

**EDUCATION**

**1972.** B.A., University of Cambridge, England, Natural Sciences (Theoretical Physics).

**1975.** Ph.D., University of Cambridge, England, High Energy Physics, (Thesis: "The Algebraic Structure of Some Dual Resonance Models").

**OVERVIEW**

Dr. Edmund Crouch is Vice President and Senior Scientist at Green Toxicology LLC. He specializes in all aspects of exposure assessment and risk assessment, but particularly the analysis of experimental and observational data and the application of such analyses to those fields. His original research, publications, and consultant work includes quantitative evaluation of uncertainties in rodent cancer bioassays and in interspecies extrapolations of carcinogenicity; meta-analysis of cancer bioassay results, epidemiological observations, experimental bacterial growth rate data, and observable effects of ethanol in humans; and construction and application of Monte Carlo analyses in exposure and risk assessments. He has applied these skills to numerous quantitative risk assessment projects involving air emissions, groundwater contamination, consumer exposures, worker exposures, indoor air, food safety, and others. Dr. Crouch (with Professor Richard Wilson) "wrote the book" in 1982 on Risk-Benefit analysis, and his work since then has been recognized by his 2008 designation as a National Associate of the National Research Council of the National Academies and in the Society for Risk Analysis Outstanding Practitioner award in 2013.

**PROFESSIONAL EXPERIENCE**

2015–Present	Vice President and Senior Scientist, Green Toxicology LLC.
2015-Present	Senior Risk Assessor, Part-time, ARM Group Inc.
1987–2016	Associate of the Department of Physics, Harvard University, Cambridge, Massachusetts.
2013–2015	Principal, CDM Smith Inc., Cambridge, MA.
1989–2012	Senior Scientist, Cambridge Environmental Inc., Cambridge, MA.
1992–1994	Lecturer in the Department of Epidemiology, Harvard University School of Public Health.

1990–1992	Assistant Professor of Community Health, Tufts University School of Medicine, Boston, Massachusetts.
1987–1989	Senior Scientist, Environmental Health and Toxicology Group, Meta Systems Inc., Cambridge, Massachusetts.
1984–1986	Consulting Associate in Risk Assessment, Meta Systems Inc., Cambridge, Massachusetts.
1979–1986	Research Associate In Physics, Jefferson Physical Laboratory, Harvard University, Cambridge, Massachusetts.
1977–1979	Research Fellow in Physics, Jefferson Physical Laboratory, Harvard University, Cambridge, Massachusetts.
1974–1977	Research Fellow in the Energy Research Group, Cavendish Laboratory, University of Cambridge, Cambridge, England.

#### **NATIONAL ACADEMIES OF SCIENCE COMMITTEES**

Committee on Assessing Causality from a Multidisciplinary Evidence Base for National Ambient Air Quality Standards, 2021–2022 (Advancing the Framework for Assessing Causality of Health and Welfare Effects to Inform National Ambient Air Quality Standard Reviews. Washington, DC: The National Academies Press. <https://doi.org/10.17226/26612>).

Committee on the Long-term Health Consequences of Exposure to Burn Pits in Iraq and Afghanistan, Institute of Medicine, 2010–2011 (Long-Term Health Consequences of Exposure to Burn Pits in Iraq and Afghanistan. National Academies Press, 2011).

Committee on the Health Risks of Phthalates, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council, 2007–2008 (Phthalates and cumulative risk assessment -- The Task Ahead. National Academies Press, 2008).

Committee to review ATSDR's Great Lake Reports, Board on Population Health and Public Health Practices, Institute of Medicine. (Letter Report: Review of ATSDR's Great Lakes Report Drafts, National Academies Press, 2008).

Committee on Superfund Site Assessment and Remediation in the Coeur D'Alene River Basin, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council, 2004–2005. (Superfund and Mining Megsites — Lessons from the Coeur d'Alene River Basin, National Academy Press, 2005).

Committee to Review the CDC-NCI Feasibility Study of the Health Consequences to the American Population from Nuclear Weapons Tests, Board on Radiation Effects Research,

Division on Earth and Life Studies, National Research Council. 2002. (Exposure of the American Population to Radioactive Fallout from Nuclear Weapons Tests, National Academy Press, 2003).

Committee to Review the Identification of Radionuclides released from the Hanford Nuclear Reservation's Facilities to the Columbia River, Board on Radiation Effects Research, Division on Earth and Life Studies, National Research Council. 2002 (Letter Report: Review of the Identification of Radionuclides Released from the Hanford Nuclear Reservation's Facilities to the Columbia River, National Academy Press, 2002).

Committee to Review Methods for Estimating Radiation Doses to Workers at Hanford, Board on Radiation Effects Research, Division on Earth and Life Studies, National Research Council. 2001. (Letter Report: Review of Methods for Estimating Radiation Doses to Workers at Hanford, National Academy Press, 2002).

Committee on An Assessment of Centers for Disease Control and Prevention Radiation Studies: Review of a Research Protocol Prepared by the University of Utah, Board on Radiation Effects Research, Division on Earth and Life Studies, National Research Council. 2001–2002. (Review of a Research Protocol Prepared by the University of Utah: Letter Report, National Academy Press, 2002).

Committee on an Assessment of CDC's Radiation Studies from DOE Contractor Sites: Review the Identification and Prioritization of Radionuclide Releases from the Idaho National Engineering and Environmental Laboratory (September 30, 2000) Report. 2001. (Letter Report to the CDC: Review Identification and Prioritization of Radionuclide Releases from the Idaho National Engineering and Environmental Laboratory, National Academy Press, 2001).

Committee on Toxicology, Subcommittee on the Atsugi Incinerator, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. 2000. (Review of the US Navy's Human Health Risk Assessment of the Naval Air Facility at Atsugi, Japan, National Academy Press, 2001).

Committee on Risk-Based Criteria for Non-RCRA Hazardous Waste, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. 1998–1999. (Risk-Based Waste Classification in California. National Academy Press, 1999).

Committee on Health Effects of Waste Incineration, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. 1995–1999. (Waste Incineration and Public Health, National Academy Press, 2000).

## SELECTED PROJECT EXPERIENCE

- Evaluated diffusive emissions of PCBS from contaminated concrete floors, through uncontaminated floors, and through topping layers applied to contaminated floors.

- Designed, wrote, and implemented the probabilistic (Monte Carlo) risk assessment for FSIS, USDA, on the risk of *C. Perfringens* in Ready-to-Eat and Partially Cooked Foods.
- Derived and used in risk assessments and in support of various litigations many quantitative exposure assessments involving transport and fate of chemicals in the natural (for example: air, soil, groundwater, surface water) and man-made (for example: indoor and outdoor air) environment.
- Performed quantitative risk assessments to demonstrate compliance with California Proposition 65 “safe harbor” limits for various consumer items, including dishwasher liquid, guitar strings, and baby shoes.
- Analyzed original human experimental data on exposure to sulfur dioxide to derived uncertainty estimates for the dose-response relationship. Applied this analysis to EPA’s justification for the 1-hr NAAQS for sulfur dioxide.
- Designed the theory and implemented in computer code a site assessment tool (called RISK-ON-SITE™) that uses Voronoi diagrams to assist in estimating risks from soil and groundwater on a site. Provided suitable color displays to allow rapid evaluation of the available data on a site. Extended the methodology to give risk-based estimates of required clean-up levels.
- Wrote and still maintains a software program (MSTAGE) to evaluate the results of carcinogenesis bioassays in laboratory animals. This program is flexible enough to incorporate the standard EPA methodologies, but may also be used with more advanced methodologies to correctly incorporate uncertainties.
- Managed and wrote several site risk assessments for Massachusetts and Federal Superfund sites.
- Managed and wrote several risk assessments for Waste-to-Energy plants.
- Performed full uncertainty analyses of cancer risk assessments for several chemicals and in several defined situations, incorporating all the known uncertainties in a consistent fashion.
- Provided expert technical comments on proposed EPA rules in such areas as exposure assessment (for example: for landfill leachate and landfill gas), and risk assessment methodology (for example, as applied to the Hazard Ranking System).

## PUBLICATIONS AND REPORTS

- Crouch, E.A.C. and Green, L.C. (2022). Public Health and Ecological Risk Assessment for The Aries Taunton Biosolids Gasification Project: Focus on Perfluorinated Alkyl Substances (PFAS) and Mercury.
- Green, L.C., and Crouch, E.A.C. (2021). Public Health Assessment of Expected Airborne Emissions from the Proposed Lambert Compressor Station Pittsylvania County, Virginia. Available at <https://www.deq.virginia.gov/home/showpublisheddocument/5324/63749957359837000>
- Green, L.C., and Crouch, E.A.C. (2021). Public Health Assessment for Airborne Emissions from the Bristol, Virginia, Landfill.
- Crump K, Crouch E, Zeltermann D, Crump C, Haseman J. (2020) Accounting for multiple comparisons in statistical analysis of the extensive bioassay data on glyphosate. *Toxicological Sciences*. 175(2):523-524. [Letter]. <https://doi.org/10.1093/toxsci/kfaa078>.
- Crump K, Crouch E, Zeltermann D, Crump C, Haseman J. (2020) Accounting for multiple comparisons in statistical analysis of the extensive bioassay data on glyphosate. *Toxicological Sciences*. 175(2):156–167. <https://doi.org/10.1093/toxsci/kfaa039>.
- Green, L.C., and Crouch, E.A.C. (2020). Public Health Assessment of Expected Emissions from the Proposed Combined Heat and Power Plant at the US Navy–Norfolk Naval Shipyard.
- Green, L.C., and Crouch, E.A.C. (2019). Comments on Wisconsin’s Department of Natural Resources’ (DNRs’) proposed groundwater standards for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). Available at [https://www.greentoxiology.com/Reports/PFAS\\_comments\\_to\\_Wisc\\_DNR.pdf](https://www.greentoxiology.com/Reports/PFAS_comments_to_Wisc_DNR.pdf)
- Green, L.C., and Crouch, E.A.C. (2019). Comments on Massachusetts Department of Environmental Protection’s (DEP’s) groundwater and soil standards for perfluoroalkyl substances (PFAS) in the Department’s proposed 2019 amendments to the Massachusetts Contingency Plan. Available at: [https://www.greentoxiology.com/Reports/PFAS\\_comments\\_to\\_MADEP.pdf](https://www.greentoxiology.com/Reports/PFAS_comments_to_MADEP.pdf)
- Green, L.C., and Crouch, E.A.C. (2019). Advancing the ball: Using guinea pigs to study perfluorinated alkyl substances (PFAS). Available at: [https://www.greentoxiology.com/Reports/Advancing\\_the\\_ball\\_on\\_PFAS.pdf](https://www.greentoxiology.com/Reports/Advancing_the_ball_on_PFAS.pdf)
- Crouch, E.A.C., and Green, L.C. (2019). Comments on U.S. EPA’s *Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3) Also Known as “GenX Chemicals”* EPA-823-P-18-001 (Public Comment Draft). Available at: <https://www.regulations.gov/document?D=EPA-HQ-OW-2018-0614-0037>
- Crouch, E.A.C. (2019). PCB Diffusion in concrete and sand. Available at [https://www.greentoxiology.com/Reports/PCB\\_diffusion\\_in\\_concrete\\_and\\_sand.pdf](https://www.greentoxiology.com/Reports/PCB_diffusion_in_concrete_and_sand.pdf)
- Crouch, E.A.C., and Green, L.C. (2018). Comments on ATSDR’s *Toxicological Profile for*

*Perfluoroalkyls*. Available at: <https://www.regulations.gov/document?D=ATSDR-2015-0004-0053>

Ashley, E., Bress, W., Charnley, G., Commerford, J., Crouch, E., Franson, M., Gendusa, A., Green, L., Keefe, J., Lamie, P., Lester, R., Murphy, L., Zemba, S. (2014). *Evaluation of Risk-based Decision Making, Connecticut Department of Energy and Environmental Protection (CT DEEP)*. Available at:

[http://www.ct.gov/deep/lib/deep/site\\_clean\\_up/comprehensive\\_evaluation/CDMSmith\\_Risk-Based\\_Decision\\_Making\\_Report-final.pdf](http://www.ct.gov/deep/lib/deep/site_clean_up/comprehensive_evaluation/CDMSmith_Risk-Based_Decision_Making_Report-final.pdf)

Green, L.C., Crouch, E.A.C., and Zemba, S.G. (2014). Cremation, air pollution, and special use permitting: a case study. *Human and Ecological Risk Assessment* 20:559-565.

Crouch, E.A.C., and Omenn, G.S. (2012). Ratcheting up Cancer Potency Estimates. *Environ. Sci. Technol.* 46(5):2538–2544 (<http://dx.doi.org/10.1021/es204310j>).

Green, L.C. and Crouch, E.A.C. (2011). Comments on California EPA's background document, "Evidence on the Developmental and Reproductive Toxicity of Sulfur Dioxide." Cambridge Environmental Inc.

Crouch, E.A.C., Green, L.C., and Galanter, J.M. (2009). Technical Comments on U.S. EPA's "Risk and Exposure Assessment to Support the Review of the SO<sub>2</sub> Primary National Ambient Air Quality Standards: Second Draft" (March 2009), Docket No. EPA-HQ-OAR-2007-0352. Available on [www.regulations.gov](http://www.regulations.gov) as Attachment 1 in EPA-HQ-OAR-2007-0352-0031.1.

Crouch, E. and Green, L. (2009). A Proposition 65 dose evaluation for DEHP from shoes. Cambridge Environmental Inc.

Crouch, E. and Green, L. (2009). A Proposition 65 risk evaluation of lead in guitar strings with an addendum that addresses risk from ball-ends. Cambridge Environmental Inc.

Crouch, E.A., LaBarre, D., Golden, N.J., Kause, J.R., and Dearfield, K.L. (2009). Application of Quantitative Microbial Risk Assessments for Estimation of Risk Management Metrics: *Clostridium perfringens* in Ready-to-Eat and Partially Cooked Meat and Poultry Products as an Example. *Journal of Food Protection* 72(10):2151-2161.

Golden, N.J., Crouch, E.A., Latimer, H., Kadry, A-R., and Kause, J. (2009) Risk assessment for *Clostridium perfringens* in Ready-to-Eat and Partially Cooked meat and poultry products. *Journal of Food Protection* 72(7):1376–1384.

Crouch, E., Green, L., and Hendrix, S. (2008). A Proposition 65 no-significant-risk evaluation of 1,4-dioxane in assorted consumer products. Cambridge Environmental Inc.

Crouch, E. and Green, L. (2008). A Proposition 65 no-significant-risk evaluation of 1,4-dioxane in dish liquid. Cambridge Environmental Inc.

Crouch, E.A.C., Zemba, S.G. and Bullister, E.T. (2008). Source term model for fine particles off indoor surfaces. Cambridge Environmental Inc.

Crouch, E. (2007). Comments on Docket APHIS-2007-0112: "Risk assessment for the importation of fresh lemon (*Citrus limon* (L.) Burm. F.) fruit from Northwest Argentina

- into the Continental United States. USDA, APHIS, August 6, 2007." Docket APHIS-2007-0112-0020.1. December 10, 2007. Cambridge Environmental Inc.
- Crouch, E. (2007). Technical memorandum, overview of draft sensitivity analysis for the Tittabawassee Human Health Risk Assessment for Dioxins/Furans. Cambridge Environmental Inc.
- Crouch, E. (2007). Comments on Docket APHIS-2007-0022: "Evaluation of asymptomatic citrus fruit (*Citrus* spp.) as a pathway for the introduction of citrus canker disease (*Xanthomonas axonopodis* pv. *citri*); USDA, APHIS, Revision 2, April, 2007, APHIS-2007-0022-0002," and "Movement of commercially packed citrus fruit from Citrus Canker Disease Quarantine Area, Risk Management Analysis; USDA, APHIS, June 2007, APHIS-2007-0022-0003." Docket APHIS-2007-0022-0069.1. August 7, 2007. Cambridge Environmental Inc.
- Crouch, E.A.C. and Green, L.C. (2007). Comment on "Persistent organic pollutants in 9/11 world trade center rescue workers: reduction following detoxification" by James Dahlgren, Marie Cecchini, Harpreet Takhar, and Olaf Paepke [Chemosphere 69/8 (2007) 1320–1325]. *Chemosphere* 69(8):1330–2.
- Crouch, E. (2006). Comments on Docket APHIS–2006–0045: "Evaluation of asymptomatic citrus fruit (*Citrus* spp.) as a pathway for the introduction of citrus canker disease (*Xanthomonas axonopodis* pv. *citri*); USDA, APHIS, March 20, 2006." Docket APHIS-2006-0045-13.1. July 3, 2006. Cambridge Environmental Inc.
- Crouch, E.A.C., Lester, R.R., Sahay, S., and Baron, J. (2006). Method 3 risk characterization W.R. Grace & Company property. Cambridge Environmental Inc.
- Popp, J.A., Crouch, E., and McConnell, E.E. (2006). A weight-of-evidence analysis of the cancer dose-response characteristics of 2,3,7,8-tetrachlorodibenzodioxin (TCDD). *Toxicol. Sci.* 89(2):361–369.
- Green, L.C. and Crouch E.A.C. (2005). Estimating cancer risks from toxic air contaminants. *EM (AWMA)*. June:23–27.
- Crouch, E. and Golden, N.J. (2005). A Risk Assessment for *Clostridium perfringens* in Ready-to-Eat and Partially Cooked Meat and Poultry Products. September, 2005. Available from [http://www.fsis.usda.gov/Science/Risk\\_Assessments/index.asp](http://www.fsis.usda.gov/Science/Risk_Assessments/index.asp).
- Green, L.C., Crouch, E.A.C., Zemba, S.G., Ames, M.R., Satterstrom, K. and Linkov, I. (2004). MATES-II: a review and analysis for the staff of the Federal Highway Administration. Cambridge Environmental Inc.
- Green, L.C. and Crouch, E.A.C. (2004). Comments for the External Peer Review Panel regarding the Draft Toxicological Review of Naphthalene: In: *Support of Summary Information on the Integrated Risk Information System (IRIS)*. Cambridge Environmental Inc.
- Crouch, E.A.C., Zemba, S.G., Ames, M.R., and Green, L.C. (2002). Comments on *Proposed Methodology for Particulate Matter Risk Analyses for Selected Urban Areas*, by Abt Associates, January 2002. Cambridge Environmental Inc.

- Green, L.C., Crouch, E.A.C., Ames, M.R., and Lash, T.L. (2002). What's wrong with the National Ambient Air Quality Standard (NAAQS) for fine particulate matter (PM<sub>2.5</sub>)? *Regulatory Toxicology and Pharmacology* 35:327–337.
- Green, L.C., Ames, M.R., and Crouch, E.A.C. (2001). Comments on “Mortality Risk Reductions and Economic Benefits of Alternative SAMI Air Quality Strategies.” Cambridge Environmental Inc.
- Alvarado, M.J., Armstrong, S., and Crouch, E. (2001). The AMSA 2000/2001 survey of dioxin-like compounds in biosolids: statistical analyses. Cambridge Environmental Inc.
- Crouch, E., Ames, M., and Green, L.C. (2001). A quantitative health risk assessment for the Kalamazoo River PCB site. Cambridge Environmental Inc.
- Crouch, E.A.C. (2000). A cost allocation scheme and its application to the Cal Compact Site. Cambridge Environmental Inc.
- Crouch, E.A.C. and Armstrong, S.R. (2000). Review of exposure assessments for Cry9C protein in StarLink Corn. Cambridge Environmental Inc.
- Valberg, P., Crouch, E., Green, L., and Zemba, S. (2000). Review of the health impacts projected in the Levy *et al.* report: “*Estimated public health impacts of criteria pollutant air emissions from the Salem Harbor and Brayton Point power plants.*” Cambridge Environmental Inc.
- Lester, R.R. and Crouch, E.A.C. (2000). Firm yield estimator — version 1.0 software documentation. Cambridge Environmental Inc.
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- Crouch, E., Armstrong, S., and Zemba, S. (2000). Comments on *EPA's Proposed Standards for the Use of Disposal of Sewage Sludge*, December 23, 1999. Cambridge Environmental Inc.
- Crouch, E., Armstrong, S., Lester, R., and Burmaster, D. (1999). Comments on "Importation of Fresh Citrus Fruit (Sweet Orange, Citrus sinensis, Lemon, C. limon, and Grapefruit, C. paradisi) from Argentina into the Continental United States: Supplemental Plant Pest Risk Assessment." Cambridge Environmental Inc.
- Bartlett, K.L. and Crouch, E.A.C. (1999). Human health risk assessment for the future Wyndham Gardens Hotel, Chelsea, Massachusetts. Exposure to volatile contaminants in groundwater. Cambridge Environmental Inc.
- Valberg, P.A. and Crouch, E.A.C. (1999). Meta analysis of rat lung tumors from lifetime inhalation of diesel exhaust. *Environmental Health Perspectives* 107:693.699.
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- Bartlett, K.L., Zemba, S.G., Crouch, E.A.C., and Green, L.C. (1998). Health risk assessment for Phase III Orchard Park Development, Boston, MA. Cambridge Environmental Inc.
- Crouch, E. (1998). Health and environmental risks due to MGP contamination at the City of Newburgh Sewage Treatment Plant. Cambridge Environmental Inc.
- Crouch, E. and Burmaster, D. (1998). Aggregate exposure assessment — an approach. Cambridge Environmental Inc.
- Zappia, A.M., Lester, R.R., Zemba, S.G., Crouch, E.A.C., and Green, L.C. (1997). Human health risk assessment for BASF Corporation, Third Street, Clifton, NJ. Cambridge Environmental Inc.
- Green, L.C. and Crouch, E.A.C. (1997). Probabilistic risk assessment: lessons from four case studies. In: Preventive Strategies for Living in a Chemical World. *Annals of the New York Academy of Sciences*, 837:387–396.
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- Bartlett, K.L., Zemba, S.G., Crouch, E.A.C., and Green, L.C. (1997). Health risk assessment for Phase II Orchard Park Development, Boston, MA. Cambridge Environmental Inc.
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- Lash, T.L., Crouch, E.A., and Green, L.C. (1997). A meta-analysis of the relation between cumulative exposure to asbestos and relative risk of lung cancer. *Occupational and Environmental Medicine* 54:254–263.
- Armstrong, S.R., Zemba, S.G., and Crouch, E.A.C. (1996). Acute health effects assessment for the Plainville Landfill. Cambridge Environmental Inc.
- Crouch, E. and Lester, R. (1996). Comments of *Cambridge Environmental Inc. on the proposed rule — Hazardous waste management system: Identification and listing of hazardous waste: Hazardous waste identification rule (60FR66344)*. Docket F-95-WHWP-FFFF. Cambridge Environmental Inc.
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epidemiological studies with laboratory bioassays — the example of acrylonitrile. *Human and Ecological Risk Assessment* 2:130–149.

Zemba, S.G., L.C. Green, E.A.C. Crouch, and R.R. Lester (1996). Quantitative risk assessment of stack emissions from municipal waste combustors. *J. Haz. Materials* 47:229–275.

Crouch, E.A.C. and Green, L.C. (1995). Properly accounting for uncertainty in current methods of risk assessment. In: Lee, S.D. and Schneider, T., ed(s), *Comparative Risk Analysis and Priority Setting for Air Pollution Issues*. Proceedings of the 4th U.S.-Dutch International Symposium, Keystone, Co. Pittsburgh, PA: Air & Waste Management Association.

Green, L.C., Crouch, E.A.C., and Lester, R.R. (1995). The carcinogenic potencies of 2,3,7,8-tetrachlorodibenzo-p-dioxin: letting the data speak for themselves. In: *Solid Waste Management: Thermal Treatment & Waste-to-Energy Technologies, Proceedings of an International Specialty Conference*, p. 251–261.

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Green, L.C., Crouch, E.A.C., Armstrong, S.R., and Lester, R.R. (1995). Comments on *Health assessment document for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds: review draft*. Cambridge Environmental Inc.

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