CE 326 Principles of Environmental Engineering - Air Dispersion Lab

"In September 2000, the North American Commission for Environmental Cooperation (NACEC) released a report entitled "Long-range Air Transport of Dioxin from North AmericanSources to Ecologically Vulnerable Receptors in Nunavut, Arctic Canada" prepared for the NACEC by Dr. Barry Commoner and his colleagues at the Center for the Biology of Natural Systems (CBNS). This report details a computer modeling study of the transport of airborne dioxin (that is, poly-chlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans, also referred to by the acronym PCDD/PCDF) from widely distributed sources on the North America continent to the Canadian polar territory of Nunavut. This computer study suggests that dioxin formed during burning of high chlorine-content fuels, such as municipal solid waste (MSW), can be transported thousands of miles through the atmosphere before being deposited in the Canadian arctic." (from http://www.city.ames.ia.us/ElectricWeb/dioxinreport.htm).

The City of Ames has asked you as the City's consultant to determine what the ground level concentrations for dioxin would be assuming the estimate from Commoner's study. They also want you to calculate the cancer risk is for an individual living at the point of maximum downwind concentration. The Commoner study assumed an emission of 58 g dioxin per year. The City has estimated that the Commoner study greatly overestimated the dioxin emissions and has come up with its own estimate of 0.24 g dioxin per year.

From the Iowa DNR permit, we have determined that the stack height is 200 feet from ground level, the stack opening is 96 inches in diameter, and the exhaust flow rate is 173,300 cubic feet per minute at 390°F. Assume that the atmospheric conditions are stable (Class C) at 105 kPa and 28°C, and the wind velocity is 3 m/s.

1. Plot the ground level concentration of dioxin as a function of distance from the stack and determine the maximum ground level concentration and the distance from the stack where the maximum concentration occurs. Plot for both the Commoner estimate (58 g/y) and the City estimate (0.24 g/y).

2. Plot the contours for ground level concentrations that equal 25%, 50% and 75% of the maximum value and indicate on your plot the location of the stack and the location of the point where the maximum ground level concentration would occur.

Using the residential default parameters, what is the target risk for an individual at the point of maximum concentration directly downwind from the plant? Calculate the risk for both the Commoner estimate and City estimate.
The general risk model is:

$$TR = \frac{RBSL \cdot IR \cdot EF \cdot ED \cdot SF_i}{BW \cdot AT_C \cdot 365\ \frac{d}{y} \cdot 10^3\ \frac{\mu g}{mg}}$$

Risk model parameters

Parameter		Residential Default	Commercial/Industrial
TR = target risk		for example, 10^{-4} to 10^{-6}	for example, 10^{-4} to 10^{-6}
RBSL = risk based screening level, μg/m^3		chemical/site specific	chemical/site specific
IR = inhalation rate, m^3/d	(indoor)	15	20
	(outdoor)	20	20
EF = exposure frequency, d/y		350	250
ED = exposure duration, y		30	25
BW = body weight, kg		70	70
AT_c = averaging time for carcinogen, y		70	70
SF_i = slope factor for inhalation (mg/kg d)$^{-1}$		chemical specific	chemical specific

Sample slope factors for risk model

Slope Factors	SF_i
Trichloroethylene (TCE)	0.006
Benzene	0.029
Benzo(a)pyrene	7.3
2,3,7,8-TCDD (dioxin)	1.16×10^5