Application of WMPT to Rank Comparable Fuels Constituents

Peer Review Report of
William Stubblefield, Andrew Salmon, and Thomas Parkerton

Submitted by:

Environmental Science Center
Syracuse Research Corporation
7502 Round Pond Road
North Syracuse, New York 13212

Submitted to:

Stiven Foster
Office of Solid Waste and Emergency Response

EPA Contract
GS-00F-0019L
FD052/SC03

April 2007

Table of Contents

I. Introduction

A panel of expert scientists was assembled to review Application of WMPT to Rank Comparable Fuels Constituents. The peer review panel was charged with reviewing the application of the WMPT tool to rank the 37 hydrocarbons and oxygenates in the comparable fuel exclusion for fuels that are produced from hazardous waste

The expert panel independently reviewed the report then two of the three reviewers participated in a teleconference on March 27 to review the charge and allow the panel to ask clarifying questions of U.S. EPA. The third reviewer could not participate due to travel.

This report serves as formal documentation of the peer review process used. This report is organized in sections corresponding to the peer review process used, including the charge to reviewers, selection of review panel, and summary of comments. In addition, this report includes the following detailed attachments:

- Complete resumes for the peer review panel; and
- Written comments from each of the peer reviewers.

II. Objective and Charge for the Peer Review

The charge to the peer review panel was developed by SRC according to guidance from U.S. EPA[1] and OMB[2] on the conduct of peer review. The specific charge questions were based on a report on peer review for considering a proposal to expand the comparable fuel exclusion for fuels that are produced from hazardous waste but which EPA believes generate emissions that are comparable to emissions from burning fuel oil when such fuels are burned in an industrial boiler operating under good combustion conditions. Such excluded fuel would be called emission-comparable fuel (ECF). ECF would be subject to the same specifications that currently apply to comparable fuels[3], except that the specifications for certain hydrocarbons and oxygenates would not apply. The ECF exclusion would be conditioned on requirements including design and operating conditions for the ECF boiler to ensure that the ECF is burned under the good combustion conditions typical for oil-fired industrial boilers.

The following section presents the peer review charge and questions that were provided to the peer review panel.

Draft Charge Questions for Peer Review of
Revised PEER REVIEW CHARGE: Application of WMPT to Rank Comparable Fuels Constituents

Overview:

Comparable fuels are secondary materials (i.e., materials that otherwise would be hazardous wastes) which have fuel value and characteristics (i.e., physical properties related to burning, and levels of toxic constituent levels) comparable to those of fuel oil.

EPA has established specifications for comparable fuels in Table 1 to §261.38. Comparable fuels meeting the prescribed specifications are not solid wastes, and hence not hazardous wastes, provided they are burned in specified units.

EPA is considering a proposal to expand the comparable fuel exclusion for fuels that are produced from hazardous waste but which we believe generate emissions that are comparable to emissions from burning fuel oil when such fuels are burned in an industrial boiler operating under good combustion conditions. Such excluded fuel would be called emission-comparable fuel (ECF). ECF would be subject to the same specifications that currently apply to comparable fuels[4], except that the specifications for certain hydrocarbons and oxygenates would not apply.[5] The ECF exclusion would be conditioned on requirements including

---

[1] U.S. EPA Science Policy Council Peer Review Handbook, 3rd edition. EPA 100-B-06-002. May 2006.
[2] OMB Policy Bulletin: "Final Information Quality Bulletin for Peer Review" 70 CFR 2664. January 14, 2005.
[3] See Table 1 to §261.38.
[4] See Table 1 to §261.38.
[5] Table 1 to §261.38 includes specification concentrations for toxic compounds (i.e., compounds listed in Appendix VIII to Part 261) that may be present in waste fuels. The compounds are listed in the table by category, including hydrocarbons and oxygenates. We believe that it would be appropriate to waive the specifications for oxygenates and (certain) hydrocarbons because: (1) oxygenates are a class of compounds that are added to fuels to enhance combustion; and (2) it is reasonable to assume that hydrocarbons may be present in fossil fuels and, when burned under good combustion conditions, emissions would be comparable to burning fossil fuel. Waiving the

design and operating conditions for the ECF boiler to ensure that the ECF is burned under the good combustion conditions typical for oil-fired industrial boilers.

To ensure that the emissions from burning ECF as a fuel remain protective, we consider it appropriate to retain the specifications for certain hydrocarbons that can pose a high potential hazard. We also consider it appropriate to restrict the firing rate of ECF containing concentrations of certain compounds that can pose a lower, but substantial relative potential hazard.

EPA used the Waste Minimization Prioritization Tool (WMPT) to rank the 37 hydrocarbons and oxygenates listed in Table 1 to §261.38 by relative potential hazard. We also defined Category A of the Relative Hazard Characterization effort as a WMPT score of 8 or 9 (the same criterion was used to generate the Agency's PBT list).

EPA concluded that naphthalene and PAHs can pose a higher hazard than the other compounds (sufficient to qualify for Category A). Of the remaining constituents, benzene and acrolein can pose a significantly higher hazard than the remaining compounds.

Based on this hazard ranking, EPA is proposing to retain the comparable fuel specifications for naphthalene and PAHs and to restrict the firing rate of ECF containing benzene and acrolein.

Given that the Relative Hazard Characterization provides a principle component of the rationale for the proposed exclusion of ECF and, as such, is influential scientific information, a peer review of the characterization is appropriate.

Charge:

- Question 1: Is it reasonable to use the Waste Minimization Prioritization Tool (WMPT) as a starting point for categorizing the relative hazard to human health and the environment posed by chemical constituents of industrial boiler stack emissions?
- Question 2: Did EPA reasonably apply the WMPT to develop and implement the Relative Hazard Ranking system for Emission-Comparable Fuels (ECF)?
- Question 3: Based on EPA's application of the WMPT and additional evaluation, is it reasonable to conclude that the 37 ECF constituents can be grouped into the three hazard categories (in descending order of hazard): (1) PAHs and naphthalene; (2) benzene and acrolein; and (3) others?

Supporting Documents

- Summary of Relative Hazard Characterization

---

specifications for metals and other categories of organic compounds—halogenated, sulfonated, and nitrogenated—would not be appropriate because metals are not destroyed by combustion, and, for the most part, those organic compounds are not likely to be found in the benchmark fuels—fuel oil and gasoline--we used to establish the specifications. In addition, those organic compounds are not added to fuels to enhance combustion. Of the 37 chemicals proposed for exemption, we recognize that 3-Methylcholanthrene and 7,12-Dimethylbenz(a)anthracene exist chiefly in labratory settings."

- Technical Support Document (TSD)for Peer Review of Application of WMPT to Rank Comparable Fuel Constituents
- Documents referenced in TSD:
  - WMPT Technical Background Document
  - EPCRA 313 [defines PAHs]
  - Excerpt from HHRAP [relevant to Benzene]

III. Selection of the Peer Experts (Expertise and Biography Sketch)

Peer Experts were selected for both independence and scientific/technical expertise. Each panel member was selected for his/her recognized technical expertise that bears on the subject matter under discussion. The evaluation of real or perceived bias or conflict of interest is an important consideration and every effort was made to avoid conflicts of interest and significant biases.

SRC was responsible for selection of the panel. SRC determined that, in order to provide a complete and thorough evaluation of the document, it was important to locate scientists with expertise in key subject areas.

SRC compiled a pool of nine candidates with expertise in the key areas from our internal database of experts, Internet and literature searches, and professional contacts and referrals.

After carefully reviewing the candidates' credentials, interest, and availability, SRC selected the following three for the peer consultation (resumes for the experts are provided in Attachment A):

1. William Stubblefield, 32760 Peoria Rd SW, Albany, OR 97321;
2. Andrew Salmon, 3220 Apache Court, Lafayette, CA 94549;
3. Thomas Parkerton, ExxonMobil Biomedical Sciences Inc., 1545 Route 22 East, PO Box 971, Annandale, NJ 08801-0971.

IV. Conflict of Interest and Bias Issues

Each potential peer consultant was given a copy of SRC's COI policy statement and asked to complete a questionnaire to determine whether their involvement in certain activities could pose a conflict of interest or could create the appearance that the peer expert might lack impartiality. A copy of the questionnaire is found in Attachment B. Answering YES (or DON'T KNOW) to any question does not necessarily indicate there is a conflict of interest or problem, rather SRC contacts the individual for further detail and discussion.

V. Summary of Peer Review Comments

Complete written comments submitted by each member of the peer review panel are available in Attachments C–E.

Summary of the Three Peer Reviewers Comments Ordered by the Three Charge Questions

Question 1: *Is it reasonable to use the Waste Minimization Prioritization Tool (WMPT) as a starting point for categorizing the relative hazard to human health and the environment posed by stack emissions of the 37 hydrocarbons and oxygenates?*

Reviewers were generally in agreement that the use of WMPT was a reasonable approach for initial screening. However, there were a number of concerns:

> Recommend that the Agency consider the implications of the combustion process on the composition of potential emissions components in terms of the parent constituents, as well as the combustion by-products.
>
> WMPT model relies upon "screening level values" which were developed for purposes other than that for which they are being used.
>
> WMPT model relies exclusively on the quality of the data contained in the database - little assessment of the quality of the data contained within the database is conducted during the assessment process - concern whether the health values used in the WMPT are reasonably up-to-date,
>
> The model does not directly consider actual environmental exposures or exposure pathways.
>
> Concern with the way different health and ecotoxicological endpoints are scored. The background document says little about comparison or weighting of different endpoints.
>
> WMPT method excludes exposure dose. The practical attention given to naphthalene and benzene as ambient air pollutants is probably greater than is implied by the hazard ranking, because although neither of these carcinogens has an especially high potency on a per-microgram basis they tend to be orders of magnitude more abundant than the more potent three- to five-ring polycyclic aromatic hydrocarbons (PAHs), so their potential public health impact is considerable.
>
> Concern that other PAHs should have been included in the assessment
>
> More volatile chemicals (e.g., benzene, toluene, acrolein) should be considered as emitted to air and staying there - effects persistence rating.

Question 2: *Did EPA reasonably apply the WMPT to develop and implement the Relative Hazard Ranking system for the 37 compounds?*

Appears to have been done reasonably and competently, but there was concern about the process:

> No justification is provided for why the particular list of 37 compounds was considered - are these from burned or unburned fuel. Although this is not part of the formal WMPT process, it certainly should be

explained more fully. The introductory section of the charge document refers to concern about emissions when the fuels are burned, whereas further descriptions in the charge and in the hazard characterization summary appear to refer to the presence of the materials with health concerns in the actual unburned fuel. Is this analysis assuming that the composition of the emissions is entirely a reflection of the composition of the fuel? If so, this is a basic error which undermines the analysis.

No scientific basis is provided for why ecological toxicity data were not considered in the evaluation process, as is called for in the WMPT (the justification provided suggested that due to time and budget constraints human concern scores were given higher priority). The WMPT requires information on both human and ecological toxicity concerns; as implemented here, only human concerns were considered.

No human or ecological toxicity data were available for five of the compounds (1,4 naphthoquinone, isosafrole, propargyl alcohol, safrole, dimethyl phthalate); therefore, it was not possible to derive overall chemical scores. These materials should have been eliminated from consideration as emission-comparable fuel components, until data become available. Concluding that these materials do not represent a hazard seems unjustified and indefensible; absence of information should not imply acceptable hazard.

Source fuel unlikely to have acrolein, but it could be generated

Concern for potential of other highly toxic combustion-generated pollutants such as dioxins and related polyhalogenated compounds

Field bioaccumulation data should have been used for PAHs but not likely to impact the overall hazard ranking and resulting conclusions.

Question 3: *Based on EPA's application of the WMPT and additional evaluation, is it reasonable to conclude that the 37 ECF constituents can be grouped into the three hazard categories (in descending order of hazard): (1) PAHs and naphthalene; (2) benzene and acrolein; and (3) others?*

Generally concluded that the conclusions reached seem consistent, reasonable, and defensible. However, there were some concerns about the justification for the three groups, especially acrolein.

Level of concern for benzene (and thus, severity of restriction) should be considered at least equivalent to naphthalene, and thus benzene should be in that hazard category

The ranking of acrolein is appropriate, but is more likely to be fuel constituent, rather than a combustion by-product.

If acrolein stays in air it will not have a high persistence score.

Attachment A: Resumes of the Panel

WILLIAM A. STUBBLEFIELD, Ph.D.

ADDRESS
Parametrix, Inc
Environmental Toxicology
33972 Texas Street SW
Albany, Oregon 97321
phone: 541-791-1667
fax: 541-791-1669
bstubblefield@parametrix.com or stubblew@onid.orst.edu

EDUCATION

Ph.D. (Aquatic Toxicology) University of Wyoming, 1987.
M.S. (Toxicology/Toxicodynamics) University of Kentucky, 1979.
B.S. (Biological Sciences/Chemistry) Eastern Kentucky University, 1977.

SCIENTIFIC SOCIETY AFFILIATIONS

Society of Environmental Toxicology and Chemistry
Society of Toxicology
American Society of Testing and Materials
American Chemical Society
Pacific Northwest Regional Chapter of the Society of Environmental Toxicology and Chemistry

PROFESSIONAL HISTORY

2002-Present Parametrix, Inc.
2002-Present Oregon State University Department of Environmental and Molecular Toxicology, Courtesy Faculty
1998-Present Colorado State University Department of Environmental Health, Affiliate Faculty
1990-Present Colorado State University Department of Fisheries and Wildlife Biology, Affiliate Faculty
1987-2002 ENSR Consulting and Engineering
1985-1987 Mobay Corporation; Health, Environment, and Safety Division
1983-1985 University of W yoming, Fish Physiology and Toxicology Laboratory
1979-1983 Exxon Corporation, Research and Environmental Health Division

PUBLICATIONS

Stubblefield WA. 1979. *Quantitative administration of insecticide vapors to rats*. M.S. thesis. University of Kentucky, Lexington, KY.

Stubblefield WA, Maki AW. 1985. Environmental hazard assessment of refinery effluents. In Bergman HL, Kimerle RA, Maki AW, eds, *Environmental Hazard Assessment of Effluents*. Pergamon Press, Elmsford, NY.

Johnson HE, Behrens DW, Dickson KL, Gulledge WP, Hamelink JL, Lee GF, Miller TG, Peltier WH, Stubblefield WA. 1985. Discussion Synopsis: Hazard Assessment Case Histories. In Bergman HL, Kimerle RA, Maki AW, eds, *Environmental Hazard Assessment of Effluents*. Pergamon Press, Elmsford, NY.

McKee RH, Stubblefield WA, Lewis SC, Scala RA, Simon GS, DePass LR. 1986. Evaluation of the dermal carcinogenic potential of tar sands bitumen-derived liquids. *Fund. Appl. Toxicol*. 7(2):228-235.

Bergman HL, Middaugh CR, LaPoint TW, Steadman BL, Stubblefield WA. 1986. *Development of procedures for the derivation of site-specific water quality criteria for complex discharges.* Final report to the American Petroleum Institute; December 1986.

Stubblefield WA. 1987. *Acclimation-induced changes in the toxicity of xenobiotics in rainbow trout*. Ph.D. dissertation. University of Wyoming, Laramie, WY.

Stubblefield WA, McKee RH, Kapp RW , Hinz JP. 1989. An evaluation of the acute toxic properties of tar sands-derived oils. *Fund. Appl. Toxicol*. 9(1):59-65.

Steadman BL, Stubblefield WA, LaPoint TW, Bergman HL. 1991. Decreased survival of rainbow trout exposed to No. 2 fuel oil caused by sublethal pre-exposure. *Environ. Toxicol. Chem*. 10(3):355-363.

Stubblefield WA, Toll, PA. 1993. Effects of incubation temperature and warm-water misting on hatching success in artificially incubated mallard duck eggs. *Environ. Toxicol. Chem.* (12)10: 695-700.

Stubblefield WA, Hancock GA, Ford WH, Prince HH, Ringer RK. 1995. Evaluation of the toxic properties of naturally weathered *Exxon Valdez* crude oil to surrogate wildlife species. In Wells PG, Butler J, Hughes JS, eds, *Exxon Valdez: Environmental Impact and Recovery Assessment*, ASTM STP 1219, American Society for Testing and Materials, Philadelphia, Pennsylvania. Pp. 665-692.

Boehm PD, Page DS, Gilfillian ES, Stubblefield WA, Harner EJ. 1995. Shoreline ecology program for Prince William Sound following the *Exxon Valdez* oil spill: Part 2 - Chemistry and toxicology. In Wells PG, Butler J, Hughes JS, eds, *Exxon Valdez: Environmental Impact and Recovery Assessment*, ASTM STP 1219, American Society for Testing and Materials, Philadelphia, Pennsylvania. Pp. 347-397.

Neff JM, Stubblefield WA. 1995. Chemical and toxicological evaluation of water quality following the *Exxon Valdez* oil spill. In Wells PG, Butler J, Hughes JS, eds, *Exxon Valdez: Environmental Impact and Recovery Assessment*, ASTM STP 1219, American Society for Testing and Materials, Philadelphia, Pennsylvania. Pp. 141-177.

Stubblefield WA, Hancock GA, Ford WH, Ringer RK. 1995. Acute and subchronic toxicity of naturally weathered *Exxon Valdez* crude oil to mallards and ferrets. *Environ. Toxicol. Chem.* 14:1941-1950.

Stubblefield WA, Hancock GA, Ford WH, Ringer RK. 1995. Effects of naturally weathered *Exxon Valdez* crude oil on mallard reproduction. *Environ. Toxicol. Chem*. 14:1951-1960.

Gerath M, Daggett R, Stubblefield WA. 1995. Estimation of water quality and toxicological impacts of large volume ammonia spills into a river. In: *Proceedings of Water Environment Federation Specialty Conference on Toxic Substances*. Cincinnati, Ohio, 14-17 May 1995.

Wood CM, Adams W J, Ankley GT, DiBona DR, Luoma SN, Playle RC, Stubblefield WA, Bergman HL, Erickson RJ, Mattice JS, Schlekat CE. 1997. Environmental toxicology of metals. In Bergman HL, Dorward-King, EJ, eds, *Reassessment of Metals Criteria for Aquatic Life Protection*, SETAC Press, Pensacola, Florida. Pp. 31-56.

Lington AW, Bird MG, Plutnick RT, Stubblefield WA, Scala RA. 1997. Chronic toxicity and carcinogenic evaluation of diisonoyl phthalate in rats. *Fund. Appl. Toxicol*. 36:79-89.

Stubblefield WA, Brinkman S, Davies P, Hockett JR, Garrison T. 1997. Effects of water hardness on the toxicity of manganese to developing brown trout (*Salmo trutta*). *Environ. Toxicol. Chem*. 16:2082-2089.

Steen A, Fritz D, Stubblefield W, Giddings J. 1999. Environmental effects of freshwater spills. In *Proceedings of the 1999 International Oil Spills Conference*. American Petroleum Institute. Washington DC.

Stubblefield WA, Steadman BL, LaPoint TW, Bergman HL. 1999. Acclimation-induced changes in the toxicity of zinc and cadmium in adult and juvenile rainbow trout (*Oncorhynchus mykiss*). *Environ. Toxicol. Chem*. 18(12):2875-2881.

Mancini ER, Steen A, Rausina GA, Wong DCL, Arnold WR, Gostomski FE, Davies T, Hockett JR, Stubblefield WA, Drottar KR, Springer TA, Errico P. 2001. MTBE ambient water quality criteria development: a public/private partnership. *Environ. Science Tech*. 36:125-129.

Naddy, RB, Stubblefield WA, May JR, Tucker SA, Hockett JR. 2002. The effect of calcium and magnesium ratios on the toxicity of copper to five aquatic species in freshwater. *Environ. Toxicol. Chem.* 21:347-352.

Page DS, Boehm PD, Stubblefield WA, Parker KR, Gilfillan ES, Neff JM, and Maki AW. 2002.

Hydrocarbon composition and toxicity of sediments following the *Exxon Valdez* oil spill in Prince William Sound, Alaska, USA. *Environ. Toxicol. Chem.* 21(7):1438-1450.

Gensemer, RW, RB Naddy, WA Stubblefield, JR Hockett, R Santore, and P Paquin. 2002. Evaluating the role of ion composition on the toxicity of copper to *Ceriodaphnia dubia* in very hard waters. Comp. Biochem. Physiol. C. 133:87-97.

Paquin, P, JW Gorsuch, S Apte, GE Batley, KC Bowles, PGC Campbell, C Delos, DM DiToro, R Dwyer, F Galvez, RW Gensemer, GG Goss, C Hogstrand, CR Janssen, JC McGeer, RB Naddy, RC Playle, RC Santore, U Schneider, WA Stubblefield, CM Wood, and KB W u. 2002. The biotic ligand model: A historical overview. Comp. Biochem. Physiol. C. 133:3-35.

Reiley MC, Stubblefield WA, Adams W J, Di Toro DM, Hodson PV, Erickson RJ, Keating FJ. 2003. *Reevaluation of the State of the Science for Water Quality Criteria Development*. SETAC Press. Pensacola, FL.

Benson WH, HE Allen, JP Connolly, CG Delos, LW Hall, SN Luoma, D Maschwitz, JS Meyer, JW Nichols, and WA Stubblefield. 2003. Re-evaluation of the State of the Science for Water Quality Criteria Development: Exposure Analysis. In: Reiley MC, Stubblefield WA, Adams W J, Di Toro DM, Hodson PV, Erickson RJ, Keating FJ., eds. *Re-evaluation of the State of the Science for Water Quality Criteria Development*. SETAC Press. Pensacola, FL.

Meyer JS, W J Adams, KV Brix, SN Luoma, DR Mount, WA Stubblefield,and CM Wood. 2005. *Toxicity of Dietborne Metals to Aquatic Organisms*. SETAC Press. Pensacola, FL.

Handy RD, JC McGeer, HE Allen, PE Drevnick, JW Gorsuch, AS Green, AL Haldorsen, SE Hook, DR Mount, and WA Stubblefield. 2005. In: Meyer JS, W J Adams, KV Brix, SN Luoma, DR Mount, WA Stubblefield,and CM Wood, eds. *Toxicity of Dietborne Metals to Aquatic Organisms*. SETAC Press. Pensacola, FL.

Brannon EL, KM Collins, JS Brown, JM Neff, KR Parker, and WA Stubblefield. 2006. Toxicity of Weathered *Exxon Valdez* Crude Oil to Pink Salmon Embryos. *Environ. Toxicol. Chem.* 25(4):962-972.

Ward, TJ, RL Boeri, C Hogstrand, JR Kramer, SM Lussier, WA Stubblefield, DC Wyskiel, and JW Gorsuch. 2006. Influence of Salinity and Organic Carbon on the Chronic Toxicity of Silver to Mysids (*Americamysis bahia*) and Silversides (*Menidia beryllina*). *Environ. Toxicol. Chem.* 25(7):1809–1816.

Jones AC, RW Gensemer, WA Stubblefield, E Van Genderen, G Dethloff, and WJ Cooper. 2006. Toxicity of Ozonated Seawater to Marine Organisms. *Environ. Toxicol. Chem.* 25(10):2683-2691.

Stubblefield WA, MR Servos, RM Gersberg, CL Riley, D Simpson, D Smith, and P Wells. 2006. Scientific and Technical Review: Capital Regional District Core Area Liquid Waste Management Plan. Society of Environmental Toxicology and Chemistry. Pensacola, FL.

Roberts AP, JT Oris and WA Stubblefield. 2006. Gene Expression in Caged Juvenile Coho Salmon (*Oncorhynchys kisutch*) Exposed to the Waters of Prince William Sound, Alaska. *Marine Pollut. Bull*. 52: 1527-1532.

Herwig RP, JR Cordell, JC Perrins, PA Dinnel, RW Gensemer, WA Stubblefield, GM Ruiz, JA Kopp, ML House, and W J Cooper. 2006. Ozone treatment of ballast water on the oil tanker *S/T Tonsina*: chemistry, biology and toxicity. *Mar Ecol Prog Ser*. 324: 37–55.

DiToro DM, JA McGrath, and WA Stubblefield. 2007. Predicting the toxicity of neat and weathered crude oil: toxic Potential and the toxicity of saturated mixtures. *Environ. Toxicol. Chem.* 26(1):24-36.

PRESENTATIONS AT PROFESSIONAL MEETINGS

Stubblefield WA, Dorough HW. 1979. Quantitative administration of insecticide vapors to rats. Society of Toxicology Annual Meeting. March 1979.

Stubblefield WA, Maki AW. 1982. Environmental risk assessment of refinery effluents. Cody Conference on Complex Effluents. August 1982.

Stubblefield WA, Foster RB, Howard PH. 1983. An environmental toxicological assessment of phthalate esters. Society of Environmental Toxicology and Chemistry Annual Meeting. November 1983.

Phillips RD, Stubblefield WA, Dodd DE, Grice HC. 1984. Acute and subchronic inhalation of methyl-DBCP. Society of Toxicology Annual Meeting. March 1984.

McKee RH, Stubblefield WA, Scala RA. 1985. Evaluation of the carcinogenic activity of bitumen-derived liquids. Society of Toxicology Annual Meeting. March 1985.

Biles RW , Stubblefield WA. 1985. Acute toxicity battery of tar sands products and intermediates. Society of Toxicology Annual Meeting. March 1985.

Bergman HL, Crossey MC, Steadman BL, Stubblefield WA, LaPoint TW. 1985. Water quality concerns: Organic pollutants. American Fisheries Society Annual Meeting. September 1985.

Stubblefield WA, Steadman BL, LaPoint TW, Bergman HL. 1985. Acclimation-induced changes in the toxicity of zinc, cadmium, and phenol in adult and fry rainbow trout. American Fisheries Society Annual Meeting. September 1985.

Stubblefield WA, Steadman BL, LaPoint TW, Bergman HL. 1985. Acclimation-induced changes in the toxicity of zinc and cadmium in adult and fry rainbow trout (*Salmo gairdneri*). Society of Environmental Toxicology and Chemistry Annual Meeting. November 1985.

LaPoint TW, Stubblefield WA, Steadman BL, and Bergman HL. 1985. Acclimation-induced changes in the toxicity of petroleum refinery wastewaters under laboratory and field conditions. Society of Environmental Toxicology and Chemistry Annual Meeting. November 1985.

Steadman BL, Farag A, Stubblefield WA, Bergman HL. 1986. Interactions of organic and metal detoxification pathways in rainbow trout. Society of Environmental Toxicology and Chemistry Annual Meeting. November 1986.

Stubblefield WA, Toll PA. 1987. Evaluation of temperature and warm water-misting on hatching success in artificially incubated mallard duck eggs. Society of Environmental Toxicology and Chemistry Annual Meeting. November 1987.

Toll PA, Stubblefield WA, Nicolich MJ. 1987. Evaluation of methods for the determination of avian eggshell strength. Society of Environmental Toxicology and Chemistry Annual Meeting. November 1987.

Stubblefield, WA, Giddings JM, deNoyelles F. 1989. Mesocosms: their utility in the hazard assessment process. American Society of Testing and Materials Annual Meeting. April 1989.

Stubblefield WA, Capps SW, Patti SJ. 1990. Toxicity of manganese to freshwater aquatic species. Society of Environmental Toxicology and Chemistry Annual Meeting. November 1990.

Pillard DA, Stubblefield WA. 1990. Community structure analysis of benthic communities subjected to metal-laden mine drainage. Society of Environmental Toxicological Chemistry Annual Meeting. November 1990.

Cohen AS, Stubblefield WA. 1991. Toxicity of bromide to freshwater aquatic species. Society of Environmental Toxicological Chemistry Annual Meeting. November 1991.

Stubblefield WA. 1991. Potential bioaccumulation of reserve pit constituents in tundra biota on Alaska's North Slope oil fields. Society of Environmental Toxicological Chemistry Annual Meeting. November 1991.

Lawhead BE, Bishop SC, Stubblefield WA. 1992. Evaluating the exposure of caribou to toxic substance and North Slope drilling muds. North Slope Terrestrial Studies Workshop, February 1992. Anchorage, Alaska.

Stubblefield WA, Cohen AS, Gulley DD, Colonell J, Fortdam CL, Klima KE, Hampton P, Jakubczak R. 1992. Potential bioaccumulation of reserve pit constituents in tundra biota on Alaska's North Slope.

North Slope Terrestrial Studies Workshop, February 1992. Anchorage, Alaska.

Cohen AS, Stubblefield WA. 1992. Bioaccumulation: Field evaluation and application in the ecological risk assessment framework. Society of Risk Analysis Annual Meeting. December 1992.

Brumbaugh WG, Wiedmeyer RH, Ingersoll CG, Mount DR, Stubblefield WA. 1992. Milltown Reservoir - Clark Fork River, Montana: Chemical characterization of metals in sediments and pore water. Society of Environmental Toxicology and Chemistry Annual Meeting, Cincinnati, Ohio. November 1992.

Ringer RK, Prince HH, Hancock GA, Stubblefield WA. 1993. An ecological risk assessment of weathered North Slope crude oil to avian wildlife following the *Exxon Valdez* oil spill. Society of Environmental Toxicology and Chemistry Annual Meeting, Houston, Texas. November 1993.

Stubblefield WA, Cohen AS. 1993. Application of the water effects ratio (WER) for site-specific water quality criteria development for copper in the Clark Fork River (CFR). Society of Environmental Toxicology and Chemistry Annual Meeting, Houston, Texas. November 1993.

Cohen AS, Stubblefield WA, Hockett JR, Mount DR. 1993. Comparison of the sensitivity of three salmonid species during separate acute exposures to copper, cadmium, and zinc. Society of Environmental Toxicology and Chemistry Annual Meeting, Houston, Texas. November 1993.

Stubblefield WA, Cohen AS, Hockett JR, Mount DR. 1993. Acute and chronic interactive effects of copper, zinc, and cadmium to rainbow trout and *Ceriodaphnia*. Society of Environmental Toxicology and Chemistry Annual Meeting, Houston, Texas. November 1993.

Stubblefield WA, Pillard DA. 1993. Evaluation of the fate and toxicity of oil residues in shoreline sediments following the *Exxon Valdez* oil spill. Society of Environmental Toxicology and Chemistry Annual Meeting, Houston, Texas. November 1993.

Stubblefield WA, Pillard DA. 1993. Evaluation of toxicity oil residues in shoreline sediments following the *Exxon Valdez* oil spill. Society of Environmental Toxicology and Chemistry Annual Meeting, Houston, Texas. November 1993.

Boehm PD, Gilfillian ES, Page DS, Stubblefield WA. 1993. Application of sediment "triad" approach to a major oil spill assessment. The *Exxon Valdez* spill. Society of Environmental Toxicology and Chemistry Annual Meeting, Houston, Texas. November 1993.

Pillard DA, Stubblefield WA. 1993. An evaluation of sediment grain size as a confounding factor in assessing toxicity in shoreline sediment samples. Society of Environmental Toxicology and Chemistry Annual Meeting, Houston, Texas. November 1993.

Cohen AS, Stubblefield WA. 1994. Chronic toxicity of Clark Fort River sediment interstitial water to *Ceriodaphnia dubia* and rainbow trout. Society of Environmental Toxicology and Chemistry Annual Meeting. Denver, Colorado. November 1994.

Cohen AS, Hockett JR, Stubblefield WA. 1994. Toxicity of pulse exposures of zinc, cadmium, and copper to pre-exposed trout and daphnia. Society of Environmental Toxicology and Chemistry Annual Meeting. Denver, Colorado. November 1994.

Stubblefield, WA, Cohen AS. 1995. Application of the water-effects ratio (WER) for site-specific water quality criteria development for copper in the Clark Fork River (CFR). Society of Environmental Toxicology and Chemistry Annual Meeting, Vancouver, BC. November 1995.

Cohen AS, Brady MD, Stubblefield WA. 1995. Changes in copper water-effect ratios in toxicity tests conducted at varying water hardness levels. Society of Environmental Toxicology and Chemistry Annual Meeting, Vancouver, BC. November 1995.

Cohen AS, Stubblefield WA. 1995. Comparison of the water-effects ratios for species ranging in copper sensitivity. Society of Environmental Toxicology and Chemistry Annual Meeting, Vancouver, BC. November 1995.

Barth A, Cohen AS, Stubblefield WA. 1995. Chronic Toxicity of Clark Fork River invertebrates to rainbow trout when administered via the diet. Society of Environmental Toxicology and Chemistry Annual Meeting, Vancouver, BC. November 1995.

Brannon EL, Neff JM, Pearson WH, Stubblefield WA, Maki AW. 1996. Application of ecological risk assessment principles to evaluation of oil spill impacts. Society of Environmental Toxicology and Chemistry Annual Meeting, Washington, D.C. November 1996.

Stubblefield WA, Garrison TD, Hockett JR, Brinkman SF, Davies PH, McIntyre MW. 1996. Effects of water hardness on the toxicity of manganese to developing brown trout (*Salmo trutta*). Society of Environmental Toxicology and Chemistry Annual Meeting, Washington, D.C. November 1996.

Hopkins K, Kangaonkar T, Parsons A, Stubblefield WA. 1996. Assessment of baseline sediment risks in the Tongass Narrows Waterway, Alaska. Society of Environmental Toxicology and Chemistry Annual Meeting, Washington, D.C. November 1996.

Stubblefield WA, Burnett SL, Hockett JR, Naddy RB, Mancini ER. 1997. Evaluation of the aquatic toxicity of methyl tertiary-butyl ether (MTBE): Implications to refinery operations. American Petroleum Institute Spring Refining Meeting. San Diego, California. April 1997.

Stubblefield WA, Burnett SL, Hockett JR, Naddy RB, Mancini ER. 1997. Evaluation of the acute and chronic aquatic toxicity of methyl tertiary-butyl ether (MTBE). American Chemical Society Annual Meeting. San Francisco, California. April 1997.

Stubblefield WA, Baroch J, Dressen P, Spraker T, Getzy D. 1997. Evaluation of the toxic properties of acid mine drainage water to Snow Geese. Society of Environmental Toxicology and Chemistry Annual Meeting, San Francisco, CA. November 1997.

Naddy RB, Barten K, Garrison T, Tucker S, Vertucci F, Stubblefield WA. 1997. Evaluation of benthic macroinvertebrate community composition and tissue residues in the Clark Fork River, Montana. Society of Environmental Toxicology and Chemistry Annual Meeting, San Francisco, CA. November 1997.

Stubblefield WA, Naddy RB, Tucker S, Barten K, Christensen K, Hockett JR. 1997. Evaluation of metals contaminated sediments within depositional and riffle habitats in the Clark Fork River. Society of Environmental Toxicology and Chemistry Annual Meeting, San Francisco, CA. November 1997.

Naddy RB, Cohen AS, Pillard D, Tucker S, Vertucci F, Stubblefield WA. 1997. Biomonitoring as a strategy for evaluating the effectiveness of wetlands remediation: Case study Warm Springs Ponds. Society of Environmental Toxicology and Chemistry Annual Meeting, San Francisco, CA. November 1997.

Mancini ER, Stubblefield WA. 1997. Physiochemical and ecotoxicological properties of gasoline oxygenates. Society of Environmental Toxicology and Chemistry Annual Meeting, San Francisco, CA. November 1997.

Christensen K, Stubblefield WA, Naddy RB, Rehner A. 1997. Use of water effect ratios in development of site-specific water quality criteria. Society of Environmental Toxicology and Chemistry Annual Meeting, San Francisco, CA. November 1997.

Stubblefield WA, Naddy RB, Tucker S, R Hockett JR. 1998. *In situ* evaluation of porewater metal concentrations in aquatic sediments. Society of Environmental Toxicology and Chemistry - Europe Annual Meeting, Bordeaux, France. April 1998.

Naddy RB, Stubblefield WA, Christensen KP, Pillard DA, Tucker,SA, Hockett JR. 1998. Evaluating the bioavailability of metals mixtures in sediments from the Clark Fork River basin. Society of Environmental Toxicology and Chemistry Annual Meeting, Charlotte, SC. November 1998.

Greenberg M, Rowland C, Burton GA, Hickey C, Stubblefield W, Clements W , Landrum P. 1998. Isolating individual stressor effects at sites with contaminated sediments and waters. Society of Environmental Toxicology and Chemistry Annual Meeting, Charlotte, SC. November 1998.

Stubblefield WA, Christensen KP, Hockett JR, Steen A, Grindstaff J, Wong DCI, Arnold WR, Rausina G. 1998. Derivation of ambient water quality criteria for MTBE: Toxicity to selected freshwater organisms. Society of Environmental Toxicology and Chemistry Annual Meeting, Charlotte, SC. November 1998.

Mancini ER, Steen A, Arnold WR, Rausina GA, Wong DCL, Gostomski FE, Davies T, Hockett JR, Stubblefield WA, Drottar KR, Springer TA, Errico P. Preliminary calculations of freshwater and marine water quality criteria for MTBE. Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA. November 1999.

Naddy RB, Stubblefield WA, May JR, Tucker SA, Hockett JR. The effect of calcium:magnesium ratios on the acute copper toxicity to five aquatic species in laboratory waters. Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA. November 1999.

Naddy RB, Vertucci FA, Stubblefield WA. Evaluation of exposure-effects relationships of metals in the benthic macroinvertebrate community in the Upper Clark Fork River, Montana. Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA. November 1999.

Pillard DA, Naddy RB, Stubblefield WA. Trends in tissue burdens, media concentrations, and toxicity at Warm Spring Pond, Anaconda, Montana. Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA. November 1999.

Long K, Ryan A, Van Genderen E, Karen DJ, Stubblefield WA, Naddy RB, Klaine SJ. Does the hardnessbased water quality criteria accurately reflect response of aquatic organisms to copper in the soft waters of the southeastern US. Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA. November 1999.

Stubblefield WA, Hockett JR, Pillard DA, Herbst DB. Application of a triad-based approach for evaluating the effects of acid mine drainage (AMD) in a high-mountain stream. Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA. November 1999.

Gensemer RW, Playle RC, Stubblefield WA, Hockett JR. Aluminum bioavailability and toxicity of freshwater biota at circumneutral and higher pH. Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA. November 1999.

Stubblefield WA, Hockett JR, Kramer JR, Wood CM, Paquin PR, and Gorsuch JW . Chronic silver toxicity: water quality parameters as modifying factors. Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville ,TN. November 2000.

Page D, Gilfillian E, Boehm P, Burns W, Maki A, Stubblefield W, and Parker K. Sediment toxicity values for a field study compared with sediment quality criteria for total PAH. Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville ,TN. November 2000.

Ward TJ, Boeri RL, Hogstrand C, Kramer JR, Lussier SM, Stubblefield WA, and Gorsuch JW. 2001. Chronic estuarine and marine silver toxicity: water quality parameters as modifying factors. Society of Environmental Toxicology and Chemistry Annual Meeting, Baltimore, MA. November 2001.

McGrath JA, Hellweger FL, Stubblefield WA, Maki AW, and DiToro DM. 2001. Predicting the effects of non-weathered and weathered crude oil using narcosis theory. Society of Environmental Toxicology and Chemistry Annual Meeting, Baltimore, MA.. November 2001.

Hellweger FL, McGrath JA Stubblefield WA, Maki AW, and DiToro DM. 2001. Equilibrium partitioning theory applied to *Exxon Valdez* crude oil. Society of Environmental Toxicology and Chemistry Annual Meeting, Baltimore, MA.. November 2001.

Stubblefield WA, Gensemer RW, Naddy RB, Brix K, DeForest D, Paquin P, and Santore R. 2001. Evaluating copper toxicity to Daphnia magna in waters greater than 400 mg/L hardness. Society of Environmental Toxicology and Chemistry Annual Meeting, Baltimore, MA.. November 2001.

Stubblefield WA, Wirtz JR, Naddy RB, DuFresne DL, De Schamphelaere K, Brix KV, Ortego LS, and Schlekat CE. 2003. Modifying effects of water quality parameters on the chronic

toxicity of nickel to *Ceriodaphnia dubia.* Society of Environmental Toxicology and Chemistry Asia-Pacific Annual Meeting, Christchurch NZ. September 2003.

Clark, J, Stubblefield W, Fairbrother, A, and Dwyer R. 2003. Distributon of soil bioavialability parameters in Europe. 7 International Conference on the Biogeochemistry th of Trace Elements. Uppsala, Sweden. June 2003.

Oris, JT, Stubblefield WA, Smith CA and Maki AW. 2003. Solar radiation intensities and water attenuation coefficients in Prince William Sound, Alaska. Society of Environmental Toxicology and Chemistry Annual Meeting. Austin, TX. November 2003.

DeForest, DK, Marx, K, Keithly, J, Santore, RC, Tobiason, S, Stubblefield, WA and Brix, KV. 2003. Zinc risks from stormwater runoff at an urban airport. Society of Environmental Toxicology and Chemistry Annual Meeting. Austin, TX. November 2003.

Gensemer, RW, Dethloff GM, Stubblefield, WA and Cooper WJ. 2003. Toxicity of ozonated ballast water to marine organisms. Society of Environmental Toxicology and Chemistry Annual Meeting. Austin, TX. November 2003.

Stubblefield WA, W irtz, JR, Naddy R, DuFresne DL, Brix KV and Oretgo LS. 2003. Modifying effects of water quality parameters on the chronic toxicity of nickel to *Ceriodaphnia dubia*. Society of Environmental Toxicology and Chemistry Annual Meeting. Austin, TX. November 2003.

Naddy RB, Stern GR, Rehner AB, Bell RA, Kramer JR, Wood CM, Paquin PR, Wu KB, Stubblefield, WA and Gorsuch JW 2003. Toxicity of silver to three freshwater organisms and effects of potential mitigating factors. Society of Environmental Toxicology and Chemistry Annual Meeting. Austin, TX. November 2003.

Oris JT, Stubblefield WA, Smith CA and Maki AW. 2004. Relationship of water quality characteristics, solar radiation, and photoinduced toxicity of PAHs in Prince William Sound, Alaska. Society of Environmental Toxicology and Chemistry Annual Meeting. Portland, OR. November 2004.

Smith CA, Stubblefield W, Clark J, Faribrother A, Allen H, Schoeters I and Dwyer R. 2004. Distribution of soil and bioavailability parameters throughout Europe and the development of Metaloregions. Society of Environmental Toxicology and Chemistry Annual Meeting. Portland, OR. November 2004

Stubblefield WA, Gensemer, R, Cooper W, Herwig R, Ruiz G. 2004. Ballast watertreatment stratagies: evaluation of efficacy and post-treatment environmental concerns. Society of Environmental Toxicology and Chemistry Annual Meeting. Portland, OR. November 2004.

Boeri R, Ward T, Hogstrand C., Kramer J, Lussier S, Stubblefield W., Gorsuch J. 2004. Marine water quality criteria development: the chronic toxicity of silver to sea urchins, *Arabacia punctulata*. Society of Environmental Toxicology and Chemistry Annual Meeting. Portland, OR. November 2004.

Ward T, Boeri R, Hogstrand C., Kramer J, Lussier S, Stubblefield W. W yskiel D, Gorsuch J. 2004. Silver water quality criteria development consideration of salinity and organic carbon influence on chronic marine toxicity.

Wirtz J, Stubblefield W, De Schamphelaere KAC, Naddy RB, Ortego LS, Schlekat CE. 2004. Effects of water quality parameters on chronic nickel toxicity to *Ceriodaphnia dubia*. Society of Environmental Toxicology and Chemistry Annual Meeting. Portland, OR. November 2004.

Stubblefield W, D DuFresne, D Robillard, D Peterson, J Gorsuch and C Staples. 2005. The evaluation of sparing soluble compounds: the toxicity of bis (2-ethylhexyl) adapate to daphnia magna under staticrenewal test conditions. Society of Environmental Toxicology and Chemistry European Annual Meeting. Lille, France. May 2005.

Smith C, W Stubblefield, A Fairbrother, H Allen, I Schoeters, and R Dwyer. 2005. Distribution of soil bioavailability parameters throughout Europe and development of t-BLM based metalloregions. Society of Environmental Toxicology and Chemistry European Annual Meeting. Lille, France. May 2005.

Phipps T, S Currie, W Stubblefield, C Farr, S Murphy, R Costlow, and M Thompson. 2005. Aquatic toxicity of mono- and dialkyltin chlorides to freshwater fish, daphnia, and algae. Society of Environmental Toxicology and Chemistry European Annual Meeting. Lille, France. May 2005.

Phipps T, S Currie, W Stubblefield, C Farr, S Murphy, R Costlow, and M Thompson. 2005. Aquatic ecotoxicity of mono- and di-organotin stabilizers to freshwater organisms. Society of Environmental Toxicology and Chemistry European Annual Meeting. Lille, France. May 2005.

Stubblefield W, J Oris , C Smith, and A Maki. 2006. Relationship of water quality characteristics, solar radiation, and photo-induced toxicity of PAHs in Prince William Sounds (PWS),Alaska. Society of Environmental Toxicology and Chemistry European Annual Meeting. The Hague, Netherlands. May 2006.

Van Genderen E, W Stubblefield , T Brock , and R W elton. 2006. Preliminary investigations into the aquatic toxicity of cobalt to freshwater biota. Society of Environmental Toxicology and Chemistry European Annual Meeting. The Hague, Netherlands. May 2006.

Oris J, A Roberts , W Stubblefield , and A Maki. 2006. Gene expression in caged juvenile Coho Salmon (Oncorhynchys kisutch) exposed to the waters of Prince William Sound, Alaska (USA). Society of Environmental Toxicology and Chemistry European Annual Meeting. The Hague, Netherlands. May 2006.

Wirtz, J.R. and W Stubblefield. 2006. Manganese Water/Sediment/Soil Quality Criteria Database: Review of Existing Data and Recommendations. Society of Environmental Toxicology and Chemistry Annual Meeting. Montreal, Canada. November 2006.

Smith, C., E Van Genderen, W Stubblefield, T Brock, and R Welton. 2006. Preliminary investigations into the aquatic toxicity of cobalt to freshwater biota. Society of Environmental Toxicology and Chemistry Annual Meeting. Montreal, Canada. November 2006.

PROFESSIONAL ACTIVITIES

Scientific Society Service

Society of Environmental Toxicology and Chemistry (SETAC)
- Past-President (2005)
- President (2004)
- Vice-President (2003)
- Board of Directors (1995-1998; 2002-2005)
- Program Chairman 1994 and 2002 annual meetings
- Chairman Publications Advisory Council (1995-2003)
- Member of *Environmental Toxicology and Chemistry* Editorial Board (1994-1997)
- Chairman Professional Opportunities Committee (1992-1995)
- Committee member Publications Committee (1989-1992) and the Nominations Committee (1985-1987)
- Assistant Editor of the Society of Environmental Toxicology and Chemistry Newsletter
- Associate Editor Society of Environmental Toxicology and Chemistry Special Publications.

Invited Conferences and Program Reviews

Surface Water Quality Standards Review Committee for the Arizona Department of Environmental Quality (1989-1990).

U.S. Environmental Protection Agency Workshop on Mesocosms. Duluth, Minnesota, September 14-17, 1987.

U.S. Environmental Protection Agency Complex Effluent Program Review. September 1990.

U.S. Environmental Protection Agency, ECOTOX Database Review, Duluth, Minnesota. August 1994.

U.S. Environmental Protection Agency, Science to Achieve Results (STAR) Fellowship Review, Wasington D.C. 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006.

U.S. Environmental Protection Agency, Peer-reviewer for National Sediment Inventory, Washington DC, 1996, 1999.

U.S. Environmental Protection Agency, Science Advisory Board, Multimedia, Multipathway, and Multireceptor Risk Assessment (3MRA) Model System Panel, Washington DC, 2003.

U.S. Environmental Protection Agency, Science Advisory Board, Framework for Inorganic Metals Risk Assessment Review Panel, Washington DC, 2005.

SETAC Pellston Conference on Environmental Hazard Assessment of Effluents. Cody, W yoming. August 1982.

SETAC Pellston Conference on Avian Toxicity Testing Methods. Pensacola, Florida, December 1994.
SETAC Pellston Conference on Sediment Risk Assessment, Pacific Grove, California, April 1995.
SETAC Pellston Conference on Reassessment of Metals Criteria for Aquatic Life Protection, Pensacola, Florida, February 1996.
SETAC Pellston Conference on Reevaluation of the State of the Science for Water Quality Criteria Development; Gregson, Montana, June 1998.
SETAC Pellston Conference on Predicting Ecological Impacts from Laboratory Toxicity Tests; Cornwall, Quebec, Canada, May 1999.
SETAC Pellston Conference on The Role of Dietary Exposures in the Evaluation of Risk of Metals to Aquatic Organisms; Florsinent, British Columbia, Canada, August 2002.
SETAC Pellston Conference on Persistent, Bioaccumulative, and Toxic Materials (PBT); Pensacola, FL, May 2003
Metals Environmental Risk Assessment Guidance (MERAG) Science Consolidation Workshop (Workshop chair); London, UK, May 2005.
SETAC Technical Workshop on Environmental Quality Standards; Faringdon, Oxfordshire, UK, August 2006.

Academic Courses or Professional Continuing Education
University of W isconsin, Madison - Department of Engineering Professional Development Program. *Understanding Aquatic Toxicity Testing*, October 1992, Anchorage, Alaska.
Colorado State University - Department of Fisheries and Wildlife, *Environmental Toxicology*, Spring 1990.
Colorado State University - Department of Environmental Health, *Environmental Risk Assessment*, Spring 1996/1998/2000/2002.
Oregon State University - Department of Molecular and Environmental Toxicology, *Ecological Risk Assessment*, Winter 2003/2004/2005/2006.
Oregon State University - Department of Molecular and Environmental Toxicology, *Aquatic Toxicology*, Spring 2005/2006.

ANDREW GALE SALMON M.A., D.Phil., C.Chem., M.R.S.C.

Degrees:	Oxford University, U.K. (St. John's College) B.A. (Biochemistry) 1969; M.A. 1972; D. Phil. 1972
Present post: (Since June 1999)	Senior Toxicologist and Chief, Air Toxicology and Risk Assessment Section, Air Toxicology and Epidemiology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. 16th floor, 1515 Clay Street, Oakland, California 94612

Previous Appointments:

1988 - 1999	Staff Toxicologist, Reproductive and Cancer Hazard Assessment Section, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency Berkeley/Oakland, California.
1988 (Feb-Oct)	Consultant Toxicologist, California Public Health Foundation, Berkeley, California.
1986 (June)	WHO Short Term Consultant, Eastern Mediterranean Region (Consultation Meeting: Curricula for Toxic Chemical Control, Gabes, Tunisia)
1982-1988	Lecturer in Industrial Toxicology, Department of Occupational Health, London School of Hygiene and Tropical Medicine, London, UK
1982 (Jan-Sept)	Associate Research Fellow, Department of Clinical Pharmacology, University College, London London, UK
1974-1982	Senior Research Assistant, ICI Central Toxicology Laboratory, Macclesfield, UK
1972-1974	Post Doctoral Scientist, Lawrence Berkeley Laboratory, University of California, Berkeley, California.
1971-1972	Senior Scholarship, St. John's College, Oxford, UK
1969-1972	SRC Research Student, Dept. Biochemistry, Oxford University, Oxford, UK.

Membership of professional organizations:
Society of Toxicology
British Toxicology Society
Member, Royal Society of Chemistry
Genetic and Environmental Toxicology Association

Recent activities of interest:
I lead the group of toxicologists in OEHHA responsible for public health risk assessments of Toxic Air Contaminants (TACs: this category is similar to the US Hazardous Air Pollutants list)

under the State of California's Air Toxics programs. This includes development of risk assessments for the TACs, which are used by the California Air Resources Board for their Air Toxics Control Measures. We also provide the methodological guidelines and health protective standards for the Hot Spots program, which are used by local Air Quality Management Districts in regulating stationary sources of TACs and other air pollutants. One of our current activities under this program is the development of Chronic Reference Exposure Levels, of which we have completed approximately 75. Recent projects include a chronic reference exposure level for crystalline silica. For these assessments we have recently emphasized the use of benchmark concentration methodology, using several software packages including the US EPA's BMDS. In 2002 I attended a consultative meeting organized by US EPA to share experiences and recommendations for the use and further development of this package. This program also provides Acute Reference Exposure Levels, exposure assessment guidelines, and carcinogenicity guidelines for air toxics. Carcinogenic potency methodology used to date has included both standard and time-dependent versions of the linearized multistage model, and also the benchmark dose approach proposed in the US EPA's new carcinogen risk assessment guidelines. My staff and I recently completed a cancer risk assessment of naphthalene, and we are currently finalizing a cancer risk assessment for ethylbenzene. I have also contributed to an updated effects assessment for environmental tobacco smoke (ETS), which was developed to support the recent listing by the California Air Resources Board of ETS as a Toxic Air Contaminants under California's AB1807 regulations.

We are currently evaluating of all the Air Toxics public health standards to determine whether these are protective of the health of children and other potentially sensitive sub-populations, in response to California's recent Children's Environmental Health Protection legislation ("SB25"). We developed a prioritization scheme to select the first five standards for re-evaluation, and are now working on revisions to the risk assessment guidelines for cancer and non-cancer effects, which are used in California Air Toxics programs. New carcinogenicity guidelines will emphasize benchmark dose methods and weighting factors for early-in-life exposures. Revised non-cancer risk assessment guidelines emphasize the use of benchmark dose methods, compound-specific pharmacokinetic models, and explicit consideration of differential impacts on infants and children. We are consulting and collaborating regularly with U.S.EPA staff and academic researchers on the development of this new methodology. Eventually all the current Air Toxics standards will be re-evaluated.

I was editor and contributing author of the health effects section of the report "Health and Environmental Assessment of the Use of Ethanol as a Fuel Oxygenate" delivered to the California Environmental Policy Council in December 1999.

I have been principal or contributing author of a number of health risk assessment of potentially carcinogenic chemicals in drinking water, including Public Health Goal documents on MTBE, DEHP, and perchloroethylene. I also worked for a number of years for the program that supplies technical support for the Proposition 65 program, and prepared several documents providing prioritization, hazard identification and dose-response assessments of carcinogenic chemicals.

Earlier research activities included a range of biochemical and toxicological studies (including inhalation exposure studies) undertaken at academic and commercial laboratories. Interests

included chemical carcinogenesis, pharmacokinetics and metabolism (including biophysical and cell culture studies of cytochrome P-450, and metabolism studies *in vivo* and *in vitro* of pesticides and volatile halocarbons), and neurobehavioral studies of hydrocarbon solvents. I also studied toxic effects of methyl isocyanate, working with epidemiologists who were examining the after-effects of the Bhopal disaster.

My list of publications currently includes 89 items, comprising articles in scientific journals and books, and conference presentations with peer-reviewed and published abstracts. This does not include the numerous internal technical reports and State of California regulatory or guidance documents to which I have contributed.

PUBLICATIONS

1. DJ Birkett, NC Price, GK Radda and AG Salmon (1970). The reactivity of SH groups with a fluorescent reagent. *FEBS Letters* **6**: 346
2. DJ Birkett, GK Radda and AG Salmon (1970). A fluorescent probe for the dimer to tetramer conversion of phosphorylases a and b. *FEBS Letters* **11**: 295
3. DJ Birkett, RA Dwek, GK Radda, RE Richards and AG Salmon (1971). Probes for the conformational transitions of phosphorylase b. *Eur J Biochem* **20**: 494
4. A Bennick, ID Campbell, RA Dwek, NC Price, GK Radda and AG Salmon (1971). Relationship between conformationally sensitive probe binding sites on phosphorylase b. *Nature New Biology* **243**: 10
5. RA Dwek, GK Radda, RE Richards and AG Salmon (1972). Probes for the conformational transition of phosphorylase a. *Eur J Biochem* **29**: 509
6. L Vickery, AG Salmon and K Sauer (1975). Magnetic circular dichroism studies on microsomal aryl hydrocarbon hydroxylase: Comparison with cytochrome b_5 and cytochrome P-450_{cam}. *Biochem Biophys Acta* **386**: 87-98
7. JC Bartholomew, AG Salmon, HB Gamper, M Calvin (1975). Benzo(a)pyrene effects on mouse epithelial cells in culture. *Cancer Research* **35**: 851
8. AG Salmon, T Green and DE Hathway (1976). Enzymes involved in vinyl chloride-biotransformation. (Poster). IUB International Congress of Biochemistry, Hamburg
9. AG Salmon (1976). Cytochrome P-450 and the metabolism of vinyl chloride. *Cancer Letters* **2**: 109
10. AG Salmon (1977). Possible mutagenic metabolites of vinyl chloride. 1st Annual Meeting, UK Section, European Environmental Mutagen Society, Manchester
11. WC Mackrodt, RB Jones, AG Salmon and J Ashby (1978). An attempt to correlate the calculated stability of a series of epoxides with the known properties of their alkene precursors. 17th Annual Meeting, Society of Toxicology, San Francisco. Abstract: *Toxicol Appl Pharmacol* **45**: 314
12. AG Salmon, WC Mackrodt, RB Jones, SK Basu and J Ashby (1978). An investigation of the dechlorination of a series of haloalkanes by rat liver microsomes and its possible role in the expression of toxic phenomena. 17th Annual Meeting, Society of Toxicology, San Francisco. Abstract: *Toxicol Appl Pharmacol* **45**: 327
13. AG Salmon (1979). Structure-activity relationships in the toxicity of halogenated ethanes. Drug Metabolism Group, Alderley Park, February 1979.

14. AG Salmon and D McGregor (1979). Mutagenicity of halocarbons under anaerobic conditions. 3rd Annual Meeting, UK Section, European Environmental Mutagen Society, Bath, April 1979
15. AG Salmon and JA Nash (1980). Reductive dechlorination of halocarbons. Drug Metabolism Group, Cardiff, February 1980
16. AG Salmon, JA Nash and C Rhodes (1980). Reductive dechlorination of hexachloroethane. British Toxicology Society, Leicester, September 1980
17. AG Salmon, JA Nash, I Pratt and C Rhodes (1981). Biochemical responses of the liver of halocarbons. British Toxicology Society, York, March 1981
18. AG Salmon and WM Provan (1981). Automated data analysis for excretion balance and tissue retention studies. British Toxicology Society, Canterbury, September 1981
19. AG Salmon, RB Jones and WC Mackrodt (1981). Microsomal dechlorination of chloroethanes: Structure-reactivity relationships. *Xenobiotica*, **11**: 723
20. CJ Purnell, AG Salmon and J Wakefield (1984). Analytical problems associated with occupational hygiene air monitoring in biotechnological workplaces. Poster presentation at symposium: "Analytical Methods and Problems in Biotechnology". Noordwijkerhout (April 1984) Abstract: *Trends in Analytical Chemistry* **3**(9): XI
21. AG Salmon, CM Walklin and RB Freedman (1984). Dechlorination of haloethanes by microsomes and cytochrome P-450. Poster presentation at 6th International Symposium on Microsomes and Drug Oxidations, Brighton, August 1984
22. AG Salmon, JA Nash, CM Walklin and RB Freedman (1985). Dechlorination of halocarbons by microsomes and vesicular reconstituted cytochrome P-450 systems under reductive conditions. *Brit J Ind Med* **42**: 305-311
23. AG Salmon and VJ Cunningham (1985). Computers in Toxicology - a perspective view. *Medical Informatics* **10**: 103-105
24. AG Salmon and R Ogilvie (1985). Clinical Pharmacokinetics: Study Control Programme. British Toxicology Society, York (March 1984) Abstract: *Medical Informatics* **10**: 175
25. AG Salmon (1985): Vinyl chloride - the evidence for human carcinogenicity in different target organs. *Brit J Ind Med* **42**: 73-74
26. N Andersson, M Kerr Muir, AG Salmon, CJ Wells, RJ Brown, CJ Purnell, PC Mittal and V Mehra (1985). Bhopal Disaster: Eye follow-up and analytical chemistry. *The Lancet* **1985(i)**: 751-762
27. AG Salmon, S Chen and HA Waldron (1985). The effect of white spirit vapour exposures on behaviour of the rat British Toxicology Society, Newcastle (September 1984). Abstract: *Human Toxicology* **4** 108
28. DC Brown, AG Salmon (1985). The metabolism of n-octane, a component of white spirit. British Toxicology Society, Newcastle (September 1984). Abstract: *Human Toxicology* **4**: 109
29. AG Salmon (1985). Does acute toxicology tell us anything useful? - Methyl isocyanate as a test case. *Brit J Ind Med* **42**: 577-578
30. AG Salmon, M Kerr Muir, N Andersson (1985). Acute toxicity of Methyl Isocyanate: A preliminary study of the Dose Response for eye and other effects. *Brit J Ind Med* **42**: 795-798
31. N Andersson, M Kerr Muir, V Mehra and AG Salmon (1985). Exposure and Response to MIC: results of a community based survey in Bhopal. *Indian J Medical Research* **82** Supplement, December 1985

32. AG Salmon, N Andersson and M Kerr Muir (1985). Toxicity of Methyl Isocyanate: the current picture. *Indian J Medical Research* **82** Supplement, December 1985
33. AG Salmon (1986). Eye injuries from industrial chemicals. *Occupational Health* **38**: 125-127
34. AG Salmon (1986). Bright red blood of Bhopal victims: cyanide or MIC? *Brit J Ind Med* **43**: 502
35. AG Salmon, M Kerr Muir and N Andersson (1986). Comparison of toxicology and epidemiology for methyl isocyanate at Bhopal British Toxicology Society, York (September 1986). Abstract: *Human Toxicology* **5**: 410-411
36. N Andersson, M Kerr Muir, MK Ajwani, S Mahashabde, AG Salmon and K Vaidyanathan (1986). Persistent eye watering among Bhopal survivors. *The Lancet* **1986(ii)**: 1152
37. T Gassert, C Mackenzie, M Kerr Muir, N Andersson and AG Salmon (1986). Long term pathology of lung, eye and other organs following acute exposure of rats to methyl isocyanate. *The Lancet* **1986(ii)**: 1403
38. World Health Organization, Regional office for the Eastern Mediterranean. (1986) Consultation Meeting on preparation of guidelines for development of curricula on toxic chemical control. Gabes, Tunisia, 23-27th June 1986. Chairman, K Chkir. Vice-Chairman, A Massoud. Rapporteurs, V Foa, AG Salmon. WHO/EMRO, Alexandria.
39. AG Salmon, K Cameron and M Kerr Muir (1987). Acute and delayed effects of methyl isocyanate on the eye. British Toxicology Society, Oxford (March 1987). Abstract: *Human Toxicology* **6**: 441-442
40. K Cameron and AG Salmon (1987). Effect of chemicals on reproduction. *Occupational Health* **1987(Dec)** 396-398
41. Andersson, M Kerr Muir, V Mehra and AG Salmon Exposure and Response to MIC: results of a community based survey in Bhopal. *Brit J Ind Med* **45**: 469-475
42. AG Salmon (1990). Toxicity testing of industrial chemicals. In: *Industrial Health Practice*, 3rd Ed. (HA Waldron, Editor) Butterworths, London.
43. AG Salmon *In vitro* studies on metabolism. In: *Xenobiotic Metabolism and Disposition: The design of Studies on Novel Compounds* (HPA Illing, Editor). CRC Press, Boca Raton, Florida, 1989. pp 171-191.
44. AG Salmon, P Painter, D Landy, T McDonald and L Zeise (1989). The use of time and dose dependent models in potency estimation of urethane. Presented at Northern California Chapter, Society of Toxicology: 3rd Annual Meeting, San Francisco, May 1989.
45. AG Salmon, P Painter, D Landy and L Zeise (1989). Consistent estimates of urethane carcinogenic potency using pharmacokinetic and time dependent models. Presented at Society for Risk Analysis, Annual Meeting, 29th October - 1st November 1989, San Francisco. In: *Advances in Risk Analysis, Vol 9; The Analysis, Communication and Perception of Risk.* Garrick BJ, Gekler WC, Eds. Plenum Publishing Corp., New York, NY, 1989.
46. AG Salmon and WN Choy (1989). Carcinogenicity and genotoxicity of food contaminants: urethane and aflatoxins. Presented at Genetic and Environmental Toxicology Association of Northern California (GETA), Fall Meeting, 1st December 1989, San Francisco.

47. L Zeise, JE Huff, AG Salmon and NK Hooper (1990). Overview of human risk from environmental exposure to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin and hexachlorodibenzo-*p*-dioxins. pp 293-342, in: *Advances in Modern Environmental Toxicology* Vol **17**: Environmental and Occupational Cancer: Scientific Update, 1990 (MA Mehlman, Editor). Princeton University Press, Princeton, NJ, 1990, 347 pp.
48. JE Huff, AG Salmon, NK Hooper and L Zeise (1991). Long-term carcinogenesis studies on 2,3,7,8-tetrachlorodibenzo-p-dioxin and hexachlorodibenzo-*p*-dioxins. *Cell Biology and Toxicology* **7**(1): 67-94.
49. AG Salmon, RJ Jackson and MT Smith (1991). Chloral hydrate: cancer risk assessment of a drug previously presumed safe. Presented at the Society of Toxicology Annual Meeting, Dallas, TX, February 1991. Abstract: *The Toxicologist* **11**(1): 350.
50. AG Salmon and L Zeise, Editors (1991). Risks of carcinogenesis from urethane exposure. (Book with 6 chapters, AGS also principal or contributing author for 5 chapters). CRC Press, Boca Raton, Florida, 231 pp.
51. AG Salmon, L Monserrat and JP Brown (1992). Use of a pharmacokinetic model in cancer risk assessment for vinyl bromide. Presented at the Society of Toxicology Annual Meeting, Seattle, WA, February 1992. Abstract: *The Toxicologist* **12**(1): 96.
52. AG Salmon (1992). Cancer Risk Assessment. Presented at the American Chemical Society Annual Meeting, San Francisco, CA, April 1992.
53. AG Salmon, L. Haroun, L. Zeise and R.J. Jackson (1992). Chloral Hydrate: Criteria for identification as a carcinogen on the basis of suggestive data. Presented at the Society for Risk Analysis Annual Meeting, San Diego, CA, December 1992.
54. AG Salmon, KW Kizer, L Zeise, RJ Jackson, and MT Smith (1995). Potential carcinogenicity of chloral hydrate - a review. Journal of Toxicology; Clinical Toxicology 33(2):115-121.
55. JP Brown and AG Salmon (1996). Issues in Data Extrapolation. In: Toxicology and Risk Assessment: Principles, Methods and Applications. Eds. Fan AM, Chang LW. Marcel Dekker, New York, 1996.
56. JP Brown, AG Salmon, RA Howd, F Bois and L Zeise (1996). Use of pharmacokinetic modeling in cancer risk assessments for regulatory purposes. Presented at the Society of Toxicology Annual Meeting, Anaheim, CA, March 1996. Abstract: *The Toxicologist* **30**(1.2): 114.
57. AG Salmon, M Sandy and L Zeise (1996). Categorical *versus* narrative carcinogen identification systems. Presented at the Society of Toxicology Annual Meeting, Anaheim, CA, 1996. Abstract: *The Toxicologist* **30**(1.2): 3.
58. MS Sandy, PA Painter, AG Salmon, J Rabovsky and L Zeise (1998). Hazard identification in the face of limited mechanistic data: 5-chloro-o-toluidine, 2,4,5-trimethylaniline, and quinoline. Presented at the Society of Toxicology Annual Meeting, Seattle, WA, March 1998. Abstract: *The Toxicologist* **42**(1-S): 59.
59. JB Faust, J Bankowska, Y Wang, JP Brown, AG Salmon, J Budroe and D Morry (1998). California public health goals for selected carcinogens in drinking water: alachlor, benzo[a]-pyrene, chlordane, di(2-ethylhexyl) phthalate, and pentachlorophenol. Presented at the Society of Toxicology Annual Meeting, Seattle, WA, March 1998. Abstract: *The Toxicologist* **42**(1-S): 223.

60. AG Salmon, JP Brown, J Budroe, M Campbell, JB Faust and L Zeise (1998). Dose-response methodology and uncertainty analysis for di(2-ethylhexyl) phthalate (DEHP). Presented at the Society of Toxicology Annual Meeting, Seattle, WA, March 1998. Abstract: *The Toxicologist* **42**(1-S): 226.
61. JF Collins, JP Brown, GV Alexeeff and AG Salmon (1998). Potency Equivalency Factors for some polycyclic aromatic hydrocarbons and polycyclic aromatic hydrocarbon derivatives. *Regulatory Toxicol Pharmacol* **28**: 45-54.
62. AG Salmon, JP Brown, MS Sandy, Y Wang and AM Fan (1999). Cancer risk assessment of methyl t-butyl ether (MTBE) for California drinking water. Presented at the Society of Toxicology Annual Meeting, New Orleans, LA, March 1999. Abstract: *The Toxicologist* **48**(1-S): 401.
63. AG Salmon, EW Fanning, JP Brown, and AM Fan (2000). Risk assessment of tetrachloroethylene (PCE) for California drinking water. Presented at the Society of Toxicology Annual Meeting, Philadelphia, PA, March 2000. Abstract: *The Toxicologist* **54**(1-S): 421.
64. A Fan, J Brown, T McDonald, T Parker, Y Wang, DTing, A Salmon, D Morry, M DiBartolomeis, G Alexeef, H Russell and E Hernandez (2000). Risk assessment of aluminium, benzene, carbofuran, carbon tetrachloride, dichloromethane, diquat, nickel, simazine, tetrachloroethylene, thiobencarb, uranium and vinyl chloride in drinking water. Presented at the Society of Toxicology Annual Meeting, Philadelphia, PA, March 2000. Abstract: *The Toxicologist* **54**(1-S): 421.
65. RA Howd, JP Brown, DW Morry, YY Wang, J Bankowska, JD Budroe, M Campbell, MJ DiBartolomeis, J Faust, L Jowa, D Lewis, T Parker, J Polakoff, DW Rice, AG Salmon, RS Tomar and AM Fan. (2000). Development of California Public Health Goals (PHGs) for chemicals in drinking water. *J Appl Toxicol* 20(5):365-80
66. RA Howd, J Bankowska, JP Brown, L Jowa, TA McDonald, D Morry, T Parker, AG Salmon, D Ting, RS Tomar, Y Wang, and AM Fan. (2001). Development of California Public Health Goals for chemicals in drinking water. Presented at the Society of Toxicology Annual Meeting, San Francisco, CA, March 2001. Abstract: *The Toxicologist* **60**(1-S): 432.
67. MA Marty, AG Salmon, D Morry, M Miller, J Brown, J Budroe, J Collins, S Dawson, D Lewis, T McDonald, J Polakoff, P Raymond and B Winder (2002). Prioritization of Toxic Air Contaminants under the California Children's Environmental Health Protection Act. Presented at the Society of Toxicology Annual Meeting, Nashville, TN, March 2002. Abstract: *The Toxicologist* **66**(1-S): 740.
68. AG Salmon and T Meehan (2002). Potential impact of environmental exposures to polycyclic organic material (POM) on children's health. Presented at the Society of Toxicology Annual Meeting, Nashville, TN, March 2002. Abstract: *The Toxicologist* **66**(1-S): 740.
69. D Shusterman, E Matovinovic and A Salmon (2002). Does Haber's Law predict sensory irritation? Presented at the Annual Meeting of the Association for Chemoreception Sciences. Sarasota, FL, April 24-28, 2002.
70. AG Salmon, JP Brown, JF Collins, and MA Marty (2003). Evaluation of alternate dose metrics for benzo[a]pyrene inhalation cancer potency using a nasal-PBPK hamster model. Presented at the Society of Toxicology Annual Meeting, Salt Lake City, UT, March 2003. Abstract #411: *The Toxicologist* **72**(S-1): 85.

71. JF Collins, AG Salmon, JP Brown, DC Lewis, DE Dodge, MA Marty and GV Alexeeff (2003). Use of benchmark concentration methodology in risk assessment for air toxics. Presented at the Society of Toxicology Annual Meeting, Salt Lake City, UT, March 2003. Abstract #688: *The Toxicologist* **72**(S-1): 142.
72. JD Budroe, AG Salmon, and MA Marty (2003). Acute and cancer risk assessment values for *tert*-butyl acetate. Presented at the Society of Toxicology Annual Meeting, Salt Lake City, UT, March 2003. Abstract #692: *The Toxicologist* **72**(S-1): 143.
73. JB Faust, AG Salmon, C Sherman, MS Sandy and L Zeise (2003). Estimation of the carcinogenic potential of polycyclic aromatic hydrocarbons. Presented at the Society of Toxicology Annual Meeting, Salt Lake City, UT, March 2003. Abstract #686: *The Toxicologist* **72**(S-1): 141.
74. JF Collins, AG Salmon, JD Budroe, MA Marty and GV Alexeeff (2004). Available toxicity data on alternative dry cleaning chemicals. Presented at the Society of Toxicology Annual Meeting, Baltimore, MD, March 2004. Abstract #1789: *The Toxicologist.* **78**(1-S): 368.
75. JD Budroe, JP Brown, AG Salmon and MA Marty (2004). Acute toxicity and cancer risk assessment values for *tert*-butyl acetate. *Regulatory Toxicology and Pharmacology*, **40**(2):168-176.
76. AG Salmon, JP Brown and S Hoover (2004). Impact of early mortality on calculation of slope factors from bioassay data: naphthalene as an example. Presented at the Society for Risk Analysis Annual Meeting, Palm Springs, CA, December 2004. Abstract #M21.2.
77. JP Brown, ME Tarter and AG Salmon (2004). Comparison of a "tolerance bound" method with the multistage-Weibull time-to-tumor carcinogenicity potency estimation. Presented at the Society for Risk Analysis Annual Meeting, Palm Springs, CA, December 2004. Abstract #M8.2.
78. GV Alexeeff, W Tong, R Broadwin and AG Salmon (2005). Development of acute emergency guideline levels (AEGLs) using benchmark dose methodology to calculate potentially lethal exposures. Presented at the Society of Toxicology Annual Meeting, New Orleans, LA, March 2005. Abstract #1476: *The Toxicologist.* **84**(S-1): 300.
79. AG Salmon, MD Miller and MA Marty (2005). Interspecies site concordance for mammary carcinogenesis by environmental tobacco smoke. Presented at the Society of Toxicology Annual Meeting, New Orleans, LA, March 2005. Abstract #1519: *The Toxicologist.* **84**(S-1): 310.
80. S Hoover, JP Brown, AG Salmon, MS Sandy, L Zeise and MA Marty (2005). Cancer risk estimation for exposure to naphthalene. Presented at the Society of Toxicology Annual Meeting, New Orleans, LA, March 2005. Abstract #1521: *The Toxicologist.* **84**(S-1): 310.
81. JD Budroe, R Fears, F Collier, AG Salmon and MA Marty (2005). A quantitative cancer risk assessment for airborne asbestos generated by vehicular traffic on a road paved with asbestos-containing serpentine rock. Presented at the Society of Toxicology Annual Meeting, New Orleans, LA, March 2005. Abstract #2109: *The Toxicologist.* **84**(S-1): 432.
82. JF Collins, AG Salmon, JP Brown, MA Marty and GV Alexeeff (2005). Development of a chronic inhalation reference exposure level for respirable crystalline silica. Presented at the Society of Toxicology Annual Meeting, New Orleans, LA, March 2005. Abstract #2111: *The Toxicologist.* **84**(S-1): 432.
83. JF Collins, AG Salmon, JP Brown, MA Marty and GV Alexeeff (2005). Development of a chronic inhalation reference level for respirable crystalline silica. *Regul Toxicol Pharmacol.* **43**:292-300.

84. AG Salmon (2006). Chapter 23: Risk Assessment for Chemical Carcinogens. In: *Molecular Carcinogenesis and the Molecular Biology of Human Cancer* (JR Landolph and D Warshawsky, Eds.), pp. 501-545. CRC Press/Taylor and Francis, Boca Raton, FL.
85. Y Kuwubara, GV Alexeeff, RL Broadwin and AG Salmon (2006). Evaluation of the RD_{50} for determining acceptable levels of exposure to airborne sensory irritants. Presented at the Society of Toxicology Annual Meeting, San Diego, CA, March 2006. Abstract #882: *The Toxicologist.* **90**(1): 179.
86. GV Alexeeff, KK Deng, RL Broadwin and AG Salmon (2006). Benchmark dose evaluation for human irritation. Presented at the Society of Toxicology Annual Meeting, San Diego, CA, March 2006. Abstract #901: *The Toxicologist.* **90**(1): 183.
87. J Yang and AG Salmon (2006). PCB congener-specific risk assessment. Presented at the Society of Toxicology Annual Meeting, San Diego, CA, March 2006. Abstract #1605: *The Toxicologist.* **90**(1): 328.
88. JP Brown, JF Collins, AG Salmon, MA Marty and GV Alexeeff (2006). Use of benchmark dose methodology on human non-cancer data to develop protective criteria for child exposures to arsenic. Presented at the Society of Toxicology Annual Meeting, San Diego, CA, March 2006. Abstract #2185: *The Toxicologist.* **90**(1): 448.
89. D Shusterman, E Matovinovic and AG Salmon (2006). Does Haber's Law apply to human sensory irritation? *Inhalation Toxicol.* **18:** 457-471.
90. MD Miller, MA Marty, R Broadwin, KC Johnson, AG Salmon, B Winder and C Steinmaus (2006). The association between exposure to environmental tobacco smoke and breast cancer: A review by the California Environmental Protection Agency. *Preventive Medicine,* in press. doi:10.1016/j.ypmed.2006.08.015

Curriculum Vitae
Thomas F. Parkerton

Education

B.S. Environmental Science, Rutgers University, New Brunswick, NJ - 1983
M.S. Aquatic Biology, University of North Texas, Denton, TX - 1986
M.S. Environmental Engineering & Science, Manhattan College, Riverdale, NY -1989
Ph.D. Exposure Assessment, Rutgers University, New Brunswick, NJ - 1993

Work Experience

Senior Science Associate, 2006

Advanced Scientific Associate, ExxonMobil Biomedical Sciences, 2003

- Develop and apply methods for risk assessment of complex petroleum products
- Direct and coordinate long range industry research in environmental sciences
- Support risk assessment and environmental research on phthalate esters
- Provide ad-hoc technical support in addressing environmental issues related to Exxon Mobil product and operations

Ecotoxicology Advisor, ExxonMobil Chemical Europe, Middle East & Africa, 1999 - 2002

- Provided science advocacy support for Product Stewardship and Regulatory Affairs
- Developed and communicated technical positions to regulatory authorities on behalf of industry for the European Union Existing Substances Risk Assessment Regulation and other legislative directives
- Served as industry expert to a variety of trade association's dealing with environmental fate and effects of petrochemicals
- Coordinated internal and eternal applied research programs to support science-based regulatory decision-making and responsible care principles

Staff Ecotoxicologist, Exxon Biomedical Sciences, 1992-1998

- Provided technical advice to Exxon affiliates world-wide on environmental issues pertaining to products and facility operations
- Develop applied research programs to assist affiliates in cost-effectively addressing regulatory requirements and emerging environmental issues
- Lead environmental research programs and advocacy support for the US & European phthalate ester industry

Research Engineer & Faculty Associate, Manhattan College, 1987-1992

- Developed mathematical models to predict environmental fate and effects of chemicals and mixtures
- Conducted experimental research in support of model calibration
- Applied statistical techniques to quantify uncertainty in model predictions
- Engaged in graduate and undergraduate teaching and mentoring

Research Scientist, University of North Texas, 1986-1987

- Investigated environmental fate/speciation of chromium compounds in natural waters, sediment and soils via lab research and geochemical modeling (MINTEQ)
- Provided laboratory support for a number of consulting projects dealing with water or whole effluent quality issues
- Supervised and trained laboratory personnel

Research & Teaching Associate, University of North Texas, 1983-1986

- Prepared protocols for the culture and testing of aquatic organisms
- Performed whole effluent toxicity identification evaluations (TIEs)
- Conducted research on the kinetics, speciation and bioavailability of zinc in the aquatic environment

Soil Technician, Testwell Labs, 1982-1983

- Conducted field and laboratory analyses of soil in support of construction industry

Publications

Dimitrov, S., N. Dimitrova, T. Parkerton, M. Comber, M. Bonnell, O. Mekenyan (2005), Base-Line Model for Identifying the Bioaccumulation Potential of Chemial;s, *SAR & QSAR Env. Res*. 16(6):531-554.

Philip Howard, William Meylan, Dallas Aronson, William Stiteler, Jay Tunkel, Michael Comber and Thomas F. Parkerton. 2005: A New Biodegradation Prediction Model Specific to Petroleum Hydrocarbons. Environmental Toxicology and Chemistry: Vol. 24, No. 8, pp. 1847–1860.

Woods, R.W., D.J. Letinski, E.J. Febbo, C.L. Dzamba, M. J. Connelly, T.F. Parkerton Assessing the Aquatic Hazard of Commercial Hydrocarbon and Rosin Resins, (In Press), Ecotox & Environmental Safety.

Foster. K.l., D. Mackay, T.F. Parkerton, E. Webster, L. Milford (2005). A Five Stage Risk Assessment Strategy for Mixtures: Gasoline As A Case Study, *Environ. Sci. Technol.* 39:2711-2718.

McGrath JA, Hellweger FL, Parkerton TF, Di Toro DM. (2005). Application of the Narcosis Target Lipid Model to Complex Mixtures Using Gasolines as a Case Study, *Environ. Toxicol. Chem*. 24:2382-2394

McGrath, J.A., T.F. Parkerton, and D.M. Di Toro (2004). Application of the narcosis target lipid model to algal toxicity and deriving predicted no effect concentrations. Environ. Toxicol. Chem., 23(10):2503–2517.

MacLeod,M., T. E. McKone, K. Foster, R. L. Maddalena, T. F. Parkerton, D. Mackay (2004). Applications of Contaminant Fate and Bioaccumulation Models in Assessing Ecological Risks of Chemicals: A Case Study for Gasoline Hydrocarbons, Environ. Sci. Technol. 38(23); 6225-6233

Parkerton, T.F., C.A. Staples (2003). An Assessment of the Potential Environmental Risks Posed by Selected Phthalates in Soil and Sediment, In: Handbook of Environmental Chemistry: Phthalate Esters, edited by C. Staples, Springer-Verlag, Heidelberg, New York, 317-350.

Cousins, I., D. Mackay, T. Parkerton (2003). Physical Chemical Properties and Evaluative Fate Modeling of Phthalate Esters, In: Handbook of Environmental Chemistry: Phthalate Esters, edited by C. Staples, Springer-Verlag, NY, In Press.

Gobas, F.A.P.C, C. E. Mackintosh, G. Webster, M. Ikonomou, T. F. Parkerton, K. Robillard (2002). Bioaccumulation of Phthalate Esters in Aquatic Food-Webs, In: Handbook of Environmental Chemistry: Phthalate Esters, edited by C. Staples, Springer-Verlag, NY, 201-226.

Parkerton. T.F. (2001). A Preliminary Analysis of Benzene Fate in Industrial Wastewater Treatment Plants: Implications for the EU Existing Substances Risk Assessment, Report submitted to the CEFIC Aromatic Producers Association, Brussels, Belgium, 17 pp.

Broschard,T., V. Koch, S. Müller, T. Parkeron, I. Schoeters, C. Stevens, F. Van Assche, A. Willing, M. (2003). Environmental Risk Assessment of Substances with Unique Properties, ECTOC Technical Report , Brussels Belgium, In Press.

Jaworska. J. ,T. Parkerton, E. Thompson (2001) Summary of the CEFIC's ad-hoc QSAR group's Preliminary Evaluation of the Danish EPA's self-advisory QSAR classification system, report to CEFIC, Brussels, Belgium, 15pp.

Armstrong, T.W., R. T. Zaleski, W. J. Konkel and T. J. Parkerton (2002). A tiered approach to assessing children's exposure: a review of methods and data, *Toxicology Letters*, 12(1-3):111-119

Letinksi, D.J., M.J. Connelly, Jr., D.R. Peterson, T.F. Parkerton (2002). Slow-Stir Water Solubility Measurements of Selected Alcohols and Diesters, *Chemosphere* 48(3):257-265.

King, D., M. Bradfiled, P. Falkenback, T. Parkerton, D. Peterson, E. Remy, R. Toy, M. Wright, B. Dmytrasz, D. Short (2001). Environmental Classification of Petroleum Substances, Summary Data and Rationale, CONCAWE Report No. 01/54, Brussels, Belgium, 138pp.

Parkerton, T.F., W.J. Konkel. Application of Quantitative Structure Activity Relationships for Assessing the Ecotoxicity of Phthalate Esters (2000), *Ecotox. & Environ. Safety* 45:61-78.

Call, D.J. , T.P. Markee, D.L. Geiger, L.T. Brooke, F.A. Vande Venter, D.A. Cox, K.I. Genisort, K.A. Robillard, J.W. Gorsuch, T.F. Parkerton, M.C. Reiley, G.T. Ankley, D.R. Mount. An Assessment of Phthalate Esters to Freshwater Benthos 1. Aqueous Exposures. (2001) *Environ. Toxicol. Chem.20(8):1798-1804.*

Call, D.J., C.A. Cox, D.L. Geiger, K.I. Genisot, T.P. Markee, L.T. Brooke, C.N. Polkinghorne, F.A. Vande Venter, K.A. Robillard, J.W. Gorsuch, T.F. Parkerton, M.C. Reiley, G.T. Ankley,

D.R. Mount, . An Assessment of Phthalate Esters to Freshwater Benthos 2. Sediment Exposures (2001). *Environ. Toxicol. Chem. 20(8):1805-1815.*

Staples, C.A., T.F. Parkerton, D.R. Peterson (2000). A Risk Assessment of Selected Phthalate Esters in North American and European Surface Waters, *Chemosphere* 40:885-891.

Patyna P.J., R.A. Davi, T.F. Parkerton, R.P. Brown, X.R. Cooper, A Proposed Multigeneration Protocol for Japanese Medaka (Oryzias Latipes) to Evaluate Effects of Endocrine Disruptions, *Sci. Total. Environ.* 233: 211 - 220 (1999).

Patyna, P.J., T.F. Parkerton, R.A. Davi, D.J. Letinski, P.E. Thomas, K.R. Cooper, R.P. Brown, Dictionary Diisononyl Phthalate (DINP) and Diisodecyl Phthalate (DIDP). Exposure in the Japanese Medaka (Oryzias Latipes) Multigeneration Assay, Submitted to *Ecotox. Environ. Safety.*

Verbruggen, E.M.J., W.H.J. Vaes, T.F. Parkerton, J.L.M. Hermens (2000). Polyacrylate coated SPME Fibers as a Tool to Simulate Body Residues and Target Concentrations of Complex Organic Mixtures for Estimation of Baseline Toxicity, *Environ. Sci. & Technol. 34(2); 324-331*

Parkerton, T.F., M.A. Stone, D.J. Letinski. Assessing the Aquatic Toxicity of Complex Hydrocarbon Mixtures using Solid Phase Microextraction, *Toxicol. Letters.* 112/113: 273-282.

Kleinow, K., J. Baker, J. Nichols, F. Gobas, T. Parkerton, D. Muir, G. Montverdi, P. Mastrodone. Exposure, Uptake and Disposition of Chemicals in Reproductive and Developmental Stages of Selected Oviparous Vertebrates in: *Reproductive and Developmental Effects of Contaminants in Oviparous Vertebrates*, R.T. Digiulo, D.E. Tillatt; Eds., SETAC Press 1999, pp. 9-112.

D. Van de Meent, T.E. McKone, T.F. Parkerton, M. Matthies, M.E. Scheringer, F. Wania, R. Purdy, D.H. Bennett. Persistence and Transport Potential of Chemicals in a Multimedia Environment, In Proceedings of SETAC Workshop: *Use of Multimedia Models in Regulatory Decision Making for Persistent Organic Pollutants*, SETAC Press, In Press.

Staples, C. A., T.F. Parkerton, W. J. Adams, J. W. Gorsuch, G. R. Biddinger, K. Reinhert. (1997). Aquatic Toxicity of Eighteen Phthalate Esters: A Review, *Environ. Toxicol. Chem.*, 16:875-891.

Staples, C. A., D. R. Peterson, T. F. Parkerton, W. J. Adams (1997). A Literature Review: The Environmental Fate of Phthalate, Chemosphere 35:667-749.

Tell, J. G., T.F. Parkerton (1997). A Comparison of Multi-Media Models Used in Regulatory Decision-Making, *QSARs and SARs in Environ. Res.* 6:29-45.

Parkerton, T.F., M.A. Stone, R.A. Davi, R.V, Thomann, J. Komlos (1996). Reducing the Uncertainty in Modeling the Dietary Transfer of Hydrophobic Contaminants, Report to U.S. Environmental Protection Agency, Cooperative Agreement No. CR821999-01-0, Large Lakes Research Station, Grosse Ile, MI.

Williams, M. D., W. J. Adams, T. F. Parkerton, G. R. Biddinger, K. A. Robillard. (1995). Sediment Sorption Coefficient Measurements for Four Phthalate Esters: Experimental Results and Model Theory, *Environ. Toxicol. Chem.* 14:1477-1486.

Parkerton, T.F., J.P. Connolly, R.V. Thomann, C.G. Uchrin (1993). Do Aquatic Effects or Human Health Endpoints Govern the Development of Sediment-Quality Criteria for Nonionic Organic Chemicals, *Environ. Toxicol. Chem.* 12:507-523.

Thomann, R.V., J.P. Connolly, T.F. Parkerton (1992). An Equilibrium Model of Organic Chemical Accumulation in Aquatic Foodwebs with Sediment Interaction, *Environ. Toxicol. Chem.* 11:615-629.

Thomann, R.V., J.P. Connolly, T.F. Parkerton (1992). Modeling the Accumulation of Organic Chemicals", *Chemical Dynamics in Freshwater Ecosystems*, F.A. Gobas, J.A. McCorquodale, Eds., Lewis Publ. Inc., Boca Raton, FL.

Thomann, R.V., T.F. Parkerton (1991). Preliminary Development and Testing of a Methodology for Developing Water Quality Criteria Intended to Protect Wildlife, *Report submitted to Office of Science & Technology*, USEPA, Washington, DC., 37pp.

Parkerton, T.F. (1991). Development of a Generic Bioenergetics-Based Model for Predicting the Bioaccumulation of Persistent Sediment Associated Contaminants, *Final Report to the New Jersey Department of Environmental Protection*, NJDEP / EIOSHI Predoctoral Fellowship Program, Trenton, N.J.

Parkerton T.F., D.M. Di Toro (1990). Modeling the Fate and Uncertainty of Toxics in the Niagara River, *Report to the U.S. Environmental Protection Agency*, Large Lakes Environmental Protection Agency, Grosse lle, MI.

Parkerton, T.F., S.M. Steward, K.L. Dickson, J.H. Rodgers and F.Y. Saleh (1990). Derivation of Site-Specific Criteria for Zinc: Implications for Waste Load Allocation, *Water Poll. Control Fed.* 61:1636-1644.

Price, E.E., T.F. Parkerton and K.L. Dickson (1990). Use of *Selanastrum capricornutum* and Microfeast @ TM as Food for *Daphnia pulex*, *Bulletin Environ. Contam. Toxicol.* 44:59-66.

Parkerton, T.F. (1989). Surface Water Quality in the United States: New Directions, Future Challenges, *Manhattan College Engineer*.

Di Toro, D.M., J.P. Connolly, T.F. Parkerton and J.R. Newton (1989). Development, Verification and Application of the Interconnecting Channels Models. *Report to the U.S. Environmental Protection Agency*, Environmental Research Laboratory, Office of Research and Development, Duluth, MN.

Saleh, F.Y., T.F. Parkerton, R.V. Lewis, J.H. Huang, K.L. Dickson (1989). Kinetics of Chromium Transformations in the Environment, *Sci. Total Environ*. 86:25-41.

Parkerton, T.F., S.S. Steward, K.L. Dickson, J.H. Rodgers and F.Y. Saleh (1988). Evaluation of the Indicator Species Procedure for Deriving Site-Specific Water Quality Criteria for Zinc. *Aquatic Toxicology and Hazard Assessment, 10th Volume,* ASTM STP 971, American Society for Testing and Materials, Philadelphia.

Gasith, A., K.M. Jop, K.L. Dickson, T.F. Parkerton, S.A. Kaczmarek (1988). Protocol for the Identification of Toxic Fractions in Industry Effluents. *Aquatic Toxicology and Hazard Assessment: 10th Volume,* ASTM STP 971, American Society for Testing and Materials, Philadelphia.

Jop, K.M. T.F. Parkerton, J.H. Rodgers, K.L. Dickson and P.B. Dorn (1987). Comparative Toxicity testing and Specification of Two Hexavalent Chromium Salts in Acute Toxicity Tests. *Environ. Toxicol. and Chem*. 6, 697-703.

Technical Presentations / Posters

Presentations

Comber, M., B. Dmytrasz, C. Eadsforth, D. King , T. Parkerton, R. Toy (2006). Developing a generic risk assessment methodology for petroleum products, Society of Environmental Toxicology & Chemistry, May 8-11, Hague, Netherlands.

Redman, A., J. McGrath, T. Parkerton, D. Di Toro (2006). PETROTOX: CONCAWE's Petroleum Product Ecotoxicity Calculator, Society of Environmental Toxicology & Chemistry, May 8-11, Hague, Netherlands.

Howard, P., W. Meylan, D. Aronson, S. Stewart, T. Parkerton, M. Comber (2006). Prediction of Environmental Fate and Transport Properties in Support of the Hydrocarbon Block Approach to Risk Assessment, Society of Environmental Toxicology & Chemistry, May 8-11, Hague, Netherlands.

Comber, M., B. Dmytrasz, C. Eadsforth, D. King , T. Parkerton, R. Toy (2006). Results and recommendations from current environmental risk assessments for petroleum products, Society of Environmental Toxicology & Chemistry, May 8-11, Hague, Netherlands.

van de Meent, D., M. Comber, T. Parkerton, B. Dmytrasz (2006). Fate-, intake- and characterization factors for calculating environmental risk of petroleum products with the the hydrocarbon block method, Society of Environmental Toxicology & Chemistry, May 8-11, Hague, Netherlands.

Prince, R., T. Parkerton, C. Lee (2006). Development of Primary Aerobic Biodegradation Half-Lives for Hydrocarbons in Water for External Validation of the BioHCWin Model, Society of Environmental Toxicology & Chemistry, May 8-11, Hague, Netherlands.

Redman, A., J. McGrath, T. Parkerton, D. DiToro (2005). Mechanistic fate and effects model to predict the aquatic toxicity of complex petroleum products in laboratory tests, Society of Environmental Toxicology & Chemistry, November 13-17, Baltimore, Maryland.

Redman, A., J. McGrath, D. Di Toro, T. Parkerton (2005). Application of the Narcosis Target Lipid Model to Waste Water Treatment Organisms, Society of Environmental Toxicology & Chemistry, November 13-17, Baltimore, Maryland

Parkerton, T., D. Letinski, E. Febbo, R. Manning, T. Jager (2005). Elucidating the Bioavailability and Ecotoxicity of Soil Hydrocarbons in Laboratory Earthworm Toxicity Tests, Society of Environmental Toxicology & Chemistry Meeting
November 13-17, Baltimore, Maryland, USA.

Stewart, S. D. Aronson, W. Meylan, P. Howard, M. Comber, and T. Parkerton (2005). Improved BCF Prediction for Hydrocarbons, Society of Environmental Toxicology & Chemistry Meeting November 13-17, Baltimore, Maryland, USA.

Parkerton, T., D. Letinski, R. Manning (2005). Assessing the Bioavailability and Narcotic Ecotoxicity of Contaminated Sediments, Presentation made at RETEC sediment bioavailability workshop, October 17, Newark, NJ.

Parkerton, T., D. J. Letinski, E. J. Febbo, R. A. Davi, C. L. Dzamba, M. J. Connelly (2005). Aquatic Hazard Assessment of Petroleum Products Using Biomimetic Solid Phase Microextraction, Fifth World Congress on Alternatives & Animal Use in the Life Sciences, August 21-25, Berlin, Germany.

Parkerton,T., D. Letkinski, E. Febbo, R. Blattenberger, M. Connelly, M. Comber (2005). An Assessment of the Bioconcentration of Isoalkanes by Fish, Society of Environmental Toxicology & Chemistry, May 22-26, Lillie, France.

Parkerton, T., D. Letinski, E. Febbo, C. Dzamba, R. Blattenberger, M. Connelly Assessing Bioconcentration Using A Pragmatic Dietary Bioaccumulation Test (2004) November 15, Fourth Society of Environmental Toxicology & Chemistry World Congress, Portland, Oregon, USA.

Dimitrov, S., N. Dinitrova, T. Parkerton, M. Comber, R. Phillips, G. Veith, O. Mekenyan (2004). QSARs and B-Profile Identification of Chemicals, 14th Society of Environmental Toxicology Europe Meeting, 18-11 April, Prague, Czech Replublic.

Dimitrov, S., T. Pavlov, S. Kotov, M.Comber, T. Parkerton, O. Mekenyan (2003). PREDICTING BIOMAGNIFICATION POTENTIAL OF CHEMICALS ACCOUNTING FOR THEIR METABOLISM, SETAC Europe Annual Meeting, Hamburg Germany.

Davi, R.A., Febbo, E.J., Letinski, D.J. , Yarusinsky, J., Peterson, D.R. , Parkerton, T.F., Blas-Machado, U., Assessment of Chronic Hazard to Rainbow Trout (Oncorhynchus mykiss) from Dietary Exposure to Di-isoheptyl Phthalate (DIHP), Poster Presentation, Society of Environmental Toxicology Annual Meeting, Austin, Texas, November 2003.

Parkerton, T., D. Peterson, M. Comber, C, Lee, J. Givens, D. Letinski, Exxon Mobil Ethoxylated Alcohols As Environmentally Preferred Surfactant, Poster Presentation, Society of Environmental Toxicology Annual Meeting, Austin, Texas, November 2003.

Foster ,K., L. Milford, D. Mackay, T. Parkerton, R. McKee, Risk Assessment of Complex Mixtures: Gasoline as an example of a Complex Substance, Platform Presentation, Society of Environmental Toxicology Annual Meeting, Austin, Texas, November 2003.

Mckee, R., T.F. Parkerton (2003). Risk Assessment of Gasoline,*A General Approach Following the EU TGD*, Presentation made to the European Chemical Bureau Existing Substances Risk Assessment Expert's Group, Arona, Italy, March 12, 2003.

Parkerton, T. (2003). Outline of a Generic Framework for Risk Assessment of Petroleum Products: A CONCAWE Proposal, CONCAWE WORKSHOP Simplifying the Environmental Risk Assessment of Complex Substances, Bilthoven, NL, April 4, 2003.

Parkerton, T. (2003). MSP Concept to Practice: A Pragmatic Test for Assessing Bioaccumulation (the "B" in PBT), Annual EMBSI ASIC meeting, Annandale, NJ, April 24,2003.

Parkerton,T., D. Peterson, D. Letinski, C. Dzamba, M. Connelly, M. Pereira (2002). Predicting the Bioavailability & Ecotoxicity of Petroleum Hydrocarbons in Soils/Sediments, Petroleum Environmental Research Forum Annual Meeting, Anandale, NJ, September 26, 2002.

Parkerton T, Konkel W (2001) Evaluation of the production, consumption, end use and potential emissions of phthalate esters. Prepared for the American Chemistry Council (Draft of November 2000) by Exxon Mobil Biomedical Sciences Inc. (EMBSI), East Millstone, N. J., USA

Armstrong, T.W., R.T. Zaleski, W.J. Konkel, T.F. Parkerton, A Tiered Apprach to Assessing Children;s Exposure: A Review of Methods & Data, EUROTOX , Sept 13, 2001, Ankara, Turkey.

Parkerton, T., Letkinski, D., Febbo, E., Davi, R. Dzambia, C., Connelly, M., Christensen, K., Peterson, D. A Practical Testing Approach for Assessing the Bioaccumulation Potential of Poorly Water Soluble Organic Chemicals, SETAC-Europe 11th Annual Meeting, May 6-10, 2001, Madrid, Spain.

Parkerton, T., Letkinski, D., Febbo, E., Davi, R. Dziamba, C., Connelly, M., Christensen, K., Peterson, D. Biomimetic Extraction as a Cost-Effective Analytical Tool for Determining the Aquatic Toxicity Hazard of Complex Petroleum Products, SETAC-Europe 11th Annual Meeting, May 6-10, 2001, Madrid, Spain.

T. Parkerton (2000). Human Exposure to Phthalate Esters: Research Update and Priorities, Presentation to the phthalate ester annual industry trade association meeting, Saint Louis, Mo, April 10, 2000.

A Novel Solid Phase Extraction Method to Measure Fugacities of Semi-Volatile Chemicals in Biological Samples, SETAC North America 20th Annual Meeting, November 16, 1999, Philadelphia, PA.

Parkerton, T.F., Test Methods for Aquatic Toxicity Assessment of Complex Hydrocarbon Mixtures. Invited lecture at EUROTOX 99, June 29, 1999, Oslo, Norway.

Letinski, D.J., Connelly, M, Parkerton, T.F., Slow-stir Water Solubility Measurements for Phthalate Ester Plasticizers, SETAC-Europe 9th Annual Meeting, May 27, 1999, Leipzig, Germany.

Higher Alcohols Bioconcentration, Influence of Biotransformation, SETAC-Europe 9th Annual Meeting, May 26, 1999, Leipzig Germany.

Bragin, G.E., E.J. Febbo, D.J. Letinski, D. A. Winkelmann, D.R. Petterson, T.F. Parkerton, Measuring Bioconcentration Factors for Volatile Chemicals, SETAC 8th Annual Meeting, Bordeaux, France, 1998

Parkerton, T.F., D.J. Letinski, E.J. Febbo, G.E. Bragin, J.R. Clark, Predicting the Aquatic Toxicity of Complex Hydrocarbon Mixtures Using A Novel Biomimetic Extraction Technique, SETAC 8th Annual Meeting, Bordeaux, France, 1998

Pateyna, S., T.F. Parkerton, R.A. Davi, K.R. Cooper, A Multigeneration Assessment of the Potential Effects of Two Commercial Phthalates on Japanese Medaka (Oryzias latipes), SETAC 8th Annual Meeting, Bordeaux, France, 1998

Parkerton. T.F., Assessing the Risks of Phthalate Esters to Sediment-Dwelling Organisms, SETAC 18th Annual Meeting, San Francisco, CA, 1997

Bragin, G.E., J.R. Clark, E.J. Febbo, D.J. Letinski, T.F. Parkerton, D.R. Petterson. Oil Toxicity: Lethal Loading and Measured Effect Concentrations, SETAC 18th Annual Meeting, San Francisco, CA, 1997

Parkerton, T.F., M.A. Stone. Ecotoxicity on a Stick: A novel Analytical Tool for Predicting the Ecotoxicity of Petroleum Contaminated Samples, SETAC, 17th Annual Meeting, Washington, DC, 1996

Parkerton, T.F. Quantitative Structure Activity Relationships (QSARS) for Assessing the Ecotoxicity of Phthalate Esters, SETAC 17th Annual Meeting, Washington, DC, 1996

Lee, C.L., C.J. Sinko, D.A. Winkelmann, D.R. Peterson, T.F. Parkerton, Ultimate Biodegradation of Dialkyl Phthalate Ester Plasticizers. SETAC 17th Annual Meeting, Washington, DC, 1996

Parkerton, T.F. A Review of Toxicokinetic Parameters for Predicting the Bioaccumulation of Organic Chemicals in Aquatic Organisms, SETAC Europe, 4th Annual Meeting, Brussels, Belgium, 1994

Parkerton, T.F. Predicting Bioaccumulation Factors for Nonionic Organic Chemicals: An Uncertainly Analysis Based on Toxicokinetic Parameters", SETAC, 15th Annual Meeting, Denver, Colorado, 1994

Parkerton, T.F., R.V. Thomann (1992). A Proposed Methodology for Developing Water Quality Criteria to Protect Wildlife. Presented at the National Wildlife Criteria Methodologies Meeting, April 13-16, Charlottesville, V.A., Sponsored by the U.S. Environmental Protection Agency Office of Water.

Parkerton, T.F. (1991). Quantifying Effluent and Receiving Water Quality Using Aquatic Bioassay Data and the Toxic Unit Model. Presented at the 36th Institute in Water Pollution Control, June 6, Manhattan College, Riverdale, NY.

Parkerton, T.F., J.P. Connolly, D.M. Di Toro (1989). Application of the Toxic Unic Concept in Assessing in-Place Sediment Pollutants of the Detroit River. Presented at the Annual Society of Environmental Toxicology and Chemistry Meetings, November 3, Toronto, Canada.

Hall, J.F., E.E. Price, T.F. Parkerton, J.H. Rodgers, Jr. and K.L. Dickson (1987) Strategies for the Development of Sediment Quality Criteria: An Overview. Presented at the South Central Chapter of the Society of Environmental Toxicology and Chemistry, May 6, Shell Development Westhollow Research Center, Houston, TX.

Lewis, R.V., S.J. Huang, T.F. Parkerton, Y. Saleh and K.L. Dickson (1986). Ion Chromatography of Chromium Chemicals. Presented at the Southwest Regional Meeting of the American Chemical Society, December 2-4, Dallas, TX.

Missimer, C.L., J.F. Hall, T.F. Parkerton and J.H. Rodgers, Jr. (1986). The use of the Geochemical Model - MINTEQ- as a Guide to Predicting the Toxicity of Chromium Compounds. Presented at the South Central Chapter of the Society of Toxicology and Chemistry, November 14, School of Pharmacy, Northeast Louisiana Univ., Monroe, LA.

Consulting Reports

Zaleski, R.T., T. F. Parkerton, W. J. Konkel (2000). An Assessment of Di-2-Ethylhexyl Phthalate Exposure for Children. Report prepared for the European Council of Plasticisers and Intermediates (ECPI), a Sector Group of CEFIC, Brussels, Belgium, by Exxon Biomedical Sciences, Inc., Annandale, NJ., 35pp + appendices.

Parkerton, T.F. Local PEC Analysis at Toluene Production & Processing Sites in W. Europe. Prepared on behalf of the Aromatic Producers Association, November 1999

W.J. Konkel, T.F. Parkerton, R.P. Brown. Phthalate Exposure Project: Comprehensive Exposure Database, Report to the Phthalate Esters Panel of the U.S. Chemical Manufacturers Association, July 1999 (final report).

D.R. Peterson and T.F. Parkerton. The Environmental Fate and Effects of Phthalate Monoesters, Report to the European Council of Plasticizers and Intermediates, June 1999

Parkerton, T.F., D.R. Peterson. Comments on the Draft EU Environmental Risk Assessment for Benzene, Report to the Aromatic Producers Association, May 1999.

Honors / Awards
Exxon Chemical Responsible Care Award, 1998

Sigma Xi Research Society, 1992. Society of Environmental Toxicology and Chemistry, Best Student Paper Presentation Award, 1992

New Jersey Department of Environmental Protection and Environmental Occupational and Health Science Institute Pre-Doctoral Fellowship.

Richard M. Fanning Award for Outstanding Graduate Student in Environmental Engineering, Manhattan College, 1989

John J. La Grosa Award for Outstanding Graduate Student in Environmental Sciences, N.J. Water Pollution Control Federation, 1989

Wesley Eckenfelder Research Fellowship, Manhattan College, 1987 - 1988

Served on the Texas Water Commission Advisory Board, Austin, Texas, 1987

J.K.G. Silvey Scholarship for the Biological Sciences, Silvey Society, North Texas State University, 1984

U.S. Environmental Protection Agency Traineeship, 1983 - 1985

Henry Vander Vliet Scholarship for Outstanding Undergraduate Student in Environmental Sciences, N.J. Water Pollution Control Fed., 1983

Graduated Rutgers with highest honors, 1983

Professional Societies
Society of Environmental Toxicology and Chemistry

American Chemistry Society

International Society for Exposure Analysis

Water Environmental Federation

Attachment B: Questionnaire

Conflict of Interest and Bias Questionnaire for Use of WMPT for Comparable Emissions Peer Review

Instructions to Candidate Reviewers

1. Please check one YES/ NO/ DON'T KNOW response for each question.
2. If your answer is YES or DON'T KNOW please provide a brief explanation of the circumstances. We do not desire a lengthy response on this form at this time. We will contact you for additional information as needed.
3. Please make a reasonable effort to accurately answer each question. For example, to the extent a question applies to individuals (or entities) other than you (e.g., spouse, dependents, or their employers), we expect you to make a reasonable inquiry, such as e-mailing the questions to such individuals (or entities) in an effort to obtain the information needed to accurately answer the questions.

Questions

1. Are you (or your spouse or dependents) or your current employer, an author, contributor, or an earlier reviewer of the document(s) being reviewed by this panel?

   YES__ NO__ DON'T KNOW__

2. Do you (or you spouse or dependents) or your current employer have current plans to conduct or seek work related to the subject of this peer review following the completion of this peer review panel?

   YES__ NO__ DON'T KNOW__

3. Do you (or your spouse or dependents) or your current employer have any known financial stake in the outcome of the review (*e.g.*, investment interest in a business related to the subject of peer review)?

   YES__ NO__ DON'T KNOW__

4. Have you (or your spouse or dependents) or your current employer commented, reviewed, testified, published, made public statements, or taken positions regarding the subject of this peer review?

   YES__ NO__ DON'T KNOW__

5. Do you hold personal values or beliefs that would preclude you from conducting an objective, scientific evaluation of the subject of the review?

   YES__ NO__ DON'T KNOW__

6. Do you know of any reason that you might be unable to provide impartial advice or comments on the subject review of the panel?

   YES__ NO__ DON'T KNOW__

7. Are you aware of any other factors that may create potential conflict of interest or bias issues for you as a member of the panel?

   YES__ NO__ DON'T KNOW__

Acknowledgement

I declare that the disclosed information is true and accurate to the best of my knowledge, and that no real, potential, or apparent conflict of interest or bias is known to me except as disclosed. I further declare that I have made reasonable effort and inquiry to obtain the information needed to answer the questions truthfully, and accurately. I agree to inform SRC promptly of any change in circumstances that would require me to revise the answers I have provided.

_____ _____

Candidate Signature Date

Attachment C: Panel Member 1 comments

PEER REVIEW CHARGE QUESTION RESPONSES
Application of WMPT to Rank Comparable Fuels Constituents

Question 1: *Is it reasonable to use the Waste Minimization Prioritization Tool (WMPT) as a starting point for categorizing the relative hazard to human health and the environment posed by stack emissions of the 37 hydrocarbons and oxygenates?*

The US EPA's WMPT is a screening-level assessment tool developed to aid in the evaluation of potential chronic risks to human health and the environment. The tool is intended to prioritize chemicals based on factors relating to their environmental persistence, bioaccumulation potential, and toxicity to both humans and environmental receptors. The WMPT has previously undergone peer-review and, therefore, is not the subject of this review effort. However, to address the charge questions that have been posed to the Review Panel and to evaluate the utility of the WMPT for this purpose, it is necessary to understand the WMPT data inputs, database components, and scoring algorithms.

This question posed to the Review Panel focused on the use of the WMPT as a hazard ranking tool for 37 selected organic compounds thought to be potential components of stack emissions. It is important to note that the WMPT evaluation is not being applied directly to the fuels in question, but rather to stack emissions resulting from combustion of the fuels. The "Peer Review Charge" suggests that the Agency's intended use of this analysis is to guide conclusions regarding the acceptability of these constituents in assessing "emission-comparable" fuels. However, the revised peer-review charge specifically excluded consideration of the role of combustion on the evaluation of fuel-related hazards. It is recommended that the Agency consider the implications of the combustion process on the composition of potential emissions components in terms of the parent constituents, as well as the combustion by-products.

Other issues for consideration include:

- the WMPT model relies upon a hierarchical scheme for assessing toxicity and many of the "screening level values" used were developed for purposes other than that for which they are being used. For example, ambient water quality criteria values represent empirically-based quantities that "if not exceeded" are considered protective of aquatic organisms. Exceedence of these values does not portend adverse effects to exposed organisms; therefore, use of these values as "numerical environmental benchmarks" is inappropriate and will result in conservative estimates of risk.

- The WMPT model relies exclusively on the quality of the data contained in the database and it appears that little assessment of the quality of the data contained within the database is conducted during the assessment process. It should also be noted that very conservative assumptions are employed in the assessment process (e.g., the use of anaerobic sediment degradation half-lifes as a measure of the chemicals environmental persistence).

- It should be particularly noted that the WMPT model considers only toxicity (human and environmental) and exposure potential in the form of environmental fate (in the form of persistence) and bioaccumulation potential. The model does not directly consider actual environmental exposures or exposure pathways. Clearly, when applying the

model to any particular use or situation, consideration must be given to exposure potential and to the data used to estimate exposure potential. This becomes critical when one considers the evaluation of the risks associated with stack emissions. This issue will be discussed later in more detail.

Question 2: *Did EPA reasonably apply the WMPT to develop and implement the Relative Hazard Ranking system for the 37 compounds?*

At face value, it appears that the US EPA did attempt to apply the WMPT uniformly to the hazard ranking for the 37 compounds of interest. However, there are a few issues that should be addressed:

• No justification is provided for why the particular list of 37 compounds was considered. Although this is not part of the formal WMPT process, it certainly should be explained more fully.

• No scientific basis is provided for why ecological toxicity data were not considered in the evaluation process, as is called for in the WMPT (the justification provided suggested that due to time and budget constraints human concern scores were given higher priority). The WMPT requires information on both human and ecological toxicity concerns; as implemented here, only human concerns were considered. (Even though it was stated that high ecological toxicity values would not have affected the categorizations and, thus, the ECF recommendations--although they may have increased the overall chemical scoring).

• No human or ecological toxicity data were available for five of the compounds (1,4 naphthoquinone, isosafrole, propargyl alcohol, safrole, dimethyl phthalate); therefore, it was not possible to derive overall chemical scores. These materials should have been eliminated from consideration as emission-comparable fuel components, until data become available. Concluding that these materials do not represent a hazard seems unjustified and indefensible; absence of information should not imply acceptable hazard.

Question 3: *Based on EPA's application of the WMPT and additional evaluation, is it reasonable to conclude that the 37 ECF constituents can be grouped into the three hazard categories (in descending order of hazard): (1) PAHs and naphthalene; (2) benzene and acrolein; and (3) others?*

Given the data that were provided, the conclusions reached seem consistent with the process. I am concerned, however, about the justification for the three groups.

PAH and naphthalene category: Little justification is provided for the grouping of all PAHs into a common group. It is stated that this approach has been taken to be consistent with the TRI; however, no discussion is provided for why this is appropriate from a hazard assessment perspective and why it was done for the TRI. Examination of Table 2 indicates PAH ranking scores of 1-3 for bioconcentration and human toxicity. Ecological toxicity scores are all "3s" but no justification is provided (there is no appendix table presenting the ecotoxicity scores). Persistence scores were also all "3s" and it is assumed that this is due to the long anaerobic sediment half-lifes (the relevance of this endpoint is questionable and will be discussed later with benzene). The text indicates that all of the compounds contained in the PAH category were assigned the final score of the highest scored constituent and because of this, all of the PAHs

are considered Category A regardless of their constituent-specific scores. As presented, little scientific justification is provided for grouping the PAHs and naphthalene into a common group.

Benzene and acrolein category: Regarding benzene, the “Technical Support Document” provided to the Review Panel indicates "Benzene is a known human carcinogen, very persistent in the environment, a PAH precursor, and very difficult to thermally destroy." I have the following comments on each of these:

- this the first statement is correct— benzene is a known human carcinogen;

- the basis for the second phrase is unclear; the data and the application of the data used in the assessment seems inconsistent with conclusions reached by others. For example, the Canadian water quality guidelines for the protection of aquatic life-benzene (CCME 1999) states "If released into water, environmental fate processes may result in rapid removal from the water column by evaporation (half-life of 5 hours) and volatilization (half-life of 2.7 hours). It does, however, go on to say that “Benzene may be relatively persistent in groundwater, where volatilization is not a viable process. Benzene can be degraded by aerobic bacteria (half-life of 33-384 hours), anaerobic biodegradation (half-life of 28-720 days), and photolysis (half-life of 17 days to 36 years)." Review of the WMPT scoring procedures indicate that sediment half-life data under anaerobic conditions are favored in estimating contaminant persistence. Examination of Table A1 (persistent scoring information) indicates a sediment half-life value of 6,815 hours for benzene-- this is clearly the basis for the persistence score of 3. Although the US EPA closely followed WMPT procedures in reaching this conclusion, one might question the applicability of the WMPT process to the assessment of stack emissions. Benzene, found in stack emissions, is not likely to reach ground water or anaerobic sediments in significant quantities given both its volatility and water solubility. Therefore, it can be argued that the persistence score for benzene would more appropriately be "1” rather than “3.” This would change the overall chemical score for benzene from “7” to “5” and would change its category from “B” to “C” (if based on environmental concerns) and from “6” to “4” or from “B” to “D” (if based on human concerns);

- benzene is a PAH precursor; but so are virtually all organic compounds that go through incomplete combustion; and

- the final statement is somewhat puzzling given that benzene is a major component of gasoline and that particular fuel seems to undergo reasonable thermal destruction in automobiles.

The important point here is that although the WMPT is a useful screening tool for evaluating the hazard of particular compounds it should not be used blindly. The application of this tool must take into consideration "real-world" conditions and plausible environmental fate pathways to ensure that erroneous conclusions are not reached.

Regarding the categorization for acrolein; the justification provided for the "special characterization" is unclear. The text states that "Acrolein's very high inhalation toxicity further brings into question the relevance of its low bioaccumulation score." The available toxicity data suggests that acrolein is a potent inhalation toxicant. The relationship between this point and its proclivity to accumulate in body tissues (i.e. bioaccumulation score) is unrelated. Many potent

inhalation intoxicants are extremely water-soluble and thus will have very low bioaccumulation scores. The more relevant question, to assess potential hazard, is the likely environmental exposure concentrations resulting from the combustion of the EC fuels (a factor not considered in the WMPT approach).

“Others” category: This grouping includes all of the "other" compounds not included in the first two groups. No additional justification for this grouping is provided, other than to state that had ecotoxicity data been evaluated and the materials found to have a high score it would not have affected the overall categorization of the compound (Ecotoxicity data were apparently not evaluated due to time and budget concerns; although it is interesting that Table 2 reflects ecological toxicity scores for some materials and not others and no chemical specific appendix is provided for the ecotoxicity scoring). It is also not clear why the five compounds for which human and environmental toxicity data are unavailable are considered of lesser risk than the Category A and B compounds. As previously stated a lack of data should not imply lower or no concern.

Attachment D: Panel Member 2 comments

Review

Question 1: *Is it reasonable to use the Waste Minimization Prioritization Tool (WMPT) as a starting point for categorizing the relative hazard to human health and the environment posed by stack emissions of the 37 hydrocarbons and oxygenates?*

Overall, WMPT appears to be a reasonable approach for an initial screening method. It is obviously a screening tool rather than something which would provide a detailed quantitative analysis (which would require a full fuel- and site-specific risk assessment). Although its originally intended use is not an exact fit for this application, it appears to serve the present purpose adequately provided its limitations are recognized. These include the following concerns:

1. There are some possible issues with the way different health and ecotoxicological endpoints are scored. The tool appears to give all the different endpoints similar or identical weighting, which may not reflect the actual levels of concern. For instance, it is not immediately clear that simply including categories for cancer and non-cancer health endpoints addresses the level and nature of the concern for public health. Cancer endpoints tend to be regarded as intrinsically more of a threat since the outcome is likely to be fatal for those individuals who are affected (even if they are relatively few in number), as compared to the non-cancer effects which are generally non-fatal (except in extreme cases) but affect a much larger number of people. It is probably impossible to address this type of concern in a general-purpose screening tool. The authors of the WMPT appear to have relied on expert judgment to select consistent levels of concern within a particular endpoint, but the background document says little about comparison or weighting of different endpoints.

2. A basic limitation of the WMPT approach is the exclusion from the rankings of any consideration of the dose likely to be involved in practical exposure situations. Clearly this consideration has to appear in any characterization of actual risk at some point, since dose is a fundamental element of the prediction of any toxicological outcome. One is forced to presume that this aspect of the evaluation is properly treated, at least for those materials where potential hazards are identified, but the scope of this review is severely limited by confining the charge strictly to a part of the evaluation where dose is not considered.

   In spite of the focus of the WMPT method, there is an inevitable interaction between the "level of concern" rating and the amount of the chemical emitted, which may result in some degree of inconsistency. Thus the practical attention given to naphthalene and benzene as ambient air pollutants is probably greater than is implied by the hazard ranking, because although neither of these carcinogens has an especially high potency on a per-microgram basis they tend to be orders of magnitude more abundant than the more potent three- to five-ring polycyclic aromatic hydrocarbons (PAHs), so their potential public health impact is considerable. Since there is no actual consideration of concentration (as opposed to "bioaccumulation" or "environmental persistence) in the consideration of human exposure potential, it is not exactly clear from the description in the TSD how this sort of consideration is dealt with, inside or outside of the WMPT.

3. One is led to assume that the health values used in the WMPT are reasonably up-to-date, but I could find no explicit statement that the tables used in this application have been checked against the latest iterations of the various sources listed in the 2001 background document. In this regard it is a little disturbing to realize that, based on the description of the California RELs and cancer potencies, that document was apparently solidified no later than 1998, in spite of its publication three years later. (Both the RELs and the cancer potencies were finalized by the Scientific Review Panel and adopted by 2000, and have undergone several additions an updates since then.) Considerable changes, including revision or deletion of several numbers, have also taken place in IRIS since that time. I was not able to identify any specific problems in this regard, but it would be reassuring to see an assurance that the issue had been addressed.

4. The use of an inclusive category of "Polycyclic Aromatic Compounds" (PACs) with a single level of concern to deal with the evaluation of various carcinogenic polycyclic aromatic hydrocarbons and related compounds is appropriate for a screening tool and protective of public health, but there is some lack of clarity as to what compounds are included. Table 1 in the TSD lists some obvious candidates, stating that "the Comp Fuels constituents which qualify as PAHs according to USEPA (2001) include the following …", but the list in the referenced document includes several other compounds not in TSD Table 1. Most significantly, the list in EPA (2001) includes 1-nitropyrene, a likely combustion product. Were these additional compounds included in the analysis? Even if not likely fuel constituents, they may well appear as emissions, and their exclusion would be hard to justify. Also, the list in USEPA (2001) is not comprehensive: some compounds (including dinitroPAHs) for which potency factors or PEFs are available are absent. It should also be noted that the actual carcinogenic potencies of these various carcinogenic PACs vary considerably (by as much as 3 orders of magnitude), so any subsequent quantitative evaluation of risk needs to treat these compounds in terms of individual concentrations and potencies, or "benzo[a]pyrene equivalents" if using the PEF approach. In view of the concerns about inclusiveness of the lists presented, it might be appropriate to consider whether some measure of overall POM (the much broader category defined in the Hazardous Air Pollutant list) would be better, especially when considering air pollution.

Question 2: *Did EPA reasonably apply the WMPT to develop and implement the Relative Hazard Ranking system for the 37 compounds?*

In the very narrow sense of the revised review charge, *i.e.* the application of the WMPT to 37 named chemicals, this appears to have been done reasonably and competently.

However, this conclusion has to be qualified by a concern about the process, including the selection of the 37 named chemicals. There seem to be two issues which need further consideration, or at least explanation, in the materials presented, before it can reasonably be concluded that a proper overall conclusion has been reached.

The first is a fundamental issue of what medium is the WMPT applied to. The introductory section of the charge document refers to concern about emissions when the fuels are burned, whereas further descriptions in the charge and in the hazard characterization summary appear to refer to the presence of the materials with health concerns in the actual unburned fuel. Is this analysis assuming that the composition of the emissions is entirely a reflection of the composition of the fuel? If so, this is a basic error which undermines the analysis.

It may well be true that for some fuel constituents that, if they are present in the source fuel, they will appear in the emissions. In other cases, such as acrolein (a highly volatile and reactive material) it seems to me rather unlikely that a source fuel would contain any significant amount of this chemical: however, depending on the composition of the fuel and the combustion conditions, a significant amount may be formed during combustion and appear in the emissions even where there was none of that compound in the source fuel. In this particular case the concern with regard to the fuel composition would be for the presence of acrolein precursors (some of which would in themselves rank low in concern for toxicity, bioaccumulation *etc*.) rather than for acrolein itself. The PAHs, identified as a class of chemicals of concern, are an interesting intermediate case in that they may appear both as fuel components (which due to their chemical stability might well at least partly survive the combustion process and appear as emissions in that way), and also as combustion-generated emissions depending on combustion conditions and the presence of precursors (especially other aromatic hydrocarbons and long-chain aliphatics). Obviously, the generic fuel oil which would be the main fuel for the boilers which handle the ECFs, and to which they should be compared, also has the potential to generate reactive oxygenates such as acrolein and stable pollutants such as PAHs, and it may well be that these considerations have been addressed somewhere in the overall analysis. However, I do not find this consideration detailed in the materials presented. There are important concerns for fuel constituents which, although themselves not highly toxic, bioaccumulative *etc*., are likely to produce elevated levels of combustion products which do have these properties. I am given to understand that the general issue of combustion efficiency and process controls has been addressed elsewhere in engineering terms, but I do not anywhere see consideration of fuel composition in this regard.

There is also a potential concern for other highly toxic combustion-generated pollutants such as dioxins and related polyhalogenated compounds, which may appear in emissions if the fuel contains halogenated organics or inorganic halogen sources, even when the fuel contains no actual dioxins. It is therefore reassuring that the description did refer briefly to fuels not passing a composition standard for halogens as being non-exempt. It would have been further reassuring if the narrative had actually explained this requirement and demonstrated that the issue of combustion-generated emissions had been thoroughly considered.

Question 3: *Based on EPA's application of the WMPT and additional evaluation, is it reasonable to conclude that the 37 ECF constituents can be grouped into the three hazard categories (in descending order of hazard): (1) PAHs and naphthalene; (2) benzene and acrolein; and (3) others?*

This seems to be a reasonable and defensible conclusion, with the following caveats:

1. Although the placing of benzene in the second tier of concern is logical given the premises, I do feel that my concerns noted above over the limitations of the basic WMPT methodology affect this ranking. Firstly, this carcinogen is potentially present in "exemptible" fuels at a rather substantial level compared to the carcinogenic PACs, thus offsetting its lower potency. (Also, combustion of aromatics may under some circumstances lead to high concentrations of PACs in the emissions.) Secondly, carcinogenesis is a severe endpoint and a subject of greater public concern than most other health outcomes. Benzene is one of the relatively few, and thus notorious, "Known Human Carcinogens" according to US EPA and IARC. It therefore seems to me that the

level of concern (and thus, severity of restriction) should be considered at least equivalent to naphthalene, and thus benzene should be in hazard category 1.

2. The ranking of acrolein is appropriate in my view. However, I find it odd that this material is variously described as a fuel constituent, rather than a combustion by-product. Is this really the case or is this reflective of the confusion in the narrative as to whether we are looking at fuel components, emissions, both, or an arbitrary list of compounds generated who knows how? The failure to clarify this undermines the credibility of the analysis as presented for review.

Attachment E: Panel Member 3 comments

Re: "Application of WMPT to Rank Comparable Fuels Constituents" - Peer Review

Question 1: Is it reasonable to use the Waste Minimization Prioritization Tool (WMPT) as a starting point for categorizing the relative hazard to human health and the environment posed by stack emissions of the 37 hydrocarbons and oxygenates?

Response:

Yes, the WMPT tool provides a logical starting point.

However, it must be recognized that the WMPT tool has obvious limitations particularly when applied to characterizing the exposure potential of more volatile chemicals that are emitted to air (which is the relevant scenario in this regulatory context). The WMPT tool uses substances-specific, primary degradation half-lives (either measured or predicted) in water, soil and sediment to obtain persistence scores. The half-life of the substance in air is not considered. For volatile substances that do not appreciably partition to water, soil and/or sediment, the half-life in these media is of little relevance (Webster & Mackay, 1998). For example, in the case on benzene, the persistence score derived from the WMPT as described in the draft hazard characterization is driven by the half-life in sediment. However, application of the multimedia level III fugacity model included in EPISuite reveals that only 0.5%, 0.13% and 0.002% of benzene mass emitted into air gets into water, soil and sediment compartments, respectively. Therefore, the initial persistence score derived from the WMPT tool for volatile substances that distribute primarily to air should be re-assessed based on the predicted half-life of the substance in air. This is logical since for volatile substances exposure is dictated by the inhalation exposure pathway and the exposure magnitude is thus proportional the persistence of the substance in air (MacLeod & McKone, 2004). Three of the 37 substances evaluated (benzene, toluene and acrolein) will remain principally in air (>90%) when emitted to air. The predicted air half-lives for these substances (estimated using AOPwin v. 1.91) are 66, 24 and 5 hrs, respectively. Thus, acrolein is expected to have approximately an order of magnitude lower exposure potential than benzene. The fact that benzene has a relatively high half-life in air (rather than sediment) provides a more appropriate technical basis for assigning benzene a high persistence score and recommending specific waste limit restrictions. In contrast, the higher combustion efficiency coupled with the rapid air half-life for acrolein is expected to reduce the relative hazard ranking of this compound and therefore could provide a sound rationale for excluding this substance from specific waste limit restrictions despite its high human toxicity score.

Question 2: Did EPA reasonably apply the WMPT to develop and implement the Relative Hazard Ranking system for the 37 compounds?

Response:

Yes. EPA has given preference to measured over predicted data and attempted to be transparent in documenting the source of data used for ranking purposes. Moreover, the strategy used to

prioritize data collection efforts was logical and effective given EPAs resource and time constraints.

Some inconsistencies in the ranking do exist. For example, measured bioaccumulation data are used to characterize selected PAHs where high quality field data are available. In all cases, bioaccumulation scores are low to moderate reflecting the known importance of PAH metabolism in limiting bioaccumulation in fish. However, for related structures, for which measured bioaccumulation data are not available, conservative models (lowest preference) are applied yielding high bioaccumulation scores. The use of measured and predicted data yield an inconsistent bioaccumulation ranking across this substance class. It would seem more appropriate to use the measured data (highest preference) as read across to the untested structures to ensure a consistent assessment. Nevertheless, the proposed methodology is relatively robust and such refinements are not likely to impact the overall hazard ranking and resulting conclusions derived from the present analysis.

Question 3: Based on EPA's application of the WMPT and additional evaluation, is it reasonable to conclude that the 37 ECF constituents can be grouped into the three hazard categories (in descending order of hazard): (1) PAHs and naphthalene; (2) benzene and acrolein; and (3) others?

Response:

Yes, with perhaps the exception of acrolein. The PAHs and naphthalene have moderate to high toxicity scores, partition to multiple environmental compartments resulting in the potential for both inhalation and ingestion exposure pathways and have moderate to high persistence scores. Benzene has specific human toxicity concerns and has a relatively high persistence in air. I question if acrolein should be included in category 2. If the persistence score is revised down based on its short half-life in air (rather than sediment) the revised hazard ranking would support placing this substance in category 3.

References:

Matthew MacLeod and Thomas E. McKone. 2004: MULTIMEDIA PERSISTENCE AS AN INDICATOR OF POTENTIAL FOR POPULATION-LEVEL INTAKE OF ENVIRONMENTAL CONTAMINANTS. *Environmental Toxicology and Chemistry*: Vol. 23, No. 10, pp. 2465–2472.

Eva Webster, Don Mackay and Frank Wania. 1998: EVALUATING ENVIRONMENTAL PERSISTENCE. *Environmental Toxicology and Chemistry*: Vol. 17, No. 11, pp. 2148–2158