Gulf Oil Spill: Assessment of Dioxin Emissions from *in situ* Oil Burns

(Note: Questions 1 through 6 were taken from the Q's and A's developed by the Interagency Working Group on Dioxins, revised in May 2010, and posted on a FDA website: http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/DioxinsPCBs/ucm077524.htm

BACKGROUND ON DIOXINS

1. What are dioxins?

"Dioxins" refers to a group of chemical compounds that share certain chemical structures and biological characteristics. Several hundred of these compounds exist and are members of three closely related families: the chlorinated dibenzo-*p*-dioxins (CDDs), chlorinated dibenzofurans (CDFs) and certain polychlorinated biphenyls (PCBs). Sometimes the term dioxin is also used to refer to the most studied and one of the most toxic dioxins, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). CDDs and CDFs are not created intentionally, but are produced as a result of human activities. Natural processes also produce CDDs and CDFs. PCBs are manufactured products, but they are no longer produced in the United States.

Dioxins are formed as a result of combustion processes such as commercial or municipal waste incineration and from burning fuels (like wood, coal or oil). The 2003 draft dioxin reassessment makes the finding that anthropogenic (man-made) emissions dominate current releases in the United States, but acknowledges the need for more data on natural sources. Dioxins can also be formed when household trash is burned and as a result of natural processes such as forest fires. Chlorine bleaching of pulp and paper, certain types of chemical manufacturing and processing, and other industrial processes all can create small quantities of dioxins. Cigarette smoke also contains small amounts of dioxins.

Over the past decade, EPA and industry have worked together to dramatically reduce dioxin emissions. It is important to note that dioxin levels in the United States environment have been declining for the last 30 years due to reductions in man-made sources. However, dioxins break down very slowly; they are extremely persistent compounds. Some past releases of dioxins from both man-made and natural sources still exist in the environment. A large part of the current exposures to dioxins in the United States is due to release of man-made dioxins that occurred decades ago. Even if all human-generated dioxins were eliminated, low levels of naturally produced dioxins would remain. EPA is working with other parts of the government to look for ways to further reduce dioxin levels entering the environment and to reduce human exposure to them.

2. Why are people concerned about dioxins?

Dioxins from natural and anthropogenic (man-made) sources have been widely distributed throughout the environment. Almost every living creature has been exposed to dioxins. Studies have shown that exposure to dioxins at high enough levels may cause a number of adverse health effects. The health effects associated with dioxins depend on a variety of factors including: the level of exposure, when someone was exposed, and for how long and how often someone is exposed. Because dioxins are so widespread, we all have some level of dioxins in our bodies.

The most common health effect in people exposed to large amounts of dioxin is chloracne. Chloracne cases have typically been the result of accidents or significant contamination events. Chloracne is a severe skin disease with acne-like lesions that occur mainly on the face and upper body. Other effects of exposure to large amounts of dioxin include skin rashes, skin discoloration, excessive body hair, and possibly mild liver damage.

One of the main concerns over health effects from dioxins is the risk of cancer in adults. Several studies suggest that workers exposed to high levels of dioxins at their workplace over many years have an increased risk of cancer. Animal studies have also shown an increased risk of cancer from long-term exposure to dioxins.

Finally, based on data from animal studies, there is some concern that exposure to low levels of dioxins over long periods (or high level exposures at sensitive times) might result in reproductive or developmental effects.

3. What happens to dioxins when they enter the environment?

When released into the air, some dioxins may be transported long distances. Because of this, dioxins are found in most places in the world. When dioxins are released into water, they tend to settle into sediments where they can be further transported or ingested by fish and other aquatic organisms. Dioxins decompose very slowly in the environment and can be deposited on plants and taken up by animals and aquatic organisms. Dioxins may be concentrated in the food chain so that animals have higher concentrations than plants, water, soil, or sediments. Within animals, dioxins tend to accumulate in fat.

4. How might I be exposed to dioxins?

Most of the population has low-level exposure to dioxins. Although dioxins are environmental contaminants, most dioxin exposure occurs through the diet, with over 95% coming through dietary intake of animal fats. Small amounts come from breathing air containing trace amounts of dioxins on particles and in vapor form, from inadvertent ingestion of soil containing dioxins, and from absorption through the skin that is in contact with air, soil, or water containing minute levels of dioxins.

5. Do all dioxin compounds pose the same risk?

No. Different dioxin compounds have different toxicities and dioxins are most often found in mixtures rather than as single compounds in the environment. The most toxic forms of dioxin are 2,3,7,8-TCDD and 1,2,3,7,8-Pentachloredibenzodioxin. A method has been established for comparing the toxicity of different types of dioxins to the toxicity of 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD and adding together the toxicity of mixtures of dioxins. This method is called the "Toxicity Equivalence" or TEQ.

6. What are the major sources of dioxins?

The amounts of dioxin released from various sources have changed significantly over time. Historically, medical and municipal waste incineration, manufacture and use of certain herbicides, and chlorine bleaching of pulp and paper resulted in the major releases of dioxins to air and water. Government regulatory actions along with voluntary industry actions have resulted in dramatic reductions in each of these sources, and they are no longer major contributors of dioxins to the environment in the United States. While the United States has taken action to control this type of emission, some of these sources of dioxin may occur elsewhere in the world. Currently, the uncontrolled burning of residential waste is thought to be the largest source of dioxins to the environment in the United States. Some evidence suggests that forest fires may also be a source.

DIOXIN SAMPLING AND ANALYSIS

7. Why did EPA look for dioxins from controlled oil burns during the Deepwater Horizon BP spill?

EPA has been actively working with the Coast Guard and BP to minimize the environmental impacts of oil discharged during the Deepwater Horizon BP spill. One approach used to reduce the spread of oil and potentially mitigate the environmental impacts is the deliberate burning of crude oil on the sea surface. This practice is termed "*in situ*" burning. BP and the US Coast Guard conducted controlled *in situ* burns of oil approximately 50 to 80 km offshore over the time period April 28 to July 19, 2010. A total of 411 controlled burn events occurred of which 410 could be quantified, resulting in the combustion of an estimated 222,000 to 313,000 barrels of oil (or 9.3 to 13.1 million gallons). EPA was concerned that *in situ* burning may form and release dioxin to the environment since dioxins can be formed from the incomplete combustion of organic matter in the presence of chlorine.

8. Are dioxins formed from the burning of oil on ocean water?

Recent measurements made by EPA during the Deepwater Horizon BP spill indicate that dioxins are emitted from the burning of oil on ocean water. Previous investigations by others suggested that dioxins were not emitted from these types of burns (i.e., dioxins levels were indistinguishable from background levels). However, the sampling in these previous

investigations was done at sea/ground level, apparently outside of the visible plume. Results from these previous studies could not be used to definitively answer the question as to whether or not dioxins are released from controlled oil burns at sea.

9. How were dioxins from the burning of oil in the Gulf of Mexico measured?

EPA adapted standard dioxin sampling and analysis methods to measure dioxins emitted from *in situ* burns. The sampling device was attached to a balloon that could be tethered above the burning oil. The aerial sampling method used cables to anchor and remotely maneuver the balloon and the attached sampling device to collect gas and particle samples from plumes. The same sampling device was deployed on the deck of the ship to measure ambient air concentrations of dioxin. A composite sample of 27 plumes taken over a four day period resulted in the detection of dioxins above the ambient background concentrations. The average measured plume concentration, approximately 200-300 m from the fire and about 75-200 meters (m) above sea level, was < 0.0002 nanograms TEQ/cubic meter (ng TEQ/m^3).

10. How do the emissions from the controlled oil burns compare to emissions from other known sources of dioxins?

Dioxins are formed as a result of combustion processes such as commercial or municipal waste incineration and from burning fuels (like wood, coal or oil). The table below puts the current sampling results into perspective relative to average emission factors (amount of dioxin emitted per weight of material burned) estimated for other known dioxins sources. (Note: PCDD/F is an abbreviation for Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans).

Source	**PCDD/F (ng TEQ/kg)**
Bituminous Coal Spreader Stoker with cyclones	0.3
Municipal Waste Combustor, Well Controlled	0.5
Open Burning, Forest Residues	0.5
Wood-Fired Boiler, no controls	0.8
Residential Woodstove	1.5
***In-Situ* Ocean-Surface Oil Burning**	**1.7 - 3**
Forest Fires	5.0
Open Burning, Domestic Waste in Barrels	77 - 300

11. How much dioxin was potentially released from the *in situ* burning of oil in the Gulf?

USCG and BP records indicate there was a total of 411 controlled burn events conducted, of which 410 of those events could be quantified, to minimize the geographic spread of oil and associated environmental impacts. The burns resulted in the combustion of an estimated 222,000 to 313,000 barrels of oil (or 9.3 to 13.1 million gallons). Based upon the estimated dioxin emission rate, the total dioxin emissions from *in situ* oil burning was approximately 0.05 to 0.13 g TEQ dioxin. For comparison, the USEPA estimated that in the year 2000, total releases of dioxin to air in the United States from all quantifiable sources was approximately 1,300 g TEQ.

12. Who conducted the dioxin measurements and where?

A team of scientists and engineers led by the USEPA conducted sampling of the controlled oil burn in the Gulf of Mexico over the period from July 13 to 16, 2010. This was carried out with the support of the USCG and the Unified Command who were responsible for the logistics and the burn operations.

RISK ASSESSMENT

13. How did the EPA estimate potential risks to human health?

A screening level risk assessment was completed to determine potential risks to human populations that may have resulted from exposure to dioxins created by the *in situ* burns. Screening level risk assessments are frequently used by the Agency to determine if potential risks may be present that warrant additional study or action. The screening risk assessment had three components: 1) Estimating exposure from breathing air and risk to workers at sea; 2) Estimating exposure from breathing air and risk to the general population on shore; and 3) Estimating exposure and risk to the general population from eating seafood.

14. Based on the dioxin sampling results, what is the estimated risk to workers exposed to the emissions near the controlled burns?

The maximum lifetime additional (or incremental) cancer risk for workers was estimated to be below the level of concern of 1 in 1 million. The calculation assumes that the worker was exposed 10 hours per day over a three month exposure period. The incremental cancer risk is based upon AERMOD modeling results of the maximum near-field air concentration of 0.48 picogram (pg) TEQ/m^3, which occurred 50 m downwind of the burn center. The estimated incremental lifetime incremental cancer risk associated with this concentration was 6×10^{-8}.

15. Based on the results of the dioxin sampling conducted during controlled burns, what is the estimated risk to residents on land?

Modeled air concentrations were much lower for onshore residents. The additional (or incremental) inhalation cancer risk was estimated to be less than 1 in 1 billion risk. This calculation was based upon the assumptions that residents were exposed 24 hour/day (hr/d) over a three month exposure period. The maximum long-term, 82-day average air concentration for shoreline exposure was estimated to be 0.034×10^{-3} pg TEQ/m^3. The estimated incremental cancer risk associated with this concentration was 6×10^{-12}.

16. Another exposure pathway evaluated as part of EPA's risk screening assessment was the ingestion of fish that may become contaminated due to the uptake of dioxins emitted from in situ burns. Why was this exposure pathway considered?

The assessment of risks resulting from the oil fire emissions included evaluating the potential for uptake of dioxins by aquatic organisms, mainly fish, and the subsequent ingestion by people. This is an important exposure pathway for two reasons. First, this exposure pathway would integrate the cumulative impact of multiple burn events. Second, the primary route of human exposure to dioxin for most people is through the consumption of contaminated fish, meat, and dairy products. It was necessary to use predictive modeling to estimate the dioxin deposition rates in the Gulf due to the fires. The NOAA HYSPLIT model was used for this purpose. The upper estimate for dioxin fluxes to the continental shelf portion of the Gulf of Mexico ecosystem was estimated to be approximately 10 pg TEQ/m^2. Using this deposition rate, the increased dioxin concentration in fish at the point of maximum deposition was estimated to be 0.024 pg TEQ/g. The increase in fish concentration predicted here is over one order of magnitude less than background levels in marine fish (0.5 pg TEQ/g).

17. Does the increased level of dioxin in fish pose a risk to human health?

The increased level of dioxin in fish resulting from the controlled burns in the Gulf of Mexico is below the level of concern. The incremental risk from the burns is approximately 16 times below the level of concern of 1 in 1 million risk. Typically, the agency takes action when the risk level is greater than 1 in 1,000,000 (i.e., 1×10^{-4} to 1×10^{-6}). The lifetime incremental cancer risk due to fish ingestion was estimated to be 6×10^{-8} from the burns. This risk would increase for children because children have higher fish ingestion rates than adults when expressed on a per kg of body weight basis.

18. What about groups of people who eat a lot of fish?

Estimates of risks to human health from eating fish containing dioxin released from controlled burns were based upon assumptions about how much fish people eat. A high end fish consumption rate estimate of 81 grams fish per day was used for this risk assessment. This estimate is the 95th percentile for the fish and shellfish consumption rate for the U.S. population. Subsistence fish consumers in the Gulf Coast region have been identified as a population of concern with regard to impacts from the oil spill. Fish consumption rates for these populations are likely higher. A consumption rate of 300 grams fish per day (the 95th percentile for Native American subsistence fish intakes) was used to represent these populations. Using this higher consumption rate resulted in an incremental cancer risk estimate of 2×10^{-7}, which is still less than the 1 in 1,000,000 risk threshold. The fish consumption rate would need to exceed 1300 grams fish per day (almost three pounds per day) to exceed the 1 in 1,000,000 risk threshold.

19. How do the incremental exposures estimated due to the *in situ* burning of oil compare with total dioxin exposure estimates for the general population?

In the United States, general population exposure to all dioxin-like compounds (including dioxin-like PCBs), or background exposure, is approximately 41 pg TEQ per day per person (Lorber et al. 2009). The results of the risk screening calculations indicated that the hypothetical ingestion of fish contaminated with dioxins released from the in situ burns would correspond to a daily intake of 1.9 pg TEQ/day, or about 5% of current background exposures.