Appendix A

Biographies of Study Participants

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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, Durda & Preziosi (CPF Associates, Inc). He is an environmental health scientist with about 30 years experience in environmental work on behalf of both government and private clients. Currently, Dr. Chrostowski's practice is divided among traditional environmental health issues, environmental forensics, strategic environmental management, and risk analysis. 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 environmental assessment. In addition, he has directed projects involving environmental chemistry, regulatory affairs, and quality assurance. In addition to EPA and OSHA programs, Dr. Chrostowski has developed expertise in indoor air quality, odor analysis, quantitative microbial risk assessment, the risk analysis of hazardous material transportation, and the risk analysis of FDA regulated products. Dr. Chrostowski's research interests include the behavior of complex mixtures, application of quantitative management tools to environmental strategy development and evaluation, pharmacokinetics, 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. Dr. Chrostowski has assisted attorneys in analyzing causation in personal injuries cases involving chemical and microbiological exposures and in scientific issues regarding the application of *Daubert* to a variety of cases associated with chemicals or microorganisms in the workplace or the environment. Details of his experience in human health and ecological risk, regulatory toxicology, and liability assessment; hazardous materials management; environmental engineering and chemistry; and environmental education are shown on the subsequent pages. This is followed by Dr. Chrostowski's employment history, professional activities, and publication list.

Risk Assessment, Risk Management, Regulatory Affairs, Regulatory Toxicology, and Liability Assessment

- Under the Environmental Protection Agency's (EPA) REM II, III, IV , TES and ARCS contracts, various state (Pennsylvania, Missouri, New Jersey, California, Colorado) Superfund contracts, and on behalf of private sector, and federal facility clients acted as task manager or senior resource person for baseline risk assessments, assessments of remedial alternatives, development of cleanup goals or ecological evaluations at numerous Superfund sites. To date, this has included approximately 350 sites. Acted as senior quality assurance reviewer for all Superfund/Resource Conservation and Recovery Act (RCRA) risk assessment work performed by Clement for EPA, Department of Defense (DOD) and the private sector. Acts as contract peer reviewer for risk assessments performed by other consulting firms and/or government agencies. Advised clients on administrative and legislative Superfund reform issues.

- Developed specialized expertise in quantitative areas of environmental analysis including failure analyses, geostatistics, mathematical modeling, sensitivity analysis, Monte Carlo simulation, decision theory, quantitative applications in risk management, and statistical dose-response modeling. Over the past 25 years, Dr. Chrostowski has conducted research in these areas, consulted with clients, prepared documents for submission to regulatory agencies and trained over 100 junior staff members in quantitative techniques. In addition to applying these methods to environmental problems, Dr. Chrostowski has developed and applied risk analytical tools to food safety, occupational safety and health, and medical device safety. Project director of a research project conducted for a private client whose goal is the use of advanced statistical techniques in risk assessment. Methodologies for imputing values for chemical non-detects, a probabilistic approach to calculating exposure, and extrapolation of risk from limited sampling are goals of the program. Developed alternatives to EPA's exposure assessment methodology . Developed methods for calculating exposure to subsurface soil including three-dimensional kriging, Monte Carlo simulation, mixing theory and frequency-weighted exposures. Applied statistical techniques to sampling plan design, non-linear regression analysis, and determination of background soil concentrations through analysis of underlying probability distributions. Performed a multivariate analysis for evaluation of sources of metals in groundwater.

- Responsible for risk assessment, ecological assessment, epidemiological evaluation, and engineering evaluation of environmental health and safety work related to incinerators in the United States, Canada, and Australia. This has included the development of emission rates, specification of chemical analytical techniques,

validation of analytical data, air dispersion modeling and developing protocols for indirect pathways. Experience includes over 30 municipal solid waste resource recovery facilities, several municipal sludge incinerators, eleven hazardous waste facilities, PCB incinerator, five cement kilns, several biomedical units, a thermal oxidizer, several thermal desorbers, and a thermal dioxin treatment unit. Consultant to industry, municipalities, and a citizens group for environmental health ramifications of waste-to-energy plants and materials recovery facilities. Assisted in developing permit requirements for a research incinerator. Evaluated permit application and developed conditions for a medical waste incinerator. Reviewed and critiqued protocols and risk assessments submitted by other consultants in support of permit applications for solid waste, hazardous waste, and medical waste incineration. Member of National Academy of Science/National Research Council committee on health effects of incineration. Directed a Monte Carlo analysis of environmental concentrations associated with hazardous waste incinerators and cement kilns using waste derived fuel on a nation-wide basis. Performed a multivariate analysis of the relationship between dioxin formation and combustion, flue gas chemistry, and air pollution control device parameters. Co-investigator in epidemiologic studies of potential exposure to incinerator emissions.

- Developed and implemented techniques for source- and liability-apportionment of chemical mixtures released into the environment. Applied these techniques to division of liability at several Superfund sites (including sites with up to 80 PRPs), to apportioning liability in toxic torts, and in cases involving New Jersey and Pennsylvania state laws. Also applied these techniques to investigate dating of releases. To date, these methods have been applied to petroleum, polychlorinated biphenyls (PCBs), toxaphene, chlordane, and polychlorinated dioxins and furans (PCDD/Fs). Developed and applied a method for distinguishing between two different sources of pesticide waste for cost recovery purposes.

- Participated in several cases involving Superfund, RCRA corrective action, or state program liability. Activities involved evaluations of divisibility, separation of municipal, mixed, and hazardous waste contributions to sites, cost allocations and recoverability on private CERCLA claims. Specific sites and/or chemicals have involved asbestos, mixed or comingled waste landfills, ink wastes, paint wastes, solvent spills, wastes associated with a contract (toll) chemical manufacturing operation, a multi-party pesticide disposal site, and a site involving co-disposal of surfactants and hazardous substances. This work included preparation of affidavits, participation in negotiations, and expert testimony in addition to technical analysis. Evaluated appropriateness of remedial actions and associated costs at Superfund sites. Evaluated compliance with the National Contingency Plan at private party Superfund sites. Evaluated costs and liabilities at a site governed by both Superfund and RCRA corrective action. Investigated conflicting requirements of state and federal regulations at inactive and spill sites. Audited investigative, community relations, construction management, quality assurance, and remedial contractor performance from engineering and cost standpoints. Determined if costs associated with cleanups were usual and customary or unusual in nature and extent. Developed and applied risk-benefit and life-cycle cost analysis models (deterministic and probabilistic) to site remediation.

- Analyzed issues related to environmental insurance claims at a variety of sites for both insurance companies and policy holders. Assessed timing of releases relevant to policy periods, sudden and accidental compared to gradual releases, historical state-of-knowledge, historical toxicology, the extent of liability associated with different regulatory

programs, future remedial costs, and separation of claimed costs into defense and indemnity components.

- Developed a protocol for good practices in bioavailability studies. Evaluated the bioavailability of arsenic, lead, and mercury in soils and sediments at inactive waste sites and in industrial byproducts such as ash and slag.

- Assisted environmental and personal injury plaintiff and defense attorneys in analyzing scientific expert reports regarding causation. Applied theories from *Daubert*, *Joiner*, and other significant cases to evaluating the reliability of scientific evidence in litigation. Assisted in preparing technical portions of pleadings and evaluating pleadings prepared by opposing counsel. Assisted at depositions of experts in personal injury and insurance cases.

- Developed and quality assured Material Safety Data Sheets (MSDS) for a variety of chemicals and chemical mixtures. Performed product analysis for metals and silicate mineralogy in support of MSDS development. Reviewed comprehensiveness of MSDS and DOT shipping requirements for a variety of reactive and explosive products. Investigated conditions for workplace and transportation reactivity of chemically reactive products.

- Principal investigator of a long-term project investigating human exposure to volatile organic chemicals ingested, inhaled, and dermally absorbed from water. Developed and maintained a comprehensive database of worldwide literature regarding exposures to volatiles from water. Developed and published an integrated human exposure model for these exposures. Validated the model with data collected from residential indoor air environments. Applied the model to potential exposure at numerous Superfund sites and actual exposure alleged by toxic tort plaintiffs. Integrated human exposure model with indoor air quality and soil gas infiltration models.

- Technical director for risk assessments at numerous pesticide sites. Performed an evaluation of the toxicological mechanism of action of DDTr. Directed a project for re-evaluation of cancer slope factors and reference doses for BHC isomers. Investigated the oncogenicity of lindane. Principal investigator of a project evaluating the potential for transboundary transport of pentachlorophenol. Evaluated analytical protocols for low level environmental measurements at a pesticide site. Other multipesticide sites included the Kem-Pest site for EPA, McIntosh manufacturing facility, Chemairspray site, and Aberdeen dump sites. Performed an environmental fate, transport, and exposure study on crop protection chemicals used in growing tomatoes. Senior science advisor to EPA's National Pesticide Survey. Included statistical evaluation of data, relational analysis, and review of study protocols. Project manager of a large-scale, nationwide pesticide exposure assessment conducted for termiticide application of chlordane and heptachlor according to EPA guidance. Negotiated with EPA on behalf of a private client concerning development of a monitoring and exposure study for chlordane. Evaluated the relative risk from home owner/applicator exposure to pesticides used for gypsy moth control, including acephate, carbaryl, DDVP, and integrated pest management. Provided expert testimony for evaluation of exposure to ethylene dibromide in ground water. Evaluated environmental fate and transport of isofenphos used as a termiticide. Co-principal investigator of a human health and ecological risk assessment for exposure to organochlorine pesticides and TBT from sediments to fish to consumers including humans and birds.

- Principal investigator for an external peer review of an epidemiologic study investigating immune system dysfunction performed by a government agency in the vicinity of a multiple party Superfund site. Taught fundamentals of epidemiology to a citizen's group. Evaluated the quantitative aspects of the use of epidemiology in risk assessment. Co-investigator for an epidemiologic study concerning emissions from a group of incinerators.

- Conducted investigations into the historical toxicology, state of knowledge, and regulatory history of PCBs, dioxins, chromium, halogenated organic solvents, mercury, asbestos, polycyclic aromatic hydrocarbons, free and complexed cyanides, phenols, and various products and wastes containing these materials.

- Conducted a substantial amount of work in regulatory toxicology. Supervised laboratory toxicological research into the induction of potentially detoxifying enzymes in rats exposed to phenoxy herbicides. Reviewed the literature and developed an oral reference dose for non-radioactive strontium. Developed reference doses for non-cancer effects of dioxin (reproductive, developmental, endometriosis). Conducted a critical review of the carcinogenicity of dichloroethylene (vinylidene chloride). Evaluated the toxicology and epidemiology of workplace and environmental exposure to sodium azide, hydrazoic acid and acrylamide. Developed IDLH for sodium azide. Researched the mode of action and dose-response relationships for DDT and congeners. Principal investigator of a re-evaluation of the human carcinogenic potential of BHCs.

- Developed a methodology for performing comparative risk assessments of implementation of remedial alternatives for Superfund and RCRA. The method, which includes and analysis of accidents and off -site hazards and risks, has been applied to three sites including one with 19 solid waste management units. Performed a risk assessment of remedial alternatives in parallel with a limited life cycle analysis of the same alternatives. Integrated cost data and quantitative measures of engineering reliability with risk data for overall remedy selection.

- Developed a methodology for calculating probabilities of occurrence and human health risks associated with chemical fires and spills. Directed a sensitivity analysis to determine the most significant variables in determining human exposures to materials associated with fires and spills. Applied the method to liquid and solid hazardous flammable and volatile material spills from storage tanks, tank trucks, and rail cars. Calculated human health and ecological risks associated with a spill of arsenic acid at a rail classification yard. Evaluated emergency response to a spill of carbon disulfide. Calculated the probability and consequences of detonation and explosion of a reactive substance under various disposal and use options.

- Technical director of risk assessments at three Superfund sites contaminated with asbestos. Evaluated human health implications of remedial actions including removal, encapsulation, and no-action. Developed experimental design for asbestos exposure assessments. Participant on EP A Region IX expert panel on asbestos at Superfund sites. Director of a project developing a mathematical asbestos exposure model. Internal consultant for environmental auditing problems concerning asbestos while at ICF. Interacts with asbestos laboratories and abatement contractors. Participant in EPA Public Buildings Asbestos Dialogue meetings. Evaluated kinetics of asbestos dissolution in physiological fluid. Calculated risks associated with asbestos abatement and disposal.

- Risk communication consultant for municipalities, chemical industry and the waste management industry. Includes development and implementation of risk communication strategies, preparation of oral and written materials, technical press releases, and public presentations at large public meetings, small groups, facility open houses, and the media. Performed comparative risk assessment of Municipal Solid Waste (MSW) management alternatives.

- Reviewed proposed regulations and/or guidance documents on behalf of the regulated community. Submitted comments and/or oral testimony on behalf of the regulated community regarding proposed EPA, OSHA, or ATSDR proposed rules. Selected projects included: Great Lakes Water Quality Initiative, Risk Assessment Guidance for Superfund; Hazardous Waste Identification Rule, guidance for institutional controls, and Indirect Exposure methodology. Monitored environmental rule-making in Florida on behalf of regulated community.

- Principal investigator of a project investigating exposure to micro-organisms, odors, and chemicals emitted from use of municipal sludge in mine reclamation. Evaluations included chemical and microbiological risk assessments, odor analysis, and assessment of the applicability of medical monitoring. Evaluated the potential for groundwater and surface water contamination associated with nitrogen compounds from composted sludge. Conducted a comparative environmental impact analysis of methods of management of POTW sludge for a municipality. Potential impacts on human health, ecological receptors, and water resources were evaluated. On behalf of EPA, peer reviewed a report in dioxins in municipal biosolids. Evaluated the potential for chemical-microbial toxicologic interactions following exposure to emissions from biosolids. Assessed health and safety ramifications of application of 503 Rule to an agricultural waste. Provided comment on EPA's draft NODA for dioxins in biosolids. Provided expert testimony regarding pathogenicity of biosolids. Performed quantitative microbiological risk assessments for pathogens potentially in biosolids.

- Developed a method for application of probabilistic risk analysis tools to determination of critical control points in the food processing industry. Applied the method to evaluation of the potential for microbial contamination in the sugar refining process. Evaluated product safety ramifications of two materials used in food processing.

- Directed the preparation of a review of the fate and effects of environmental mercury. Participated in a debate regarding mercury regulation and disposal. Senior advisor for evaluation of numerous sites contaminated by mercury releases from measuring devices. Evaluated air pollution control technologies for controlling mercury emissions. Conducted workshops for the Gas Research Institute (GRI) and the Southern Gas Association on mercury emissions at gas metering sites. Consultant to GRI to develop a mercury risk model. Participating in workgroup to develop emission standard for mercury in New Jersey. Directed a project involving source apportionment for mercury releases in Florida. Developed and implemented a methodology for assessing risks for exposure to mercury along three natural gas transmission systems. Critically reviewed USEPA's *Mercury Report to Congress* on behalf of a regulated industry. Member of ATSDR expert panel on mercury bioavailability. Applied IEM2 model to predict and evaluate mercury environmental fate and transport.

- On behalf of a private client, evaluated the probability, effects, and costs of a release

predicted in association with a Treatment, Storage, and Disposal Facility (TSDF) expansion. The liability assessment was used to negotiate a permit and host community agreement. Evaluated the probability of a release occurring and the probability of a release not being detected in conjunction with determining financial assurance requirements for a landfill under RCRA. Project director of risk analysis in support of a major TSDF continuation. Responsibilities include multichemical multipathway human health and ecological risk assessments, risk analysis of on-site accidents and transportation accidents, communication with the public and regulatory agencies. Project director of an Environmental Impact Statement being prepared for a new landfill. Conducted multimedia risk assessment and presented expert testimony in support of a hazardous waste landfill expansion. Evaluated RCRA financial assurance requirements for several TSDFs.

- Developed methodology for calculating risk associated with drinking water exposure to radiation at Superfund sites. Conducted an assessment at the Nuclear Lake, New York, abandoned processing site. Senior science advisor for an Environmental Impact Statement (EIS) prepared for an uranium enrichment facility. Principal scientist for the exposure component of a radiation dose reconstruction project at a major Department of Energy (DOE) nuclear facility. Evaluated human health and ecological ramifications of tritium emissions from a radionuclide labeling facility.

- Directed or acted as senior reviewer for risk or ecological assessment at five mining/milling/smelting sites. Developed new methodology for calculation of lead cleanup objectives. Conducted regulatory analysis of options for cleanup of mining sites. Used integrated uptake/biokinetics model to predict lead exposure. Reviewed toxicology of low level lead exposure. Reviewed and contributed to field and laboratory protocols for measuring blood lead, lead in paint, and lead bioavailability. Senior advisor for risk assessment at a secondary lead smelter. Developed protocol for integration of biological and environmental monitoring of lead assessment. Performed a comprehensive evaluation of the epidemiology and dose response for human exposure to arsenic in the workplace and environment. Designed, implemented, and interpreted a biomonitoring study for human exposure to arsenic in soil. Performed a study to measure worker exposure to soil-borne arsenic during maintenance activities. Implemented a risk management plan for residential development of an arsenic-contaminated property.

- Provided expert testimony related to exposure of a group of residents to airborne chemical emissions associated with cleanup of a hazardous waste site. Determined the relationship of acute health effects to a foam that was being used for suppression of volatile emissions. Directed an exposure assessment for residents accidentally exposed to spilled naphtha and petroleum cracking catalyst.

- Managed risk assessment of numerous wood-treating sites. Chemicals of concern included creosote, pentachlorophenol, copper/chromium/arsenic compounds, and chlorinated dioxins. Both human health and environmental impacts were evaluated. Of particular interest, was an analysis of the differential toxicology of components and contaminants of pentachlorophenol. In addition, Dr. Chrostowski developed a methodology for assessing dermal effects of exposure to creosote components and critically evaluated dose-response of mixtures of Polycyclic Aromatic Hydrocarbons (PAHs). Critically reviewed carcinogenicity of carbazole. Principal investigator of a multi-year project involving environmental fate and transport of wood treatment chemicals. Included development and application of a large-scale transboundary atmospheric transfer model and a mass transfer model for preservative volatilization from wood.

- Directed a project that developed a guidance document for multipathway exposure assessment procedure for the South Coast Air Quality Management District (California). Directed a project providing written comment on EPA's proposed multiple pathway risk assessment guidance.

- Directed both field and theoretical studies of speciation and migration of chromium in soil and ground water. Work included design of the investigation study, development of an innovative technique for measuring oxidation/reduction potential, and assessment of risks from chemicals in soil. Conducted human health and ecological risk assessments for chromium at the site. The culmination was a remedial action plan preparing the site for development. Evaluated remedial alternatives of *in-situ* chromium treatment at another site. Evaluated the status of a natural renovation chromium treatment program at a Midwest plating plant. Conducted a critical review of cleanup levels for chromium in soil.

- Conducted a review of indoor air exposures to complex mixtures of chemicals in the workplace and residential environments. Investigated the epidemiology and dose response of lung cancer and cardiovascular disease associated with indoor air exposure. Directed a risk assessment for workplace exposure to polyacrylamide dust.

- Acted as an expert witness for litigation concerning human exposure to dioxins at Missouri dioxin sites. This work involved process chemistry of dioxin formation, phenoxyherbicide manufacturing, environmental fate and transport, statistical analysis of analytical data, and pharmacokinetics. Evaluated the chemical kinetics and thermodynamics of formation of dioxin during combustion and in PCB-containing heat exchangers.

- Acted as a consultant to three private clients on the subject of human health and environmental impacts of disposal of ash from MSW incinerators. Included expert testimony and litigation support. Developed a methodology for conducting a screening risk assessment for ash disposal. Performed a full-scale risk assessment for a proposed ash monofill. Evaluated options for re-use of ash from wood combustion.

- Performed an evaluation of the potential relative risk associated with ground water, air, and surface water contamination, as well as fire and transportation spills all within one political jurisdiction. This involved seven facilities, including a hazardous waste TSDF, oil refinery and several Publicly Owned Treatment Works (POTWs)

- Supervised the development of Polychlorinated Biphenyl (PCB) cleanup goals in aquatic sediment at the ReSolve Superfund site. This project included the use of several complex mathematical models in addition to integrating field biology with exposure and toxicological concepts. Senior technical advisor to development of a technical guidance document for cleanup of PCBs from sediments for Pennsylvania Department of Environmental Resources. Advisor to State of Mississippi regarding PCB issues. Principal investigator for review of a PCB toxicology assessment. Developed mathematical models for evaluating co-mobility of PCBs and solvents in soil. Developed a congener-specific risk assessment methodology for PCBs. Advisor to a project evaluating PCBs spilled from natural gas pipelines on behalf of a gas distribution company. Advisor to Department of Justice regarding PCB environmental chemistry. Evaluated types of PCB releases and remedial responses for an insurance carrier.

Evaluated non-cancer systemic effects of ingested PCB exposure.

- Project director of an investigation into the status of viability of the endangered Desert Tortoise in the Las Vegas Valley. On behalf of the development community, participated in negotiations with the Fish and Wildlife Service (FWS) and Bureau of Land Management in addition to litigation involving the Desert Tortoise. Project culminated in a listing of the tortoise as threatened rather than endangered. Project manager for a task involving evaluation of ecological risk models for EPA. Developed work plans including sampling requirements and data quality objectives for ecological risk assessments and environmental toxicity testing. Performed an ecological risk assessment for the Florida panther. Evaluated potential ecological ramifications of converting farmlands to natural areas.

- Performed endangerment and/or risk assessments of four sites associated with abandoned coal-gasification facilities. Assisted in developing a protocol for rapid assessment at manufactured gas plants. Conducted remedial investigations at two gas plant sites for a utility. Evaluated the bioavailability and toxicity of cyanide wastes at gas sites. Investigated liability at a former manufactured gas plant site in conjunction with a property acquisition. Assisted legal defense team regarding a lawsuit over property transfer at an inactive manufactured gas site. Evaluated exposure from a former manufactured gas site associated with CERCLA and toxic tort claims. Evaluated the historical toxicology and state-of-regulation of by-products and wastes from manufactured gas plants and coke byproduct plants.

- Managed the development and application of a cost-effectiveness risk assessment methodology for the Electric Power Research Institute. This project included original contributions in fate and transport of unstable substances in water and developing a link between benefits, costs, and both human health and aquatic life risks.

- Co-principal investigator of a long-term project investigating the hypothetical endocrine modulation effects of bisphenol A and phthalate esters. Investigated structure-activity relationships and conducted risk and exposure assessments for these effects. Performed a risk assessment of potential endocrine effects of ingested phthalates and phthalate substitutes.

Hazardous Materials Management

- Developed and implemented protocols for auditing contractor performance and costs in association with cleanup of inactive waste sites. Evaluated contracts, proposals, invoices, and other evidence of costs. Analyzed NCP consistency, necessity for cleanup, conformance to generally accepted practices, and cost-effectiveness. Worked with accounting firms on remedial cost-control measures. Evaluated regulatory agency claims for oversight costs. Advised clients on remediation strategy and cost-control of remediation contractors. Retrospectively apportioned costs at sites among various regulatory programs. To date, these methods have been applied to sites with in excess of $1 billion in liability. Co-author of a Superfund cost recovery handbook.

- Principal investigator for a project investigating EP A's development of exit criteria for the Hazardous Waste Identification Rule (HWIR). Constituents investigated include

acrylonitrile, arsenic, beryllium, chromium, and toxaphene. Evaluated and made recommendations regarding EPA's use of quantitative structure-activity-relationships and peer review in HWIR.

- Performed an analysis of trends associated with mercury in the MSW stream. This included a mass balance that calculated mercury diverted into stack gas and ash from the operation of an incinerator. The analysis predicted both current and future mercury levels. Evaluated physico-chemical unit operations for gaseous mercury control. Determined recycling options for mercury waste.

- Performed analysis and submitted documentation to support the waste classification of a combustion residue as a non-hazardous waste. Conducted waste characterization for spent sandblast material.

- Managed a project to develop a remedial action plan for remediation of a development site contaminated with PCBs, PAHs, asbestos and petroleum. Included technical and regulatory aspects of remediation, health and safety planning, and monitoring of the extent of remediation.

- Technical director of Remedial Investigation/Feasibility Study (RI/FS) activities conducted by ICF at the Hopewell Landfill Superfund site on behalf of the York County Solid Waste Authority. Activities included preparation and implementation of workplans, QAPPs, H & S plans, community relations, supervising junior staff, developing remedial action objectives, negotiating with EPA and state regulators, remedy selection and monitoring the effectiveness of the remedy. Technical manager of RI/FS activity at two state-lead Superfund sites. This included the Wide Beach, New York, PCB site. Participated in sampling design, data analysis, risk assessment, environmental assessment, development of cleanup levels, community relations, conceptual design of alternatives, evaluation of remedial alternatives, and negotiations among interested parties.

- Advised a private client on RCRA; the Federal Insecticide, Fungicide, Rodenticide Act (FIFRA); and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) issues associated with purchase of a property previously contaminated with organochlorine pesticides. Activities included interpretation of the Toxicity Characteristic Leaching Procedure (TCLP) data, manifesting, conducting a risk assessment, and meeting with regulatory agencies.

- For a private client, directed oversight of contractor activities involved in remediation of a site contaminated with organic arsenicals. This work involved monitoring sampling, analysis, and development of remedial alternatives, including evaluation of technology and costs for treating inorganic and organic arsenic in waste, water, sediment, and soil.

- For a private client, conducted a study of PCB migration from an inactive sanitary landfill. This project included both field studies and mathematical modeling for passive and active vapor phase transport. The work culminated in a decision not to remediate.

- For a private client, investigated the impact of RCRA and FIFRA on pentachlorophenol manufacturing. The project included a review of process chemistry, an evaluation of waste minimization programs, a commercial TSDF survey, and a review of applicable treatment technologies. Performed an analysis for disposal options for F027 waste.

- Performed modeling and developed monitoring plans for air exposure analysis at hazardous waste sites. Designed and implemented an ambient air monitoring program for lead in response to a New Jersey Environmental Cleanup Responsibility Act action. Used air modeling to aid in design of PCB storage barn.

- For a private client, performed an evaluation of health, safety, and environmental impacts of a proposed TSDF expansion. Included testimony before an administrative law judge.

- For a private client, directed studies to support a treatment program that will remove dioxins/furans from groundwater. These studies included locating the source of the dioxins, predicting their mobility, recommending personal protection for remedial personnel, evaluating treatment techniques, and advising on risk communications.

- For a county government POTW , directed a program to assess the hazards posed by aqueous chlorine emissions. Used the MERGE model and EPA's approach based on water quality criteria. This included development of a stochastic technique for evaluating exposure of aquatic life to chlorine.

- One of two authors of a RCRA exposure information report for a private client. Project manager for an Alternate Concentration Limit (ACL) demonstration project for the same client. Additional RCRA-related assignments have included development of a risk-based closure plan, assessing liability requirements for owner operators and advising clients on listing and categorization of wastes. Advise clients on the impact of land disposal restrictions and anticipated revisions to RCRA. Managed activities for a RCRA closure equivalency demonstration for a private client

- Project manager of an RI/FS of an oil spill in Delaware Bay. Senior advisor to a team developing ACLs for service stations with groundwater contamination by petroleum. Developed a model to predict the rate of dissolution of spilled gasoline in groundwater for EPA. Senior advisor to an Underground Storage Tank (UST) investigative team. Senior reviewer for EP A's gasoline risk assessment methodology . Assisted a building contractor in evaluating a fuel oil spill that contaminated a development site. Director of field and evaluation work for litigation involving a gasoline release from a UST. Evaluated probability of failure of USTs including impact of corrosion and maintenance.

- Advised local governments (Dutchess County, New York, and York County, Pennsylvania) on management options for both active and inactive hazardous waste sites and solid waste disposal options. Performed hazardous materials audits for a dye factory for the city of Poughkeepsie, New York, and a specialty organic chemicals facility for the town of Woodbury, New York. Performed a due diligence audit for the acquisition of a chrome plating plant in New York state by a foreign investor. Assisted in the environmental audit of a major Washington, D.C., hotel complex for a foreign investor. Formerly senior advisor to Clement's environmental audit practice.

- Performed preliminary evaluations of numerous potential Superfund sites using the Hazard Ranking System (HRS). Performed QA/QC on HRS scoring conducted by others. Participated in the National Priority List (NPL) de-listing operation and audit of Superfund participation for private clients. Provided input to EPA's HRS revisions. Performed a sensitivity analysis of the HRS. Used HRS to contest rankings performed

by EPA and state agency contractors.

- Provided oversight for contractor compliance to remedial plans at several former hazardous waste sites undergoing development. This included negotiations with state officials in New Jersey and California.

- Advised the FWS about environmental liabilities associated with purchase of property. This evaluation resulted in savings of millions of dollars.

Environmental Chemistry and Engineering

- On behalf of Superfund Potentially Responsible Parties, traced chemical processes in a manufacturing plant to ascertain contributions to an NPL site. Performed analyses of divisibility of Superfund liability and recovery of response costs. Performed mass and materials balances of chemical production. Conducted analyses of waste streams that can be produced under various chemical manufacturing process scenarios. Evaluated the production of metal alloys and their subsequent environmental fate.

- Pioneered in the application of forensic techniques to environmental science. Developed protocols for environmental sampling to meet strict evidentiary requirements. Developed and applied chemical fingerprinting, isotope analysis, dating, co-occurrence and other source apportionment techniques.

- Principal investigator of a project designed to validate over 20 years of environmental radiation measurements of a DOE site. Developed a statistical Quality Assurance/Quality Control *(QA/QC)* program to implement the validation. Developed techniques to perform second-level analytical data validation to data which had already passed the contract laboratory procedure validation. Applied technique to numerous cases resulting in major impacts on regulatory decisions.

- Developed an analytical methodology for rapid field detection and quantification of organophosphate pesticides. Compared results to laboratory methods using the gas chromatography/flame photometric detector. Applied methods to a multiple pesticide release incident in New York. Hands-on experience with numerous methods for sample collection, sample preparation and analysis. Sample preparation experience includes the use of Kuderna-Danish evaporators, Soxhlet extractors, continuous liquid-liquid extractors, and sonification. Analytical experience includes gas chromatography/mass spectrometry , flame ionization, electron capture, Hall, and photoionization detectors, high performance liquid chromatography, spectroscopy, electrochemistry, and wet methods. Data handling experience includes statistics, data reduction, use of electronic integrators, and chemometric pattern recognition.

- Developed in-depth chemical fate and transport profiles of polychlorinated aromatics (PCBs, PCDD/ PCDFs) and PAHs. Developed criteria for organic volatiles and metals in drinking water based on their effects on human health. Senior peer reviewer for exposure sections of the Agency for Toxic Substances and Disease Registry toxicological profiles. Directed laboratory research projects following the Toxic Substances Control Act (TSCA) protocols on environmental fate and transport of four chemicals. Modeled environmental performance and estimated properties of over 50 chemicals. Used structure-activity relationships to evaluate environmental fate of

chemicals.

- Developed chromatographic methods for rapid analysis of PCBs absorbed to surfaces of vegetation and in surface films on water bodies. Applied the technique to evaluating PCB exposure at the Schatz Bearing Site, Poughkeepsie, New York.

- Developed a technique for rapidly assessing emissions from chemical fires based on thermodynamics, kinetics, and mass transfer .

- During the 4 years from 1969 to 1972 performed as an industrial quality control/process control chemist. Included statistical analysis, development of sampling plans, development of control charts, and specification of raw materials. Developed a *QNQC* plan for an independent contract laboratory . Audited *QA/QC* programs for private labs. Performed *QA/QC* audits on six contract laboratories and field labs in the REM III Superfund contract. This involved several lab visits per year with inspection of QA documentation and standard operating procedures along with observation of all activities from receipt of samples of chain-of-custody to printing data reports. Audited a private laboratory for discrepancies in *QA/QC* program.

- Compared TCLP to the extraction procedure toxicity methods for extraction of metals from tailings at the Palmerton Zinc site. Evaluated efficiency of TCLP, EP Tox, and WET extraction fluids on various metal species. Evaluated impact of modifications of TCLP extraction, digestion, and analytical methods for lead. Conducted laboratory and theoretical studies on lead behavior during extraction testing.

- Conceptual design of treatment operations including stripping and activated-carbon treatment for aqueous organics and on-site chemical reaction for soil-bound PCBs. Developed and implemented laboratory and pilot plant protocols for testing of aquatic ozonation systems. Conducted treatability studies in many areas of water and wastewater treatment.

- Conducted laboratory testing and advised a client on technical and regulatory basis of the FIFRA registration of a disinfectant.

- Evaluated a series of new techniques developed by a pesticide manufacturer to quantify low level analytical sensitivities. Performed data validation of applications of the method to herbicides in groundwater.

- Developed and implemented chemometric methods for fingerprinting and source-apportionment of complex mixtures including PCBs, dioxins, toxaphene, chlordane, volatile organic compounds, metals, petroleum, and PAHs. Includes pattern recognition, multi-variate analysis, principal components analysis, factor analysis and theoretical chromatography.

- Evaluated the mass migration of PCBs from a series of industrial heat exchangers. Determined the total quantity of PCBs on-site and off -site soil. Developed a method for dating a PCB release. Advised law-firm client on waste-water treatment of wastes containing PCBs. Evaluated whether PCB releases were sudden and accidental or continuous with respect to time.

- Designed and placed in a laboratory a study of the geochemistry of arsenic in a specific

waste material. Integrated results from numerous different analytical methods and interpreted the results regarding ramifications to environmental mobility, human bioavailability, and ecological toxicity. Methods included ion chromatography, sequential extraction, and electron spectroscopy. Applied chemometric techniques to apportion arsenic in fill among soil, coal ash, and other materials.

- Developed and implemented a protocol for calculating time-to-cleanup for sites undergoing natural attenuation remedies using advanced kinetic modeling and Monte Carlo techniques.

- Developed a protocol for the application of disinfectants to shock treat recreational waters focusing on the control of waterborne pathogens. Provided comment to WHO on recreational water risk assessment.

Environmental Education

- Developed and taught an environmental chemistry curriculum at Vassar College. Course work at both undergraduate and graduate level and included both lecture and laboratory courses.

- Developed and taught a course on exposure assessments and risk characterization to EPA Regional Superfund personnel, U.S. Air Force, and California Department of Health Services. Taught impact of other laws on Superfund to U.S. Air Force.

- Lectured to numerous groups on risk assessment, environmental regulation, and hazardous waste management, including the University of California, Rutgers University, Pace University Law School, and George Mason University.

EMPLOYMENT HISTORY

1999-present	President, CPF Associates, Inc.
1993-1999	Director, Environment, Safety & Health practice, The Weinberg Group Inc.
1985-1993	Vice President and Senior Science Advisor, Clement Division of ICF/Kaiser
1984-1985	Senior Scientist, EA Engineering, Science & Technology
1981-1984	Assistant Professor, Vassar College
1979-1984	Consulting scientist in private practice
1976	Information Analyst, Solar Energy Information Center
1974-1976	Research technician, University of California
1970-1972	Laboratory/industrial hygiene technician, C&D Batteries
1968-1970	Laboratory/pollution control technician, Jack Frost Sugar
1964-1968	Petty Officer, 2nd Class, U.S. Navy

PROFESSIONAL SOCIETIES

Air and Waste Management Association
American College of Toxicology (Regular member)
American Society for Quality (Former member)
American Chemical Society

American Chemical Society Environmental Division
American Industrial Health Council (Exposure assessment, hazard identification and ecological risk assessment committees)
American Society for Testing and Materials
American Statistical Association (Risk Group)
Association for the Environmental Health of Soils
Hazardous Material Control Research Institute (Former member)
International Society for Exposure Analysis
National Environmental Health Association
Society for Environmental Toxicology and Chemistry (former member)
Society for Risk Analysis
History of Science Society
Water Environment Federation

PRO BONO COMMUNITY ACTIVITIES

Montgomery County, MD Energy and Air Quality Advisory Committee
Takoma Park, MD Committee on the Environment
Science Fair Judge Environmental Science Projects
Montgomery College Expansion Advisory Team

PROFESSIONAL ACTIVITIES

Participant in EPA's Metals Assessment Issue Papers Workshop December 2002.

Member Montgomery Co., MD Committee on Energy and Air Quality.

November 2001. Presentation on Environmental Issues in Real Estate Transactions to Shulman Rogers real estate practice group.

Peer Reviewer, EPA's Workshop to Peer Review the Risk Assessment Guidance for Superfund Volume 3 Part A: Process for Conducting Probabilistic Risk Assessment. November 8-9, 2000. Arlington, VA.

Seminar "Solving Environmental Mysteries with Forensic Science" presented to faculty and students of Drexel University School of Environmental Engineering Science and Policy, January 28, 2000.

Peer Consultant, EPA 's Workshop on Issues Associated with Dermal Exposure and Uptake. Bethesda, MD, December 10-11,1998.

Participant at 22nd Information Network for Superfund Settlements Conference, Washington DC, October 1998.

Listed in International Who's Who of Professionals.

Member of International Life Sciences Institute committee on bioavailability in risk assessment.

Member of Drexel University School of Environmental Science, Engineering & Policy Advisory Board.

Member of Agency for Toxic Substances Disease Registry expert panel on bioavailability of mercury.

Member of the National Academy of Sciences/National Research Council Committee on Health Effects of Waste Incineration.

Peer reviewer for several journals including *Environmental Science and Technology, Water Research, Risk Analysis, Human and Ecological Risk Assessment, Journal of the Air and Waste Management Association,* and *Journal of the American Water Works Association.*

Participant on the A WW ARF/KIW A Committee for the joint publication of "Non-Specific Analysis in Water Treatment."

American Chemical Society contact for "Science Behind the News" on subjects of PCBs, dioxin, incineration, and exposure assessment.

Session Chairperson - Permitting and Risk Assessment - 1989 Conference on Hazardous Wastes and Hazardous Materials.

EPA/Clean Sites Workshop on Standard Exposure Assumptions and Superfund Cleanup Standards participant,

EPA Workshop on Technical Issues in CERCLA Municipal Settlements, December 1991 participant.

Gas Research Institute Workshop on Mercury Contamination at natural Gas Industry Sites, January 1992.

Instructor, Virginia Bar Association continuing education course on environmental problems associated with railroad operations. 1996.

Instructor, Federal Bar Association continuing education course on regulatory toxicology. 1997.

Participant ICMA/EPA conferences on Superfund risk assessment reform, 1997, 1998.

Panel member, "Criteria for Selection of PBT Chemicals – Scientific Underpinnings". ABA Section of Environment, Energy and Resources. Nov. 15, 1999.

PUBLICATIONS AND PRESENTATIONS

Chrostowski, P.C., Dietrich, A.M., and Suffet, I.H. 1980. Bench scale testing of an ozone system prior to pilot plant operations. Paper presented at the American Water Works Association Conference, Atlanta, Georgia. pp. 683ff.

Chrostowski, P.C., Dietrich, A.M., Suffet, I.H., and Cairo, P.R. 1980. An experimental program for optimization of the application of ozone in drinking water treatment. Paper presented at the American Chemical Society's 14th Middle Atlantic Regional Meeting, King of Prussia, Pennsylvania.

Dietrich, A.M., Chrostowski, P.C., Brunker, T.M., and Suffet, I.H. 1981. Physical-chemical mechanisms of aqueous ozonation. Paper presented at the American Society of Civil

Engineers National Environmental Engineering Conference, Atlanta, Georgia.

Chrostowski, P.C., Dietrich, A.M., and Suffet, I.H. 1981. Difference in physical-chemical properties of aquatic humics on treatment with ozone. Paper presented at the Symposium on Terrestrial and Aquatic Humic Materials at University of North Carolina, Chapel Hill, North Carolina.

Chrostowski, P .C. and Suffet, I.H. 1981. Ozonation of aquatic humics. Paper presented at the American Chemical Society National Meeting, New York, New York.

Crawford, J.A., Hassett, J.P., Chrostowski, P.C., and Suffet I.H. 1981. Evaluation of fractionation techniques for aquatic humic materials. Paper presented at the American Chemical Society's 15th Middle Atlantic Regional Meeting, Washington, D.C.

Chrostowski, P.C., Wright, R.L., and Suffet, I.H. 1982. Water quality factors affecting ozone demand. Paper presented at the Conference on Progress in Chemical Disinfection: New Concepts and Materials at State University of New York, Binghamton, New York.

Chrostowski, P.C. and Pearsall, L.J. 1982. Environmental fate of pesticides used in gypsy moth suppression: Data acquisition and modeling. Paper presented at the American Chemical Society's 12th Northeast Regional Meeting, Burlington, Vermont.

Chrostowski, P.C., Dietrich, A.M., Suffet, I.H., and Yohe, J. 1982. The role of mass transfer in pollutant removal by air stripping. Paper presented at the ASCE National Environmental Engineering Conference.

Chrostowski, P.C., Dietrich, A.M., and Suffet, I.H. 1982. Laboratory testing of ozonation systems as a prelude to pilot plant operations. J. Am. Water Works Assoc. 74:38-44.

Chrostowski, P.C., Pearsall, L.J., Thomas, H., and Shaw, C. 1983. The role of environmental chemistry in risk assessment at inactive landfill sites. Paper presented at the American Chemical Society National Meeting at Washington, D.C.

Chrostowski, P.C. 1983. A physical approach to undergraduate environmental chemistry. Paper presented at the American Chemical Society's 13th Northeast Regional Meeting, Hartford, Connecticut.

Neukrug, H., et al. 1983. Removing organics from Philadelphia drinking water by combined ozonation and adsorption. Prepared for the Office of Research and Development, U.S. Environmental Protection Agency. EPA 6OO/S2-83-048.

Chrostowski, P .C., Dietrich, A.M., Suffet, I.H., and Chrobak, R.S. 1983. A comparison of granular activated carbon and a carbonaceous resin for removal of halogenated organics from groundwater . In McGuire M. and Suffet I.H. (eds.). Treatment of Water by Granular Activated Carbon. American Chemical Society Advance in Chemistry Series No.202. Washington, D.C.: American Chemical Society. Pp.481-502.

Chrostowski, P .C. 1983. Detection and elimination of an organic interference in the indigo method of aqueous ozone. Anal. Lett. 16: 1177 -1186.

Chrostowski, P.C., Dietrich, A.M., and Suffet, I.H. 1983. Ozone and oxygen induced oxidative coupling of aqueous phenolics. Water Res. 17:1427-1633.

Fava, J .A., Rue, W .R., Chrostowski, P .C., and Ferris, J .S. 1984. Management considerations in the use of chlorine and chlorination alternatives. Paper presented at the 5th Conference on Water Chlorination, Williamsburg, Virginia.

Chrostowski, P .C., Suffet, I.H., and Neukrug, H. 1984. Comparison of the effects of ozonation and combined chlorination/ozonation on organic compounds in drinking water treatment. Paper presented at the 5th Conference on Water Chlorination, Williamsburg, Virginia.

Chrostowski, P.C. and Suffet, I.H. 1984. Application of non-specific organic analyses to oxidation processes. Paper presented at the American Water Works Association Annual Conference, Dallas, Texas.

Chrostowski, P.C., Hinchee, R.E., Ferris, J.S., and Goodfellow, W. 1984. Thermal effects on bioaccumulation: A thermodynamic approach. Paper presented at the Society for Environmental Toxicology and Chemistry National Meeting, Arlington, Virginia.

Bancroft, K.L., Chrostowski, P.C., Wright, R.L., and Suffet, I.H. 1984. Ozonation and oxidation competition value: Relationship to disinfection and microorganisms regrowth. Water Res. 4:473478.

Chrostowski, P .C. 1985. Applications of risk assessment to soil contamination at hazardous waste sites. Paper presented at a meeting of the New York State Public Health Association, Bear Mountain, New York.

Chrostowski, P.C., Ferris, J.S., Rue, W.J., and Fava, J.A. 1985. Modeling the fate and transport of biocides in estuarine power plant cooling water discharges. Paper presented at the Coastal Zone ASCE, Baltimore, Maryland.

Chrostowski, P .C. 1985. Risk assessment of groundwater contamination at hazardous waste sites. Paper presented at the SETAC 9th National Meeting, St. Louis, Missouri, November.

Chrostowski, P. C. 1985. The environmental chemistry program at Vassar College. J. Chem. Educ. 60:137-138.

Chrostowski, P.C., Pearsall, L.J., and Shaw, C. 1985. Use of risk assessment in management decisions in inactive hazardous waste sites. Environ. Manage. 9:422-433.

Foster, S.A. and Chrostowski, P .C. 1986. Integrated household exposure model for the use of tap water contaminated with volatile organic chemicals. Paper presented at the 79th Annual Air Pollution Control Association Meeting, Minneapolis, Minnesota. Paper #86.12.3.

Norton, S.B. and Chrostowski, P.C. 1986. A conceptual model for the biouptake of xenobiotic chemicals by plants. Paper presented at the SET AC Annual Meeting, Alexandria, Virginia.

Chrostowski, P.C. and Pearsall, L.J. 1986. Risk assessment of chemical mixtures at hazardous waste sites. Paper presented at the SET AC Annual Meeting at Alexandria, Virginia.

Chrostowski, P .C. and Pearsall, L.J. 1986. Environmental behavior of polynuclear aromatic hydrocarbons at hazardous waste sites. Paper presented at the HMCRI 7th Annual Superfund Conference, Washington, D.C.

Sager, S.L. and Chrostowski, P .C. 1987. ACLs: The link between CERCLA and RCRA. Proceedings of the National Conference on Hazardous Wastes and Hazardous Materials, at Washington D.C.

Foster, S.A. and Chrostowski, P.C. 1987. Inhalation exposures to volatile organic contaminants in the shower. Paper presented at the 80th Annual Air Pollution Control Association Meeting, June, New York, New York. Paper #87-42.6.

Anderson, E.L., Chrostowski, P.C., and Vreeland, J.L. 1988. Risk assessment for use in groundwater management. Paper presented at the CSCE-ASCE National Conference on Environmental Engineering. Pp. 121-129.

Chrostowski, P.C. and Sager, S.L. 1988. Field and theoretical study of the subsurface mobility of chromium waste. Paper presented at the SET AC Annual Meeting.

Anderson, E.L., Chrostowski, P.C., and Foster, S.A. 1988. Calculating the risks. Solid Waste and Power. June.

Chrostowski, P . C. , Foster, S .A. , and Fogg, A. 1989. Assessing the risks of incinerating of dioxin contaminated soil. . Haz. Mat. Control J. 2:17-24.

Chrostowski, P.C. and Pearsall, L.J. 1989. Alternatives to the remedial investigation/feasibility study process. Paper presented at the 10th Annual Hazardous Materials Control Research Institute Superfund 1989 Conference, Washington D.C.

Chrostowski, P.C. and Foster S.A. 1989. Recent advances in asbestos assessment at Superfund sites. Paper presented at the l0th Annual Hazardous Materials Control Research Institute Superfund 1989 Conference, November 28, Washington D.C.

Chrostowski, P.C. and Shipp, A. 1990. State of the art for PCB site risk assessments. Paper presented at the PCB Forum at Houston, Texas. pp.47-61.

Foster, S.A. and Chrostowski, P.C. 1990. Estimating risks for hazardous waste incinerator emissions. Paper presented at the Incineration Conference, San Diego, California.

Anderson, E., Chrostowski, P.C., and Vreeland, J. 1990. Risk assessment issues associated with cleaning up inactive hazardous waste sites. In Kunrenther H. and Gouda M. U .R. (eds.). Integrating Insurance and Risk Management for Hazardous Wastes. Boston: Kluner Academic Publishers. Pp. 15-40.

Chrostowski, P .C. 1990. Measurement techniques for evaluating environmental asbestos, and risks associated with asbestos abatement activities. Paper presented at the Society for Risk Analysis Forum on Risk of Indoor Asbestos Building Materials, May 7-8, Arlington, Virginia.

Chrostowski, P .C. and Pearsall, L.J. 1990. Role of risk assessment in the selection of remedial alternatives. Presented at the 83rd Annual Meeting & Exhibition of the Air and Waste Management Association, June 24-29, Pittsburgh, Pennsylvania.

Chrostowski, P.C. 1990. Communication of risks associated with municipal solid waste management alternatives. Presented at Wastecycle 1990, October 3-4, New York, New York.

Chrostowski, P.C., Foster S.A., and Anderson, E.L. 1991. Human health risks associated with asbestos abatement. *Risk Analysis* 11 :465-481.

Draper, D., Chrostowski, P.C., and Greenberg, A. 1991. Polycyclic aromatic hydrocarbon source apportionment study for an urban development site. Paper No.91-82. 7 presented at the Air and Waste Management Association Annual Meeting.

Chrostowski, P.C., Durda, J., and Edelmann, K.C. 1991. The use of natural processes for the control of chromium migration. Remediation 1:341-351.

Durda, J. and Chrostowski, P .C. 1991. Integration of ecological risk assessment and biological risk assessment and biological assessment in risk management: The Aberdeen experience. Paper presented at 12th Annual Meeting of the Society of Environmental Toxicology & Chemistry, November 3- 7, Seattle, Washington.

Chrostowski, P .C. and Durda, J. 1991. Effects of air pollution on the desert tortoise: An ecological risk assessment. Paper presented at 12th Annual Meeting of the Society of Environmental Toxicology & Chemistry, November 3- 7, Seattle, Washington.

Chrostowski, P.C. 1991. Risk assessment methodologies for municipal solid waste management. Paper presented at ASH IV , Arlington, Virginia.

Foster, S.A., Chrostowski, P.C., and Dolan, D. 1991. The use of log-normal kriging to calculate exposure point concentrations. Paper presented at Measuring, Understanding and Prediction Exposures in the 21st Century, November 18-21, Atlanta, Georgia.

Chrostowski, P.C. and Wheeler, J.A. 1991. Actual compared to predicted chemical exposures at Superfund sites. Hazardous Materials Control/Superfund 91, December 3-5, Washington, D. C. Pp. 585-589.

Chrostowski, P.C., Foster, S.A., and Dolan, D. 1991. Monte Carlo analysis of the reasonable maximum exposure (RME) concept. Hazardous Materials Control/Superfund 91. Pp.577-584.

Chrostowski, P.C. and Sager, S.L. 1991. Management of ash from municipal solid waste combustion. In Travis and Hattemer-Frey (eds.) Health Effects of Municipal Waste Incineration Boca Raton, Florida: CRC Press. Chapter 13.

Chrostowski, P .C. and Wheeler, J .A. 1992. A comparison of the integrated uptake biokinetic model to traditional risk assessment approaches for environmental lead. In Hoddinott K.B. (ed.). Superfund Risk Assessment in Soil Contamination, Pennsylvania Studies. Philadelphia: ASTM. Pp. 151-166.

Chrostowski, P.C. 1993. Air toxics: Lead, mercury & other hazardous air pollutants. Lecture presented at the Environmental Issues in Utility Sitings. April 29, 1993. The Public Utilities Law Committee of the Florida Bar. Pp.5.1-5.5.

Chrostowski, P.C. 1994. Exposure assessment principles. In Patrick, D.E. (ed.). Handbook of Toxic Air Pollution. New York: Van Nostrand Reinhold Co., Inc. Pp. 133-163.

Chrostowski, P .C. 1994. A critical analysis of mathematical models used to assess exposure to lead. Paper presented at Lead Tech '94 Conference. Pp. 130-145.

Foster, S.A., Chrostowski, P.C., and Lape, J.F., Jr. 1994. Screening health risk assessment of flammable materials fires. Paper presented at 1994 International Incineration Conference, Houston, TX. pp.657-661.

Chrostowski, P.C. 1994. Risk assessment and accepted regulatory cleanup levels. *Remediation* Autumn. pp. 383-398.

Osborne, C.G. and Chrostowski, P.C. 1995. Quantifying the tree. Food Quality. June/July. Pp. 32-38.

Chrostowski, P.C. 1996. Environmental Considerations in Railroad Property Transactions. Presentation to the Virginia Bar Association, Continuing Legal Education, 106th Summer Meeting, July 19, The Homestead, Hot Springs, Virginia.

Chrostowski, P.C. 1996. Risk Assessment of Polymers: Case Study of Bisphenol A. National Academy of Engineering Workshop on Polymers and the Environment. Woods Hole, MA.

Chrostowski, P.C. and Foster, S.A. 1996. A methodology for assessing congener-specific partitioning and plant uptake of dioxins and dioxin-like compounds. Chemosphere 32(11):22852304.

Chrostowski, P.C., Foster, S.A., and Kimball, H.J. 1996. Applications of Risk Management to Waste Combustion in Boilers and Industrial Furnaces. Presentation at the Air and Waste Management Conference, March 27, Kansas City, Missouri.

Chrostowski, P. C. and Huggard, J. 1996. International Considerations Regarding Product Labelling and Material Safety Data Sheets. Government Institutes Course on European Environmental Laws and Regulations, October 2, Alexandria, V A.

Chrostowski, P . C. , and Durda, J .L. 1997. Estrogenic activity: Does chemical structure provide any clues? Presented at the International Society of Regulatory Toxicology and Pharmacology, Assessing the Risks of Adverse Endocrine - Mediated Effects, 13-14 January , Research Triangle Park, North Carolina.

Chrostowski, P.C., Foster, S.A., and Lape, J.F. 1997. The impact of EPA's dioxin reassessment on waste-to-energy risk assessment. Proceedings of the 90th Annual Meeting and Exhibition of Air and Waste Management Association, June 8-13, Toronto, Ontario, Canada.

Durda, J .L., Kowalski, L., Preziosi, D., and Chrostowski, P .C. 1997. Ecological risk assessment of landfill air emissions from a hazardous waste management facility in Ontario. Proceedings of the 90th Annual Meeting and Exhibition of Air and Waste Management Association, June 8-13, Toronto, Ontario, Canada.

Foster, S.A., Chrostowski, P.C., Smegal, D.C., Lape, J.F., and Preziosi, D. 1997. Stochastic odor impact analysis for a hazardous waste landfill. Proceedings of the 90th Annual Meeting

and Exhibition of Air and Waste Management Association, June 8-13, Toronto, Ontario, Canada.

Foster, S.A., Pearsall, L.J., and Chrostowski, P.C. 1997. Comparative risk assessment of remedial alternatives for contaminated sludge. Proceedings of the 90th Annual Meeting and Exhibition of Air and Waste Management Association, June 8-13, Toronto, Ontario, Canada.

Huggard, J ., Chrostowski, P .C., and Weinberg, M.S. 1997. Product Policy: The Intersection of Life Cycle Assessment and Risk Management. SRA-Europe Conference, June 16, Stockholm, Sweden.

Durda, J.L., and Chrostowski, P.C. 1997. Phthalate ester estrogenic activity: Similarities, differences, and implications for risk assessment. Presented at the Estrogens in the Environment Conference on Linking Fundamental Knowledge, Risk Assessment, and Public Policy, July 20-23, Alexandria, V A.

Chrostowski, P.C. 1997. Defining Uncertainty in the Mathematics of Risk. Presented at The Challenges of Responsible Good Risk Management Practices, October 6- 7, Brussels, Belgium.

Chrostowski, P.C. and Witkin, K.B. 1997. Quantitative Integrated Risk Assessment for Medical Devices. Presented at the Medical Equipment Design and Technology Exhibition and Conference (MEDTEC), October 21-23, Amsterdam, The Netherlands.

Chrostowski, P.C. and Foster, S.A. 1997. An integrated quantitative decision approach for risk management problem solving. Proceedings of the International Conference and Workshop on Risk Analysis in Process Safety, pp. 259-272.

Chrostowski, P. C. 1997. Endocrine Modulating Chemicals as a Case Study in the Use and Misuse of Science. Presented at the American College of Toxicology 18th Annual Meeting, November 9-12, at the McLean Hilton, McLean, Virginia.

Durda, J .L. and Chrostowski, P .C. 1997. Assessment of Reproductive and Endocrine Modulation Risks from Exposure to Phthalate Esters in Food. Presented at the International Life Sciences Institute (ILSI) Conference on Human Diet and Endocrine Modulation: Estrogenic and Androgenic Effects, November 19-21, at the Hyatt Fair Lakes, Fairfax, Virginia.

Chrostowski, P.C., Weinberg, M.S., and Witkin, K.B. 1997. A Systematic Approach for Risk Analysis of Medical Devices. Presented at the Society of Risk Analysis 1997 Annual Meeting, December 9, at the Capitol Hilton, Washington, DC.

Chrostowski, P .C. 1997. Good Bioavailability Practice. Presented at IBC's International Congress on Human Health Bioavailability , December 11-12, at The Radisson Scottsdale Resort, Scottsdale, Arizona.

Paustenbach, D.J., Bruce, G.M., and Chrostowski, P. 1997. Current views on the oral bioavailability of inorganic mercury in soil: Implications for health risk assessment. *Risk Anal.* 17(5):533-544.

Chrostowski, P .C. 1997. A Survey of Current Practice in Environmental Health Risk Assessment. Drexel/Olin workshop, Risk Assessment: Policy, Philosophy and Methods.

March 13, 1997, Philadelphia, P A.

Chrostowski, P.C., Durda, J.L., Preziosi, D.V. 1998. Human Health Risks Associated with Endocrine Effects of Phthalates. Presented at IBC's Third International Congress on Endocrine Disrupters, April 14-15, Washington DC.

Chrostowski, P .C. 1998. Volatilization of Microcontaminants from Penta Treated Wood Poles. Presented at AWPA/USWAG specialty conference, Treated Wood Handling, Use, and Recycling Issues Workshop. May 15, Scottsdale, AZ.

Chrostowski, P .C. and Foster, S .A. 1998. Predicting and Averting Food Safety Crises. Food Quality Annual Conference. Chicago. Il." October 1998.

Chrostowski, P.C. 1998. Modeling Issues in Multi-Pathway Risk Assessment. NCAC-SOT Meeting, Bethesda, MD, November 1998.

Chrostowski, P.C.,Foster, S.A.,Durda, J.L., Preziosi, D. V. 1998. Good Ecological Risk Assessment Practices. SETAC Annual Meeting, Charlotte, NC, November 1998.

Woltering, D.M. and Chrostowski, P .C. 1998. Pentachlorophenol as a Case Study in the Evaluation of Chemicals as Persistent Organic Pollutants (POPs). SETAC Annual Meeting, Charlotte, NC, November 1998.

Chrostowski, P .C. and Charnley, G. 1998. Re-evaluation of the potential carcinogenicity of lindane. Society for Risk Analysis, Annual Meeting, Phoenix, AZ. December 6-9,1998.

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Bland, J.A., Sargent, E.V., Tyls, L., Ruby, M. V., Chrostowski, P.C., Bingman, T. 1998. Use of bioavailability data for the establishment of alternative cleanup levels for environmental media. Society for Risk Analysis, Annual Meeting, Phoenix, AZ. December 6-9, 1998.

Chrostowski, P.C. and Pearsall, L.J. 1998. Forensic environmental chemistry. *Metropolitan Corporate Counsel*, October 1998.

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Chrostowski, P.C., Durda, J.L., and Estreicher, H. 1999. Endocrine-modulating chemicals as a case study of science in the courtroom. Intl. Jour. Toxicol. 18:201-207.

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Chrostowski, P.C., Pearsall, L.J., Foster, S.A., and Preziosi, D.V. 2000. A Probabilistic Model of Time-to-Cleanup by Natural Attenuation. in Wickramanayake, G.B. et al. eds, *Natural Attenuation Considerations and Case Studies: Remediation of Chlorinated and*

pre-bid meetings as Engineer's representative, reviewed contractor bids, and provided construction management/inspection of executed work.

Landfill Gas Management Plan, Cumberland County Landfill, Inc., Newville, Pennsylvania – Prepared site specific gas system operations and maintenance plan that incorporated all aspects of system operation. Plan included compliance monitoring and reporting, wellfield balancing procedures, system maintenance schedule and gas construction safety guidelines.

Landfill Construction Specifications, Contract Documents and Drawings, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania – Prepared construction specifications and construction drawings/details for vertical gas well, horizontal gas collection loop and gas collection system construction projects. Prepared bid and contract documents, attended pre-bid meetings as Engineer's representative, reviewed contractor bids, and provided construction management/inspection of executed work.

Landfill Expansion Design and Permitting, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania - Assisted in the preparation of a 28-acre municipal solid waste landfill expansion including permit preparation, AutoCAD plans and detail drawings. Prepared gas management control plan and assisted in wetland delineation survey.

Landfill Construction Quality Assurance, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania – Performed construction quality assurance during gas system construction and deployment of HDPE, LLDPE, and various geosynthetic materials (i.e. geotextiles, composites, geonet, and geosysnthec clay liner).

Landfill Gas System Management, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania – Performed all aspects of gas system management including monitoring, maintenance, system performance analysis, wellfield balancing/optimization, compliance reporting, construction management and inspection for the maintenance and installation of HDPE piping, valves, horizontal and vertical wells, wellheads, and condensate pump stations/ knockout tanks. Performed weekly wellfield monitoring using a GEM 500 gas analyzer and an Airdata ADM-870 Mutlimeter, quarterly NSPS surface gas surveys using a Foxboro TVA 1000 Flame Ionization Detector (FID), building monitoring, perimeter gas probe monitoring, gas system performance analysis, designed gas reading database. Reporting included monthly gas system performance reports, quarterly DEP and annual EPA compliance reporting. Gas system maintenance included repair of gas collection wells, routine inspection and maintenance of two (2) enclosed ground flares (5,000 cfm total).

Landfill Minor Permit Modification, Grand Central Sanitary Landfill, Inc., Pen Argyl, Pennsylvania – Completed a minor permit modification for the use of fabricated non-woven geotextile as an Alternative Daily Cover (ADC) material. The application included product research and a comparative evaluation with PA DEP cover material requirements to establish equivalency with previously permitted cover materials.

Permit Reporting, Various Municipal Waste Facilities, Pennsylvania -- Preparation of PA DEP major and minor permit modification applications for various landfills and transfer stations.

Confined Space Entry Leachate Sampling, IESI – Bethlehem Landfill, Bethlehem, Pennsylvania - Performed permit required confined space entry into landfill vaults to obtain samples from the leachate collection and leak detection systems, and measurement of respective flowrates.

Tulpehocken Spring Water Company, Whitehaven, Pennsylvania – Conducted geologic and hydrogeologic studies for a bottled water new source permit. Activities included investigation and placement of exploratory probes, construction oversight of probe installations, and preparation of probe drillings logs for the client.

Air Quality Permitting, Keystone Cement Company, Inc., Bath, Pennsylvania – Assisted in preparation of PA DEP Air Quality Permits, including emissions calculations and data entry.

Hydrogeological Sampling, Grand Central Sanitary Landfill, Inc., Pen Argyl, Pennsylvania - Performed groundwater, surface water, and storm water sampling required for PA DEP landfill permit. Conducted a slug test on an assessment and abatement well for the determination of aquifer parameters and recharge rate.

Hydrogeological Sampling, Keystone Cement Co, Inc., Bath, Pennsylvania – Performed groundwater and surface water sampling required for PA DEP landfill permit. Developed permitted monitoring wells and collected monthly water level readings.

SPCC Plan Preparation, Grand Central Sanitary Landfill, Inc., Pen Argyl, Pennsylvania – Prepared a Spill Prevention Countermeasure and Control Plan for the facility. The plan required determining the various types and maximum quantities of potential releases based on stored material inventories and preparing countermeasure and control procedures for mitigating potential released. The plan required mapping of the site surface and stormwater drainage, and providing specific countermeasure procedures for containing spills on site.

VOC Monitoring, Keystone Cement Company, Inc., Bath, Pennsylvania – Performed Quarterly VOC air emissions monitoring of a hazardous waste fuel system in accordance with 40 CFR Part 264, Subparts BB and CC, using a Foxboro TVA 1000 flame ionization detector (FID). Prepared leak reports and incident response reports when applicable.

Environmental Investigation, Travelers Insurance, Sunbury, Pennsylvania – Performed site investigation activities at a petroleum-impacted site. Activities included product recovery beneath a concrete basement slab; demolition and removal of the concrete slab; excavation and removal of contaminated soils and basement restoration.

Environmental Investigation, Travelers Insurance, Mount Wolf, Pennsylvania – Performed site characterization and remediation of a residential petroleum release. Tasks included the demolition of basement flooring, removal of contaminated materials and product recovery.

Environmental Investigation, Travelers Insurance, Greenville, Maryland – Performed site investigation and sampling of a potential petroleum release site. Tasks included sampling for No. 2 Fuel Oil and characterization of a residential pond.

Major Permit Modifications, Various Transfer Stations, Pennsylvania – Prepared major permit modifications for the use of a paper de-inking sludge as an Alternative Daily Cover (ADC) material. The application included product research and a comparative evaluation with PA DEP cover material requirements to establish equivalency with previously permitted cover materials.

Geotechnical Investigation, Gabion Wall Construction Verification, Bloomfield, NJ – Performed a field investigation consisting of mapping and probe installation to verify and record gabion wall construction and stability. Work included all aspects of field investigation and report preparation.

Surveying, Various Sites, Pennsylvania – Assisted in field surveys including topographic mapping, construction stakeout and grading. Survey instruments include a total station, GPS, and auto-level.

Insurance Recovery, Major Petroleum Distributor – Reviewed environmental characterization and remediation files for retail facilities and bulk storage petroleum facilities. Prepared litigation support documents and site profile databases for cost recovery efforts.

SARAH A. FOSTER
CPF ASSOCIATES, INC.

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EDUCATION

1985	M.S., Environmental Health Sciences, Air Pollution Control Program, Harvard University School of Public Health, Cambridge, Massachusetts
1981	B.A., Political Science (Environmental Law/Energy Policy), Williams College, Williamstown, Massachusetts

EXPERIENCE

Ms. Foster is a founding member of CPF Associates, Inc. (Chrostowski, Pearsall & Foster). She has over 17 years of consulting experience in environmental health sciences, with expertise in developing strategies for and conducting exposure and risk analyses related to environmental issues and commercial and consumer products. Previously, Ms. Foster was a Senior Consultant with The Weinberg Group, a Project Manager at the Clement Division of ICF/Kaiser, an Environmental Analyst with the U.S. Environmental Protection Agency's Office of Policy Analysis, and a researcher for the Harvard Public Health School's Six City Study. Her areas of specialty include the application of quantitative methods for evaluating potential risks, including multiple chemical, multiple exposure pathway risk assessments for air toxics sources and waste sites, Monte Carlo simulation, and environmental epidemiology. She has managed and performed over 100 comprehensive risk assessment projects for combustion sources, waste sites and consumer and commercial products, with specialized knowledge in the conduct of risk assessments for municipal solid waste combustors and hazardous waste incinerators. She has developed and applied a wide variety of environmental fate and transport models, and critically analyzed and compiled a broad array of human activity pattern data, in exposure assessment projects involving inhalation, ingestion and dermal pathways as well as the use of household tap water. She has also developed and applied innovative risk assessment methods to assess risks from combustion sources, indoor water use, waste sites, and pesticides and anti-microbial materials that include geostatistical kriging and stochastic simulation. Ms. Foster has analyzed issues regarding contaminated site remedy selection, cleanup goals, cost and liability allocation evaluations under CERCLA, RCRA and state regulatory programs, and the historical state-of-knowledge of toxicological and environmental health sciences. Ms. Foster has also provided risk communication and technical support for public, regulatory and permit hearings, and for litigation. Ms. Foster has authored or co-authored publications focusing on risk assessment, air toxics and emissions from industrial sources and is a member of several professional societies. She also has experience in developing and conducting risk assessment training courses. Details of Ms. Foster's experience are shown on the subsequent pages. This is followed by Ms. Foster's employment history, professional society memberships, and publication list.

Risk Assessment

- **Site Risk Assessments.** Conducted and managed site-specific risk assessments for Superfund and other hazardous waste sites and landfill facilities in Rhode Island, Maine, Colorado, California, Maryland, Michigan, Montana, Nebraska, Pennsylvania, Florida, New Jersey, Michigan, Ohio, Ontario and Wisconsin. The projects have typically included a review of chemical compounds at the site, selection of chemicals of primary concern, calculation of potential human and environmental exposures to site-related compounds, and determination of the likelihood and severity of associated effects. Some projects also included risk assessments of remedial alternatives and development of cleanup goals.

- **Hazardous Waste Incinerator Risk Assessments.** Conducted and managed multiple pollutant, multiple pathway risk assessments for proposed and existing hazardous waste incinerators in Louisiana, Alabama, Texas, New York, Ontario and Arizona. The projects typically required a review of waste feed types and their chemical composition, estimation of chemical emission rates, selection of chemicals for detailed evaluation, identification of direct and indirect exposure pathways for evaluation, assessment of potential chronic and acute risks, and evaluation of uncertainties. Some projects also involved evaluation of acute risks associated with emissions from upset conditions, fugitive sources, and chemical waste spills and fires.

- **Critical Review of Regulatory Hazardous Waste Risk Model.** Performed a scientific peer review of the U.S. EPA's "Development of Human Health Based and Ecologically Based Exit Criteria for the Hazardous Waste Identification Project," and managed production of comments formally submitted to the Agency. The analysis included an in-depth examination of the use and treatment of uncertainty and simulation analyses in developing exit criteria, the use of measured data in developing input values, a critique of the surface water and soil loss constant modeling, and review of information related to dermal exposure pathways, chemical/physical properties, selection of exposure pathways, and regulatory target risk levels.

- **Cement Kiln Risk Assessments.** Conducted and managed risk assessments for cement kilns co-burning hazardous waste with fossil fuels in Michigan, Ohio, Kentucky, Mississippi, and Oklahoma. Projects addressed the potential human health and ecological risks associated with stack emissions of numerous compounds through multiple pathways of exposure for a variety of receptors. Hypothetical accident scenarios were also evaluated, including transportation accidents, spills, and fires involving hazardous wastes.

- **Critical Reviews of Combustion Source Risk Assessment Methodologies.** Provided critical reviews and comments on emerging U.S. EPA national and regional guidance for the performance of combustion source risk assessments, focusing on fate and transport modeling and human exposure assessment algorithms. Sensitivity analyses of the proposed U.S. EPA methods were conducted by applying the default methodologies and refined approaches in several site-specific risk assessments.

- **Resource Recovery Facility Risk Assessments.** Conducted and managed multiple pollutant, multiple pathway risk assessments for proposed and existing resource

recovery facilities in New York, Massachusetts, Minnesota, New Jersey, Pennsylvania and Florida. The projects typically required a review of potential chemical emissions, selection of chemicals for detailed evaluation, identification of exposure pathways, assessment of potential chronic and acute risks, and evaluation of uncertainties.

- **Innovative Risk Assessment Techniques.** Applied innovative statistical techniques, including Monte Carlo simulation and geostatistical kriging in site-specific risk assessments of waste sites and combustion sources. The assessments involved extrapolation of risk from limited sampling data, development of probability distributions for input parameters and risks, and identification of not-to-exceed and average cleanup levels for sites. Also managed a research project that addressed methodologies for imputing values for chemical non-detects, a probabilistic approach to calculating exposure, and application of kriging.

- **Good Risk Assessment Practice Principles.** Developed set of principles for good risk assessment practice, reviewed existing good practice methods for exposure assessment, epidemiology, and Monte Carlo simulation, good laboratory and manufacturing practice requirements, and North American and European risk assessment constructs to use as basis for development of the good risk assessment practice principles.

- **Critical Review of Hazardous Waste Incineration Paper.** Co-authored a scientific peer review of Greenpeace's position on hazardous waste incineration. The review focused on statements and arguments presented in Greenpeace reports on topics including destruction and removal efficiencies, products of incomplete combustion, incineration of metal-containing wastes, and health and environmental impacts of hazardous waste incineration.

- **California Multiple Pathway Guidance Document.** Managed and produced a guidance document for evaluating exposures through multiple pathways for the South Coast Air Quality Management District. Presented and described algorithms for calculating exposures and identified ranges of values for key parameters. Pathways evaluated included: inhalation, dermal absorption from soil and ingestion of soil, indoor dust, vegetables, saltwater fish, freshwater fish, beef, dairy milk, surface water, and human breast milk. This methodology was adopted by California's Air Resources Board and has provided the basis for subsequent guidance for use by permit applicants throughout the state.

- **Training Courses.** Conducted and participated in the development of exposure and risk assessment training courses, including a Superfund site risk assessment course for the U.S. EPA and the U.S. Air Force, an exposure assessment course for the California Department of Health Services, a citizens' risk assessment workshop for Region 8 of the U.S. EPA, and an Executive Enterprises course on Risk Assessment under the U.S. Clean Air Act and the Resource Conservation and Recovery Act.

- **New York Incineration 2000 Risk Assessment.** Conducted and directed the Incineration 2000 health risk assessment for the New York State Department of Environmental Conservation (NYSDEC) to evaluate potential risks associated with future incineration capacity anticipated in the New York/New Jersey metropolitan area including municipal solid, hazardous, hospital, and sewage sludge waste incinerators.

Exposures to 16 chemicals or families of chemicals were examined through multiple pathways including inhalation, soil and dust ingestion, ingestion of human breast milk, and ingestion of fish and shellfish. As part of the project, a detailed health risk assessment protocol was developed for review by the NYSDEC, the New Jersey Department of Environmental Protection, and the U.S. EPA.

- **Hospital Waste Incinerator Risk Assessments.** Participated in risk assessments of hospital waste incinerators in New York, Pennsylvania, Massachusetts, and Michigan. Examined waste streams, developed emission rates, conducted air dispersion modeling, evaluated potential exposures, and calculated chronic and acute risks associated with chemical emissions.

- **Environmental Mercury.** Participated in an examination of environmental mercury which included a detailed review of the sources, fate, and effects of mercury in the environment and a source apportionment study in the state of Florida. Published a white paper (*Sources, Fate, and Effects of Environmental Mercury)* focusing on these issues as well as the role of waste-to-energy (W-T-E) facilities in the global emissions of mercury. Critically reviewed the U.S. EPA's *Mercury Report to Congress* and prepared an issues document for use in technical meetings with key U.S. EPA scientists to highlight technical issues of concern and to provide concrete suggestions for short-term and long-term improvements. Issues studied included mercury modeling methods, the treatment of uncertainty in USEPA's mercury risk assessment, and exposure and risk assessment approaches.

- **Risk Assessment of Remedial Alternatives for Contaminated Sludge.** Conducted quantitative comparative risk analysis of four proposed remedial alternatives for sludge containing PCBs, solvents and metals. Emissions, air impacts, potential exposures and risks were calculated from a variety of unit operations including sludge excavation, drying, low temperature thermal desorption (LTTD), disposal in an on-site monofill, *ex-situ* stabilization and *in-situ* stabilization. The four risk metrics examined were: excess lifetime cancer risks to residents; non-cancer risks to residents; non-cancer health risks to remediation workers; and the potential for injuries to workers during remediation.

- **Dioxin Remedial Alternative Risk Assessment.** Conducted risk assessments of several remedial alternatives proposed for disposal of dioxin-contaminated soils and debris at a U.S. Army base, including use of an on-site incinerator.

- **Petroleum Refinery Waste Air and Odor Analyses.** Conducted air quality and odor impact analyses and risk assessments for an Environmental Impact Statement examining alternative disposal methods for petroleum refinery wastes. The alternatives included a landfarm, a landfill, and an incinerator. Risks associated with several exposure pathways (e.g., inhalation; water, produce, and beef ingestion) were evaluated.

Litigation Support

- **Municipal Sludge Land Application.** Conducted odor impacts analysis for land application of sewage sludge. Both Monte Carlo simulation and refined air dispersion modeling were performed to predict the likelihood and magnitude of potential odor impacts to nearby residents.

- **Cost Allocation at Pesticide Formulation Site.** Determined the extent of contamination associated with formulation of pentachlorophenol for a specific manufacturer compared to contamination associated with other materials and products present at the formulation facility. Conducted research into the composition and methods of formulation of different chlorophenol products and their chemical/physical properties, and evaluated risk assessments and site sampling data to identify chemicals of concern.

- **Exposure Assessment for Trichloroethylene in Groundwater.** Performed comprehensive modeling of historical plaintiff exposures to trichloroethylene (TCE) associated with indoor water use and soil gas infiltration into homes. Modeling algorithms addressed showering, bathing, drinking water, indoor house and outdoor of house exposures via inhalation, dermal and oral routes of exposure.

- **Waste Analysis at Former Aluminum Reduction Facility.** Directed and performed in-depth geostatical kriging analysis to determine the extent and magnitude of polychlorinated biphenyl contamination in soil and sediment at a former aluminum reduction facility. Key aspects of the analysis included statistical methods for sample data treatment, development of concentration contours and calculation of PCB mass above regulatory cleanup levels.

Product Safety Evaluation

- **Disinfection of Pool and Spa Water.** Researched data related to use of pool and spa water chemicals and shock treatment of recreational water focusing on waterborne pathogens. Compiled and evaluated information related to occurrence of disease associated with recreational water use. Provided comments to WHO on recreational water risk assessment.

- **Assessment of Dioxin in Consumer Products.** Identified methods for calculating potential risks associated with the presence of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs) in products used for both human and animal consumption. Researched approaches to develop protocols for assessing PCDD/F bioaccessibility from various media, and for PCDD/F sampling and analysis.

- **Environmental Assessments of Pentachlorophenol-Treated Wood.** Performed environmental analyses of potential releases from pentachlorophenol-treated utility poles to address issues regarding its classification as a Persistent Organic Pollutant (POP) and its regulation and use in Canada and the U.S. Evaluations included fugacity modeling of pentachlorophenol and microcontaminants, including PCDD/Fs and hexachlorobenzene, that may be emitted from pentachlorophenol-treated utility poles in North America and Europe; development and application of volatilization modeling for pentachlorophenol and microcontaminants from pentachlorophenol-treated utility poles; Monte Carlo simulation of leaching from pentachlorphenol-treated poles and associated potential risks; comprehensive literature compilation and review regarding the environmental release, fate and transport of compounds from pentachlorophenol-treated poles; and preparation of presentation materials describing these analyses for the United Nations Environment Programme, Environment Canada and the U.S. Environmental Protection Agency.

- **Fault Tree Analysis of Medical Product.** Developed fault tree to assess the likelihood that a pain-relieving medication's product development timeline would be achieved. Key assumptions and uncertainties affecting the analysis were identified, including measurement and reliability of the dose delivery system, interpatient variability, the approvability of clinical and project plans, and post-approval manufacturing capabilities.

Exposure Assessment and Air Quality Modeling

- **Air and Deposition Modeling.** Supervised and performed atmospheric dispersion and deposition modeling for municipal, hazardous, and hospital waste incinerators. Modeling analyses included the Industrial Source Complex model, complex terrain modeling, evaluation of particle size distribution and deposition rates, estimation of building cavity concentrations, and examination of complex wake effects. Emission sources addressed in modeling projects have included lagoons, waste sites, surface water, waste, construction activities, and contaminated soils as well as both indoor and outdoor air.

- **Accident Modeling.** Developed conceptual approaches and applications of air dispersion models for accidents, including liquid waste spills, solid and liquid waste fires, and transportation accidents.

- **Indoor Modeling.** Investigated human exposure to volatile organic chemicals ingested, inhaled, and dermally absorbed from water. Developed and maintained a comprehensive database of literature regarding exposures to volatiles from water. Developed and published an integrated human exposure model for indoor water use, and validated the model with data collected from residential indoor air environments. Applied the model to potential exposure at Superfund sites and exposure alleged by toxic tort plaintiffs. Integrated human exposure model with indoor air quality and soil gas infiltration models. Modeled potential air exposures to indoor gasoline vapors resulting from a leaking underground gasoline tank for a private client.

Air Pollution/Epidemiology

- **Epidemiological Study of Communities Surrounding a Municipal Waste Combustor.** Assisted in the design and development of an epidemiological study to evaluate occurrence of asthma and cancer in communities surrounding a combustion facility compared to other communities in the state. Examined demographic statistics to identify and determine comparability of study and comparison groups. Compiled exposure data and developed exposure metric to objectively identify study groups.

- **Air Modeling Use in Health Survey**. Participated in review of an air dispersion modeling analysis and its use in a community health survey. Issues addressed included characterization of emission sources and evaluation of methods for using modeling output information in designating potentially exposed and control populations.

- **Chlorofluorocarbon (CFC) Use in Metered Dose Inhalers.** Prepared comments on the U.S. Environmental Protection Agency's Advance Notice of Proposed Rulemaking regarding CFC use in metered dose inhalers (MDIs), focusing on potential environmental impacts. Developed materials to describe atmospheric modeling performed to assess the potential impacts on equivalent effective stratospheric chlorine of continued CFC use

in MDIs through the early 2000's.

- **Stratospheric Ozone Depletion.** Participated in the development of a risk assessment associated with stratospheric ozone depletion. Reviewed and critically summarized epidemiological literature on effects of ultraviolet radiation on skin cancer incidence and mortality.

- **Health Benefit Analysis of Ambient Sulfate Reductions.** Conducted a health benefit analysis of potential reductions in mortality associated with regional reductions in ambient sulfate levels while working for U.S. EPA's Office of Policy Analysis. Reviewed epidemiological literature presenting quantitative estimates of the health effects of exposure to air pollutants. Performed statistical analysis of the spatial variability and relationships among different measures of particulate air pollution.

Environmental Audits

- **Utility Industry.** Conducted environmental audits for several industrial facilities involved in the utility industry in Pennsylvania and North Carolina. Audits required site inspections, review of pertinent facility information on past and current site uses, on waste generation and disposal approaches, examination of regulatory compliance, and identification of potential environmental liabilities.

- **Industrial Property.** Conducted an environmental audit for an industrial property in Maryland located adjacent to a former landfill. In addition to review of site and its history, the task required evaluation of past uses and potential impacts of the former landfill on the property under investigation.

- **Residential Property.** Conducted an environmental audit prior to property development for residences at a site in Maryland. Project required review of site history and site investigation.

EMPLOYMENT HISTORY

1999-present	Principal, CPF Associates, Inc., Takoma Park, MD and Bethesda, MD
1993-1999	Senior Consultant/Managing Associate, The Weinberg Group Inc., Washington, D.C.
1985-1993	Project Manager, Clement Division of ICF/Kaiser, Fairfax, VA
1984-1985	Data Reviewer, Six City Study, Harvard University School of Public Health, Boston, MA
1984	Environmental Protection Specialist, U.S. Environmental Protection Agency, Office of Policy Analysis, Washington, D.C.

PROFESSIONAL AFFILIATIONS

Air and Waste Management Association
Society for Risk Analysis

SELECTED PUBLICATIONS AND PRESENTATIONS

Foster, S.A. 1984. Control technologies. In Environmental Law Institute Acid Rain in Europe and North America: National Responses to an International Problem. (Reprinted in Acid Rain: A Survey of Data and Current Analysis, Congressional Research Service Report for House Subcommittee on Health and the Environment, Washington, DC, May.)

Spengler, J.D., Allen, G.A., Foster, S.A., Severance, P., and Ferris, B., Jr. 1985. Sulfuric acid and sulfate aerosol events in two U.S. cities. Paper presented at 2nd U.S.-Dutch International Symposium, 19-24 May, at Williamsburg, VA.

Foster, S.A. and Chrostowski, P.C. 1986. Integrated household exposure model for use of tap water contaminated with volatile organic chemicals. Paper presented at 79th Annual Air Pollution Control Association Meeting, June, at Minneapolis, MN. Paper 86-12.3.

Foster, S.A. and Chrostowski, P.C. 1987. Inhalation exposures to volatile organic contaminants in the shower. Paper presented at 80th Annual Air Pollution Control Association Meeting, June, at New York City, NY. Paper 87-42.6.

Anderson, E.L., Chrostowski, P.C., and Foster S.A. 1988a. Calculating the risks. Solid Waste and Power (June).

Anderson, E.L., Chrostowski, P.C., and Foster, S.A. 1988b. Recent trends in health risk assessment: Impact on risk assessment of resource recovery facilities. Paper presented at 7th Annual Resource Recovery Conference, U.S. Conference of Mayors, at Washington, DC.

Foster, S.A. 1988. Advances in risk assessment for municipal incinerators. Paper presented at 34th Mid-Atlantic States Section of the Air Pollution Control and Hazardous Waste Management Conference, 19-21 October, at Atlantic City, NJ.

Foster, S.A. and Chrostowski, P.C. 1988. Comparison of results of site-specific risk assessments conducted for resource recovery facilities. Paper presented at the 13th National Waste Processing Conference of the American Society for Mechanical Engineers, 1-4 May, at Philadelphia, PA.

Chrostowski, P.C. and Foster, S.A. 1989. Recent advances in asbestos assessment at Superfund sites. Paper presented by S.A. Foster at the 10th Annual Hazardous Materials Control Research Institute Superfund 1989 Conference, 28 November, at Washington, DC.

Chrostowski, P.C., Foster, S.A., and Fogg, A. 1989. Assessing the risks of incinerating of dioxin-contaminated soil. Haz. Mat. Control J. 2:17-24.

Tilly, J., Kalagnanam, R., Pyne, D., Foster, S.A., and Doucet, L. 1989. Risk assessment of medical waste incinerators. Paper presented at the American Industrial and Chemical Engineers National Meeting, 23 August 23, at Philadelphia, PA.

Foster, S.A. and Chrostowski, P.C. 1990. Estimating risks for hazardous waste incinerator emissions. Paper presented at Incineration Conference, at San Diego, CA.

Chrostowski, P.C., Foster, S.A., and Anderson, E.L. 1991. Human health risks associated with asbestos abatement. Risk Analysis 11:465-481.

Chrostowski, P.C., Foster, S.A., and Dolan, D. 1991. Monte Carlo analysis of the reasonable maximum exposure (RME) concept. Paper presented at Processing Hazardous Materials Control/Superfund '91. Pp. 577-584.

Foster, S.A., Chrostowski, P.C., and Dolan, D. 1991. The use of log-normal kriging to calculate exposure point concentrations. Paper presented at Measuring, Understanding, and Predicting Exposures in the 21st Century, 18-21 November, at Atlanta, GA.

Foster, S.A. 1992a. Health risks associated with waste fuel use at a cement kiln. Paper presented at Hazardous Materials and Environmental Management Conference, 10-12 June, at Atlantic City, NJ.

Foster, S.A. 1992b. Presentation before the Ohio State Hazardous Waste Facility Siting Board regarding permit to store, handle, and use hazardous waste fuel, at the Southdown, Inc., Fairborn, OH, Cement Kiln (February).

Foster, S.A. 1993. Burning hazardous waste fuel at a cement kiln: What are the risks relative to burning fossil fuels? Paper presented at the 1993 Incineration Conference, 3-7 May, at Knoxville, TN.

Foster, S.A. 1994. Human intake. In Patrick D.R. (ed.). Toxic Air Pollution Handbook. New York: Van Nostrand Rheinhold. Pp. 249-262.

Chrostowski, P.C. and Foster, S.A. 1996. A methodology for assessing congener-specific partitioning and plant uptake of dioxins and dioxin-like compounds. Chemosphere 32(11):2285-2304.

Foster, S.A. 1996. Risk Assessment in the U.S. Environmental Protection Agency's Hazardous Waste Identification Rule. Presentation to the Women's Council on Energy and the Environment: RCRA Interest Group, February 29, Washington, DC.

Foster, S.A. and Chrostowski, P.C. 1996. Applications of Risk Management to Waste Combustion in Boilers and Industrial Furnaces. Presentation at the Air and Waste Management Conference, March 27, Kansas City, Missouri.

Chrostowski, P.C., Foster, S.A., and Lape, J.F. 1997. The impact of EPA's dioxin reassessment on waste-to-energy risk assessment. Proceedings of the 90th Annual Meeting and Exhibition of Air and Waste Management Association, June 8-13, Toronto, Ontario, Canada.

Foster, S.A., Chrostowski, P.C., Smegal, D.C., Lape, J.F., and Preziosi, D. 1997. Stochastic odor impact analysis for a hazardous waste landfill. Proceedings of the 90th Annual Meeting and Exhibition of Air and Waste Management Association, June 8-13, Toronto, Ontario, Canada.

Foster, S.A., Pearsall, L.J., and Chrostowski, P.C. 1997. Comparative risk assessment of remedial alternatives for contaminated sludge. Proceedings of the 90th Annual Meeting and Exhibition of Air and Waste Management Association, June 8-13, Toronto, Ontario, Canada.

Chrostowski, P.C. and Foster, S.A. 1997. An integrated quantitative decision approach for risk management problem solving. Proceedings of the International Conference and Workshop on Risk Analysis in Process Safety, October 21-24, at the Atlanta Airport Marriott Hotel, Atlanta, Georgia.

Chrostowski, P.C. and Foster, S.A. 1998. Predicting and Averting Food Quality Crises. Presentation by S. Foster at the Food Quality 98 Conference, 28 October, Chicago, Illinois.

Foster, S.A., Chrostowski, P.C. and Charnley, G. 1998. Principles of good risk assessment practice. Presentation at the Society for Risk Analysis Annual Meeting, Phoenix, AZ. June 1998.

Foster, S.A., Chrostowski, P.C. and Preziosi, D.V. 1998. Stochastic impact analysis for a sulfuric acid spill in water. Poster presentation. 20th Annual International High Technology Safety, Industrial Hygiene, and Environmental Conference, 14-17 April, San Antonio, Texas.

Paul C. Chrostowski, Sarah A. Foster, CPF Associates, Inc. and James L. Lape, The Weinberg Group. 1999. Integrated Multipathway Exposure Model for Volatile Organic Compounds. Presentation at the Society For Risk Analysis Annual Meeting, Atlanta, Georgia. December 7, 1999.

Chrostowski, P.C., Pearsall, L.J., Foster, S.A., and Preziosi, D.V. 2000. A Probabilistic Model of Time-to-Cleanup by Natural Attenuation. in Wickramanayake, G.B. et al. eds, *Natural Attenuation Considerations and Case Studies: Remediation of Chlorinated and Recalcitrant Compounds*. Batelle Press, Columbus, OH.

Chrostowski, P.C. and Foster, S.A. 2001. Forensic Applications of Environmental Health Sciences. in Sullivan, P.J., Agardy, F.J., Traub, R.K., Wiley & Sons, NY. *Practical Environmental Forensics*.

Chrostowski, P.C., Foster, S.A., Preziosi, D. 2001. The Global Dioxin Balance – Is There an Emissions Deficit? Paper #208, AWMA 94th Annual Conference, Orlando, FL.

Foster, S.A. & Chrostowski, P.C. 2001. Model Validation of Indoor Exposure to Volatile Organic Compounds from Showering. Paper # 77. AWMA 94th Annual Conference, Orlando, FL.

Chrostowski, P.C., Foster, S.A., & Preziosi, D.P. 2002. Scientific peer review of "The Case for Caution". New York Water Environment Association, 74th Annual Meeting, New York, February 3-6, 2002.

Chrostowski, P.C. and Foster, S.A. 2002. Chemical intervention in swimming pools: A proposed definition for shock treatment. NEHA 66th Annual Educational Conference. Minneapolis, MN, July 2002.

Foster, S.A., Chrostowski, P.C. and Preziosi, D.V. 2003. A Comparison of Two Mercury Environmental Fate And Transport Models In Evaluating Incinerator Emissions. IT3'03 Conference, May 12-16, 2003, Orlando, Florida.

Chrostowski, P.C. and Foster, S.A. 2003. Human Health Risk Assessment for Polybrominated Diphenyl Ethers in Biosolids. 23rd International Symposium on Halogenated Organic Pollutants and Persistent Organic Pollutants. Boston, Aug 2003.

CHRISTINE H. HEATH, E.I.T
Project Supervisor

AREAS OF SPECIALIZATION

- NJDEP RADIUS Permitting Software Program
- State and Title V Permitting
- Emissions Quantification
- Air Dispersion Modeling

At Trinity, Ms. Heath assists industrial clients with state, PSD, and Title V air quality permitting projects. Ms. Heath also has experience quantifying emissions from various industrial sources, generating emission statements, and preparing permit applications. As a result, Ms. Heath has experience negotiating permit conditions that ensure operational flexibility. Ms. Heath has completed NJDEP courses on RADIUS, air permitting, and compliance auditing. Ms. Hess has taught the section on RADIUS permitting in Trinity's New Jersey state regulatory course offered to industrial clients. Additionally, she has conducted dispersion modeling for emission sources using ISCST3, CALPUFF, and SCREEN3 models and assisted in the generation of NO_x Budget Program Reports. Ms. Heath has specialized experience in quantifying emissions and preparing permit applications for industrial clients located in New Jersey.

EDUCATION

B.S. Environmental Systems Engineering, Pennsylvania State University

Ms. Heath graduated from the Pennsylvania State University with a Bachelor of Science degree in Environmental Systems Engineering. Her work experience includes two summer internships at the Pennsylvania Department of Environmental Protection's (PADEP) Bureau of Abandoned Mine Reclamation and at the National Institute for Environmental Renewal (NIER). At PADEP, Ms. Heath assisted engineers in reclaiming abandoned mine sites and conducted wetland delineation studies. At NIER, Ms. Heath completed geomorphological studies on the Brodhead Watershed in Pennsylvania.

CERTIFICATIONS

Engineer-In-Training

DIRECTLY RELATED EXPERIENCE

ConocoPhillips, Inc. – Petroleum Refinery, New Jersey.
Prepared a PSD permit application for expanding the FCCU and for modifications required to meet Tier II low-sulfur gasoline standards. Quantified emissions including HAPs for the FCCU and other associated equipment. Conducted a PSD/Non-attainment NSR netting analysis for the project. Conducted an inhalation risk assessment using ISCST3 to show that the project would not adversely affect soils, vegetation, or health. Performed a dispersion modeling analysis using ISCST3 and to show that the project would not violate federal or state ambient air quality standards, and evaluated additional impacts in the Brigantine Class I Area using CALPUFF.

Valero Refining Company – Petroleum Refinery, New Jersey.
Assisted in preparing a PSD permit application for expanding the FCCU and for modifications required to meet Tier II low-sulfur gasoline standards. Conducted a BACT analysis for the FCCU and refinery process heaters. Prepared the PSD

application in NJDEP's RADIUS program. Quantified HAP emissions and conducted an additional impacts screening analysis for soils and vegetation and an inhalation risk assessment using ISCST3 to show that the project would not adversely affect soils, vegetation, or health. Performed a dispersion modeling analysis using ISCST3 to show that the project would not violate federal or state ambient air quality standards, and evaluated additional impacts in the Brigantine Class I Area using CALPUFF.

Assisted in researching refinery TRI requirements. Conducted a quality control review of the refinery's emission statement and TRI report.

Amerada Hess Corporation – Petroleum Refinery, New Jersey.
Assisted in preparing a PSD permit application for expanding the refinery's FCCU. Prepared a BACT analysis for the FCCU. Prepared a significant modification to the facility's Title V permit in NJDEP's RADIUS program. Performed a dispersion modeling analysis using ISCST3 to show that the project would not violate federal or state ambient air quality standards. Assisted in the evaluation of additional impacts in the Brigantine Class I Area using CALPUFF. Conducted an additional impacts screening analysis for soils and vegetation and an inhalation risk assessment using ISCST3 to show that the project would not adversely affect soils, vegetation, or health.

Assisted in preparing a modification to the facility's Title V permit for modifications required to meet Tier II low-sulfur gasoline standards. Assisted in preparing a facility-wide netting analysis for Non-Attainment New Source Review and PSD. Prepared a modification to the facility's Title V permit in NJDEP's RADIUS program.

Conducted a review of the facility Title V permit. Reviewed the facility's comments on the draft permit and identified permit conditions which had not been changed per the facility's request. Assisted in drafting letter appealing the Title V permit.

Motiva Enterprises, LLC – Petroleum Bulk Terminals, New Jersey.
Prepared annual emission statements for two facilities. Quantified VOC and HAP emissions using EPA's TANKS program and other approved methodologies. Prepared emission statements using NJDEP's RADIUS program.

Prepared various preconstruction permit applications relating to

facility loading and storage operations. Negotiated permit conditions with NJDEP permit reviewers to maintain the facility's operational flexibility. Performed a Non-Attainment New Source Review netting analysis for the facility.

Revised the facility's Title V application to incorporate recent permit applications. Updated emissions calculation methodologies for tank cleaning and landing operations. Reformatted the application based on comments from NJDEP.

Provided ongoing regulatory assistance to the terminal. Attended project review meetings and identified potential environmental issues associated with the implementation of proposed projects.

Engelhard Corporation – Research and Development Facility, New Jersey
Prepared three state construction permit applications for combustion engines used to test catalysts in this research and development facility. The permit applications were prepared using NJDEP's RADIUS software. Assisted the facility in applying for two general permits. Conducted negotiations with the permit reviewer to ensure operational flexibility.

Johns Manville, Inc. – Chemical Manufacturer, New Jersey.
Conducted a review of facility operations and existing permits. Updated nine facility permits using NJDEP's RADIUS software to allow the facility greater operational flexibility. Negotiated permit conditions with the NJDEP permit reviewer.

Hercules, Inc. – Chemical Manufacturer, New Jersey.
Quantified potential emissions for the treatment of energetic materials in the UXB process. Prepared a batch permit application in NJDEP's RADIUS program. Reviewed and commented on draft permit conditions.

Omni Baking Company – Bakery, New Jersey.
Prepared an air permit application for two baking ovens. Coordinated a control technology review evaluating the feasibility of a wet scrubber and catalytic oxidizer.

Leone Industries – Glass Manufacturer, New Jersey.
Calculated annual emissions for the facility using customized spreadsheets. Prepared the emission statement in NJDEP's RADIUS program. Also, prepared a compliance plan in RADIUS for the facility.

Kimble Glass – Glass Manufacturer, New Jersey.
Created customized spreadsheets for the facility so that the facility could generate emission statements more efficiently. Prepared emission statements using NJDEP's RADIUS program.

Milford Power, L.P. – Power Generator, New Jersey.
Calculated annual emissions for the facility. Prepared emission statements in NJDEP's RADIUS. Also, assisted in the preparation of the facility's NO_x Budget Monitoring Plan.

Seabrook Brothers & Sons – Frozen Food Processor, New Jersey.
Assisted in the review of the facility's air quality compliance plan. Negotiated permit conditions with NJDEP permit reviewer.

EMPLOYMENT HISTORY

May 2000-Present, Trinity Consultants
1999, Pennsylvania Department of Environmental Protection
1998, National Institute for Environmental Renewal

Jan C. Hutwelker, P.E.
President

EDUCATION

B.S., Engineering of Mines, West Virginia University, Morgantown, WV, 1981

PROFESSIONAL REGISTRATIONS & AFFILIATIONS

Pennsylvania Registered Professional Engineer
New Jersey Registered Professional Engineer
National Society of Professional Engineers
National Solid Waste Management Association
Solid Waste Association of North America
Society of Mining Engineers of AIME

CERTIFICATIONS

New Jersey UST Program Certification
Pennsylvania Certified Act 101 Landfill Inspector
MSHA Certified - Methane Detection
Tennessee Certified - Mine Foreman, Preparation Plant

AREAS OF SPECIALIZATION

Project Management in Solid Waste, Environmental, and Mining Engineering; Landfill and Mine Design, Permitting and Evaluation; Design/Evaluation of Landfill Gas and Leachate Management Systems; Computer Applications and CAD.

PROFESSIONAL PROJECT EXPERIENCE

Mr. Hutwelker has more than 20 years of diverse experience in the solid waste and mining industries. He specializes in the management of projects relating to the planning, design, permitting and operation of solid waste and mining disposal facilities as well as various civil and environmental projects. In addition to his design experience, Mr. Hutwelker has several years of experience in mine/plant production management and has been responsible for the implementation of much of his design work while managing those operations.

Landfill/Solid Waste Projects
JCH-LNG RES

Landfill Gas System and Flare Design, Pennsylvania, Principal Engineer -- Managed design and installation of landfill gas collection and enclosed flare system.

Landfill Expansion Design and Permitting, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania, Principal Engineer/Project Manager -- Managed design and permitting efforts required for the construction of a six-cell, 27-acre municipal waste landfill expansion. Work included liner, leachate and landfill gas management system design, slope stability analysis, cell layout, grading and stormwater management design.

Residual Waste Landfill Feasibility Study and Design, Pennsylvania, Principal Engineer -- Managed a feasibility study for the siting of a captive residual waste landfill. Work included development of a preliminary geological study and preparation of conceptual designs and cost analyses. After feasibility determination, directed the design and preparation of permit application documents.

Landfill Cell Construction Certification/Quality Assurance, Grand Central Sanitary Landfill Cells 1 through 7, Pen Argyl, Pennsylvania, CQA Engineer/Manager -- Managed CQA activities and certified the construction of 7 municipal waste landfill cells. Materials installed included; HDPE and PVC Geomembrane, Geosynthetic Clay Liner, Geotextiles and Geonet.

Municipal Waste Transfer Station Design, U.S.A. Waste, Beach Lake Transfer Station, Beach Lake Pennsylvania, Principal Engineer -- Coordinated layout, design and construction specifications for construction of a 400 ton per day top load transfer station.

Hazardous Waste Vault Liner Construction Certification/Quality Assurance, Confidential Client, Pennsylvania, CQA Manager/Engineer -- Managed and performed CQA activities for the installation of double lined containment for a hazardous waste sludge processing facility. Material installed included; HDPE Geomembrane, Bentonite Geosynthetic Clay Liner, Geonet and Geotextiles.

Landfill Closure Design and Permitting, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania, Project Engineer -- Assisted with preparation of closure plan and permit application for the capping and closure of a 52 acre municipal waste landfill. Work included preparation of cap system design, gas collection system design, slope stability analysis, terrace layout, grading, drainage and stormwater management design.

Landfill Gas Extraction and Flare System Design, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania, Project Engineer/Manager -- Gas well, piping and extraction system design for the management of gas from 70 acres of municipal waste landfill. Work included pipe sizing, layout and preparation of specifications for a centrifugal blower and enclosed flare system.

Landfill Gas Control System Design, Land Developer, New Jersey, Project/ Engineer/Manager B Design of system to control and monitor methane at a retail shopping center to be constructed above a closed landfill.

Landfill Design and Permitting, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania, Project Engineer/Manager -- Performed design work required for the permitting and construction of a nine-cell, 60-acre double-lined municipal waste landfill. Work included liner and leachate management system design, slope stability analysis, cell layout, grading and stormwater management design. The application was approved and the permit was issued in September 1990.

Landfill Design and Permitting, Confidential Client, Barbour County, West Virginia, Project Engineer -- Performed design work required for the permitting of 625-acres of double-lined municipal waste landfill. Work included liner, leachate and landfill gas management system design, slope stability analysis, cell layout and grading.

Landfill Design and Permitting , Pennsylvania, Project Engineer/Manager -- Performed and managed work required for the siting and permitting of a proposed 30 acre lined landfill expansion. Work included research and documentation of multiple abandoned deep mine workings beneath the site and management of a subsidence investigation. Design work consisted of liner, leachate and gas collection system design, fill area grading, stability and settlement analyses and stormwater management system design.

Residual Waste Landfill Feasibility Study, Pharmaceutical Manufacturer, Eastern Pennsylvania, Project Engineer/Manager -- Performed feasibility study for the siting of a dedicated residual waste landfill. Work included preparation of conceptual designs and cost analyses for several siting options. One option included an analysis of costs involved in relocating waste from an unlined municipal waste landfill to construct a lined facility in the same location.

Landfill Construction and Operation Cost Analysis, Confidential Client, Barbour County, West Virginia, Project Engineer -- Performed detailed cost analysis for a proposed municipal waste landfill. Work included estimating and obtaining costs for materials, equipment, buildings, and operations to estimate start-up and yearly operating expenses.

Landfill Cap Construction Quality Assurance, Grand Central Sanitary Landfill, Pen Argyl, Pennsylvania, CQA Engineer/Manager -- Managed CQA activities for the installation of a cap system on 20 acres∀ of an active municipal waste landfill. Materials installed included; PVC and LLDPE Geomembrane, HDPE Geonet and Geotextiles.

Closure of Foundry Sand Fill Area, Grandview Speedway, Boyertown, Pennsylvania, Project/CQA Engineer -- Responsible for monitoring final grading and the installation of a low-permeability soil cap for the closure of an area where waste foundry sand was placed as structural fill. Work included performing field topographic surveys, revising the design grades and stormwater management plan and certifying the construction to the State.

Landfill Cap Construction Quality Assurance, Aberdeen Proving Ground, Aberdeen, Maryland, CQA Engineer/Manager -- Managed CQA activities for the installation of a cap geosynthetic cap system on a 25 acre ∀ municipal waste landfill. Materials installed included; PVC Geomembrane, HDPE Geonet and Geotextiles.

Landfill Expansion Planning, Confidential Client, Pennsylvania, Project Engineer -- Prepared conceptual design and cost analysis for presentation at zoning hearing for a proposed landfill expansion.

Composting Operation Cost Analysis, Confidential Client, Barbour County, West Virginia, Project Engineer -- Performed detailed cost analysis for proposed yard waste composting operation. Work included pricing and analysis of costs for building, equipment and operations to predict return on investment.

Mining and Mineral Processing Projects

Production Management of Sand and Gravel Dredging/Processing Operation, Dallenbach Sand Co., Inc., South Brunswick, New Jersey, Plant Superintendent -- Responsible for all aspects of dredge and plant production, quality control, operation and maintenance at a 900,000 TPY union mine. Work included process control and electrical troubleshooting, crusher, screen, pump, classifier and conveyor maintenance. Also responsible for managing maintenance and repair of heavy equipment including dozers, loaders, hydraulic cranes, dredge engines and hydraulics.

Quarry Expansion Design and Permitting, Eureka Quarries - Daleville Quarry, Moscow, Pennsylvania, Project Engineer -- Assisted with preparation of a design and permit application for the expansion of a stone quarry. Work included preparation of volume calculations, layout, grading, drainage and stormwater management design.

Aggregate Blending Circuit Design, Purchase and Installation, Dallenbach Sand Co., Inc., South Brunswick, New Jersey, Plant Superintendent -- Designed processing circuit to blend mill fines from a stone crushing operation with dredged sand. Work included the design of an automatic control system to proportion and blend the materials in the proper ratio to meet concrete sand gradation specifications while maximizing production. Supervised the installation of two conveyors, vibrating screen, 50-ton bin and belt feeder. Performed wiring, installation, start-up and tuning of motors and automatic controllers.

Cyclone Fines Recovery Circuit Design, Purchase and Installation, Dallenbach Sand Co., Inc., South Brunswick, New Jersey, Plant Superintendent -- Designed, purchased and installed circuit to recover waste fines from sand plant process water and blend them back into saleable product. Work included performance of a cost analysis based on sampling of process water to calculate payback for the system purchase.

Mineral Reserves Study, Dallenbach Sand Co., Inc., South Brunswick, New Jersey, Plant Superintendent -- Performed an exploration work and reserve analysis to identify minable sand and

gravel reserves remaining on a mine property. Work consisted of preparing a layout for drilling and sampling of the deposit, locating the borings by field survey, then sampling and logging each boring as it was advanced. Samples were analyzed for quality and estimated recovery then volumes were calculated using cross-sections developed from the boring logs.

Coal Reserves Analysis and Washability Study, Conrich Tennessee, Inc., Huntsville, Tennessee, Project Engineer-- Assisted in the preparation coal thickness and quality maps for several coal seams located on a 50,000 acre mine property. Work included float-sink testing and quality analysis of core samples from each seam. Results of the testing were tabulated, analyzed and used to predict recovery rates quality of product from a proposed coal preparation plant.

Hollow Fill Design and Permitting, Conrich Tennessee, Inc., Huntsville, Tennessee, Project Engineer -- Designed two head-of-hollow fills totaling 38 million cubic yards in volume for the storage of excess overburden from a proposed mountaintop removal coal mining project. Work included the collection of undisturbed samples for triaxial testing and analysis of slope stability.

Coal Refuse Disposal Area Design and Permitting, Conrich Tennessee, Inc., Huntsville, Tennessee, Project Engineer -- Performed siting, design and permitting work required for the construction of a coal refuse disposal area. Work included the design of a clay liner system and was integrated with the reclamation of an abandoned contour strip mine. The facility was permitted under both federal and state permits.

Contour Coal Mine Design and Permitting, Conrich Tennessee, Inc., Huntsville, Tennessee, Project Engineer -- Assisted with siting, design and permitting work required for several contour mine areas. Work included surveying, mine layout, erosion and sedimentation control, haul road and reclamation design.

Mountaintop Removal Coal Mine Design and Permitting, Conrich Tennessee, Inc., Huntsville, Tennessee, Project Engineer -- Assisted with the siting, design and permitting work required for the development of a 220 acre mountaintop removal project to extract coal from 5 different seams. Work included surveying, reserves analysis, mining cost analysis, mine layout, erosion and sedimentation control, haul road and reclamation design.

Construction Monitoring and Start-up of 150 Ton-Per-Hour Coal Preparation Plant, Conrich Tennessee, Inc., Huntsville, Tennessee, Project Engineer -- Monitored construction, supervised and assisted with the start-up of a 150 TPH heavy media cyclone coal preparation plant. Work included the calibration and setting of automatic controls for media gravity control, pH control and all associated motor controls. Responsible for troubleshooting and correcting several plant material flow problems. The plant utilized a closed circuit process water system with a 70 ft. diameter static thickener and belt filter press for dewatering of waste fines.

Underground Mine Design, Layout, Surveying and Mapping, Richland Coal Co., Inc., Barbourville, Kentucky, Project Engineer -- Prepared design and performed layout of two deep mine portals for development of a new mine in the Blue Gem coal seam. Performed periodic mine

surveys and maintained mine maps for five separate deep mines in the Blue Gem seam. Assisted with ventilation and mine design.

Production Management of 150 Ton-Per-Hour Coal Preparation Plant, Conrich Tennessee, Inc., Huntsville, Tennessee, Plant Superintendent -- Responsible for all aspects of plant production, quality control, operation and maintenance at a heavy media cyclone coal preparation plant. Work included process control and electrical troubleshooting, crusher, screen, pump, conveyor, filter press and dryer maintenance.

Civil and Environmental Projects

Slope Stability Analysis, Confidential Client, Pennsylvania, Principal Engineer -- Performed Slope stability analysis to determine factor of safety for an existing sidehill rock fill. Work included evaluation of foundation soils and pre-fill topography for use in computer aided stability analysis.

Specification of Wastewater Aeration System, Confidential Client, Pennsylvania, Principal Engineer -- Specified fine bubble diffuser system for the aeration of 1.5 million gallon landfill leachate storage tank. Work included evaluation of historical leachate quality data and analysis of various available systems to maximize efficiency and minimize required maintenance.

Retaining Wall Design, Grandview Speedway, Boyertown, Pennsylvania, Project Engineer -- Prepared design for the construction of a 30 foot high gabion retaining wall as part of final grading for a constructed fill. Work included calculation of lateral earth pressures and resistance of the wall against sliding and overturning failures.

Sodium Hydroxide Storage and Transfer System Design, Conrich Tennessee, Inc., Huntsville, Tennessee, Project Engineer -- Designed system for storing 4,000 gallons of 50% caustic solution to be used in pH control of coal preparation plant process water. Work included design of a building, tank, piping and heating system to maintain solution temperature above freezing.

Groundwater Remediation System Installation, Confidential Client, Eastern Pennsylvania, Project Engineer/Manager -- Installed dual and total fluids pumping system in four wells to remediate fuel oil and gasoline contaminated groundwater. Responsibilities consisted of piping and electrical system layout, pump and controller installation, system start-up, tuning and maintenance.

PUBLICATIONS AND PRESENTATIONS

Hutwelker, J.C., F.X. Taylor, 1993. **Oil-Resistant PVC Geomembrane Compatibility for Residual Waste**; Proceedings, Geosynthetics >93, Vancouver, B.C., Vol. 2, p. 877.

Hutwelker, J.C., F.X. Taylor, and T.G. Pullar, 1991. **The Evolution of Geosynthetics in a Landfill Lining System**; Proceedings, Geosynthetics >91, Atlanta, GA,Vol. 1, p. 31.

MICHAEL K. TSAKALOYANNIS

Project Supervisor

AREAS OF SPECIALIZATION

- Dispersion Modeling and Class I Analyses
- Title V & PSD/NSR Permitting
- New York State Permitting
- Compliance Audits
- Odorous Emissions Modeling

EDUCATION

- M.Eng., Environmental Engineering, McGill University.
- B.Eng., Civil Engineering, McGill University.

AFFILIATIONS

Air & Waste Management Association

Mr. Tsakaloyannis is a Project Supervisor specializing in air dispersion modeling analyses and the preparation of Title V, Prevention of Significant Deterioration (PSD), and state permit applications. He has expertise with a wide range of dispersion models (e.g., CALPUFF, CTDMPLUS, ISC3, AERMOD, and SCREEN3) and has been involved in numerous modeling projects.

Mr. Tsakaloyannis graduated from McGill University with a Master of Environmental Engineering degree. His thesis, "Development of a Regulatory Strategy for Odor Impact Assessment," examined methods of predicting and modeling a community's degree of annoyance to industrial odorous emissions.

DIRECTLY RELATED EXPERIENCE

Amerada Hess Corporation – Petroleum Refinery, New Jersey.
Prepared a PSD permit application to increase the charge rate of the refinery's FCC Unit. The application included a BACT analysis for the FCCU, and a dispersion modeling analysis using ISCST3 to show that the project would not violate federal or state ambient air quality standards. The modeling analysis also evaluated additional regional haze impacts at the Brigantine Class I Area using CALPUFF. The project was submitted to the state as a significant modification to the facility's Title V permit using NJDEP's RADIUS program.

Also, prepared a modification to the facility's Title V permit for a construction project that was required to meet new federal Tier II low-sulfur gasoline standards, and conducted a facility-wide netting analysis for Non-Attainment New Source Review and Prevention of Significant Deterioration.

Coastal Eagle Point Oil Company – Petroleum Refinery, New Jersey.
Assisted the facility with reviewing NJDEP's draft compliance plan and with negotiating permit conditions for the facility's Title V permit.

Valero Refining Company – Petroleum Refinery, New Jersey.
Prepared a PSD permit application for a proposed expansion of the refinery's FCC unit. Performed ISC3 dispersion modeling to demonstrate that the project would comply with Federal and New Jersey ambient air quality standards. Class I modeling was conducted using the CALPUFF dispersion model to demonstrate

that the project would not have an adverse effect on the Brigantine Wilderness Area.

Lafarge North America Gypsum – Wallboard Manufacturer, New Jersey.
Assisted the Port Newark wallboard facility with complying with a NJDEP settlement agreement. Prepared Annual Air Emissions Inventories as required by the NJDEP for its gypsum wallboard plant located in Port Newark, New Jersey.

Lafarge North America Gypsum – Wallboard Manufacturer, New York.
Assisted the Buchanan wallboard facility with preparing a Title V permit modification for the addition of a new emissions unit.

TWA Airlines, LLC – Airline Operations, New York.
Prepared a semi-annual and annual Title V Compliance Certification report for the TWA Airlines, LLC operations at JFK Airport. The operating permit conditions were reviewed and a site visit was conducted to determine compliance.

Dragon Products Company – Portland Cement Manufacturer, Maine.
Performed a particulate matter netting analysis in support of a state air permit application for an expansion project that converted the existing wet process kiln to a dry preheater kiln.

Longview Fibre Company - Pulp and Paper, Washington.
Performed Class I modeling for regional haze and deposition compliance in support of a PSD permitting project for a pulp and paper client. Trinity negotiated with the Federal Land Manager and the Washington DOE over the details of the modeling protocol to most accurately and reasonably represent client interests.

Lafarge Corporation – Portland Cement, Pennsylvania.
Assisted with the preparation of an odor characterization project at this Portland cement manufacturing facility. The project consisted of sampling stack gas streams and chemical characterization with gas chromatography.

National Cement Company of Alabama, Inc. – Portland Cement, Alabama.
Assisted this Portland cement manufacturing facility by providing continuing consulting services to address a variety of air quality compliance and permitting concerns. Work included a regulatory review for the facility and revising the facility's Title V operating permit application.

Performed emissions calculations and a PSD netting analysis for a cement clinker handling and storage facility and finish mill operations. Prepared a construction permit application.

Quantified fugitive emissions and performed an emissions inventory in support of a PSD netting analysis for a Portland cement manufacturing facility. Prepared a state construction permit application.

Trigen-BioPower, Inc. – Cogeneration Facility, Georgia.
Performed refined dispersion modeling analyses in support of a PSD permitting project. A regional haze analysis was performed using CALPUFF and ISCST3 to determine the potential change in visibility at the Wolf Island and Okefenokee Swamp Class I Wilderness Areas. Trinity negotiated with the U.S. Fish & Wildlife Service and the Georgia EPD over the details of the modeling protocol to most accurately and reasonably represent client interests. Numerous modeling analyses were performed.

Yamaha Music Manufacturing Incorporated – Facility, Georgia.
Prepared an emissions inventory and performed a preliminary air toxics dispersion modeling analysis in preparation for a planned expansion at the facility. Advised client on a dispersion modeling procedure and system that would allow the facility to quickly demonstrate compliance with state air toxics standards for minor modifications.

Performed regulatory analyses and assisted in the modification of the Title V permit application for this piano manufacturing plant. Provided strategic guidance on regulatory review and representation of emissions units in application.

Gulf States Paper – Pulp and Paper, Alabama.
Performed dispersion modeling analyses and prepared a PSD permit application, which covered the installation of new equipment and additional production shifts.

Kimberly-Clark Corporation – Loudon, Tennessee.
Assisted in conducting a compliance audit for this tissue mill. A thorough review of current and past compliance history with respect to applicable air quality regulations was performed.

Langboard, Inc. – Pulp and Paper, Georgia.
Assisted in the preparation of an air permit application for a greenfield medium density fiberboard mill. Consulted on control technologies necessary to avoid PSD permitting. Performed

refined dispersion modeling analyses to help determine optimum stack configurations and demonstrate compliance with state formaldehyde standards.

Confidential Client – Lime Manufacturing, Maine.
Assisted lime manufacturing client in assessing the possibility of permitting the construction of a greenfield lime kiln in the state of Maine. Assessment included regulatory applicability analysis and review of EPA's RBLC database for potential BACT determinations.

Confidential Client – West Virginia.
Performed detailed modeling analyses in support of a proposed PSD permitting project. Scope of analyses included processing on-site meteorological data, modeling using CALPUFF, CTDMPLUS and ISCST3, and an investigation into using AERMOD. Trinity negotiated with the WV DEP and U.S. EPA over the details of the modeling protocol to most accurately and reasonably represent client interests.

Confidential Client – Cogeneration Facility, California.
Conducted dispersion modeling analysis for the proposed construction of a greenfield cogeneration facility in the South Coast Air Quality Management District using SCREEN3.

Confidential Client – Lime Manufacturing, South Carolina.
Conducted a facility-wide regulatory compliance audit and reviewed air quality compliance procedures for lime manufacturing facility.

PUBLICATIONS

Tsakaloyannis, M.K. and J. Nicell (1997). A proposed method for the assessment of the impact of odorous emissions from stationary sources. *Proceedings of the 3rd International Interdisciplinary Conference on the Environment*, June 25-28, Cambridge, MA.

Tsakaloyannis, M.K. and J. Nicell (1997). A protocol for odor impact assessment. *Proceedings of the 4th International Conference on Characterization and Control of Emissions of Odors and VOCs*, Air & Waste Management Association, October 20-22, Montreal, QC.

PRESENTATIONS

Tsakaloyannis, M.K., John Wilhelmi, "Public Health Assessment of Air Emissions from Military Training Exercises on the Island of Vieques, Puerto Rico", AWMA's 96th Annual Conference & Exhibition, San Diego, CA, June 22-26, 2003.

Tsakaloyannis, M.K., "Major Source Permitting and Class I Areas: Visibility and Deposition Modeling Challenges", AWMA Environmental Permitting Symposium II, Chicago, IL, November 14-16, 2000.

EMPLOYMENT HISTORY

1999 – Present: Trinity Consultants, Parsippany, NJ.
1997 – 1999: Trinity Consultants, Atlanta, GA.
1995 – 1997: McGill University, Montreal, QC.

HONORS AND AWARDS

Scholarship Recipient, Hellenic Board of Trade, Montreal, QC.

Appendix B

Risk Assessment Protocol (May 2003)

PROTOCOL FOR RISK ASSESSMENT WORK AT THE GRAND CENTRAL LANDFILL IN PLAINFIELD TOWNSHIP, PENNSYLVANIA

Prepared by:

CPF Associates, Inc.
Takoma Park, Maryland

EarthRes Group, Inc.
Pipersville, Pennsylvania

May 15, 2003

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APPENDICES

PROTOCOL FOR RISK ASSESSMENT WORK AT THE GRAND CENTRAL LANDFILL IN PLAINFIELD TOWNSHIP, PENNSYLVANIA

INTRODUCTION

This document outlines the approach proposed for the performance of risk assessment work at the Grand Central Sanitary Landfill (GCSL) in Plainfield Township, Pennsylvania. The risk assessment work has been developed to respond to community concerns that have been raised about potential health effects associated with the landfill. Specifically, the risk assessment will aim to address possible health concerns related to landfill gases and dusts. The information obtained from the risk assessment will allow an evaluation of the potential public health risks to surrounding communities due to landfill gases and dust that may be associated with current landfill operations.

Waste Management has requested that a team of scientists and engineers with expertise in risk assessment, environmental engineering and air dispersion modeling perform the risk assessment work. CPF Associates, Inc. will perform health risk evaluations for both landfill gas and dust. CPF is a Washington, D.C.-based scientific and health consulting firm with expertise in performing health risk evaluations for a variety of different types of waste treatment technologies, including landfills. Key technical information regarding landfill gas composition and emissions will be provided by EarthRes Group, Inc. (ERG). In addition, ERG will conduct ambient particulate matter monitoring efforts at the landfill. ERG is a full-service environmental engineering firm that specializes in providing design and environmental services to the solid waste industry. ERG has been the primary environmental consultant to GCSL since 1995, and ERG personnel have been active in environmental affairs at the site for over 20 years. Mr. Jan Hutwelker, P.E. of ERG is the GCSL Engineer of Record. Trinity Consultants, a nationally recognized air dispersion modeling firm, will perform air dispersion modeling for this assessment.

SITE SETTING

The Grand Central Sanitary Landfill is located in Plainfield Township, Northampton County, Pennsylvania. The general landscape in the area is comprised of rolling hills, farmland and woodland, with both residential and industrial development. Northampton County, with a population of 267,066 (based on the 2000 U.S. Census) is comprised of many townships and boroughs. The boroughs located closest to the landfill include Pen Argyl and Wind Gap (with populations of 3,615, and 2,812, respectively, based on the 2000 U.S. Census).

The GCSL is located on a 516.7-acre tract of land which includes a municipal solid waste landfill, a stone crushing operation[1], and a landfill gas-to-energy electric

[1] The rock crushing plant located within the landfill property boundary is owned by NAPA Development Corporation, Inc. Most of the crushed rock, which is obtained from the landfill property, is used for landfill construction and some is also sold in the area by NAPA.

generating plant. All three operations are owned by separate entities and operate under permits issued by the Pennsylvania Department of Environmental Protection (PADEP) in accordance with PADEP and U.S. Environmental Protection Agency (USEPA) regulations.

The municipal solid waste landfill at GCSL consists of two separate disposal areas that encompass roughly 139 acres. The 52-acre original landfill began accepting waste in the 1950's, was closed in 1991 and completely capped by 1993. The 87-acre more recent landfill, also referred to as the Northern Expansion, began accepting waste in 1991 and is currently permitted and projected to accept waste until 2007. A portion of the Northern Expansion has been filled and is capped. Another portion is currently used for municipal solid waste disposal activities. USA Waste Services assumed ownership of the landfill in the spring of 1996. In the summer of 1998, Waste Management, Inc. assumed ownership of the landfill when it merged with USA Waste Services.

Landfill gas at GCSL is controlled and collected through an extensive series of vertical and horizontal underground perforated pipes. The gas collection piping system and the landfill perimeter are monitored daily to protect against possible gas migration using an array of subsurface landfill perimeter gas probes. Methane gas readings are also collected at least quarterly at the landfill surface as required by federal regulation (60 CFR Subpart WWW, Section 60.756). The gas collection piping system is connected to a 9.9 MW gas-to-energy plant within the landfill property boundary (owned by the Green Knights Economic Development Corporation). Gas from the landfill is directed through the pipes to the gas-to-energy plant which uses three turbines to produce electricity from the combusted landfill gas. There are also two enclosed flare facilities at the landfill which are connected to the gas collection piping system and are used if one or more of the gas-to-energy plant turbines are off line. The flares can also operate if the landfill gas production exceeds the capacity of the gas-to-energy plant.[2]

Dust control measures taken at GCSL include road sweeping of parking areas, landfill access roadways from the public highway to the landfill and other haul roads inside the landfill. In addition, water is applied to all road surfaces to reduce fugitive dusts.

RISK ASSESSMENT OF LANDFILL GAS

The risk assessment will include an evaluation of the potential long-term and short-term human health risks associated with inhalation of landfill gas emissions in the nearby surrounding community. Potential chronic (long-term) excess lifetime cancer risks and the potential for chronic non-cancer health effects will be evaluated for residential locations around the landfill. The potential for short-term irritant effects from landfill gas will also be evaluated for residential locations around the landfill.

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[2] The emission controls on the gas-to-energy plant and the enclosed flares are state-of-the-art and meet or exceed applicable federal and state regulations. Federal requirements are addressed in Subpart WWW – Standards of Performance for Municipal Solid Waste Landfills (60 CFR 750 through 60 CFR 759). The Commonwealth of Pennsylvania requires installation and use of "Best Available Technology" to control emissions, as codified in 25 Pa. Code §121, 25 Pa. Code §127.12(a)(5) et al.

The landfill gas risk assessment will conform to general human health risk assessment methods that are well-established by both the USEPA and the U.S. National Academy of Sciences. The key steps in this process, which are briefly discussed below, consist of:

- Hazard Identification
- Exposure Assessment
- Risk Characterization
- Discussion of Uncertainties

Although the USEPA has not developed a risk assessment guidance document specifically for municipal solid waste landfills, there are a number of guidance documents that are useful for this type of study and that will be used where appropriate (even though they may have been developed for different types of facilities or sites). These guidance documents may include USEPA's *Risk Assessment Guidance for Superfund* (USEPA 1989), USEPA's *Exposure Factors Handbook* (USEPA 1997a), USEPA's *Guidelines for Exposure Assessment* (USEPA 1992), USEPA's *Draft Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (USEPA 1998a), and the Agency for Toxic Substances and Disease Registry (ATSDR) *Landfill Gas Primer: An Overview for Environmental Health Professionals* (ATSDR 2001). Consistent with the guidance outlined in these documents, site-specific data will be included as available in the risk assessment. The basis for each site-specific value used in the analysis will be provided in the risk assessment.

The risk assessment will include a description of the equations used to calculate environmental concentrations, exposures and potential risks associated with landfill gas emissions. These equations will be obtained directly from USEPA guidance documents, except where specifically noted in the risk assessment. The risk assessment will also include a complete list of all citations relied upon, fully referenced tables summarizing the input parameters used to calculate environmental concentrations and the exposure parameters, air dispersion modeling results, and a description of how the modeling results were be used in the risk assessment.

The remainder of this section describes how each step of the risk assessment will be performed.

HAZARD IDENTIFICATION

The Hazard Identification discusses toxicity information for compounds that may be present in landfill gas emissions and also presents the selection of compounds for evaluation in the landfill gas risk assessment.

The first step in the risk assessment will be the identification of toxicity data for landfill gas constituents. The toxicity data used to evaluate chronic, long-term risks includes cancer slope factors for predicting excess lifetime cancer risks and reference doses (RfDs) for predicting the potential for long-term non-cancer effects. Toxicity data for both cancer and non-cancer effects for each chemical will be obtained from data reported in USEPA's Integrated Risk Information System (IRIS) and USEPA's Health Effects Assessment Summary Tables (HEAST). The list of compounds for which toxicity data will be compiled will be determined based on available landfill gas monitoring data collected at the Grand Central Landfill. Compounds that have been detected in Grand

Central Landfill gas samples will be considered in the risk assessment and toxicity data will be compiled for these constituents.

In addition to long-term toxicity data, the potential for short-term acute effects from emissions to air will be evaluated using acute reference air concentrations. These reference concentrations, representing the short-term level in air above which adverse effects may occur and below which adverse effects are not expected to occur, will be derived from the published literature in accordance with USEPA's (1998a) guidance. This guidance provides a hierarchy of sources from which acute reference air concentrations can be compiled.

The next step of the risk assessment will identify a subset of compounds potentially present in landfill gas emissions for detailed evaluation in the risk assessment. This subset will be identified from the list of compounds that have been analyzed for in Grand Central Landfill gas. The selection of a subset of compounds for consideration in a quantitative risk assessment is a well-known practice (e.g., see USEPA 1994a, USEPA 1995a, and USEPA 1989). The selection of a subset compounds is supported by risk assessment experience which shows that typically only a small number of compounds dominate the results of a risk assessment. Compounds will be selected based on a consideration of their emission rates from the landfill surface and their toxicity data. Emission rates will be calculated using data describing landfill gas flow rates and chemical concentrations in the landfill gas. The risk assessment will provide a detailed discussion of the methods used to select a subset of compounds for detailed analysis in the risk assessment.

EXPOSURE ASSESSMENT

The key steps involved in an exposure assessment consist of:

- quantification of emission rates,
- air dispersion modeling,
- population analysis,
- identification of exposure pathways,
- calculation of environmental concentrations, and
- calculation of human exposures.

A brief discussion is provided below of each of these steps.

One of the most important inputs to an exposure assessment is the chemical emission rate. Landfill gas emission rates will be developed to address releases associated with actual facility operations and will include not only ground-level surface releases, but also stack emissions from the gas-to-energy plant and the landfill gas enclosed flares in operation at Grand Central. The methods that will be used to calculate ground-level surface emission rates from the three landfill areas, and stack emission rates from the gas-to-energy plant and enclosed flares will be described in the risk assessment.

A brief description of methods anticipated to be used to calculate landfill gas emission rates is provided below. Ground-level surface emission rates will be calculated for each of three landfill areas that comprise the Grand Central Landfill. The three areas have been identified to reflect differences in potential landfill gas generation rates as well as

potential differences in the efficiency of the facility's landfill gas collection system. The three areas will consist of:

- Area A - closed capped portions of the original landfill
- Area B - capped areas in the Northern Expansion
- Area C - active uncapped areas in the Northern Expansion

Emission rates from the gas-to-energy plant and enclosed flares will be calculated based on operating data from these facilities, including available stack test measurements, stack gas flow rates and pollutant destruction efficiency data.

Air dispersion modeling is required in order to calculate chemical concentrations in air surrounding the landfill and, ultimately, human exposures from landfill-related emissions. The air dispersion modeling will be performed using the USEPA-approved Industrial Source Complex Short-Term 3 (ISCST3) model (USEPA 2001, USEPA 1995b). This model can calculate ambient air concentrations from a wide variety of sources including area sources (such as a landfill surface) and point sources (such as a stack).

Descriptions of each type of potential emission source modeled for the Grand Central Landfill will be provided in the risk assessment. Ground-level surface emissions from the three landfill areas will be modeled in ISCST using an emission rate expressed in units of g/m^2-sec. Stack emissions (i.e., from the gas-to-energy plant and the enclosed flares) will be modeled using emission rates expressed in units of g/sec. The treatment of emissions in this manner is consistent with USEPA guidance for the ISCST model (USEPA 1995b).

The ISCST3 model will be used to calculate annual average and 1-hour average ambient air concentrations across a study area surrounding the landfill property boundary. All model runs will use a unitized emission rate as an input (i.e., either 1 g/m^2-sec or 1 g/sec), also consistent with USEPA guidance (USEPA 1995b, 1998a). Therefore, the modeled ambient air concentrations output from ISCST will be unitized concentrations, expressed in units of $\mu g/m^3$ per 1 g/m^2-sec or $\mu g/m^3$ per 1 g/sec. Chemical-specific concentrations will then be calculated by multiplying the unitized results by the chemical-specific emission rates. The chemical-specific ambient air concentrations will be calculated to reflect the combined impact of all modeled emission sources at the landfill (i.e., the sum of impacts associated with the three landfill areas, the gas-to-energy plant and the enclosed flares).

The ISCST3 model will be run using meteorological data obtained from the U.S. National Weather Service (NWS). The nearest NWS stations are Allentown, Pennsylvania (NWS Station No. 14737) which will provide surface meteorological data (e.g., wind speed and direction) and Sterling, Virginia (NWS Station No. 93734) which will provide upper air data (e.g., atmospheric mixing height).

The next step in the exposure assessment involves identifying populations in the landfill area through demographic and land use data. This information will be used to identify locations in the surrounding area at which risks will be calculated.

Subsequently, exposure pathways will be selected for evaluation in the risk assessment. The most important exposure pathway relevant for gas emissions from a landfill is

inhalation and, accordingly, this risk assessment will focus on the inhalation pathway of exposure. Potential inhalation exposures to both children and adults will be addressed. The volatile compounds that are typically present in landfill gases tend to remain in the air phase and generally do not accumulate or partition to any appreciable extent into soil or edible plants. As a result, potential exposures due to indirect pathways such as soil ingestion or ingestion of homegrown produce will be negligible relative to the direct inhalation pathway.

The next step will be the calculation of ambient air concentrations in the area surrounding the landfill. Long-term chronic inhalation risks will be calculated using modeled annual average ambient air concentrations and chemical emission rates. Short-term acute inhalation risks will be predicted using 1-hour average modeling results and chemical emission rates. Ambient air concentrations will be calculated for several residential locations in the landfill vicinity.

The last exposure assessment step is the calculation of chronic human inhalation exposures in the landfill area.[3] These calculations require information on the calculated air concentrations, inhalation rates, and data on body weight, exposure frequency (i.e., hours/day and days/year exposed) and exposure duration (i.e., total years exposed). The risk analysis will rely on USEPA default exposure parameters for adults and children (USEPA 1998a). These parameters will be used with the modeled annual average ambient air concentrations in standard USEPA equations to calculate chronic exposures in the risk assessment.

RISK CHARACTERIZATION

The next part of the risk assessment is referred to as risk characterization. In this part of the assessment, potential risks associated with landfill gas emissions from the Grand Central Landfill will be addressed.

Chronic long-term inhalation risks will be calculated by combining the exposure estimates with toxicity values for cancer and non-cancer effects. Cancer risks reflect the upper bound probability that an individual may develop cancer over a 70-year lifetime under the assumed exposure conditions. The risks are referred to as "upper bound" because they are unlikely to be underestimated and, in fact, may range from as low as zero to the upper bound value. Cancer risks will be calculated separately for each chemical and also summed across chemicals. For example, a cancer risk of $1x10^{-5}$ means that an individual could have, at most, a one in 100,000 chance of developing cancer over a 70-year lifetime under the evaluated exposure conditions. In comparison, each person in the U.S. has a background risk of developing cancer over a lifetime of about one in three.

The potential for chronic non-cancer health effects will be determined by comparing the calculated exposures with non-cancer reference doses (RfDs). A hazard quotient will be calculated for each chemical by dividing its exposure by its reference dose. Each chemical will be evaluated separately, with results added across chemicals for similar target organs and health effect endpoints. The sum of a number of hazard quotients is

[3] Exposures are not calculated for evaluation of short-term acute effects since the 1-hour average ambient air concentrations are compared directly to short-term reference air concentrations.

referred to as a hazard index. The hazard index result will be evaluated against the commonly used regulatory target risk level of 1.

The potential for short-term acute inhalation risks will be evaluated by comparing modeled short-term, 1-hour average air concentrations with the acute reference air concentrations in a manner similar to the evaluation of non-cancer risks. An acute hazard quotient will be calculated by dividing each chemical's modeled 1-hour average air concentration by its acute reference concentration.[4] The quotients will be compared to a target risk level of one. Quotients below one are not expected to result in health effects. Quotients above one indicate a potential for health effects, but actual health effects are still unlikely to occur because safety factors are incorporated in the acute reference air concentrations. Acute hazard quotients will also be summed for similar health effects endpoints.

DISCUSSION OF UNCERTAINTIES

All risk assessments involve the use of assumptions, judgment and incomplete data to varying degrees. This results in uncertainty in the final estimates of risk. In accordance with standard risk assessment practice, this section of the risk assessment will present a discussion of key uncertainties affecting the risk assessment.

RISK EVALUATION OF DUST IMPACTS

The risk assessment will also include a comprehensive dust monitoring program to evaluate potential dust impacts associated with landfill operations. A monitoring program will be conducted to generate data for input to a risk assessment.

The dust monitoring program includes measurement of total suspended particulate matter (TSP) in ambient air at regular intervals around the perimeter of the landfill property using a mobile hand-held device. Respirable dust concentrations in ambient air will also be monitored at several locations around the landfill property perimeter using stationary sampling equipment and USEPA-recommended methods.

Meteorological data and land use information will be carefully considered in the dust monitoring program. Data indicating predominant wind patterns (wind speed and direction) will be obtained from the nearest National Weather Service station (Allentown, PA) and will be supplemented with data collected from an on-site meteorological station that is expected to be operational in the near future. Meteorological conditions will be tabulated during all ambient air monitoring efforts.

TOTAL SUSPENDED PARTICULATE (TSP) MONITORING

Monitoring for TSP has been conducted a few times over the past several months using a mobile device that allows measurement of concentrations in ambient air around the entire perimeter of the landfill property boundary. The device that is used is a MIE DataRAM Aerosol Monitor which provides real-time measurement of TSP

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[4] For example, HQ_{acute} = (1-hr average air concentration in $\mu g/m^3$) / (acute reference air concentration in $\mu g/m^3$).

concentrations.[5] The DataRAM monitoring program includes measurement of TSP levels at regular intervals around the property boundary. Other information collected during sampling includes meteorological data (e.g., wind speed, wind direction, air temperature) and activities at the time of sampling that may affect measured dust levels (e.g., vehicle traffic). Additional perimeter monitoring may be conducted in the future. TSP monitoring is not conducted during wet weather conditions.

The information from the TSP monitoring program will be used as a "screening" tool with several purposes. First, the measured TSP ambient air concentrations will be examined to determine whether concentrations downwind of the landfill are generally elevated compared to concentrations upwind of the landfill. Second, the TSP monitoring program results will be examined to determine whether certain activities that may have occurred during sampling tend to be associated with observed dust levels (e.g., vehicle traffic on community roads and on the landfill's access road). Third, the TSP levels will be compared with available public health benchmarks as well as available information on background TSP levels in the area to provide some insight into the potential for dust-related public health impacts. Finally, the TSP results will be examined to identify monitoring locations for stationary respirable dust monitors.

RESPIRABLE DUST MONITORING (PM10 AND PM2.5)

The other element in the dust monitoring program will be sampling of respirable dust, which is a subset of TSP. Stationary sampling monitors will be placed at several locations around the landfill property boundary to measure 24-hour average respirable particulate matter concentrations in ambient air. Two types of respirable dust concentrations will be measured – PM10 and PM2.5. PM10 refers to particles with an aerodynamic diameter[6] less than or equal to 10 micrometers (10 μm). PM2.5 refers to particles with an aerodynamic diameter less than or equal to 2.5 micrometers (2.5 μm). These particle sizes were identified based on USEPA's National Ambient Air Quality Standards for particulate matter as well as USEPA research efforts on the health effects of respirable particulate matter (USEPA 2002).

It will be important to choose locations that will specifically identify and, if possible, differentiate between landfill-related impacts and upwind or non-landfill-related air conditions. The TSP monitoring results will provide one piece of information used to identify appropriate locations for stationary respirable dust monitors. Other factors that will be considered in locating samplers will include meteorological data (e.g., predominant downwind directions), the location of nearby residential and community areas, and the locations of known or suspected dust-producing activities both at the landfill and in the surrounding area. Relevant USEPA (1994b) requirements will also be considered in identifying sampling points, including sampler height, avoidance of spatial obstructions, security, operator safety, etc.

USEPA-recommended sampling methods will be used to collect and analyze PM10 and PM2.5 samples (USEPA 1997b, 1998b, 1998c, 1998d). A detailed discussion of the PM10 sampling protocol, based on USEPA recommendations, is provided in Appendix

[5] http://www.iemiinc.com/Spec%20Pages/mie_dataram_dr_2000.htm

[6] Aerodynamic diameter depends on particle density and is defined as the diameter of a particle with the same settling velocity as a spherical particle with a unit density (1 g/cm^3).

A. A similar protocol is provided in Appendix B for PM2.5. It is anticipated that the samplers will be operated simultaneously for 24-consecutive hours every sixth day for each of the two types of PM samples. This means, for example, that a six-week sampling period would provide seven 24-hour samples at each sampling point, and each sample will have been collected on a different day of the week.

The PM10 and PM2.5 particulate matter sampling results will be compared with available public health benchmarks (e.g., existing and proposed U.S. National Ambient Air Quality Standards) as well as available information on background PM10 and PM2.5 levels in the area. The data will also be analyzed to determine whether there are any differences between upwind and downwind results, in order to determine the extent to which landfill activities may be affecting respirable dust levels.

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Appendix A
Sampling Protocol for the Determination of Particulate Matter as PM10 in the Atmosphere

Introduction

This appendix describes the PM10 sampling protocol for the Grand Central Sanitary Landfill (GCSL) in Plainfield Township, Northampton County, Pennsylvania. PM10 sampling refers to the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM10)[7] in ambient air over a 24-hour period through periodic sampling over a 6-week timeframe. This protocol has been designed to meet all applicable provisions of the relevant U.S. Environmental Protection Agency (USEPA) regulatory reference method for PM10 testing (i.e. 40 CFR §50, Appendix M; 40 CFR §58, *Appendix E*). This protocol includes information on sampling procedures, laboratory analysis, and procedures for quality assurance and data validation.

Sampling Technique

Sampling will be conducted using four separate Partisol®-FRM Model 2000 air samplers, with each sampler installed at a discrete sampling point. The samplers will be installed in accordance with manufacturer's instructions and applicable EPA guidance.[8] The samplers are manufactured by Rupprecht & Patashnick Co., Inc., and are designated as an EPA reference method for PM10 sampling in ambient air ((PM10 Designation #RFPS-1298-126, 63 Fed. Reg. 69624, December 17, 1998).

The samplers will be operated simultaneously for 24-consecutive hours every sixth day. After six full weeks, seven 24-hour samples at each sampling point will have been obtained, and each sample will have been collected on a different day of the week.

Sampler Calibration

Calibration of the sampler's flow measurement device is required to establish traceability of subsequent flow measurements to a primary standard. A flow rate transfer standard calibrated against a primary flow or volume standard shall be used to calibrate or verify the accuracy of the sampler's flow measurement device.

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[7] A more precise definition of PM10 is provided by USEPA (2002). USEPA defines PM10 as those particles small enough to enter the thoracic region of the human respiratory tract (i.e., tracheobronchial and alveolar portions of the lower respiratory tract). A PM10 sample includes all fine particles (particles ranging from <0.1 um up to roughly 2 um in aerodynamic diameter) and some coarse particles (particles generally greater than 1 um up to approximately 100 um in aerodynamic diameter). PM10 is collected using a measurement device that has an upper 50% cut point of 10 um aerodynamic diameter, which means that the device collects 50% of 10 um particles and excludes 50% of 10 um particles. It also means that some particles > 10 um are collected and not all particles < 10 um are collected.

[8] Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Specific Methods, Section 2.10; EPA-600/4-94/038b, April 1994.

Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. Therefore, the flow rate through the sampler's inlet must be maintained throughout the sampling period within the design flow rate range specified by the manufacturer. Design flow rates are specified as actual volumetric flow rates, measured at existing conditions of temperature and pressure.

The sampler will be calibrated in accordance with the following general calibration procedures.

PM10 samplers employ various types of flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification will vary depending on the type of flow controller and flow rate indicator employed. Calibration is in terms of actual volumetric flow rates. The general procedure given here serves to illustrate the steps involved in the calibration. Consult the sampler manufacturer's instruction manual for specific guidance on calibration.

Calibrate the flow rate transfer standard against a primary flow or volume standard traceable to NIST. Establish a calibration relationship, e.g., an equation or family of curves, such that traceability to the primary standard is accurate to within 2 percent over the expected range of ambient conditions, i.e., temperatures and pressures, under which the transfer standard will be used. Recalibrate the transfer standard periodically.

Following the sampler manufacturer's instruction manual, remove the sampler inlet and connect the flow rate transfer standard to the sampler such that the transfer standard accurately measures the sampler's flow rate. Make sure there are no leaks between the transfer standard and the sampler.

Choose a minimum of three flow rates (actual m^3/min), spaced over the acceptable flow rate range specified for the inlet, that can be obtained by suitable adjustment of the sampler flow rate. In accordance with the sampler manufacturer's instruction manual, obtain or verify the calibration relationship between the flow rate (actual m^3/min) as indicated by the transfer standard and the sampler's flow indicator response. Record the ambient temperature and barometric pressure.

Field calibration will occur before each sampling event, and will be documented in the field log book. Where conflicts between the general calibration procedures and the manufacturer's instructions occur, the manufacturer's instructions will control.

Sampler Installation

The filter magazines supplied by the sampler manufacturer shall be sent to IML Air Science[9]. IML Air Science shall provide the filters, install them in the filter cartridges (which are then placed in the filter magazines), and ship them directly to ERG for installation in the samplers.

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[9] IML Air Services supports particulate ambient air monitoring networks in 12 states, and analyzes tens of thousands of these samples annually. IML Air Services has an on-site laboratory dedicated solely to PM10 and total suspended particulate analysis. IML Services has been performing PM10 analysis since 1979.

1. Upon receipt of the sampler from the manufacturer, a visual inspection will be performed to ensure that all components are present and in good condition.
2. Before transportation to the site, the equipment will be assembled and energized to ensure that the sampler is operational.
3. Transport samplers to GCSL.
4. Install and secure sampler at sampling location
5. Install the control module, if separate from sampler, in accordance with manufacturer's recommendations.
6. Install the filter cartridge magazine.
7. Connect vacuum lines, and examine all tubing for crimps, cracks, or breaks.
8. Connect power supply.
9. Calibrate in accordance with manufacturer's instructions.

Filter Preparation and Analysis

IML Air Science, based in Wyoming, will supply and prepare the filters prior to sampling and will analyze the filters after testing. IML Air Science has been selected due to their extensive experience in filter preparation and ambient air sampling analysis for particulate matter. Utilizing the laboratory to supply and prepare the filters is a standard practice in particulate ambient air sampling due to the necessity of weighing the filters before and after use with the same microbalance.

Sufficient filters to last the entire sampling cycle (i.e. seven 24-hour tests over a 6-week period) will be prepared for each sampler. Each filter will be individually inspected and then weighed by an IML Air Science technician wearing nylon (or similar) gloves and using non-serrated forceps. After weighing, each filter will be packed so that each filter is encased in a filter cassette. The filter cassettes will be loaded into the filter magazine.

Visual Examination Criteria

1. Pinhole leaks: examine over a bright light or against a dark surface.
2. Separation of ring: visual examination for separation/seal integrity between filter and filter ring
3. Chaff, flashing, residual material: visual examination for any additional extraneous material either on the filter or in the area of the filter seal.
4. Discoloration and surface irregularity: Visual examination and bright light or dark surface for any discoloration (indicating contamination) or other surface irregularities indicating a non-uniform surface.

Filter Equilibration

1. Filters shall be equilibrated for at least 24 hours at a relative humidity between 20% to 45% with a variability of ±5% and a temperature between 15° and 30° C with a variability of ±3%.
2. Equilibration data will logged and maintained on-site by the laboratory, including at a minimum: relative humidity, temperature, chamber malfunctions, discrepancies, and maintenance activities.

Initial Weighing Procedures

1. Filters will be will be weighed on a microbalance with a minimum resolution of 0.001 mg and a precision of ±0.001 mg.
2. Each balance used shall be identified to ensure that the final weighing is conducted using the same balance.
3. The balance will have been calibrated, at a minimum, within the last 12 months and in accordance with IML Air Service's QC plan.
4. All measurements and QC checks will be performed in accordance with IML Air Service's QC plan, which meets all relevant EPA standards.
5. If the filters are weighed outside the conditioning chamber, the weighing procedure will begin within 30 seconds of removal from the chamber (Note: IML Air Service standard procedure is to weigh the filters inside the chamber).
6. Each filter shall have the following information recorded: Identity, microbalance number, filter number, and tare weight.
7. Install the filter inside the cassette.
8. Prepare the sample magazines and ship in secure shipping containers.

Sampler Operation

The sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is collected on a separate 47 mm diameter filter over the specified sampling period. The particle size discrimination characteristics (sampling effectiveness and 50 percent cutpoint) of the sampler inlet are prescribed as performance specifications and have been approved by the EPA as part of the Reference Method designation.

Each sampler shall be operated for a 24-hour period. Once the 24-hour sampling event is complete, the filter(s) contained in the filter cartridge shall be removed in accordance with manufacturer's instructions and shipped to IML Air Science for analysis. All pertinent data, such as total flow, sampling times, any collected meteorological data, etc. will be downloaded to a laptop computer. Filters will be packaged for shipping in accordance with manufacturer's instructions and shipped in coolers containing frozen ice packs to ensure that the particles do not volatilize from the filters. A chain of custody will accompany the samples.

When the filters are installed, the following information will be logged:

For the Filter Petri Dish:

1. Sampler ID number.
2. Filter number
3. Sample date

In the field logbook

1. Site designation and location
2. Sampler ID number
3. Filter ID number

4. Sample Date
5. Initial flow rate(s) and rotameter readings. Other data per manufacturer's instructions.
6. Any unusual conditions (weather, nearby construction or other particulate emitters, etc.).
7. Signature

General Sampler Operating Procedures[10]

Turn on the sampler and allow it to establish run-temperature conditions. Record the flow indicator reading and, if needed, the ambient temperature and barometric pressure. Determine the sampler flow rate (actual m^3/min) in accordance with the instructions provided in the sampler manufacturer's instruction manual.

If the flow rate is outside the acceptable range specified by the manufacturer, check for leaks, and if necessary, adjust the flow rate to the specified setpoint.

Stop the sampler.

Set the timer to start and stop the sampler at appropriate times. Set the elapsed time meter to zero or record the initial meter reading.

Record the sample information (site location or identification number, sample date, filter identification number, and sampler model and serial number).

Sample for 24 ±1 hours.

Filter Removal

1. Record all pertinent operational data, such as elapsed-time indicator value, and final rotameter and gauge readings.
2. Reverse the filter installation process, removing each filter individually.
3. Examine each filter for damage, such as tears.
4. Place the filter cassettes in their original marked sampling containers and verify all label information.
5. Collect meteorological data, including pressure and average ambient temperature.
6. Observe conditions around the monitoring site, noting any activities that may have affected the sampling integrity such as paving, mowing, tree removal, unusual traffic, etc.
7. Record the information listed below

In the field logbook

1. Elapsed time of sample run

[10] The most current version of published manufacturer's instructions will be used for specific operating procedures, in accordance with 40 CFR §50, Appendix M, Section 9. Where these general sampler operating procedures conflict with manufacturer's instructions, the manufacturer's instructions will control.

2. Final flow rate(s) and rotameter readings. Other data per manufacturer's instructions.
3. Any unusual conditions (weather, nearby construction or other particulate emitters, etc.).
4. Explanations for voided or questionable samples.
5. Signature

Filter(s) contained in the filter cartridge shall be removed in accordance with manufacturer's instructions and shipped to IML Air Science for analysis. Filters will be packaged for shipping in accordance with manufacturer's instructions and shipped in coolers containing frozen ice packs to ensure that any volatile particles do not volatilize from the filters. A chain of custody will accompany the samples.

Analysis

At IML Air Science, each filter will be weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM10. The total volume of air sampled, measured at the actual ambient temperature and pressure, is determined from the measured flow rate and the sampling time. The mass concentration of PM10 in the ambient air is computed as the total mass of collected particles in the PM10 size range divided by the volume of air sampled, and is expressed in micrograms per actual cubic meter (µg/m 3).

The sampler shall be field recalibrated before each 24-hour sampling event.

Final Weighing Procedures

1. Group the filters according to their recorded balance number.
2. Open the petri dish, place the lid underneath the jar, cover the container with a clean laboratory paper towel, and equilibrate the filter.
3. Weigh the filters will be on the same microbalance used in the initial weighing (minimum resolution of 0.001 mg and a precision of ±0.001 mg).
4. Each balance used shall be identified to ensure that the final weighing is conducted using the same balance as the initial weighing.
5. The balance will have been calibrated, at a minimum, within the last 12 months and in accordance with IML Air Service's QC plan.
6. Perform all measurements and QC checks in accordance with IML Air Service's QC plan.
7. If the filters will be weighted outside the conditioning chamber, the weighing procedure will begin within 30 seconds of removal from the chamber (Note: IML Air Service standard procedure is to weigh the filters inside the chamber).
8. Each filter shall have the following information recorded: Identity, microbalance number, filter number, and gross weight.
9. Insert the filter back into the petri dish for archiving.

The gross weight, minus the tare weight, is the net mass of particulate for that filter.

The following equations will be used to calculate the PM10 concentrations in the ambient air.

Total volume of air sampled as: $V = Q_a t$ where:

V = total air sampled, at ambient temperature and pressure, m^3;
Q_a = average sample flow rate at ambient temperature and pressure, m^3/min; and
t = sampling time, min.

PM10 concentration is:

PM10 = $(Wf - Wi) \times 10^{-6}/V$ where:
PM10 = mass concentration of PM10, µg/m 3;
Wf, Wi = final and initial weights of filter collecting PM10 particles, g; and
10^{-6}= conversion of g to µg.

Note: Only one size fraction in the PM10 size range is collected by the sampler.

Additional formulas are published[11] and will be used, if and where necessary.

Sampler Maintenance

The PM10 sampler shall be maintained in strict accordance with the maintenance procedures specified in the sampler manufacturer's instruction manual, as abstracted below for procedures to be performed during the 6-week sampling period:

1. Filter cassettes: Inspect filter cassettes for contamination or damage after every use. Discard any damaged cassettes. Wipe with a clean dry cloth as required.
2. Impactor: Clean the greased impactor section of the impactor after each complete sampling cycle according to the instructions in the Operating Manual. The impactor must be cleaned when the unit is not sampling.
3. External leak check: Perform an external leak check after every 4 weeks of use.
4. 1st stage inlet: Clean the 1st stage inlet after every 14 days of use according to the instructions in the Operating Manual.
5. "V" seals: Check the "V" seals (see Service Manual) every month. Replace, if necessary.

Potential Sources of Error

Volatile Particles. Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing. This error will be minimized by shipping the samples in insulated containers containing ice packs.

Artifacts. Positive errors in PM10 concentration measurements may result from retention of gaseous species on filters. Such errors include the retention of sulfur dioxide and

[11] Quality Assurance Handbook for Air Pollution Measurement Systems, 2.10.5.

nitric acid. Retention of sulfur dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity. The magnitude of nitrate artifact errors in PM10 mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small. Based on site characteristics at GCSL, artifact errors are expected to be small. In addition, any errors would bias the sampling results upwards.

Humidity. The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure is designed to minimize the effects of moisture on the filter medium.

Filter Handling. Careful handling of filters between presampling and postsampling weighings is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette greatly reduces the magnitude of these errors. In addition, higher quality filters (Teflon® coated) will be used for all sampling events.

Flow Rate Variation. Variations in the sampler's operating flow rate may alter the particle size discrimination characteristics of the sampler inlet. The magnitude of this error will depend on the sensitivity of the inlet to variations in flow rate and on the particle distribution in the atmosphere during the sampling period. The use of a flow control device is required to minimize this error, and a flow control device will be in use at all times.

Air Volume Determination. Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter will serve to minimize the error in the sampling time measurement.

Data Validation

Data necessary to compute the mass concentration of PM10 originates from both field and laboratory operations. This data will be validated to ensure it is accurate relative to the overall scope of the sampling and QA program. When the final mass concentration of PM10 in a sample has been computed, the validation procedure will check these calculations and flag any questionable mass concentrations.

Environmental Standards, Inc.[12] will perform all data validation activities. General data validation procedures are as follows:

1. Gather all sample data, including sampling time, flow rates, tare, gross and net weights of filters.

[12] Environmental Standards, Inc. (ESI) is a leading firm in the area of geoscience and environmental chemistry, and has extensive experience in data validation of ambient air particulate samples. ESI has been performing data validation of laboratory sample results since 1987, and its scientists have been published in a variety of peer-reviewed publications.

2. Compute total mass concentration of PM10 for seven samples per 100 (and a minimum of four per lot). If any calculation errors are found, recalculate all values in the sample lot.
3. Scan all total mass concentration values and re-compute the total mass concentrations for all values that appear excessively high or low. Correct any areas, initial them, and indicate date of correction. Proceed to step four for any out-riding values that do not have computation errors.
4. Review all raw data for the out-riding data for completeness and correctness.

Data Forms

All data forms will be provided by the sampler manufacturer and/or EML Air Services.

Appendix B
Sampling Protocol for the Determination of Particulate Matter as PM2.5 in the Atmosphere

Introduction

This appendix describes the PM2.5 sampling protocol for the Grand Central Sanitary Landfill (GCSL) in Plainfield Township, Northampton County, Pennsylvania. PM2.5 sampling refers to the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers (PM2.5) [13] in ambient air over a 24-hour period through periodic sampling over a 6-week timeframe. This protocol has been designed to meet all applicable provisions of the relevant regulatory reference method for PM2.5 testing (i.e. 40 CFR §50, Appendix L; 40 CFR §58, Appendix E). This protocol includes information on sampling procedures, laboratory analysis, and procedures for quality assurance and data validation.

Sampling Technique

Sampling will be conducted using four separate Partisol-FRM Model 2000 air samplers, with each sampler installed at one of the discrete sampling points to be determined at a later time. The samplers will be installed in accordance with manufacturer's instructions and applicable EPA guidance.[14] The samplers are manufactured by Rupprecht & Patashnick Co., Inc., and are designated as an EPA reference method for PM2.5 sampling in ambient air (Designation #RFPS-0498-117, 63 Fed. Reg. 18911, April 16, 1998).

The samplers will be operated simultaneously for 24-consecutive hours every sixth day. After six full weeks, seven 24-hour samples at each sampling point will have been obtained, and each sample will have been collected on a different day of the week.

Sampler Calibration

Calibration of the sampler's flow measurement device is required to establish traceability of subsequent flow measurements to a primary standard. A flow rate transfer standard calibrated against a primary flow or volume standard shall be used to calibrate or verify the accuracy of the sampler's flow measurement device.

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[13] PM2.5 is defined by USEPA as an indicator of fine-mode particles. Although a PM2.5 sample contains all fine-mode particles (particles ranging from <0.1 μm up to roughly 2 μm in aerodynamic diameter), it may also collect a small fraction of coarse particles (particles generally greater than 2 μm up to approximately 100 μm in aerodynamic diameter). PM2.5 is collected using a measurement device that has an upper 50% cut point of 2.5 um aerodynamic diameter, which means that the device collects 50% of 2.5 μm particles and excludes 50% of 2.5 μm particles. It also means that some particles > 2.5 μm are collected and not all particles < 2.5 μm are collected.

[14] Quality Assurance Guidance Document 2.12, Section 6.3, United States Environmental Protection Agency, November 1998.

Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. Therefore, the flow rate through the sampler's inlet must be maintained throughout the sampling period within the design flow rate range specified by the manufacturer. Design flow rates are specified as actual volumetric flow rates, measured at existing conditions of temperature and pressure.

The sampler will be calibrated in accordance with the following general calibration procedures.

PM2.5 samplers employ various types of flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification will vary depending on the type of flow controller and flow rate indicator employed. Calibration is in terms of actual volumetric flow rates. The general procedure given here serves to illustrate the steps involved in the calibration. The sampler manufacturer's instruction manual will be cross-referenced with Section 2.12 of the Quality Assurance Handbook for specific guidance on calibration.

Calibrate the flow rate transfer standard against a primary flow or volume standard traceable to NIST. Establish a calibration relationship, e.g., an equation or family of curves, such that traceability to the primary standard is accurate to within 2 percent over the expected range of ambient conditions, i.e., temperatures and pressures, under which the transfer standard will be used. Recalibrate the transfer standard at least annually.

Following the sampler manufacturer's instruction manual, remove the sampler inlet and connecting the flow rate transfer standard to the sampler downtube such that the transfer standard accurately measures the sampler's flow rate. Make sure there are no leaks between the transfer standard and the sampler.

Choose a minimum of three flow rates (actual m^3/min), spaced over the acceptable flow rate range specified for the inlet, that can be obtained by suitable adjustment of the sampler flow rate. In accordance with the sampler manufacturer's instruction manual, obtain or verify the calibration relationship between the flow rate (actual m^3/min) as indicated by the transfer standard and the sampler's flow indicator response. Record the ambient temperature and barometric pressure, and correct the readings as necessary based on these parameters.

Ensure that the flow rate and flow standard agree within ±4%. If they do not agree within that data precision, then perform a new multi-point calibration.

Insert a clean filter and ensure that the sampler flow rate is ±2% from the required sampler flow rate. If the difference is greater than 2%, then adjust the sampler flow rate in accordance with applicable regulations and manufacturer's instructions.

Field calibration will occur before each sampling event, and will be documented in the field log book. Where conflicts between the general calibration procedures and the manufacturer's instructions occur, the manufacturer's instructions will control[15].

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[15] "A full, detailed, EPA-approved calibration procedure, tailored specifically to each commercially available PM2.5 sampler, is contained in the operating or instruction manual associated with each

Sampler Installation

The filter magazines supplied by the sampler manufacturer shall be sent to IML Air Science[16]. IML Air Science shall provide the filters, install them in the filter cartridges (which are then placed in the filter magazines), and ship them directly to ERG for installation in the samplers.

1. Upon receipt of the sampler from the manufacturer, a visual inspection will be performed to ensure that all components are present and in good condition.

2. Before transportation to the site, the equipment will be assembled and energized to ensure that the sampler is operational. This test will follow the procedures in the Test and Acceptance Guide that will be provided by the manufacturer. Impactor oil will not be added to the impactor well at this time. Evaluate the following parameters, at a minimum:

    a. Flow rate at 16.67 L/min ±10%
    b. Temperature and pressure sensors
    c. Flow verification check
    d. Timing and sequencing functions
    e. Conduct data downloading and operate the first model received for 3 days

3. Transport samplers to GCSL.

4. Install and secure sampler at sampling location

5. Install the filter cartridge magazine.

6. Connect vacuum lines, and examine all tubing for crimps, cracks, or breaks.

7. Connect power supply.

8. Field calibrate, in accordance with manufacturer's instructions, the following:

    f. Perform a leak test. Do not use the leak test filter for subsequent sampling
    g. Allow the system to operate for 15 minutes to equilibrate
    h. Perform temperature and pressure sensor checks

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sampler designated as a reference or equivalent method under 40 CFR Part 53. Follow that specific procedure carefully and thoroughly to calibrate the sampler." Quality Assurance Guidance Document 2.12, Section 6.3, United States Environmental Protection Agency, November 1998.

[16] IML Air Services supports particulate ambient air monitoring networks in 12 states, and analyzes tens of thousands of these samples annually. IML Air Services has an on-site laboratory dedicated solely to PM2.5 analysis. IML Services has been performing particulate analysis since 1979.

i. Perform a flow rate verification
j. Correct any observed problems

Filter Preparation and Analysis

IML Air Science, based in Wyoming, will supply and prepare the filters prior to sampling and will analyze the filters after testing. All filters will be certified as meeting the design specifications of 40 CFR §50, Appendix L, Section 6. IML Air Science has been selected due to their extensive experience in filter preparation and ambient air sampling analysis for particulate matter. Utilizing the laboratory to supply and prepare the filters is a standard practice in particulate ambient air sampling due to the necessity of weighing the filters before and after use with the same microbalance (whenever possible).

Filters will be prepared and shipped in batches such that each filter will be used within 30 days of its initial weighing. Each filter will be individually inspected and then weighed by an IML Air Science technician wearing nylon (or similar) gloves and using non-serrated forceps. After weighing, each filter will be packed so that each filter is encased in a filter cassette. The filter cassettes will be loaded into the filter magazine.

Visual Examination Criteria

1. Pinhole leaks: examine over a bright light or against a dark surface.

2. Separation of ring: visual examination for separation/seal integrity between filter and filter ring

3. Chaff, flashing, residual material: visual examination for any additional extraneous material either on the filter or in the area of the filter seal.

4. Discoloration and surface irregularity: Visual examination and bright light or dark surface for any discoloration (indicating contamination) or other surface irregularities indicating a non-uniform surface.

Filter Equilibration

1. Filters shall be equilibrated for at least 24 hours at a relative humidity between 30% to 40% with a variability of no more than ±5% over 24 hours and a mean temperature between 20° and 23° C with a variability of no more ±2°C over 24 hours.

2. Equilibration data will logged and maintained on-site by the laboratory, including at a minimum: relative humidity, temperature, chamber malfunctions, discrepancies, and maintenance activities.

3. Laboratory blanks should be used in the conditioning area.

Initial Weighing Procedures[17]

1. Filters will be will be weighed on a microbalance with a minimum resolution of 0.001 mg and a precision of ±0.001 mg.

2. Each balance used shall be identified to ensure that the final weighing is conducted using the same balance.

3. The balance will have been calibrated, at a minimum, within the last 12 months and in accordance with IML Air Service's QC plan.

4. Static electricity must be neutralized on the filters.

5. All measurements and QC checks will be performed in accordance with IML Air Service's QC plan, which meets all relevant EPA standards, including:
    a. Weighing two working reference standards prior to filter weighing
    b. Weighing laboratory blanks
    c. Reweighing at least one working standard after approximately each 10 filter weighings
    d. Verify the weight of one routine filter at the conclusion of the session.

6. The filters and balance both will be stored within the conditioning chamber, and the weighing procedure will occur in the chamber.

7. Each filter shall have the following information recorded: Identity, microbalance number, filter number, atmospheric conditions, and tare weight.

8. Return each filter to its protective container and store within the conditioning chamber to protect it from contamination.

9. Immediately prior to shipping, the filters cassettes should be visually examined and then loaded with the conditioned, weighed filters. Extra filters must be included.

10. Prepare the sample magazines and ship in secure shipping containers.

Sampler Operation

The sampler draws ambient air at a constant flow rate into a specially shaped inlet and through an inertial particle size separator (impactor) where the suspended particulate matter in the PM2.5 size range is collected on a Polytetrafluoroethylene filter over the specified sampling period. The particle size discrimination characteristics (sampling effectiveness and 50 percent cutpoint) of the sampler inlet are prescribed as performance specifications and have been approved by the EPA as part of the Reference Method designation.

[17] See Quality Assurance Guidance Document 2.12, Section 7.0.

Each sampler shall be operated for a period of 1,380 to 1,500 minutes (i.e. 24±1 hour). Once the sampling event is complete, the filter(s) contained in the filter cartridge shall be removed in accordance with manufacturer's instructions and shipped to IML Air Science for analysis. All pertinent data, such as total flow, sampling times, any collected meteorological data, etc. will be downloaded to a laptop computer. Filters will be packaged for shipping in accordance with manufacturer's instructions and shipped in coolers containing frozen ice packs to ensure that the particles do not volatilize from the filters. A chain of custody will accompany the samples.

When the filters are installed, the following information will be logged:

1. Date and time of sampler setup visit

2. Site location and identification

3. Sampler model and unique ID number

4. Sample start date and time

5. Any unusual conditions (weather, nearby construction or other particulate emitters, etc.).

6. Operator's signature

General Sampler Operating Procedures[18]

Turn on the sampler and allow it to establish run-temperature conditions. Record the flow indicator reading and, if needed, the ambient temperature and barometric pressure. Determine the sampler flow rate (actual m^3/min) in accordance with the instructions provided in the sampler manufacturer's instruction manual.

If the flow rate is outside the acceptable range specified by the manufacturer, check for leaks, and if necessary, adjust the flow rate to the specified setpoint.

Stop the sampler.

Set the timer to start and stop the sampler at appropriate times. Set the elapsed time meter to zero or record the initial meter reading.

Record the sample information (site location or identification number, sample date, filter identification number, and sampler model and serial number).

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[18] The most current version of published manufacturer's instructions will be used for specific operating procedures, in accordance with 40 CFR §50, Appendix L, Section 9. Where these general sampler operating procedures conflict with manufacturer's instructions, the manufacturer's instructions will control.

Sample for 1380 to 1500 minutes.

Filter Removal

Visually inspect the sampler readouts to ensure that the sampler is operating properly. Examine the sampler for other obvious problems, such as a full water collection jar, damage to the unit, etc.

Record the following information in a logbook or data file:

1. Date and time of post-sampling site visit; display sampler readout and/or download computer file

2. Stop time and total elapsed run time

3. Final flow rate, average flow rate, coeeficient of variation of the flow rate, and total volume sampled

4. Sampler's indicated ambient temperature and barometric pressure at the end of the run

5. Record, if the manufacturer's instructions instruct, the current temperature, pressure, and flow rate.

6. Observe and record any conditions around the monitoring site that may have affected the sampling integrity such as paving, mowing, tree removal, unusual traffic, etc.

7. Any sampler flags, such as power outage, flow rate variation, etc.

8. Explanation for questionable or voided samples

9. Operator's signature.

Download runtime data for the completed run using a laptop computer or other equivalent device as permitted in the operator's manual.

Filter(s) contained in the filter cartridge shall be carefully removed in accordance with manufacturer's instructions and shipped to IML Air Science for analysis.

After removal, any unusual conditions of the filter or internal to the sampler shall be noted. Conduct required maintenance.

Filters will be packaged for shipping in accordance with manufacturer's instructions and shipped in coolers containing frozen ice packs to ensure that any volatile particles do not volatilize from the filters. A chain of custody will accompany the samples.

Analysis

At IML Air Science, each filter will be weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM2.5. The total volume of air sampled, measured at the actual ambient temperature and pressure, is determined from the measured flow rate and the sampling time. The mass concentration of PM2.5 in the ambient air is computed as the total mass of collected particles in the PM2.5 size range divided by the volume of air sampled, and is expressed in micrograms per actual cubic meter (µg/m 3).

The sampler shall be field calibrated before each 24-hour sampling event.

Final Weighing Procedures

1. Weigh the filters will be on the same microbalance used in the initial weighing and with the sample technician, if possible.

2. Each balance used shall be identified to ensure that the final weighing is conducted using the same balance as the initial weighing.

3. Humidity in the conditioning chamber at the time of final weighing must be within ±5% of initial weighing.

4. The balance will have been calibrated, at a minimum, within the last 12 months and in accordance with IML Air Service's QC plan.

5. Perform all measurements and QC checks in accordance with IML Air Service's QC plan.

6. Static electrical charges must be neutralized.

7. Each filter shall have the following information recorded: Identity, microbalance number, filter number, atmospheric conditions, and gross weight.

8. At least one laboratory blank (or 10% of the number of filters being weighed, if greater than 10) and all field blanks shall be weighed.

9. One routine filter (i.e. sampled filter) shall be re-weighed at the end of the weighing session.

10. Insert the filter back into its protective container dish for archiving.

The gross weight, minus the tare weight, is the net mass of particulate for that filter.

The following equations will be used to calculate the PM2.5 concentrations in the ambient air.

PM2.5 concentration is:

PM2.5 = $(Wf - Wi) \times 10^{-3}/V_a$ where:
PM2.5 = mass concentration of PM2.5, µg/m 3;
Wf, Wi = final and initial weights of filter collecting PM2.5 particles, g;
V_a is the volume of air sampled (read directly from the sampler), and
10^{-3}= conversion of mg to µg.

Additional formulas are published[19] and will be used, if and where necessary.

Sampler Maintenance

Preventive maintenance is defined as a program of planned actions aimed at preventing failure of monitoring and analytical systems. The overall objective of a routine preventive maintenance program is to increase measurement system reliability and to provide for more complete data acquisition.

Some sampler maintenance can be performed at the field site. Major maintenance of the sampler or components, such as the pump, can be performed more conveniently when the equipment is brought to a laboratory or maintenance facility, provided time and labor are available to move the equipment.

A maintenance schedule should be established for each sampler and systematic records should be kept as scheduled and unscheduled maintenance occurs. Files should reflect the history of maintenance, including all replacement parts, suppliers, and cost expenditures and should include an inventory of on-hand spare equipment for each sampler.

Recommended supplies for all maintenance activities include an alcohol-based general-purpose cleaner that leaves no residue, cotton swabs, a small soft-bristle brush, paper towels, distilled water, and miscellaneous hand tools. Additional supplies may be necessary for specific procedures, as indicated below.

Note: The impactor and filter cassette must always be removed before cleaning the inlet downtube or cleaning any of the instrument parts upstream of these items. Such activities could dislodge dirt, oil, grease, or other materials that could deposit into the impactor well or onto the sampling filter. Temporarily store the impactor and filter cassette in a clean, dry location, away from contaminating materials (dust, dirt, rain, and so on) and direct sunlight.

The PM2.5 sampler shall be maintained in strict accordance with the maintenance procedures specified in the sampler manufacturer's instruction manual, including requirements under the 5-sampling day/monthly/quarterly chart in the Quality Assurance Guidance Document 2.12, Section 9.2-9.4.

Potential Sources of Error

Volatile Particles. Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing. This error will be minimized by shipping the samples in insulated containers containing ice packs.

[19] Quality Assurance Guidance Document 2.12, Section 11.2.

Artifacts. Positive errors in PM2.5 concentration measurements may result from retention of gaseous species on filters. Such errors include the retention of sulfur dioxide and nitric acid. Retention of sulfur dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity. The magnitude of nitrate artifact errors in PM2.5 mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small. Based on site characteristics at GCSL, artifact errors are expected to be small. In addition, any errors would bias the sampling results upwards.

Humidity. The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure is designed to minimize the effects of moisture on the filter medium.

Filter Handling. Careful handling of filters between presampling and postsampling weighings is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette greatly reduces the magnitude of these errors. In addition, higher quality filters (Teflon® coated) will be used for all sampling events.

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Air Volume Determination. Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter will serve to minimize the error in the sampling time measurement.

Data Validation

Data necessary to compute the mass concentration of PM2.5 originates from both field and laboratory operations. This data will be validated to ensure it is accurate relative to the overall scope of the sampling and QA program. When the final mass concentration of PM2.5 in a sample has been computed, the validation procedure will check these calculations and flag any questionable mass concentrations.

Environmental Standards, Inc.[20] will perform all data validation activities. General data validation procedures are as follows:

[20] Environmental Standards, Inc. (ESI) is a leading firm in the area of geoscience and environmental chemistry, and has extensive experience in data validation of ambient air particulate samples. ESI has been performing data validation of laboratory sample results since 1987, and its scientists have been published in a variety of peer-reviewed publications.

1. Gather all sample data, including sampling time, flow rates, tare, gross and net weights of filters.

2. Compute total mass concentration of PM2.5 for seven samples per 100 (and a minimum of four per lot). If any calculation errors are found, recalculate all values in the sample lot.

3. Scan all total mass concentration values and re-compute the total mass concentrations for all values that appear excessively high or low. Correct any areas, initial them, and indicate date of correction. Proceed to step four for any out-riding values that do not have computation errors.

4. Review all raw data for the out-riding data for completeness and correctness.

All data validation will occur in conformance with applicable EPA standards.[21]

Data Forms

All data forms will be provided by the sampler manufacturer and/or EML Air Services.

[21] Quality Assurance Guidance Document 2.12, Section 11; Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I: A Field Guide to Environmental Quality Assurance, US Environmental Protection Agency, EPA/600/R-94/038a; Washington, DC; April 1994.

Appendix C

Evaluation of Draft Risk Assessment Protocol at the Grand Central Landfill (May 2003)

Evaluation of the Draft Protocol for Risk Assessment at the Grand Central Landfill

Introduction:

I have been asked to review the draft protocol for Risk Assessment at the Grand Central Landfill located in Plainfield Township, PA. My involvement with this activity began when I was requested by officials at the Pennsylvania State Department of Health, located in Harrisburg, to consider lending my professional assistance for oversight of activities to be held in connection with this assessment. Upon the recommendation of the State Department of Health I was contacted by the operator of the Grand Central Landfill, Waste Management, and after discussion of their needs of an independent oversight it seem appropriate to undertake this activity on their behalf, and for the communities of concern.

To date, I have reviewed materials which have given me background information regarding the Grand Central facility, had the opportunity to visit the site, and see it in its full environmental setting with regard to adjacent communities. This document will comment on the draft protocol noted above, as well as the generic issues lying behind this matter.

Generic Community Concerns:

It is not uncommon for communities near various industrial sites to have concern about potential impact on that community. The impacts can be both of a positive and negative nature. Among the positive aspects are the economic benefit to a community and corporate integration into the life of that community, and generic concern exist over potential health impacts and other matters of a social nature.

Specifically, it has come to my attention that some members of the surrounding community near the Grand Central Landfill have had concerns regarding a variety of issues. Specifically, these have to do with the matter of litter, odors, asthetics, noise, the potential for animal vectors, traffic patterns, real estate and dust. Clearly, most of these are issues of a social and potential economic nature, and will not be further commented upon by me in their reviews of health matters.

The issues for further comment and oversight have to do with the potential health issues related to the operation of the Grand Central Landfill. One of these potentially health related matters, that of noise, will also not be further dealt with since it is unlikely that the operation of the landfill would affect the surrounding community in any way would lead to a potential harmful impact upon health.

Potential Health Issues:

From the list of concerns there are two that have relevance to the issue of direct health concerns. This would have to do with the matter of dust, and, exposure to chemicals, which, incidentally, may also be associated with odors. It is necessary to recognize that chemicals may exist in the environment that are not perceived by the odor threshold that should otherwise be considered for their health impact. Without question, health hazards have been documented with certain chemicals, and with exposure to dust and particulates. It should be noted that other potential concerns such as water and soil contamination are not significant issues here given the nature of the landfill, the linings that are used, and the monitoring of soil and water as is generally carried out. It should also bc noted that landfills such as this generate considerable amounts of potentially flammable gases, and, in fact, these are utilized, on site, for the generation of power with other parts of the gas production at the facility being burned through use of the flares.

There are currently in place requirements for the monitoring of landfills such as this, but the proposed protocol will go beyond such routine testing looking at the risk for the development of disease among individuals in the surrounding communities.

Epidemiological Principles:

While there are concerns at the level of surrounding communities, it should be understood that the small population size and the low anticipated numbers for any specific disease makes any real empidemiologic study among these communities extremely difficult, if not impossible, to undertake. Given the multi-factorial nature of the diseases of special concern, the small population would ultimately create extremely large confidence limits making it quite likely that insufficient power is available among these small populations to carry out any meaningful study. It is further my understanding that an

evaluation for cancer has already be undertaken, and has not shown there to be any specific cancer hazard.

Risk Assessment:

Given that the size of the communities in question would not allow for a meaningful epidemiologic study of health, an appropriate methodological approach to the matter of health is to undertake a risk assessment. There is a full body of literature on disease outcome following exposure to various substances in question with regard to the landfill, and rather than undertaking an inadequate epidemiologic study, it is appropriate to undertake a systematic evaluation of what levels of exposure obtain in the communities, and assess from that data the likelihood that anyone in the community might become ill. Given the nature of this site, and the materials that would be expected to become fugitive off the site, one can decide which substances should be evaluated for their potential health impact.

The materials which are appropriate for evaluation are those suggested in the risk assessment document, namely landfill gases, and the measurement of small particulates, both PM_{10s} and $PM_{2.5s}$.

Proposed Methodology:

In reviewing the document as submitted to me, not only is the proposed list of materials to be sampled appropriate, but the methodology appears to be consistent with best scientific and public health practice. The groups scheduled to do the evaluations are well familiar with the procedures, and the test methods proposed seem appropriate. Proper levels of care and concern regarding technique are addressed and the difficulties in carrying out these evaluations are also addressed. When the data is collected it will be looked at for the potential of both short-term and long-term health affects. As noted above, the health effects of the materials in questions are well appreciated and documented in a scientific literature. By undertaking the measurements as proposed one can assess any risk to health for the populations in the neighborhood of the Grand Central Landfill. Being taken into consideration are regular wind patterns, and the assessment will be able to be geographically appropriate given the location of the landfill and the surrounding populations.

Future Oversight Activities:

In the future it will be incumbent upon me to ascertain that the types of data collected were appropriate, as proposed, although it will not be possible to have me independently verify if the collection techniques were as stated. It is anticipated that this should not be an issue given the experience of the entities involved and their past involvement in similar assessment situations. In addition, there will be other independent data available for comparison from ongoing measurements that might be required as part of other activities related to permitting.

When the data is collected it will be necessary to review the levels documented, and compare those to what is known from the literature as to potential health impacts at those levels. This will be done independently of any group that will have taken such measurements, or the commentary of others. Given the nature of the fugitive emissions it should be possible to predict what the consequences might be, and then to ultimately make the assessment if the levels recorded would be those that are associated with any documentable health difficulties.

Arthur L. Frank MD — 5/14/03

Arthur L. Frank, MD, PhD — Date

Appendix D

Calculation of Landfill Gas Emission Rates

APPENDIX D

CALCULATION OF LANDFILL GAS EMISSION RATES

INTRODUCTION

In support of the Human Health Risk Assessment (HRA), EarthRes Group, Inc. (ERG) compiled data and calculated emission rates for landfill gas constituents at the Grand Central Sanitary Landfill (GCSL) located in Plainfield Township, Northampton County, PA.

Three types of potential landfill gas emission sources exist at GCSL. They include surface emissions from the landfill itself, exhaust from the two enclosed flares and exhaust from the LFG-fired turbine generators at the Green Knight Energy Center. Accordingly, ERG calculated emission rates for the following sources at the facility:

- Fugitive landfill gas
- Landfill gas flare emissions
- Landfill gas-fueled turbine emissions

Landfill gas related emission rates were estimated for the five-year period of 2003 through 2007. This time period includes years when gas generation at the facility is peaking.

The generation of landfill gas results from the biodegradation of waste within the landfill. Anaerobic bacteria (bacteria that live in the absence of air) consume organics within the waste and generate methane. This complex biological process is dependant on several environmental variables including but not limited to moisture, waste composition and temperature.

LANDFILL GAS GENERATION RATE

One of the key components in evaluating landfill gas emissions is the quantity or generation rate of landfill gas within the landfill. To predict the current and future production rate of landfill gas, ERG developed landfill gas (LFG) generation curves for the two landfills surfaces using two different methods. For the closed inactive landfill, current and future LFG generation rates were estimated by plotting historical gas flow data, which incorporated an assumed collection efficiency of 95%, and fitting a curve to projected gas generation rates (Table D-1). The old landfill has been entirely capped since 1993 and has been in a declining gas production trend for the past several years. Consequently, it does not lend itself to the same modeling techniques typically used for active landfills.

ERG modeled gas generation rates from the current active landfill using the United States Environmental Protection Agency's (USEPA's) Landfill Gas Emissions Model (LandGEM) Version 2.1 (Radian 1996) (Table D-2). Site-specific inputs including waste in-place and future waste acceptance rates were used in the model. Other model inputs, including methane generation potential (L_o) and gas generation rate constant (k), were selected through an iterative process in which the modeled gas generation rates were adjusted to match historical gas generation rates recorded at the site. The historical gas generation rates were based on measured gas flows to the enclosed flares and the power plant, and an assumed system-wide collection efficiency of 90%.