In re: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF LOUISIANA
MDL NO. 2179, SECTION J
JUDGE BARBIER; MAGISTRATE JUDGE SHUSHAN

Expert Report of
Robert Cox, M.D., Ph.D.

August 15, 2014

Prepared on Behalf of BP Exploration & Production Inc.

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1. Professional Background and Qualifications

I am a board-certified Emergency Physician and board-certified Medical Toxicologist. I am currently employed as a professor in the School of Medicine at the University of Mississippi Medical Center in Jackson, Mississippi. I am the Director of the Mississippi Poison Control Center and the Director of the Medical Toxicology Service at the University of Mississippi Medical Center. I am also an attending physician at the Emergency Department at the University of Mississippi Medical Center, where approximately 70,000 adults and 30,000 children are treated yearly.

I earned a doctorate in Analytical Chemistry from the University of Iowa in 1980 and a doctorate in Medicine from the University of Texas Southwestern Medical School in 1987. I have practiced and taught medicine and toxicology for over 20 years, including in Mississippi for the past 19 years and in Georgia for the preceding 5 years. I hold my board certifications in Medical Toxicology and Emergency Medicine through the American Board of Medical Specialties, and a certification in Toxicology through the American Board of Toxicology. Both organizations require specific training to become eligible and a lengthy examination to become certified. Both also have continuing education processes and recertification examinations to maintain certification.

I have taught toxicology to medical students and physicians specializing in Emergency Medicine at the University of Mississippi Medical Center for the past 19 years. Among the topics taught are Occupational and Environmental Toxicology, Evaluation of the Poisoned Patient, and Medical Management of Hazardous Exposure Victims. My courses include segments on training for hazardous occupational endeavors, personal protective equipment ("PPE"), and patient decontamination. I have also taught on the evaluation and treatment of heat-related illnesses, a common problem encountered in emergency departments in Mississippi.

I have personally conducted research on hydrocarbon air pollutants in Houston and Nashville, and I developed some of the original methods for measuring hydrocarbons at part-per-billion levels in the atmosphere. I have published extensively on the development of methods to measure trace-level hydrocarbons in ambient air and hazardous waste sites and wastewater emissions, including quality control methods for these measurements. I have also published on the contribution of organic solvents to indoor air pollution.

My clinical practice and my research involve patients with both acute and chronic exposures to potentially hazardous substances and the potential health effects from those exposures. Additionally, many of the chemical exposures that I evaluate in my practice involve occupational exposures, including those of oil rig workers, welders, and agricultural workers. I have published articles regarding occupational exposures to a variety of hazards and hazardous materials, including lead, arsenic, chemical burns, and occupational lung disease. I have published and presented regarding the use of PPE, decontamination procedures, and scene management in settings involving exposure or potential exposure to hazardous chemicals. I, personally, have used PPE and have supervised teams using it in hot conditions in the Southern United States.

I have worked on various public health matters throughout my career, particularly with the Mississippi State Department of Health. The public health matters on which I have worked include issues pertaining to Hurricane Katrina, exposure to agricultural pesticides, anthrax biomonitoring, influenza biomonitoring, and biomonitoring and evaluation of lead levels in children.

Also included within my public health work are aspects of mental health care delivery and management in Mississippi and other Gulf States. I have extensive experience with acute mental health care and the mental health care system (including its failures). As a Medical Toxicologist, I routinely treat patients suffering from psychiatric problems, drug overdoses, and adverse reactions to psychiatric medications. The Emergency Department at the University of Mississippi Medical Center includes a Psychiatric Emergency Department, in which I am an Attending Emergency Physician. We receive transfers of patients with psychiatric and mental health conditions from throughout Mississippi. Over the course of my medical career, I have treated, on average, 150-200 psychiatric patients per year. I have reviewed literature regarding mental health issues following natural disasters and other oil spills and in the Gulf States following different types of large-scale incidents, including the *Deepwater Horizon* ("DWH") oil spill.

I was involved in the health surveillance response concerning the DWH oil spill for the State of Mississippi. I reviewed, on a daily basis, environmental monitoring data collected along the Gulf Coast of Mississippi, and worked with the Mississippi State Department of Health to ensure that Mississippi residents were protected from potential exposures to contaminants released in connection with the oil spill. My work with the Department of Health included evaluating air monitoring data, receiving calls directed to the state poison control center related to potential exposures, and assisting with the review of hospital admissions data. During the DWH response, I also spent time at the Mobile Incident Command Post, interacting with federal and state agencies responding to the oil spill.

A copy of my curriculum vitae is attached to this report as Appendix B. I am compensated at the hourly rate of $450 for all records review, analysis, and similar work, and at the hourly rate of $550 for testimony, depositions, and related activity. Over the past four years, I have testified as an expert witness, either in deposition or at trial, in the matters set forth in Appendix C.

2. Scope of Work

I have been retained by BP Exploration & Production Inc. ("BP")[1] to provide my opinions regarding the potential[2] health risks to individuals who were engaged in clean-up activities, remediation efforts, or other responsive actions in connection with the DWH oil spill (collectively "Clean-Up Workers"), and to residents of the Gulf Coast communities of Alabama, Florida, Louisiana, and Mississippi (collectively "Gulf Coast Residents") resulting from potential inhalation, dermal, and oral exposures to the components of MC252 crude oil, dispersants, and other compounds associated with the DWH oil spill.[3]

Additionally, I have been asked to provide my opinion regarding the potential public health implications, specifically with respect to mental health of members of Gulf Coast communities, as a result of the DWH spill.

Finally, I have been asked to provide my opinion regarding efforts taken by BP to minimize health risks to both Clean-Up Workers and Gulf Coast Residents in the aftermath of the DWH oil spill.

1 BP Exploration & Production Inc. was the entity named as the Responsible Party under the Oil Pollution Act ("OPA") in the DWH response. For ease of reference, I refer to "BP" throughout this report.

2 Throughout this report, when I refer to potential health risks or potential exposures, I am not referring to actual, realized health effects or actual exposures. I do not consider potential health risks or potential exposures to be probative of any actual impact of the DWH oil spill on human health.

3 The scope of my work does not include any assessment of the human health impact resulting from the explosion and fire on the DWH oil rig on April 20, 2010, and the resulting rig worker deaths and injuries. My work also does not include assessment of the deaths of four men not involved in response activity tasks at the times of their deaths (one death in a swimming pool; one death in a vehicular accident; one death from a firearm discharge; one death of a BP employee in an airplane incident). Robbins, Liz. BP Temporarily Removes Containment Cap from Well. NY Times, June 24, 2010; Aug. 17, 2010 Memo from Seale to Durbin re Investigation of Death of Member that Occurred at Galveston, TX on 21 June 2010. HCG729-009058-63; Powell II, A. Houma Man in Town to Work on Oil Spill Drowns in Gretna Hotel Pool, nola.com, June 24, 2010. OSE209-022006; Nov. 24, 2010 Email from Utsler to Precourt re Jim Black - GC_IMT Incident Commander - Tragic Loss. HCE109-001657.

3. Executive Summary of Opinions

Based on my review and analysis of the data and materials set forth in Appendix A, and as an expert in the fields of medicine, toxicology, public health, and acute mental health care in Gulf Coast communities, I find no compelling evidence for significant adverse health effects to Clean-Up Workers or to Gulf Coast Residents as a result of the DWH oil spill, and it is highly unlikely that any adverse health effects will become manifest in these populations in the future. My specific opinions are as follows:

1. Clean-Up Workers and Gulf Coast Residents were not exposed to airborne concentrations of the components of crude oil, dispersants, or other compounds associated with the DWH oil spill and response at levels that would be expected to result in any significant adverse health effects, and if Gulf Coast Residents were exposed to any such airborne concentrations, it was only at or below levels typical of outdoor ambient air concentrations and less than indoor air concentrations found throughout the United States.

2. The potential for significant dermal exposures to the components of crude oil and dispersants for Clean-Up Workers was small, and would be highly unlikely to result in any significant adverse health effects, especially given requirements for use of appropriate PPE. The potential for significant dermal exposures to the components of crude oil and dispersants for Gulf Coast Residents was small to non-existent because of the low concentrations of potentially toxic compounds in oil or dispersants that reached the Gulf Coast and the low probability for prolonged human skin contact with those compounds.

3. The potential for significant oral exposures to the components of crude oil and dispersants for Gulf Coast Residents was small to non-existent because of low concentrations of dispersants or the potentially toxic components of oil in Gulf waters (and because people do not drink seawater). Further, there is no evidence of any long-term contamination of Gulf seafood, as federal efforts with respect to seafood safety protected the public from ingestion of any potentially contaminated seafood. Following the spill, testing of seafood samples from areas open to fishing showed no residual levels of oil contaminants, dispersants, or metals resulting from the DWH oil spill.

4. There is no scientific evidence relevant to this oil spill to support concerns that either Clean-Up Workers or Gulf Coast Residents will suffer any future adverse health effects resulting from any exposures associated with the DWH oil spill. Potential exposure levels were non-existent or extremely low, and any potential exposures would not have occurred over sufficient lengths of time, to have resulted in any injury.

5. No direct causal relationship exists between chemical exposures following the DWH oil spill and mental health conditions, and it is difficult to posit a direct and exclusive causal relationship between the socioeconomic conditions following the DWH oil spill and adverse public and mental health effects within a population of Gulf Coast Residents. A number of socioeconomic factors, including primarily loss of income and support systems, affect public health, and specifically mental health, of community members in the aftermath of any event affecting the stability of a given community. This is particularly true given that the DWH oil spill occurred only five years after Hurricanes Katrina and Rita and on the heels of the financial/housing crisis of 2008/2009. In the aftermath of the DWH oil spill, BP supported employment and financial recovery in Gulf Coast

communities, and also provided significant funding to expand and enhance mental health care in those communities, helping to mitigate potential negative public health effects of the DWH oil spill.

6. BP, working in cooperation with federal and state entities, undertook efforts to minimize and to prevent any serious human health effects resulting from the DWH oil spill and the attendant response and clean-up efforts. BP effectively participated in monitoring for potential or actual human health impact resulting from the DWH oil spill in order to facilitate a rapid and effective response to any threat, and provided comprehensive and effective training and protection for Clean-Up Workers engaged in the DWH oil spill response.

Throughout this report, I indicate that numerous federal agencies, including the U.S. Environmental Protection Agency ("EPA"), Food and Drug Administration ("FDA"), National Institute for Occupational Safety and Health ("NIOSH"), and Occupational Safety and Health Administration ("OSHA"), along with various state and other official entities, have corroborated my conclusions in their own independent work.

My opinions are also buttressed by my firsthand knowledge and experience from my health surveillance work concerning the DWH oil spill for the State of Mississippi. Over the course of the DWH incident, no evidence came to my attention regarding any significant exposures to chemicals of concern or significant exposure-related health effects as a result of the DWH incident.

4. Background

4.1 Human Health Risk Assessment

In evaluating the potential human health effects to Clean-Up Workers and Gulf Coast Residents associated with the DWH oil spill, I employ the standard four-step process to human health risk assessment defined by the National Research Council 30 years ago[4] and still used by the EPA today.[5] The four basic steps as applied to the DWH oil spill are:

1. **Hazard identification:** This step involves identifying the potential toxic components of crude oil and/or dispersants that Clean-Up Workers and Gulf Coast Residents may have been exposed to during the DWH oil spill. In Section 5, I cover extensively the components of crude oil and dispersants and their respective toxicologies. This step was also done at the beginning of the response to the DWH oil spill by federal agencies and BP when they were designing the monitoring programs for Clean-Up Workers and Gulf Coast Residents.

2. **Dose-response assessment:** This step refers to determining what degree of exposure, or dose, can potentially produce adverse health effects. Prior to the DWH oil spill, toxicology benchmarks had been established for chemicals of concern in both oil and dispersants, and I relied on these benchmarks in my assessment. These benchmarks are discussed in Section 6.

3. **Exposure assessment:** This step refers to determining levels of potential exposure based on sampling, monitoring, or other qualitative and quantitative efforts. In the context of the DWH oil spill, a tremendous amount of environmental sampling and analysis was performed by BP and federal agencies to enable comprehensive exposure assessment. I have analyzed this monitoring data, and the results of my analyses are presented in Sections 7 and 8.

4. **Risk characterization**: The final and critical step of the standard approach to risk assessment is risk characterization, simply defined as: ***risk = toxicity x exposure***.[6] For purposes of assessing the potential for exposure-related health risks to a population of individuals, the critical factors to characterize are the toxicity of the chemical constituents and the level of exposure to those constituents (e.g., duration and frequency). Thus, in order for there to be a potential health risk from particular chemicals, those chemicals must be inherently toxic *and* there must be a significant human exposure to those chemicals.[7] In Section 8, I compare exposure data with health benchmarks in order to characterize risk.

   Because toxicity and risk must be evaluated in connection with the level of exposure and the dose, a fundamental principle of toxicology is that the dose makes the toxin. Even essential substances, such as water and oxygen, can be toxic in large enough doses.

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4 Risk Assessment in the Federal Government: Managing the Process. Washington, DC: The National Academies Press, 1983, at 3.

5 EPA. Assessing Health Risks for Pesticides. Available at: http://www.epa.gov/pesticides/factsheets/riskassess.htm.

6 *Id.* at 2.

7 In other words, if the toxicity of a given substance is not sufficiently high, risk can be minimized even if exposure levels are high. Similarly, even if toxicity is high, risk can be minimized if exposure levels are low.

Throughout this report, I follow the steps outlined above in assessing the health risk to populations potentially exposed to chemicals of concern as a result of the DWH oil spill. These principles apply to inhalation, dermal, and oral routes of potential exposure.

4.2 Unique Aspects of the DWH Oil Spill and Minimal Potential for Exposure

Before addressing the toxicology of DWH-related compounds, it is important to note that the unique characteristics of the oil spill reduced the potential for exposures to the constituents of oil that are of toxicological concern, thereby minimizing potential health impacts to Clean-Up Workers and Gulf Coast Residents.

First, the spill occurred nearly one mile beneath the ocean surface. In fact, it took on the order of three hours for the oil that surfaced to reach the surface after escaping the well site.[8] As a result, many of the more water-soluble oil components — such as benzene, toluene, ethylbenzene, and xylenes (often referred to collectively as "BTEX") — dissolved in the water column prior to reaching the surface. Therefore, only small amounts of these components reached the surface of the Gulf of Mexico, thus significantly reducing the potential for human exposure to these compounds.[9]

Second, the spill occurred nearly 50 miles from the southernmost tip of Louisiana and over 100 miles from populated areas in southern Mississippi, Louisiana, and Alabama. Volatile organic compounds ("VOCs") that did reach the ocean surface (such as hexane) underwent evaporation, photodegredation, and significant dilution prior to any oil or oil compounds reaching the Gulf Coast. As a result, there was little to no potential for exposure of Clean-Up Workers and Gulf Coast Residents to the volatile compounds typically associated with surface oil spills (e.g., BTEX and lighter alkanes).[10] As expected, and as discussed in greater detail below, air monitoring conducted along the Gulf Coast found airborne concentrations of VOCs to be well below levels of concern for potential human health risks and consistent with levels normally found in ambient air.

The "weathered" oil that remained after the more volatile components were removed, and that actually reached shore, spent weeks to months at sea prior to reaching the coast. A number of processes, including photooxidation, biodegradation, evaporation, dispersion, and dissolution, acted on the less-volatile components of the oil as it moved toward the shoreline. As a result, crude oil rapidly weathered, and any oil or oil compounds that reached the shoreline were significantly depleted of most of the remaining potentially toxic components of crude oil (e.g., polycyclic aromatic hydrocarbons ("PAHs")).[11]

Understanding the changes to the oil as it traveled from the ocean floor to the surface, then to the shore, is important for several reasons. First, it is highly unlikely that workers or the public were directly

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8 Ryerson TB, Camilli R, Kessler JD, et al. Chemical data quantify *Deepwater Horizon* hydrocarbon flow rate and environmental distribution. *PNAS Early Edition*, January 10, 2012, at 2.

9 Middlebrook AM, Murphy DM, Ahmadov R, et al. Air quality implications of the *Deepwater Horizon* oil spill. *PNAS Early Edition*, December 28, 2011, at 20281; Ryerson TB, Aiken KC, Angevine WM, et al. Atmospheric emissions from the Deepwater Horizon spill constrain air-water partitioning, hydrocarbon fate, and leak rate. *Geophys Res Lett* 2011;38: L07803, at 1.

10 Middlebrook AM, Murphy DM, Ahmadov R, et al. Air quality implications of the *Deepwater Horizon* oil spill. *PNAS Early Edition*, December 28, 2011, at 20281.

11 Operational Science Advisory Team (OSAT-2) Gulf Coast Management Team. Summary Report for Fate and Effects of Remnant Oil in the Beach Environment. Prepared for Lincoln D. Stroh, CAPT, U.S. Coast Guard Federal On-Scene Coordinator. February 10, 2011, at 19-20. Available at: http://www.restorethegulf.gov/sites/default/files/u316/OSAT-2%20Report%20no%20ltr.pdf.

exposed to unweathered crude oil,[12] and second, most of the components of crude oil with the greatest potential human toxicity were removed as a result of these processes.[13]

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12 Some crude oil was piped to the surface in connection with containment efforts, and thus did not travel through approximately one mile of water. BP. Containing the leak. Available at http://www.bp.com/en/global/corporate/gulf-of-mexico-restoration/deepwater-horizon-accident-and-response/containing-the-leak.html. There may have been some potential for dermal exposure to this "fresh" crude oil for some Clean-Up Workers in the source-control area. If used as instructed, however, PPE likely would have prevented any significant dermal exposures to crude oil that was piped to the surface.

13 It is my understanding that issues regarding fate and transport of the oil are being covered in depth in the expert report of Dr. Damian Shea.

5. Toxicology of DWH-Related Compounds

In connection with the DWH oil spill, the potentially toxic compounds to which Clean-Up Workers and Gulf Coast Residents could have been exposed are the constituents of MC252 crude oil, constituents of the two dispersant products used during the response (Corexit 9500A and Corexit 9527A), and compounds released from the controlled in-situ burning of crude oil.

5.1 Constituents of MC252 Oil

The crude oil released during the DWH oil spill was composed of a number of components: (a) volatile[14] aliphatic hydrocarbons, such as pentane, heptane, butane, and hexane; (b) less volatile aliphatic hydrocarbons, such as decane and undecane; (c) volatile aromatic hydrocarbons, such as the BTEX compounds; (d) less volatile aromatic hydrocarbons, such as propylbenzene and pentylbenzenes; (e) naphthenic hydrocarbons, which are cyclic aliphatics; and (f) PAHs, such as naphthalene, benzo(a)pyrene, and phenanthrene.[15]

Many of the components of crude oil are not of significant concern from a human health perspective, regardless of the route of exposure, when experienced at levels typically present in the aftermath of an oil spill. For example, the volatile aliphatic hydrocarbons, such as heptane and pentane, do not have sufficient human toxicity to result in significant health effects unless inhaled or ingested at extremely high concentrations and for long periods. Likewise, the less-volatile aliphatic hydrocarbons, such as decane and higher aliphatic compounds, are similar to the components of paraffin wax and mineral oil and also have low human toxicity.[16]

5.1.1 Inhalational Exposure

The components of crude oil that are of greatest concern from a human toxicology perspective, if inhaled at significant concentrations, are the volatile aromatic hydrocarbons (e.g., BTEX), hexane, and naphthalene.[17] These compounds have been associated with adverse health effects when inhaled at sufficient concentrations and for sufficient durations.[18]

Other components of crude oil, such as the PAHs and less-volatile aromatic hydrocarbons, are generally of less toxicological concern for respiratory exposures from oil sources because they have relatively limited volatility, and thus are not likely to be present in ambient air at concentrations of concern. Some PAHs and other less-volatile hydrocarbons can be associated with particulates that are formed when oil is burned (for example, as a result of the controlled in-situ burning of oil). PAHs are typically of more concern if chronically ingested as a result of our food supply or from chronic inhalational exposure as occurs during tobacco smoking.

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14 "Volatility" refers to the tendency to evaporate at normal temperatures and pressures. The higher the volatility of a substance, the more likely it is to evaporate.

15 ATSDR. Toxicological Profile for Total Petroleum Hydrocarbons (TPH) 1999.

16 *Id.*

17 ATSDR. Toxicological Profile for Benzene. 2007; ATSDR. Toxicological Profile for Toluene 2000; ATSDR. Toxicological Profile for Xylene. 2007; ATSDR. Toxicological Profile for Ethylbenzene. 2010; ATSDR. Toxicological Profile for Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene 2005; ATSDR. Toxicological Profile for Total Petroleum Hydrocarbons (TPH). 1999; ATSDR. Toxicological Profile for N-Hexane. 1999.

18 ATSDR. Toxicological Profile for Total Petroleum Hydrocarbons (TPH). 1999.

Many of the components of crude oil such as BTEX, hexane, and PAHs have many emission sources, including engine exhaust, industrial emissions, cigarette smoke, fires and charcoal grills, and are present in the ambient air of most communities.[19] PAHs, for instance, are formed during the incomplete burning of coal, oil, gas, wood, tobacco, or charbroiled meat, and are present throughout the environment and food chain.[20] The greatest sources of exposure to PAHs for most of the United States population are inhalation of these compounds in tobacco and wood smoke, and urban air pollution and in the food chain.[21] Therefore, when evaluating the air monitoring data collected in connection with the DWH oil spill, it is important to keep in mind that these compounds are regularly present at low levels in ambient air because of the sources discussed above. Representative ambient concentrations of these compounds that have been measured at various locations across the United States are provided below in Table 1.

Table 1: Representative Ambient Concentrations in Air in the United States (concentration ranges in μg/m³)*

Compound	Rural	Urban	Indoor
Benzene	1.3-2.6	1.6-58	1.6-10.5
Toluene	1.3-264	0.4-735	2.6-90
Ethylbenzene	0.04-0.4	3.5-78	4.3-17
Xylenes	0.04-3.5	1.3-382	4.3-43
Hexane	0.04-0.4	5.6-88	1.9-10.6
Naphthalene	0.02**	0.9-891	0.8-1599

* Data sources: ATSDR. Toxicological Profile for Benzene. 2007; ATSDR. Toxicological Profile for Toluene 2000; ATSDR. Toxicological Profile for Xylene. 2007; ATSDR. Toxicological Profile for Ethylbenzene. 2010; ATSDR. Toxicological Profile for Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene 2005; ATSDR. Toxicological Profile for Total Petroleum Hydrocarbons (TPH). 1999; ATSDR. Toxicological Profile for N-Hexane. 1999; Baker AK, Byersdorf AJ, Doezema LA, et al. Measurements of nonmethane hydrocarbons in 28 United States cities. *Atmos Environ* 2008;42:170-182; Kinney PL, Chillrud SN, Ramstrom S, et al. Exposures to multiple air toxics in New York City. *Environ Health Perspect* 2002;110:539-546.

** Data collected from the Sandhill Crane National Wildlife Refuge in Gautier, Mississippi, which is a remote, not rural, location.

In general, airborne concentrations of these compounds in urban areas result primarily from industrial sources and automobiles, and airborne concentrations of these compounds in indoor areas result primarily from emissions from building materials, carpets, and consumer products.

5.1.2 Dermal/Oral Exposure

Some of the components of MC252 crude oil also can be of toxicological concern if there is direct contact with the skin for prolonged periods or if these components are ingested orally. The main oil

19 ATSDR. Toxicological Profile for Benzene. 2007; ATSDR. Toxicological Profile for Toluene 2000; ATSDR. Toxicological Profile for Xylene. 2007; ATSDR. Toxicological Profile for Ethylbenzene. 2010; ATSDR. Toxicological Profile for Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene 2005; ATSDR. Toxicological Profile for Total Petroleum Hydrocarbons (TPH). 1999; ATSDR. Toxicological Profile for N-Hexane. 1999; ATSDR. Toxicological Profile for N-Hexane. 1999, at 170-72; Kinney PL, Chillrud SN, Ramstrom S, et al. Exposures to multiple air toxics in New York City. *Environ Health Perspect* 2002;110:539-546.

20 ATSDR. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs). 1995, at 244-45; FDA. Protocol for interpretation and use of sensory testing and analytical chemistry results for reopening oil impacted areas close to seafood harvesting due to the Deepwater Horizon oil spill. July 29, 2010, at 3. Available at: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Emergencies/ucm217601.htm.

21 ATSDR. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs). 1995, at 4.

constituents of toxicological concern for dermal or oral exposures are the PAHs. As discussed above, these were mostly removed during weathering processes as the oil reached the shore.

The greatest sources of dermal and oral exposure to PAHs for most of the United States population are ingestion of the compounds in foodstuffs such as charbroiled and smoked meat, and contact with the compounds in cosmetics and shampoos made with coal tar.[22] PAHs are also present in significant amounts in coal tar medications used to treat dermatologic disorders.[23] PAHs have been used in these common products for over 100 years without any known adverse effects. There have been several epidemiological studies and coal tar has not been shown to cause an increase in cancer.[24]

Figure 1: Common Household Products, Foods, and Medication Containing PAHs*

* Data sources: ATSDR. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs) 1995, at 4, 281; Ryerson TB, Camilli R, Kessler JD, et al. Chemical data quantify *Deepwater Horizon* hydrocarbon flow rate and environmental distribution. *PNAS Early Edition*, January 10, 2012; Neutrogena T/Gel Therapeutic Shampoo Ingredients; MG217 Medicated Tar Ointment Ingredients; Aroma Naturals Coal Tar Shampoo Ingredients.

Any prolonged dermal exposures to PAHs by Clean-Up Workers were highly unlikely given the risk-based control procedures, which required the use of PPE. Furthermore, given weathering processes that removed the majority of the PAHs, if Clean-Up Workers and Gulf Coast Residents did contact weathered oil, it was highly unlikely to contain significant quantities of PAHs.[25] Finally, any oil components contacting the skin were likely to be washed off within a few hours, making prolonged contact extremely unlikely. As a result, significant adverse health effects are unlikely to have been caused by dermal exposures related to the DWH oil spill.

Regular monitoring of PAHs in seawater and in seafood collected from areas open to fishing by state and federal agencies, including the FDA, in the course of the DWH incident did not demonstrate levels that would be expected to produce adverse effects.

22 ATSDR. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs) 1995; Cosmetic Review Expert Panel. Final safety assessment of coal tar as used in cosmetics. *Int J Toxicol* 2008;27 suppl:1-24.

23 *Id.*; FDA. Miscellaneous external drug products for over-the counter human use. 21 CFR 358.710.

24 Cosmetic Review Expert Panel. Final safety assessment of coal tar as used in cosmetics. *Int J Toxicol* 2008;27 suppl:1-24, at 17-18, 20.

25 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011, at 13. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

5.2 Constituents of the Corexit Dispersants

Two dispersants were used during the DWH response: Corexit 9500A and, to a lesser extent, Corexit 9527A.[26] Corexit 9500A contains propylene glycol, dioctyl sodium sulfosuccinate ("DOSS"), and petroleum distillates.[27] Corexit 9527A contains propylene glycol, DOSS, and 2-butoxyethanol.[28] In addition, both Corexit dispersants may have contained dipropylene glycol monobutyl ether ("DPnB") and sorbitans.[29]

All of the dispersant components are commonly encountered in the home environment and in everyday life. They are commonly permitted and used in foods, cosmetics, medications, and cleaning agents because they are of very low toxicity. The amounts of these substances that we are exposed to during our everyday lives are far greater than the amounts that Clean-Up Workers or Gulf Coast Residents might have been exposed to as a result of the use of dispersants. I will discuss the individual components of dispersants below.

Propylene glycol is a Generally Recognized as Safe ("GRAS") food additive by the FDA, and is commonly found in foods, cosmetics, bath and shower soaps, facial cleansers, deodorants, mouthwashes, toothpastes, and children's cough syrup. Propylene glycol is also an ingredient in products used to make artificial smoke and mists for theatrical productions and rock concerts. Propylene glycol is not known to be associated with any significant adverse health effects. Frequent dermal contact with propylene glycol at sufficiently high concentrations may cause minor skin irritation.[30]

DOSS (dioctyl sodium sulfosuccinate) is used in food as a wetting and emulsifying agent, in cosmetics, and in stool-softener medications. DOSS is relatively non-toxic, although the product Material Safety Data Sheet states that dermal contact with DOSS at sufficiently high concentrations may cause sensitization and contact dermatitis.[31] In addition, DOSS contains sulfur, but is not a sulfonamide-type drug associated with allergies. When used as a medication it has an excellent safety profile and is now available over-the-counter.

DPnB is used in disinfectant sprays, home cleaning products, acrylic latex paints, paint removers, and adhesives. According to a thorough toxicological evaluation of DPnB by the International Organisation for Economic Cooperation and Development ("OECD"), DPnB has minimal human toxicity. Acute exposure studies summarized by OECD conclude that DPnB has low toxicity via all routes of exposure, though it can result in slight irritation to the skin (dermal) and mucous membranes (inhalation) at sufficiently high concentrations.[32]

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26 Operational Science Advisory Team (OSAT) Unified Area Command. Summary Report for Sub-Sea and Sub-Surface Oil and Dispersant Detection: Sampling and Monitoring. Prepared for Paul F. Zukunft, RADM, U.S. Coast Guard Federal On-Scene Coordinator Deepwater Horizon MC252. December 17, 2010. Available at: http://www.restorethegulf.gov/sites/default/files/documents/pdf/OSAT_Report_FINAL_17DEC.pdf.

27 Nalco. Material Safety Data Sheet for COREXIT® 9500. MSDS for 9500. Sugar Land, TX, June 14, 2005.

28 Nalco. Material Safety Data Sheet for COREXIT® EC9527A. MSDS for 9500. Naperville, IL, May 11, 2010, at 1.

29 EPA Mobile air monitoring on the Gulf Coast: TAGA Buses. Available at: http://www.epa.gov/bpspill/taga.html; Nalco. COREXIT Ingredients. Aug. 23, 2011. Available at: http://www.nalco.com/news-and-events/4297.htm

30 ATSDR. Toxicological Profile for Propylene Glycol 1997, at 34-36.

31 Anderson SE, Franco J, Lukonska E, et al. Potential immunotoxicological health effects following exposure to Corexit 9500A during cleanup of the Deepwater Horizon oil spill. *J Toxicol Environ Health, Part A* 2011;74:1419-1430, at 1427-28.

32 The Dow Chemical Co. Propylene Glycol Ethers. Product Safety Assessment 2008.

Petroleum distillates are used in air fresheners, deodorizers, adhesives, and car wax. The petroleum distillates used in Corexit 9500A (hydrotreated light) are a mixture of naphthenic hydrocarbons (cyclic aliphatics) and paraffins, and might contain a small amount (less than 0.1% by volume) of aromatic hydrocarbons[33]. If inhaled at sufficiently high levels, petroleum distillates can cause dizziness, headache, and nausea. Petroleum distillates can also cause skin irritation with prolonged and/or repeated contact at sufficiently high concentrations.[34]

Sorbitans, which are derivatives of sorbitol, a naturally occurring sugar, were used in dispersants. Sorbitans are generally considered non-toxic and, in fact, certain sorbitans have been approved for use in foods such as whipped oil toppings and cake mixes.[35] In their pure form, sorbitans can be irritating to the skin. The sorbitans in the two dispersants[36] are widely used in consumer products, such as shampoos, skin creams, tanning lotions, mouthwash, and baby bath products.

2-Butoxyethanol is commonly used in liquid soaps and household cleaners, and has been used to replace hydrocarbons in many paints, varnishes, and strippers. Humans are exposed to 2-butoxyethanol on a daily basis, and breathing low concentrations of vapors or intermittent dermal contact is not known to be toxic. For instance, occupational exposures to low levels of 2-butoxyethanol have not been found to cause changes in liver, kidney, or blood parameters outside of normal clinical ranges. However, 2-butoxyethanol can be toxic if ingested or inhaled in large enough quantities. In this respect, human toxicity data have shown that the primary effects of exposure to large doses of 2-butoxyethanol are reversible metabolic acidosis and some hematologic changes. 2-Butoxyethanol has been found to cause hemolysis (a breakdown of red blood cells) in laboratory rodents. However, based on research conducted by EPA, humans are much less sensitive to this effect than are laboratory species, and hemolysis is unlikely to occur in humans unless they are exposed to extremely high concentrations, such as those that occur in overdoses.[37]

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33 ATSDR. Toxicological Profile for Total Petroleum Hydrocarbons (TPH) 1999; IPCS INCHEM. Distillates (Petroleum), Hydrotreated Light. ICSC 1379, 2001.

34 CDC, Pocked Guide to Chemical Hazards. Petroleum Distillates (Naphtha). Available at: http://www.cdc.gov/niosh/npg/npgd0492.html

35 Code of Federal Regulations for Sorbitan Monostearate, 2011. CFR 172.842.

36 The sorbitans in the Corexit dispersants are sorbitan, mono-(9Z)-9-octadecenoate; sorbitan, tri-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs; and sorbitan, mono-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs. EPA. EPA Response to BP Spill in the Gulf of Mexico. EPA's List of Authorized Dispersants (NCP Product Schedule), at 6. Available at: http://www.epa.gov/bpspill/dispersants-qanda.html#list.

37 ATSDR. Toxicological Profile for 2-Butoxyethanol and 2-Butoxyethanol Acetate 1998; EPA. Toxicological Review of Ethylene Glycol Monobutyl Ether (EGBE). March 2010. 2010 EPA/635/R-08/006F.

Figure 2: Common Household Products, Foods, and Medication Containing Corexit Dispersant Ingredients*

* Data sources:.. Arm & Hammer Ultramax Wide Antiperspirant & Deodorant invisible Solid, Active Sport Ingredients; Rust-Oleum Premium Textured Aerosol 7220 Black Product Information Ingredients; Delsym Children's 12 Hour Cough Liquid (Grape Flavor) Ingredients; Neutrogena Deep Facial Cleanser Ingredients; Cover Girl Exact Eyelights Eye-Brightening Waterproof Mascara Ingredients; Sunshine Makers, Inc., Material Safety Data Sheet, Simple Green All-Purpose Cleaner Ingredients; Act Restoring Anticavity Flouride Mouthwash Cool Mint Ingredients.; Lysol Antibacterial Kitchen Cleaner Ingredients; Jiffy: Chocolate Muffin Mix Ingredients; Cool Whip Ingredient; J. Penner Corp. Material Safety Data Sheet for Board Gear Extra Strength Marker Board Cleaner Ingredients.

5.3 Compounds Released from Controlled In-Situ Burning of Oil

In some cases, crude oil on the ocean surface was destroyed by in-situ burning. This was done 3-15 miles from the source and approximately 50 miles offshore.[38] Burning oil in this manner will produce certain types of air pollutants, similar to burning oil, trash, or any other type of organic materials on land. Because these burns were performed several miles from land, any pollutants produced by the burning would be significantly diluted prior to reaching the coast and would not be expected to impact air quality or human health.

The controlled in-situ burning of crude oil in connection with the DWH oil spill could have contributed to the formation of certain "criteria pollutants" — six pollutants identified by EPA in the Clean Air Act as harmful to public health and the environment.[39] Criteria pollutants are usually present in ambient air to

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38 Mabile N. The Coming of Age of controlled In-Situ Burning. BP America. January 12, 2012.

39 Criteria pollutants are also considered for EPA's Air Quality Index.

some extent and can be generated by numerous industrial processes and automobile exhaust[40], as well as natural processes such as forest fires[41].

Criteria pollutants include carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, particle pollution, and lead.[42]

- Particulate matter ("PM") is a mixture of solid particles and liquid droplets and is found in ambient air. PM is defined based on its size — PM10, or coarse particulate matter, refers to particles that are less than 10 micrometers; and PM2.5, or fine particulate matter, refers to particles that are less than 2.5 micrometers in diameter. The smaller particles are considered respirable particles since they can travel into the lungs due to their size, and thus pose a greater risk to human health.[43]

- Ozone is formed through the reaction of hydrocarbons and nitrogen oxides in the atmosphere in the presence of sunlight. Ozone is a natural component of the atmosphere. The ozone layer in the stratosphere serves a vital function of filtering out ultraviolet rays. Ground level ozone is present as a result of numerous industrial sources and other human activities. Ozone is most likely to be of concern on hot, sunny days in urban environments. Inhalation of ozone can cause a number of respiratory symptoms, including coughing, throat irritation, and exacerbation of pre-existing respiratory conditions[44].

- Sulfur dioxide ("SO_2") is produced by the burning of sulfur-containing fuel. However, the oil released during the DWH spill was "sweet" crude oil, which contains very low sulfur content[45]. Because of the low sulfur content of the MC252 oil, SO_2 would not be expected to form in appreciable concentrations as a result of the DWH oil spill or the burning of MC252 oil. To the extent SO_2 was present in air in measurable quantities during the course of the DWH incident, it was likely not the result of spilled oil.

- Carbon monoxide is produced through the incomplete combustion of organic material. It can be highly toxic at high levels, such as when automobiles are run inside closed garages, or gasoline-powered electrical generators are run inside a home.

- Lead is a metal that polluted the globe primarily from leaded-gasoline and industrial processes. In the past it was used in paints and can be a danger to children when living in older homes. Lead is not of concern as a component of crude oil.

EPA has set standards, called National Ambient Air Quality Standards ("NAAQS"), for criteria pollutants that are designed to be protective of public health. The primary NAAQSs are intended to be protective of vulnerable populations, including children, people with asthma, and the elderly. States perform

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40 EPA. Air Emission Sources. Basic Information. Available at: http://epa.gov/air/emissions/basic.htm; EPA. Air Emission Sources. Particulate Matter. Available at: http://www.epa.gov/airscience/air-particulatematter.htm.

41 British Columbia. How Forest Fires Affect Air Quality. Available at http://www.bcairquality.ca/topics/forest-fires-air-quality.html; Jaffe JA, Wigder NL. Ozone production from wildfires: A critical review. *Atmos Environ* 2012;51:1-10; EPA. Wildfires and Prescribed Burning. Available at: http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s01.pdf.

42 EPA. National Ambient Air Quality Standards. Available at http://epa.gov/air/criteria.html.

43 EPA. Particulate Matter. Available at http://epa.gov/airquality/particlepollution/.

44 EPA Ground Level Ozone. Available at http://epa.gov/airquality/ozonepollution/, at 3.

45 EPA Response to BP Spill in the Gulf of Mexico. Hydrogen Sulfide Monitoring on the Gulf Coast. Available at: http://www.epa.gov/BPSpill/h2s.html.

regular air monitoring for criteria pollutants to assess air quality generally and to determine compliance with the NAAQS[46].

Burning of oil can also potentially form polychlorinated dibenzodioxins and furans (commonly referred to as dioxins). These are a class of compounds formed from the incomplete combustion of organic matter in the presence of chlorine. Low levels of dioxins are ubiquitous in the environment and the food chain. Humans are primarily exposed to dioxins through the diet, primarily in fish and fatty foods.

46 Mississippi Department of Environmental Quality. 2010 Air Quality Data Summary. Available at http://www.deq.state.ms.us/MDEQ.nsf/pdf/Air_2010AirQualityDataSummary/$File/2010%20Air%20Quality%20Data%20Summary.pdf?OpenElement; State of Alabama Ambient Air Monitoring 2010 Consolidated Network Review. Available at http://www.adem.state.al.us/programs/air/airquality/2010AmbientAirPlan.pdf; Florida Department of Environmental Protection. Division of Air Resource Management Bureau of Air Monitoring and Mobile Sources. Air Monitoring Report 2010. Available at http://www.dep.state.fl.us/air/air_quality/techrpt/2010%20Annual%20Monitoring%20Report.pdf; Louisiana Department of Environmental Quality. Ambient Air Monitoring Data and Reports. Available at: http://www.deq.louisiana.gov/portal/DIVISIONS/Assessment/AirFieldServices/AmbientAirMonitoringProgram/AmbientAirMonitoringDataandReports.aspx.

6. Toxicology Benchmarks

A toxicology benchmark is a value up to which humans or animal exposure (depending on the benchmark), even for a prolonged time, would not be expected to result in health consequences. Toxicology benchmarks have been developed by government agencies and professional organizations for a number of the components of crude oil, petroleum products, and dispersants. These are the dose metrics that I used in the risk characterization process.

6.1 Benchmarks for Occupational Exposures

Several different organizations have defined occupational exposure limits ("OELs") for workplace exposures to chemicals of concern — here, exposures to Clean-Up Workers. An OEL is the average concentration of a substance to which an individual may be exposed to during an 8-hour or 10-hour workday over a 40-year working lifetime and not experience adverse health effects from this exposure.[47] These OELs include Permissible Exposure Limits ("PELs") established by OSHA, Recommended Exposure Limits ("RELs") established by NIOSH, and Threshold Limit Values ("TLVs") established by the American Conference of Governmental Industrial Hygienists ("ACGIH"). OSHA PELs are legally enforceable, whereas the NIOSH RELs and the ACGIH TLVs are guidelines published by their respective organizations.

The OSHA PELs, NIOSH RELs, and ACGIH TLVs for constituents of the MC252 oil and the two Corexit dispersants are provided in Table 2 below.

Table 2: Occupational Exposure Limits for Oil and Dispersant Constituents*

Substance	Units†	OSHA PEL	NIOSH REL	ACGIH TLV
2-Butoxyethanol	ppm	50	5	20
Benzene	ppm	1	0.1	0.5
Coal Tar Pitch Volatiles (CTPV) (benzene soluble fraction)	mg/m^3	0.2	0.1	0.2***
Ethylbenzene	ppm	100	100	20
n-Hexane	ppm	500	50	50
Hydrogen Sulfide	ppm	20	10	1
Naphthalene	ppm	10	10	10
Oil Mist, Mineral	mg/m^3	5	5	5
Toluene	ppm	200	100	20
Total Particulates	mg/m^3	15	NS**	10****
Trimethylbenzenes, total	ppm	25	25	25
Xylenes	ppm	100	100	100

* Data source: OSHA. Permissible Exposure Limits-Annotated Tables. Available at: https://www.osha.gov/dsg/annotated-pels/.
** "NS" = no standard exists
*** 1 cyclohexane extractable fraction
**** ACGIH TLV applies to inhalable dust rather than total dust.
† "ppm" = parts per million; "mg/m^3" = milligrams per cubic meter.

47 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011, at 9. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf

6.2 Benchmarks for Community Exposures

Regarding community exposures, two main sets of benchmarks are available for ambient airborne exposure levels below which no adverse health effects are expected. These benchmarks are DWH-specific Screening Levels established by EPA and Minimal Risk Levels ("MRLs") established by the U.S. Agency for Toxic Substances and Disease Registry ("ATSDR"). These and other ambient air standards developed for community exposures are generally more conservative (i.e., lower) than occupational standards because they are based on continuous, 24-hour per day exposures, and are intended to protect vulnerable populations, such as the elderly and children.

For the DWH oil spill, EPA established Screening Levels for select VOCs — specifically the BTEX compounds[48] and PAHs[49]. EPA's Screening Levels assume a person is breathing a pollutant continuously (24 hours a day, 7 days a week) for as long as one year. Results that are below the health-based Screening Level generally indicate a low potential for health concerns for exposures up to a year. In addition, EPA has stated that a single daily reading that is higher than the Screening Level does not indicate a health problem will occur: "Concentrations slightly above these levels for short durations do not generally pose health concerns. There may be some health concern if people are exposed to these levels continuously for a year or more."[50]

An ATSDR MRL is an estimate of the maximum level of daily human exposure to a compound that is likely to be without an appreciable risk of adverse health effects (non-carcinogenic) over a specified duration of exposure. MRLs are established for chemicals for which reliable and sufficient data exist to identify either the target organ(s) of effect, or the most sensitive health effect(s), for a specific duration within a given route of exposure. MRLs are derived for three durations of exposure: Acute (up to two weeks of exposure), Intermediate (15 to 365 days of exposure) and Chronic (over 365 days of exposure).

Table 3 below sets forth the ATSDR MRLs for the oil spill-related compounds that are potentially of concern from a toxicological perspective, and the EPA Screening Levels for BTEX. The MRLs, which are typically expressed as parts per billion ("ppb") concentration units, have been converted to micrograms per cubic meter ("$\mu g/m^{3}$"") for all compounds except 2-butoxyethanol. Considering the duration of the DWH oil spill (86 days), and the duration over which the oil spill potentially could have impacted ambient air quality along the Gulf Coast, only Acute and Intermediate MRLs should be used for comparison.[51] However, comparisons to the Chronic MRLs are provided in Table 3 below for compounds for which Intermediate MRLs are not available and the Chronic MRLs are the only comparison value available.

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48 EPA Response to BP Spill in the Gulf of Mexico. Volatile Organic Compounds (VOCs) on the Gulf Coastline. Available at: http://www.epa.gov/bpspill/vocs.html.

49 EPA PAHs. Available at: http://www.epa.gov/bpspill/pahs.html.

50 EPA Response to BP Spill in the Gulf of Mexico. Volatile Organic Compounds (VOCs) on the Gulf Coastline, at 2. Available at: http://www.epa.gov/bpspill/vocs.html.

51 Chronic MRLs are not appropriate benchmarks for comparison for measurements collected in connection with the DWH oil spill because no exposures could have occurred over a period greater than 365 days. The last overflight observation of potentially recoverable oil on the ocean surface was August 3, 2010, OSAT at 6. Additionally, other than one small application near the source-control area on September 4, 2010, dispersants were not applied in connection with the DWH oil spill after July 19, 2010. EPA. Dispersant Application. Available at: http://www.epa.gov/bpspill/dispersants-qanda.html#appl. In other words, by August 2010, there was little potential for community exposures to airborne concentrations of the constituents of oil and dispersants in connection with the DWH oil spill.

Table 3: EPA and ATSDR Toxicology Benchmark Values*

Substance (unit**)	EPA DWH Screening Level	ATSDR MRLs		
		Acute	Intermediate	Chronic
Benzene (μg/m^3)	20	28.8	19.2	
Toluene (μg/m^3)	5,000	3,770	-	302
Ethylbenzene (μg/m^3)	3,000	21,700	8,684	
Xylenes, total (μg/m^3)	3,000	8,684	2,605	
n-Hexane (μg/m^3)	-	-	-	2115
Naphthalene (μg/m^3)	-	-	-	3.7
Hydrogen sulfide (μg/m^3)	-	98	28	
2-Butoxyethanol (ppm)	-	6	3	
Propylene glycol (μg/m^3)	-	-	28	

* Data source: Operational Science Advisory Team (OSAT) Unified Area Command. Summary Report for Sub-Sea and Sub-Surface Oil and Dispersant Detection: Sampling and Monitoring. Prepared for Paul F. Zukunft, RADM, U.S. Coast Guard Federal On-Scene Coordinator Deepwater Horizon MC252. December 17, 2010. Available at: http://www.restorethegulf.gov/sites/default/files/documents/pdf/OSAT_Report_FINAL_17DEC.pdf.

** "μg/m3" = micrograms per cubic meter

EPA's Screening Levels for PAHs in air are shown in Table 4. EPA focused on these pollutants because they are present in weathered oil and are also released from burning oil and, at elevated concentrations, could potentially cause health problems, including long-term health effects such as cancer. EPA developed these Screening Levels from health effects information about each PAH, including information regarding exposure levels that might pose an increased risk for cancer. These health-protective Screening Levels assume that a person is breathing a pollutant 24 hours a day, every day, for one year.[52]

Table 4: EPA Screening Levels for One-Year Average Exposure to PAHs in Crude Oil*

Chemical	Human Health Benchmark Air - ng/m^3**
Benzo(a)pyrene	640
Benzo(a)anthracene	6,400
Benzo(b)fluoranthene	6,400
Benzo(k)fluoranthene	6,400
Chrysene	64,000
Dibenz(a,h)anthracene	580
Indeno(1,2,3-c,d)pyrene	6,400
Naphthalene	30,000

* Data source: EPA. Polycyclic Aromatic Hydrocarbons on the Gulf Coastline. February 14, 2013. Available at: http://www.epa.gov/bpspill/pahs.html.

** "ng/m^3" = nanograms per cubic meter

EPA has also developed standards for criteria pollutants. Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. These are somewhat difficult to apply to the DWH oil spill, since they are based on yearly or three-year statistical values (98th percentile). The more relevant measurement for the DWH oil spill is

52 EPA PAHs. Available at: http://www.epa.gov/bpspill/pahs.html.

the Air Quality Index that is based on any of the six criteria pollutants being elevated daily.[53] This measurement is produced on a daily basis on local levels and is used to warn communities across the United States of unhealthy air conditions.

There are several types of standards for oral exposures. EPA has established drinking water standards to define the maximal amount of certain substances allowable in drinking water. For more general applications, EPA has developed the concept of the reference dose ("RfD") to define the daily exposure of the human population (including sensitive human subgroups) that is unlikely to be without deleterious effects during a lifetime. The ATSDR MRLs are also available for oral exposures when appropriate. In the case of the DWH oil spill, EPA and the U.S. Department of Health and Human Services ("HHS") developed toxicology benchmarks for components of oil and dispersants in seawater.[54] These are shown in Table 5 below.

Table 5: EPA/HHS Human Health Benchmarks for Water Samples*

Chemical	Human Health Benchmark Water - μg/L**
Benzene	380
Cumene	20,000
Ethylbenzene	610
Total xylene	18,000
Toluene	120,000
2-Methylnaphthalene	170
Acenaphthene	2500
Fluorene	12,000
Anthracene	22,000
Pyrene	4,100
Nickel	15,000
Vanadium	5,400

* Data source: OSAT

** "μg/L" = microgram per liter

These benchmarks are based on potential cancer and non-cancer health risks. The benchmarks accounted for both skin contact and incidental ingestion of water by a child swimmer, assuming 90 hours of exposure (or 1 hour per day for 90 days). Human health benchmarks were not developed for sediments or for dispersants in water.[55]

For seafood, the PAHs in petroleum mixtures are of greatest concern for human health because of their persistence (lower evaporation rates), and their potential for toxic or carcinogenic effects. The FDA established levels of concern for PAHs in seafood based both on cancer and non-cancer endpoints.[56]

53 EPA. EPA. Guidelines for Reporting of Daily Air-Quality Index (AQI). EPA-454/B-06-001, 2006.

54 OSAT, at 12.

55 *Id.*, at 11-12.

56 FDA. Protocol for interpretation and use of sensory testing and analytical chemistry results for reopening oil impacted areas close to seafood harvesting due to the Deepwater Horizon oil spill. July 29, 2010, at 3-4. Available at: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Emergencies/ucm217601.htm.

There is not a single accepted method for defining dermal toxicology benchmarks. Dermal toxicity is a function not only of the toxicity of an agent, but also how readily an agent can move through the skin barrier, the surface area of the skin that is exposed, and the duration and frequency of that exposure. All of these factors must be considered when assessing risk from a dermal exposure. Models are available to calculate chemical intake based on all of these factors. Using an absorption coefficient, EPA's RfDs, ATSDR's MRLs, or EPA's cancer risk factors can be applied to dermal exposures when the duration of exposure and body surface area exposed are known. This method was used by the Operational Science Advisory Team ("OSAT"), an interagency team of specialists from various agencies, to evaluate risks from dermal exposure to oil components.

6.3 Approach to Multiple Substances

In situations involving multiple potential exposures, the possibility exists that different agents can have a combined effect to increase or decrease the overall toxicity of the mixture. This can potentially occur for agents with similar mechanisms of action and target organ effects at medium or high exposure levels. For chemicals with different modes of action, there is no robust evidence that exposure to a mixture is of health concern if the individual chemicals are present below their zero-effect levels.[57] Toxicology agencies for the European Union believe that mixture toxicity should be considered when two or more components with a similar mechanism of action are present at or near toxicological levels of concern.[58]

In the United States, government agencies use a slightly different approach that is based on the same principles. The general approach used in the United States is known as a "Hazard Index." This is the concentration of the agent that is measured divided by the toxicology benchmark. The agencies responsible for establishing occupational benchmarks (OSHA, NIOSH, and ACGIH) recommend that the sum of the Hazard Indices for mixtures of components should be less than one, and if it is greater than one, then mixture toxicity should be considered. ACGIH further specifies that the components must act on the same organ system.[59]

For community exposures, ATSDR also recommends a Hazard Index approach, but one that is more conservative than the European Union approach. ATSDR recommends that if the Hazard Index is not greater than 0.1 for at least two of the mixture components, then additivity and interactions are unlikely to result in a health hazard. ATSDR also recommends that if a Toxicology Profile is available for the mixture, then it should be consulted for guidance.[60]

I also used a third approach for the evaluation of the risk of multiple exposures. I compared the concentrations of components found along the Gulf Coast and during response and clean-up operations with typical concentrations found in air around the United States, both indoor and outdoor. This approach is not a direct measurement of risk, but presents an assessment of risk relative to risk associated with usual, daily life. I used a similar approach to assess risk with respect to dermal exposures.

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[57] European Commission, Directorate-General for Health & Consumers. Toxicity and Assessment of Chemical Mixtures. 2012, at 3-4. Available at: http://www.atsdr.cdc.gov/interactionprofiles/IP-ga/ipga.pdf.

[58] *Id.*, at 9.

[59] ATSDR. Guidance Manual for the Assessment of Joint Action of Chemical Mixtures 2007, at 26.

[60] *Id.*, at 30-31.

7. Sources and Strengths of Exposure Data

7.1 Sources of Data

I have reviewed robust sets of air monitoring data collected by BP and several government agencies, representing hundreds of thousands of measurements, including both occupational (industrial hygiene) exposure data and community (environmental) exposure data, in reaching my conclusions.

- Occupational exposure data concern samples collected on or around Clean-Up Workers. Generally, occupational exposure data are collected to ensure compliance with OELs (toxicology benchmarks) established to protect workers against the potential health effects of exposure to hazardous substances.

- Community exposure data relate to samples of ambient air collected at locations along the Gulf Coast. These data can be compared to various other health-based standards (toxicology benchmarks) that have been established to ensure that members of the public are not exposed to potentially harmful levels of chemicals.

7.1.1 Occupational Exposure Data

(a) BP Data

From April 2010 through at least January 2012, BP and its contractors collected more than 28,000 personal breathing zone ("PBZ") air samples — an exceptionally large sampling set — from workers involved in the DWH response. These samples were analyzed for chemical substances specifically selected to assess oil and dispersant-related exposures and potential health hazards, resulting in approximately 165,000 individual analyses. Samples were collected from Clean-Up Workers at different locations near the well site, in the offshore environment, and from onshore during beach clean-up and other response activities. Samples for BTEX and other compounds were generally collected from Clean-Up Workers conducting tasks with the highest potential for exposure in order to be as conservative — and thus as protective of worker health — as possible.[61] Data from these samples collected from April 2010 through October 2010 are publicly available on the BP website.[62]

(b) NIOSH Data

In response to BP's request for Health Hazard Evaluations ("HHEs"), NIOSH industrial hygienists launched a comprehensive program of air sampling to assess exposures of Clean-Up Workers to chemicals related to specific offshore and onshore response activities, including constituents of the MC252 oil, the two Corexit dispersants used during the DWH response, and cleaning agents. Data collected were released in a series of HHE interim reports, issued from June 23, 2010, to December 7, 2010,[63] and a final report issued in August 2011.[64]

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61 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011, at 2-3. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf.

62 BP Gulf Science Data, http://gulfsciencedata.bp.com/go/doc/6145/1942258/.

63 CDC. National Institute for Occupational Safety and Health. Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0115. Interim Report #1A; HETA 2010-0115. Interim Report #2A; HETA 2010-0115. Interim Report

(c) OSHA Data

OSHA sent inspectors to the Gulf Coast region as part of the DWH response to ensure that Clean-Up Workers were not exposed to potentially harmful levels of chemicals. Inspectors conducted over 4,500 exposure measurements from May 2010 to August 2010. Most of these measurements were collected on Clean-Up Workers for substances regulated by OSHA and expected to be present in an oil spill situation. Data collected were made available on the OSHA website.[65]

7.1.2 Community Exposure Data

(a) EPA Data

From May 1, 2010, to September 18, 2010, EPA conducted extensive air sampling to assess potential exposures of members of the Gulf Coast communities of Alabama, Florida, Louisiana, and Mississippi to contaminants from the DWH oil spill.[66]

The Gulf States and EPA routinely monitored air quality for criteria pollutants in the Gulf region prior to the DWH spill to assess air quality conditions. The states report their data to EPA's national Air Quality System. Following the DWH oil spill, the capabilities of at least four coastal sites operated by EPA were upgraded to permit measurement of additional substances, such as total VOCs, and sampling for specific VOCs (such as BTEX). During the course of the DWH response, EPA increased the sampling frequency at these sites from once every six days to daily.[67]

In addition to the routine fixed-site air monitoring stations, EPA set up 19 temporary fixed sites, primarily along the coasts of the Gulf States, for air monitoring and sampling of these same substances.[68]

EPA also deployed Trace Atmospheric Gas Analyzer ("TAGA") buses, which are self-contained mobile laboratories that conduct real-time monitoring of air quality. The TAGA buses measured airborne concentrations of benzene, toluene, and xylene and constituents of both of the dispersants used during the response (specifically, 2-butoxyethanol and DPnB). The TAGA bus sampling took place from May 5, 2010, to August 20, 2010, along the coastal roads of Alabama, Florida, Louisiana, and Mississippi.[69]

#3A; HETA 2010-0115. Interim Report #4A; HETA 2010-0129. Interim Report #5; HETA 2010-0129. Interim Report #7; HETA 2010-0129. Interim Report #8A; HETA 2010-0129. Interim Report #9. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html.

64 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

65 OSHA. OSHA's Efforts to Protect Workers. Available at: https://www.osha.gov/oilspills/index.html; OSHA. OSHA Activities During the Deepwater Horizon Oil Spill. Available at: https://www.osha.gov/oilspills/index_sampling.html.

66 EPA Response to BP Spill in the Gulf of Mexico. Volatile Organic Compounds (VOCs) on the Gulf Coastline. Available at: http://www.epa.gov/bpspill/vocs.html.

67 *Id.*

68 *Id.*

69 EPA Mobile air monitoring on the Gulf Coast: TAGA Buses. Available at: http://www.epa.gov/bpspill/taga.html.

(b) BP Data

BP and its contractors employed sampling strategies and procedures very similar to those described for EPA above. Data were collected from 40 fixed-site locations along the shorelines of the Gulf States.[70] The 24-hour samples collected from the fixed-site locations were analyzed for concentrations of volatiles and semi-volatiles, particulates, and hydrogen sulfide ("H_2S").[71]

BP also performed air sampling and monitoring at the perimeter of waste storage/disposal sites and vessel or boom decontamination sites that operated during the response. These samples were collected downwind from disposal and decontamination activities. The purpose was to monitor for air concentrations of potential pollutants that may be released during the decontamination and disposal processes.[72] BP made this data publicly available in a separate database. This is part of databases C and D in Table 6, below.

Table 6 summarizes air sampling and monitoring data collected by BP, NIOSH, OSHA, and EPA during the response.

Table 6: Sources of Air Sampling and Monitoring Data for DWH Oil Spill*

Database	Type	Dates	Analyses
OSHA	Occupational	5/27/10-9/6/10	4,539
NIOSH	Occupational	6/4/10-8/10/10	2,577
BP	Occupational	4/27/10-1/30/12	164,083
EPA Sampling	Community	4/28/10-9/18/10	78,771
EPA Monitoring	Community	4/28/10-9/6/10	58,112
EPA TAGA	Community	5/5/10-8/20/10	91,897
BP Community Sampling - A	Community	4/29/10-12/21/10	158,554
BP Community Monitoring - B	Community	4/29/10-10/3/10	473,757
BP Perimeter Sampling - C	Branch Area Perimeter	5/18/10-12/19/10	105,550
BP Perimeter Monitoring - D	Branch Area Perimeter	4/28/10-11/7/10	277,659

* Data sources: EPA Mobile air monitoring on the Gulf Coast: TAGA Buses. Available at: http://www.epa.gov/bpspill/taga.html; Gulf Science data. Data Publication Summary Report. Community Air Sampling and Monitoring, April 2014. Available at https://www.piersystem.com/go/doctype/6145/207606; EPA. EPA Response to BP Spill in the Gulf of Mexico. Download Environmental Data. Available at: http://www.epa.gov/bpspill/download.html; OSHA. OSHA Activities During the Deepwater Horizon Oil Spill. Available at: https://www.osha.gov/oilspills/index_sampling.html, This does not include some of the research data collected by NOAA.

7.1.3 Dermal and Oral Exposure Data

For my evaluation of potential health risks for individuals contacting water or sand along the Gulf Coast, I relied on the data summaries produced by the OSAT.[73] This was an enormous cooperative effort of various federal agencies under the Unified Area Command. The OSAT consisted of scientific expertise from the National Oceanic and Atmospheric Administration ("NOAA"), the U.S. Coast Guard ("USCG"),

70 Gulf Science data. Data Publication Summary Report. Community Air Sampling and Monitoring, April 2014, at 2. Available at https://www.piersystem.com/go/doctype/6145/207606.

71 *Id.*

72 *Id.*, at 1.

73 OSAT; OSAT-2.

EPA, the U.S. Geological Survey ("USGS"), BP, and the Bureau of Ocean Energy Management, Regulation, and Enforcement ("BOEMRE"). The data summary involved over 17,000 samples of water and sediment collected and analyzed for numerous oil and dispersant chemicals. I also personally evaluated the data that EPA posted on its website regarding the analyses of 58 samples of weathered oil for PAHs.[74]

7.1.4 Health Surveillance Data

I also reviewed health surveillance data from the Centers for Disease Control and Prevention ("CDC") and the States of Alabama, Florida, Louisiana, and Mississippi. CDC, along with state and local health departments, employed several different surveillance systems to monitor potential health effects across the Gulf Coast region following the DWH oil spill. These surveillance tools were designed to identify acute or sub-acute health effects potentially related to exposure to oil or dispersant constituents. These tools were used to provide health authorities with any signs of possible health impacts on people or groups within the Gulf region.

My conclusions set forth below are founded on my review and analysis of the data described in Section 7.1 above. The sources for the data on which I rely to reach my conclusions are publicly available and include BP's Gulf Science website as well as websites of several government agencies.

7.2 Strengths of the Exposure Dataset

This overall dataset is robust, and while it may not include all measurements and analyses collected during the DWH incident, it reliably provides a source of information on which to base conclusions regarding potential adverse health effects to Clean-Up Workers and Gulf Coast Residents. I have been involved in a number of different cases of community exposures to potentially toxic chemicals involving polychlorinated biphenyls ("PCBs"), wood treatment chemicals, and dioxins. The quantity and quality of data on possible worker and community exposures and other general environmental data for the DWH oil spill dwarfs anything that I have ever witnessed. In total, there were over 1.4 million chemical analyses of the air performed as part of the evaluation of the DWH oil spill. There were over 17,000 samples of water and sediment analyzed. The dataset is more than sufficient in size, magnitude, and quality to answer any questions of potential human toxicity.

Several important factors beyond the size of this dataset make it particularly reliable:

First, the sampling plans and protocols used for the DWH response called for monitoring of appropriate chemicals from different sources (e.g., oil, dispersants) and related potential health outcomes. Toxicologists, industrial hygienists, environmental scientists, food scientists, public health officials, and representatives of appropriate government agencies chose the chemicals to be monitored based on established science for the purpose of protecting public health.[75] Thus, the dataset produced was specifically designed to assess potential human health risks as a result of exposure to chemicals of concern associated with the DWH incident.

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74 EPA. EPA Response to BP Spill in the Gulf of Mexico. Download Environmental Data. Available at: http://www.epa.gov/bpspill/download.html.

75 EPA Response to BP Spill in the Gulf of Mexico. Volatile Organic Compounds (VOCs) on the Gulf Coastline. Available at: http://www.epa.gov/bpspill/vocs.html; Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers, July 18, 2012 Field Report. *PLOS Currents Disasters* 2012;July 18. Edition 1; NIOSH Interim Information. Chemical Exposure Assessment Considerations for Use in Evaluating DWH Response Workers and Volunteers. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/pdfs/NIOSH%20Interim%20_Chemical%20Exposure%20Assessment.pdf.

Second, the overall analytical effort was a cooperative effort of multiple government agencies and private laboratories including the USCG, EPA, OSHA, NIOSH, FDA, state environmental and health agencies, BP, and numerous private support laboratories.[76] The analytical protocols were based on established methods recommended by appropriate federal agencies. Sampling and monitoring protocols were modified as new needs arose.[77]

Third, the breadth of the data ensures the representativeness of the dataset and, consequently, the legitimacy of conclusions drawn from the dataset. Occupational samples were collected beginning April 27, 2010, through at least January 2012. Community air monitoring samples were collected along the Gulf Coast from April 28, 2010, to December 2010. Furthermore, the samples contributing to this dataset were taken from locations across the DWH response area — near the Macondo well site, offshore, nearshore, and along the Gulf Coast. As a result, this dataset provides a thorough picture of potential exposures along the Gulf Coast, as well as virtually all time periods of potential exposure for both Clean-Up Workers and Gulf Coast Residents.

Fourth, the transparency of the data collection process lends to the reliability of the dataset. Data were collected and publicly released via easily accessible sources. This openness allowed for ongoing commentary and review regarding the data as well as necessary adjustments to improve the data collection and analysis process.

Finally, the most convincing aspect of the entire dataset to me is the consistency of the data. Occupational data collected both onshore and offshore, as well as around decontamination and disposal facilities, were consistent with community air monitoring data. These data were consistent with the concentrations found in weathered surface oil, showing the absence of volatile components. All of these different types of data were collected using very different techniques and under very different circumstances: on airplanes, on ships, at fixed sites on land, and on a mobile laboratory on land. Some data were PBZ samples, and some were environmental samples. The results from all data sources were still in agreement. Additionally, the data agree with our knowledge of the chemistry of the substances involved, and their removal prior to its reaching the nearshore area. Finally, the chemistry monitoring results and the comparisons to toxicology benchmarks agree with the lack of positive health surveillance findings, which did not detect any significant adverse health effects.

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76 EPA Response to BP Spill in the Gulf of Mexico. Volatile Organic Compounds (VOCs) on the Gulf Coastline. Available at: http://www.epa.gov/bpspill/vocs.html; OSHA. OSHA Assessing Worker Exposures. Available at: http://www.osha.gov/oilspills/index_sampling.html; NOAA. Protecting the Public from Oil-Contaminated Seafood: Fishery Area Closure and Surveillance Plan. Deepwater Horizon (DWH) Oil Spill, June 14, 2010, Available at: http://docs.lib.noaa.gov/noaa_documents/DWH_IR/reports/Protecting_Public_Fisheries_Closure_Surveill_Plan.pdf; King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf; OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf; Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers, July 18, 2012 Field Report. *PLOS Currents Disasters* 2012;July 18. Edition 1.

77 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf; NIOSH Interim Information. Chemical Exposure Assessment Considerations for Use in Evaluating DWH Response Workers and Volunteers. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/pdfs/NIOSH%20Interim%20_Chemical%20Exposure%20Assessment.pdf.

8. Analysis and Discussion of Exposure Data

My review and analysis of occupational and community exposure data focuses first on the inhalation route of potential exposure, or concentrations of atmospheric contaminants potentially breathed in by Clean-Up Workers and Gulf Coast Residents. I summarize the results of the occupational and community sampling and monitoring data and compare those results to established toxicology benchmarks. I focus next on additional routes of potential exposure, including potential dermal and oral exposures.

Since toxicology benchmarks are based on exposures occurring over defined periods of time, it is very important in analyzing exposure data to use average or median levels of chemicals found and not to focus on a few high levels. EPA has noted: "Since the screening levels are based on exposure lasting for many months, this average is more appropriate for evaluating the potential risk to health than any single measurement."[78] Additionally, the duration of exposure is a critical factor in assessing the potential for health risk. EPA noted: "[A] single daily reading that is higher than the screening level does not indicate a health problem will occur."[79] Rather, an individual must be exposed repeatedly at levels that exceed relevant benchmarks before there is a potential health risk.

Routine filling of gas tanks at gas stations provides an excellent example of why a few high values can be misleading with respect to health effects. Studies have shown that the concentration of benzene in the air we breathe during refueling at gas stations is over 100 times greater than the toxicology benchmark for benzene.[80] Of course, any such exposure is very brief (a few minutes) and relatively infrequent (once every week or so).

As noted by EPA with respect to VOCs and the DWH incident, "[t]hese chemicals are also emitted by many other sources, such as motor vehicles, industries, and paints or solvents. The monitors cannot determine where the VOCs originate. Therefore VOC levels in the air around the monitors could be coming from the oil spill or from other sources."[81]

8.1 Inhalational Exposure Characterization

8.1.1 Occupational Exposure Data

(a) Components of MC252 Oil

OSHA, NIOSH, and BP collected over 30,000 occupational air samples and analyzed the data for a variety of components of MC252 oil. The results of this occupational sampling and analysis are presented in

78 EPA Response to BP Spill in the Gulf of Mexico. Volatile Organic Compounds (VOCs) on the Gulf Coastline. Available at: http://www.epa.gov/bpspill/vocs.html.

79 *Id.*

80 Egeghy PP, Tornero-Valez R, Rapport SM. Environmental and biological monitoring of benzene during self-service automobile refueling. *Environ Health Perspect* 2000;108:1195-1202, at 1195; Backer L, Egeland GM, Ashley DL, et al. Exposure to regular gasoline and ethanol oxyfuel during refueling in Alaska. *Environ Health Perspect* 1997;105:850-855.

81 EPA Response to BP Spill in the Gulf of Mexico. Volatile Organic Compounds (VOCs) on the Gulf Coastline. Available at: http://www.epa.gov/bpspill/vocs.html. When the vast majority of samples are non-detects or reveal substances present at very low levels and a few very high levels are detected, it is most likely that the source of high levels is a local gasoline engine of some type, a local combustion source, or certain types of cleaning agents that contain hydrocarbons.

Tables 7 through 9 below.[82] I summarize the data and compare them to the OSHA PELs, NIOSH RELs, and ACGIH TLVs (where available). Within these tables, for each substance (chemical or mixture), I report the percentage of the results that were below the minimum detectable limit ("MDL") ("% Non-Detects"), the median concentration ("Median"), the 95th percentile,[83] and the percentage of samples that were below the selected OELs ("%< OSHA PEL," "%< NIOSH REL," "%< ACGIH TLV").

Table 7: OSHA Occupational Air Sampling Results for MC252 Oil Constituents (concentration units as noted)*

Substance (units)	# Results	% Non-Detects	Median**	95th Percentile ***	%< OSHA PEL	%< NIOSH REL	%< ACGIH TLV
Benzene (ppm)	919	100%	<0.2	0.20	100%	100%	100%
CTPV (benzene soluble fraction) (mg/m^3)	24	63%	<0.4	-	79%	-	79%
Ethylbenzene (ppm)	850	100%	<0.6	0.70	100%	100%	100%
Naphthalene (ppm)	2	100%	-	-	100%	100%	100%
Oil Mist, Mineral (mg/m^3)	16	13%	0.37	-	94%	94%	94%
Toluene (ppm)	642	99.8%	<2	0.73	100%	100%	100%
Trimethylbenzene, mixed isomers (ppm)	77	100%	<0.5	3.3	100%	100%	100%
Xylene (ppm)	906	99.8%	<0.6	0.74	100%	100%	100%

* Data source: OSHA. OSHA Activities During the Deepwater Horizon Oil Spill. Available at: https://www.osha.gov/oilspills/index_sampling.html.

** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

*** For calculating the 95th percentile, data for non-detectable samples were assigned a value of ½ the limit of detection. For situations where > 95% of the values were non-detects, the 95th percentile is based on values assigned to the limit of detection.

\- Insufficient values to calculate accurate 95th percentile.

Here, five samples exceeded the OSHA PEL and the ACGIG TLV. This does not mean that the workers were inhaling this concentration. OSHA ensured that respirators were used wherever the data indicated that they were necessary to protect workers. For example, OSHA noted exposure data from some decontamination operations that exceeded the most protective OELs. Upon investigation, OSHA confirmed that protective measures, which were based on guidance from the Unified Area Command, were already in place to protect the workers and prevent them from inhaling or having skin contact with hazardous chemicals.[84]

82 I focused my analysis of this data on the compounds and substances that are considered the most toxic, have OELs for comparison, and that have the greatest potential to be present at detectable concentrations in air. OSHA, NIOSH, and BP did not analyze for the exact same list of substances, although the lists were similar. The majority of the samples did not have concentrations of most substances present above the analytical minimum detectable limit ("MDL").

83 In other words, the value which 95% of measurements are below and only 5% would be above. For results less than the MDL, this was calculated by assigning a value of ½ the MDL. For results where more than 95% of samples were non-detects, this becomes a somewhat arbitrary value, since it becomes whatever value was assigned to the MDLs.

84 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011, at 8. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf

Table 8: NIOSH Occupational Air Sampling Results for MC252 Oil Constituents (concentration units as noted)*

Substance (units)	# Results	% Non-Detects	Median**	95th Percentile***	% <OSHA PEL	%<NIOSH REL	% <ACGIH TLV
Benzene (ppm)	104	81%	<0.001	0.003	100%	100%	100%
Ethylbenzene (ppm)	104	47%	0.0011	0.008	100%	100%	100%
n-Hexane (ppm)	17	24%	0.00087	-	100%	100%	100%
Hydrogen sulfide (ppm)	26	100%	-	-	100%	100%	100%
Naphthalene (ppm)	115	43%	0.00090	0.012	100%	100%	100%
Toluene (ppm)	104	43%	0.0016	0.024	100%	100%	100%
Total hydrocarbons (mg/m^3)	87	0%	0.72	8.5	-	-	-
Total PAHs (mg/m^3)	19	0%	0.0055	-	-	-	-
CTPV (benzene soluble fraction) (mg/m^3)	37	95%	<0.1	0.32	100%	-	100%
Total particulates (mg/m^3)	29	55%	<0.08	0.16	100%	100%	100%
1,2,4-Trimethylbenzene (ppm)	17	12%	0.00063	-	100%	100%	100%
1,3,5-Trimethylbenzene (ppm)	17	59%	<0.0003	-	100%	100%	100%
Total Xylenes (ppm)	104	32%	0.0040	0.035	100%	100%	100%

* Data source: CDC. NIOSH Deepwater Horizon Response. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html ; NIOSH Deepwater Horizon Response. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html. (168)

** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

*** For calculating the 95th percentile, data for non-detectable samples were assigned a value of ½ the limit of detection. For situations where > 95% of the values were non-detects, the 95th percentile is based on values assigned to the limit of detection.

\- Insufficient values to calculate accurate 95th percentile.

Table 9: BP Occupational Air Sampling Results for MC252 Oil Constituents (concentration units as noted)*

Substance (units)	# Results	% Non-Detects	Median**	95th Percentile***	% <OSHA PEL	%<NIOSH REL	% <ACGIH TLV
Benzene (ppm)	28,827	97%	<0.02	0.02	> 99.9%	99.7%	> 99.9%
Ethylbenzene (ppm)	28,827	98%	<0.09	0.10	100%	100%	100%
n-Hexane (ppm)	3,722	81%	<0.03	0.31	100%	100%	100%
Oil Mist (mg/m^3)	546	51	<0.2	0.54	100%	100%	100%
Toluene (ppm)	28,827	96%	<0.09	0.10	100%	100%	> 99.9%
Total Hydrocarbons (ppm)	28,827	83%	<0.8	3.0	-	-	-
Trimethylbenzene, total (ppm)	3,722	92%	<0.1	0.16	> 99.9%	> 99.9%	> 99.9%
Total Xylenes (ppm)	28,828	96%	<0.3	0.31	100%	100%	100%

* Data source: BP. Gulf Science Data. Available at: https://www.piersystem.com/go/doctype/6145/207610; Gulf Science data. Data Publication Summary Report. Community Air Sampling and Monitoring, April 2014. Available at https://www.piersystem.com/go/doctype/6145/207606.

** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

*** For calculating the 95th percentile, data for non-detectable samples were assigned a value of ½ the limit of detection. For situations where > 95% of the values were non-detects, the 95th percentile is based on values assigned to the limit of detection.

\- Insufficient values to calculate accurate 95th percentile.

As to oil-related components, the occupational exposure results provided in Tables 7 through 9 above demonstrate that:

- With the exception of 40 samples analyzed for hydrocarbon mixtures during decontamination procedures by OSHA, 100% of the results for other compounds of interest in the OSHA dataset were below all OELs. During its investigations, OSHA noted exposure data from some decontamination operations that exceeded the OELs. OSHA confirmed that protective measures were already in place to protect the workers from inhaling or having skin contact.[85]

- For the NIOSH dataset, 100% of the results for 11 compounds of interest and 1 mixture were below all OELs.

- The BP dataset was much larger than the other two. There were over 28,800 samples for each of the BTEX chemicals in the BP dataset. Results for 8 chemicals of interest and 1 mixture demonstrate that >99.7% of the samples were below all OELs.

(b) Components of Corexit Dispersants

BP, OSHA, and NIOSH also collected occupational samples for 2-butoxyethanol and propylene glycol from Clean-Up Workers, including over 1,000 samples for 2-butoxyethanol. I compared the results for 2-

85 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf.

butoxyethanol in each of the three datasets to OELs for 2-butoxyethanol. There are no OELs for propylene glycol.[86] The results are represented in Table 10, below.

Table 10: OSHA, NIOSH, and BP Occupational Air Sampling Results for Corexit Dispersant Constituents (concentration units as noted)*

Source	# Results	% Non-Detects	Median****	95th Percentile†	%< OSHA PEL	%< NIOSH REL	%< ACGIH TLV
2-Butoxyethanol (ppm)							
OSHA*	18	100%	<0.08	-	100%	100%	100%
NIOSH**	34	3%	0.0042	0.29	100%	100%	100%
BP***	1,029	80%	<0.05	0.14	100%	100%	100%
Propylene Glycol (mg/m^3)							
OSHA*	30	100%	<0.2	0.31	-	-	-
NIOSH**	24	46%	0.012	-	-	-	-
BP***	8	49%	<0.3	-	-	-	-

* Data source: OSHA. OSHA Activities During the Deepwater Horizon Oil Spill. Available at: https://www.osha.gov/oilspills/index_sampling.html.

** Data source: CDC. NIOSH Deepwater Horizon Response. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html

*** Data source: BP. Gulf Science Data. Available at: https://www.piersystem.com/go/doctype/6145/207610.

**** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

† For calculating the 95th percentile, data for non-detectable samples were assigned a value of ½ the limit of detection. For situations where > 95% of the values were non-detects, the 95th percentile is based on values assigned to the limit of detection.

\- Insufficient values to calculate accurate 95th percentile.

As Table 10 shows, analyses for 2-butoxyethanol in each of the three datasets showed that no sample exceeded any of the OELs for 2-butoxyethanol. Additionally, the low levels of propylene glycol measured by both BP and NIOSH demonstrate that dispersant components were not present in air at levels that might be expected to cause significant adverse health effects. As noted above, propylene glycol is not known to be associated with any significant adverse health effect — it is used in children's cough syrup and is considered safe in food by the FDA.

Thus, in the vast majority of cases, Clean-Up Workers were not exposed to airborne concentrations of the constituents of oil and dispersants at levels that would be expected to result in adverse health effects, based on comparison to established OELs, even before use of PPE is taken into account. In the few instances in which exposure levels measured high, there likely were alternative causes for the elevated readings, and Clean-Up Workers were most likely protected by PPE.

I applied the Hazard Index ratio method to the occupational data above to determine if mixture toxicity to the Clean-Up Workers should be considered. For the OSHA dataset, no individual component was detected with a high enough frequency to make the calculation meaningful. For the NIOSH dataset, Hazard Index ratios were calculated for eight individual components with OELs. The sum of these were <0.0013 for the OSHA PELs, <0.012 for the NIOSH RELs, and <0.003 for the ACGIH TLVs, indicating that there was no concern for mixture toxicity. Hazard Index ratios were calculated for six individual chemicals from the BP dataset. The sum of these indices were <0.03 for the OSHA PELs, <0.22 for the NIOSH RELs, and <0.06 for the ACGIH TLVs, again showing that mixture toxicity was highly unlikely.

[86] Though no OEL exists, the American Industrial Hygiene Association established a Workplace Environmental Exposure Level for propylene glycol of 10 mg/m^3. This value was not exceeded. AIHA, *2013 ERP/WEEL Handbook*, WEEL Values (2011), *available at* https://www.aiha.org/get-involved/AIHAGuidelineFoundation/WEELs/Documents/2011WEELValues.pdf.

Statements made by the relevant federal agencies support the conclusion that Clean-Up Workers were not exposed to airborne concentrations of the constituents of oil and dispersants at levels that would be expected to result in significant adverse health effects. For example, in its final HHE report, NIOSH concluded: "Throughout the evaluation, results for all airborne chemicals sampled were uniformly nondetectable or at levels well below applicable OELs."[87] OSHA has reached similar conclusions, stating on its website that: "No air sampling by OSHA detected any hazardous chemical at levels of concern."[88] The Directors of OSHA and NIOSH recently reaffirmed these conclusions in a scientific publication co-authored by them.[89] I found no mention of mixture toxicity by any of the federal agencies.

(c) Compounds Released from Controlled In-Situ Burning of Crude Oil

NIOSH investigators conducted PBZ and air sampling for any potential exposures to Clean-Up Workers during controlled in-situ burns of surface oil. NIOSH sampled for various chemicals of concern on vessels participating in controlled in-situ burn activities, including boats from which the burns were ignited. In its HHE final report, NIOSH concluded: "Exposures for all compounds sampled were either below detectable concentrations or well below applicable OELs, with one exception being a peak exposure of 220 parts per million (ppm) of CO recorded on the double-engine ignition boat. This peak was likely due to the build-up of exhaust from the gasoline powered engines when idling with no movement of the boat and little wind."[90]

In addition, EPA conducted sampling to measure emissions of dioxins — specifically, polychlorinated dibenzodioxins and furans ("PCDD/PCDFs") — from the controlled in-situ burns.[91] Based on this sampling, EPA and NOAA performed a risk assessment to identify the potential health risks to Clean-Up Workers (and Gulf Coast Residents) from inhalation exposures to PCDD/PCDFs.[92]

EPA concluded that while PCDD/PCDFs were created from the controlled in-situ burning of oil, they were created at low levels — levels similar to the emissions from residential woodstoves and forest fires and two orders of magnitude lower than open burning of residential waste.[93]

The two most toxic dioxin compounds, 2,3,7,8-TCDD and 1,2,3,7,8-PCDD, were not detected in sampling from above the controlled in-situ burn sites. EPA concluded, using very conservative methodology, that levels of PCDD/PCDFs generated by the controlled in-situ burns did not pose an appreciable cancer risk for Clean-Up Workers (or Gulf Coast Residents). Similarly, the measured levels of PCDD/PCDFs from the

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87 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011, at 13. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

88 OSHA. OSHA's Efforts to Protect Workers. Available at: https://www.osha.gov/oilspills/index.html.

89 Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers, July 18, 2012 Field Report. *PLOS Currents Disasters* 2012;July 18. Edition 1.

90 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011, at 4. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

91 Aurell J, Gullett BK. Aerostat Sampling of PCDD/PCDF Emissions from the Gulf Oil Spill in Situ Burns. *Environ. Sci. Technol.* 2010; 44:9431-9437.

92 Schaum J, Cohen M, Perry S, et al. Screening Level Assessment of Risks due to Dioxin Emissions from Burning Oil from the BP Deepwater Horizon Gulf of Mexico Oil Spill. *Environ. Sci. Technol.* 2010:44:9383-9389.

93 Aurell J, Gullett BK. Aerostat Sampling of PCDD/PCDF Emissions from the Gulf Oil Spill in Situ Burns. *Environ. Sci. Technol.* 2010; 44:9431-9437.

controlled in-situ burns were far below the ATSDR MRL for non-carcinogenic health effects for these compounds.[94]

Based on this data and analysis, there is no expectation of health risk to Clean-Up Workers based on any exposure to emissions resulting from the controlled in-situ burning of crude oil in connection with DWH oil spill.

8.1.2 Community Exposure Data

(a) Components of MC252 Oil

I have also reviewed, compiled, and analyzed the results of community air sampling collected by BP and EPA along the Gulf Coasts of Alabama, Florida, Louisiana, and Mississippi, as well as data from EPA's TAGA bus mobile laboratory. My analyses of the data from each of those efforts are presented in Tables 11 through 14 below. The sample numbers were sufficient to allow me to also analyze the data by state.

I have summarized and provided statistical data for the volatile chemicals that have toxicology benchmarks. For each chemical of interest, the number of samples, percent non-detects, median, 95th percentile, and the percent below the toxicology benchmark are listed for each of the four Gulf states and combined for all states.[95]

94 Schaum J, Cohen M, Perry S, et al. Screening Level Assessment of Risks due to Dioxin Emissions from Burning Oil from the BP Deepwater Horizon Gulf of Mexico Oil Spill. *Environ. Sci. Technol.* 2010:44:9383-9389, at 9378-88.

95 The toxicology benchmarks that are most applicable are the ATSDR Intermediate MRLs. These are roughly equivalent to the EPA Screening Levels for benzene and the xylenes. For ethylbenzene, ATSDR has a separate, higher Intermediate MRL, and EPA uses a higher level for toluene. ATSDR does not have Intermediate MRLs for toluene, naphthalene, or n-hexane. For these three chemicals, I used the Chronic MRL as is recommended by the ATSDR method for petroleum mixtures. ATSDR. Toxicological Profile for Total Petroleum Hydrocarbons (TPH) 1999. These benchmarks are thus more conservative than those for the other chemicals with intermediate benchmarks. For example, the ATSDR Chronic benchmark for toluene is over 16 times lower than the EPA screening level (see Table 3).

Table 11: EPA Community Analytical Results*

State	# of Results	% Non-Detects	Median** ($\mu g/m^3$)	95th Percentile ($\mu g/m^3$)***	% Below Benchmark
Benzene Toxicology Benchmark ATSDR Intermediate MRL – 19.2 $\mu g/m^3$					
All	**1241**	**71%**	**<0.6**	**1.1**	**99.8%**
Alabama	26	7.7%	0.62	3.2	100%
Florida	52	12%	0.52	1.4	100%
Louisiana	1110	75%	<0.6	1.1	99.8%
Mississippi	53	91%	<0.5	0.9	100%
Toluene Toxicology Benchmark ATSDR Chronic MRL**** – 302 $\mu g/m^3$					
All	**1263**	**51%**	**<0.8**	**2.8**	**100%**
Alabama	32	0%	1.5	3.6	100%
Florida	58	0%	1.5	3.5	100%
Louisiana	1109	58%	<0.7	2.7	100%
Mississippi	64	0%	1.2	2.4	100%
Ethylbenzene Toxicology Benchmark ATSDR Intermediate MRL – 8684 $\mu g/m^3$					
All	**1281**	**88%**	**<0.8**	**1.1**	**100%**
Alabama	35	31%	0.28	1.1	100%
Florida	65	30%	0.29	0.95	100%
Louisiana	1107	96%	<0.8	1.1	100%
Mississippi	74	30%	0.23	0.90	100%
m,p-Xylene† Toxicology Benchmark ATSDR Intermediate MRL**** – 2,605 $\mu g/m^3$					
All	**1017**	**85%**	**<0.8**	**1.8**	**100%**
Louisiana	1017	85%	<0.8	1.8	100%
o-Xylene† Toxicology Benchmark ATSDR Intermediate MRL**** – 2,605 $\mu g/m^3$					
All	**1276**	**87%**	**<0.8**	**1.1**	**100%**
Alabama	33	27%	0.27	1.1	100%
Florida	68	40%	0.32	1.0	100%
Louisiana	1108	95%	<0.8	1.2	100%
Mississippi	67	24%	0.22	0.90	100%
Naphthalene Toxicology Benchmark ATSDR Chronic MRL – 3.7 $\mu g/m^3$					
All	**355**	**0.56%**	**0.030**	**0.13**	**100%**
Alabama	22	0%	0.025	0.16	100%
Florida	38	0%	0.020	0.061	100%
Louisiana	245	0.82%	0.027	0.17	100%
Mississippi	50	0%	0.050	0.080	100%
Hydrogen Sulfide (ppm)†† Toxicology Benchmark ATSDR Chronic MRL**** – 20 ppm					
All	**11,093**	**79%**	**<0.1**	**0.5††**	**100%**
Alabama	1058	97%	<0.1	0.5	100%
Florida	604	98%	<0.1	0.05	100%
Louisiana	8682	74%	<0.1	0.5	100%
Mississippi	749	95%	<0.1	0.5	100%

State	# of Results	% Non-Detects	Median** ($\mu g/m^3$)	95th Percentile ($\mu g/m^3$)***	% Below Benchmark
Volatile Organic Compounds – VOC (ppm) No Toxicology Benchmark					
All	**23799**	**63%**	**<0.1**	**2.1**	
Alabama	1585	98%	<0.1	0.05	
Florida	1150	99%	<0.1	0.05	
Louisiana	19,831	56%	<0.1	2.2	
Mississippi	1233	95%	<0.1	0.06	

* Data Source: EPA. EPA Response to BP Spill in the Gulf of Mexico. Air Data from the Gulf Coastline. Available at: http://www.epa.gov/bpspill/air.html ,

** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

*** The 95th percentile was calculated by assigning non-detect samples the value of ½ the detection limit.

**** No Intermediate MRL available. The Chronic MRL is less appropriate and more conservative since it considers exposure greater than 365 days.

† MRL for all three xylene isomers combined.

†† During the first 19 days of monitoring, the detection limit for H_2S was 1 ppm. After that, it was 0.1 ppm. Since few samples were detected, the value of ½ the detection limit dominated the data.

Table 12: EPA TAGA Analytical Results*

State	# of Results	Percent Non-Detects	Median** (ppbv)	95th Percentile***	Percent Below Benchmark
Benzene Toxicology Benchmark ATSDR Intermediate MRL – 6 ppbv					
All	**89,911**	**75%**	**<2**	**3.2**	**98.2%**
Alabama	16,113	73%	<2	4.8	97.4%
Florida	40,263	80%	<2	2.4	98.6%
Louisiana	23,724	70%	<2	3.2	98.4%
Mississippi	9,811	70%	<2	5.5	96.1%
Toluene Toxicology Benchmark ATSDR Chronic MRL**** – 80 ppbv					
All	**89,869**	**79%**	**<4**	**7.4**	**99.9%**
Alabama	16,113	75%	<4	7.1	99.9%
Florida	40,263	80%	<3	5.1	>99.9%
Louisiana	23,682	78%	<6	15	99.8%
Mississippi	9,811	72%	<3	7.9	>99.9%
Xylenes Toxicology Benchmark ATSDR Intermediate MRL – 600 ppbv					
All	**90,819**	**3.4%**	**0.90**	**5.4**	**100%**
Alabama	16,113	3.5%	0.94	7.7	100%
Florida	40,263	2.2%	0.78	3.9	100%
Louisiana	24,627	5.1%	0.91	4.5	100%
Mississippi	9,816	4.0%	0.98	8.7	100%
2-Butoxyethanol Toxicology Benchmark ATSDR Intermediate MRL – 3,000 ppbv					
All	**905**	**30%**	**0.24**	**1.6**	**100%**
Alabama	75	12%	0.41	7.0	100%
Florida	21	71%	<0.2	0.48	100%
Louisiana	635	39%	0.079	1.0	100%
Mississippi	174	1.7%	0.54	1.8	100%
1-(2-Butoxy-1-methlyethoxy)-2-propanol No Toxicology Benchmark					
All	**905**	**38%**	**0.018**	**0.039**	
Alabama	75	39%	0.0005	0.021	
Florida	21	0%	0.019	0.026	
Louisiana	635	33%	0.027	0.053	
Mississippi	174	61%	<0.0006	0.0075	

* Data Source: EPA Response to BP Spill in the Gulf of Mexico. Mobile Air Monitoring on the Gulf Coast: TAGA Buses. Available at: http://www.epa.gov/bpspill/taga.html#tagadata

** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

*** The 95th percentile was calculated by assigning non-detect samples the value of ½ the detection limit.

**** No Intermediate MRL available. The Chronic MRL is less appropriate and more conservative since it considers exposure greater than 365 days.

Table 13: BP Community Analytical Results*

State	# of Results	% Non-Detects	Median** ($\mu g/m^3$)	95th Percentile ($\mu g/m^3$)***	% Below Benchmark
Benzene Toxicology Benchmark ATSDR Intermediate MRL – 19.2 $\mu g/m^3$					
All	**1563**	**93%**	**<16**	**8.0**	**98.9%**
Alabama	126	89%	<16	8.0	99.2%
Florida	347	95%	<16	8.0	99.4%
Louisiana	710	93%	<16	8.0	98.9%
Mississippi	380	94%	<16	8.0	98.4%
Toluene Toxicology Benchmark ATSDR Chronic MRL**** – 302 $\mu g/m^3$					
All	**1564**	**81%**	**<20**	**26**	**99.9%**
Alabama	126	66%	<20	68	100%
Florida	348	83%	<20	45	100%
Louisiana	710	82%	<20	19	99.9%
Mississippi	380	81%	<20	25	99.7%
Ethylbenzene Toxicology Benchmark ATSDR Intermediate MRL – 8684 $\mu g/m^3$					
All	**1562**	**94%**	**<22**	**11**	**100%**
Alabama	126	90%	<22	11	100%
Florida	347	94%	<22	11	100%
Louisiana	1284	96%	<22	11	100%
Mississippi	379	94%	<22	11	100%
m,p-Xylene Toxicology Benchmark ATSDR Intermediate MRL – 2,605 $\mu g/m^3$					
All	**1477**	**95%**	**<43**	**22**	**100%**
Alabama	120	91%	<43	22	100%
Florida	333	95%	<43	22	100%
Louisiana	656	96%	<43	22	100%
Mississippi	368	94%	<43	22	100%
o-Xylene Toxicology Benchmark ATSDR Intermediate MRL† – 2,605 $\mu g/m^3$					
All	**1563**	**93%**	**<22**	**11**	**100%**
Alabama	228	94%	<22	11	100%
Florida	644	96%	<22	11	100%
Louisiana	1284	97%	<22	11	100%
Mississippi	688	96%	<22	11	100%
Total-Xylenes Toxicology Benchmark ATSDR Intermediate MRL† – 2,605 $\mu g/m^3$					
All	**86**	**50%**	**<3**	**19**	**100%**
Alabama	6	17%	14	-	100%
Florida	14	43%	3.6	-	100%

State	# of Results	% Non-Detects	Median** (μg/m³)	95th Percentile (μg/m³)***	% Below Benchmark
Louisiana	54	54%	<3	16	100%
Mississippi	12	58%	<3	-	100%
Naphthalene Toxicology Benchmark ATSDR Chronic MRL**** – 3.7 μg/m³					
All	**3468**	**95%**	**<0.4**	**2.1**	**98.3%**
Alabama	269	99%	<0.4	0.24	99.3%
Florida	736	94%	<0.4	2.0	97.3%
Louisiana	1657	94%	<0.4	2.3	98.5%
Mississippi	806	97.6%	<0.4	1.9	98.5%
n-Hexane Toxicology Benchmark: ATSDR Chronic MRL**** – 2115 μg/m³					
All	**1560**	**90%**	**<18**	**9**	**100%**
Alabama	126	88%	<18	9	100%
Florida	347	94%	<18	9	100%
Louisiana	707	88%	<18	9	100%
Mississippi	380	91%	<18	9	100%
Hydrogen Sulfide†† Toxicology Benchmark ATSDR Chronic MRL**** – 28 μg/m³					
All	**2034**	**99%**	**<12**	**6.1**	**100%**
Alabama	162	100%	<12	6.1	100%
Florida	444	100%	<12	6.1	100%
Louisiana	954	97%	<12	6.4	100%
Mississippi	474	99.8%	<12	6.1	100%

* Data source: BP Gulf Science Data. Community Air. Available at: https://www.piersystem.com/go/doctype/6145/207606

** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

*** The 95th percentile was calculated by assigning non-detect samples the value of ½ the detection limit.

**** No Intermediate MRL available. The Chronic MRL is less appropriate and more conservative since it considers exposure greater than 365 days.

† MRL for all three xylene isomers combined.

†† During the first 19 days of monitoring, the detection limit for H_2S was 1 ppm. After that, it was 0.1 ppm. Since few samples were detected, the value of ½ the DL dominated the data.

Table 14: EPA Community Air PAH Results*

Chemical	# of Results	% Non-Detects	Median** (ng/m^3)	95th Percentile*** (ng/m^3)	EPA Screening Level	% Below Benchmark
Benzo(a)pyrene	353	98%	<0.09	20	640	100%
Benzo(a)anthracene	355	99%	<0.1	20	6,400	100%
Benzo(b)fluoranthene	353	96%	<0.2	20	6,400	100%
Benzo(k)fluoranthene	356	99%	<0.06	20	6,400	100%
Chrysene	352	75%	<0.2	20	64,000	100%
Dibenz(a,h)anthracene	351	100%	-	-	580	100%
Indeno(1,2,3-c,d)pyrene	349	96%	<0.09	20	6,400	100%
Naphthalene	355	0.56%	30	130	30,000	100%

* Data Source: EPA. EPA Response to BP Spill in the Gulf of Mexico. Air Data from the Gulf Coastline. Available at: http://www.epa.gov/bpspill/air.html

** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

*** For calculating the 95th percentile, data for non-detectable samples were assigned a value of ½ the limit of detection. For situations where > 95% of the values were non-detects, the 95th percentile is based on values assigned to the limit of detection.

As Tables 11 through 14 show, the concentrations of the compounds measured by EPA and BP in community air were extremely low — far below levels at which any significant adverse health effects might be expected. For example, for the EPA dataset for benzene, the median value was over 30 times lower than the toxicology benchmark, and 95% of the results were more than 17 times lower. For toluene, using the conservative Chronic MRL benchmark, the median result was more than 375 times lower, and 95% of the results were more than 100 times below, the MRL. For naphthalene, the median value was over 120 times lower than the MRL, and 95% of the results were 28 times lower than the MRL. As discussed above, the concentrations measured during community air sampling by EPA and BP are not necessarily related to the DWH oil spill, because many onshore sources (such as industries, cars, and cigarette smoke) emit the same compounds.[96]

One of the main health concerns during any burning is that PAHs could be formed. As I have mentioned previously, there are many sources for PAHs, including tobacco smoke and other sources of combustion. EPA analyzed over 350 air samples for eight different PAHs. My analysis of EPA's results showed that 100% of the results for each PAH were well below EPA's health-based Screening Levels. The median measured value for naphthalene was 1,000 times below EPA's Screening Level and the maximum value for each of the seven other PAHs was over 5,000 times lower than EPA's Screening Levels. EPA stated that results that are below the health-based Screening Level generally indicate a low potential for health concerns.[97]

Hazard Index ratios for 7 individual VOC chemicals from the EPA dataset and 1 dispersant from the TAGA dataset were all <0.03. The ATSDR-recommended approach for evaluating mixture toxicity states that if no two individual components have a Hazard Index >0.1 then interactions are unlikely to result in a

96 EPA Response to BP Spill in the Gulf of Mexico. Volatile Organic Compounds (VOCs) on the Gulf Coastline. Available at: http://www.epa.gov/bpspill/vocs.html.

97 EPA PAHs. Available at: http://www.epa.gov/bpspill/pahs.html.

health hazard.[98] The BP dataset did not have adequate detection limits to apply the Hazard Index method.

The other method recommended by ATSDR for evaluating mixture toxicity for total petroleum hydrocarbons is to use representative marker compounds for classes of hydrocarbons based on their volatility and transport characteristics. ATSDR pointed out that a major limitation of this method is that the composition of a petroleum product can change significantly due to weathering,[99] as it did in this case. For this method, benzene, toluene, xylene, ethylbenzene, n-hexane, and naphthalene are all representatives for their respective classes of volatile hydrocarbons. All of these were well below their respective toxicology benchmarks. Based on both methods, there is no indication that there should be any concern for potential mixture toxicity.

I also compared the EPA's community air results for BTEX concentrations (also called mixing ratios) collected along the Gulf Coast in 2010 to BTEX concentrations found in regional Southern cities and Los Angeles. For these, I used only the EPA dataset since it had the lowest detection limits. Then, I compared each of the BTEX concentrations to their respective toxicology benchmarks. These comparisons are shown in Table 15 below.

Table 15. Comparison of BTEX Concentrations (ppbv) from the Gulf Coast in 2010 to U.S. Cities and Toxicology Benchmarks[100]

Chemical	Gulf Coast 2010*	Baton Rouge 2001**	Birmingham 2001**	Houston-Galveston Bay 2006***	Los Angeles 2005**	Benchmark*****
Benzene	<0.19	0.15	0.17	0.42	0.48	**6**
Toluene	<0.16	0.54	0.46	0.5	1.4	**1300**
Ethylbenzene	<0.18	0.02	0.04	0.08	0.047	**2000**
o-Xylene, total	<0.18	0.018	0.037	0.09	0.2	**600**
m,p-Xylene, total	<0.18	0.046	0.11	0.22	0.62	**600**

* Data source: 1-4. All values are less than the value shown in the table.

** Data source: Baker AK, et al. Measurements of nonmethane hydrocarbons in 28 United States cities. Atmosph Environ 2008; 42:170-182.

*** Data source: Middlebrook AM, Murphy DM, Ahmadov R, et al. Air quality implications of the *Deepwater Horizon* oil spill. *PNAS Early Edition*, December 28, 2011. Available at: www.pnas.org/cgi/doi/10.1073/pnas.1110052108.

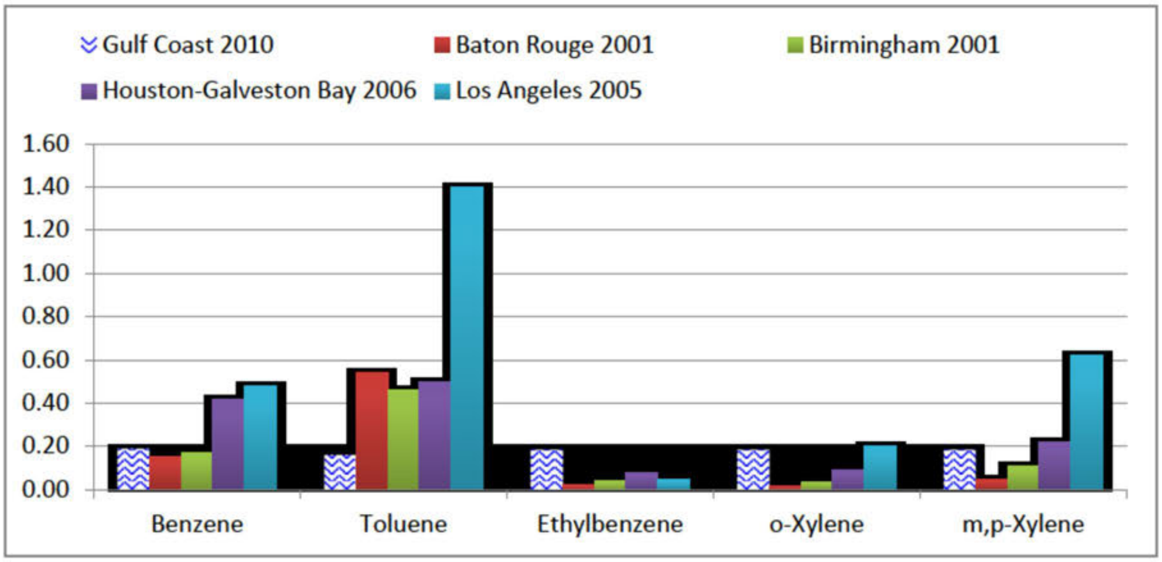
The BTEX data from the EPA dataset are shown graphically in Figures 3, 4, and 5 below. For these charts, the median concentrations of chemicals measured along the Gulf Coast in 2010 are shown in stripes, since the concentrations are actually less than the values shown.

98 ATSDR. Guidance Manual for the Assessment of Joint Action of Chemical Mixtures 2007. Available at: http://www.atsdr.cdc.gov/interactionprofiles/IP-ga/ipga.pdf.

99 ATSDR. Toxicological Profile for Total Petroleum Hydrocarbons (TPH) 1999.

100 In evaluating these comparisons, it is important to note that the sampling and analytical methods used by EPA and BP were not intended to have extremely low detection limits for comparison to ambient air background levels. The analyses were designed to have detection limits that were well below toxicology levels of concern to protect public health.

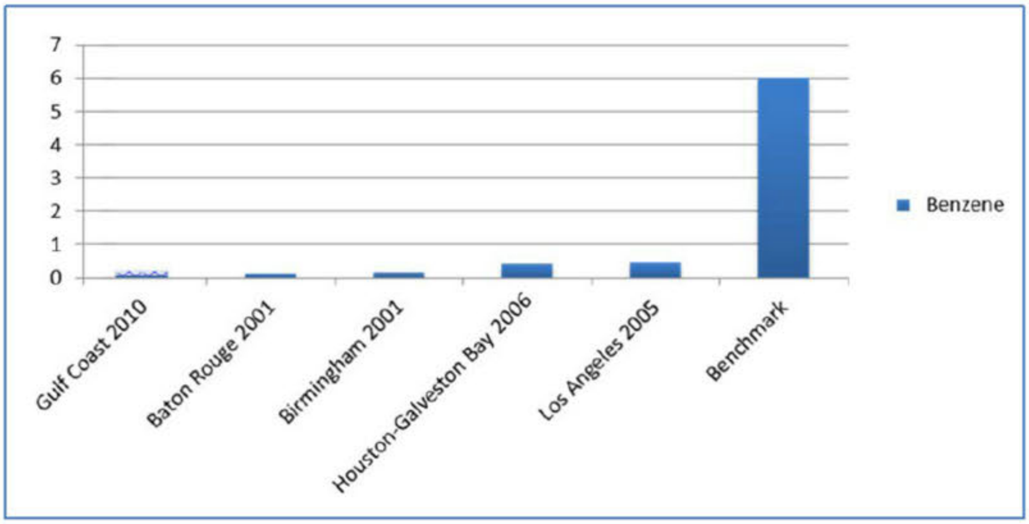
Figure 3. Comparison of BTEX Concentrations (ppbv) from the Gulf Coast During the DWH Oil Spill to U.S. Cities*



* Based on data in Table 15.

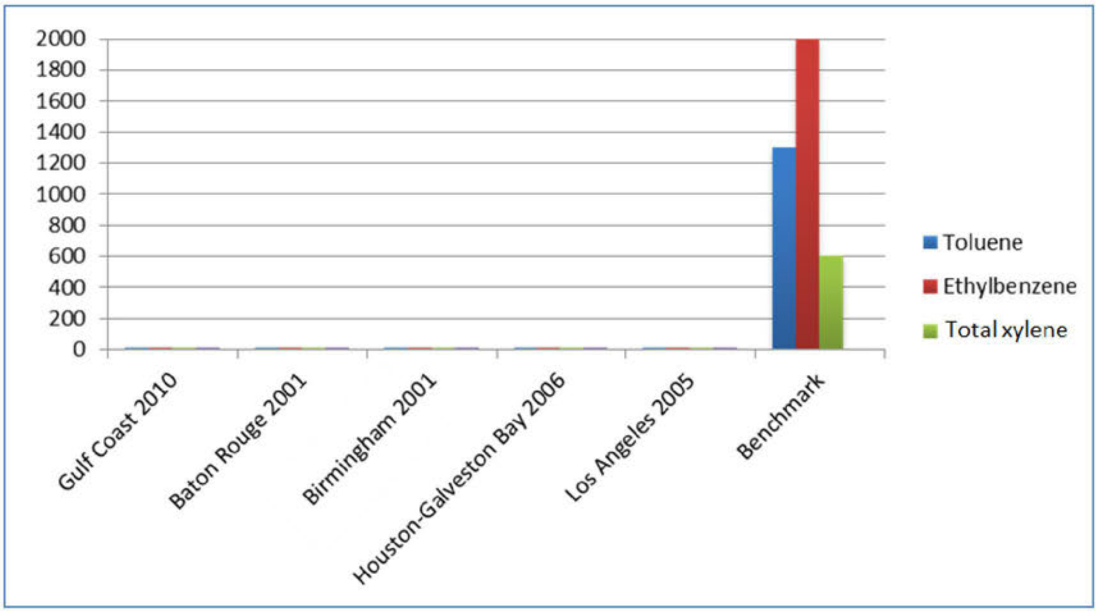
As Figure 3 shows, the concentrations observed along the Gulf Coast during the DWH oil spill were lower than or equivalent to concentrations in found in local cities in Louisiana and Alabama and in Houston-Galveston Bay and Los Angeles. Thus, the concentrations observed in the aftermath of the DWH spill were typical of atmospheric levels in U.S. cities.[101]

Figure 4. Comparison of Benzene Concentrations (ppbv) from the Gulf Coast and U.S. Cities to Toxicology Benchmarks



101 Also, if there had been any risk from mixture toxicity, that risk would be no different than the risk from routinely breathing air in other cities in the United States. Any mixture toxicity risk would be greater for anyone breathing indoor air.

Figure 5. Comparison of Toluene, Ethylbenzene, and Xylene Concentrations (ppbv) from the Gulf Coast and U.S. Cities to Toxicology Benchmarks



Figures 4 and 5 show that the concentrations of BTEX chemicals measured along the Gulf Coast during the DWH oil spill are well below the toxicology benchmarks for potential health effects. In fact, as Figure 5 shows, the concentrations of toluene, ethylbenzene, and xylenes were so low that they do not even show up when plotted against their respective toxicology benchmarks. Given our knowledge of removal of the majority of the BTEX compounds prior to the oil reaching the ocean surface and complete removal prior to the oil reaching the shore, it is evident that the low concentrations of these substances that were measured along the Gulf Coast during the DWH oil spill were local ambient concentrations.

Studies have also shown that the concentrations of these chemicals in indoor air are typically 2-3 times greater than those of outdoor air.[102] In Table 16 below, I compare the concentrations of BTEX chemicals measured along the Gulf Coast during the DWH oil spill with concentrations measured inside homes in the United States.

[102] Wallace LA. Personal exposure to 25 volatile organic compounds EPA's 1987 TEAM study in Los Angeles, California. *Toxicol Ind Health* 1991;7:203-208, at 2; Kinney PL, Chillrud SN, Ramstrom S, et al. Exposures to multiple air toxics in New York City. Environ Health Perspect 2002;110:539-546; EPA. EPA Response to BP Spill in the Gulf of Mexico. Air Data from the Gulf Coastline. Available at: http://www.epa.gov/bpspill/air.html; Dawson H., Background Indoor Air Concentrations of Volatile Compounds in North American Residences, Vapor Intrusion Workshop – AEHS Spring 2008, San Diego, CA. Available at https://iavi.rti.org/attachments/WorkshopsAndConferences/05_EPA_Background.pdf.

Table 16. Comparison of Outdoor Ambient Air Concentrations of BTEX (µg/m³) from the Gulf Coast During the DWH Oil Spill to Indoor Concentrations in the U.S.

Chemical	Gulf Coast 2010*	Indoor Air EPA 2008**	NHANES 2008***	New York City 2002****	Los Angeles 1987†
Benzene	<0.6	2.4	2.8	1.75	6
Toluene	<0.8	13	16.8	14.9	
Ethylbenzene	<0.8	2.2	3	2	2.8
o-Xylene	<0.8	2.2	2.8	2.3	4.3
m,p-Xylene	<0.8	4.0	7.5	10.4	12

* Data source:. EPA. EPA Response to BP Spill in the Gulf of Mexico. Air Data from the Gulf Coastline. Available at: http://www.epa.gov/bpspill/air.html. Median - all values are < this value.

** Data source: Dawson H., Background Indoor Air Concentrations of Volatile Compounds in North American Residences, Vapor Intrusion Workshop – AEHS Spring 2008, San Diego, CA. Available at https://iavi.rti.org/attachments/WorkshopsAndConferences/05_EPA_Background.pdf

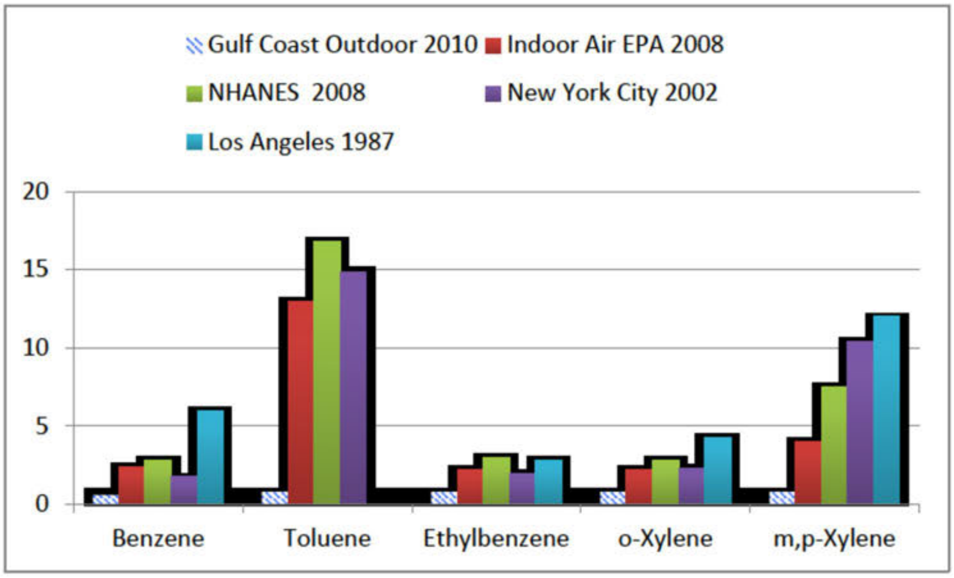
*** Data source: Lin YS, Egehy PP, Rappaport SM. Relationships between levels of volatile organic compounds in air and blood from the general population. *J Exp Science Environ Epidemiol* 2008;18:421-429. U.S. personal breathing zone data for non-smokers.

**** Data source: Kinney PL, Chillrud SN, Ramstrom S, et al. Exposures to multiple air toxics in New York City. Environ Health Perspect 2002;110:539-546. Summer data, winter values higher.

† Data source: Wallace LA. Personal exposure to 25 volatile organic compounds EPA's 1987 TEAM study in Los Angeles, California. *Toxicol Ind Health* 1991;7:203-208. Summer data, winter values higher.

The data for Table 16 is represented graphically in Figure 6 below. Again, the median concentrations of chemicals measured along the Gulf Coast in 2010 are shown in stripes, since the concentrations are actually less than the values shown.

Figure 6. Comparison of Outdoor Ambient Air Concentrations of BTEX (µg/m³) from the Gulf Coast During the DWH Oil Spill to Indoor Concentrations in the U.S.*



* Based on data in Table 16.

These comparisons show that the concentrations of the BTEX chemicals along the Gulf Coast area during the DWH oil spill are less than indoor air from a typical U.S. home. Thus, any potential risk from breathing the air along the Gulf Coast during the DWH oil spill (individual or mixture) would be less than the risk of breathing indoor air in U.S. cities during everyday life.

(b) BP Branch Area Sampling

I analyzed data from BP's Branch Area Perimeter sampling program for the volatile components of crude oil that are of toxicological interest. The samples analyzed were collected downwind from decontamination sites or waste storage communities. The results are presented in Table 17. Even though these samples were collected around decontamination and disposal activities, the vast majority of the results were still well below the toxicology benchmarks. In fact, the air sampling results from the decontamination and disposal activities were remarkably similar to the community air sampling results.

Table 17: BP Branch Area Analytical Results*

Chemical	# of Results	% Non-Detects	Median** (µg/m3)	95th Percentile (µg/m3)***	Benchmark (ATSDR Intermediate MRL)	% Below Benchmark
Benzene	1243	95%	<16	8.0	19.2 µg/m^3	98.3%
Toluene	1245	88%	<19	20	302 µg/m^3****	99.9%
Ethylbenzene	1244	97%	<22	11	8684 µg/m^3	100%
m,p-Xylene	1197	98%	<43	22	2,605 µg/m^3†	100%
o-Xylene	1244	96%	<22	11	2,605 µg/m^3†	100%
Total Xylenes	47	47%	2.9	17	2,605 µg/m^3	100%
Naphthalene	1579	82%	<0.4	2.7	3.7 µg/m^3****	94%
n-Hexane	1241	94%	<18	9	2115 µg/m^3****	100%
Hydrogen Sulfide	1370	94%	<12	12	28 µg/m^3****	100%

* Data source: BP Gulf Science Data. Community Air. Available at: https://www.piersystem.com/go/doctype/6145/207606

** Non-detect values were assigned the value of the detection limit for the purpose of calculating the median. If greater than 50% of the values for a substance were non-detects, the median is expressed as less than the calculated median.

*** The 95th percentile was calculated by assigning non-detect samples the value of ½ the detection limit.

**** No Intermediate MRL available. Chronic MRL used. The Chronic MRL is less appropriate and more conservative since it considers exposure greater than 365 days.

† MRL for all three xylene isomers combined.

†† During the first 19 days of monitoring, the detection limit for H_2S was 1 ppm. After that, it was 0.1 ppm. Since few samples were detected, the value of ½ the DL dominated the data.

The extremely low concentrations of volatile oil compounds in these samples confirm that the volatile and semi-volatile components of the MC252 oil were removed prior to the oil getting close to the shoreline. The low concentrations of these compounds in both sampling efforts and the close agreement between the community air sampling and the perimeter air sampling is further support that the concentrations measured are the baseline concentrations for the area.

These data show that there was no risk to communities that were located close to the waste disposal and decontamination activities during the DWH oil spill cleanup and response. They also are consistent with and support the results derived from PBZ samples from cleanup workers who were working around the weathered oil, and confirm that there was no inhalational risk from this work.

(c) Components of Corexit Dispersants

The potential for Gulf Coast Residents to be exposed to airborne concentrations of the components of the two Corexit dispersants was extremely low. That Gulf Coast Residents were not exposed to airborne concentrations of the dispersant constituents at levels of concern is supported by the available air monitoring. BP and EPA did not sample for the components of Corexit 9500A and Corexit 9527A at the fixed-monitoring stations described above. However, EPA utilized the TAGA buses to sample for airborne concentrations of various chemicals, including 2-butoxyethanol and DPnB. According to EPA, these are "the two chemicals found in the COREXIT dispersants that have the highest potential to get into the air in any significant amounts."[103] EPA monitored for these two dispersant components from May 18, 2010, through June 6, 2010, at locations along the Gulf Coasts of Alabama, Florida, Louisiana, and Mississippi. These data were shown in Table 12 above. These showed that 100% of the samples for 2-butoxyethanol were below the toxicology benchmark and the concentrations of DPnB were extremely low.

Based on the results of this monitoring, EPA concluded:

> The TAGA buses detected very low levels of [2-butoxyethanol and DPnB] in the air, at a limited number of the locations sampled along the Gulf Coast. The levels found were well below those that are likely to cause health effects, and suggest that the use of dispersants on the oil spill would not have a significant impact on air quality on land.[104]

EPA also collected seven air samples from offshore boats within 30 minutes of aircraft application of dispersants. Neither 2-butoxyethanol nor propylene glycol was detected in any of these samples. EPA concluded that "[t]hese results do not indicate any concern for on-shore air quality."[105] EPA also analyzed these samples for VOCs and found results similar to onshore samples and concluded that these results were below levels of health concern.

With the exception of petroleum distillates, the components of the Corexit dispersants are water soluble and relatively non-volatile. Because the Corexit dispersants were generally applied more than 3 nautical miles ("nmi") off the Gulf Coast, none of these components would be expected to be present in the ambient air along the coast. Based on the sampling results described above and my knowledge of the chemistry and toxicology of the chemicals in the Corexit dispersants, it is my opinion that Gulf Coast Residents were exposed to negligible levels, if any, of the components of Corexit 9500A and Corexit 9527A, and would not be expected to develop adverse health conditions as a result of such potential minimal exposures. While most of the dispersant components are known to degrade quickly, any persistent chemical entities, measurable or immeasurable, would be subject to continual dilution.

The CDC reached a similar conclusion, stating in a report prepared for health professionals in connection with the DWH oil spill: "Once the dispersant is applied to the oil slick it begins to break down in the environment. In aquatic environments it begins to break down within 16 days. Because of the strict

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[103] EPA Mobile air monitoring on the Gulf Coast: TAGA Buses. Available at: http://www.epa.gov/bpspill/taga.html.

[104] *Id*.

[105] EPA. Offshore air sampling for dispersant –related compounds. Available at: http://www.epa.gov/bpspill/dispersant-air-sampling.html.

guidelines that must be followed to utilize dispersants it is unlikely that the general public will be exposed to straight product."[106]

(d) Compounds Released from Controlled In-Situ Burning of Crude Oil

As discussed above, EPA and the Gulf States conducted regular air monitoring at fixed-monitoring locations in Alabama, Florida, Louisiana, and Mississippi to assess airborne concentrations of the criteria pollutants and to determine compliance with the NAAQS. This air monitoring was conducted before, during, and after the DWH oil spill.

Based on this air monitoring, EPA has concluded that the DWH oil spill (including the controlled in-situ burning of oil in connection with the spill) did not have a significant impact on ozone and particulate concentrations along the Gulf Coast, stating:

> Since late April, 2010, EPA has been monitoring the air at multiple sites along the Gulf Coast for certain pollutants that are associated with petroleum products and from the burning oil out at sea. EPA's air monitoring to date, has found that air quality levels for ozone and particulates are normal on the Gulf coastline for this time of year and odor-causing pollutants associated with petroleum products are being found at low levels.[107]

Studies by EPA showed that the Air Quality Index showed primarily "good" air quality during the periods of the burns with fewer "moderate" air days compared with the month of April prior to the burns. Also, there were fewer unhealthy air days as measured by the AQI in 2010 than in each of the previous five years. The data generally showed levels in the good to moderate range for both ozone and PM2.5 — "consistent with historical values for the region and typical air quality for this time of year."[108] I have reviewed the data on levels of ozone and fine particulates along the coast for the four Gulf States for 2010 (and for 2007-2009 for comparison). This included two coastal sites from Mississippi, and three coastal sites from Louisiana, Alabama, and Florida. For fine particulate matter (PM2.5), the 2010 average was less than the average for the previous three years for all sites except one in Alabama (Baldwin-Fairhope) and the 98th percentile daily value, a measure of peaks that could have occurred during controlled in-situ burning, for 2010 was less than the values for the previous three years for all sites. For ozone, all values from the coastal sites for 2010 were less than or equal to the average of the previous three years. Review of the data regarding potential hazards of the burning of crude oil indicates no expected increased health risk to Gulf Coast Residents. Thus, based on my personal review, I agree with the statements above made by EPA. Accordingly, one would not expect increased health risk to Gulf Coast Residents based on exposure to ozone and particulate matter as a result of the DWH oil spill and cleanup activities. The Air Quality Indices showed that the air along the Gulf Coast was overall healthier in 2010 than it was during the previous five years.

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106 CDC. Agency for Toxic Substances Disease Registry. Oil Spill Dispersant (COREXIT ®EC9500A and EC9527A) Information for Health Professionals. May 13, 2010. Available at: http://www.cdc.gov/nceh/oil_spill/docs/Oil%20Spill%20Dispersant.pdf.

107 EPA. EPA Response to BP Spill in the Gulf of Mexico. Odors from the BP Oil Spill, at 2013. Available at: http://www.epa.gov/bpspill/odor.html.

108 Devlin R, USEPA. Global implications of oil spills on mankind and the environment. Presented at Chest 2011, Hawaii, October 2011, at slide 5.

I compared the concentrations of PAHs in homes with different types of heaters and with and without smokers to the concentrations of PAHs in 350 EPA air samples from along the Gulf Coast during the DWH oil spill. The results are shown in Table 18 and Figure 7 below.

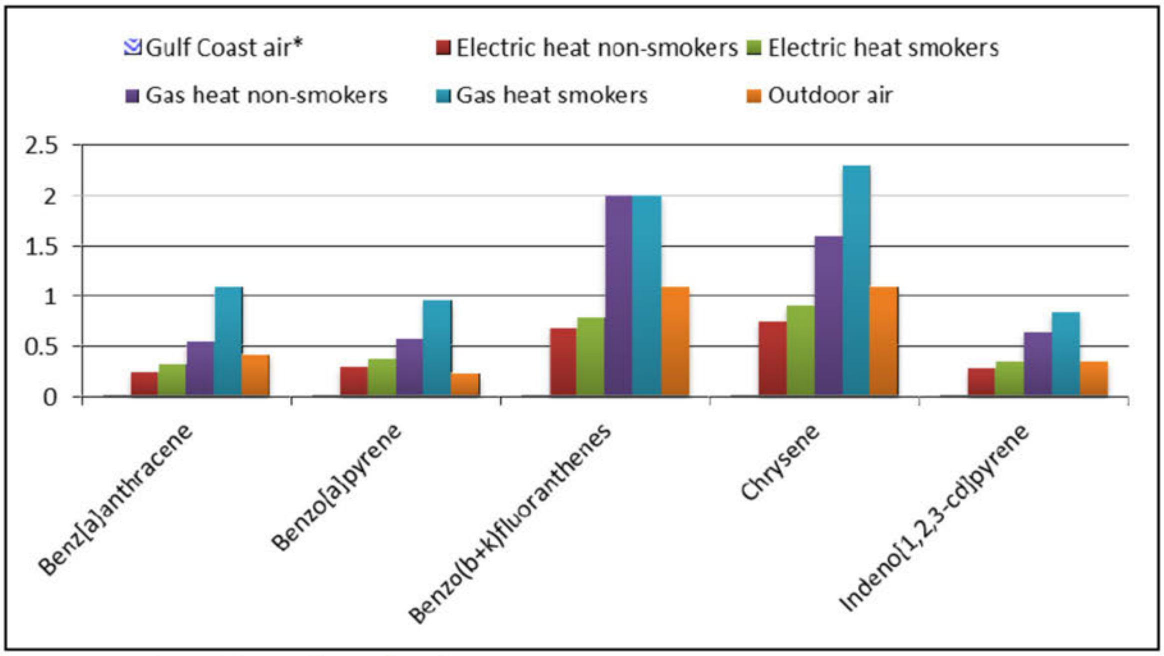
Table 18. Comparison of Concentrations of PAHs (μg/m³) Along Gulf Coast to Indoor Air

PAH	Gulf Coast Air 2010*	Electric Heat - Non-Smokers**	Electric Heat - Smokers**	Gas Heat - Non-Smokers**	Gas Heat - Smokers**	Outdoor Air**
Benz[a]anthracene	<0.00015	0.25	0.32	0.55	1.1	0.42
Benzo[a]pyrene	<0.000086	0.3	0.37	0.58	0.96	0.23
Benzo(b+k)fluoranthenes	<0.00021	0.68	0.79	2	2	1.1
Chrysene	<0.00012	0.76	0.91	1.6	2.3	1.1
Indeno[1,2,3-cd]pyrene	<0.000082	0.28	0.35	0.64	0.84	0.35

* Median values from 350 air samples from EPA.. EPA. EPA Response to BP Spill in the Gulf of Mexico. Air Data from the Gulf Coastline. Available at: http://www.epa.gov/bpspill/air.html. All values are less than the value shown in the table, with 75-100% non-detects.

** Indoor and outdoor data from Columbus, Ohio, in winter.. ATSDR. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs) 1995.

Figure 7. Comparison of Concentrations of PAHs (μg/m³) Along Gulf Coast to Indoor Air*



* Based on data in Table 17. All values for Gulf Coast air are <values.

The PAH concentrations measured along the Gulf Coast were thousands of times below their toxicology benchmarks and far less than those found in U.S. homes. Thus, I see no health concern with PAHs in air during the DWH oil spill.

In addition, in Section 8.1.1(c), I discuss sampling and analysis done by EPA and NOAA that pertains to both Clean-Up Workers and Gulf Coast Residents showing no appreciable risk to health of either population resulting from exposure to emissions (including PCDD/PCDFs) from controlled in-situ burns.

Accordingly, one would not expect increased health risk to Gulf Coast Residents based on exposure to PAHs or PCDD/PCDF emissions resulting from the controlled in-situ burning of crude oil in connection with the DWH oil spill.

8.2 Dermal Exposure Characterization

For both Clean-Up Workers and Gulf Coast Residents, there was little potential for dermal exposures to the components of crude oil and dispersants at concentrations and for durations sufficient to cause potential health concerns. First, the potentially toxic volatile components of the MC252 oil and the Corexit dispersants, described in greater detail above, were not present onshore in sufficient quantities to cause any significant adverse health effects. Second, Clean-Up Workers, who were generally closer in proximity to the oil and dispersants, were required to wear appropriate PPE, which should have prevented most, if not all, dermal exposures. Accordingly, the evidence leads to the conclusion that there were not widespread dermal exposures to the components of crude oil or dispersants for either Clean-Up Workers or Gulf Coast Residents at concentrations and for durations that might be expected to cause significant adverse health effects.

8.2.1 Clean-Up Workers

(a) MC252 Oil

Clean-Up Workers potentially could have been exposed to oil at different stages of weathering, depending on the location in which they were working and other factors. Clean-Up Workers engaged in response activities nearshore and onshore potentially could have been exposed to weathered oil. As described above, intermittent dermal contact with weathered crude oil is unlikely to result in significant adverse health effects, particularly if good personal hygiene practices are utilized. In addition, all Clean-Up Workers were required to wear appropriate PPE, such as gloves and coveralls, as specified in the PPE Matrices created by BP and OSHA.[109] If used properly, PPE likely would have prevented any significant dermal exposures to the components of crude oil, and there would be little potential health risk.

Clean-Up Workers engaged in response activities closer to the source of the discharge could have been exposed to crude oil that was less weathered. But like other Clean-Up Workers, the workers engaged in response activities near the source were required to wear appropriate PPE, which should have prevented or substantially reduced dermal exposures to crude oil. In addition, many of the Clean-Up Workers at the source were professional oil spill responders, who had received extensive training in handling crude oil and protecting themselves from potentially harmful exposures to crude oil.[110]

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109 OSHA. On-Shore PPE Matrix for Gulf Operations, Version 2.1. Available at: https://www.osha.gov/oilspills/gulf-operations-ppe-matrix.pdf; OSHA. Off-Shore PPE Matrix for Gulf Operations, Version 2.1. Available at: https://www.osha.gov/oilspills/gulf-operations-ppe-matrix.pdf.

110 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf; Restore the Gulf. Unified Incident Command Medevcs Crewmen. May 28, 2010. Available at: http://www.restorethegulf.gov/release/2010/05/28/unified-incident-command-medevacs-crewmen.

The conclusion that Clean-Up Workers did not experience widespread dermal exposures to crude oil in connection with the DWH oil spill is corroborated by the findings of NIOSH. NIOSH conducted numerous HHEs to evaluate potential exposures and health effects among Clean-Up Workers involved in the response to the DWH oil spill. As part of the HHE, NIOSH investigators conducted exposure monitoring and observational assessments for the full spectrum of response activities. At the conclusion of its investigation, NIOSH concluded that dermal exposures to crude oil were minimal, and that Clean-Up Workers wore appropriate PPE in most cases, stating:

> [W]e sought to identify potential dermal exposures to oil, dispersant, or other chemicals. Observational exposure characterization was performed at numerous beaches in Louisiana, Mississippi, Alabama, and Florida where cleanup was occurring. Even at beach cleaning worksites where oil residue was judged by our teams to be heavy, worker exposure to oil residue was typically observed to be limited, with no evidence of exposure to dispersant. While the use of PPE (gloves, coveralls, face shields, goggles, etc.) was typically found to be matched to the level of expected or potential dermal exposure at many sites, PPE was not always used as directed.[111]

The potential existed for dermal contact with oil while placing and removing the skimmer and boom from the water and during cleaning activities on deck. However, workers were required to wear the necessary PPE during tasks with increased potential for dermal contact. Dr. John Howard, Director of NIOSH, testified that PPE was generally effective at preventing health risks to DWH response workers, including by preventing and minimizing dermal contact with chemicals of concern.[112] According to him, actual dermal exposures to components of crude oil and dispersants were small, based on protections that were put in place by BP and the Unified Area Command. Dr. Howard had no knowledge of any DWH workers being exposed to any chemicals of concern at levels that could potentially cause harm.[113]

NIOSH investigators did find that some Clean-Up Workers had the potential for dermal exposure to the components of crude oil. For example, NIOSH investigators noted that wildlife cleaning and rehabilitation and decontamination operations presented the opportunity for repeated and prolonged skin contact with oily water.[114] However, as previously mentioned, oil that reached the Gulf Coast was extremely weathered and depleted of the majority of the potentially toxic PAHs.[115] In addition, in most cases, Clean-Up Workers wore appropriate PPE, the use of which was rigorously required and monitored, which should have significantly reduced the frequency and extent of any dermal exposures to crude oil.[116] Given the weathered condition of the oil and the use of appropriate PPE in most cases,

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111 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011, at 13-14. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf.

112 Tr. of John Howard Dep., at 130.

113 *Id.*

114 CDC. National Institute for Occupational Safety and Health. Summary of Potential Hazards to Deepwater Horizon Response Workers. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/hazsumm.html; CDC. National Institute for Occupational Safety and Health. Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0129. Interim Report #8A. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html.

115 OSAT-2.

116 CDC. National Institute for Occupational Safety and Health. Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0129. Interim Report #5, at 5-2. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html; CDC. National Institute for Occupational Safety and Health. Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0129. Interim Report #9, at 9-C5. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html.

the potential for significant human health risks from dermal exposure to crude oil, even for those Clean-Up Workers with the highest potential for exposure, was minimal. Also, if any exposures did occur, they would have been of minimal duration since they would have been washed off within several hours.

(b) Corexit Dispersants

Most Clean-Up Workers had little or no potential for significant dermal exposure to the two Corexit dispersants. Dispersants were not applied onshore, and aerial applications of dispersants were not permitted to occur within 2 nmi of any rig, platform, or vessel.[117] In addition, as described above, once applied to oil slicks on the surface of the Gulf, the Corexit dispersants biodegraded and were significantly diluted, thus reducing the potential for potentially harmful dermal exposures to the dispersants and their constituents.[118] The OSAT evaluation showed that out of 4,850 water and 412 sediment samples analyzed for dispersant chemicals, only 66 samples had detectable quantities of dispersants and all were below EPA's benchmark.[119] Finally, Clean-Up Workers were required to wear appropriate PPE, which, if used as instructed, should have prevented any significant dermal exposures to the dispersants.

Clean-Up Workers engaged in the vessel application of dispersants had among the highest potential for dermal exposures to the Corexit dispersants. NIOSH conducted multiple investigations of dispersant spraying operations in connection with the DWH oil spill, and determined that appropriate use of PPE, which was observed by NIOSH investigators to have been worn by Clean-Up Workers applying the dispersants, should have prevented any significant dermal exposures to the Corexit dispersants.[120] Dr. Howard also concluded that PPE generally prevented or minimized dermal contact with dispersant constituents.[121]

Accordingly, widespread or prolonged dermal exposures of Clean-Up Workers to the Corexit dispersants and their constituents were unlikely, and I would not expect significant adverse health effects from any exposures that did occur.

8.2.2 Gulf Coast Residents

(a) MC252 Oil

Gulf Coast Residents located onshore had no potential for dermal exposure to fresh crude oil, which was released from approximately 1 mile beneath the ocean surface and approximately 50 miles offshore and 100 miles from large population centers. However, Gulf Coast Residents potentially could have come into contact with "weathered" oil and tar balls (oil that has undergone a number of physical and biological processes, such as evaporation, dissolution, and biodegradation).

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117 Houma ICP, Aerial Dispersant Group, After Action Report: Deepwater Horizon MC252 Response, Aerial Dispersant Response. HAZWOPR Requirement. December 31, 2010, at 32 and 27. http://www.ncbi.nlm.gov/pmc/articles/PMC2920106/

118 FDA. Seafood Dispersants. Available at: http://www.fda.gov/downloads/food/foodsafety/product-specificinformation/seafood/ucm221659.pdf

119 OSAT, at 25.

120 CDC. National Institute for Occupational Safety and Health. Interim Guidance for Protecting Deepwater Horizon Response Workers and Volunteers. July 26, 2010. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/protecting/#effects.

121 Tr. of John Howard Dep., at 130.

As discussed above, weathered oil and tar balls did not contain significant amounts of the more water-soluble, volatile compounds from oil (such as BTEX). For instance, in samples analyzed for BTEX by the Operational Science Advisory Team ("OSAT") to the Federal On-Scene Coordinator ("FOSC"), BTEX compounds were never detected in MC252 oil that reached the shore or in nearshore sediments.[122] As a result, PAHs are the primary compounds of concern with regard to the potential for adverse health effects from dermal exposure to weathered oil or tar balls. Government studies have concluded that PAHs in weathered crude oil samples collected along the Gulf Coast were significantly depleted by the time the oil reached the shoreline (approximately 86-98% depletion), thus reducing the potential for health risks to Gulf Coast Residents from dermal exposure to weathered oil or tar balls.[123]

In addition, any Gulf Coast Residents' exposure to weathered oil and tar balls, on beaches or along other parts of the Gulf Coast generally, would have been restricted to short-term dermal exposure. Significant adverse health effects are not expected without repeated, prolonged dermal exposure to these compounds.[124] Moreover, intermittent or occasional skin contact with weathered oil or tar balls is not expected to have significant adverse health effects if good personal hygiene measures are followed (e.g., washing any contacted oil off of the skin).[125]

Based on the low concentration of PAHs (and other potentially toxic compounds) in the weathered oil, and the low probability for prolonged human skin contact, it is my opinion that there is little risk of significant adverse human health effects from dermal exposures to crude oil for Gulf Coast Residents in connection with the DWH oil spill.

The Gulf water, oil, and sediment sampling plan was developed by the OSAT at the direction of the Unified Area Command. Over 17,000 samples were collected for the purpose of environmental review. The samples were collected between April 30, 2010, and October 18, 2010. Data on Gulf water and sediment samples were compared to human and aquatic benchmarks, using an approach very similar to the one that I used above for evaluating inhalational exposures. The human health benchmarks were developed by EPA and HHS, considering both cancer and non-cancer risks. Where applicable, the benchmarks accounted for both dermal as well as incidental ingestion of water by a child, assuming one hour of exposure per day for 90 days. The benchmark included screening levels for several possible components of oil (including VOCs, PAHs, and metals) and dispersants. The sampling plan was separated into nearshore samples (those within 3 nmi of the shore), offshore (3 nmi to 200 m depth), and deep water (beyond 200 m depth). Of the 6,090 water samples tested in the nearshore zone, 56% had no detectable parameters and none of the samples exceeded the human health benchmarks.[126]

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122 OSAT, at 2.

123 OSAT; OSAT-2.

124 ATSDR. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs). Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Atlanta, GA, 1995; BP. Material Safety Data Sheet for Mississippi Canyon 252 Weathered Crude Oil (Louisiana Light Sweet Crude). Houston, TX, June 28, 2010. Available at: http://gulfresearchinitiative.org/wp-content/uploads/2012/05/Weathered-Crude-Oil-MC252.062810.pdf; NOAA. U.S. Department of Commerce. NOAA's Oil Spill Response Understanding Tar Balls. May 24, 2010. Available at: http://www.noaa.gov/factsheets/new%20version/tar_balls.pdf.

125 BP. Material Safety Data Sheet for Mississippi Canyon 252 Weathered Crude Oil (Louisiana Light Sweet Crude). Houston, TX, June 28, 2010. Available at: http://gulfresearchinitiative.org/wp-content/uploads/2012/05/Weathered-Crude-Oil-MC252.062810.pdf; CDC. Agency for Toxic Substances Disease Registry. Oil Spill Dispersant (COREXIT ®EC9500A and EC9527A) Information for Health Professionals. May 13, 2010. Available at: http://www.cdc.gov/nceh/oil_spill/docs/Oil%20Spill%20Dispersant.pdf.

126 OSAT, at 19.

My conclusions are corroborated by risk assessments performed for the FOSC of the USCG by the OSAT-2 team. At the request of the FOSC, the OSAT-2 team evaluated the risk from dermal contact with weathered oil in connection with the DWH oil spill. The OSAT-2 team concluded that the risk from dermal exposure to weathered oil from the DWH spill was far below EPA standards for both carcinogenic and non-carcinogenic human health risks.[127]

To contrast the concentrations of PAHs in weathered oil, I compare the potential toxic chemicals of concern for dermal exposure to the concentrations of PAHs in over-the-counter coal tar shampoos and medications.[128] These shampoos and medications are approved for use on humans by the FDA.[129] I used the data of PAHs in 53 weathered oil samples from the EPA database.[130]

Table 19. Comparison of PAHs in 53 Weathered Oil Samples to Concentrations in OTC Coal Tar Shampoos (all concentrations in ppm)

PAH	Weathered oil*	Coal tar shampoo† 0.5%	Coal tar shampoo† 2%	Psoriasis gel† 5%
Benzo[a]pyrene	<6.3	36	144	360
Benzo(b)fluoranthene	<0.5	30	120	300
Dibenz[a,h]anthracene	<0.13	8	32	80
Fluoranthene	<1.7	54	216	540
Indeno[1,2,3-cd]pyrene	<0.35	19	76	190
Pyrene	9.7	40.5	162	405

* Median values from 53 weathered oil samples from EPA (125). EPA. EPA Response to BP Spill in the Gulf of Mexico. Download Environmental Data. Available at: http://www.epa.gov/bpspill/download.html. All values except pyrene are less than the value shown in the table.

† Data sources: Cosmetic Review Expert Panel. Final safety assessment of coal tar as used in cosmetics. *Int J Toxicol* 2008;27 suppl:1-24; FDA. Miscellaneous external drug products for over-the counter human use. 21 CFR 358.710.

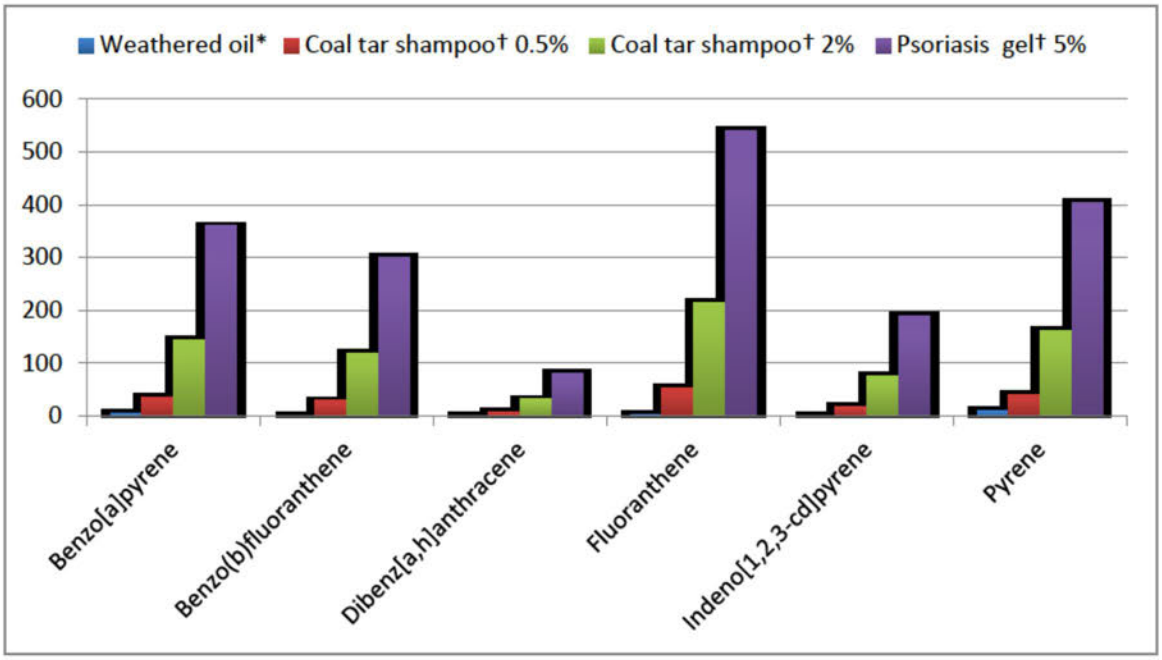
127 OSAT-2, at 21-22.

128 Cosmetic Review Expert Panel. Final safety assessment of coal tar as used in cosmetics. *Int J Toxicol* 2008;27 suppl:1-24, at 2-3.

129 FDA. Miscellaneous external drug products for over-the counter human use. 21 CFR 358.710.

130 EPA. EPA Response to BP Spill in the Gulf of Mexico. Download Environmental Data. Available at: http://www.epa.gov/bpspill/download.html.

Figure 8. Comparison of PAHs in 53 Weathered Oil Samples to Concentrations in OTC Coal Tar Shampoos (all concentrations in ppm)*



* Based on data in Table 19.

This chart shows that the concentrations of PAHs in weathered oil is 10 to 600 times less than the concentrations in human shampoos and medications routinely used by people with dandruff, eczema, or psoriasis and considered safe by the FDA.

(b) Corexit Dispersants

Gulf Coast Residents had little or no potential for significant dermal exposure to the two Corexit dispersants. The Corexit dispersants were applied subsea in the source control area, which was approximately 50 miles offshore and 100 miles from state populations, and by airplane and vessel at various locations across the Gulf of Mexico. The vessel applications occurred primarily in the source control area, all but one of the aerial dispersant applications occurred greater than 3 nmi offshore, and 98% of the aerial dispersant applications occurred greater than 10 nmi offshore.[131]

In addition, because the dispersants biodegraded in surface water and were significantly diluted after they were applied to oil slicks on the water surface, any components of the Corexit dispersants that did reach shore would have done so at levels so low as to have no meaningful impact on human health. In this respect, Lisa Jackson, EPA Administrator at the time of the DWH response, stated: "We know that surface use of dispersants decreases the environmental risks to shorelines and organisms at the surface and when used this way, dispersants break down over several days to weeks." EPA Administrator

[131] EPA. Dispersant Application. Available at: http://www.epa.gov/bpspill/dispersants-qanda.html#appl; BP. Offshore Dispersants. Available at: http://www.bp.com/en/global/corporate/gulf-of-mexico-restoration/deepwater-horizon-accident-and-response/completing-the-response/offshore.html; Houma ICP, Aerial Dispersant Group, After Action Report: Deepwater Horizon MC252 Response, Aerial Dispersant Response. HAZWOPR Requirement. December 31, 2010, at 14 and 27. http://www.ncbi.nlm.gov/pmc/articles/PMC2920106/.

Jackson also recognized that "when they are used on the surface, dispersants biodegrade much more rapidly than oil."[132]

The conclusion that the Corexit dispersants biodegraded and were diluted in the Gulf, and thus would be unlikely to reach the shore in any significant quantities, is corroborated by OSAT. In a report prepared for the FOSC, the OSAT team analyzed 4,790 near-shore water samples collected between May 13, 2010, and October 20, 2010, for dispersant-related compounds (specifically, 2-butoxyethanol, DPnB, propylene glycol, and DOSS). The OSAT team concluded that "none of the concentrations of dispersant-related chemicals found in water samples collected during the response exceeded the [EPA aquatic life] benchmarks" for these substances in water and "[o]nly 66 samples (60 water and 6 sediment, 1.4% of total) had detectable levels of dispersant-related chemicals." In the few cases where a dispersant compound was detected, DPnB was the most common; however, concentrations of DPnB never exceeded 0.003 milligrams per liter ("mg/L"), 333 times lower than the EPA Screening Level for DPnB in water — 1 mg/L.[133] Researchers from Auburn University found that the most likely source of nearshore dispersant chemicals were from storm-water discharge.[134]

As a result, Gulf Coast Residents had limited potential for dermal exposure to the Corexit dispersants and their constituents, and any exposures that did occur would have been to extremely low levels of these compounds. Dermal exposures to low levels of the Corexit dispersants and their constituents (which, in any event, would have been rare) would not be expected to result in significant adverse health effects.

8.3 Oral Exposure Characterization

8.3.1 MC252 Oil and Corexit Dispersants

Gulf Coast Residents and the general public had little to no potential for oral exposure to the components of oil or the two Corexit dispersants, as shown by the OSAT sampling data and analysis. The OSAT concluded that there were no exceedances of EPA's human health benchmarks in water and no exceedances of EPA's dispersant benchmarks.[135] Concerning potential risks from contact with sediments or contaminated sand, or the ingestion of sediments, the OSAT-2 team's assessment, based a child swimmer, concluded that this risk was far below EPA standards for both carcinogenic and non-carcinogenic human health risks.[136]

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132 Statement of Lisa P. Jackson, Administrator, U.S. Environmental Protection Agency, Deepwater Horizon Response Teleconference, May 12, 2010, at 3. Available at: http://www.epa.gov/bpspill/dispersants/may12transcript-final.pdf.

133 OSAT, at 25.

134 "The preponderance of evidence presented here supports the conclusion that the presence of propylene glycol, 2-butoxyethanol, and DOSS detected in surface water samples in the vicinity of Orange Beach between September, 2010 and January, 2011 did not originate from the use of Corexit dispersants during the Deepwater Horizon accident response. Rather, it is very likely these compounds are present in the Orange Beach water samples as a result of point and nonpoint source pollution from stormwater discharge related to rainfall events. This perhaps is a common occurrence in this and other similarly situated urban environments." Hayworth JS, Clement TP. Provenance of Corexit-related chemical constituents found in nearshore and inland Gulf Coast waters. *Mar Pollut Bull* 2012;64:2006-2014, at 2013.

135 OSAT, at 48.

136 OSAT-2, at 21-22.

8.3.2 Seafood Safety

As part of my analysis of seafood safety after the DWH oil spill, I reviewed summaries of seafood-related analyses released by the affected states, the FDA, and NOAA. I have also reviewed the protocols for closing areas to fishing as well as the protocols for testing and reopening fishing areas. The protocols were more than sufficient to protect the public from the possibility of eating contaminated seafood.

During the DWH oil spill, over 88,500 square miles of the Gulf of Mexico were closed to fishing.[137] Fisheries were closed by NOAA when there was visible oil on the surface or when there was evidence of subsurface oil.[138] Individual states were responsible for closing their own fishing areas within 3 miles of the shoreline. However, all areas were encouraged to use the same closure and opening criteria. Reopening of a given fishing area was based upon testing of the seafood in that given area by the FDA. The FDA used a protocol that combined organoleptic screening (trained human sniffers) followed by detailed chemical analysis. The purpose of the organoleptic screening was primarily to identify potential oil and dispersant contamination for further testing by the FDA. The chemical analysis of seafood was primarily for PAHs and dispersant constituents, the chemicals in petroleum mixtures of primary concern for human health following oil spills.[139] The FDA established levels of concern for PAHs in seafood based both on cancer and non-cancer endpoints.[140]

Seafood samples analyzed prior to reopening of fishing areas showed levels of PAHs that were consistently 100 to 1,000 times lower than the FDA levels of concern. Over 2,500 water samples were analyzed for dispersants. Only 2 showed trace amounts of a dispersant and these were during the times when fishing areas were closed and not being considered for reopening. In addition, thousands of samples of seafood were analyzed by the FDA for DOSS, the dispersant marker that was chosen for testing, and no detectable residue of this substance was found.[141]

An independent analysis of seafood samples from fishing areas that were not closed during the DWH oil spill found only 2 of 92 samples of commercially caught fish had detectable concentrations of PAHs that were below the federal level of concern. No fish sample had detectable levels of DOSS. Using ratios of lower molecular weight hydrocarbons, it was estimated that greater than half had non-oil-based sources of the low levels found. Metals were largely absent.[142]

On November 30, 2011, the Louisiana Department of Health and Hospitals ("LDHH") released a report stating that of 2,384 seafood samples that had been analyzed to date, trace levels of PAHs were detected in 740 samples and the dispersant DOSS was detected in 99. No sample results showed levels

137 SOAT, at 10.

138 NOAA. Protecting the Public from Oil-Contaminated Seafood: Fishery Area Closure and Surveillance Plan. Deepwater Horizon (DWH) Oil Spill, June 14, 2010, Available at: http://docs.lib.noaa.gov/noaa_documents/DWH_IR/reports/Protecting_Public_Fisheries_Closure_Surveill_Plan.pdf

139 FDA. Protocol for interpretation and use of sensory testing and analytical chemistry results for reopening oil impacted areas close to seafood harvesting due to the Deepwater Horizon oil spill. July 29, 2010. Available at: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Emergencies/ucm217601.htm.

140 *Id.*, at 3-4.

141 Schwaab E, Kraemer D, Guidry J. Consumers can be confident in the safety of Gulf seafood. Joint statement released by NOAA, FDA, and the Louisiana Department of Health and Hospitals, March 2011. Available at: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Emergencies/ucm251969.htm.

142 EPA. Monitoring Air Quality Along the Gulf Coast. Available at: http://www.epa.gov/bpspill/air-mon.html.

of concern.[143] In Mississippi, 278 seafood samples were analyzed. The maximum concentrations of PAHs were hundreds to thousands of times lower than the FDA levels of concern. Also, samples of oysters were compared with 10-year data from the NOAA Mussel Watch program. The PAH levels in the oyster samples from areas affected by the DWH oil spill were similar or even lower than historical values. In addition, PAH levels in smoked and processed meats purchased from local grocery stores were similar to those seen in the oysters collected off of the Mississippi coast during the DWH oil spill (86). Similar negative sampling results were reported in Alabama and Florida.[144]

In 2011, the FDA did further sampling to evaluate for any residual PAHs in Gulf seafood. At that time, the FDA also sampled mussels for metals and compared the sampling results to historical data. FDA's testing showed that levels of arsenic, cadmium, lead, and mercury were consistent with background levels in seafood not impacted by the oil spill and did not present a public health concern.[145] I also reviewed FDA charts comparing levels of vanadium and nickel from mussels in the Gulf Coast area prior to 2009 with 2011 levels. These two metals are often found at low levels in oil. Levels in 2011 were variable, but overall consistent with those from the previous years.[146]

Representatives of NOAA and FDA and the Louisiana State Health Officer released a joint statement after the conclusion of their seafood safety program, stating that the seafood safety program put in place during the incident was unprecedented.[147] They wrote: "As is the case with so many parts of the response to the BP/Deepwater Horizon oil spill, the seafood safety program put in place during this crisis was unprecedented. The system set up to keep tainted seafood out of circulation worked." They continued: "Driven by science and with human health as the highest priority, the extensive sampling and testing plan allowed areas to open only when every piece of seafood sampled there passed both sensory and chemical testing." NOAA and FDA worked together to develop a chemical test to detect traces of dispersant in fish tissue. Their results showed that every sample tested was far below the safety threshold established by FDA, and over 99% of the thousands of samples tested showed no detectable residue.[148]

In summary, the closure and reopening protocol for fisheries in the Gulf of Mexico during the DWH oil spill were sufficient to protect the public health. Testing from the year after the spill did not show any residual levels of concern of oil contaminants, dispersants, or metals in the seafood samples. I found no evidence of any long-term contamination of the seafood from the Gulf of Mexico.

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143 State of Louisiana Department of Health and Hospitals, Louisiana Seafood Safety Surveillance Report. November 30, 2011. Available at: http://new.dhh.louisiana.gov/assets/docs/SurveillanceReports/SeafoodSurveillance/SeafoodUpdate_11_30_11.pdf

144 FDA. Gulf of Mexico Oil Spill. Reopening of Closed Waters by State. Available at: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Emergencies/ucm221959.htm.

145 FDA. Assessing the impact of the oil spill. Surveillance samples. Available at: http://www.fda.gov/food/recallsoutbreaksemergencies/emergencies/ucm210970.htm#Surveillance_Samples.

146 FDA. Comparison of Vanadium levels at Mussel Watch sites before and after the Deepwater Horizon oil spill. Available at: http://www.fda.gov/downloads/Food/RecallsOutbreaksEmergencies/UCM293120.pdf; FDA. Comparison of Nickel levels at Mussel Watch sites before and after the Deepwater Horizon oil spill. Available at: http://www.fda.gov/downloads/Food/RecallsOutbreaksEmergencies/UCM293118.pdf.

147 Schwaab E, Kraemer D, Guidry J. Consumers can be confident in the safety of Gulf seafood. Joint statement released by NOAA, FDA, and the Louisiana Department of Health and Hospitals, March 2011. Available at: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Emergencies/ucm251969.htm.

148 FDA. Seafood Dispersants. Available at: http://www.fda.gov/downloads/food/foodsafety/product-specificinformation/seafood/ucm221659.pdf.

8.4 Conclusions Regarding Data Analysis for Occupational and Community Exposures

After a thorough review of the relevant exposure data associated with the DWH oil spill, I conclude that Clean-Up Workers and Gulf Coast Residents were not exposed to airborne concentrations of the components of crude oil, dispersants, or other spill-related compounds at levels that would be expected to result in any significant adverse health effects. This was corroborated by EPA, which stated: "Based on monitoring to date, EPA has not seen onshore levels of pollutants that are of significant concern for long-term health effects".[149] With respect to Clean-Up Workers, NIOSH found: "Throughout the [HHE] evaluation, results for all airborne chemicals sampled were uniformly nondetectable or at levels well below applicable OELs."[150] (17) Additionally, OSHA found: "No air sampling by OSHA has detected any hazardous chemical at levels of concern."[151]

I also conclude that the potential for significant dermal exposures to the components of crude oil and dispersants for Clean-Up Workers and Gulf Coast Residents was very small, and any such exposures for Clean-Up Workers, who were in closer proximity to the oil and dispersants, were likely prevented by appropriate use of PPE. Further, based on the weathered nature of the oil and the lack of opportunity for prolonged skin contact with the oil and dispersants, I would not expect significant adverse health effects from any dermal exposures to the components of crude oil and dispersants that did occur in connection with the DWH oil spill. Members of OSAT, consisting of scientists from many disciplines within the USCG, BOEMRE, NOAA, EPA, USFWS, USGS, and BP concluded that "[c]alculated potential cancer and non-cancer health effects from short and long-term exposures are below [EPA] acceptable health based risk and hazard levels."[152]

The CDC reviewed sampling data for air, water, and soil/sediment and determined that "the samples collected in places where non-response workers would spend time showed none of those substances at levels high enough to cause long-term health effects." Working together, EPA and CDC both concluded that there were no direct exposures to these substances at levels high enough to be expected to cause harm.[153]

I also conclude that Gulf Coast Residents and the general public had little to no potential for oral exposures to the components of crude oil and dispersants. The seafood safety program designed and run by government agencies was very conservative and did an excellent job of protecting Gulf Coast Residents and the public from ingesting potentially contaminated seafood resulting from the DWH oil spill. Testing from the year after the spill did not show any residual levels of oil contaminants, dispersants, or metals in the seafood samples. I found no evidence of any long-term contamination of the seafood from the Gulf of Mexico. Dr. David Michaels and Dr. John Howard, the Directors of OSHA and NIOSH, respectively, published a joint article in which they reported that "[o]verall, the efforts to ensure the safety and health of these Clean-up Workers were very effective," and that "[b]ecause

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149 EPA. Monitoring Air Quality Along the Gulf Coast. Available at: http://www.epa.gov/bpspill/air-mon.html

150 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

151 OSHA. OSHA's Efforts to Protect Workers. Available at: https://www.osha.gov/oilspills/index.html.

152 OSAT-2, at 2.

153 CDC. CDC Response to the Gulf of Mexico Oil Spill. Available at: http://www.bt.cdc.gov/gulfoilspill2010/cdcresponds.asp.

protection efforts were so effective, few safety and health issues emerged as significant concerns in the media at the national level.[154]

Others have registered similar conclusions concerning seafood safety. In 2010, the FDA, NOAA, National Marine Fisheries Service, EPA, and USCG took unprecedented steps to ensure that the seafood harvested from the Gulf was safe -- first by closing areas exposed to the oil and then by establishing a reopening protocol designed to ensure that seafood from any given area was safe from harmful oil and dispersant residues before the area reopened to harvest.[155] Representatives from NOAA, FDA and the Louisiana State Health Officer stated:

> Driven by science and with human health as the highest priority, the extensive sampling and testing plan allowed areas to open only when every piece of seafood sampled there passed both sensory and chemical testing. The results of the tests, all publicly available, should help Americans buy Gulf seafood with confidence: the seafood has consistently tested 100 to 1000 times lower than the safety thresholds established by the FDA for the residues of oil contamination.[156]

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154 Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers, July 18, 2012 Field Report. *PLOS Currents Disasters* 2012;July 18. Edition 1.

155 FDA. Gulf of Mexico Oil Spill. Available at: http://www.fda.gov/food/recallsoutbreaksemergencies/emergencies/ucm210970.htm#Surveillance_Samples.

156 Schwaab E, Kraemer D, Guidry J. Consumers can be confident in the safety of Gulf seafood. Joint statement released by NOAA, FDA, and the Louisiana Department of Health and Hospitals, March 2011. Available at: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Emergencies/ucm251969.htm.

9. Evaluation of Federal Health Analysis and General Health Surveillance Efforts

My analysis thus far has centered on potential exposures of Clean-Up Workers and Gulf Coast Residents to chemicals of concern from the DWH oil spill and how these might impact human health. It is also important to note that NIOSH performed Health Hazard Evaluations ("HHEs") of Clean-Up Workers performing their jobs, and NIOSH and OSHA evaluated worker injury and illness data. Also, during the DWH oil spill, CDC and health departments for the Gulf States conducted health surveillance to determine whether the DWH incident was affecting human health. I will briefly review the types of surveillance and the findings.

9.1 Federal Health Analysis

9.1.1 NIOSH: Health Hazard Evaluations

At the request of BP, NIOSH conducted a series of HHEs during the DWH response. NIOSH's HHEs involved quantitative and qualitative exposure evaluations for potential hazards to Clean-Up Workers across all major onshore and offshore response activities. As part of its HHEs, NIOSH sampled for a large number of chemicals of concern, including constituents from crude oil, dispersants, and controlled in-situ burning of oil. NIOSH also investigated for potential hazards across numerous response activities and job duties, including wildlife and beach clean-up; oil booming, skimming, and vacuuming; vessel decontamination; and source control activities. Finally, NIOSH also distributed voluntary health symptom surveys to workers at offshore and onshore locations.[157]

The results of NIOSH's HHE investigations were released in a series of interim reports[158] and a final report.[159] NIOSH also compiled and posted on its website all of its exposure and health symptom survey data. I have reviewed all HHE reports and all of NIOSH's exposure and survey data.

In the HHE final report, NIOSH reported that "results for all airborne chemicals sampled were uniformly nondetectable or at levels well below applicable OELs." NIOSH also conducted qualitative assessments of work practices for potential dermal exposures to oil, dispersants, or other chemicals, and found that the use of PPE was generally effective at preventing exposure. NIOSH concluded that heat stress, not chemical exposure, was "often the most pressing concern for the health and safety of response workers," but observed that BP successfully developed heat stress management plans that were used at the evaluated sites. Additionally, NIOSH observed required work-rest cycles and mandatory rehydration

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157 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011, at 1-2. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

158 CDC. National Institute for Occupational Safety and Health. Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0115. Interim Report #1A; HETA 2010-0115. Interim Report #2A; HETA 2010-0115. Interim Report #3A; HETA 2010-0115. Interim Report #4A; HETA 2010-0129. Interim Report #5; HETA 2010-0129. Interim Report #7; HETA 2010-0129. Interim Report #8A; HETA 2010-0129. Interim Report #9. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html.

159 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf.

with water or electrolyte-providing beverages, which were "uniformly observed to be plentiful and readily available."[160]

9.1.2 OSHA: Report on Worker Exposure Assessments

OSHA also published a report of its analysis of its activities to ensure worker safety during the DWH oil spill[161]. OSHA reviewed all of the 119,000-plus exposure assessments conducted by BP during the response, and validated these assessments by performing more than 7,000 independent worker exposure assessments. OSHA posted the sampling data on its website. In its report, OSHA compared the exposure data to its PELs. OSHA concluded that "[b]ecause oil cleanup workers would only be exposed for a few days, weeks, or months, instead of a working lifetime, using OELs was a very conservative approach for protecting response workers."[162]

9.2 Evaluation of General Health Surveillance Efforts

9.2.1 CDC: Biosense

The CDC runs a national health surveillance system called Biosense, which conducts electronic surveillance of health information between cooperating hospitals and health departments. Biosense is the only public health surveillance system that enables state and local health departments and the CDC to share health information across state jurisdictions. Following the DWH incident, Biosense was used to monitor for 21 conditions across 86 coastal health care facilities in the five Gulf States.[163]

The CDC used Biosense during the DWH response to produce daily situational health reports for the Gulf States and from those created weekly summaries. I reviewed all weekly summaries posted to the CDC website that were prepared between May 3, 2010, and September 4, 2010.[164] During the monitoring period, Biosense surveillance did not detect any health events determined to be associated with the DWH oil spill.[165]

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160 *Id.*, at 12.

161 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf.

162 *Id.*, at 8-9.

163 CDC. Emergency Preparedness and Response, Health Surveillance. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/health_surveillance.asp; CDC. Biosense. Public Health Surveillance Through Collaboration. Available at: http://www.cdc.gov/biosense/files/DHIS_BioSense%20Overview_244951_12_3_2013.pdf.

164 "There were no reports between May 28 and June 7, 2010 due to a hardware malfunction." CDC. Emergency Preparedness and Response, Health Surveillance. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/health_surveillance.asp.

165 Biosense detections identifying an increase in the number of visits for skin rash at a Florida health care facility on May 17 were determined through investigation by Florida authorities to be unrelated to the oil spill. Early investigations of an increase in asthma visits at a health care facility on May 21 likewise indicated that the increase was unrelated to the oil spill. Exacerbations of asthma, COPD, bronchitis, and upper respiratory infections are extremely common medical conditions. Factors such as heat, humidity, local pollen counts, and airborne fungi on the Gulf Coast are exacerbating factors. As to the remainder of the Biosense monitoring period, the CDC found "no trends in the number of illnesses and injuries in the monitored healthcare facilities that would require further public health investigation." CDC. Emergency Preparedness and Response, Health Surveillance. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/health_surveillance.asp.

9.2.2 State Health Surveillance

(a) Mississippi

Mississippi state agencies engaged in several health surveillance efforts. The Mississippi State Department of Health ("MSDH") reviewed the number of visits to coastal hospital emergency departments for the occurrence of four symptoms potentially related to DWH chemical exposures and compared that number to the number of visits to inland hospital emergency departments for those same symptoms. The MSDH concluded that "[r]eviews of the data indicate that there were no increases attributable to oil in the monitored illnesses in the coastal area over the time of the spill."[166]

From April 30, 2010, to November 15, 2010, the Mississippi Poison Control Center fielded 305 calls concerning the DWH oil spill; 249 of the calls were self-reported exposure calls and 56 were information requests. Only 11 of the exposures were referred to health care providers and all of those individuals were seen and discharged. None required hospitalization.[167] Poison control data are based completely on the caller reporting an exposure. There was no attempt to verify the exposure.

As to mental health, the MSDH and the Mississippi Department of Mental Health monitored the number of calls for mental health assistance in two coastal regions and compared them to two regions in central Mississippi. These agencies also analyzed the electronic database of emergency department chief complaints from three coastal hospitals for new psychological issues. Neither system showed any increase in the demand for mental health services.[168]

Mississippi also requested that the CDC conduct a Community Assessment for Public Health Emergency Response ("CASPER") in the three coastal counties to assess mental health issues. This was a door-to-door survey of households in this area.[169] The survey measured levels of symptoms of depression, stress, and financial worry. This was repeated one year later and the mental health symptoms decreased.[170] The authors pointed out that the worry and stress regarding finance and decreased income cannot be attributed to the DWH oil spill based on this study.[171]

(b) Alabama

Alabama tracked the number of individuals who self-reported potential contact with oil to emergency departments, urgent care facilities, and community health centers. No comparative system was used.

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166 MSDH evaluated the number of emergency department visits for rash, respiratory, gastrointestinal, and neurological symptoms. No significant differences were observed as to the latter three symptoms. As to rashes, investigations revealed that the increases observed at coastal hospitals were not oil-related. CDC. Emergency Preparedness and Response, Health Surveillance – State of Mississippi. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/surveillance_MS.asp; Mississippi State Department of Health. Deepwater Horizon Oil Spill – One Year Later. *Mississippi Morbidity Report* 2011;27:1-3. Available at: http://www.msdh.state.ms.us/msdhsite/_static/resources/4506.pdf.

167 *Id*.

168 *Id*.

169 *Id*., Buttke D, Vagi S, Bayleyegn T, et al. Mental health needs assessment after the Gulf Coast oil spill – Alabama and Mississippi, 2010. *Prehosp Disaster Med* 2012;27:401-408.

170 Buttke D, Vagi S, Schnall A, et al. Community assessment for public health emergency response (CASPER) one year following the Gulf Coast oil spill: Alabama and Mississippi, 2011. *Prehosp Disaster Med* 2012;27:496-502.

171 Buttke D, Vagi S, Bayleyegn T, et al. Mental health needs assessment after the Gulf Coast oil spill – Alabama and Mississippi, 2010. *Prehosp Disaster Med* 2012;27:401-408, at 407.

There was no determination that any reported health complaints had any relationship to potential exposure to oil.[172]

The Alabama Department of Public Health ("ADPH") also asked the CDC to conduct a CASPER in two coastal counties to assess mental health issues and needs. The survey measured levels of symptoms of depression, stress, and financial worry.[173] One year later the study was repeated and found a decrease in reports of mental health issues.

(c) Florida

Florida tracked symptoms reported by emergency department patients around the state and data from calls to state poison control centers using the Electronic Surveillance System for Early Notification of Community-Based Epidemics ("ESSENCE"), which monitored for specific symptoms that could potentially be related to breathing, swallowing, or touching oil. There was one period with an increase in breathing problems and asthma that was determined not to be related to the oil spill. There are no reports of medical evaluation of any of the 135 individuals who called the poison control centers to report some type of suspected exposure to oil.[174]

(d) Louisiana

Louisiana used several different health surveillance systems to track possible human health implications of the Gulf oil spill. LDHH compiled reports received from emergency departments and occupational, primary care, and urgent care clinics close to the DWH response staging areas into weekly summaries. Louisiana also used a hotline and the state poison control center to monitor callers' self-reported exposures and conditions. The 404 self-reported exposure calls largely reporting symptoms considered to be mild or determined to likely be attributable to heat issues or odors from cleaning agents. Louisiana reported that 169 workers had heat-related complaints through September 25, 2014. Louisiana also reported that there were 18 workers that had short hospitalizations.[175]

The State of Louisiana also monitored seven New Orleans hospitals using a CDC surveillance system called Early Aberration Reporting System ("EARS"). State and local health authorities analyzed information from these seven hospitals for any increases in complaints of upper respiratory illnesses and asthma in the region and compared rates from the 2010 analysis period to data from the previous three years. The comparison revealed no increases in the number of complaints during any or all of the analyzed 2010 period.[176]

Joint efforts of the CDC, four state health departments, and numerous coastal health care facilities did not find evidence of specific illnesses attributable to the DWH oil spill. This is consistent with my

172 CDC. Emergency Preparedness and Response, Health Surveillance – State of Alabama. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/surveillance_AL.asp.

173 CDC. Emergency Preparedness and Response, Health Surveillance – State of Florida. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/surveillance_FL.asp.asp; CDC. Emergency Preparedness and Response, Health Surveillance – State of Florida. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/surveillance_FL_061010.asp.

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175 CDC. Emergency Preparedness and Response, Health Surveillance – State of Louisiana. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/surveillance_LA.asp.

176 CDC. Emergency Preparedness and Response, Health Surveillance – State of Louisiana. Available at: http://emergency.cdc.gov/gulfoilspill2010/2010gulfoilspill/surveillance_LA.asp.

analysis of potential chemical exposures for both Clean-Up Workers and Gulf Coast Residents and the risk characterization discussed in detail above.

9.2.3 Evaluation of Recorded Clean-Up Worker Injuries, Illnesses, and Hospitalizations

According to OSHA, "BP and government agencies engaged in unprecedented levels of activity to document injuries and illnesses during the Gulf oil spill response".[177] NIOSH reviewed BP/Unified Area Command data regarding injuries and illnesses to Clean-Up Workers recorded between April 23, 2010, and July 27, 2010, and published the findings from its review in a report.[178] A total of 1,136 injuries and 994 illnesses were recorded between April 23, 2010, and July 27, 2010. Of these, nearly 87% were considered first aid cases, and 13% were considered OSHA-reportable cases. Less than 2% required missed or restricted duty.[179]

I also reviewed the BP Medical Encounters Database.[180] This was a register of on-site health clinic visits at various sites during the response to the DWH oil spill, including for several months after the well had been capped. These clinics were staffed by paramedics, who I assume recorded the information and made the majority of the classifications reflected in the database.

There were a total of 20,032 documented visits between April 23, 2010, and March 31, 2011 (329 visits had a date of January 1, 2010). Thirty percent (5,977) of the visits were documented as injuries and 70% (14,155) were considered illnesses. Heat-related illnesses were suspected in 2109 visits – 10.5% of the total. Of these visits, 76% received first-aid treatment and were released. There were 370 heat-related visits (1.8% of all visits) that resulted in further care or time off work.

Overall, there were 14,086 visits (70.3%) that were treated and released by a medic and 3,936 visits (20%) that were sent for further evaluation. Given that the health clinics were staffed by paramedics, I find this an appropriate referral rate. Sixty-three percent of the visits (12,672) were sent back to work and 9% (1,794) were either sent home for the day or placed on restricted duty. Unfortunately, we have no follow-up information on those visits that were referred for further evaluation, other than the data on hospitalizations discussed below.

There were 18 Clean-Up Workers hospitalized in Louisiana. There were no other states that reported hospitalizations. NIOSH evaluated each of these and published its findings.[181]

- Seven fishermen were hospitalized on May 28, 2010. Most of their symptoms of headache, congestion, and nausea were improved by arriving to the hospital. They were admitted for observation and six were discharged in one day and the seventh in two days. An investigation

177 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011, at 13. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf.

178 CDC. National Institute for Occupational Safety and Health. NIOSH Reports of Deepwater Horizon Response/Unified Area Command Illness and Injury Data. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/data.html.

179 *Id.*, at 4.

180 Medical Encounters Database, and the associated coding index. BP-HZN-2179MDL08472030, BP-HZN-2179MDL08472031, BP-HZN-2179MDL09096597.

181 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011, at 12. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf; King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011, at 2-3, 12, 16. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

by NIOSH concluded that their symptoms were not related to dispersants, but most likely to work-related factors such as heat, fatigue, and unpleasant odors from undiluted solutions for cleaning vessels and equipment.[182]

- Ten response workers were hospitalized between May 28 and June 22, 2010. Eight were involved in oil spill clean-up and the other two did other work. Five of these workers identified heat as a major problem and had evidence of dehydration or other heat-related injury including a diagnosis of heat exhaustion and possible heat stroke. These five were hospitalized for 1 to 6 nights. Three of the 10 hospitalizations were for common medical problems in the United States. Reasons for two of the workers were not given.

- There was a report of one additional hospitalization for heat-related illness. LDHH stated that all 18 workers had short hospitalizations.[183]

There do not appear to be any cases of serious injuries or fatalities among Clean-Up Workers.

9.3 Additional Information from the Public and Factual Records

9.3.1 Public Statements of Government Officials

(a) OSHA/NIOSH

Dr. David Michaels and Dr. John Howard, the Directors of OSHA and NIOSH, respectively, published a joint article in which they reported that "[o]verall, the efforts to ensure the safety and health of these Clean-up Workers were very effective," and that "[b]ecause protection efforts were so effective, few safety and health issues emerged as significant concerns in the media at the national level." The authors noted that advanced planning and immediate deployment, collaboration across multiple agencies, and more safety and health protections than required by law, helped ensure that BP implemented controls to protect workers and properly trained workers to perform their jobs safely. All of this, and a multi-agency response, helped ensure that the response and clean-up operations resulted in no worker fatalities and relatively few injuries and illnesses."[184]

(b) FDA

FDA Deputy Commissioner for Foods Michael Taylor noted in an FDA blog that Gulf of Mexico seafood is safe to eat, and that it is "safe to eat for everyone." Taylor felt confident that the PAH testing levels that were set for Gulf of Mexico seafood following the DWH incident were safe and would protect the health of anyone, including children and pregnant women, who eats such seafood. He acknowledged that, "Given the low levels of PAHs we found, when we found them at all, someone could eat 63 lbs of peeled

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182 *Id.*, at 2-3.

183 State of Louisiana Department of Health and Hospitals, MS Canyon 252 Oil Spill Surveillance Report Week 38 from September 19, 2010 to September 25, 2010. Available at: http://new.dhh.louisiana.gov/assets/docs/SurveillanceReports/OilSpillHealth/ OilSpillSurveillance2010_17.pdf.

184 Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers, July 18, 2012 Field Report. *PLOS Currents Disasters* 2012;July 18. Edition 1.

shrimp (that's 1,575 jumbo shrimp); or 5 lbs. of oyster meat (that's 130 individual oysters); or 9 lbs. of fish (that's 18 8-ounce fish filets) every day for five years and still not reach the levels of concern."[185]

9.3.2 FOSC Report

In a report submitted to the National Response Team, the FOSC acknowledged that BP and the federal government took action to prevent injuries, illnesses, and exposure to hazardous substances among Clean-Up Workers and Gulf Coast Residents.[186] He noted that BP, along with federal and state leaders and government agencies, made worker and public safety a priority.[187] The FOSC noted, "Given the immense geographic scope, maritime operations from the well site to 50 miles offshore skimming, to near-shore, aviation operations and land based cleanup, decontamination, and waste management — and the vast mixture of people thrown together ad hoc - the *Deepwater Horizon* response produced an exceptional safety record."[188]

9.3.3 Testimony of Government Officials

I have also reviewed Dr. John Howard's deposition testimony in this litigation. His testimony is consistent with the public record regarding lack of any significant exposure-related illnesses or injuries to Clean-Up Workers.

Dr. Howard testified to the potential toxicity of MC252 oil, confirming that in his view, swallowing small amounts (i.e., less than a coffee cup) is unlikely to have long-lasting health effects.[189] He also maintained that aged, or weathered, crude oil is unlikely to pose inhalation risks to humans from VOCs.[190] He also testified that he was aware that a majority of dispersant constituents are considered to have minimal to no toxicity, and that none would be expected to cause significant human health effects at the low levels measured during the DWH spill.[191]

Dr. Howard testified that throughout NIOSH's HHE evaluations, results for all airborne chemicals sampled were uniformly non-detectable or at levels well below applicable occupational exposure levels.[192] Thus, NIOSH did not find any "evidence of significant short-term health effects due to the exposure of cleanup workers to any chemicals encountered during the response," and Dr. Howard is not aware of any other evidence of any such effects.[193] In addition to NIOSH's sampling and monitoring, Dr. Howard is not aware of any air sampling or monitoring detecting any hazardous levels of chemicals of concern for DWH response workers or the Gulf Coast public.[194]

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185 FDA Blog. FDA Voice, Gulf Seafood is Safe to Eat After Oil Spill. January 11, 2012. Available at: https://blogs.fda.gov/fdavoice/?tag=gulf-seafood.

186 On Scene Coordinator Report ("OSCR Report"), Deepwater Horizon Oil Spill, Sept. 2011, at 79. Available at http://www.uscg.mil/foia/docs/dwh/fosc_dwh_report.pdf ("hereinafter FOSC"),

187 *Id*., at 90.

188 *Id*.

189 Tr. of John Howard Dep., at 136.

190 *Id.* at 141.

191 *Id.* at 151-52.

192 Specifically, NIOSH "did not measure any exceedances . . . of the occupational exposure limits" during the DWH response except for a single instance involving elevated levels of CO_2 from the idling engine of a fishing vessel. *Id.* at 49, 173.

193 *Id.* at 51-52.

194 *Id.* at 174-75.

Dr. Howard testified that he was not aware of any air monitoring data indicating that the health of Gulf Coast community residents was at risk as a result of the DWH incident.[195] He testified that from a "geographic proximity" perspective, he would "not expect community workers" onshore "to have adverse health effects from exposure to the oil or the dispersant."[196] Dr. Howard believes that the general public and Gulf Coast community members were at lowest risk of exposure to contaminants as a result of the DWH spill.[197]

I also reviewed additional testimony from Dr. Howard regarding BP's efforts to mitigate any human health impact of the spill, including through effective use of PPE and other measures. That testimony is separately covered in Section 12.

9.4 Conclusions Regarding Federal Health Analysis and General Health Surveillance Efforts

These federal and state government analyses and health surveillance findings for Clean-Up Workers and Gulf Coast Residents are consistent with my conclusions that there is no compelling evidence for significant adverse health effects to either population as a result of the DWH oil spill.

Health surveillance efforts by CDC and state health departments did not find evidence of specific diseases or disease patterns that were related to the DWH oil spill. Worker evaluations by NIOSH and OSHA did not reveal any worker exposures that would be expected to result in health effects. They concluded, and testimony by Dr. Howard reaffirms, that heat exposures were the main health concern for Clean-Up Workers. The health clinic logs showed that most visits were resolved with first-aid treatment. There is not sufficient medical information in these logs to draw any further conclusions. I did not see any information suggesting serious injuries or deaths. There were 18 Clean-Up Workers hospitalized for short periods. From the available data, none of these was the result of a chemical exposure.

Considering that there were between 30,000 and 46,000 workers per week, doing jobs and using PPE equipment that they may have been unfamiliar with prior to the DWH oil spill, in very hot and humid weather, it appears to me that the safety programs established by federal agencies and BP functioned well to protect workers. I concur with the directors of NIOSH and OSHA when they said "[o]verall, the efforts to ensure the safety and health of these Clean-up Workers were very effective," and that all of this, and a multi-agency response, "helped ensure that the response and clean-up operations resulted in no worker fatalities and relatively few injuries and illnesses.[198]

[195] *Id.* at 149.

[196] *Id.* at 147.

[197] *Id.* at 176.

[198] Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers, July 18, 2012 Field Report. *PLOS Currents Disasters* 2012;July 18. Edition 1.

10. Consideration of Potential Long-Term Health Effects

It is my opinion that Clean-Up Workers and Gulf Coast Residents were not exposed to any constituents of oil or dispersants at levels that would result in long-term health effects. There are several pieces of information that support the absence of risk of long-term health effects.

First, the toxicology benchmarks that I used for my comparison with exposure data take into account the potential for long-term health effects. For example, the various OELs represent the average concentration of a substance to which an individual may be repeatedly exposed working an 8-hour day, 40 hours a week, over a 40-year working lifetime without incurring adverse health effects. The occupational exposure monitoring for Clean-Up Workers showed that the concentrations found in worker's breathing zones were well below all of the OELs established by OSHA, NIOSH, and ACGIH. Thus, even for the relatively short duration of the clean-up work, there were no exposures that exceeded these working-life limits. OSHA also noted that "because oil cleanup workers would only be exposed for a few days, weeks, or months, instead of a working lifetime, using OELs was a very conservative approach for protecting response workers."[199] NIOSH concluded that PBZ and air sampling at specific sites and during specific activities consistently showed non-detectable to low levels of individual components of oil or dispersants.[200]

Similarly, the EPA and ATSDR toxicology benchmarks were developed in consideration of both acute and chronic health effects. EPA's DWH Screening Levels assumed a person was breathing the target concentration continuously for as long as 1 year, even though the DWH oil spill only lasted 86 days. EPA also stated that concentrations slightly above these levels do not indicate that a health problem will occur. EPA also stated: "Based on monitoring to date, EPA has not seen onshore levels of pollutants that are of significant concern for long-term health effects."[201]

Second, the air concentrations of oil and dispersant chemicals measured along the Gulf Coast were so low that they were between 17 and 1,800 times lower than the toxicology benchmarks. In fact, the concentrations of these chemicals along the Gulf Coast during the DWH oil spill were so low that they were equal to or lower than concentrations found in air in U.S. cities and several times lower than concentrations found inside U.S. homes. Thus, if there were any short- or long-term risks from exposures along the Gulf Coast, it would be no more than the risks from living in local cities in the South, such as Birmingham and Baton Rouge, and actually less than the risk of breathing the air in our homes.

Third, it is highly unlikely that either Clean-Up Workers or Gulf Coast Residents were dermally or orally exposed to oil or its constituents. However, even if they were, exposure levels were insufficient to cause long-lasting adverse health effects. As Dr. Howard acknowledged in his deposition, in his view, swallowing small amounts of oil (i.e., less than a coffee cup) is unlikely to have long-lasting effects.[202] No Clean-Up Worker or Gulf Coast Residents were exposed to any dose of oil remotely close to the ingestion of a coffee cup of oil. Additionally, data I presented showed that the concentrations of PAHs,

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199 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011, at 9. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf.

200 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011, at 3-4. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

201 EPA. Monitoring Air Quality Along the Gulf Coast. Available at: http://www.epa.gov/bpspill/air-mon.html.

202 Tr. of John Howard Dep., at 145-46.

the main chemical of concern in weathered oil, were far less than those in FDA-approved shampoos and skin medications.

Concerning potential risks from contact with sediments and sand, the OSAT-2 team's assessment, based on a child swimmer, concluded that this risk was far below EPA standards for both carcinogenic and non-carcinogenic human health risks.[203]

Finally, the CDC reviewed sampling data to determine whether exposure to oil, oil components, or dispersants might cause short- or long-term health effects. The sampling included results for air, water, soil/sediment, and waste oil samples. The CDC concluded that "the samples collected in places where non-response workers would spend time showed none of those substances at levels high enough to cause long-term health effects." Working together, EPA and CDC both concluded that there were no direct exposures to these substances at levels high enough to be expected to cause harm.[204]

Dr. Howard testified that he is not aware of any acute health effects to DWH response workers from exposure to oil or dispersant constituents, and he would not expect to see significant adverse physical health effects in the future from exposure to oil or dispersant constituents.[205] Based on the absence of any measured levels of chemicals exceeding NIOSH's RELs (or any other OELs), NIOSH did not agree to participate in NIH's long-term study of potential worker health issues ("GuLF worker study"). Dr. Howard does not believe the GuLF worker study would be "productive," as NIOSH could not find a way to "characterize exposure" based on exposure data.[206]

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[203] OSAT-2.

[204] CDC. CDC Response to the Gulf of Mexico Oil Spill. Available at: http://www.bt.cdc.gov/gulfoilspill2010/cdcresponds.asp.

[205] Tr. of John Howard Dep., at 145-46.

[206] *Id.* at 187-89, 211, 232.

11. Consideration of Mental Health Impact of the DWH Oil Spill

Studies on populations that experienced natural disasters, such as hurricanes and earthquakes, or man-made disasters such as the 9/11 terrorist attacks, have shown an association with depression, anxiety, and post-traumatic stress disorder.[207] Oil spills have also been associated with the same conditions.[208] One of the primary factors that has been identified in these vastly differing situations is loss of economic resources.[209] With respect to many disasters, the most severe, lasting, and pervasive psychological effects are those resulting from serious and ongoing financial problems.[210]

It is important to note that the Gulf Coasts of Mississippi and Louisiana were devastated by Hurricanes Katrina and Rita in 2005. Many communities in these areas had not fully recovered by 2010 when the DWH oil spill occurred. Moreover, Mississippi is one of the poorest states in the nation.[211] The financial housing crisis of 2008/2009 also heavily impacted the Gulf States. For many years, insurance rates for those living along the Gulf Coast have been increasing considerably.[212] All of these factors have added to the financial instability and stress for those living on the Gulf Coast. There have been several studies on mental health of Gulf Coast Residents during and after the DWH oil spill.[213] It has been pointed out that other stressors have affected the lives and therefore the mental health of Gulf Coast Residents for years both preceding and since the DWH oil spill.[214] Given the existing data, it is not possible to assert a direct and exclusive causal relationship between the DWH oil spill and the mental health of Gulf Coast Residents.

As stated above, loss of income and loss of social support have been implicated as central factors in the development of mental health problems following disasters. It follows that restoring income and support systems are important factors in mitigating the mental health effects of technological and natural disasters. Following the *Prestige* oil spill in Spain, studies showed that substantial economic aid

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207 Grattan LM, Roberts S, Mahan W, et al. The early psychological impacts of the Deepwater Horizon oil spill on Florida and Alabama communities. *Environ Health Perspect* 2011;119:838-843.

208 *Id.*

209 *Id.*

210 Nandi, A. et al, Patterns and Predictors of Trajectories of Depression after an Urban Disaster, Ann *Epidemiol.* Nov. 2009;19(11):761-770.

211 U.S. Census Bureau. State Median Income, Historical (1984-2012). Available at: http://www.census.gov/hhes/www/income/data/statemedian/; U.S. Census Bureau, Persons Below Poverty Level, 2007. Available at: http://www.census.gov/statab/ranks/rank34.html.

212 Buttke D, Vagi S, Bayleyegn T, et al. Mental health needs assessment after the Gulf Coast oil spill – Alabama and Mississippi, 2010. *Prehosp Disaster Med* 2012;27:401-408, at 407; Gulf Coast Residents Crumble Under Rising Homeowners Insurance Costs. Associated Press. June 1, 2013. Available at: http://blog.al.com/wire/2013/06/gulf_coast_residents_crumble_u.html.

213 Buttke D, Vagi S, Bayleyegn T, et al. Mental health needs assessment after the Gulf Coast oil spill – Alabama and Mississippi, 2010. Prehosp Disaster Med 2012;27:401-408; Buttke D, Vagi S, Schnall A, et al. Community assessment for public health emergency response (CASPER) one year following the Gulf Coast oil spill: Alabama and Mississippi, 2011. Prehosp Disaster Med 2012;27:496-502; Buttke D, Vagi S, Schnall A, et al. Community assessment for public health emergency response (CASPER) after the Gulf Coast oil spill: Alabama. CDC, September 3, 2010; Grattan LM, Roberts S, Mahan W, et al. The early psychological impacts of the Deepwater Horizon oil spill on Florida and Alabama communities. *Environ Health Perspect* 2011;119:838-843; OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf.

214 Buttke D, Vagi S, Bayleyegn T, et al. Mental health needs assessment after the Gulf Coast oil spill – Alabama and Mississippi, 2010. *Prehosp Disaster Med* 2012;27:401-408.

and social support were crucial in alleviating the psychological impact of the oil spill[215] and that the spill had a smaller effect on long-term mental health, especially for individuals with high levels of social support and recovery aid.[216] The study of Gulf Coast Residents in 2013 by SAMHSA found that the resources that were mobilized to reduce the economic and behavioral health impacts of the oil spill on Gulf Coast Residents may have resulted in a reduction in mental health problems relative to what would have occurred if those resources had not been mobilized.[217] In connection with the DWH oil spill, BP has spent substantial sums on cleanup activities and other compensation.

Additionally, in the aftermath of the DWH oil spill, BP has committed to improving public health, and specifically mental health care systems, throughout the Gulf States. BP has funded multiple initiatives designed to minimize any mental health impacts from the DWH oil spill. These efforts include:

1. $42 million in the following amounts to state agencies and non-governmental organizations for behavioral health services:

    - $15 million to LDHH and the Catholic Charities Archdiocese of New Orleans;
    - $12 million to the Alabama Department of Mental Health;
    - $12 million to the Mississippi Department of Mental Health; and
    - $3 million to the Florida Department of Children and Families.[218]

2. $10 million to HHS's Substance Abuse and Mental Health Services Administration ("SAMHSA"), which provided first-year funding for the development of enhanced media outreach materials and the establishment of a toll-free behavioral health hotline.[219]

3. Under the Medical Settlement, a total of $105 million will be paid by BP over five years to four Gulf Region Health Outreach Projects ("GRHOP"):

    - $50 million under the Primary Care Capacity Project to expand and improve access to health care in certain underserved Gulf Coast communities in Louisiana, Mississippi, Alabama, and the Florida Panhandle;

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215 Sabucedo JM, Arce C, Ferraces MJ, et al. Psychological impact of the Prestige catastrophe. *Int J Clin Health Psychol* 2009;9:105-116.

216 Corrasco JM, Perez-Gomez Bet al. Health-related quality of life and mental health in the medium-term aftermath of the Prestige oil spill in Galiza (Spain): a cross-sectional study. *BMC Public Health* 2007;7:245.

217 CDC. Substance Abuse and Mental Health Services Administration. Behavioral Health in the Gulf Coast Region Following the Deepwater Horizon Oil Spill. 2013.

218 Restore the Gulf. Secretary of the Navy Ray Mabus, America's Gulf Coast: A Long Term Recovery Plan after the Deepwater Horizon Oil Spill. Sept. 2010, at 60. Available at: http://www.restorethegulf.gov/sites/default/files/documents/pdf/gulf-recovery-sep-2010.pdf; Gulf States Receive $52 Million from BP for Behavioral Health, U.S. Dept. of Health & Human Servs., Substance Abuse & Mental Health Servs. Admin. ("SAMHSA") Newsletter, July/Aug. 2010.

219 *Id.*, at 101; U.S. Department of Health & Human Services. Substance Abuse & Mental Health Services Administration ("SAMHSA"). Gulf States Receive $52 Million from BP for Behavioral Health. July/Aug. 2010, at 101. Available at: http://www.samhsa.gov/samhsanewsletter/Volume_18_Number_4/GulfStates.aspx; Deepwater Horizon Medical Benefits Class Action Settlement Agreement, as Amended on May 1, 2012, MDL No. 2179 (EDLA, filed May 3, 2012) at 9. Available at: https://deepwaterhorizonmedicalsettlement.com/en-us/courtbrdocuments/dwhsettlementagreement.aspx ("Medical Settlement").

- $36 million under the Mental and Behavioral Health Capacity Project to address behavioral and mental health needs, expertise, capacity, and literacy in certain Gulf Coast communities in Louisiana, Mississippi, Alabama, and the Florida Panhandle;

- $4 million under the Community Health Workers Training Project to train community health workers on peer listening, community resiliency, and other related issues in certain Gulf Coast communities in Louisiana, Mississippi, Alabama, and the Florida Panhandle; and

- $15 million under the Environmental Health Capacity and Literacy Project to expand and improve environmental health expertise, capacity, and literacy in certain Gulf Coast communities in Louisiana, Mississippi, Alabama, and the Florida Panhandle.[220]

[220] *Id.*, at 72.

12. Actions by BP to Prevent, Minimize, or Mitigate Any Human Health Impact

In collaboration with other entities within the Unified Area Command, BP worked effectively to prevent or minimize any human health effects of the DWH oil spill. It is my opinion that these efforts were effective, and that this success is demonstrated, in part, by the facts that no Clean-Up Workers or Gulf Coast Residents were exposed to any chemical of concern at levels sufficient to cause any significant adverse health effects, and that there were no serious injuries or deaths.[221]

12.1 Training

Clean-Up Workers were involved in a wide variety of tasks that many of them most likely had not previously performed. Training was considered an immediate priority due to the large numbers of workers involved. Soon after the explosion and well before the oil reached shore, OSHA established requirements for training all Clean-Up Workers. The requirements set forth the minimum number of training hours required for each clean-up task and identified job-specific PPE.[222]

BP created a series of training modules tailored to the different clean-up functions.[223] BP also developed a corresponding training matrix which identified the work practices, safety measures, and type of training required for each clean-up job.[224] The training was provided in English, Spanish, and Vietnamese. An OSHA compliance officer continually monitored training sessions and conducted on-site visits at staging areas and work sites to confirm that workers received appropriate training.[225] BP training courses were approved by OSHA, the USCG, NIOSH, and NIEHS.[226]

BP also established a credentialing program and issued certificates and cards to workers as evidence of completion of a specific training module. OSHA personnel interviewed Clean-Up Workers and ensured that they were carrying their certification cards. By the time the first tar balls reached land, approximately 10,000 workers had been trained. Over the course of the clean-up work, over 130,000 workers were trained.[227]

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221 As previously noted in footnote 3, I am not addressing in this report the rig worker injuries and deaths resulting from the explosion and fire on the DWH oil rig on April 20, 2010, nor am I addressing the deaths of four men who were not involved in response activity tasks at the time of their deaths (one death in a swimming pool; one death in a vehicular accident; one death from a firearm discharge; one death of a BP employee in an airplane incident). Robbins, Liz. BP Temporarily Removes Containment Cap from Well. NY Times, June 24, 2010; Aug. 17, 2010 Memo from Seale to Durbin re Investigation of Death of Member that Occurred at Galveston, TX on 21 June 2010. HCG729-009058-63; Powell II, A. Houma Man in Town to Work on Oil Spill Drowns in Gretna Hotel Pool, Nola.com, June 24, 2010. OSE209-022006;Nov. 24,2010 Email from Utsler to Precourt re Jim Black - GC_IMT Incident Commander - Tragic Loss. HCE109-001657

222 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf.

223 BP, Basic HSE Training. BP-HZN, 2179MDL01893385-406; BP. Post-Emergency Spilled Oil Cleanup. Module 3 - Shoreline Cleanup. BP-HZN, 2179MDL01891791; BP. Post-Emergency Spilled Cleanup. May 2010. BP-HZN-2179MDL05450129; BP. Post-Emergency Spilled Oil Response. Marine Vessel Health and Safety. BP-HZN-2179MDL01891935.

224 BP. MC252 Minimum Training Requirements for Response Workers PPE Matrix. BP-HZN-2179MDL05001702.

225 Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers, July 18, 2012 Field Report. *PLOS Currents Disasters* 2012;July 18. Edition 1.

226 OSHA. Deepwater Horizon Oil Spill: OSHA's Role in the Response. May 2011. Available at: https://www.osha.gov/oilspills/dwh_osha_response_0511a.pdf.

227 *Id*.

12.2 Preventative Action

12.2.1 Personal Protective Equipment

PPE is essential to protecting workers from chemical exposures during chemical incidents. PPE, depending on the task, can include chemical-resistant clothes, gloves, boots, and possibly respiratory devices to prevent chemical or biological exposure. The type of protection is dependent on the chemicals or agents involved, their concentrations, and the work function, such as laying boom or picking up debris on a beach. Decisions about PPE should be based on scientific characterization of the potential hazards involved. In the DWH response, BP and OSHA developed matrices outlining the PPE that workers should use for each category of clean-up work.[228] NIOSH and OSHA also published Interim Guidance for protecting Clean-Up Workers.[229]

Excessive use of PPE can exacerbate heat stress. I found the BP PPE matrix and the NIOSH/OSHA respirator guidelines appropriate for protecting Clean-Up Workers. Also, there was flexibility built into the safety guidelines such that offshore vessels were equipped with real-time monitoring capabilities such that workers could be warned of changing chemical conditions requiring additional PPE (e.g., respirators) and clear conditions when additional protection would not be needed.

12.2.2 Heat Management

Heat stress was the most significant health threat to Clean-Up Workers.[230] The use of PPE can exacerbate the risks of heat-related illness. BP worked with OSHA and the USCG to develop a comprehensive heat stress plan.[231] Heat stress warnings and safety measures were included in job descriptions in the job matrix. To protect workers from heat illnesses, BP developed protocols involving work-rest cycles. A common cycle involved a 20-minute work period followed by a 40-minute rest period and mandatory rehydration.[232] This program was a success in reducing the severity of heat-related illness. Dr. Michaels and Dr. Howard concluded that worker safety and health efforts, such as the heat stress mitigation program, likely prevented injuries and deaths.[233]

Dr. Howard testified that heat stress was "the most significant problem being faced by DWH response workers,"[234] and acknowledged that BP implemented programs intended to prevent and treat heat stress during the DWH response, including heat stress management plans.[235] Dr. Howard testified that most response workers with heat stress were able to be treated by first aid and return to work and that only two cases of heat stress illness from April 23-July 27 resulted in restricted duty or a missed day of

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228 OSHA. On-Shore PPE Matrix for Gulf Operations, Version 2.1. Available at: https://www.osha.gov/oilspills/gulf-operations-ppe-matrix.pdf; OSHA. Off-Shore PPE Matrix for Gulf Operations, Version 2.1. Available at: https://www.osha.gov/oilspills/gulf-operations-ppe-matrix.pdf.

229 NIOSH OSHA. Interim Guidance for Protecting Deepwater Horizon Response Workers and Volunteers. July 26, 2010. Available at: http://www.cdc.gov/niosh/topics/oilspillresponse/protecting/pdfs/DeepwaterHorizonNIOSHRec072610.pdf.

230 *Id*., at 7.

231 MDL 02179 Ex. 13026, Heat Stress Management Plan - On-Shore Clean-Up Task Force, dated May 26, 2010..

232 King BS, Gibbons JD. Health Hazard Evaluation of the Deepwater Horizon Response Workers. Final HHE. National Institute for Occupational Safety and Health, 2011, at 6-8. Available at: http://www.cdc.gov/niosh/hhe/reports/pdfs/2010-0115-0129-3138.pdf

233 Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers, July 18, 2012 Field Report. *PLOS Currents Disasters* 2012;July 18. Edition 1.

234 Tr. of John Howard Dep., at 124.

235 *Id.* at 125.

work.[236] Ultimately, Dr. Howard agreed that no workers involved in the response developed “serious heat illness,” and that efforts by BP and the Unified Area Command to prevent serious heat illness were successful.[237]

12.3 Additional Response Efforts

12.3.1 Controlled In-Situ Burns

During controlled in-situ burning, all vessels in the area were instructed to maintain a position upwind from the smoke plume to minimize exposures to in-situ burn by-products. Direct reading monitors were used by the safety officer to warn of the possibility of potential in-situ burn emissions. Controlled in-situ burns were only used on calm sea days. Several vessels were involved on in-situ burn teams. Each pair of trawlers had a safety officer monitoring the safety of the operation. PPE was required to be used at all times by ignition boat personnel. During an in-situ burn, the trawlers were located approximately 300 ft. from the in-situ burn and all vessels remained upwind. During a NIOSH evaluation, all chemicals tested were well below the OELs. Based on this data, NIOSH concluded that continuous wearing of respirators was not warranted.[238] The controlled in-situ burns occurred 3-15 miles from the source and approximately 50 miles from the shore.[239] This distance minimized any potential impact to onshore air quality.

12.3.2 Dispersant Applications

When dispersants were applied by ships, all non-essential personnel were required to remain inside the cabin. The individual applying the dispersant was required to wear appropriate PPE, including a respirator. During dispersant applications, any ships in the area were required to be 1 nmi upwind of the release and wait 30 minutes before re-entering the area. Even though respiratory protection was used, air concentrations of oil components and dispersants around workers were well below OELs. NIOSH considered the PPE use and procedures to be appropriate.[240]

12.4 Medical Support

Clean-Up Workers had access to free medical support and evaluation at local clinics. These clinics were staffed by paramedics with backup by occupational nurses and access to occupational physicians and to ambulance or helicopter transport to local hospitals.[241] Given the low acuity of the problems of workers who presented to these clinics, this type of medical support was adequate for the situation.

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236 *Id.* at 127-28.

237 *Id.* at 128.

238 CDC. National Institute for Occupational Safety and Health. Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0115. Interim Report #2A, at 2B-8.

239 Mabile N. The Coming of Age of controlled In-Situ Burning. BP America. January 12, 2012, at 19.

240 CDC. National Institute for Occupational Safety and Health. Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0115. Interim Report #1A, at 1B-2, 1B-5.

241 CDC. National Institute for Occupational Safety and Health. Health Hazard Evaluation of Deepwater Horizon Response Workers HETA 2010-0115. Interim Report #2A, at 1; BP, Health and Safety in the response effort. Available at: http://www.bp.com/en/global/corporate/gulf-of-mexico-restoration/deepwater-horizon-accident-and-response/health-and-safety-in-the-response-effort.html; Email from J. Howard to F. Hearl, dated May 23, 201010. MDL 02179 Exhibit 12222.

13. Summary and Conclusions

This report contains my analysis, my opinions, and the reasons for them. I may perform further analysis to supplement my analysis or opinions after receiving any subsequent expert reports or other relevant information. Based on my review and analysis of materials listed in Appendix A, and based on my knowledge and experience, I conclude to a reasonable degree of scientific and medical certainty that:

- Clean-Up Workers and Gulf Coast Residents were not exposed through inhalation, dermal contact, or orally to crude oil, dispersants, and other compounds associated with the DWH oil spill at levels sufficient to cause any significant adverse health effects.

- There is no scientific evidence relevant to this oil spill to support concerns that either Clean-Up Workers or Gulf Coast Residents will suffer any future adverse health effects resulting from any exposures associated with the DWH oil spill. I have reviewed a tremendous amount of monitoring and sampling data relevant to potential exposures to any chemicals of concern associated with the DWH oil spill and the response, and I have seen no evidence supporting the prospect of long-term effects.

- The concentrations of pollutants and other chemicals measured along the Gulf Coast during the DWH oil spill were extremely low — consistent with those expected in ambient air in the United States. In fact, the air quality along the Gulf Coast during the DWH oil spill was comparable to, or even better than, air quality in the previous five years.

- Any mental health effects in Clean-Up Workers and Gulf Coast Residents are not a result of chemical exposure or toxicity. Any mental health effects following natural disasters and oil spills are primarily the result of loss of economic and social support systems. Loss of economic resources affecting mental health could be caused by other significant socioeconomic factors unrelated to the DWH oil spill. BP invested a significant amount of financial resources in the Gulf Coast community, helping to mitigate the prospect of mental health effects.

I also conclude that BP worked cooperatively and successfully in partnership with other entities to prevent or minimize any adverse human health effects associated with the DWH oil spill.

August 15, 2014

Appendix A - Materials Considered

PRODUCED DOCUMENTS
BP-HZN-2179MDL08472030
BP-HZN-2179MDL08472031
BP-HZN-2179MDL01891935
BP-HZN, 2179MDL01893385
BP-HZN-2179MDL01891791
BP-HZN-2179MDL05001702
BP-HZN-2179MDL05450129
BP-HZN-2179MDL09096597
HCE037-000977
HCE086-001793
HCE109-001657
HCG729-009058
N11E156-000294
OSE209-022006
BP-HZN-2179MDL09216013
PUBLICLY AVAILABLE AND COURT DOCUMENTS
CIR_1998-DSS Cosmetic Ingredient Review - Amended Final report on the Safety Assessment of Dioctyl Sodium Sulfosucciante
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EPA Weathered oil Data Sheet
EPA_MONITORING_ALL Data Sheet
EPA_SAMPLING_ALL Data Sheet
NIOSH Working Copy Data Sheet
OSHA Working Copy Data Sheet
TAGA Dispersants Data Sheet
TAGA Vol All Data Sheet

Appendix B - Curriculum Vitae

CURRICULUM VITAE

Name: Robert D. Cox, M.D., Ph.D. **Date of Appointment**: January 2, 1996

Present Position: Professor, Department of Emergency Medicine
Medical Director, Mississippi Regional Poison Control Center
Director, Medical Toxicology Service
University of Mississippi Medical Center (all)

Date and Place of Birth: November 20, 1954 - Chicago, IL

Marital Status: Married; Spouse - Dawna M. Cox

Educational Background:

College:	B.A., Chemistry and Biology Augustana College Rock Island, IL	1976
Graduate:	Ph.D., Chemistry University of Iowa Iowa City, IA	1980
Medical	M.D. University of Texas Southwestern Medical School Dallas, TX	1987

Postgraduate Training:

Internship:	Internal Medicine Baylor University Medical Center	1987 - 1988

	Dallas, Texas	
Residency:	Emergency Medicine UCLA Medical Center Los Angeles, California	1988 - 1991
Preceptorship:	Medical Toxicology Preceptorship Los Angeles Regional Poison Control Center Los Angeles, California	1988 - 1991

Honors and Awards:

Fellow American College of Medical Toxicology	2007
Fellow American College of Emergency Physicians	2003
Outstanding Faculty Award Emergency Medicine Residency University of Mississippi Medical Center	1998
Faculty Career Development Award Emergency Medicine Foundation	1992
Lieutenant Colonel, Aide De Camp, Governor's Staff State of Georgia	1991
Alpha Omega Alpha Medical Honor Society University of Texas Southwestern Medical School	1987
Vernie A. Stembridge Award in Pathology University of Texas Southwestern Medical School	1987
Southwestern Medical Foundation Scholar University of Texas Southwestern Medical School	1986
Southwestern Medical Foundation Scholar	1985

University of Texas Southwestern Medical School	
Chilton Research Fellowship	1984
Biochemistry Department	
University of Texas Southwestern Medical School	
Phi Beta Kappa Scholastic Honor Society	1976
Augustana College	
Magna Cum Laude	1976
Augustana College	
Beta Beta Beta Biological Honor Society	1975
Augustana College	

Specialty Certification:

Medical Toxicology, ABMS - ABEM	2000
(recertification)	2008
Emergency Medicine, ABMS - ABEM	1993
(recertification)	2002
(recertification)	2011
Toxicology, American Board of Toxicology	1993
(recertification)	1998
(recertification)	2003
(recertification)	2007
(recertification)	2014

Licensure:

State of Mississippi Medical License	1996 - present
State of Texas Medical License	1996 – 1997
State of Georgia Medical License	1991 – 1997
State of California Medical License	1988 – 1991
State of Texas Medical License	1987 – 1988

Professional Memberships:

American College of Medical Toxicology
American Academy of Clinical Toxicology
American College of Emergency Physicians
American Academy of Emergency Physicians

Academic and Professional Appointments:

Acting Managing Director Mississippi Poison Control Center University of Mississippi Medical Center	2005 – present
Professor Department of Emergency Medicine University of Mississippi Medical Center	2004 – present
Medical Director Mississippi Poison Control Center University of Mississippi Medical Center	2002 – present
Associate Chair Department of Emergency Medicine University of Mississippi Medical Center	2001 - 2010
Associate Professor Department of Emergency Medicine (and) Department of Pharmacology and Toxicology University of Mississippi Medical Center	1996 - 2004

Director — 1996 - present
Medical Toxicology Service
University of Mississippi Medical Center

Assistant Professor — 1991 - 1995
Section of Emergency Medicine
Department of Surgery (and)
Department of Pharmacology & Toxicology
Medical College of Georgia

Research Director — 1991 - 1995
Section of Emergency Medicine
Medical College of Georgia

Senior Scientist — 1983
Radian Corporation
Austin, TX

Staff Scientist — 1980
Radian Corporation
Austin, TX

Research Chemist — 1979
Analytical Chemistry Department
Gulf South Research Institute
New Orleans, LA

Publications:

1. Lin A, Confait C, Ahmad M, Cox R, Chen C. Severe ocular trauma in the emergency department. *J Miss Med Assoc* 2014;55:176-178.

2. Moriarity RS, Harris JT, Cox RD. Lead toxicity as an etiology for abdominal pain in the emergency department. J Emerg Med 2014;46:e35-e38.

3. Sterling SA, Cox RD. Increasing prevalence of adult-onset diabetes Mellitus in patients seeking care in the emergency department. Ann Emerg Med 2013;62:S73.

4. Parker CS, Cox RD. Potassium permanganate poisoning in a woman in labor. *Clin Toxicol* 2013;51:707.

5. Cox RD. Chemical Burns. Medscape Emergency Medicine. Updated September 2013. Available at: http://emedicine.medscape.com/article/769336-overview.

6. Cox RD, Orledge J. Inadvertent poisoning of seven teenagers with monosodium methanearsonate. *Clin Toxicol* 2011;49:167-170.

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9. Cox RD, Nony PA. A quantitative method for polychlorinated dioxin/furan congener source comparisons. *Organohalogen Compd* 2010;72:61-63.

10. Cox RD, Hood A, Calcote T. Impact of pill identification calls on poison control center volume: Influence of a policy on controlled substances. *Clin Toxicol* 2010;48:643.

11. Cox RD, Kyle PB, Brackin B, Snazelle MS. Blood lead levels in Mississippi children. *J Miss Med Assoc* 2010;51:206-210.

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15. Cox RD, Amundson, T, Bracken B. Evaluation of the patterns of potentially toxic exposures in Mississippi following Hurricane Katrina. *Clin Toxicol* 2008;46:722-727.

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17. Mills WJ, Nienow C, Swetman GLM, Cox R, Tondeur Y, Webber JP, Leblanc A. Lipids analysis as a significant, often unrecognized source of uncertainty in pops results for human blood. Organohalogen Compounds 2007;60:1158-1161.

18. Cox RD, Amundson T, Smith C, McKay K. Impact of Hurricane Katrina on Poison Control Center call volume and type. *Clin Toxicol* 2006;44:675-676.

19. Thompson JR, Mueller HW, Cox RD. Returns and recurrence for Bartholin's Cysts in an emergency department setting. *Ann Emerg Med* 2006;48:S49.

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21. Kolb JC, Cox RD, Jackson-Williams L, Nicholson S. Incidence of acute neurological abnormalities associated with hyperglycemia. *Ann Emerg Med* 2005;46:S71.

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23. Cox RD. Chemical Burns. in *Emergency Medicine On-Line*. Boston Medical Publishing Group, Boston, MA, 2005, (Chapter update).

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25. Cox RD, Koelliker DE, Bradley KG. Association between Droperidol use and sudden death in two patients intoxicated with illicit drugs. *Vet Human Toxicol* 2004;46:21-23.

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27. Cox RD. Use patterns for a university hospital-based medical toxicology service. *J Toxicol / Clin Toxicol* 2003;41:677-678.

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patient: monitoring practices in the ED. *Am J Emerg Med* 2002;20:524-527.

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33. Gitter MF, Cox RD. Clonidine overdose in an adolescent patient. J *Miss Med Assoc* 2000;41:757-759.

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24. Kolb JC, Carlton FB, Cox RD, Summers RL. Evaluation of the obstetric trauma patient: a survey of teaching programs. *Ann Emerg Med* 1997;30:399.

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28. Cox RD, Slott ER. Organic solvents: contribution to indoor air pollution. in *Indoor Air Pollution*, EJ Bardana, A Montanaro, eds, Marcel Dekker Inc, New York, 1995.

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37. Smiley RS, Koehler G, Cox RD, et al. *Hazardous Materials Medical Management Protocols*. State of California Emergency Medical Services Authority, Sacramento CA, 1991; EMSA #231.

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49. Cox RD, Frank C W. Determination of total N-nitroso content in cutting fluids. *Anal Chem* 1982;54: 557-559.

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51. Cox RD, McDevitt MA, Tannahill GK, Lee KW. Determination of low levels of total nonmethane hydrocarbon content in ambient air. *Environ Sci Technol* 1982;16:57-61.

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Hospital Documents:

1. Cox RD, Parker CS. Service Summary for the Mississippi Poison Control Center, University of Mississippi Medical Center, 2012.

2. Cox RD. 2010 Service Summary for the Mississippi Poison Control Center, University of Mississippi Medical Center, 2011.

3. Cox RD. Summary of calls to the Mississippi Poison Control Center concerning the Gulf Oil Crisis. Submitted to the Mississippi State Department of Health - 2010

4. Cox RD. 2009 Service Summary for the Mississippi Poison Control Center, University of Mississippi Medical Center, 2010.

5. Cox RD. 2008 Service Summary for the Mississippi Poison Control Center, University of Mississippi Medical Center, 2009.

6. Cox RD. 2007 Service Summary for the Mississippi Poison Control Center, University of Mississippi Medical Center, 2008

7. Cox RD. 2006 Service Summary for the Mississippi Poison Control Center, University of Mississippi Medical Center, 2007

8. Cox RD. 2005 Service Summary for the Mississippi Poison Control Center, University of Mississippi Medical Center, 2006

9. Cox RD. 2004 Summary of Emergency Department Outpatient Transfer Calls, University of Mississippi Medical Center, 2005.

10. Cox RD. 2003 Summary of Emergency Department Outpatient Transfer Calls, University of Mississippi Medical Center, 2004.

11. Cox RD. 2002 Summary of Emergency Department Outpatient Transfer Calls, University of Mississippi Medical Center, 2003.

12. Cox RD. 2001 Summary of Emergency Department Outpatient Transfer Calls, University of Mississippi Medical Center, 2002.

13. Cox RD. Hazardous Materials Exposure Medical Response Plan. University of Mississippi Medical Center, 2001.

14. Vaughn CA, Phillips WJ, Cox RD. University Medical Center Procedural Sedation Protocol, University of Mississippi Medical Center, 2001.

15. Cox RD. 2000 Summary of Emergency Department Outpatient Transfer Calls, University of Mississippi Medical Center, 2001.

16. Cox RD. 1999 Summary of Emergency Department Outpatient Transfer Calls, University of Mississippi Medical Center, 2000.

17. Cox RD. Medical Disaster Response Plan. University of Mississippi Medical Center, 1998.

18. Cox RD. Protocol for the Use of Fentanyl for Procedural Sedation in the Adult Emergency Department. University of Mississippi Medical Center, 1998.

19. Cox RD. Protocol for the Use of IV N-Acetylcysteine for the Treatment of Acetaminophen Toxicity. University of Mississippi Medical Center, 1998.

20. Cox RD. Hazardous Materials Disaster Preparedness Plan. Medical College of Georgia, 1993.

Presentations:

Research Presentations:

1. Sterling SA, Cox RD. Increasing prevalence of adult-onset diabetes Mellitus in patients seeking care in the emergency department. presented at the 2013 American College of Emergency Physicians Research Forum, Seattle, WA, October 2013. No. 196.

2. Parker CS, Cox RD. Potassium permanganate poisoning in a woman in labor. Presented at the 2013 North American Congress of Clinical Toxicology Annual Meeting, Atlanta, GA, October 2013. No. 290.

3. Moriarity RS, Cox RD, Nony PA. Mortality due to diabetes-related conditions in human PCB cohort studies. presented at the Global Obesity Summit 2010, Jackson, MS, November 2010. No 56.

4. Cox RD, Hood A, Calcote T. Impact of pill identification calls on poison control center volume: Influence of a policy on controlled substances. presented at the 2010 North American Congress of Clinical Toxicology Annual Meeting, Denver, CO, October 2010. No 189.

5. Cox RD, Nony PA, Liles CH. Summary of mortality due to diabetes and diabetes-related conditions in human PCB cohort studies. presented at Dioxin 2010-30th International Symposium on Halogenated Persistent Organic Pollutants (POPs), San Antonio, TX, September 2010. No 314.

6. Cox, RD, Nony, PA. A quantitative method for polychlorinated dioxin/furan congener source comparisons. presented at Dioxin 2010-30th International Symposium on Halogenated Persistent Organic Pollutants (POPs), San Antonio, TX, September 2010. No 245.

7. Cox RD, Orledge J, Burns BA. Accidental poisoning with monosodium methanearsonate. presented at the 2009 North American Congress of Clinical Toxicology Annual Meeting, San Francisco, CA, September, 2009. No 47.

8. Mills WJ, Nienow C, Swetman GLM, Cox R, Tondeur Y, Webber JP, Leblanc A. Lipids analysis as a significant, often unrecognized source of uncertainty in pops results for human blood. presented at Dioxin 2007-27th International Symposium on Halogenated Persistent Organic Compounds, Tokyo, Japan, September, 2007. Paper number 91019.

9. Cox RD, Amundson T, Smith C, McKay K. Impact of Hurricane Katrina on Poison Control Center call volume and type. presented at the 2006 North American Congress of Clinical Toxicology Annual Meeting, San Francisco, CA, September, 2006. No 103.

10. Thompson JR, Mueller HW, Cox RD. Returns and recurrence for Bartholin's Cysts in an emergency department setting. presented at the 2006 American College of Emergency Physicians ACEP Research Forum, New Orleans, LA, October 2006. No. 155.

11. Finley RW, Goddard J, Raoult D, Eremeeva ME, Cox RD, Paddock CD. *Rickettsia parkeri*: A case of tick-borne, eschar-associated spotted fever in Mississippi. presented at the International Conference on Emerging Infectious Diseases, Atlanta, Georgia, March, 2006. No. 188.

12. Kolb JC, Cox RD, Jackson L, Nicholson S. Incidence of acute neurologic abnormalities associated with hyperglycemia. presented at the 2005 American College of Emergency Physicians Scientific Assembly, Washington, DC, September, 2005. No. 253.

13. Cox RD. Comparison of urinary paranitrophenol and plasma/RBC cholinesterase measurements in the evaluation of domestic methylparathion exposure. presented at the 2003 North American Congress of Clinical Toxicology Annual Meeting, Chicago, IL, September, 2003, No. 228.

14. Cox RD. Use patterns for a university hospital-based medical toxicology service. presented at the 2003 North American Congress of Clinical Toxicology Annual Meeting, Chicago, IL, September, 2003, No. 89.

15. Flowers WM Jr., Lawhon NC, Kays RK, Habig GH, Wallace S, Stephens S, Thompson J, Cox RD, Kolb JC. Performance Improvement by a Radiology/Emergency Department Team. presented at the Southern Medical Association 96th Annual Scientific Assembly, Washington DC, November, 2002.

16. Kolb J, Cox R, Summers R. Interobserver Reliability of Well's Criteria Using a Checksheet. presented at the 2002 American College of Emergency Physicians Scientific Assembly, Seattle, WA, October, 2002, No. 100.

17. Kolb J, Cox R, Jackson L Focal Neurologic Changes in Hyperglycemia. presented at the 2002 American College of Emergency Physicians Scientific Assembly, Seattle, WA, October, 2002, No. 278.

18. Kolb J, Cox R, Reed S. Emergency Department Patient Accuracy of Subjective Fever. presented at the 2002 American College of Emergency Physicians Scientific Assembly, Seattle, WA, October, 2002, No. 97.

19. Kolb J, Cox R, Rock W, Summers R Reliability of Rapid D-Dimer ELISA in Urban Predominantly African American Emergency Department. presented at the 2002 American College of Emergency Physicians Scientific Assembly, Seattle, WA, October, 2002, No. 94.

20. Cox RD, Summers RL. Quantitative Comparison of fluoride neutralization potential of various hydrofluoric acid burn therapies. presented at the 1999 Scientific Assembly for the American College of Emergency Physicians, Las Vegas, NV, 1999, No. 209.

21. Cox RD, Galli RL, Kolb JC, Carlton FR, Houpt AM. Evaluation of Adverse Health Effects From Domestic Methylparathion Exposure. presented at the 38th Annual Meeting of the Society of Toxicology, New Orleans, LA March, 1999, Paper No. 1187.

22. Kolb JC, Cox RD, Galli RL, Carlton FR, Houpt AM. Impact of Domestic Methylparathion Exposure on Children's Health. presented at the 38th Annual Meeting of the Society of Toxicology, New Orleans, LA March, 1999, Paper No. 1188.

23. Galli RL, Cox RD, Kolb JC, Carlton FR, Houpt AM. The Utility of Plasma and RBC Cholinesterase Measurements in the Evaluation of Chronic Organophosphate Toxicity. presented at the 38th Annual Meeting of the Society of Toxicology, New Orleans, LA March, 1999, Paper No. 1189.

24. Kolb JC, Carlton FB, Cox RD, Summers RL: Evaluation of the Obstetric Trauma Patient: A Survey of Teaching Programs. presented at the 1997 Scientific Assembly for the American College of Emergency Physicians, San Francisco, CA, 1997, No. 94.

25. Hughes M, Brackin B, Cox R, Hotchkiss R, Hume A. Illegal Use of Methylparathion. presented at the 1997 North American Congress of Clinical Toxicology, St. Louis, MO, September, 1997, No. 88.

26. Holp DL, Hobbs E, Cox RD. Incidence of drug interactions in elderly

patients in the emergency department. presented at 1993 National Meeting of the Society of Academic Emergency Medicine, San Francisco, CA, May 1993, Paper No. 112.

27. Cox RD, Osgood KA. Evaluation of intravenous magnesium sulfate and intradermal calcium gluconate for the treatment of acute hydrofluoric acid dermal burns. presented at the 1993 Scientific Assembly for the American College of Emergency Physicians, Chicago, IL, October 1993.

28. Cox RD. Sample collection and analytical techniques for volatile organics in air presented at the APCA International Specialty Conference on: *Measurement and Monitoring of Non-Criteria (Toxic) Contaminants in Air* Chicago, IL, March, 1983.

29. Lewis DL, Cox RD, Lee KW. Specialized quality assurance for measurement of volatile organics in the environment. presented at the APCA International Specialty Conference on: *Measurement of Non-Criteria (Toxic) Contaminants in Air* Chicago, IL, March, 1983.

30. Cox RD, Baughman KJ. A generalized screening and analysis procedure for organic emissions from hazardous waste disposal sites. presented at the 3rd National Conference and Exhibition on: *Management of Uncontrolled Hazardous Waste Sites* Washington, DC, November, 1982.

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32. Cox RD, Lee KW, Earp RF. A purge and cryogenic trapping technique used to correlate ambient air organics with wastewater emissions. presented at the 184th National Meeting of the American Chemical Society, Kansas City, MO, September, 1982, Paper No ENVR-044.

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34. Cox RD, Langley GJ, Balfour DF. Quality assurance for ambient level hydrocarbon sampling and analysis. presented at the 1982 National Meeting of the Air Pollution Control Association, New Orleans, LA, June 1982, Paper No. 82-232.

35. McDevitt MA, Cox RD, Earp RF. Part per billion level determination of C2-C10 hydrocarbon species in ambient air. presented at the 33rd Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Atlantic City, NJ, March 1982, Paper No. 781.

36. Cox RD, Lee KW, Earp RF. Simultaneous use of photoionization (PID) and flame ionization (FID) detection for ambient air hydrocarbon analysis. presented at the 33rd Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Atlantic City, NJ, March 1982, Paper No. 782.

37. Cox RD, Ogle LD, Lee KW. Design and development of a sampling system for trace level organic species in ambient air using multicomponent sorbent traps. presented at the 33rd Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Atlantic City, NJ, March 1982, Paper No. 545.

38. Brennan ST, Frank CW, Cox RD. Nitrate, nitrite and N-nitrosamines in animal feeds. presented at the 32nd Pittsburgh Conference on Analytical Chemistry and applied Spectroscopy, Atlantic City, NJ, March 1981, Paper No. 373.

39. Brennan ST, Frank CW, Cox RD. Determination of nitrate and nitrite in atmospheric particulate. presented at the 32nd Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Atlantic City, NJ, March 1981, Paper No. 374.

40. Williams CH, Lewis DS, Ogle LD, Lee KW, Cox RD. Thermal desorption or solvent extraction of tenax resin for the trace analysis of C6-C20 organic pollutants in air. presented at the 3rd Annual Utah Conference on Industrial Hygiene, Salt Lake City, UT, October 1980.

41. Gebhart JE, Cox RD, Ryan JF. The master analytical scheme: development of effective techniques for isolation and concentration of organics in water. presented at the 2nd Chemical Congress of the North American Continent symposium on: *Advances in the Identification and Analysis of Organic Pollutants in Water,* San Francisco, CA, August 1980.

42. Nikolaisen L, Cox RD, Frank CF. A practical method for the determination of N-nitrosamines in urine. presented at the 31st Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Atlantic City, NJ, March 1980, Paper No. 351.

43. Cox RD, Frank CW. Rapid determination of nitrate in blood and urine. presented at the 31st Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Atlantic City, NJ, March 1980, Paper No. 521.

44. Cox RD, Frank CW. Determination of total N-nitrosamines in cutting oils. presented at the 30th Pittsburgh Conference on analytical Chemistry and Applied Spectroscopy, Cleveland, OH, March 1979, Paper No. 482.

45. Cox RD. The determination of nitrate and nitrite at the parts per billion level" presented at the 30th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Cleveland, OH, March 1979, Paper No. 483.

Invited Lectures:

1. “Using Drug and Alcohol Screens to Prove Impairment” presented at Markow Walker 2013 Worker’s Compensation Seminar, Ridgeland, MS, February 2013.

2. “Proving Impairment in Mississippi”. presented at Markow Walker 2012 Worker’s Compensation Update Seminar, Ridgeland, MS, February 2012.

3. “Home Health Hazards and Creating a Contaminant Free Environment”. presented at the Creating and Sustaining a Healthy Home Conference, Mississippi State Department of Health, Jackson, MS, April 2011.

4. “Regional Response: Coordinating a State and Local Response from the Disaster Center” presented at Oil & Water: Toxicology in Emergency Response, American College of Medical Toxicology, Clearwater Beach, FL. March, 2011.

5. “Interpretation of Drug and Alcohol Screens”. presented to the Mississippi Board of Nursing, Jackson, MS. April, 2009.

6. “Surveillance of Lead Levels in Mississippi Children”. presented at the Lead and Healthy Homes Meeting, Mississippi State Department of Health, Jackson, MS. June, 2008.

7. “Prevalence of Elevated Blood Lead Levels in Mississippi Children”. presented to the Lead Advisory Committee, Mississippi State Department of Health and the Centers for Disease Control and Prevention, Jackson, MS. November, 2007.

8. “Taking a Medical History for Agricultural Occupations”. presented at the Agromedicine Safety and Health Summit, Stoneville, MS, March 2007.

9. "Potential Chemical Agents of Terrorism". presented to the Mississippi Association of Public Health Physicians, Jackson, MS, 2005.

10. "Interpretation of Alcohol Levels and Urine Drug Screens". presented to AMFED Companies, Madison, MS, 2005.

11. "Cyanides and Fumigating Agents as Potential Agents of Chemical Terrorism". presented at the ATSDR/ACMT Symposium on Chemical Agents of Opportunity, University of Alabama School of Medicine, Birmingham, AL, 2004.

12. "Cyanides and Fumigating Agents as Potential Agents of Chemical Terrorism". presented at the ATSDR/ACMT Symposium on Chemical Agents of Opportunity, The Second Mediterranean Emergency Medicine Congress, Barcelona, Spain, September, 2003.

13. Moderator, Disaster Medicine: Emergency Medicine/Disaster Medicine Thesis Presentations. The Second Mediterranean Emergency Medicine Congress, Barcelona, Spain, September, 2003.

14. "Ketamine for Procedural Sedation". presented at Procedural Sedation for the Non-Anesthesiologist, July, 2001.

15. "Evaluation of the Sick Child". presented at Update in Emergency Medicine, Jackson, MS, 1999.

16. "Basic Management of the Overdose Patient". presented at the 1999 Nurse Practitioner Update, Jackson, MS, June, 1999.

17. "Evaluation of Potential Adverse Health Effects from Domestic Malathion Exposure". presented at the North Texas Poison Center Clinical Toxicology Lecture Series, Dallas, TX, April, 1999.

18. "Acetaminophen Toxicity", presented at the University of Mississippi Continuing Education Symposium on Medical Toxicology, Jackson, MS, April, 1998.

19. "The Chemically-Altered Trauma Patient", presented at the Medical College of Georgia Multiple Trauma Symposium, Augusta, Georgia, Sept., 1995.

20. "Management of Hazardous Materials Exposure Victims", presented at Grand Rounds, Department of Emergency Medicine, University of Mississippi, Jackson, Mississippi, April, 1995.

21. "An Emergency Department Protocol for Management of Hazardous Materials Exposure Victims", presented at the Medical College of Georgia Multiple Trauma Symposium, Augusta, Georgia, Sept., 1993.

22. "Prehospital Management of Hazardous Materials Exposure Victims", presented at the Georgia Changes Symposium for Emergency Care Providers, Augusta, Georgia, March, 1993.

23. "Management of Hazardous Materials Exposure Victims", presented at the Toxicology Seminar, Department of Pharmacy, University of Georgia, Athens, Georgia, Nov., 1992.

Patents:

1. Cox RD, Frank CW. Method for determination of nitrate and nitrite. US Patent No 4412006, October, 1983.

2. Frank CW, Nord PJ, Cox RD. Method for composition and determination of N-nitrosamines. US Patent No 4256462, March, 1981.

Software authored:

1. Cox, RD, Program for Extracting Performance Improvement Data from Combined Cerner EMStation and Patient Tracking Databases. Jackson, MS, 2008.

2. Cox RD, Perry A. Mississippi Poison Control Center Internet Site. http://poisoncontrol.umc.edu 2006.

3. Cox RD. Program to Extract Daily Influenza Clinical Monitoring Data from the Emergency Department Clinical Database for the Mississippi Department of Health and the Centers for Disease Control and Prevention - Influenza Biomonitoring Program. University of Mississippi Medical Center, Jackson, MS, 2006.

4. Cox RD. Hospital Antidote and Disaster Preparedness Database. (FileMaker Pro) 2005.

5. Cox RD. Emergency Medicine Resident Procedure Log. Allows importation and categorization of procedures from EMStation to a separate database and separate resident procedure entry for non-ED procedures, to meet RRC requirements, (Microsoft Access). University of Mississippi Medical Center, Jackson, MS, 2000, updated 2002, updated 2003.

6. Cox RD. Emergency Medicine Resident Follow-up Log. Allows storage and access of resident follow-up cases to meet RRC requirements, (Microsoft Access). University of Mississippi Medical Center, Jackson, MS, 2000, updated 2002, updated 2003.

7. Cox RD. Customization for Vitalworks Emergency Medicine Physician Documentation Software for the Teaching Hospital Environment, (Microsoft SQL). University of Mississippi Medical Center, Jackson, MS, 2000, updated 2001, updated 2002, updated 2003.

8. Cox RD. Program to Extract Daily Anthrax Clinical Monitoring Data from the Emergency Department Clinical Database for the Mississippi Department of Health and the Centers for Disease Control and Prevention - Anthrax Biomonitoring Program. University of Mississippi Medical Center, Jackson, MS, 2001.

9. Cox RD. Performance Improvement Program for using Vitalworks Emergency Medicine Physician Documentation Software in the Teaching Hospital Environment, (Microsoft Access). University of Mississippi Medical Center, Jackson, MS, 2000, updated 2001.

10. Cox RD. Patient Transfer Database (FileMaker Pro). University of Mississippi Medical Center, Jackson, MS, 1999.

11. Cox RD, Houpt AM. Department of Emergency Medicine, University of Mississippi Medical Center Internet Site. http://emergencymedicine.umc.edu 1998, updated 1999 - 2002.

12. Cox RD, Cox DM. Emergency Nursing Performance Improvement Software (Microsoft Excel). University of Mississippi Medical Center, Jackson, MS, 1998; updated 1999.

13. Cox RD. Fast-Track Patient Volume and Time to Treatment Database (Microsoft Excel). University of Mississippi Medical Center, Jackson, MS, 1998.

14. Cox RD. Emergency Department Patient Log and Time to Treatment Database (Microsoft Excel). University of Mississippi Medical Center, Jackson, MS, 1998.

15. Cox RD. Emergency Department Chart Tracking Program (Microsoft Excel). University of Mississippi Medical Center, Jackson, MS, 1998.

16. Cox RD. Emergency Medicine Residency Procedure Log (Microsoft Excel). University of Mississippi Medical Center, Jackson, MS 1997; network update 1998.

17. Cox RD. Emergency Medicine Residency Conference Attendance Database (Microsoft Excel). Medical College of Georgia, Augusta, GA 1994, updated for University of Mississippi Medical Center, Jackson, MS, 1997; network update 1998.

18. Cox RD. Acetaminophen Kinetics, Nomogram and Treatment Program (Microsoft Excel). University of Mississippi Medical Center and Mississippi Regional Poison Control Center, Jackson, MS, 1998.

19. Cox RD. Cardiac Ischemia Risk Predictive Instrument (Microsoft Excel). University of Mississippi Medical Center, Jackson, MS 1997; network update 1998.

20. Cox RD. Schedule Tracking and Preparation Software for Emergency Medicine (Microsoft Excel).. Medical College of Georgia, Augusta, Georgia, 1993; updated 1994; updated for the University of Mississippi Medical Center, Jackson, MS, 1997.

21. Cox RD. Environmental Chemical Data Mapping Software. Governor's Task Force for Assessment of Health Needs of Southern Wood Piedmont Residents (Microsoft Excel)., Augusta, Georgia, 1993.

22. Cox RD. Software for Gas Chromatographic Peak Identification Using Dual Flame Ionization and Photoionization Detectors (Basic). Radian Corporation, Austin, TX, 1982.

Other Activities and Appointments:

Administrative Appointments:

2005 – present	Managing Director Mississippi Poison Control Center University of Mississippi Medical Center
2002 – present	Medical Director Mississippi Poison Control Center University of Mississippi Medical Center
1999 – 2012	Project Director EMStation Clinical Documentation System Department of Emergency Medicine

	University of Mississippi Medical Center
1997 – present	Director Medical Toxicology Service University of Mississippi Medical Center
2007 – 2008	Chair Agromedicine Committee University of Mississippi Medical Center
2000 – 2002	Chair Pharmacy and Therapeutics Committee University of Mississippi Medical Center
1998 – 2002	Performance Improvement Director Department of Emergency Medicine University of Mississippi Medical Center
1997 – 2004	Compliance Officer Department of Emergency Medicine University of Mississippi Medical Center
1995	Medical Advisor Richmond County Emergency Management Agency Augusta, Georgia
1995	Medical Advisor Medical College of Georgia Public Safety Division Augusta, Georgia
1993 - 1995	Chair Subcommittee for Technical Evaluation of Environmental Data for the Governor's Task Force for Assessment of Health Needs of Southern Wood Piedmont Residents Augusta, Georgia

Committee Assignments

National:

2003 – present	Council of Medical Directors American Association of Poison Control Centers
2003 – 2004	National Advisory Committee for Acute Exposure Guideline Levels for Hazardous Substances American College of Medical Toxicology/US Environmental Protection Agency
2002 – 2004	Chemical/Bioterrorism Preparedness Committee American College of Medical Toxicology
1994 - 1995	Independent Review Panel Human Radiation Experimentation Research at the DOE Savannah River Site US Department of Energy
1994 - 1995	Peer Review Board Consolidated Incineration Facility Heath Risk Assessment at the DOE Savannah River Site US Department of Energy

State:

2012 – present	External Advisory Board for Eliminating Health Disparities Jackson State University Jackson, Mississippi
2006 - present	Childhood Lead Poisoning Prevention Advisory Board Mississippi State Department of Health Jackson, Mississippi
2002, 2006	The Mississippi Pesticide Advisory Task Force Jackson, Mississippi
1992-1995	Task Force

	State of Georgia Governor's Task Force for Assessment of Health Needs of Southern Wood Piedmont Residents Augusta, Georgia
1992 - 1995	Advisory Board Georgia Environmental Technologies Consortium, Georgia Research Alliance
1992 - 1995	Advisory Committee Georgia Hazardous Waste Trust Fund, Georgia Environmental Protection Division, Georgia Department of Natural Resources
1989 - 1991	Advisory Committee on Hazardous Materials, State of California Emergency Medical Systems

Institutional:

2010 – present	Emergency Medicine Promotions Evaluation Committee
2007 – present	Pharmacy and Therapeutics Committee University of Mississippi Medical Center
2010 – 2013	University Physicians Profit Sharing Plan Oversight Committee
2013	Consensus Committee to Evaluate Vendors for Extermination Services at UMC Campus
2005 – 2006	Public Health Project Tracking and Liaison Committee University of Mississippi Medical Center
1997 - 2002	Pharmacy and Therapeutics Committee University of Mississippi Medical Center

1996 – 2001, 2003	Disaster Preparedness Committee University of Mississippi Medical Center
1993 - 1995	Toxic and Hazardous Materials/Chemical Carcinogens Committee, Medical College of Georgia

Other Positions Held:

1989 - 1991	Emergency Physician Southern California Kaiser Permanente Medical Group Woodland Hills Hospital, Woodland Hills, CA
1986 - 1987	Extern Labor and Delivery Department, Parkland Memorial Hospital, Dallas, TX
1984	Chilton Research Fellow Biochemistry Department University of Texas Health Science Center Dallas, TX
1978 - 1979	Project Manager East Kentucky Power Environmental Impact Project Institute of Agricultural Medicine University of Iowa, Oakdale, IA
1978 - 1979	Private Consultant Water Quality Management Incorporation, Corralville, IA, John Deere Corporation, Dubuque, IA, 3M Corporation, Minneapolis, MN

Journal Peer Review Staff

2012 - present	Human and Experimental Toxicoogy
2006 – present	Clinical Toxicology
2009 - present	Medical Toxicology
2011	Journal of the Louisiana State Medical Society
2004 – 2005	Journal of Toxicology/Clinical Toxicology
2005	Environmental Pollution
2005	Environmental Health Perspectives
2004 – 2006	Medical Sciences
1981 – 1983	Analytical Chemistry

Research And Training Grants Awarded:

2013	Program Director/Principal Investigator Poison Control Stabilization and Enhancement Program Health Resources Services Administration, $151,639
2013	Principal Investigator Public Health Emergency Preparedness (PHEP) Cooperative Agreement, Surveillance and Reporting of Events to the Mississippi State Department of Health Mississippi State Department of Health, Department of Epidemiology and the Centers for Disease Control and Detection, $250,000
2013	Project Director RADARS® – Researched Abuse, Diversion and Addiction-Related Surveillance - Year 2 Rocky Mountain Poison and Drug Center, $27,124

2012	Principal Investigator Observational Study of Recovery from Copperhead Snake Envenomation BTG International, $11,000
2012	Program Director/Principal Investigator Poison Control Stabilization and Enhancement Program Health Resources Services Administration, $160,342
2012	Project Director Improved Detection and Surveillance for Chemical, Biological, Radiological and Nuclear Events The Mississippi State Department of Health, Department of Epidemiology and the Centers for Disease Control and Detection, $222,500
2012	Project Director RADARS® – Researched Abuse, Diversion and Addiction-Related Surveillance -Year 1 Rocky Mountain Poison and Drug Center, $27,124
2011	Project Director Poison Control Stabilization and Enhancement Program Health Resources Services Administration, $190,960
2011	Principal Investigator Real Time Disease Detection The Mississippi State Department of Health, Department of Epidemiology and the Centers for Disease Control and Detection, $250,000
2010	Project Director Poison Control Stabilization and Enhancement Program Health Resources Services Administration, $262,856
2010	Principal Investigator Real Time Disease Detection The Mississippi State Department of Health, Department of Epidemiology and the Centers for Disease Control and Detection, $250,000

2009	Project Director Poison Control Center Upgrade Grant Health Resources Services Administration, $248,000
2009	Principal Investigator Real Time Disease Detection The Mississippi State Department of Health, Department of Epidemiology and the Centers for Disease Control and Detection, $250,000
2008	Principal Investigator Real Time Disease Detection The Mississippi State Department of Health, Department of Epidemiology and the Centers for Disease Control and Detection, $253,403.
2006	Principal Investigator Poison Control Center, Emergency Planning and Response The Mississippi State Department of Health, Office of Emergency Preparedness and Response, funded through the Department of Homeland Security and HRSA, $550,000.
2005	Principal Investigator Poison Control Center, Emergency Planning and Response The Mississippi State Department of Health, Office of Emergency Preparedness and Response, funded through the Department of Homeland Security and HRSA, $600,000.
2004	Principal Investigator Emergency Bioterrorism Preparedness Grant for the Mississippi Regional Poison Control Center The Mississippi State Department of Health, Office of Emergency Preparedness and Response, funded through HRSA and the Department of Homeland Security, $600,000.
1997	Principal Investigator Investigation of Human Health Effects Resulting from Domestic Exposure to Methylparathion, The University of Mississippi Medical Center, $100,000.

1994	Principal Investigator Establishment of the Georgia Toxicology Center of Excellence, Research Equipment Grant, Georgia Environmental Technology Consortium, Georgia Research Alliance, $216,945.
1994	Independent Review Panel Human Radiation Experimentation Search at the DOE Savannah River Site, US Department of Energy, Environmental Research and Development Association, $5,000.
1994	Peer Review Board Member

Heath Risk Assessment for the Consolidated Incineration Facility at the Savannah River Site, US Department of Energy, Environmental Research and Development Association, $36,538.

1993	Principal Investigator Evaluation of Health Risks and Public Concerns Involving the Savannah River Site Consolidated Incinerator Facility for Treatment of Mixed Hazardous Wastes, US Department of Energy, Environmental Research and Development Association, $30,921.
1992	Principal Investigator Emergency Medicine Foundation Faculty Development Grant, Evaluation of the Treatment of Hydrofluoric Burns with Intravenous Magnesium Sulfate, $13,085; Study of Gastric Volatilization and Inhalation of Hydrocarbons Following Ingestion, $11,915, Emergency Medicine Foundation.
1982	Principal Investigator Development of Hazard Recognition Guidelines for the NIOSH Hazardous Waste Occupational Safety and Health Guidance Manual, National Institute for Occupational Safety and Health, $5,000.

1981	Program Director Evaluation of VOC (Volatile Organic Carbon) Emissions from Wastewater Systems - Secondary Emissions US Environmental Protection Agency, $63,500.

Teaching Activities:

The University of Mississippi Medical Center

1997 - present	Medical Toxicology Rotation for Medical Students. Course Director.
1997 - present	Pharmacology for Medical and Graduate Students. PH620/722: Lectures include: Principles of Medical Management of Poisoned Patients, Medical Toxicology Clinical Correlation, Occupational and Environmental Toxicology, Common Drug Overdoses, Pesticides and Heavy Metal Toxicity, Chemical Warfare Agents, Spiders and Snakes, Toxic Syndromes.
1996 - present	Medical Toxicology Series for Emergency Medicine Residents. Lectures include: Interpretation of Alcohol and Drug Screens, Cyanide Toxicity, Toxic Alcohols, Cardiotoxic Agents-Cocaine/Amphetamines, Evaluation and Treatment of the Poisoned Patient, Caustic Agents, Toxic Syndromes, Toxic Gases, Gastric Decontamination of the Poisoned Patient, Acetaminophen Toxicity-Mechanism and Treatment, Salicylate Toxicity and Treatment, Organophosphate Insecticide Toxicity, Toxicity of Herbicides and Fumigants, Hydrofluoric Acid Toxicity, Medical Management of Hazardous Materials Exposure Victims, Heavy Metal Toxicity, Food Poisoning, Iron Toxicity, Lithium Toxicity, Toxicity of Psychiatric Medications.

1996 - present Emergency Medicine Resident Lecture Series. Lectures include: Statistical Evaluation of Medical Studies, Medico-legal Aspects of Emergency Medicine, Disaster Medicine, Pharmacology and Toxicology of Diabetes Medications, Pharmacology and Toxicology of Hypertension Medications, Occult Bacteremia in Febrile Children, Evaluation of the Sick Child, HCFA Charting Guidelines.

2005 - 2012	Advanced Disaster Life Support. Potential Chemical Agents of Terrorism, Bioterrorism Agents, Case Scenarios. Decontamination Procedures.
2005 - 2012	Basic Disaster Life Support Chemical Incidents.
2004 – 2010	Didactic Lecture Series for 4th-year Medical Student Emergency Medicine Clerkship. Lectures include: Medical Management of the Poisoned Patient, Environmental Emergencies, Common Overdoses, Treatment of Common Infections.

Medical College of Georgia:

1992 - 1995	PHM 501: Introduction to Toxicology for Senior Medical Students. Lectures include: Medical Management of Overdose Patients, Hydrocarbon Ingestions, Toxic Syndromes, Acetaminophen Ingestions, Computer Databases in Toxicology.
1992 - 1995	PHM 551: Pharmacology for Medical and Graduate Students. Lectures include: Medical Toxicology Clinical Correlation.
1991 - 1995	Medical Toxicology Series for Emergency Medicine Residents. Lectures include: Evaluation and Treatment of the Poisoned Patient, Acetaminophen Toxicity-Mechanism and Treatment, Iron Toxicity-Mechanism and Treatment, Lithium Toxicity-Renal Mechanism and Treatment, Cyclic Antidepressant Toxicity, Toxicity of Alcohols, Toxicity of Antiarrhythmics, Neuroleptic Malignant Syndrome, Organophosphate Insecticide Toxicity, Antihypertensive Overdoses, Hydrofluoric Acid Toxicity, Medical Management of Hazardous Materials Exposure Victims.
.	
1991 - 1995	Emergency Medicine Resident Lecture Series. Lectures include: Occult Bacteremia in Febrile Children, Outpatient Antibiotic use in the Emergency Department, Introduction to Research, Use of Computer Databases, Use of Thrombolytic Agents for Acute MIs.
1994	Surgery Department Research Conference: Hydrofluoric Acid Burns.
1991	Pharmacology and Toxicology Department Seminar: Medical

Management of Hazardous Materials Exposure Victims.

UCLA

1990	Emergency Medicine Grand Rounds: Environmental Toxicology of Sulfur Compounds

University of Iowa

1976-1978	Quantitative Chemical Analysis
1977-1979	Chemistry and Physics of the Environment
1979	Introduction to Analytical Research for Chemistry Graduate Students

Community Activities

Television interviews:

July 6, 2010	Spice/K-2 Abuse in Mississippi and Nationally Channel 3, Jackson, MS
Jan 2009	Hypothermia Dangers Channel 16, Jackson, MS
Mar 2006	Increase in Mississippi Poison Control Center Volume Channel 16, Jackson, MS

Aug 2002	Hospital Overcrowding Channel 12, Jackson, MS
Mar 2002	Snakebite Antivenom Shortage Channels 3, 12 and 16, Jackson, MS
Aug 2000	Hyperthermia Channel 12, Jackson, MS
July 1999	Hyperthermia Channel 3, Jackson, MS
Nov 1997	Hospital Disaster Preparedness Channel 3, Jackson, MS
Oct 1997	Health Effects of Methylparathion Exposure Channel 12, Jackson, MS
Jan 1995	Effect of Lowering the Legal Blood Alcohol Level on Trauma Channel 6, Augusta, GA
Feb 1995	Hypothermia and Protection from the Cold Channel 6, Augusta, GA
Apr 1994	Protection of Children from Household Poisoning Channel 6, Augusta, GA
Dec 1993	Hypothermia and Frostbite Channel 12, Augusta, Georgia

Radio Interviews

Aug 2006	Arsenic in Soil in the Mississippi Coast The Mississippi Network
Jan 2006	The EMS Report Card for Mississippi PBS, Jackson, MS

Newspaper/On-line News interviews:

April 2014	Snakebite Do's and Don'ts Clarion Ledger, Jackson, MS
Oct 2013	Diabetes Prevalence Increasing in the ED Consultant Live, ConsultantLive.com, Oct 17, 2013
June 2010	K-2 Use in Mississippi Desoto Appeal, Memphis, TN
June 2007	Antibiotics in Asian Fish USA Today, Atlanta, GA
June 2007	Snake Dangers in Mississippi Clarion Ledger, Jackson, MS
May 2007	Antibiotics in Asian Fish Clarion Ledger, Jackson, MS
Jan 2007	Streptococcal Toxic Shock Syndrome Enterprise General News Hattiesburg, MS
Aug 2006	Normal Arsenic Levels in Mississippi Coastal Soils Mississippi Sun Herald Biloxi, MS
Aug 2006	Report on Arsenic Contamination in the Mississippi Coast API press release
Feb 2006	Poisoning Dangers in Children Mississippi Methodist Rehabilitation Center Newsletter Jackson, MS
Jan 2006	The EMS Report Card for Mississippi Mississippi Medical News

Dec 2005	Potential Ethylene Glycol Toxicity in Schoolchildren in Chechnya Almanac Panorama, Russian Weekly Newspaper
Dec 2005	Christmas Safety Precautions Hattiesburg American, Hattiesburg, MS
Dec 2005	Christmas Toxic Injuries Mississippi Methodist Rehabilitation Center Newsletter Jackson, MS
Sep 2005	Hurricane Katrina UMC Medical Response Clarion Ledger, Jackson, MS
Sep 2005	Press release on Carbon Monoxide Toxicity and Generators Following Hurricaine Katrina Jackson, MS
Dec 2004	Fireworks Injuries Madison Herald, Madison, MS
Jul 1999	Snake Bites in Mississippi Clarion Ledger, Jackson, MS
Oct 1997	Adverse Health Effects from Illegal Domestic Methylparathion Use Los Angeles Times, Los Angeles, CA
Oct 1997	Adverse Health Effects from Illegal Domestic Methylparathion Use Clarion Ledger, Jackson, MS
Sep 1997	Dangerous Adulterated Marijuana Clarion Ledger, Jackson, MS
Nov 1995	Findings of the Technical Subcommittee of the Governor's Task Force on Southern Wood Piedmont Residents Augusta Chronicle, Augusta, GA
Sep 1994	Yellow Jacket Stings

	Augusta Chronicle, Augusta, GA
May 1994	Snakebites Augusta Chronicle, Augusta, GA
Sep 1993.	Environmental conditions in the Hyde Park area Augusta Chronicle, Augusta, GA

Medical services:

2011 – present	Physician volunteer, Lantern Medical Clinic, Pearl, MS
Oct 2011	Physician volunteer, ATV & gun safety and health information provider, United Healthcare/ 4-H of Mississippi Wellness Celebration, Jackson, MS
Sep 2005	Red Cross Shelter physician volunteer following Hurricaine Katrina, Brandon, MS
Mar 1994	Provided medical support for the Georgia United Methodist Convention, Augusta, Georgia
1994 -1995	Medical Advisor for the Richmond County Emergency Management Agency
1992 - 1995	Member, Governor's Task Force for the Evaluation of Long Term Health needs of Southern Wood Piedmont Residents in Richmond County, Georgia
Feb 1991	Medical Staff Member, Los Angeles County Earthquake Disaster Drill

Donations:

2014 – present	Emergency Development Fund University of Mississippi Medical Center
2012 - present	Wounded Warrior Project
1997 - present	Toxicology Research Fund University of Mississippi Medical Center

2011	American Red Cross
2005 - 2010	Mississippi Methodist Children's Home
2004	Tsunami Relief Fund, American Red Cross
1994 - 1995	President's Club, Partner's Level, Medical College of Georgia Foundation

Appendix C - Prior Expert Testimony

Over the past four years, I have testified as an expert at deposition and at trial in the following litigation matters:

Date	Case Name/ Number	State	Organization/ Law Firm	Deposition/ Testimony	Subject
2/3/10	Dyanne Lewis v City of Jackson & Combined Systems	MS	Frilot LLC New Orleans, LA	Court Testimony- Trial	Tear Gas Exposure
3/24/10	Sandy Adams v Wesley Clark	AL	Hare, Wynn, Newell & Newton, LLP Birmingham, AL	Deposition	Ethylene glycol toxicity
4/21/10	Wendell Blount v USA	MS	US Department of Justice Northern District of Mississippi, Oxford, MS	Court Testimony	Manslaughter trial – MVC Morphine impairment
6/28/10	Joyce Tubbs v South Street Pharmacy	MS	Williford, McAllister & Jacobus, MS	Deposition	Isosorbide, tamoxifen toxicity
7/19/10	Dawn Patterson v Malcolm Driskill Trucking	MS	Greer, Russell, Dent & Leathers Tupelo, MS	Deposition	Cocaine intoxication
8/29/11	Derek Lapeyrouse v Stewart's Testing	MS	Markow Walker Ridgeland, MS	Deposition	Alcohol impairment
5/9/12	Anthony Brown v Jack Strain *et al.*	LA	Talley, Anthony, Hughes & Knight, LLC Mandeville, LA	Deposition	Cocaine intoxication
5/21/12	Betty Ruth Fox, et al v Richard Troy Jones et al	MS	Pittman, Germany, Roberts & Welsh LLP Jackson, MS	Deposition	Alcohol Impairment Dram Shop
6/4/12	Alvarez v Engel Reality CV-2011-900022/00, Jefferson County, Al	AL	Forman, Perry, Watkins, Krutz &Tardy, PLLC, Jackson, MS	Deposition	Mercury Staphlococcal sepsis
6/11/12	Dilmore v Holifield, Simson County Court, 2011-16	MS	Stubbs Law Firm, PLLC, Mendenhall, MS	Deposition	MVC, Marijuana Hydrocodone
11/9/12	Colony National Insurance Company v. The Teaford Company.Inc.. *et al.*	FL	Traub Lieberman Straus & Shrewsberry, LLP St. Petersburg, FL	Deposition	Industrial burn, wood ash, calcium oxide

Date	Case Name/ Number	State	Organization/ Law Firm	Deposition/ Testimony	Subject
3/20/13	Pace v Palmer Petroleum & Harmony Producing Co.	MS	Forman, Perry, Watkins, Krutz &Tardy, PLLC, Jackson, MS	Testify @ Mississippi Oil & Gas Board	Oil contamination
5/8/13	Jackson Fitzpatrick v State of Mississippi	MS	Capital Defense Counsel, Jackson, MS	Court Testimony	Murder trial Bath Salts methamphetamine intoxication
5/13/13	Calvin Parnell v McCoy Corporation	MS	Daniel Coker Horton & Bell, Jackson, MS	Deposition	MVC Alcohol impairment
5/29/13	Misty Lipe v City of Corinth	MS	Daniel Coker Horton & Bell, Oxford, MS	Court Testimony	MVC oxycodone Xanax impairment
6/26/13	Pinnacle Trust v Babcock & Wilcox	MS	Wells Marble & Hurst PLLC	Deposition	Lung Cancer Chromium welding
9/25/13	McElroy v City of Brandon	MS	Daniel Coker Horton & Bell, Jackson, MS	Deposition	MVC, Alcohol Marijuana impairment
2/12/14	Burkhalter v Thompson et al	MS	Wright Law Group, Upshaw Williams, Page Kruger, Williams	Trial Testimony	Lindane, Multiple sclerosis, Raynauds Disease
3/18/14	Cohen v HCA Summit Medical Center	TN	Rainey, Kizer, Reviere & Bell, Jackson, TN	Deposition	Fentanyl Toxicity

Appendix D - Glossary of Abbreviations

ACGIH - American Conference of Governmental Industrial Hygienists

AQI - Air Quality Index

AQS - Air Quality System

ATSDR - Agency for Toxic Substances and Disease Registry

BOEMRE - Bureau of Ocean Energy Management, Regulation and Enforcement

BP - British Petroleum

BTEX - Benzene, Toluene, Ethylbenzene and Xylenes

CASPER - Community Assessment for Public Health Emergency

CDC - Centers for Disease Control and Prevention

CO_2 - Carbon Dioxide

COPD - Chronic Obstructive Pulmonary Disease

CTPV - Coal Tar Pitch Volatiles

DOSS - Dioctyl Sodium Sulfosuccinate

DPnB - Dipropylene Glycol Monobutyl Ether

DWH - Deepwater Horizon

EARS - Early Aberration Reporting System

EPA - United States Environmental Protection Agency

ESSENCE - Electronic Surveillance System for Early Notification of Community-Based Epidemics

FDA - U.S. Food and Drug Administration

FOSC - Federal On-Scene Coordinator

GRAS - Generally Recognized as Safe

GRHOP - Gulf Region Health Outreach Projects

H_2S - Hydrogen Sulfide

HHE - Health Hazard Evaluation

HHS - U.S. Department of Health & Human Services

LDHH - Louisiana Department of Health and Hospitals

MC252 - Mississippi Canyon 252 Weathered Crude Oil

MDL - Minimal Detectable Limit

MRLs - Minimal Risk Levels

MSDH - Mississippi State Department of Health

NAAQS - National Ambient Air Quality Standards

NIEHS - National Institute of Environmental Health Sciences

NHANES - National Health and Nutrition Examination Survey

NIOSH - National Institute for Occupational Safety and Health

nmi - Nautical Miles

NOAA - National Oceanic and Atmospheric Administration

OECD - International Organisation for Economic Cooperation and Development

OSAT - Operational Science Advisory Team

OSHA - Occupational Safety and Health Administration

PAHs - Polycyclic Aromatic Hydrocarbons

PBZ - Personal Breathing Zone

PCBs - Polychlorinated Biphenyls

PCDD/PCDFs - Polychlorinated dibenzo-*p*-dioxins and Polychlorinated dibenzofurans

PEL - Permissible Exposure Limits (established by OSHA)

PM - Particulate Matter

PM2.5 - Fine Particulate Matter

PPE - Personal Protective Equipment

REL - Recommended Exposure Limits (established by NIOSH)

RfD - Reference Dose

SAMHSA - Substance Abuse and Mental Health Services Administration

SO_2 - Sulfur Dioxide

TAGA - Trace Atmospheric Gas Analyzer

TCDD - Tetrachlorodibenzo-p-dioxin

TLV - Threshold Limit Values (established by ACGIH)

TPH - Total Petroleum Hydrocarbons

USCG - United States Coast Guard

USGS - United States Geological Survey

VOCs - Volatile Organic Compounds