

This water is definitely not potable and is probably so unpalatable that it would not be inadvertently ingested. The high concentrations of iron, chloride and sulfate will impart a bad taste to this water.

Further investigation at this location should be able to identify the exact source of the contamination. It is important to note, however, that this water has not been used for drinking and therefore no exposure has occurred, and the contaminants found in this water are not associated with the cancers found in the neighborhood.

Weiser Run Transects

DEP found several polycyclic aromatic hydrocarbons (PAHs) at low levels in the sediments and soils around Weiser Run. One of these compounds, benzo(a)pyrene was found to be slightly above the Act 2 standard.

PAHs are ubiquitous products of combustion that are found in emissions of everything from vehicular exhaust to home heating to backyard grills to cigarettes. In urbanized areas, it is not unusual to have concentrations of total PAHs up to 12 ppm, higher than those found by

the DEP.

The benzo(a)pyrene levels of 2.82 and 2.89 parts per million (ppm) are also well below the non-residential Act 2 standard of 11 ppm. Since this is partially submerged stream sediment, the nonresidential standard is probably more appropriate than the residential standard.

In addition, DEP found low levels of some herbicides including ametryn, terbutryn, simetryn, and prometryn. There are no Act 2 standards for these materials; however, review of other published standards and toxicological information leads to the conclusion that these chemicals are present at levels below those that could cause health problems.

Susquehanna University Sampling Locations

The DEP analysis found low levels of PAHs, herbicides, and arsenic in soil. The levels of PAHs were below the Act 2 standards and EPA's risk-based criteria and are therefore below levels of health concern. Levels of herbicides for which there are no Act 2 standards were well below additional standards and toxicological benchmarks. I also reviewed the usage of commercial fertilizers and lawn treatment chemicals by the University and found that both the products and their application are safe as far as human health is concerned.

Although two of the arsenic measurements were elevated above the Act 2 standards, the levels were well within naturally occurring background in Pennsylvania as determined by the DEP and also below the background levels in the Middle Atlantic States as determined by my independent investigations. The levels are much lower than the Act 2 non-residential standard of 53 ppm which is more appropriate given the activities that take place at these locations. This testing shows that a student athlete who contacted soil during his or her time at the University would be safe with respect to soil contamination.

In 2000, an underground heating oil storage tank at the Theta Chi fraternity house was removed due to a change in the heating fuel used. At the time the tank was removed, it was inspected and found to be properly protected and not leaking. Several groundwater monitoring wells were installed in 2000 following the removal and cleanup of the tank. During the tank removal in 2000, soils were removed and disposed of until the relevant standards were met. There has been no additional evidence of contamination of either groundwater or soil since that time. The University brought this location to the attention of the DEP who included it in their recent sampling program. The DEP also failed to find contamination at the site where the tank had been located. Because of limitations in the DEP sampling they recommended further investigation.

Based on the DEP request, Susquehanna undertook an additional investigation of potential groundwater contamination by petroleum products at the Theta Chi site[7]. This investigation involved the installation of three bedrock groundwater monitoring wells. Two rounds of sampling were conducted at these wells and at an existing well for a total of seven groundwater samples. There were no detectable petroleum constituents in any of the samples. These results confirm the previous results and the DEP conclusions that there is no contamination at this site.

[7] See Pennsylvania Tectonics. Site Characterization Activities: Theta Chi Properties. October 4, 2007.

DOH Health Study

The second main part of the state-sponsored investigation was a health study of cancer incidence in Selinsgrove residents and Susquehanna alumni conducted by the DOH. In contrast to the DEP investigation, which focused on the environment, the DOH investigation focused on people who lived in Selinsgrove and former students of the University. The object of the study was to determine if there was an environmentally-associated elevated cancer risk in these groups compared to the general population. The full DOH report, released on January 29, 2009 may be found at http://www.dsf.health.state.pa.us/health/cwp/view.asp?A=171&Q=252248

The first portion of this study analyzed the occurrence of cancer in Selinsgrove residents over the time period from 1996 to 2004, coincident with the time period for occurrence of the cancers in students who lived at the warehouse property. The incidence of total cancers in Selinsgrove was 10% lower than in the general population of Pennsylvania. No individual type of cancer occurred at a rate in Selinsgrove residents that was significantly[8] higher than the general population.

The second portion of the study focused on former students at the University. The study methodology was designed to compare cancer incidence rates in former students to incidence rates from the general population. The alumni list provided by the University included 13,097 entries. Pennsylvania residents made up the largest state category with 44% of the alumni population. This was followed by New Jersey with 17.8%, New York with 6.1%, Maryland, Virginia and Massachusetts each with less than 5%. The remaining 22.9% of the alumni were not accounted for by state.

The DOH obtained cancer incidence data among the alumni population identified by Susquehanna from each of the individually listed states. The state incidence data were also adjusted to account for the missing 23% of the data. Several other simplifications were also made to streamline the data analysis process. For example, the DOH assumed that the baseline age of a student's time of departure from the University was 20 years. The study compared the incidence of cancer in the alumni population of the various states to that of the general population in the State of Pennsylvania (i.e., state by state comparison of incidence rates were not performed). The results of the study showed that there was an elevated incidence of cancer at all sites in the alumni population. The risk ratio was 1.56 indicating a 56% increase in cancer in the alumni compared to the population at large. Two particular cancers – melanoma and testicular cancer - were responsible for this increase. The melanoma increase was the highest (358% over the general population) and the testicular increase was somewhat lower (214% over the general population), but still significant. None of the other cancers including colon/rectum, breast, bone, cervix, thyroid, Hodgkin's lymphoma, and leukemia were significantly higher than the general State of Pennsylvania population. The statistics used to perform the calculations were not available so the statistical methods and conclusions could not be adequately reviewed. An overwhelming

[8] In epidemiologic studies, the term "significant" refers to statistical significance which generally means that the incidence of the health effect is not due to random chance.

preponderance of evidence shows that environmental factors were not responsible for the additional cancer cases

Melanoma is on the rise in the United States in general and in Pennsylvania and New Jersey in particular. According to the National Cancer Institute[9], the national rate for melanoma is 16.9 cases per 100,000 individuals compared to 17.0 for Pennsylvania residents and 19.9 for New Jersey residents. The national rate reflects a 1.6% increase over the last 10 year period for which data are available. The most important risk factor for melanoma is skin color as reflected by race. Whites (Caucasians) have a 2.11% chance of contracting melanoma over a lifetime compared to a 0.08% chance for blacks (African Americans), a 0.17% chance for Asians/Pacific Islanders, and a 0.28% for Native Americans. To the extent that the population of Susquehanna alumni is dominated by whites (up to approximately 97%), the excess of melanoma in Susquehanna alumni may be associated with an excess in the number of white students. In addition, since the incidence of melanoma is substantially higher among New Jersey residents than Pennsylvania residents, it is possible that the excess of melanoma noted by DOH in the Susquehanna alumni population would have been lowered if the New Jersey population had been used as a comparison group for the relatively high proportion of alumni who are New Jersey residents.

Melanoma is thought to be caused by a complex interplay between genetics and exposure to sunlight. Heredity predispositions to the occurrence of a particular type of moles (dysplastic nevi) are strongly associated with melanoma as are sunburns and duration of exposure to the sun, especially in adolescents and children. Children are generally more prone to dysplastic nevi than adults and it is thought that exposure to sunlight during childhood may lead to dysplastic nevi and subsequently to melanoma. There are no environmental chemical risk factors for melanoma. For prevention of melanoma, the National Cancer Institute (NCI) recommends wearing long sleeves and pants, hats with a wide brim, sunscreens, and sunglasses with UV-deflecting lenses[10].

Testicular cancer is also on the increase in the United States. For males under the age of 55, the incidence of testicular cancer has almost doubled since 1975. According to the American Cancer Institute, the most significant risk factor for testicular cancer is an undescended testicle (cryptorchidism), a condition that occurs in about 3% of boys[11]. This condition can be surgically corrected. Surgical correction early in life decreases the risk of testicular cancer. Other risk factors include family history, HIV infection, age between 20 and 54 years, and race/ethnicity. As with melanoma, whites are more disposed to testicular cancer than blacks (5 times) or Asians and Native Americans (3 times). This racial disparity may help to explain the excess in Susquehanna alumni who are predominantly white.

There is little evidence to suggest that testicular cancer is caused by environmental factors. One type of testicular cancer, known as testicular germ cell cancer, has been weakly

[9] National Cancer Institute, Surveillance Epidemiology and End Results (SEER) data. http://seer.cancer.gov/csr/1975_2005/index.html

[10] What you need to know about melanoma. http://www.nci.nih.gov/cancertopics/wyntk/melanoma/page7.

[11] http://www.cancer.org/docroot/cri.

associated with exposure to the banned pesticide DDT[12]. It is not known if any of the alumni suffered from this rare form of cancer, however, the environmental investigations undertaken by the DEP failed to find DDT in the Selinsgrove environment. A recent study found an association between the use of marijuana by men between the ages of 18 and 44 and testicular germ cell cancer[13]. The evidence supporting marijuana as a risk factor is generally stronger than the evidence supporting DDT as a risk factor.

The DOH concluded that "although the total number of cancers detected in the alumni cohort exceeded the expected number, there is no evidence that this results from an environmental exposure that occurred at the university or that it is associated with university attendance". The DOH presented three lines of evidence to support this conclusion:

- There was no increase in cancer in the surrounding community that potentially would have had a greater degree of exposure
- The types of cancer responsible for the excess cases have known alternative explanations or are known not to be associated with environmental exposure
- The sampling conducted by the DEP did not find hazardous substances in or around the locations of greatest concern.

Conclusions

The publication of the DOH report "Susquehanna University Cancer Study" represents the culmination of almost two years of investigation of the purported cancer cluster reported in the news media in 2007. Analysis of the alleged cluster using commonly accepted scientific methods failed to present evidence that an actual cluster or an atypical occurrence of cancer existed. A comprehensive and unprecedented environmental sampling study undertaken by the DEP and supplemented by additional investigation undertaken by Susquehanna failed to find any evidence of environmental contamination. The epidemiologic study undertaken by the DOH also failed to find evidence that there was an excess of cancer related to environmental contamination. The excess of melanoma and testicular cancer found by the DOH may be an artifact of study methodology or related to non-chemical causes. Overall these results, when evaluated using generally recognized criteria for disease causation, failed to support the hypothesis that environmental contamination in Selinsgrove caused cancer in the student or resident population. These studies are sufficient to conclude that the environment in Selinsgrove and on the Susquehanna campus is healthy and that no further investigation is necessary.

[12] http://www.cancer.gov/cancertopics/causes/testicular/pesticides0408

[13] Daling, JR; Doody, DR; Sun, X et al. 2009. Association of marijuana use and the incidence of testicular germ cell tumors. *Cancer* published online 9 Feb 2009: http://www3.interscience.wiley.com/journal/121685776/abstract

BIOGRAPHY OF REPORT AUTHOR
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EDUCATION

Ph.D. Environmental Engineering and Science, Drexel University, Philadelphia, PA (1981).

M.S. Environmental Science, Drexel University, Philadelphia, PA (Environmental Chemistry and Health Specializations, USPHS Traineeship) (1979).

B.S. Chemistry, University of California, Berkeley, California (American Chemical Society Certified, Honors) (1976).

PROFESSIONAL CERTIFICATION

Dr. Chrostowski is a Qualified Environmental Professional (QEP) (#02970014) and a Fellow of the Royal Society of Health (FRSH).

EXPERIENCE

Dr. Chrostowski is a founding member of Chrostowski, Pearsall, & Foster. He is an environmental engineer, applied toxicologist, and chemist with over 30 years experience in environmental science and engineering work on behalf of both government and private clients. Previously, he was Director of Environment, Health & Safety programs at The Weinberg Group, Vice President and Senior Science Advisor at ICF/Clement, Senior Scientist at EA Engineering, Science & Technology, Assistant Professor at Vassar College, a consultant in private practice and a pollution control/industrial hygiene technician in industry. He has specialized experience in the scientific and technical aspects of federal, state, and international regulatory programs including the CWA, CAA, CERCLA/SARA, RCRA, TSCA, FIFRA, OSHA, waste management technologies and ecological assessment. In addition, he has directed projects involving environmental chemistry, remedial investigation, pollution control, regulatory affairs, and quality assurance. A substantial portion of this effort is directed to Superfund, RCRA, and private party cost and liability issues including divisibility, allocation, modeling remedial costs at complex sites, auditing environmental contractor performance, and analyzing consistency with the NCP and state programs. In addition to EPA and OSHA programs, Dr. Chrostowski has developed substantial expertise in indoor air quality, the risk analysis of hazardous material transportation, and the risk analysis of FDA-regulated products. Dr. Chrostowski has conducted research into environmentally-friendly new product development and has directed registration and approval petition processes for the environmental and occupational aspects of new products, pesticides, and pharmaceuticals. Dr. Chrostowski's research interests include the behavior of complex mixtures, radiation and chemical dose reconstruction, quantitative microbiological risk assessment, pharmacokinetics, application of quantitative management tools to environmental strategy development and evaluation, biomonitoring, use of epidemiology in risk assessment, mass transfer phenomena, applied statistics, and mathematical modeling for risk management decision making. Dr. Chrostowski is active in numerous professional societies and expert panels and has authored or co-authored over 100 publications or presentations in the environmental field. In addition to his technical work, Dr. Chrostowski has taught university-level environmental sciences and has presented expert testimony in litigation cases, regulatory, and permitting hearings and public meetings and has conducted technical negotiations on behalf of private and governmental clients**.**