APPENDIX A

Example Cases

1. Case A

A. Source Characterization

Case A is one of four hazardous waste incinerators selected for this analysis. Facility and source parameters used in the air dispersion modeling and risk assessment of this site are presented in Table A-1.1. Values listed in the table were obtained from facility-specific information provided by EPA.

Table A-1.1. Facility and Source Parameters for Case A

Parameter	Case A
Facility type	Incinerator
Land use w/in 5 km	Industrial/rural
Terrain use	No
Operating hours (8,760/yr possible)	7,324
Stack parameters	Stack 1
Stack height (m)	30.5
Diameter (m)	1.8
Total flow rate (dscfm) / (dscms)	31,860 / 15.0
Exit velocity (m/s)	6.1
Exit temperature (K)	309

B. Setting Characterization

Case A is located in the south-central United States, in an area of flat terrain. Land use surrounding the site is industrial/commercial to the south and east and open/rural to the north and west.

The National Weather Service Station at Baton Rouge, Louisiana, provided the most appropriate meteorologic data for Case A. Upper air data from Lake Charles, Louisiana, were paired with the surface data for air dispersion modeling. Five years of meteorological data, for the years 1985 and 1987-1990, were used to determine long-term average air dispersion and deposition estimates. Table A-1.2 lists the annual average meteorologic parameters, which were obtained from the International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992). Also listed in Table A-1.2 are the average evapotranspiration rate and annual runoff. These values were used with the precipitation rate to calculate a water balance for Case A. One-half of the average annual runoff value cited in the *Water Atlas* (Geraghty et al., 1973) was used in the analysis. The adjustment was made to account for surface runoff only, and not the subsurface inflows to surface waters. The evapotranspiration rate was calculated by assuming 70 percent of the precipitation evaporates.

Table A-1.2. Annual Average Meteorologic Parameters for Case A

Ave. Annual Evapotranspiration[a] (cm/yr)	Ave. Annual Runoff[a] (cm/yr)	Ave. Annual Precipitation[b] (cm/yr)	Ambient Air Temperature[b] (K)	Mean Annual Wind-speed[b] (m/s)
100.7	22.5	143.8	293	4.12

[a] *Water Atlas* (Geraghty et al., 1973).
[b] International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992).

C. Characterization of Exposed Populations

Table A-1.3 presents the locations of exposed populations identified for Case A. Information regarding the location of the residence and farms likely to be most impacted by Case A was obtained through telephone interviews with local planning offices and local agricultural extension agents. The local officials were asked to identify farms near the facility where subsistence activities would be likely. Farms identified by local officials were assessed to determine which would be most impacted by the facility emissions, and the maximally impacted farms were assumed to represent the location of the subsistence farmers.

Table A-1.3. Location of Receptors Identified for Case A

Receptor	Location (Distance (km)/Direction)	Source
Residence of home gardener	0.4 km northeast	City Planning Office
Subsistence beef farm	1 km north	Agricultural Extension Agent
Subsistence dairy farm	1 km north[a]	Agricultural Extension Agent
Subsistence poultry farm	1 km north[a]	Agricultural Extension Agent
Subsistence pork farm	1 km north[a]	Agricultural Extension Agent
Subsistence fisher location (inhalation and soil ingestion) Lake Clause Fish ponds University Lake Comite River	 12 km northwest 9 km west-southwest 16.5 km south-southeast 6 km east	Location of maximum air concentration of vapors within the watershed
Waterbody identified as surface drinking water source	None	Parish Water Company

[a] Default assumption based on location of subsistence beef farmer.

The waterbodies were selected from U. S. Geological (USGS) topographical maps as those that would be large enough to support fish yet would reflect the highest impact from the facility. Phone calls to local officials verified that individuals might consume fish caught in the selected waterbodies. The topographic maps were also used to identify watersheds associated with each waterbody and to estimate waterbody and watershed surface areas. Table A-1.4 lists the surface areas and other surface water parameters for Case A. References for the surface water parameters are also listed in the table.

The fraction of food contaminated was varied depending on the scenario. In this analysis, the fraction contaminated is defined as the fraction of what is consumed that is contaminated by facility emissions. The fraction contaminated is independent of the level of contamination, which is dependent upon the production location. Contamination levels calculated for a subsistence farm located near the facility would be higher than those calculated for the typical farm (air concentrations and deposition rates averaged to 20 kilometers). The terms "subsistence level of contamination" and "typical level of contamination" are used to reflect the different levels.

Central tendency and high-end contaminated fractions were developed based on an economic analysis of regional production and processing capacity and the fraction home-produced recommendations from the *Exposure Factors Handbook* (U.S. EPA, 1990). The fractions were developed using data from parishes within 50 kilometers of the site. The economic analysis is discussed in detail in Section II.E.2 of the main report. The commodity with the highest fraction locally produced was assumed to be the commodity produced by the typical farmer. Local agricultural production indicated that the typical farmer for Case A was a dairy farmer. The fractions assumed to be locally produced and processed for Case A are as follows:

Beef	0.01	Pork	0.01
Dairy	0.34	Poultry	0.01
Produce	0.03	Eggs	0.01
Fish	0.01		

The subsistence farmers considered for Case A were beef, dairy, poultry, and pork farmers. The locations of the subsistence farmers, listed in Table A-1.3, were used for estimating exposures from direct inhalation and soil ingestion. The fraction contaminated is assumed to be 1 for the livestock the subsistence farmer is identified as producing. He was also assumed to grow all the fruits and vegetables he consumed. For example, the subsistence beef farmer was assumed to produce all the beef, vegetables, and fruits that he ingested and to purchase all other dietary items -- such as milk, pork, fish, etc. -- from local markets. The items raised on the subsistence farms had higher levels of contamination than what was available in the local market. The local items purchased in the market were contaminated at levels that reflected the average impact from the stack out to 20 kilometers from the facility. Because the water supplied to the area surrounding Case A came from sources other than surface waterbodies, the subsistence farmers did not drink contaminated water. Tables A-1.5 through A-1.8 list the locations of contamination and the contaminated fraction by pathway for the subsistence farm scenarios.

Table A-1.4. Surface Water Parameters for Case A

Waterbody	Surface Area (m^2)[a]	Watershed Area (m^2)[a]	Impervious Watershed Area (m^2)[b]	Average Volumetric Flow Rate (m3/yr)[c]	Current Velocity (m/s)[d]	Depth of Water Column (m)[c]	USLE Rainfall/ Erosivity Factor [f]
Comite River	1.9E+06	3.4E+08	1.7E+07	5.3E+08	0.48	1.1	510
Fish Ponds	2.8E+06	2.9E+07	1.5E+05	1.3E+07	NA	1	510
Lake Clause	1.8E+05	1.5E+07	7.7E+04	6.9E+06	NA	4.5	510
University Lake/ City Park Lake	9.5E+05	7.6E+06	1.9E+06	3.4E+06	NA	0.9	510

[a] Surface areas for the watersheds and waterbodies were determined from the USGS 1.25 000-scale Topographic 7.5 min X 15 min quadrangles.

[b] Impervious watershed areas were estimated from USGS quadrangles, site-specific land use, and a study of percent imperviousness for different land uses conducted by Camp, Dresser, and McKee (1989).

[c] The volumetric flow rate for the Comite river was obtained from the REACH (U.S. EPA, 1995a) database. Flow rates for the other waterbodies were calculated from the watershed area and average annual surface runoff.

[d] Current velocity for the Comite river was obtained from the REACH (U.S. EPA, 1995a) database. Current velocities for lakes were not required and are listed as NA (Not Applicable).

[e] Depth for the Comite River was calculated from the volumetric flow rates, the current velocity, and the width. Depths for the lakes were estimated from topographic maps and an assumed depth of 4 to 6 meters.

[f] USLE Erosivity/Rainfall Factor was obtained from Edwards (1993) and was used in the universal soil loss equation (USLE).

Table A-1.5. Exposure Scenario for Subsistence Beef Farmer, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence beef farm (1 km north)	1.0
Soil ingestion	Location of subsistence beef farm (1 km north)	1.0
Belowground vegetables	Location of subsistence beef farm (1 km north)	1.0
Aboveground produce	Location of subsistence beef farm (1 km north)	1.0
Beef ingestion	Location of subsistence beef farm (1 km north)	1.0
Milk ingestion	Average to 20 km	0.34
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

Table A-1.6. Exposure Scenario for Subsistence Dairy Farmer and Child, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (1 km north)[a]	1.0
Soil ingestion	Location of subsistence dairy farm (1 km north)[a]	1.0
Belowground vegetables	Location of subsistence dairy farm (1 km north)[a]	1.0
Aboveground produce	Location of subsistence dairy farm (1 km north)[a]	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Location of subsistence dairy farm (1 km north)[a]	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence beef farmer.

Table A-1.7. Exposure Scenario for Subsistence Pork Farmer, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence pork farm (1 km north)[a]	1.0
Soil ingestion	Location of subsistence pork farm (1 km north)[a]	1.0
Belowground vegetables	Location of subsistence pork farm (1 km north)[a]	1.0
Aboveground produce	Location of subsistence pork farm (1 km north)[a]	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.34
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Location of subsistence pork farm (1 km north)[a]	1.0
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence beef farmer.

Table A-1.8. Exposure Scenario for Subsistence Poultry Farmer, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence poultry farm (1 km north)[a]	1.0
Soil ingestion	Location of subsistence poultry farm (1 km north)[a]	1.0
Belowground vegetables	Location of subsistence poultry farm (1 km north)[a]	1.0
Aboveground produce	Location of subsistence poultry farm (1 km north)[a]	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.34
Chicken meat ingestion	Location of subsistence poultry farm (1 km north)[a]	1.0
Egg ingestion	Location of subsistence poultry farm (1 km north)[a]	1.0
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence beef farmer.

A subsistence fisher was modeled for each watershed. The fish consumption rate for the subsistence fisher was 60 g/d, rather than the 1.64-g/d rate of the general population. The locations of the residences of the subsistence fishers were assumed to be the site of highest vapor air concentration within the affected watershed. The residence location was used for estimating exposures from direct inhalation and soil ingestion. All fish in the diet was assumed to be from the watershed where the subsistence fisher resided. All other dietary items were assumed purchased from the local market and to contain typical levels of contamination. Because the water supplied to the area surrounding Case A came from sources other than surface waterbodies, the subsistence fishers did not drink contaminated water. Table A-1.9 lists the locations of contamination and the contaminated fraction by pathway for the subsistence fisher scenario.

Table A-1.9. Exposure Scenario for Subsistence Fisher, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of maximum vapor air concentration in each watershed	1.0
Soil ingestion	Location of maximum vapor air concentration in each watershed	1.0
Belowground vegetables	Average to 20 km	0.03
Aboveground produce	Average to 20 km	0.03
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.34
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion (60 g/d)	Each watershed	1.0

The location of the home gardener and child was derived from the location of the closest actual residence to the facility. This residential location was used to estimate exposures from direct inhalation and soil ingestion. The contaminated fractions of aboveground produce and belowground vegetables were determined by adding the fraction contaminated in the local market to the fraction that the gardener home-raised and consumed, as cited in the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.27 by adding the homegrown fraction of 0.25 to 3 percent of the remaining 0.75 purchased from local markets. All other dietary items were assumed purchased from local markets and to contain typical levels of contamination derived from average air dispersion and deposition estimates to 20 kilometers from the facility. Because the water supplied to the area surrounding Case A came from sources other than surface waterbodies, the home gardener did not drink contaminated water. Table A-1.10 lists the locations of contamination and the contaminated fraction by pathway for the home gardener scenarios.

The typical adult resident and child exposures were based on averages of air concentrations and deposition rates out to 20 km. The averages were used for estimating exposures from direct inhalation and soil ingestion. All dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. Because the surface water supplied to the area surrounding Case A came from sources other than the selected waterbodies, the typical resident did not drink contaminated water. Table A-1.11 lists the locations of contamination and the contaminated fraction by pathway for the typical resident scenarios.

Table A-1.10. Exposure Scenario for Home Gardener and Child, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Location of closest residence (0.4 km northeast)	1.0	
Soil ingestion	Location of closest residence (0.4 km northeast)	1.0	
		Central Tendency	**High End**
Belowground vegetables	Location of closest residence (0.4 km northeast)	0.25 Typical farmer + 0.75 x Local market = 0.27	0.40 Typical farmer + 0.60 x Local market = 0.42
Aboveground produce	Location of closest residence (0.4 km northeast)	0.25 Typical farmer + 0.75 x Local market = 0.27	0.40 Typical farmer + 0.60 x Local market = 0.42
Beef ingestion	Average to 20 km	0.01	0.01
Milk ingestion	Average to 20 km	0.34	0.34
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.01	0.01
Fish ingestion	Each watershed	0.01	0.01

Table A-1.11. Exposure Scenario for Typical Adult Resident and Child, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average out to 20 km	1.0
Soil ingestion	Average out to 20 km	1.0
Belowground vegetables	Average out to 20 km	0.03
Aboveground produce	Average out to 20 km	0.03
Beef ingestion	Average out to 20 km	0.01
Milk ingestion	Average out to 20 km	0.34
Chicken meat ingestion	Average out to 20 km	0.01
Egg ingestion	Average out to 20 km	0.01
Pork ingestion	Average out to 20 km	0.01
Fish ingestion	Each watershed	0.01

The typical farmer for this site was assumed to be a dairy farmer because the fraction of dairy locally produced was higher than the fractions for the other commodities in the analysis. The typical dairy farmer was assumed to produce a fraction of the dairy, vegetables, and fruits he consumed and to purchase all other dietary items from the local market. The fractions contaminated for each pathway were determined by adding the fraction contaminated in the local market to the fraction that the farmer home-raised and consumed from the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.27 by adding the homegrown fraction of 0.25 to 3 percent of the remaining 0.75 purchased from local markets. Both the items raised on the typical farm and the items purchased from local markets had typical levels of contamination. The typical dairy farmer's exposures from direct inhalation and soil ingestion were estimated to be at levels derived from averages of air dispersion and deposition outputs to 20 kilometers. Because the water supplied to the area surrounding Case A came from sources other than surface waterbodies, the typical farmer did not drink contaminated water. Table A-1.12 lists the locations of contamination and the contaminated fraction by pathway for the typical farmer scenario.

Table A-1.12. Exposure Scenario for Typical Farmer, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Average to 20 km	1.0	
Soil ingestion	Average to 20 km	1.0	
		Central tendency	**High-end**
Belowground vegetables	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.27	0.40 Typical farmer + 0.60 x Local market = 0.42
Aboveground produce	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.27	0.40 Typical farmer + 0.60 x Local market = 0.42
Beef ingestion	Average to 20 km	0.01	0.01
Milk ingestion	Average to 20 km	0.40 Typical farmer + 0.60 x Local market = 0.60	0.75 Typical farmer + 0.25 x Local market = 0.84
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.01	0.01
Fish ingestion	Each watershed	0.01	0.01

Recreational fishers were modeled for each waterbody by combining the typical resident scenario with an increased consumption of contaminated fish recreationally caught (30 g/d). The recreational fisher's exposures from direct inhalation and soil ingestion were derived from averages of air dispersion and deposition output to 20 kilometers. All fish in the diet was assumed to be from a single waterbody. For instance, the recreational fisher identified for the Comite River only ate fish caught in the Comite River. All other dietary items were assumed purchased from the local market and to contain typical levels of contamination. Because the water supplied to the area surrounding Case A came from sources other than surface waterbodies, the recreational fishers did not drink contaminated water. Table A-1.13 lists the location of contamination and the contaminated fraction by pathway for the recreational fisher scenario.

Table A-1.13. Exposure Scenario for Recreational Fisher, Case A

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average to 20 km	1.0
Soil ingestion	Average to 20 km	1.0
Belowground vegetables	Average to 20 km	0.03
Aboveground produce	Average to 20 km	0.03
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.34
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion (30 g/d)	Each watershed	1.0

D. Air Modeling and Air Modeling Results

A test version of ISCSTDFT was the air dispersion and deposition model used to estimate air concentrations and deposition rates for Case A. Source inputs used in the modeling are listed in Table A-1.1. The meteorologic data required for the air modeling were created using PCRAMMET, DEPMET, and PMERGE preprocessors. Table A-1.14 lists site-specific data needed for the DEPMET preprocessor. The actual anemometer height was used as a DEPMET input. For the other inputs, recommendations from the DEPMET User's Guide (U.S. EPA, 1994b) based on the site-specific land use data were used. The noontime albedo for summer was used because it is most representative of Louisiana due to the State's year-round lack of snow cover. Land use information for Case A was obtained from telephone surveys and assessed through topographic maps.

Table A-1.14. Air Modeling Inputs Used in ISCSTDFT Modeling

Meteorologic Location	
Surface / upper air	Baton Rouge, LA/Lake Charles, LA
Anemometer height (m)	10.0
DEPMET Preprocessor Inputs	
Land use within 5 km	Industrial/rural
Min. M-O length (m)	50.
Roughness height (m)	0.5[a]
Displacement height (m)	2.5
Noontime albedo (fraction)	0.16
Soil moisture available (fraction)	0.9
Net radiation absorbed in ground (fraction)	0.22
Anthropogenic heat flux (W/m2)	0.

[a] Based on a maximum roughness height of 1/20th of the anemometer height.

The ISCSTDFT model was run using 5 years of meteorological data concatenated into a multiple-year meteorological file (U.S. EPA, 1995b). Therefore, results of the ISCSTDFT modeling conducted with this multiple-year meteorological file represent a 5 year average.

The ISCSTDFT model was run using the "default" model options. The terrain option was not used because this site is an area of flat terrain, and the effects of terrain on air dispersion would not be significant for this site. Additionally, the good engineering practices (GEP) stack height was calculated using EPA's Building Profile Input Program (BPIP) to determine if building downwash should be considered for this site. Inputs to BPIP -- site-specific information on the building height, width, and location -- were available for several buildings having the potential to influence the plume dispersion from the stack. Based on this site-specific information, the GEP stack height for Case A, as calculated by BPIP, was 65 meters. Although this value is greater than the actual stack height of 30.5 meters, the stack was not located in the area of influence of any of the buildings. A building's area of influence on a stack is defined as five times the lesser of the building height or the maximum projected width, and it will vary for each building. For Case A, the building closest to the stack is located approximately 75 meters to the south. The building would have to be approximately 30 meters from the stack for the stack to be in the building's area of influence. Since the stack was not located in the area of influence for any buildings considered, downwash was not used in the air dispersion modeling for Case A.

Specific receptor locations evenly spaced every 1,000 meters were identified for each watershed and waterbody using USGS topographic maps. The 5 year averages of air dispersions and deposition rates were then areally averaged over each specific watershed and waterbody.

The point of maximum combined deposition and the point of maximum vapor air concentration were used for "bounding" estimates. For a given scenario, the point of maximum concentration was used in calculating bounding risks for direct inhalation, while the maximum combined deposition or maximum concentration was used in estimating risks for other pathways. However, bounding exposure was considered for only the pathways involved in the subsistence activities for a given scenario. For example, bounding exposure for the subsistence poultry farmer was due to ingestion of soil, produce, poultry, and eggs (based on the point of maximum deposition) and to direct inhalation (based on the point of maximum concentration). The other exposure routes -- ingestion of beef, pork, milk, fish, and drinking water -- were not bounding but were, instead, based on the location of the subsistence poultry farmer. For the subsistence fisher scenario, a default watershed, which lies at the highend of the distribution of watersheds (Van der Leeden et al., 1990), was centered at the point of maximum combined deposition. Parameters for the bounding watershed are contained in the body of the document (Section II).

The ISCSTDFT air modeling results are presented in Figures A-1.1 through A-1.4. Figure A-1.1 shows the combined deposition of particles within 20 kilometers of Case A; Figure A-1.2 shows the air concentration of vapors within 20 kilometers of Case A; and Figures A-1.3 and 4 show the wet and dry deposition of particles, respectively, within 3 kilometers of Facility A. The results are also presented in tabular form in Table A-1.15.

Table A-1.15. Results of ISCSTDFT Air Modeling for Case A[a]

Scenario	Location Distance m/Direction	Particles				Vapors	
		Combined Deposition (g/m²-yr)/(g/s)	Wet Deposition (g/m²-yr)/(g/s)	Dry Deposition (g/m²-yr)/(g/s)	Air Concentration (µg/m³)/(g/s)	Wet Deposition (g/m²-yr)/(g/s)	Air Concentration (µg/m³)/(g/s)
Point of maximum combined deposition	100/S	0.39	0.39	0.0013	0.0077	0.54	0.0078
Point of maximum vapor concentration	700/S	0.19	0.039	0.15	0.47	0.066	0.50
Home gardener (closest resident)	400/NE	0.12	0.036	0.080	0.29	0.054	0.30
General population	--	7.3E-04	2.3E-04	5.0E-04	0.012	2.9E-04	0.013
Subsistence farmer - beef/ dairy/ poultry/ pork	1000/N	0.11	0.015	0.092	0.31	0.025	0.34
Subsistence fisher - Lake Clause	12000/NW	0.0030	--	--	0.029	0.0007	0.031
Subsistence fisher - fish ponds	9000/WSW	0.0030	--	--	0.041	0.00079	0.042
Subsistence fisher - University Lake	16500/SSE	0.0015	--	--	0.015	0.00024	0.015
Subsistence Fisher - Comite River	6000/E	0.0034	--	--	0.033	0.0014	0.034
		Averages over Watershed			**Averages over Waterbody**		
		Combined Deposition of Particles (g/m²-yr)/(g/s)	**Wet Deposition of Vapors (g/m²-yr)/(g/s)**	**Air Concentration of Vapors (µg/m³)/(g/s)**	**Combined Deposition of Particles (g/m²-yr)/(g/s)**	**Wet Deposition of Vapors (g/m²-yr)/(g/s)**	**Air Concentration of Vapors (µg/m³)/(g/s)**
Lake Clause	--	0.0015	0.00055	0.023	0.0013	0.00052	0.020
Fish Ponds	--	0.0013	0.00045	0.027	0.00099	0.00032	0.027
University Lake	--	0.00091	0.00023	0.013	0.00084	0.00022	0.014
Comite River	--	0.00057	0.00017	0.0092	0.00057	0.00018	0.0094

[a] The air modeling results in the table are based on an emission rate of 1 g/s for the stack.

Figure A-1.1 Combined deposition of particles within 20 kilometers of Facility A. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

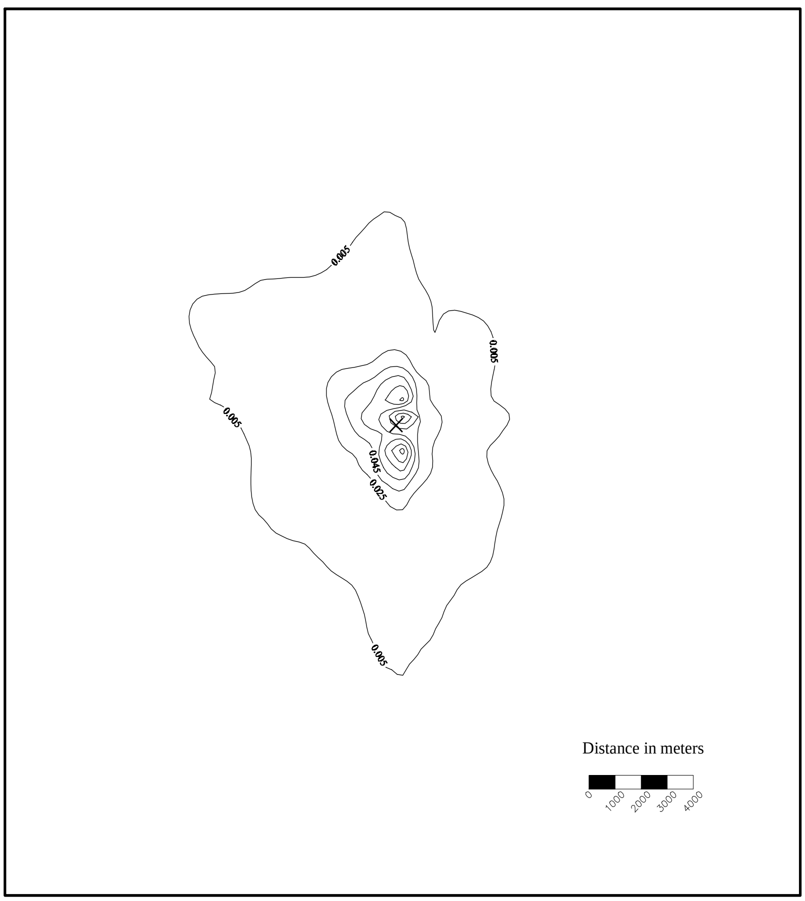


Figure A-1.2 Air concentration of vapors within 20 kilometers of facility A. Air concentration in units of micrograms per cubic meter, resulting from a unit emission rate of 1 gram per second.

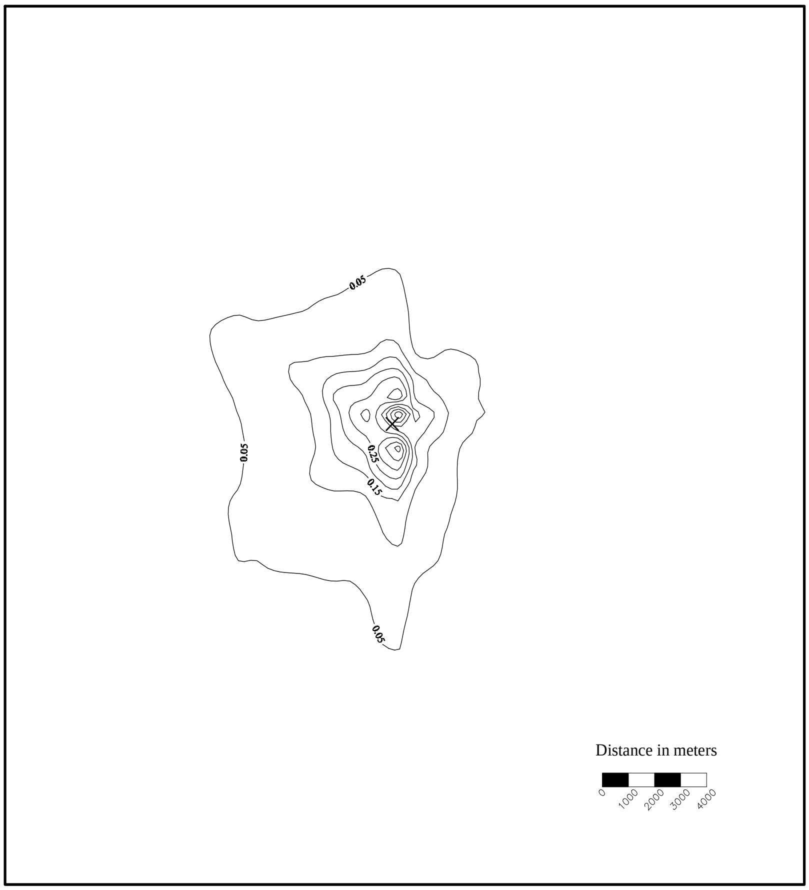


Figure A-1.3 Wet deposition of particles within 3 kilometers of Facility A. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

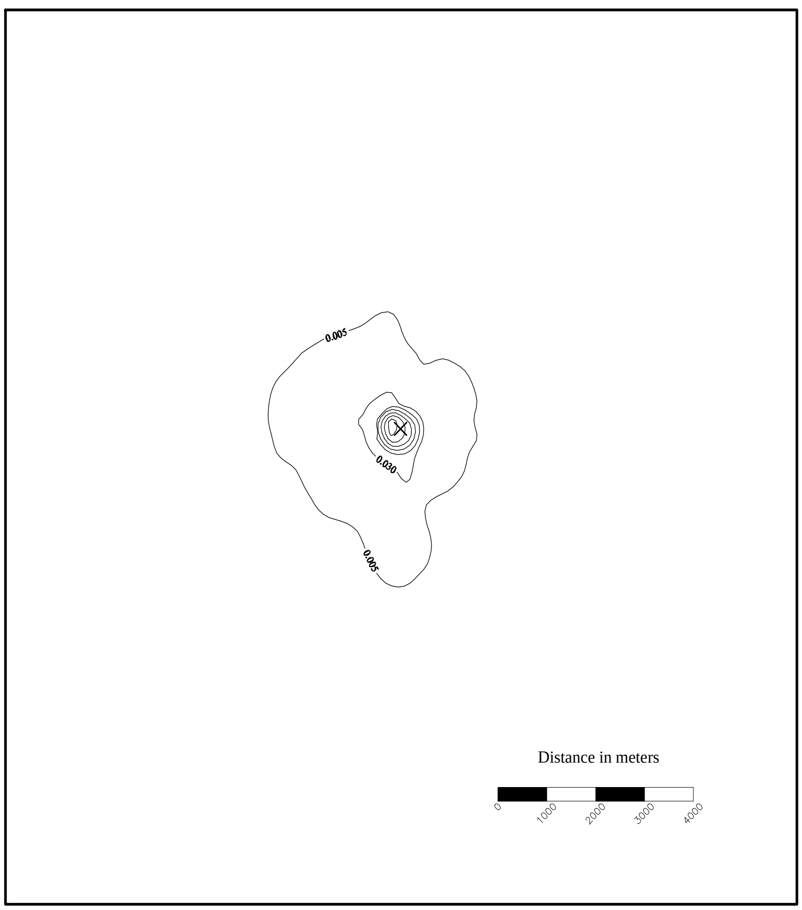
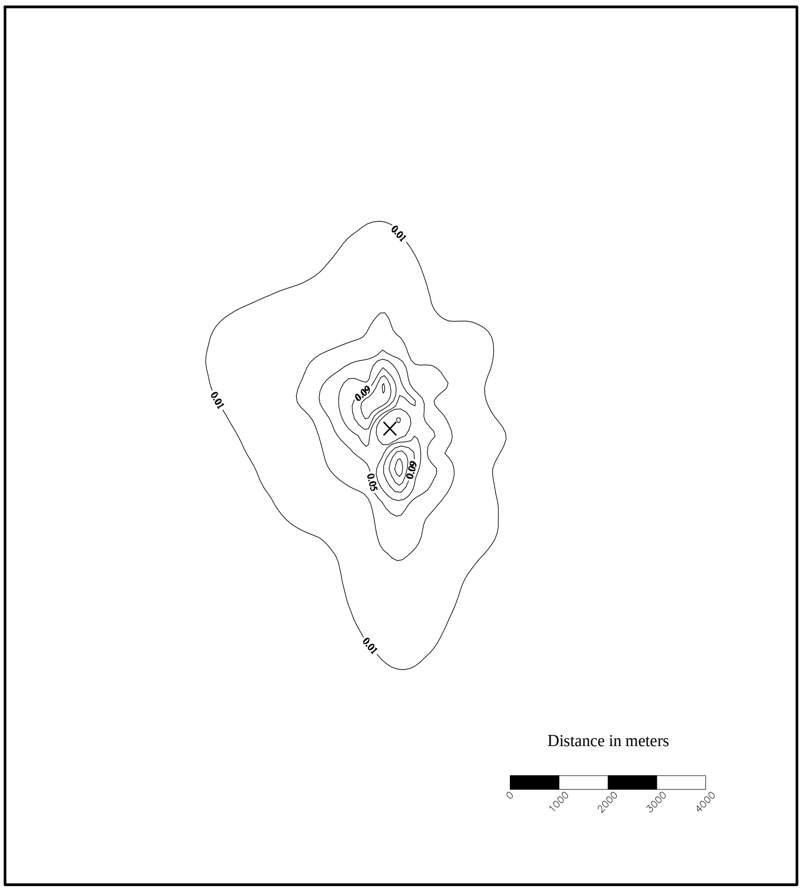


Figure A-1.4 Dry deposition of particles within 3 kilometers of Facility A. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.



2. Case B

A. Source Characterization

Case B is one of five cement kilns selected for this analysis. Facility and source parameters used in the air dispersion modeling and risk assessment of this site are presented in Table A-2.1. Values listed in the table were obtained from facility-specific information provided by EPA.

Table A-2.1. Facility and Source Parameters for Case B

Parameter	Case B	
Facility type	Cement kiln	
Land use w/in 5 km	Forest	
Terrain use	No	
Operating hours (8,760/yr possible)	7,560	
Stack parameters	Stack 1	Stack 2
Stack height (m)	45.7	48.8
Diameter (m)	4.1	3.8
Total flow rate (dscfm) / (dscms)	252,300 / 119.1	
Exit velocity (m/s)	5.9	8.6
Exit temperature (K)	457	476

B. Setting Characterization

Case B is located in the southeastern United States in an area of flat terrain. The land surrounding the site is mainly forested.

The National Weather Service Station at Charleston, South Carolina, provided the most appropriate meteorologic data for Case B. Upper air data, also from Charleston, was paired with the surface data for air dispersion modeling. Five years of meteorologic data, for the years 1986 to 1990, were used to determine long-term average air dispersion and deposition estimates. Table A-2.2 lists the annual average meteorologic parameters, which were obtained from the International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992). Also listed in Table A-2.2 are the average evapotranspiration rate and annual runoff. These values were used with the precipitation rate to calculate a water balance for Case B. One-half of the average annual runoff value cited in the *Water Atlas*, (Geraghty et al., 1973) was used in the analysis. The adjustment was made to account for surface runoff only, and not the subsurface inflows to surface waters. The evapotranspiration rate was calculated by assuming 70 percent of the precipitation evaporated.

Table A-2.2. Annual Average Meteorological Parameters for Case B

Ave. Annual Evapotranspiration[a] (cm/yr)	Ave. Annual Runoff [a] (cm/yr)	Ave. Annual Precipitation[b] (cm/yr)	Ambient Air Temperature[b] (K)	Mean Annual Windspeed[b] (m/s)
90.7	12.5	129.5	291.3	4.1

[a] *Water Atlas* (Geraghty et al., 1973).
[b] International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce 1992).

C. *Characterization of Exposed Populations*

Table A-2.3 presents the locations of exposed populations identified for Case B. Information regarding the location of the residence and farms likely to be most impacted by Case B was obtained from a site survey of the local area and through telephone interviews with local planning offices and local agricultural extension agents. From the site survey, farms were identified where subsistence activities would be likely, near the facilities and in the direction of the maximum impact. These farms were assumed to be the maximally impacted subsistence farms.

Table A-2.3. Location of Receptors Identified for Case B

Receptor	Location (Distance (km)/Direction)	Source
Residence of home gardener	0.2 km south	County Mapping Coordinator
Subsistence beef farm	5 km east-northeast	Survey of local area
Subsistence dairy farm	15 km west	Survey of local area
Subsistence poultry farm	3 km northeast	Survey of local area
Subsistence pork farm	3 km north-northeast	Survey of local area
Subsistence fisher location (inhalation and soil ingestion) Lake Marion Lake Merkel Huttos Lake	 7 km northeast 17 km southeast 9 km south-southeast	Location of maximum air concentration of vapors within the watershed
Waterbody identified as surface drinking water source	None	County Mapping Coordinator

The waterbodies were selected from USGS topographical maps as those that would be large enough to support fish, yet would reflect the highest impact from the facility. Phone calls to local officials verified that individuals might consume fish caught in the selected waterbodies. The topographic maps were also used to identify the watersheds associated with each waterbody and to estimate waterbody and watershed surface areas. Table A-2.4 lists the surface areas and other surface water parameters for Case B. References for the surface water parameters are also listed in the table.

The fraction of food contaminated was varied depending on the scenario. In this analysis, the fraction contaminated is defined as the fraction of what is consumed that is contaminated by facility emissions. The fraction contaminated is independent of the level of contamination, which is dependent upon the production location. Contamination levels calculated for a subsistence farm located near the facility would be higher than those calculated for the typical farm (air concentrations and deposition rates averaged to 20 kilometers). The terms "subsistence level of contamination" and "typical level of contamination" are used to reflect the different levels.

Central tendency and high-end contaminated fractions were developed based on an economic analysis of regional production and processing capacity and the fraction home-produced recommendations from the *Exposure Factors Handbook* (U.S. EPA, 1990). The fractions were developed using data from counties within 50 kilometers of the site. The economic analysis is discussed in detail in Section II.E.2 of the main report. The commodity with the highest fraction locally produced was assumed to be the commodity produced by the typical farmer. Local agricultural production indicated that the typical farmer for Case B was a dairy farmer. The fractions assumed to be locally produced and processed for Case B are as follows:

Beef	0.01	Pork	0.06
Dairy	0.20	Poultry	0.01
Produce	0.24	Eggs	0.01
Fish	0.01		

The subsistence farmers considered for Case B were beef, dairy, poultry, and pork farmers. The locations of the subsistence farmers, listed in Table A-2.3, were used for estimating exposures from direct inhalation and soil ingestion. The fraction contaminated is assumed to be 1 for the livestock the subsistence farmer is identified as producing. He was also assumed to grow all the fruits and vegetables he consumed. For example, the subsistence beef farmer was assumed to produce all the beef, vegetables, and fruits that he ingested and to purchase all other dietary items -- such as milk, pork, fish, etc.-- from local markets. The items raised on the subsistence farms had higher levels of contamination than what was available in the local market. The local items purchased in the market were contaminated at levels that reflected the average impact from the unit out to 20 kilometers from the facility. Because the water supplied to the area surrounding Case B came from sources other than surface waterbodies, the subsistence farmers did not drink contaminated water. Tables A-2.5 through A-2.8 list the locations of contamination and the contaminated fraction by pathway for the subsistence farm scenarios.

Table A-2.4. Surface Water Parameters for Case B

Waterbody	Surface Area (m^2)[a]	Watershed Area (m^2)[a]	Impervious Watershed Area (m^2)[b]	Average Volumetric Flow Rate[c] (m^3/yr)	Current Velocity (m/s)[d]	Depth of Water Column (m)[e]	USLE Rainfall/ Erosivity Factor[f]
Huttos Lake	1.5E+05	2.5E+06	1.3E+04	6.3E+05	NA	1.4	325
Lake Marion	3.6E+08	3.0E+09	1.5E+07	7.5E+08	NA	3.9	325
Lake Merkel	1.3E+05	6.6E+06	3.3E+04	1.7E+06	NA	1.4	325

[a] Surface areas for the watersheds and waterbodies were determined from the USGS 1.25 000-scale Topographic 7.5 min X 15 min quadrangles.

[b] Impervious watershed areas were estimated from USGS quadrangles, site-specific land use, and a study of percent imperviousness for different land uses conducted by Camp, Dresser, and McKee (1989).

[c] Volumetric flow rates for the waterbodies were calculated from the watershed area and average annual surface runoff.

[d] Current velocities for lakes were not required and are listed as NA (Not Applicable).

[e] Depths for Lake Marion and Lake Huttos were calculated by dividing the total volume of the lake by the surface area of the lake (data provided by South Carolina Water Resource Division). Lake Merkel was assumed to have a depth similar to Lake Huttos.

[f] USLE Erosivity/Rainfall Factor was obtained from Edwards (1993) and was used in the universal soil loss equation (USLE).

Table A-2.5. Exposure Scenario for Subsistence Beef Farmer, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence beef farm (5 km east-northeast)	1.0
Soil ingestion	Location of subsistence beef farm (5 km east-northeast)	1.0
Belowground vegetables	Location of subsistence beef farm (5 km east-northeast	1.0
Aboveground produce	Location of subsistence beef farm (5 km east-northeast	1.0
Beef ingestion	Location of subsistence beef farm (5 km east-northeast	1.0
Milk ingestion	Average to 20 km	0.20
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.06
Fish ingestion	Each watershed	0.01

Table A-2.6. Exposure Scenario for Subsistence Dairy Farmer and Child, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (15 km west)	1.0
Soil ingestion	Location of subsistence dairy farm (15 km west)	1.0
Belowground vegetables	Location of subsistence dairy farm (15 km west)	1.0
Aboveground produce	Location of subsistence dairy farm (15 km west)	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Location of subsistence dairy farm (15 km west)	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.06
Fish ingestion	Each watershed	0.01

Table A-2.7. Exposure Scenario for Subsistence Pork Farmer, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence pork farm (3 km north-northeast)	1.0
Soil ingestion	Location of subsistence pork farm (3 km north-northeast)	1.0
Belowground vegetables	Location of subsistence pork farm (3 km north-northeast)	1.0
Aboveground produce	Location of subsistence pork farm (3 km north-northeast)	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.20
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Location of subsistence pork farm (3 km north-northeast)	1.0
Fish ingestion	Each watershed	0.01

Table A-2.8. Exposure Scenario for Subsistence Poultry Farmer, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence poultry farm (3 km northeast)	1.0
Soil ingestion	Location of subsistence poultry farm (3 km northeast)	1.0
Belowground vegetables	Location of subsistence poultry farm (3 km northeast)	1.0
Aboveground produce	Location of subsistence poultry farm (3 km northeast)	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.20
Chicken meat ingestion	Location of subsistence poultry farm (3 km northeast)	1.0
Egg ingestion	Location of subsistence poultry farm (3 km northeast)	1.0
Pork ingestion	Average to 20 km	0.06
Fish ingestion	Each watershed	0.01

A subsistence fisher was modeled for each watershed. The fish consumption rate for the subsistence fisher was 60 g/d, rather than the 1.64-g/d rate of the general population. The locations of the residences of the subsistence fishers were assumed to be the site of highest vapor air concentration within the affected watershed. The residence location was used for estimating exposures from direct inhalation and soil ingestion. All fish in the diet was assumed to be from the watershed where the subsistence fisher resided. All other dietary items were assumed purchased from the local market and to contain typical levels of contamination. Because the water supplied to the area surrounding Case B came from sources other than surface waterbodies, the subsistence fishers did not drink contaminated water. Table A-2.9 lists the locations of contamination and the contaminated fraction by pathway for the subsistence fisher scenario.

Table A-2.9. Exposure Scenario for Subsistence Fisher, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of maximum vapor air concentration in each watershed	1.0
Soil ingestion	Location of maximum vapor air concentration in each watershed	1.0
Belowground vegetables	Average to 20 km	0.24
Aboveground produce	Average to 20 km	0.24
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.20
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.06
Fish ingestion (60 g/d)	Each watershed	1.0

The location of the home gardener and child was derived from the location of the closest actual residence to the facility. This residential location was used to estimate exposures from direct inhalation and soil ingestion. The fractions contaminated for the aboveground produce and belowground vegetables were determined by adding the fraction contaminated in the local market to the fraction that the gardener home-raised and consumed, as cited in the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.43 by adding the homegrown fraction of 0.25 to 24 percent of the remaining 0.75 purchased from local markets. The other dietary items were assumed purchased from local markets and to contain typical levels of contamination derived from average air dispersion and deposition estimates to 20 kilometers from the facility. Because the water supplied to the area surrounding Case B came from sources other than surface waterbodies, the home gardener did not drink contaminated water. Table A-2.10 lists the locations of contamination and the contaminated fraction by pathway for the home gardener scenarios.

The typical adult resident and child exposures were based on averages of air concentrations and deposition rates out to 20 km. The averages were used for estimating exposures from direct inhalation and soil ingestion. All dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. Because the surface water supplied to the area surrounding Case B came from sources other than the selected waterbodies, the typical resident did not drink contaminated water. Table A-2.11 lists the locations of contamination and the contaminated fraction by pathway for the typical resident scenarios.

Table A-2.10. Exposure Scenario for Home Gardener and Child, Farmer, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Location of closest residence (0.2 km south)	1.0	
Soil ingestion	Location of closest residence (0.2 km south)	1.0	
		Central Tendency	**High End**
Belowground vegetables	Location of closest residence (0.2 km south)	0.25 Typical farmer + 0.75 x Local market = 0.43	0.40 Typical farmer + 0.60 x Local market = 0.54
Aboveground produce	Location of closest residence (0.2 km south)	0.25 Typical farmer + 0.75 x Local market = 0.43	0.40 Typical farmer + 0.60 x Local market = 0.54
Beef ingestion	Average to 20 km	0.01	0.01
Milk ingestion	Average to 20 km	0.20	0.20
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.06	0.06
Fish ingestion	Each watershed	0.01	0.01

Table A-2.11. Exposure Scenario for Typical Adult Resident and Child, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average out to 20 km	1.0
Soil ingestion	Average out to 20 km	1.0
Belowground vegetables	Average out to 20 km	0.24
Aboveground produce	Average out to 20 km	0.24
Beef ingestion	Average out to 20 km	0.01
Milk ingestion	Average out to 20 km	0.20
Chicken meat ingestion	Average out to 20 km	0.01
Egg ingestion	Average out to 20 km	0.01
Pork ingestion	Average out to 20 km	0.06
Fish ingestion	Each watershed	0.01

The typical farmer for this site was assumed to be a dairy farmer because the fraction of dairy produced and processed locally was higher than the fractions for the other commodities in the analysis. The typical dairy farmer was assumed to produce a fraction of the dairy, vegetables, and fruits he consumed and to purchase all other dietary items from the local market. The fractions contaminated for each pathway were determined by adding the fraction contaminated in the local market to the fraction that the farmer home-raised and consumed from the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.43 by adding the homegrown fraction of 0.25 to 24 percent of the remaining 0.75 purchased from local markets. Both the items raised on the typical farm and the items purchased from local markets had typical levels of contamination. The typical dairy farmer's exposures from direct inhalation and soil ingestion were estimated to be at levels derived from averages of air dispersion and deposition outputs to 20 kilometers. Because the water supplied to the area surrounding Case B came from sources other than surface waterbodies, the typical farmer did not drink contaminated water. Table A-2.12 lists the locations of contamination and the contaminated fraction by pathway for the typical farmer scenario.

Table A-2.12. Exposure Scenario for Typical Farmer, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Average to 20 km	1.0	
Soil ingestion	Average to 20 km	1.0	
		Central tendency	**High-end**
Belowground vegetables	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.43	0.40 Typical farmer + 0.60 x Local market = 0.54
Aboveground produce	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.43	0.40 Typical farmer + 0.60 x Local market = 0.54
Beef ingestion	Average to 20 km	0.01	0.01
Milk ingestion	Average to 20 km	0.4 Typical farmer + 0.60 x Local market = 0.52	0.75 Typical farmer + 0.25 x Local market = 0.80
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.06	0.06
Fish ingestion	Each watershed	0.01	0.01

Recreational fishers were modeled for each waterbody by combining the typical resident scenario with an increased consumption of contaminated fish recreationally caught (30 g/d). The recreational fisher's exposures from direct inhalation and soil ingestion were derived from averages of air dispersion and deposition output to 20 kilometers. All fish in the diet was assumed to be from a single waterbody. For instance, the recreational fisher identified for the Lake Marion only ate fish caught in Lake Marion. All other dietary items were assumed purchased from the local market and to contain typical levels of contamination. Because the water supplied to the area surrounding Case B came from sources other than surface waterbodies, the recreational fishers did not drink contaminated water. Table A-2.13 lists the location of contamination and the contaminated fraction by pathway for the recreational fisher scenario.

Table A-2.13. Exposure Scenario for Recreational Fisher, Case B

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average to 20 km	1.0
Soil ingestion	Average to 20 km	1.0
Belowground vegetables	Average to 20 km	0.24
Aboveground produce	Average to 20 km	0.24
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.20
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.06
Fish ingestion (30 g/d)	Each watershed	1.0

D. Air Modeling and Air Modeling Results

A test version of ISCSTDFT was the air dispersion and deposition model used to estimate air concentrations and deposition rates for Case B. Source inputs used in the modeling are listed in Table A-2.1. The meteorologic data required for the air modeling were created using PCRAMMET, DEPMET, and PMERGE preprocessors. Table A-2.14 lists site-specific data needed for the DEPMET preprocessor. The actual anemometer height was used as a DEPMET input. For the other inputs, recommendations from the DEPMET User's Guide (U.S. EPA, 1994) based on the site-specific land use data were used. Land use information for Case B was obtained from telephone surveys and assessed through topographic maps.

The ISCSTDFT model was run using 5 years of meteorological data concatenated into a multiple-year meteorological file (U. S. EPA 1995b). Therefore, results of the ISCSTDFT modeling conducted with this multiple-year meteorological file represent a 5 year average.

The ISCSTDFT model was run using the "default" model options. The terrain option was not used because this site is an area of flat terrain, and the effects of terrain on air dispersion would not be significant for this site. Additionally, downwash was not used in the air dispersion modeling for Case B because site-specific information indicated that building downwash was not expected to occur.

The point of maximum combined deposition and the point of maximum vapor air concentration were used for "bounding" estimates. For a given scenario, the point of maximum concentration was used in calculating bounding risks for direct inhalation, while the maximum combined deposition or the point of maximum concentration was used in estimating risks for other pathways. However, bounding exposure was considered for only the pathways involved in the subsistence activities for a given scenario. For example, bounding exposure for the subsistence poultry farmer was due to ingestion of soil, produce, poultry, and eggs (based on the point of maximum deposition) and to direct inhalation (based on the point of maximum concentration). The other exposure routes -- ingestion of beef, pork, milk, fish, and drinking water -- were not bounding but were, instead, based on the location of the subsistence poultry farmer. For the subsistence fisher scenario, a default watershed, which lies at the high-end of the distribution of watersheds (Van der Leeden et al., 1990), was centered at the point of maximum combined deposition. Parameters for the bounding watershed are contained in the body of the document (Section II).

The ISCSTDFT air modeling results are presented in Figures A-2.1 through A-2.4. Figure A-2.1 shows the combined deposition of particles within 20 kilometers of Case B; Figure A-2.2 shows the air concentration of vapors within 20 kilometers of Case B; and Figures A-2.3 and 4 show the wet and dry deposition of particles, respectively, within 3 kilometers of Facility B. The results are also presented in tabular form in Table A-2.15.

Table A-2.14. Air Modeling Inputs Used in ISCSTDFT Modeling

Meteorologic Location	
Surface / upper air	Charleston, SC/ Charleston, SC
Anemometer height (m)	6.1
DEPMET Preprocessor Inputs	
Land use within 5 km	Forest
Min. M-O length (m)	50.
Roughness height (m)	0.3[a]
Displacement height (m)	1.5
Noontime albedo (fraction)	0.12
Soil moisture available (fraction)	0.9
Net radiation absorbed in ground (fraction)	0.15
Anthropogenic heat flux (W/m^2)	0.

[a] Based on a maximum roughness height of 1/20th of the anemometer height.

Table A-2.15. Results of ISCSTDFT Air Modeling for Case B[a]

Scenario	Location Distance (meters) /Direction	Particles				Vapors	
		Combined Deposition (g/m^2-yr)/(g/s)	Wet Deposition (g/m^2-yr)/(g/s)	Dry Deposition (g/m^2-yr)/(g/s)	Air Concentration (μg/m^3)/(g/s)	Wet Deposition (g/m^2-yr)/(g/s)	Air Concentration (μg/m^3)/(g/s)
Point of maximum combined deposition	100/SSW	0.50	0.50	0	0	0.68	0
Point of maximum vapor concentration	2000/NE	0.021	0.0070	0.014	0.035	0.011	0.038
Home gardener (closest resident)	200/S	0.16	0.16	0	0	0.22	0
General population	--	0.0038	0.0021	0.0017	0.0098	0.0051	0.0099
Subsistence farmer beef	5000/ENE	0.0068	0.0011	0.0057	0.022	0.0018	0.024
Subsistence farmer dairy	15000/W	0.00092	0.00026	0.00065	0.0048	0.00037	0.0053
Subsistence farmer poultry	3000/NE	0.016	0.0039	0.012	0.033	0.0060	0.034
Subsistence farmer pork	3000/NNE	0.017	0.0042	0.012	0.031	0.0064	0.035
Subsistence fisher - Huttos Lake	9000/SSW	0.0041	--	--	0.016	0.0019	0.018
Subsistence fisher - Lake Merkel	17000/SE	0.00099	--	--	0.0054	0.00015	0.0059
Subsistence fisher - Lake Marion	7000/NE	0.0070	--	--	0.023	0.0019	0.026
		Averages over the Watershed			Averages over the Waterbody		
		Combined Deposition of Particles (g/m^2-yr)/(g/s)	Wet Deposition of Vapors (g/m^2-yr)/(g/s)	Air Concentration of Vapors (μg/m^3)/(g/s)	Combined Deposition of Particles (g/m^2-yr)/(g/s)	Wet Deposition of Vapors (g/m^2-yr)/(g/s)	Air Concentration of Vapors (μg/m^3)/(g/s)
Huttos Lake	--	0.0029	0.0014	0.015	0.0029	0.0014	0.015
Lake Merkel	--	0.0008	0.00016	0.0056	0.00086	0.00017	0.0058
Lake Marion	--	0.00080	0.00017	0.0063	0.0011	0.00023	0.0081

[a] The air modeling results in the table are based on an emission rate of 1 g/s for each of the two stacks for Case B, for a total emission rate of 2 g/s.

Figure A-2.1 Combined deposition of particles within 20 kilometers of Facility B. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second from each stack.

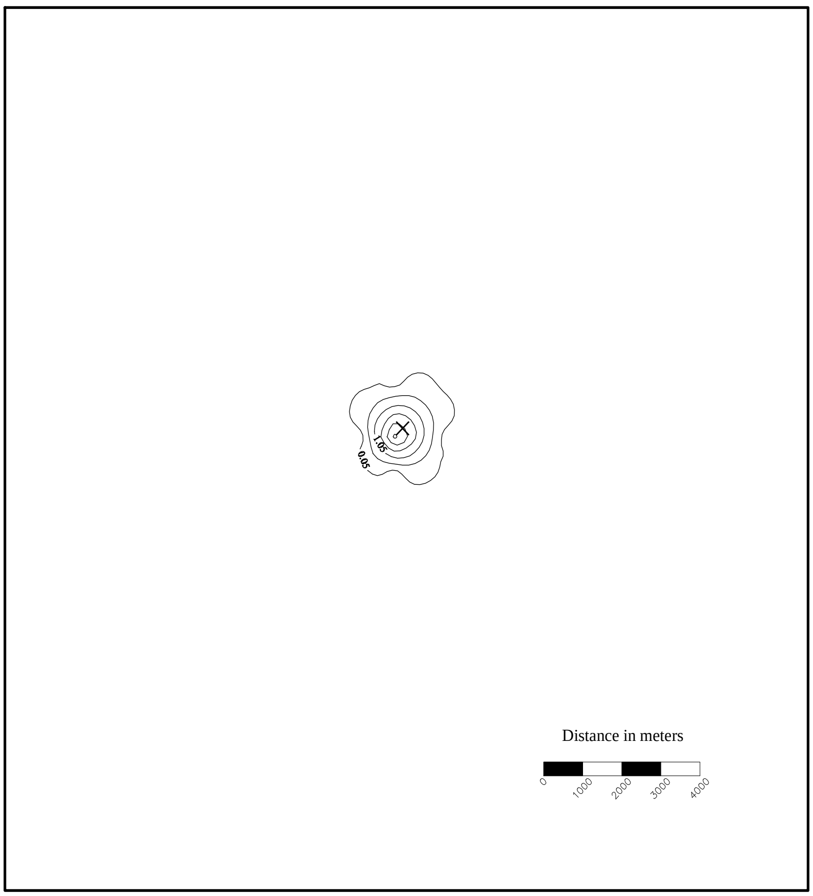


Figure A-2.2 Air concentration of vapors within 20 kilometers of Facility B. Air concentration in units of micrograms per cubic meter, resulting from a unit emission rate of 1 gram per second from each stack.

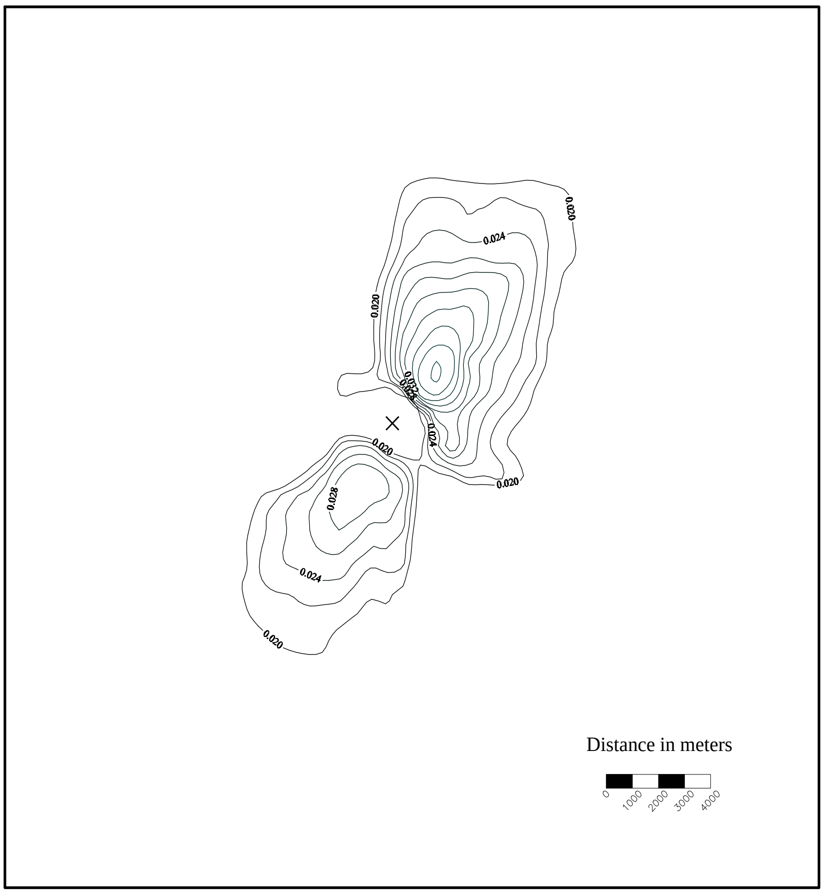


Figure A-2.3 Wet deposition of particles within 3 kilometers of Facility B. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second from each stack.

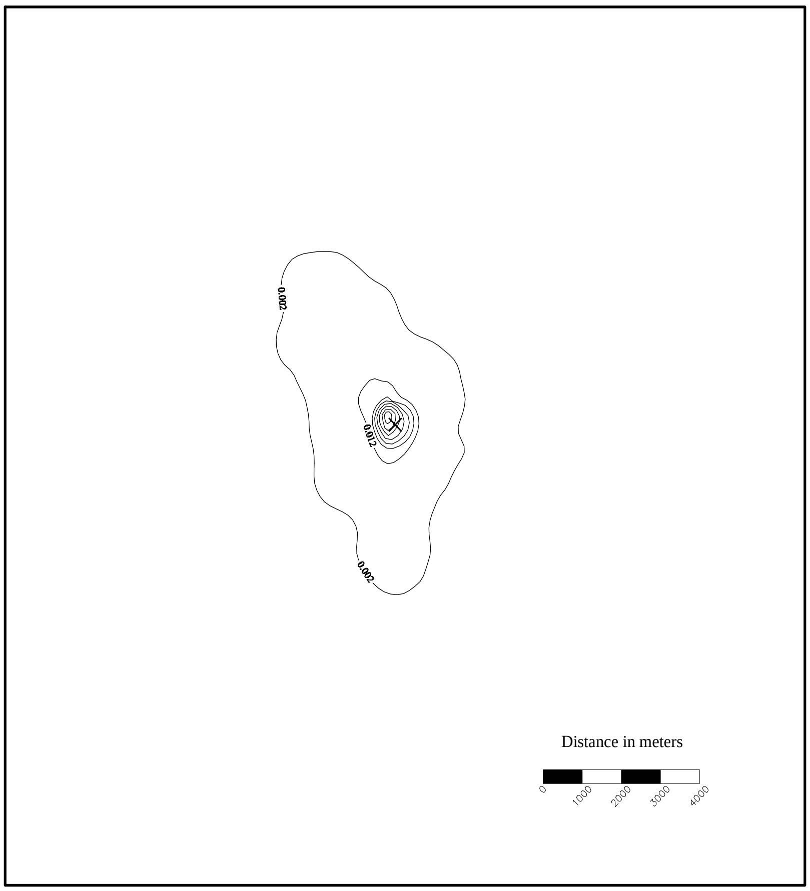
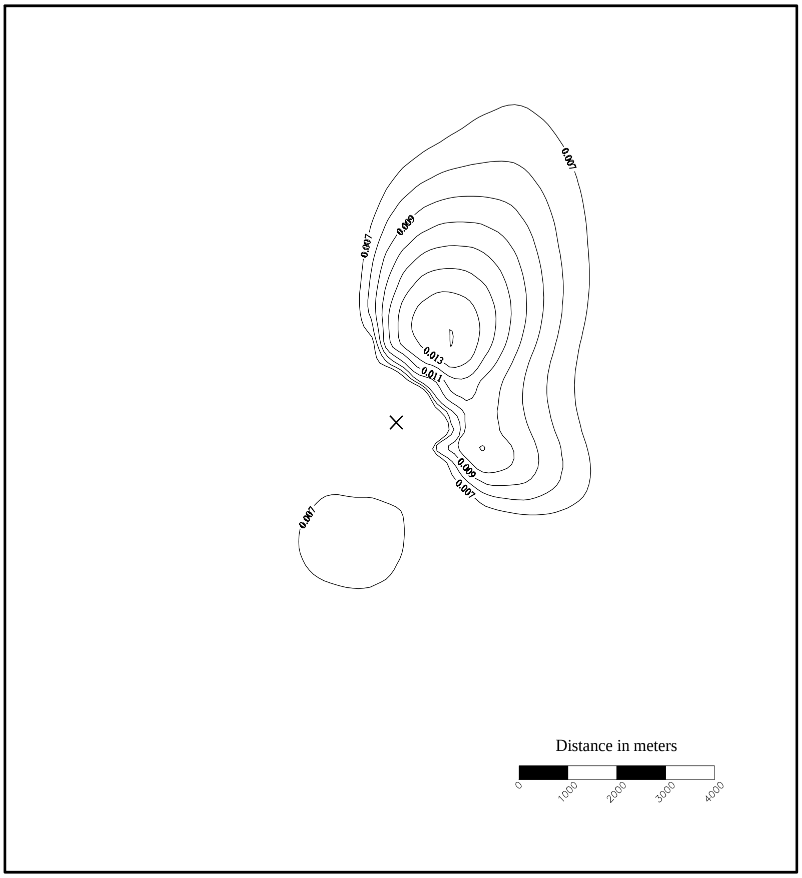


Figure A-2.4 Dry deposition of particles within 3 kilometers of Facility B. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second from each stack.



3. Case C

A. Source Characterization

Case C is one of five cement kilns selected for this analysis. Facility and source parameters used in the air dispersion modeling and risk assessment of this site are presented in Table A-3.1. Values listed in the table were obtained from facility-specific information provided by EPA.

Table A-3.1. Facility and Source Parameters for Case C

Parameter	Case C
Facility type	Cement kiln
Land use w/in 5 km	Agricultural
Terrain use	Yes
Operating hours (8,760/yr possible)	7,972
Stack parameters	Stack 1
Stack height (m)	68.3
Diameter (m)	3.7
Total flow rate (dscfm) / (dscms)	124,000 / 58.5
Exit velocity (m/s)	22.2
Exit temperature (K)	366.5

B. Setting Characterization

Case C is located in the north-central United States in an area of rolling terrain. Land use surrounding the site is agricultural and residential.

The National Weather Service Station at Indianapolis, Indiana, provided the most appropriate meteorologic data for Case C. Upper air data from Dayton, Ohio, were paired with the surface data for air dispersion modeling. Five years of meteorologic data, for the years 1986 to 1990, were used to determine long-term average air dispersion and deposition estimates. Table A-3.2 lists the annual average meteorologic parameters, which were obtained from the International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992). Also listed in Table A-3.2 are the average evapotranspiration rate and annual runoff. These values were used with the precipitation rate to calculate a water balance for Case C. One-half of the average annual runoff value cited in the *Water Atlas*, (Geraghty et al., 1973) was used in the analysis. The adjustment was made to account for surface runoff only, and not the subsurface inflows to surface waters. The evapotranspiration rate was calculated by assuming 70 percent of the precipitation evaporated.

Table A-3.2. Annual Average Meteorologic Parameters for Case C

Ave. annual evapotranspiration (cm/yr)	Ave. annual runoff [a] (cm/yr)	Ave. annual precipitation[b] (cm/yr)	Ambient air temperature[b] (K)	Mean annual windspeed[b] (m/s)
70.4	15.	100.5	284.7	4.63

[a] *Water Atlas* (Geraghty et al., 1973).
[b] International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992).

C. Characterization of Exposed Populations

Table A-3.3 presents the locations of exposed populations identified for Case C. Information regarding the location of the residence and farms likely to be most impacted by Case C was obtained through telephone interviews with local planning offices and local agricultural extension agents. The local officials were asked to identify farms near the facility where subsistence activities would be likely. Farms identified by local officials were assessed to determine which would be most impacted by the facility emissions, and the maximally impacted farms were assumed to represent the location of the subsistence farmers.

Table A-3.3. Location of Receptors Identified for Case C

Receptor	Location (Distance (km)/Direction)	Source
Residence of home gardener	1 km northeast	County Official
Subsistence beef farm	3 km south-southeast	Agricultural Extension Agency
Subsistence dairy farm[a]	0.7 km west-southwest	Agricultural Extension Agency
Subsistence poultry farm[a]	0.7 km west-southwest	Agricultural Extension Agency
Subsistence pork farm	0.7 km west-southwest	Agricultural Extension Agency
Subsistence fisher location (inhalation and soil ingestion) Big Walnut Creek Cecil M. Harden Lake Deer Creek Glenn Flint Lake	 1.4 km northwest 15 km north-northwest 3 km east 10 north-northwest	Location of maximum air concentration of vapors within the watershed
Waterbody identified as surface drinking water source	None	City Water Works

[a] Default assumption based on location of subsistence pork farmer.

The waterbodies were selected from USGS topographical maps as those that would be large enough to support fish yet would reflect the highest impact from the facility. Phone calls to local officials verified that individuals might consume fish caught in the selected waterbodies. The topographic maps were also used to identify the watersheds associated with each waterbody and to estimate waterbody and watershed surface areas. Table A-3.4 lists the surface areas and other surface water parameters for Case C. References for the surface water parameters are also listed in the table.

The fraction of food contaminated was varied depending on the scenario. In this analysis, the fraction contaminated is defined as the fraction of what is consumed that is contaminated by facility emissions. The fraction contaminated is independent of the level of contamination, which is dependent upon the production location. Contamination levels calculated for a subsistence farm located near the facility would be higher than those calculated for the typical farm (air concentrations and deposition rates averaged to 20 kilometers). The terms "subsistence level of contamination" and "typical level of contamination" are used to reflect the different levels.

Central tendency and high-end contaminated fractions were developed based on an economic analysis of regional production and processing capacity and the fraction home-produced recommendations from the *Exposure Factors Handbook* (U.S. EPA, 1990). The fractions were developed using data from counties within 50 kilometers of the site. The economic analysis is discussed in detail in Section II.E.2 of the main report. The commodity with the highest fraction locally produced was assumed to be the commodity produced by the typical farmer. Local agricultural production indicated that the typical farmer for Case C was a pork farmer. The fractions assumed to be locally produced and processed for Case C are as follows:

Beef	0.01	Pork	1.00
Dairy	0.14	Poultry	0.01
Produce	0.02	Eggs	0.01
Fish	0.01		

The subsistence farmers considered for Case C were beef, dairy, poultry, and pork farmers. The locations of the subsistence farmers, listed in Table A-3.3, were used for estimating exposures from direct inhalation and soil ingestion. The fraction contaminated is assumed to be 1 for the livestock the subsistence farmer is identified as producing. He was also assumed to grow all the fruits and vegetables he consumed. For example, the subsistence beef farmer was assumed to produce all the beef, vegetables, and fruits that he ingested and to purchase all other dietary items -- such as milk, pork, fish, etc. -- from local markets. The items raised on the subsistence farms had higher levels of contamination than what was available in the local market. The local items purchased in the market were contaminated at levels that reflected the average impact from the stack out to 20 kilometers from the facility. Because the water supplied to the area surrounding Case C came from sources other than surface waterbodies, the subsistence farmers did not drink contaminated water. Tables A-3.5 through A-3.8 list the locations of contamination and the contaminated fraction by pathway for the subsistence farmer scenarios.

Table A-3.4. Surface Water Parameters for Case C

Waterbody	Surface Area (m^2)[a]	Watershed Area (m^2) [a]	Impervious Watershed Area (m^2) [b]	Average Volumetric Flow Rate (m^3/yr) [c]	Current Velocity (m/s) [d]	Depth of Water Column (m) [e]	USLE Rainfall/ Erosivity Factor [f]
Big Walnut Creek	1.8E+06	3.2E+08	1.6E+06	3.2E+08	0.39	1.2	185
Cecil M. Harden Lake	7.1E+06	1.0E+08	5.0E+05	3.0E+07	NA	18	185
Deer Creek	7.3E+05	1.8E+08	8.9E+05	5.3E+07	0.1	1.0	185
Glenn Flint Lake	1.2E+06	1.8E+07	9.4E+04	5.5E+06	NA	19.8	185

[a] Surface areas for the watersheds and waterbodies were determined from the USGS 1.25 000-scale Topographic 7.5 min X 15 min quadrangles.

[b] Impervious watershed areas were estimated from USGS quadrangles, site-specific land use, and a study of percent imperviousness for different land uses conducted by Camp, Dresser, and McKee (1989).

[c] Volumetric flow rate for the Big Walnut Creek form the REACH (U.S. EPA, 1995a) database. Volumetric flow rates for the other waterbodies were calculated from the watershed area and average annual surface runoff.

[d] Current velocity for the Big Walnut Creek from the REACH database (U.S. EPA, 1995a). Default velocity of 0.1 m/s was assumed for Deer Creek. Current velocities for lakes were not required and are listed as Not Applicable (NA).

[e] Depths for Glenn Flint Lake and Harden Lakes were obtained from the Indiana Division of Water. Depths for the Big Walnut Creek and Deer Creek were calculated from the volumetric flow rates and the cross-sectional areas.

[f] USLE Erosivity/Rainfall Factor was obtained from Edwards (1993) and was used in the universal soil loss equation (USLE).

Table A-3.5. Exposure Scenario for Subsistence Beef Farmer, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence beef farm (3 km south-southeast)	1.0
Soil ingestion	Location of subsistence beef farm (3 km south-southeast)	1.0
Belowground vegetables	Location of subsistence beef farm (3 km south-southeast)	1.0
Aboveground produce	Location of subsistence beef farm (3 km south-southeast)	1.0
Beef ingestion	Location of subsistence beef farm (3 km south-southeast)	1.0
Milk ingestion	Average to 20 km	0.14
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	1.0
Fish ingestion	Each watershed	0.01

Table A-3.6. Exposure Scenario for Subsistence Dairy Farmer and Child, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Soil ingestion	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Belowground vegetables	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Aboveground produce	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	1.0
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence pork farmer.

Table A-3.7. Exposure Scenario for Subsistence Pork Farmer, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (0.7 km west-southwest)	1.0
Soil ingestion	Location of subsistence dairy farm (0.7 km west-southwest)	1.0
Belowground vegetables	Location of subsistence dairy farm (0.7 km west-southwest)	1.0
Aboveground produce	Location of subsistence dairy farm (0.7 km west-southwest)	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.14
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Location of subsistence dairy farm (0.7 km west-southwest)	1.0
Fish ingestion	Each watershed	0.01

Table A-3.8. Exposure Scenario for Subsistence Poultry Farmer, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Soil ingestion	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Belowground vegetables	Location of subsistence dairy farm (0.7 km West-Southwest)[a]	1.0
Aboveground produce	Location of subsistence dairy farm (0.7 km West-Southwest)[a]	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.14
Chicken meat ingestion	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Egg ingestion	Location of subsistence dairy farm (0.7 km west-southwest)[a]	1.0
Pork ingestion	Average to 20 km	1.0
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence pork farmer.

A subsistence fisher was modeled for each watershed. The fish consumption rate for the subsistence fisher was 60 g/d, rather than the 1.64-g/d rate of the general population. The locations of the residences of the subsistence fishers were assumed to be the site of highest vapor air concentration within the affected watershed. The residence location was used for estimating exposures from direct inhalation and soil ingestion. All fish in the diet was assumed to be from the watershed where the subsistence fisher resided. All other dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. Because the water supplied to the area surrounding Case C came from sources other than surface waterbodies, the subsistence fishers did not drink contaminated water. Table A-3.9 lists the locations of contamination and the contaminated fraction by pathway for the subsistence fisher scenario.

Table A-3.9. Exposure Scenario for Subsistence Fisher, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of maximum vapor air concentration in each watershed	1.0
Soil ingestion	Location of maximum vapor air concentration in each watershed	1.0
Belowground vegetables	Average to 20 km	0.02
Aboveground produce	Average to 20 km	0.02
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.14
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	1.0
Fish ingestion (60 g/d)	Each watershed	1.0

The location of the home gardener and child was derived from the locations of the closest actual residences to the facility. This residential location was used to estimate exposures from direct inhalation and soil ingestion. The fractions contaminated for the aboveground produce and belowground vegetables were determined by adding the fraction contaminated in the local market to the fraction that the gardener home-raised and consumed, as cited in the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.27 by adding the homegrown fraction of 0.25 to 2 percent of the remaining 0.75 purchased from local markets. All other dietary items were assumed to be purchased from local markets and to contain typical levels of contamination derived from average air dispersion and deposition estimates to 20 kilometers from the facility. Because the water supplied to the area surrounding Case C came from sources other than surface waterbodies, the home gardener did not drink contaminated water. Table A-3.10 lists the locations of contamination and the contaminated fraction by pathway for the home gardener scenarios.

Table A-3.10. Exposure Scenario for Home Gardener and Child, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Location of closest residence (1 km northeast)	1.0	
Soil ingestion	Location of closest residence (1 km northeast)	1.0	
		Central tendency	**High-end**
Belowground vegetables	Location of closest residence (1 km northeast)	0.25 Typical farmer + 0.75 x Local market = 0.27	0.40 Typical farmer + 0.60 x Local market = 0.41
Aboveground produce	Location of closest residence (1 km northeast)	0.25 Typical farmer + 0.75 x Local market = 0.27	0.40 Typical farmer + 0.60 x Local market = 0.41
Beef ingestion	Average to 20 km	0.01	0.01
Milk ingestion	Average to 20 km	0.14	0.14
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	1.0	1.0
Fish ingestion	Each watershed	0.01	0.01

The typical adult resident and child exposures were based on averages of air concentrations and deposition rates out to 20 km. The averages were used for estimating exposures from direct inhalation and soil ingestion. All dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. Because the surface water supplied to the area surrounding Case C came from sources other than the selected waterbodies, the typical resident did not drink contaminated water. Table A-3.11 lists the locations of contamination and the contaminated fraction by pathway for the typical resident scenarios.

Table A-3.11. Exposure Scenario for Typical Adult Resident and Child, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average out to 20 km	1.0
Soil ingestion	Average out to 20 km	1.0
Belowground vegetables	Average out to 20 km	0.02
Aboveground produce	Average out to 20 km	0.02
Beef ingestion	Average out to 20 km	0.01
Milk ingestion	Average out to 20 km	0.14
Chicken meat ingestion	Average out to 20 km	0.01
Egg ingestion	Average out to 20 km	0.01
Pork ingestion	Average out to 20 km	1.0
Fish ingestion	Each watershed	0.01

The typical farmer for this site was assumed to be a pork farmer because the fraction of pork produced and processed locally was higher than the fractions for the other commodities in the analysis. The typical pork farmer was assumed to produce a fraction of the pork, vegetables, and fruits he consumed and to purchase all other dietary items from the local market. The fractions contaminated for each pathway were determined by adding the fraction contaminated in the local market to the fraction that the farmer home-raised and consumed (fractions from the *Exposure Factors Handbook* [U.S. EPA, 1990]). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.27 by adding the homegrown fraction of 0.25 to 2 percent of the remaining 0.75 purchased from local markets. Both the items raised on the typical farm and the items purchased from local markets had typical levels of contamination. The typical pork farmer's exposures from direct inhalation and soil ingestion were estimated to be at levels derived from averages of air dispersion and deposition outputs to 20 kilometers. Because the water supplied to the area surrounding Case C came from sources other than surface waterbodies, the typical farmer did not drink contaminated water. Table A-3.12 lists the locations of contamination and the contaminated fraction by pathway for the typical farmer scenario.

Recreational fishers were modeled for each waterbody by combining the typical resident scenario with an increased consumption of contaminated fish recreationally caught (30 g/d). The recreational fisher's exposures from direct inhalation and soil ingestion were derived from averages of air dispersion and deposition output to 20 kilometers. All fish in the diet was assumed to be from a single waterbody. For instance, the recreational fisher identified for Deer Creek only ate fish caught in Deer Creek. All other dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. Because the water supplied to the area surrounding Case C came from sources other than surface waterbodies, the recreational fishers did not drink contaminated water. Table A-3.13 lists the location of contamination and the contaminated fraction by pathway for the recreational fisher scenario.

Table A-3.12. Exposure Scenario for Typical Farmer, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Average to 20 km	1.0	
Soil ingestion	Average to 20 km	1.0	
		Central tendency	**High-end**
Belowground vegetables	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.27	0.40 Typical farmer + 0.60 x Local market = 0.41
Aboveground produce	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.27	0.40 Typical farmer + 0.60 x Local market = 0.41
Beef ingestion	Average to 20 km	0.01	0.01
Milk ingestion	Average to 20 km	0.14	0.14
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.44 Typical farmer + 0.56 x Local market = 1.0	0.75 Typical farmer + 0.25 x Local market = 1.0
Fish ingestion	Each watershed	0.01	0.01

Table A-3.13. Exposure Scenario for Recreational Fisher, Case C

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average to 20 km	1.0
Soil ingestion	Average to 20 km	1.0
Belowground vegetables	Average to 20 km	0.02
Aboveground produce	Average to 20 km	0.02
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.14
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	1.0
Fish ingestion (30 g/d)	Each watershed	1.0

D. Air Modeling and Air Modeling Results

A test version of ISCSTDFT was the air dispersion and deposition model used to estimate air concentrations and deposition rates for Case C. Source inputs used in the modeling are listed in Table A-3.1. The meteorologic data required for the air modeling were created using PCRAMMET, DEPMET, and PMERGE preprocessors. Table A-3.14 lists site-specific data needed for the DEPMET preprocessor. The actual anemometer height was used as a DEPMET input. For the other inputs, recommendations from the DEPMET User's Guide (U.S. EPA, 1994) based on the site-specific land use data were used. Land use information for Case C was obtained from telephone surveys and assessed through topographic maps.

The ISCSTDFT model was run using 5 years of meteorological data concantenated into a multiple-year meteorological file (U.S. EPA, 1995b). Therefore, results of the ISCSTDFT modeling conducted with this multiple-year meteorological file represent a 5 year average.

The ISCSTDFT model was run using the "default" model options. The terrain option was used because this site is located in an area of rolling terrain, where the terrain may have an effect on the dispersion modeling results. Additionally, downwash was not used in the air dispersion modeling for Case C because site-specific information indicated that building downwash was not expected to occur.

Specific receptor locations evenly spaced every 1,000 meters were identified for each watershed and waterbody using USGS topographic maps. The 5 year averages of air dispersions and deposition rates were then areally averaged over each specific watershed and waterbody.

The point of maximum combined deposition and the point of maximum vapor air concentration were used for "bounding" estimates. For a given scenario, the point of maximum concentration was used in calculating bounding risks for direct inhalation, while the maximum combined deposition or maximum concentration was used in estimating risks for other pathways. However, bounding exposure was considered for only the pathways involved in the subsistence activities for a given scenario. For example, bounding exposure for the subsistence poultry farmer was due to ingestion of soil, produce, poultry, and eggs (based on the point of maximum deposition) and to direct inhalation (based on the point of maximum concentration). The other exposure routes -- ingestion of beef, pork, milk, fish, and drinking water -- were not bounding but were, instead, based on the location of the subsistence poultry farmer. For the subsistence fisher scenario, a default watershed, which lies at the high end of the distribution of watersheds (Van der Leeden et al., 1990), was centered at the point of maximum combined deposition. Parameters for the bounding watershed are contained in the body of the document (Section II).

The ISCSTDFT air modeling results are presented in Figures A-3.1 through A-3.4. Figure A-3.1 shows the combined deposition of particles within 20 kilometers of Case C; Figure A-3.2 shows the air concentration of vapors within 20 kilometers of Case C; and Figures A-3.3 and 4 show the wet and dry deposition of particles, respectively, within 3 kilometers of Facility C. The results are also presented in tabular form in Table A-3.15.

Table A-3.14. Air Modeling Inputs Used in ISCSTDFT Modeling

Meteorologic Location	
Surface / upper air	Indianapolis, IN/ Dayton, OH
Anemometer height (m)	6.1
DEPMET Preprocessor Inputs	
Land use within 5 km	Agricultural
Min. M-O length (m)	2.0
Roughness height (m)	0.2
Displacement height (m)	1.0
Noontime albedo (fraction)	0.20
Soil moisture available (fraction)	0.5
Net radiation absorbed in ground (fraction)	0.15
Anthropogenic heat flux (W/m^2)	0.0

Table A-3.15. Results of ISCSTDFT Air Modeling for Case C[a]

Scenario	Location Distance (meters)/ Direction	Particles				Vapors	
		Combined Deposition (g/m²-yr)/(g/s)	Wet Deposition (g/m²-yr)/(g/s)	Dry Deposition (g/m²-yr)/(g/s)	Air Concentration (µg/m³)/(g/s)	Wet Deposition (g/m²-yr)/(g/s)	Air Concentration (µg/m³)/(g/s)
Point of maximum combined deposition	100/NE	0.16	0.16	0	0	0.22	0
Point of maximum vapor concentration	1500/NE	0.012	0.0069	0.0054	0.0181	0.011	0.019
Home gardener (closest resident)	1000/NE	0.015	0.012	0.0038	0.0126	0.017	0.013
General population	--	7.9E-04	2.9E-04	5.0E-04	0.00286	4.6E-4	0.0030
Subsistence farmer - beef	3000/SSE	0.056	0.0020	0.0035	0.0051	0.0031	0.012
Subsistence farmer - dairy/ poultry/ pork	700/WSW	0.012	0.012	3.6E-5	0.00035	0.018	0.00035
Subsistence fisher - Cecil Harden Lake	15000/NNW	0.00063	--	--	0.0031	3.7E-04	0.0032
Subsistence fisher - Glen Flint Lake	10000/NNW	0.0011	--	--	0.0039	9.6E-04	0.0040
Subsistence fisher - Deer Creek	3000/E	0.0021	--	--	0.0072	0.0010	0.0077
Subsistence fisher - Big Walnut Creek	1400/NW	0.0065	--	--	0.011	0.0055	0.012
		Averages over Watershed			Averages over Waterbody		
		Combined Deposition of Particles (g/m²-yr)/(g/s)	Wet Deposition of Vapors (g/m²-yr)/(g/s)	Air Concentration of Vapors (µg/m³)/(g/s)	Combined Deposition of Particles (g/m²-yr)/(g/s)	Wet Deposition of Vapors (g/m²-yr)/(g/s)	Air Concentration of Vapors (µg/m³)/(g/s)
Cecil Harden Lake	--	3.5E-04	1.9E-04	0.0022	3.3E-04	1.9E-04	0.0022
Glen Flint Lake	--	6.8E-04	4.8E-04	0.0031	7.0E-04	5.1E-04	0.0031
Deer Creek	--	0.0012	5.5E-04	0.0038	0.0013	5.5E-04	0.0042
Big Walnut Creek	--	0.0013	8.9E-04	0.0041	0.0012	8.0E-04	0.0039

[a] The air modeling results in the table are based on an emission rate of 1 g/s for the stack.

Figure A-3.1 Combined deposition of particles within 20 kilometers of Facility C. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

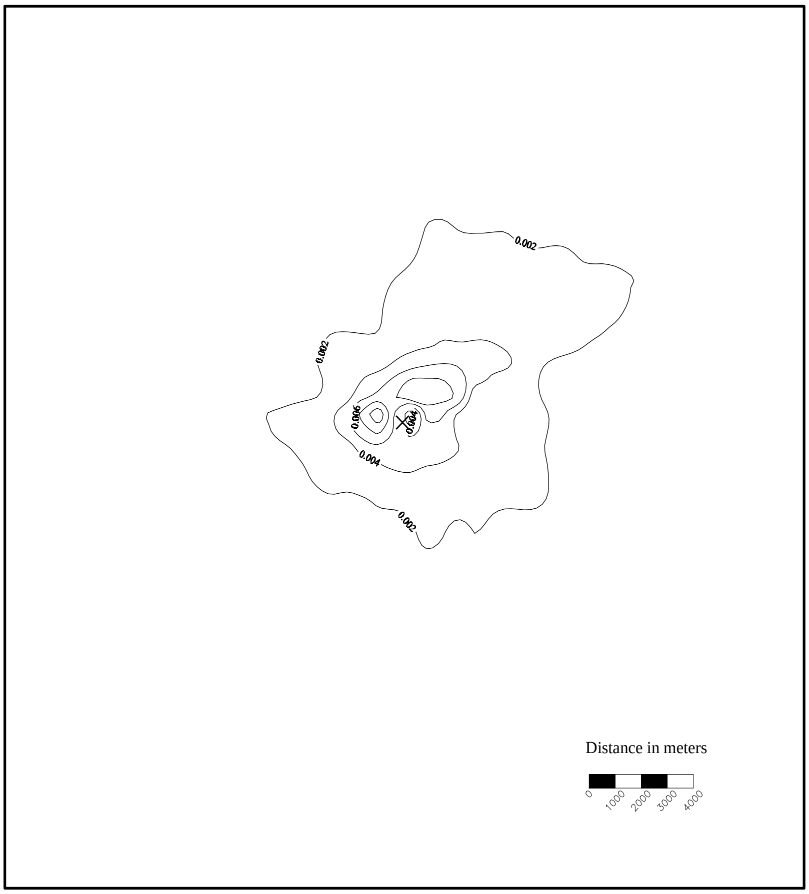


Figure A-3.2 Air concentration of vapors within 20 kilometers of Facility C. Air concentration in units of micrograms per cubic meter, resulting from a unit emission rate of 1 gram per second.

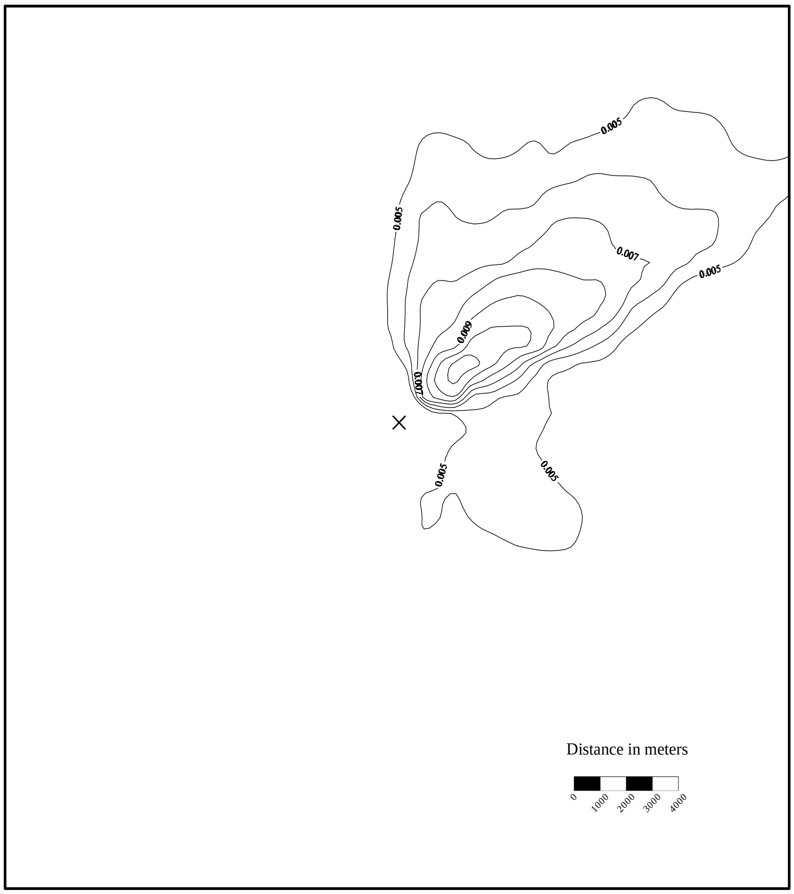


Figure A-3.3 Wet deposition of particles within 3 kilometers of Facility C. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

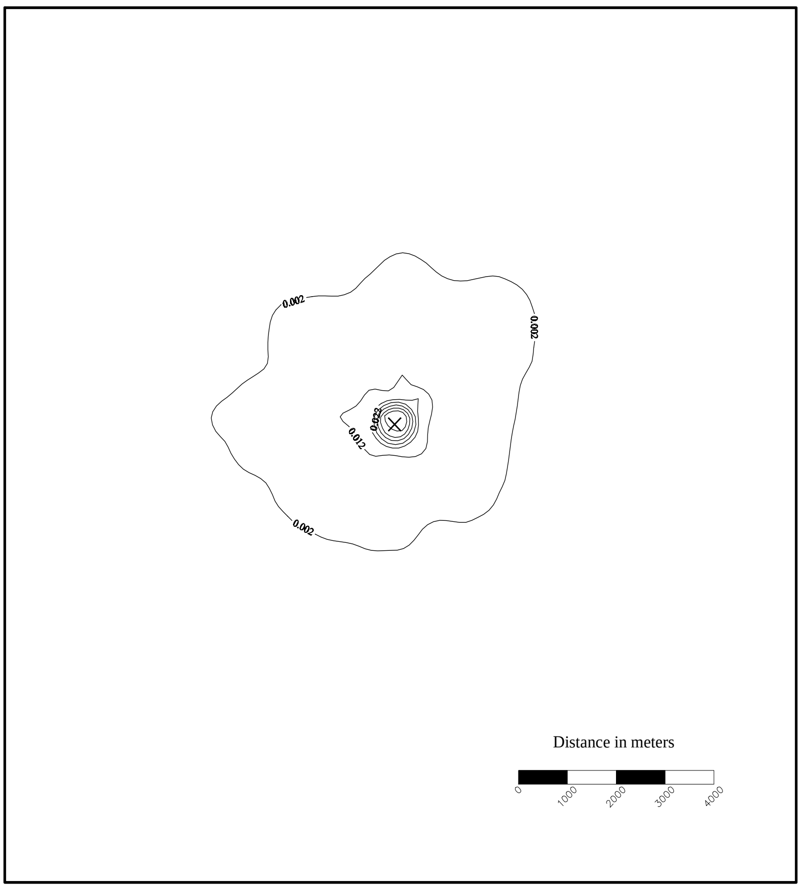
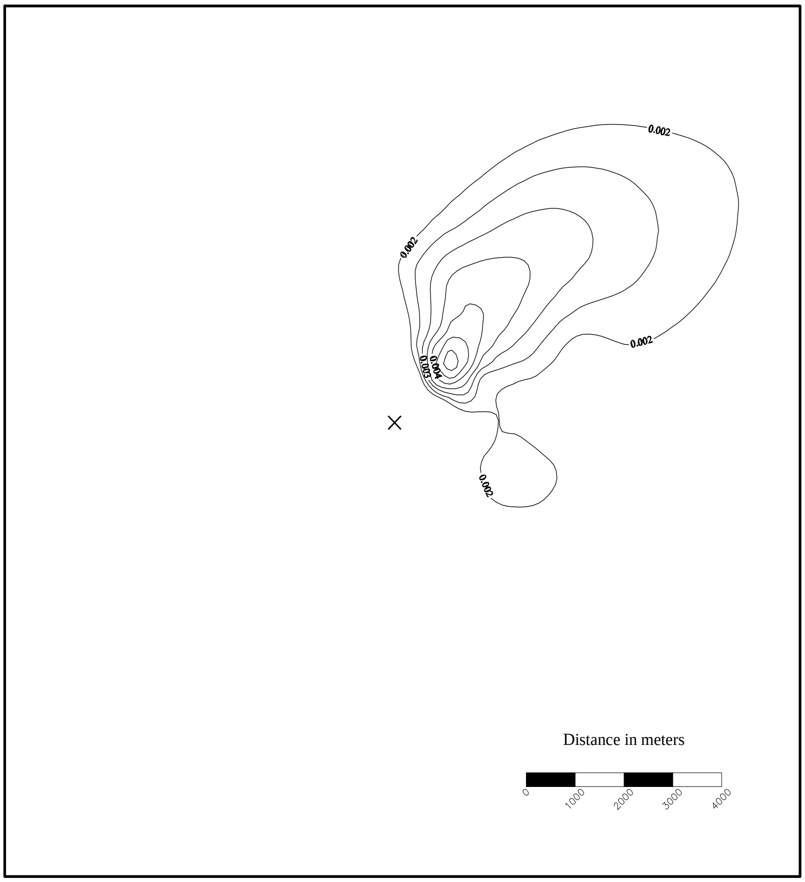


Figure A-3.4 Dry deposition of particles within 3 kilometers of Facility C. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.



4. Case D

A. Source Characterization

Case D is one of five cement kilns selected for this analysis. Facility and source parameters used in the air dispersion modeling and risk assessment of this site are presented in Table A-4.1. Values listed in the table were obtained from facility-specific information provided by EPA.

Table A-4.1. Facility and Source Parameters for Case D

Parameter	Case D
Facility type	Cement kiln
Land use w/in 5 km	Agricultural
Terrain use	Yes
Operating hours (8,760/yr possible)	7,603
Stack parameters	Stack 1
Stack height (m)	90.8
Diameter (m)	3.7
Total flow rate (dscfm) / (dscms)	166,100 / 78.4
Exit velocity (m/s)	11.3
Exit temperature (K)	502

B. Setting Characterization

Case D is located in the central United States in an area of rolling terrain. Land use surrounding the site is agricultural.

The National Weather Service Station at Springfield, Missouri, provided the most appropriate meteorologic data for Case D. Upper air data from Monnet, Missouri, were paired with the surface data for air dispersion modeling. Five years of meteorologic data, for the years 1985 and 1987-1990, were used to determine long-term average air dispersion and deposition estimates. Table A-4.2 lists the annual average meteorologic parameters, which were obtained from the International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992). Also listed in Table A-4.2 are the average evapotranspiration rate and annual runoff. These values were used with the precipitation rate to calculate a water balance for Case D. One-half of the average annual runoff value cited in the *Water Atlas* (Geraghty et al., 1973) was used in the analysis. The adjustment was made to account for surface runoff only, and not the subsurface inflows to surface waters. The evapotranspiration rate was calculated by assuming 70 percent of the precipitation evaporates.

Table A-4.2. Annual Average Meteorologic Parameters for Case D

Ave. annual evapotranspiration[a] (cm/yr)	Ave. annual runoff[a] (cm/yr)	Ave. annual precipitation[b] (cm/yr)	Ambient air temperature[b] (K)	Mean annual windspeed[b] (m/s)
73.5	9.4	105.	286	5.14

[a] *Water Atlas* (Geraghty et al., 1973).
[b] International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992).

C. Characterization of Exposed Populations

Table A-4.3 presents the locations of exposed populations identified for Case D. Information regarding the location of the residence and farms likely to be most impacted by Case D was obtained through telephone interviews with local planning offices and local agricultural extension agents. The local officials were asked to identify farms near the facility where subsistence activities would be likely. Farms identified by local officials were assessed to determine which would be most impacted by the facility emissions, and the maximally impacted farms were assumed to represent the location of the subsistence farmers.

Table A-4.3 Location of Receptors Identified for Case D

Receptor	Location (Distance (km)/Direction)	Source
Residence of home gardener	3 km northeast	City Mapping Department
Subsistence beef farm	0.7 km north	City Mapping Department
Subsistence dairy farm	0.7 km north[a]	City Mapping Department
Subsistence poultry farm	0.7 km north[a]	City Mapping Department
Subsistence pork farm	0.7 km north[a]	City Mapping Department
Subsistence fisher location (inhalation and soil ingestion) Allen Lake Neosho River Sante Fe Lake	 3 km north-northeast 3 km south-southwest 6 km north-northwest	Location of maximum air concentration of vapors within the watershed
Waterbody identified as surface drinking water source	Neosho River	City Mapping Department

[a] Default assumption based upon location of subsistence beef farmer.

The waterbodies were selected from USGS topographical maps as those that would be large enough to support fish yet would reflect the highest impact from the facility. Phone calls to local officials verified that individuals might consume fish caught in the selected waterbodies. The topographic maps were also used to identify the watersheds associated with each waterbody and to estimate waterbody and watershed surface areas. Table A-4.4 lists the surface areas and other surface water parameters for Case D. References for the surface water parameters are also listed in the table.

The fraction of food contaminated was varied depending on the scenario. In this analysis, the fraction contaminated is defined as the fraction of what is consumed that is contaminated by facility emissions. The fraction contaminated is independent of the level of contamination, which is dependent upon the production location. Contamination levels calculated for a subsistence farm located near the facility would be higher than those calculated for the typical farm (air concentrations and deposition rates averaged to 20 kilometers). The terms "subsistence level of contamination" and "typical level of contamination" are used to reflect the different levels.

Central tendency and high-end contaminated fractions were developed based on an economic analysis of regional production and processing capacity and the fraction home-produced recommendations from the *Exposure Factors Handbook* (U.S. EPA, 1990). The fractions were developed using data from counties within 50 kilometers of the site. The economic analysis is discussed in detail in Section II.E.1. The commodity with the highest fraction locally produced was assumed to be the commodity produced by the typical farmer. Local agricultural production indicated that the typical farmer for Case D was a beef farmer. The fractions assumed to be locally produced and processed for Case D are as follows:

Beef	0.01	Pork	0.01
Dairy	0.01	Poultry	0.01
Produce	0.01	Eggs	0.01
Fish	0.01		

The subsistence farmers considered for Case D were beef, dairy, poultry, and pork farmers. The locations of the subsistence farmers, listed in Table A-4.3, were used for estimating exposures from direct inhalation and soil ingestion. The fraction contaminated is assumed to be 1 for the livestock the subsistence farmer is identified as producing. He was also assumed to grow all the fruits and vegetables he consumed. For example, the subsistence beef farmer was assumed to produce all the beef, vegetables, and fruits that he ingested and to purchase all other dietary items -- such as milk, pork, fish, etc. -- from local markets. The items raised on the subsistence farms had higher levels of contamination than what was available in the local market. The local items purchased in the market were contaminated at levels that reflected the average impact from the stack out to 20 kilometers from the facility. Subsistence farmers consuming fish from the Neosho River were also assumed to drink contaminated water from the Neosho River. Tables A-4.5 through A-4.8 list the locations of contamination and the contaminated fraction by pathway for the subsistence farmer scenarios.

Table A-4.4 Surface Water Parameters for Case D

Waterbody	Surface Area (m^2)[a]	Watershed Area (m^2)[a]	Impervious Watershed Area (m^2)[b]	Average Volumetric Flow Rate (m^3/yr)[c]	Current Velocity (m/s)[d]	Depth of Water Column (m)[e]	USLE Rainfall/ Erosivity Factor[f]
Allen Lake	2.5E+05	2.6E+06	1.3E+04	5.4E+05	NA	4	244
Neosho River	2.2E+06	5.0E+08	2.5E+06	5.5E+08	0.5	2.2	244
Sante Fe Lake	3.2E+05	1.4E+07	8.4E+05	3.0E+06	NA	1.9	244

[a] Surface areas for the watersheds and waterbodies were determined from the USGS 1.25 000-scale Topographic 7.5 min X 15 min quadrangles.

[b] Impervious watershed areas were estimated from USGS quadrangles, site-specific land use, and a study of percent imperviousness for different land uses conducted by Camp, Dresser, and McKee (1989).

[c] The volumetric flow rate for the Neosho river was obtained from the REACH (U.S. EPA, 1995a) database. Flow rates for the other waterbodies were calculated from the watershed area and average annual surface runoff.

[d] Current velocity for the Neosho river was obtained from the REACH (U.S. EPA, 1995a) database. Current velocities for lakes were not required and are listed as NA (Not Applicable).

[e] Depths of the waterbodies were obtained from local water authorities.

[f] USLE Erosivity/Rainfall Factor was obtained from Edwards (1993) and was used in the universal soil loss equation (USLE).

Table A-4.5 Exposure Scenario for Subsistence Beef Farmer, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence beef farm (0.7 km north)	1.0
Soil ingestion	Location of subsistence beef farm (0.7 km north)	1.0
Below ground vegetables	Location of subsistence beef farm (0.7 km north)	1.0
Above ground produce	Location of subsistence beef farm (0.7 km north)	1.0
Beef ingestion	Location of subsistence beef farm (0.7 km north)	1.0
Milk ingestion	Average to 20 km	0.01
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

Table A-4.6 Exposure Scenario for Subsistence Dairy Farmer and Child, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Soil ingestion	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Below ground vegetables	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Above ground produce	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

[a] Default assumption based upon location of subsistence beef farmer.

Table A-4.7 Exposure Scenario for Subsistence Pork Farmer, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence pork farm (0.7 km north)[a]	1.0
Soil ingestion	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Belowground vegetables	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Aboveground produce	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.01
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Location of subsistence dairy farm (0.7 km north)[a]	1.0
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence beef farmer.

Table A-4.8 Exposure Scenario for Subsistence Poultry Farmer, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence poultry farm (0.7 km north)[a]	1.0
Soil ingestion	Location of subsistence poultry farm (0.7 km north)[a]	1.0
Belowground vegetables	Location of subsistence poultry farm (0.7 km north)[a]	1.0
Aboveground produce	Location of subsistence poultry farm (0.7 km north)[a]	1.0
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.01
Chicken meat ingestion	Location of subsistence poultry farm (0.7 km north)[a]	1.0
Egg ingestion	Location of subsistence poultry farm (0.7 km north)[a]	1.0
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence beef farmer.

A subsistence fisher was modeled for each watershed. The fish consumption rate for the subsistence fisher was 60 g/d, rather than the 1.64-g/d rate of the general population. The locations of the residences of the subsistence fishers were assumed to be the site of highest vapor air concentration within the affected watershed. The residence location was used for estimating exposures from direct inhalation and soil ingestion. All fish in the diet was assumed to be from the watershed where the subsistence fisher resided. All other dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. The subsistence fisher residing in the Neosho River watershed and consuming fish from the river was also assumed to drink contaminated water from the Neosho River. Table A-4.9 lists the locations of contamination and the contaminated fraction by pathway for the subsistence fisher scenario.

Table A-4.9 Exposure Scenario for Subsistence Fisher, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of maximum vapor air concentration in each watershed	1.0
Soil ingestion	Location of maximum vapor air concentration in each watershed	1.0
Belowground vegetables	Average to 20 km	0.01
Aboveground produce	Average to 20 km	0.01
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.01
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion (60 g/d)	Each watershed	1.0

The location of the home gardener and child was derived from the location of the closest actual residence to the facility. This residential location was used to estimate exposures from direct inhalation and soil ingestion. The fractions contaminated for the aboveground produce and belowground vegetables were determined by adding the fraction contaminated in the local market to the fraction that the gardener home-raised and consumed, as cited in the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central-tendency contaminated fraction for belowground vegetables was calculated as 0.26 by adding the homegrown fraction of 0.25 to 1 percent of the remaining 0.75 purchased from local markets. All other dietary items were assumed to be purchased from local markets and to contain typical levels of contamination derived from average air dispersion and deposition estimates to 20 kilometers from the facility. The home gardener consuming fish from the Neosho River was also assumed to drink contaminated water from the Neosho River. Table A-4.10 lists the locations of contamination and the contaminated fraction by pathway for the home gardener scenarios.

Table A-4.10 Exposure Scenario for Home Gardener and Child, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Location of closest residence (3 km northeast)	1.0	
Soil ingestion	Location of closest residence (3 km northeast)	1.0	
		Central Tendency	**High End**
Belowground vegetables	Location of closest residence (3 km northeast)	0.25 Typical farmer + 0.75 x Local market = 0.26	0.40 Typical farmer + 0.60 x Local market = 0.41
Aboveground produce	Location of closest residence (3 km northeast)	0.25 Typical farmer + 0.75 x Local market = 0.26	0.40 Typical farmer + 0.60 x Local market = 0.41
Beef ingestion	Average to 20 km	0.01	0.01
Milk ingestion	Average to 20 km	0.01	0.01
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.01	0.01
Fish ingestion	Each watershed	0.01	0.01

The typical adult resident and child exposures were based on averages of air concentrations and deposition rates out to 20 km. The averages were used for estimating exposures from direct inhalation and soil ingestion. All dietary items were assumed purchased from the local market and to contain typical levels of contamination. The typical resident consuming fish from the Neosho River was also assumed to drink contaminated water from the Neosho River. Table A-4.11 lists the locations of contamination and the contaminated fraction by pathway for the typical resident scenarios.

Table A-4.11 Exposure Scenario for Typical Adult Resident and Child, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average out to 20 km	1.0
Soil ingestion	Average out to 20 km	1.0
Belowground vegetables	Average out to 20 km	0.01
Aboveground produce	Average out to 20 km	0.01
Beef ingestion	Average out to 20 km	0.01
Milk ingestion	Average out to 20 km	0.01
Chicken meat ingestion	Average out to 20 km	0.01
Egg ingestion	Average out to 20 km	0.01
Pork ingestion	Average out to 20 km	0.01
Fish ingestion	Each watershed	0.01

The typical farmer for this site was assumed to be a beef farmer because the fraction of beef locally produced and processed was higher than the fractions for the other commodities in the analysis. The typical beef farmer was assumed to produce a fraction of the beef, vegetables, and fruits he consumed and to purchase all other dietary items from the local market. The fractions contaminated for each pathway were determined by adding the fraction contaminated in the local market to the fraction that the farmer home-raised and consumed from the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central-tendency contaminated fraction for belowground vegetables was calculated as 0.26 by adding the homegrown fraction of 0.25 to 1 percent of the remaining 0.75 purchased from local markets. Both the items raised on the typical farm and the items purchased from local markets had typical levels of contamination. The typical beef farmer's exposures from direct inhalation and soil ingestion were estimated to be at levels derived from averages of air dispersion and deposition outputs to 20 kilometers. The typical farmer consuming fish from the Neosho River was also assumed to drink contaminated water from the Neosho River. Table A-4.12 lists the locations of contamination and the contaminated fraction by pathway for the typical farmer scenario.

Recreational fishers were modeled for each waterbody by combining the typical resident scenario with an increased consumption of contaminated fish recreationally caught (30 g/d). The recreational fisher's exposures from direct inhalation and soil ingestion were derived from averages of air dispersion and deposition output to 20 kilometers. All fish in the diet was assumed to be from a single waterbody. For instance, the recreational fisher identified for the Neosho River only ate fish caught in the Neosho River. All other dietary items were assumed purchased from the local market and to contain typical levels of contamination. The recreational fisher consuming fish from the Neosho River was also assumed to drink contaminated water from the Neosho River. Table A-4.13 lists the location of contamination and the contaminated fraction by pathway for the recreational fisher scenario.

Table A-4.12 Exposure Scenario for Typical Farmer, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Average to 20 km	1.0	
Soil ingestion	Average to 20 km	1.0	
		Central tendency	**High-end**
Belowground vegetables	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.26	0.40 Typical farmer + 0.60 x Local market = 0.41
Aboveground produce	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.26	0.40 Typical farmer + 0.60 x Local market = 0.41
Beef ingestion	Average to 20 km	0.44 Typical farmer + 0.56 x Local market = 0.45	0.75 Typical farmer + 0.25 x Local market = 0.75
Milk ingestion	Average to 20 km	0.01	0.01
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.01	0.01
Fish ingestion	Each watershed	0.01	0.01

Table A-4.13 Exposure Scenario for Recreational Fisher, Case D

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average to 20 km	1.0
Soil ingestion	Average to 20 km	1.0
Belowground vegetables	Average to 20 km	0.01
Aboveground produce	Average to 20 km	0.01
Beef ingestion	Average to 20 km	0.01
Milk ingestion	Average to 20 km	0.01
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion (30 g/d)	Each watershed	1.0

D. Air Modeling and Air Modeling Results

A test version of ISCSTDFT was the air dispersion and deposition model used to estimate air concentrations and deposition rates for Case D. Source inputs used in the modeling are listed in Table A-4.1. The meteorologic data required for the air modeling were created using PCRAMMET, DEPMET, and PMERGE preprocessors. Table A-4.14 lists site-specific data needed for the DEPMET preprocessor. The actual anemometer height was used as a DEPMET input. For the other inputs, recommendations from the DEPMET User's Guide (U.S. EPA, 1994) based on the site-specific land use data were used. Land use information for Case D was obtained from telephone surveys and assessed through topographic maps.

The ISCSTDFT model was run using 5 years of meteorological data concatenated into a multiple-year meteorological file (U.S. EPA, 1995b). Therefore, results of the ISCSTDFT modeling conducted with this multiple-year meteorological file represent a 5 year average.

The ISCSTDFT model was run using the "default" model options. The terrain option was used because this site is located in an area of rolling terrain, where the terrain may have an effect on the dispersion modeling results. Additionally, the good engineering practices (GEP) stack height was calculated using EPA's Building Profile Input Program (BPIP) to determine if building downwash should be considered for this site. Inputs to BPIP -- site-specific information on the building height, width, and location -- were available for several buildings having the potential to influence the plume dispersion from the stack. Based on this site-specific information, the actual stack height exceeded the GEP stack height as calculated by BPIP. Therefore, downwash was not used in the air dispersion modeling for Case D.

Specific receptor locations evenly spaced every 1,000 meters were identified for each watershed and waterbody using USGS topographic maps. The 5 year averages of air dispersions and deposition rates were then areally averaged over each specific watershed and waterbody.

The point of maximum combined deposition and the point of maximum vapor air concentration were used for "bounding" estimates. For a given scenario, the point of maximum concentration was used in calculating bounding risks for direct inhalation, while the maximum combined deposition or maximum air concentration was used in estimating risks for other pathways. However, bounding exposure was considered for only the pathways involved in the subsistence activities for a given scenario. For example, bounding exposure for the subsistence poultry farmer was due to ingestion of soil, produce, poultry, and eggs (based on the point of maximum deposition) and to direct inhalation (based on the point of maximum concentration). The other exposure routes -- ingestion of beef, pork, milk, fish, and drinking water -- were not bounding but were, instead, based on the location of the subsistence poultry farmer. For the subsistence fisher scenario, a default watershed, which lies at the high end of the distribution of watersheds (Van der Leeden, 1990), was centered at the point of maximum combined deposition. Parameters for the bounding watershed are contained in the body of the document (Section II).

The ISCSTDFT air modeling results are presented in Figures A-4.1 through A-4.4. Figure A-4.1 shows the combined deposition of particles within 20 kilometers of Case D; Figure A-4.2 shows the air concentration of vapors within 20 kilometers of Case D; and Figures A-4.3 and 4 show the wet and dry deposition of particles, respectively, within 3 kilometers of Facility D. The results are also presented in tabular form in Table A-4.15.

Table A-4.14. Air Modeling Inputs Used in ISCSTDFT Modeling

Meteorologic location	
Surface / upper air	Springfield, MO/Monnet MO
Anemometer height (m)	6.1
DEPMET Preprocessor Inputs	
Land use within 5 km	Agricultural
Min. M-O length (m)	2.0
Roughness height (m)	0.25
Displacement height (m)	1.25
Noontime albedo (fraction)	0.20
Soil moisture available (fraction)	0.5
Net radiation absorbed in ground (fraction)	0.15
Anthropogenic heat flux (W/m^2)	0.

Table A-4.15 Results of ISCSTDFT Air Modeling for Case D[a]

Scenario	Location Distance (m)/ Direction	Particles				Vapors	
		Combined Deposition (g/m^2-yr)/(g/s)	Wet Deposition (g/m^2-yr)/(g/s)	Dry Deposition (g/m^2-yr)/(g/s)	Air Concentration (µg/m^3)/(g/s)	Wet Deposition (g/m^2-yr)/(g/s)	Air Concentration (µg/m^3)/(g/s)
Point of maximum combined deposition	100/NW	0.21	0.21	0	0	0.27	0
Point of maximum vapor concentration	1000/NNW	0.0035	0.00057	0.0029	0.011	0.00098	0.012
Home gardener (closest resident)	3000/NE	0.0021	0.0012	0.00090	0.0039	0.0019	0.0042
General population	--	7.7E-04	2.8E-04	4.9E-04	0.0022	4.4E-04	0.0023
Subsistence farmer - beef/ dairy/ poultry/ pork	700/N	0.015	0.015	0.000096	0.0007	0.022	0.00071
Subsistence fisher - Allen Lake	3000/NNE	0.0039	--	--	0.0071	0.0024	0.0077
Subsistence fisher - Santa Fe Lake	3000/SSW	0.024	--	--	0.0037	0.0020	0.0040
Subsistence fisher - Neosho River	6000/NNW	0.0049	--	--	0.010	0.0027	0.011
		Averages over Watershed			**Averages over Waterbody**		
		Combined Deposition of Particles (g/m^2-yr)/(g/s)	**Wet Deposition of Vapors (g/m^2-yr)/(g/s)**	**Air Concentration of Vapors (µg/m^3)/(g/s)**	**Combined Deposition of Particles (g/m^2-yr)/(g/s)**	**Wet Deposition of Vapors (g/m^2-yr)/(g/s)**	**Air Concentration of Vapors (µg/m^3)/(g/s)**
Allen Lake	--	0.0021	0.0013	0.0049	0.0021	0.0013	0.0051
Santa Fe Lake	--	0.0024	0.0023	0.0031	0.0025	0.0020	0.0036
Neosho River	--	0.0015	0.00092	0.0038	0.0015	0.00066	0.0045

[a] The air modeling results in the table are based on an emission rate of 1 g/s for the stack.

Figure A-4.1 Combined deposition of particles within 20 kilometers of Facility D. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

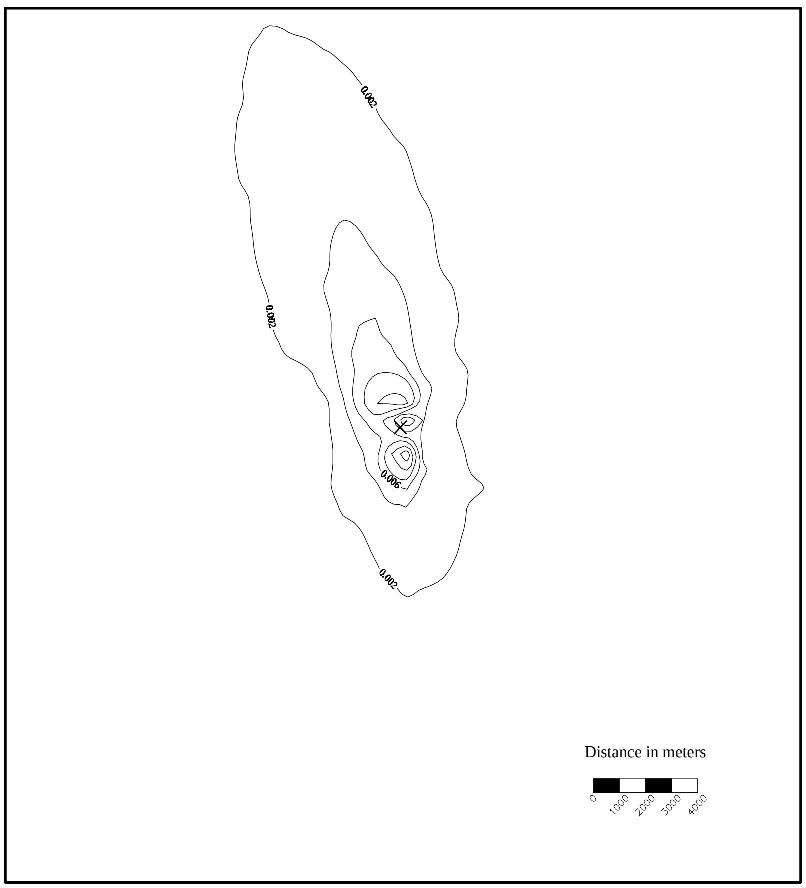


Figure A-4.2 Air concentration of vapors within 20 kilometers of facility D. Air concentration in units of micrograms per cubic meter, resulting from a unit emission rate of 1 gram per second.

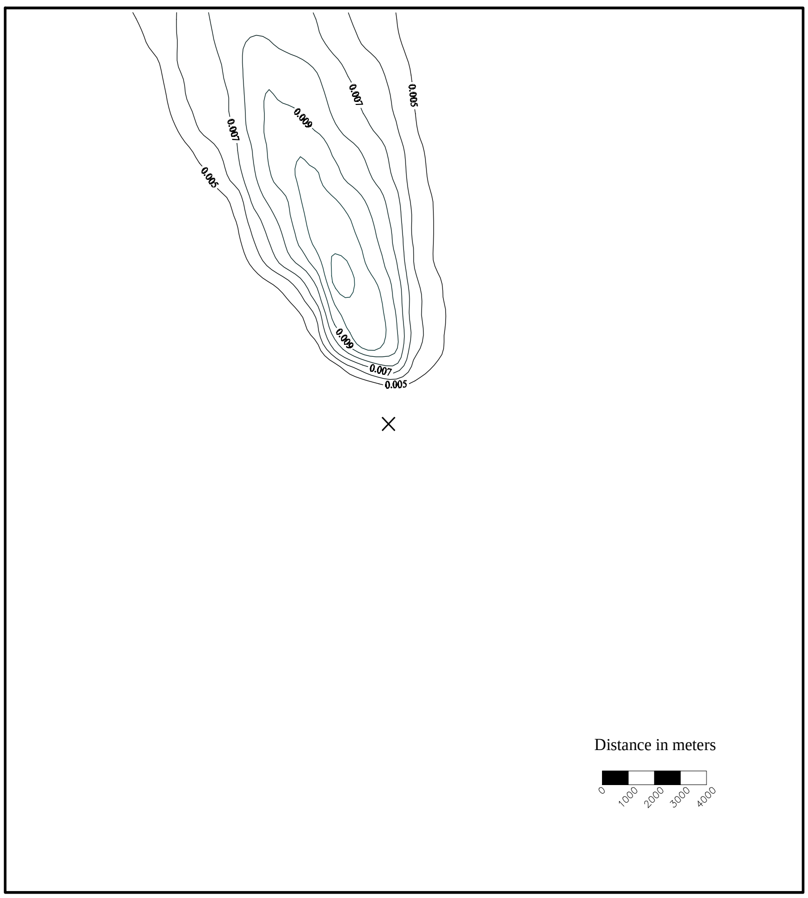


Figure A-4.3 Wet deposition of particles within 3 kilometers of Facility D. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

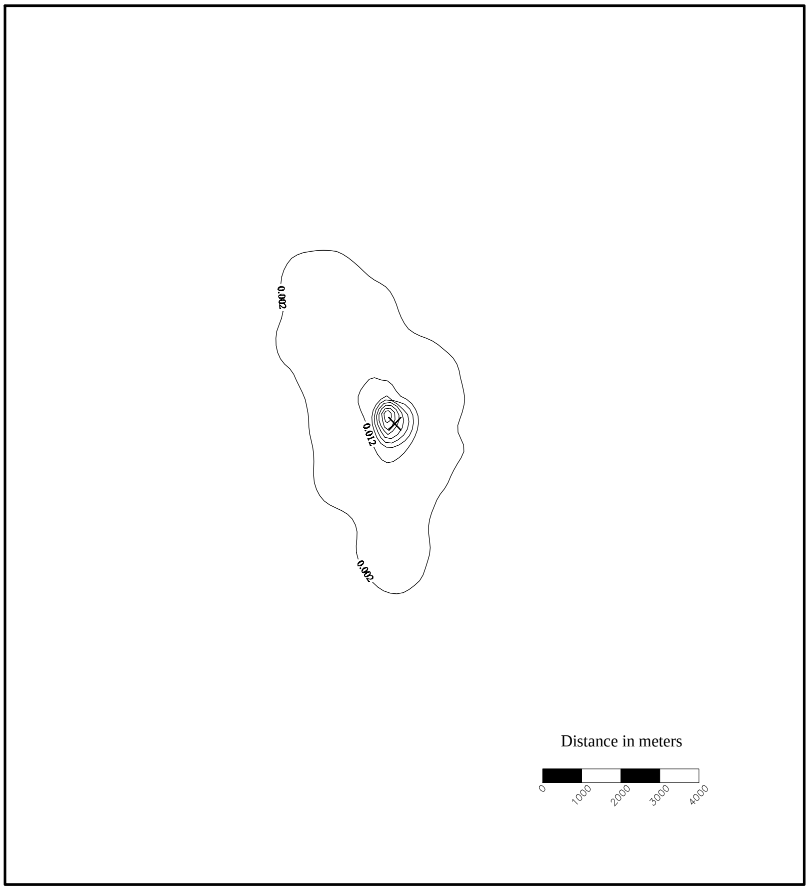
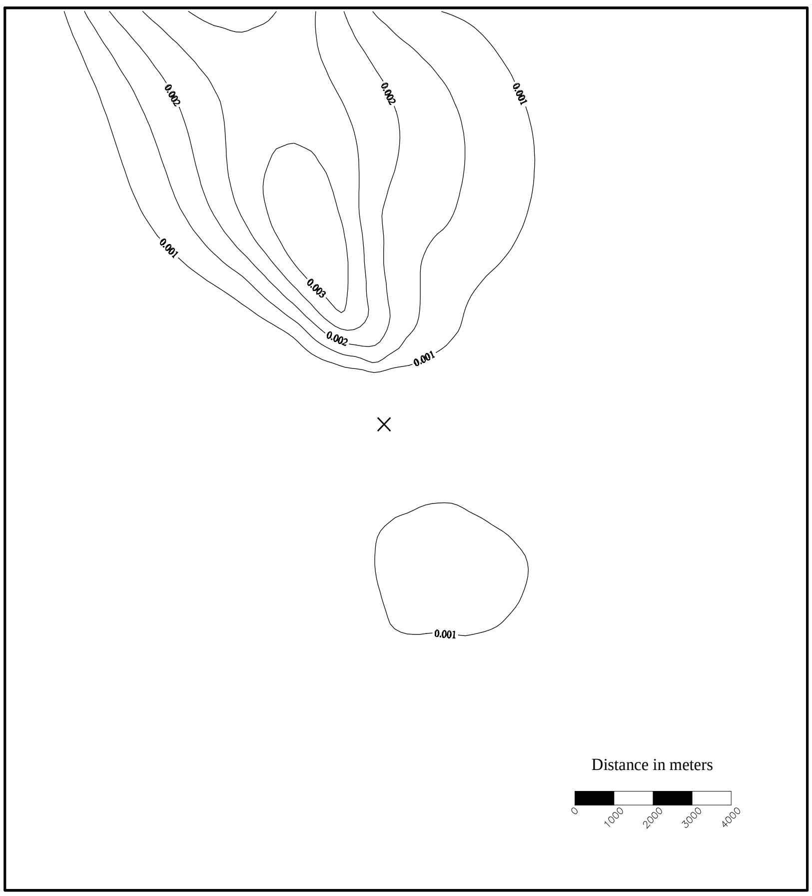


Figure A-4.4 Dry deposition of particles within 3 kilometers of Facility D. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.



5. Case E

A. Source Characterization

Case E is one of four hazardous waste incinerators selected for this analysis. Facility and source parameters used in the air dispersion modeling and risk assessment of this site are presented in Table A-5.1. Values listed in the table were obtained from facility-specific information provided by EPA.

Table A-5.1. Facility and Source Parameters for Case E

Parameter	Case E
Facility type	Incinerator
Land use w/in 5 km	Agricultural
Terrain use	No
Operating hours (8,760/yr possible)	7,560
Stack parameters	Stack 1
Stack height (m)	61
Diameter (m)	1.5
Total flow rate (dscfm) / (dscms)	39,205 / 18.5
Exit velocity (m/s)	10.8
Exit temperature (K)	297

B. Setting Characterization

Case E is located in the north-central United States in an area of relatively flat terrain. Land use surrounding the site is agricultural.

The National Weather Service Station at Rochester, Minnesota, provided the most appropriate meteorologic data for Case E. Upper air data from St. Cloud, Minnesota, were paired with the surface data for air dispersion modeling. Five years of meteorologic data, for the years 1985 and 1987-1990, were used to determine long-term average air dispersion and deposition estimates. Table A-5.2 lists the annual average meteorologic parameters, which were obtained from the International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992). Also listed in Table A-5.2 are the average evapotranspiration rate and annual runoff. These values were used with the precipitation rate to calculate a water balance for Case E. One-half of the average annual runoff value cited in the *Water Atlas* (Geraghty et al., 1973) was used in the analysis. The adjustment was made to account for surface runoff only, and not the subsurface inflows to surface waters. The evapotranspiration rate was calculated by assuming 70 percent of the precipitation evaporates.

Table A-5.2. Annual Average Meteorologic Parameters for Case E

Ave. annual evapotranspiration (cm/yr)	Ave. annual runoff [a] (cm/yr)	Ave. annual precipitation[b] (cm/yr)	Ambient air temperature[b] (K)	Mean annual windspeed[b] (m/s)
31.8	51.6	73.7	279.7	6.2

[a] *Water Atlas* (Geraghty et al., 1973).
[b] International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992).

C. Characterization of Exposed Populations

Table A-5.3 presents the locations of exposed populations identified for Case E. Information regarding the location of the residence and farms likely to be most impacted by Case E was obtained through telephone interviews with local planning offices and local agricultural extension agents. The local officials were asked to identify farms near the facility where subsistence activities would be likely. Farms identified by local officials were assessed to determine which would be most impacted by the facility emissions, and the maximally impacted farms were assumed to represent the location of the subsistence farmers.

Table A-5.3. Location of Receptors Identified for Case E

Receptor	Location (Distance (km)/Direction)	Source
Residence of home gardener	2 km north	City Zoning Office
Subsistence beef farm	1.5 km west	Farm Extension Service
Subsistence dairy farm	1.5 km north-northeast	Farm Extension Service
Subsistence poultry farm	1.5 km north-northeast[a]	Farm Extension Service
Subsistence pork farm	1.5 km north-northeast[a]	Farm Extension Service
Subsistence fisher location (inhalation and soil ingestion) Vermillion River Lake Isabelle Mississippi River Colby Lake	 5.5 km south 5 km southeast 1.5 km north 11.5 km north	Location of maximum air concentration of vapors within the watershed
Waterbody identified as surface drinking water source	None	City Public Works

[a] Default assumption based upon location of subsistence dairy farmer.

The waterbodies were selected from USGS topographical maps as those that would be large enough to support fish, yet would reflect the highest impact from the facility. Phone calls to local officials verified that individuals might consume fish caught in the selected waterbodies. The topographic maps were also used in identifying the watersheds associated with each waterbody and in estimating waterbody and watershed surface areas. Table A-5.4 lists the surface areas and other surface water parameters for Case E. References for the surface water parameters are also listed in the table.

The fraction of food contaminated was varied depending on the scenario. In this analysis, the fraction contaminated is defined as the fraction of what is consumed that is contaminated by facility emissions. The fraction contaminated is independent of the level of contamination, which is dependent upon the production location. Contamination levels calculated for a subsistence farm location near the facility would be higher than those calculated for the typical farm (air concentrations and deposition rates averaged to 20 kilometers). The terms "subsistence level of contamination" and "typical level of contamination" are used to reflect the different levels.

Central tendency and high-end contaminated fractions were developed based on an economic analysis of regional production and processing capacity and the fraction home-produced recommendations from the *Exposure Factors Handbook* (U.S. EPA, 1990). The fractions were developed using data from counties within 50 kilometers of the site. The economic analysis is discussed in detail in Section II.E.2 of the main report. The commodity with the highest fraction locally produced was assumed to be the commodity produced by the typical farmer. Local agricultural production indicated that the typical farmer for Case E was a dairy farmer. The fractions assumed to be locally produced and processed for Case E are as follows:

Beef	0.24	Pork	0.01
Dairy	1.0	Poultry	0.01
Produce	0.12	Eggs	0.01
Fish	0.01		

The subsistence farmers considered for Case E were beef, dairy, poultry, and pork farmers. The locations of the subsistence farmers, listed in Table A-5.3, were used for estimating exposures from direct inhalation and soil ingestion. The fraction contaminated is assumed to be 1 for the livestock the subsistence farmer is identified as producing. He was also assumed to grow all the fruits and vegetables he consumed. For example, the subsistence beef farmer was assumed to produce all the beef, vegetables, and fruits that he ingested and to purchase all other dietary items -- such as milk, pork, fish, etc. -- from local markets. The items raised on the subsistence farms had higher levels of contamination than what was available in the local market. The local items purchased in the market were contaminated at levels that reflected the average impact from the stack out to 20 kilometers from the facility. Because the water supplied to the area surrounding Case E came from sources other than surface waterbodies, the subsistence farmers did not drink contaminated water. Tables A-5.5 through A-5.8 list the locations of contamination and the contaminated fraction by pathway for the subsistence farm scenarios.

Table A-5.4. Surface Water Parameters for Case E

Waterbody	Surface Area (m^2)[a]	Watershed Area (m^2)[a]	Impervious Watershed Area (m^2)[b]	Average Volumetric Flow Rate (m^3/yr)[c]	Current Velocity (m/s)[d]	Depth of Water Column (m)[e]	USLE Rainfall/ Erosivity Factor [e]
Mississippi River	7.0E+07	7.6E+08	4.2E+07	1.3E+09	0.87	4.0	150
Vermillion River	1.7E+06	3.5E+08	3.5E+07	7.3E+07	0.27	3.1	150
Colby Lake	3.8E+05	6.1E+06	3.0E+04	3.8E+05	NA	4.5	150
Lake Isabelle	7.6E+05	1.0E+06	1.0E+05	6.4E+04	NA	1.5	150

[a] Surface areas for the watersheds and waterbodies were determined from the USGS 1.25 000-scale Topographic 7.5 min X 15 min quadrangles.

[b] Impervious watershed areas were estimated from USGS quadrangles, site-specific land use, and a study of percent imperviousness for different land uses conducted by Camp, Dresser, and McKee (1989).

[c] The volumetric flow rates for the Mississippi River and the Vermillion River were obtained from the REACH (U.S. EPA, 1995a) database. Flowrates for the other waterbodies were calculated from the watershed area and average annual surface runoff.

[d] Current velocities for the Mississippi River and the Vermillion River were obtained from the REACH (U.S. EPA, 1995a) database. Current velocities for lakes were not required and are listed as NA (Not Applicable).

[e] Depths for the Vermillion River, Mississippi River, and Lake Isabelle were based on information from local officials. Depth of Colby Lake was based on a default value for lakes of 4 to 6 meters.

[f] USLE Erosivity/Rainfall Factor was obtained from Edwards (1993) and was used in the universal soil loss equation (USLE).

Table A-5.5. Exposure Scenario for Subsistence Beef Farmer, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence beef farm (1.5 km west)	1.0
Soil ingestion	Location of subsistence beef farm (1.5 km west)	1.0
Belowground vegetables	Location of subsistence beef farm (1.5 km west)	1.0
Aboveground produce	Location of subsistence beef farm (1.5 km west)	1.0
Beef ingestion	Location of subsistence beef farm (1.5 km west)	1.0
Milk ingestion	Average to 20 km	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

Table A-5.6. Exposure Scenario for Subsistence Dairy Farmer and Child, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (1.5 km north-northeast)	1.0
Soil ingestion	Location of subsistence dairy farm (1.5 km north-northeast)	1.0
Belowground vegetables	Location of subsistence dairy farm (1.5 km north-northeast)	1.0
Aboveground produce	Location of subsistence dairy farm (1.5 km north-northeast)	1.0
Beef ingestion	Average to 20 km	0.24
Milk ingestion	Location of subsistence dairy farm (1.5 north-northeast)	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

Table A-5.7. Exposure Scenario for Subsistence Pork Farmer, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Soil ingestion	Location of subsistence dairy farm (1.5 km North-Northeast)[a]	1.0
Belowground vegetables	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Aboveground produce	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Beef ingestion	Average to 20 km	0.24
Milk ingestion	Average to 20 km	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence dairy farmer.

Table A-5.8. Exposure Scenario for Subsistence Poultry Farmer, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Soil ingestion	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Belowground vegetables	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Aboveground produce	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Beef ingestion	Average to 20 km	0.24
Milk ingestion	Average to 20 km	1.0
Chicken meat ingestion	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Egg ingestion	Location of subsistence dairy farm (1.5 km north-northeast)[a]	1.0
Pork ingestion	Average to 20 km	0.01
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence dairy farmer.

A subsistence fisher was modeled for each watershed. The fish consumption rate for the subsistence fisher was 60 g/d, rather than the 1.64 g/d rate of the general population. The locations of the residences of the subsistence fishers were assumed to be the site of highest vapor air concentration within the affected watershed. The residence location was used for estimating exposures from direct inhalation and soil ingestion. All fish in the diet was assumed to be from the watershed where the subsistence fisher resided. All other dietary items were assumed purchased from the local market and to contain typical levels of contamination. Because the water supplied to the area surrounding Case E came from sources other than surface waterbodies, the subsistence fishers did not drink contaminated water. Table A-5.9 lists the locations of contamination and the contaminated fraction by pathway for the subsistence fisher scenario.

Table A-5.9. Exposure Scenario for Subsistence Fisher, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of maximum vapor air concentration in each watershed	1.0
Soil ingestion	Location of maximum vapor air concentration in each watershed	1.0
Belowground vegetables	Average to 20 km	0.12
Aboveground produce	Average to 20 km	0.12
Beef ingestion	Average to 20 km	0.24
Milk ingestion	Average to 20 km	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion (60 g/d)	Each watershed	1.0

The location of the home gardener and child was derived from the location of the closest actual residence to the facility. This residential location was used to estimate exposures from direct inhalation and soil ingestion. The fractions contaminated for the aboveground produce and belowground vegetables were determined by adding the fraction contaminated in the local market to the fraction that the gardener home-raised and consumed, as cited in the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.34 by adding the homegrown fraction of 0.25 to 12 percent of the remaining 0.75 purchased from local markets. All other dietary items were assumed to be purchased from local markets and to contain typical levels of contamination derived from average air dispersion and deposition estimates to 20 kilometers from the facility. Because the water supplied to the area surrounding Case E came from sources other than surface waterbodies, the home gardener did not drink contaminated water. Table A-5.10 lists the locations of contamination and the contaminated fraction by pathway for the home gardener scenarios.

Table A-5.10. Exposure Scenario for Home Gardener and Child, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Location of closest residence (2 km north)	1.0	
Soil ingestion	Location of closest residence (2 km north)	1.0	
		Central tendency	**High-end**
Belowground vegetables	Location of closest residence (2 km north)	0.25 Typical farmer + 0.75 x Local market = 0.34	0.40 Typical farmer + 0.60 x Local market = 0.47
Aboveground produce	Location of closest residence (2 km north)	0.25 Typical farmer + 0.75 x Local market = 0.34	0.40 Typical farmer + 0.60 x Local market = 0.47
Beef ingestion	Average to 20 km	0.24	0.24
Milk ingestion	Average to 20 km	1.0	1.0
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.01	0.01
Fish ingestion	Each watershed	0.01	0.01

The typical adult resident and child exposures were based on averages of air concentrations and deposition rates out to 20 km. The averages were used for estimating exposures from direct inhalation and soil ingestion. All dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. Because the surface water supplied to the area surrounding Case E came from sources other than the selected waterbodies, the typical resident did not drink contaminated water. Table A-5.11 lists the locations of contamination and the contaminated fraction by pathway for the typical resident scenarios.

Table A-5.11. Exposure Scenario for Typical Adult Resident and Child, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average out to 20 km	1.0
Soil ingestion	Average out to 20 km	1.0
Belowground vegetables	Average out to 20 km	0.12
Aboveground produce	Average out to 20 km	0.12
Beef ingestion	Average out to 20 km	0.24
Milk ingestion	Average out to 20 km	1.0
Chicken meat ingestion	Average out to 20 km	0.01
Egg ingestion	Average out to 20 km	0.01
Pork ingestion	Average out to 20 km	0.01
Fish ingestion	Each watershed	0.01

The typical farmer for this site was assumed to be a dairy farmer because the fraction of dairy locally produced and processed was higher than the fractions for the other commodities in the analysis. The typical dairy farmer was assumed to produce a fraction of the dairy, vegetables, and fruits he consumed and to purchase all other dietary items from the local market. The fractions contaminated for each pathway were determined by adding the fraction contaminated in the local market to the fraction that the farmer home-raised and consumed from the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency belowground vegetable fraction contaminated of 0.34 was 0.25 homegrown, plus 0.12 of the remaining 0.75 consumed that was purchased at the local market. Both the items raised on the typical farm and the items purchased from local markets had typical levels of contamination. The typical dairy farmer's exposures from direct inhalation and soil ingestion were estimated to be at levels derived from averages of air dispersion and deposition outputs to 20 kilometers. Because the water supplied to the area surrounding Case E came from sources other than surface waterbodies, the typical farmer did not drink contaminated water. Table A-5.12 lists the locations of contamination and the contaminated fraction by pathway for the typical farmer scenario.

Table A-5.12. Exposure Scenario for Typical Farmer, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated	
Direct inhalation	Average to 20 km	1.0	
Soil ingestion	Average to 20 km	1.0	
		Central tendency	**High-end**
Belowground vegetables	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.34	0.40 Typical farmer + 0.60 x Local market = 0.47
Aboveground produce	Average to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.34	0.40 Typical farmer + 0.60 x Local market = 0.47
Beef ingestion	Average to 20 km	0.24	0.24
Milk ingestion	Average to 20 km	0.40 Typical farmer + 0.60 x Local market = 1.0	0.75 Typical farmer + 0.25 x Local market = 1.0
Chicken meat ingestion	Average to 20 km	0.01	0.01
Egg ingestion	Average to 20 km	0.01	0.01
Pork ingestion	Average to 20 km	0.01	0.01
Fish ingestion	Each watershed	0.01	0.01

Recreational fishers were modeled for each waterbody by combining the typical resident scenario with an increased consumption of contaminated fish recreationally caught (30 g/d). The recreational fisher's exposures from direct inhalation and soil ingestion were derived from averages of air dispersion and deposition output to 20 kilometers. All fish in the diet was assumed to be from a single waterbody. For instance, the recreational fisher identified for the Vermillion River only ate fish caught in the Vermillion River. All other dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. Because the water supplied to the area surrounding Case E came from sources other than surface waterbodies, the recreational fishers did not drink contaminated water. Table A-5.13 lists the location of contamination and the contaminated fraction by pathway for the recreational fisher scenario.

Table A-5.13. Exposure Scenario for Recreational Fisher, Case E

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average to 20 km	1.0
Soil ingestion	Average to 20 km	1.0
Belowground vegetables	Average to 20 km	0.12
Aboveground produce	Average to 20 km	0.12
Beef ingestion	Average to 20 km	0.24
Milk ingestion	Average to 20 km	1.0
Chicken meat ingestion	Average to 20 km	0.01
Egg ingestion	Average to 20 km	0.01
Pork ingestion	Average to 20 km	0.01
Fish ingestion (30 g/d)	Each watershed	1.0

D. Air Modeling and Air Modeling Results

A test version of ISCSTDFT was the air dispersion and deposition model used to estimate air concentrations and deposition rates for Case E. Source inputs used in the modeling are listed in Table A-5.1. The meteorologic data required for the air modeling were created using PCRAMMET, DEPMET, and PMERGE preprocessors. Table A-5.14 lists site-specific data needed for the DEPMET preprocessor. The actual anemometer height was used as a DEPMET input. For the other inputs, recommendations from the DEPMET User's Guide (U.S. EPA, 1994) based on the site-specific land use data were used. Land use information for Case E was obtained from telephone surveys and assessed through topographic maps.

The ISCSTDFT model was run using 5 years of meteorological data concatenated into a multiple-year meteorological file (U.S. EPA, 1995b). Therefore, results of the ISCSTDFT modeling conducted with this multiple-year meteorological file represent a 5 year average.

The ISCSTDFT model was run using the "default" model options. The terrain option was not used because this site is an area of flat terrain, and the effects of terrain on air dispersion would not be significant for this site. Additionally, downwash was not used in the air dispersion modeling for Site D, because site-specific information indicated that building downwash was not expected to occur.

Specific receptor locations evenly spaced every 1,000 meters were identified for each watershed and waterbody using USGS topographic maps. The 5 year averages of air dispersions and deposition rates were then areally averaged over each specific watershed and waterbody.

The point of maximum combined deposition and the point of maximum vapor air concentration were used for "bounding" estimates. For a given scenario, the point of maximum concentration was used in calculating bounding risks for direct inhalation, while the maximum combined deposition or maximum air concentration was used in estimating risks for other pathways. However, bounding exposure was considered for only the pathways involved in the subsistence activities for a given scenario. For example, bounding exposure for the subsistence poultry farmer was due to ingestion of soil, produce, poultry, and eggs (based on the point of maximum deposition) and to direct inhalation (based on the point of maximum concentration). The other exposure routes -- ingestion of beef, pork, milk, fish, and drinking water -- were not bounding but were, instead, based on the location of the subsistence poultry farmer. For the subsistence fisher scenario, a default watershed, which lies at the high end of the distribution of watersheds (Van der Leeden et al., 1990), was centered at the point of maximum combined deposition. Parameters for the bounding watershed are contained in the body of the document (Section II).

The ISCSTDFT air modeling results are presented in Figures A-5.1 through A-5.4. Figure A-5.1 shows the combined deposition of particles within 20 kilometers of Case E; Figure A-5.2 shows the air concentration of vapors within 20 kilometers of Case E; and Figures A-5.3 and 4 show the wet and dry deposition of particles, respectively, within 3 kilometers of Facility E. The results are also presented in tabular form in Table A-5.15.

Table A-5.14. Air Modeling Inputs Used in ISCSTDFT Modeling

Meteorologic location	
Surface / upper air	Rochester, MN/ St. Cloud, MN
Anemometer height (m)	9.1
DEPMET Preprocessor Inputs	
Land use within 5 km	Agricultural
Min. M-O length (m)	2.0
Roughness height (m)	0.20
Displacement height (m)	1.0
Noontime albedo (fraction)	0.28
Soil moisture available (fraction)	0.5
Net radiation absorbed in ground (fraction)	0.15
Anthropogenic heat flux (W/m^2)	0.0

Table A-5.15. Results of the ISCSTDFT Air Modeling for Case E[a]

Scenario	Location Distance (m)/ Direction	Particles				Vapors	
		Combined Deposition (g/m²-yr)/(g/s)	Wet Deposition (g/m²-yr)/(g/s)	Dry Deposition (g/m²-yr)/(g/s)	Air Concentration (µg/m³)/(g/s)	Wet Deposition (g/m²-yr)/(g/s)	Air Concentration (µg/m³)/(g/s)
Point of maximum combined deposition	100/W	0.11	0.11	0	0	0.14	0
Point of maximum vapor concentration	1,500/N	0.043	0.0049	0.038	0.10	0.0074	0.11
Home gardener (closest resident)	2,000/N	0.036	0.0034	0.032	0.094	0.0052	0.10
General population	--	0.0018	2.2E-04	0.0016	0.0077	3.5E-04	0.0082
Subsistence farmer - beef	1,500/W	0.011	0.0046	0.0068	0.030	0.0070	0.031
Subsistence farmer - dairy/ pork/ poultry	1,500/NNE	0.035	0.0037	0.032	0.081	0.0058	0.086
Subsistence fisher - Vermillion River	5,500/S	0.0059	--	--	0.021	0.0013	0.022
Subsistence fisher - Lake Isabelle	5,000/SE	0.010	--	--	0.035	0.00049	0.038
Subsistence fisher - Mississippi River	1,500/N	0.044	--	--	0.10	0.0066	0.11
Subsistence fisher - Colby Lake	11,500/N	0.0035	--	--	0.015	0.00048	0.016
		Averages over Watershed			**Averages over Waterbody**		
		Combined Deposition of Particles (g/m²-yr)/(g/s)	**Wet Deposition of Vapors (g/m²-yr)/(g/s)**	**Air Concentration of Vapors (µg/m³)/(g/s)**	**Combined Deposition of Particles (g/m²-yr)/(g/s)**	**Wet Deposition of Vapors (g/m²-yr)/(g/s)**	**Air Concentration of Vapors (µg/m³)/(g/s)**
Vermillion River	--	0.0014	0.00031	0.0068	0.0016	0.00031	0.0074
Lake Isabelle	--	0.0056	0.0005	0.021	0.0048	0.00049	0.019
Mississippi River	--	0.0027	0.00053	0.011	0.0052	0.0012	0.019
Colby Lake	--	0.0027	0.00036	0.013	0.0026	0.00034	0.013

[a] The air modeling results in the table are based on an emission rate of 1 g/s for the stack.

Figure A-5.1 Combined deposition of particles within 20 kilometers of Facility E. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

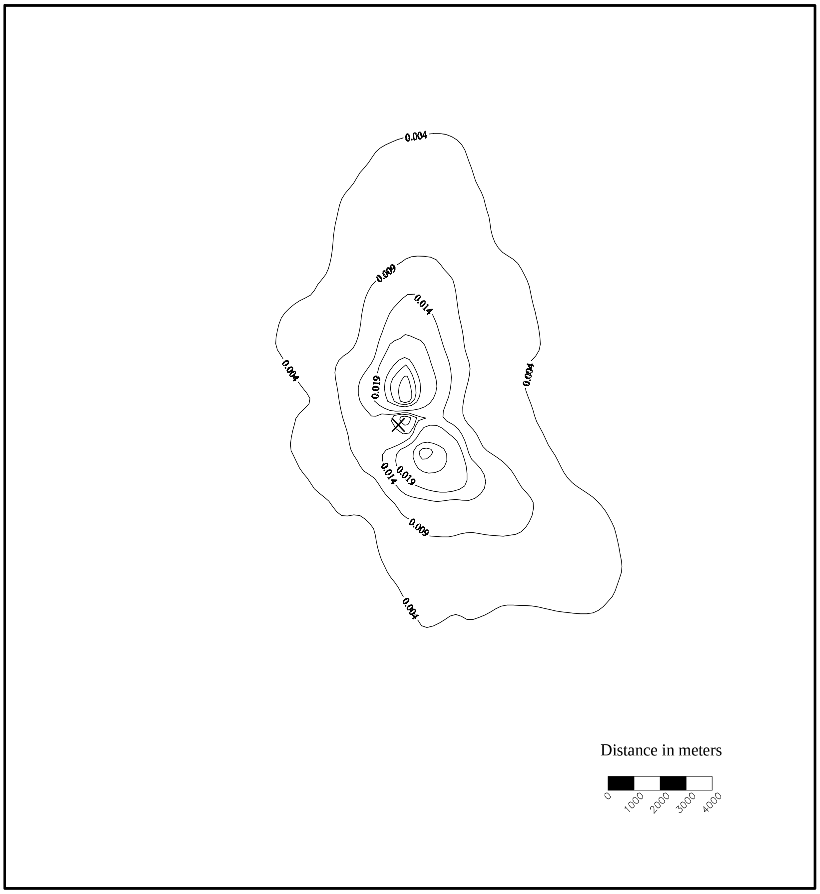


Figure A-5.2 Air concentration of vapors within 20 kilometers of Facility E. Air concentration in units of micrograms per cubic meter, resulting from a unit emission rate of 1 gram per second.

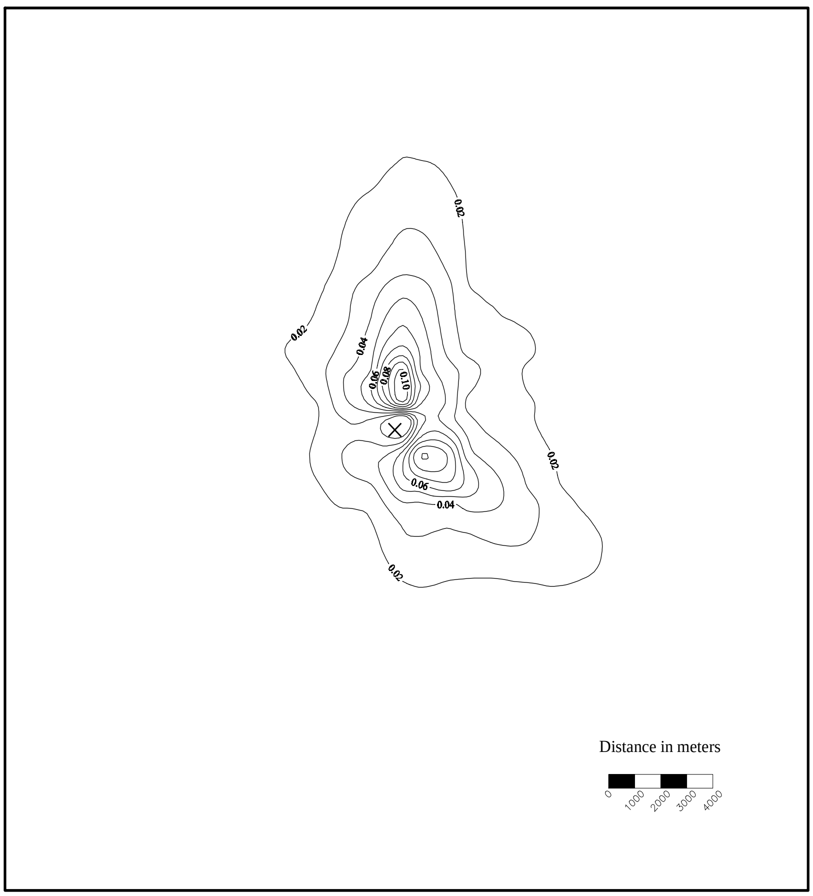


Figure A-5.3 Wet deposition of particles within 3 kilometers of Facility E. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

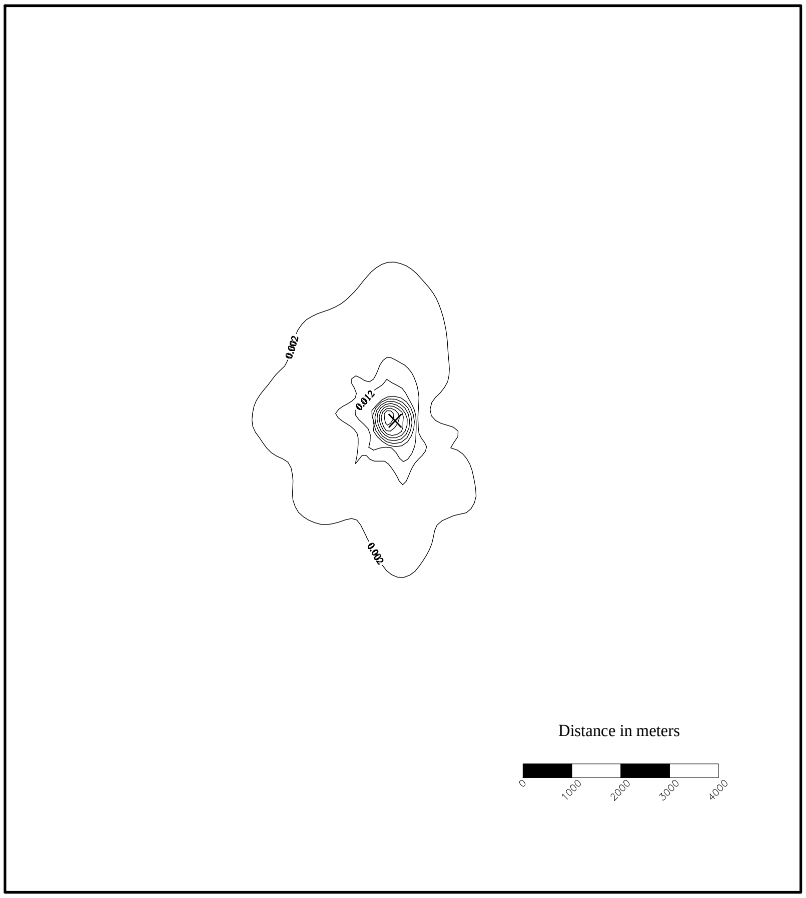
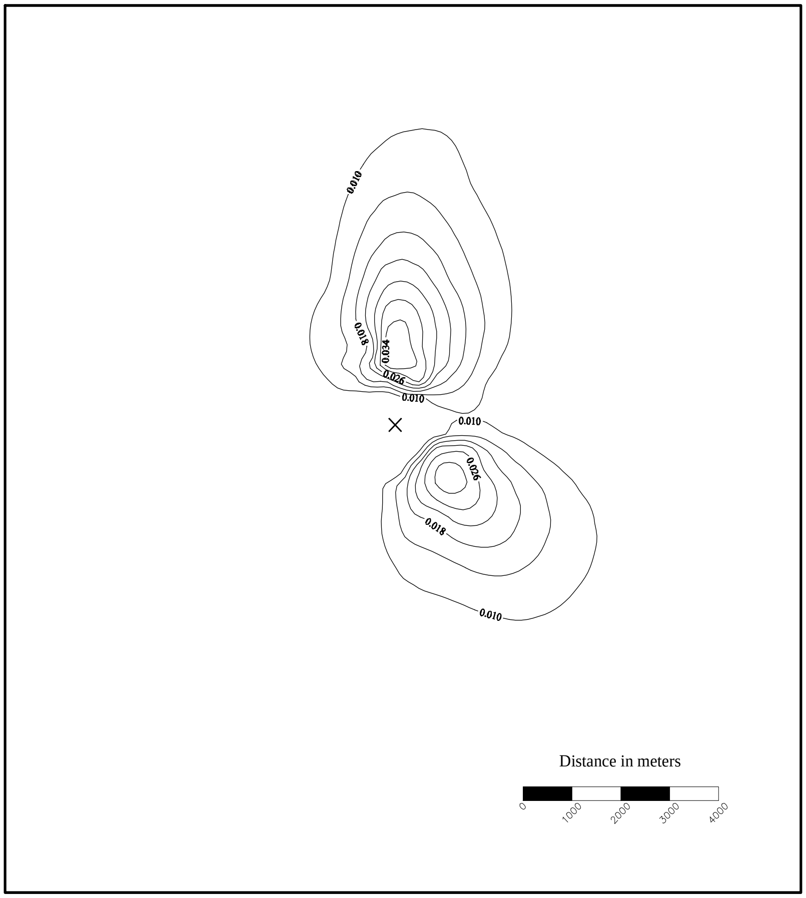


Figure A-5.4 Dry deposition of particles within 3 kilometers of Facility E. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.



6. Case F

A. Source Characterization

Case F is one of five cement kilns selected for this analysis. Facility and source parameters used in the air dispersion modeling and risk assessment of this site are presented in Table A-6.1. Values listed in the table were obtained from facility-specific information provided by EPA.

Table A-6.1. Facility and Source Parameters for Case F

Parameter	Case F
Facility type	Cement Kiln
Land-use w/in 5 km	Forest
Terrain use	No
Operating hours (8760/year possible)	7,560
Stack Parameters	Stack 1
Stack height (m)	89
Diameter (m)	7.3
Total flow rate (dscfm) / (dscms)	310,800 / 146.6
Exit velocity (m/s)	6.53
Exit temp. (K)	414

B. Setting Characterization

Case F is located in the north-central United States, in an area of relatively flat terrain. One of the Great Lakes borders the facility to the east, while the land use is mainly forested to the west.

The National Weather Service Station at Alpena, Michigan, provided the most appropriate meteorologic data for Case F. Upper air data from Sault Sainte Marie, Michigan, were paired with the surface data for air dispersion modeling. Five years of meteorologic data, for the years 1985 and 1987-1990, were used to determine long-term average air dispersion and deposition estimates. Table A-6.2 lists the annual average meteorologic parameters, which were obtained from the International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992). Also listed in Table A-6.2 are the average evapotranspiration rate and annual runoff. These values were used with the precipitation rate to calculate a water balance for Case F. One-half of the average annual runoff value cited in the *Water Atlas* (Geraghty et al., 1973) was used in the analysis. The adjustment was made to account for surface runoff only, and not the subsurface inflows to surface waters. The water evapotranspiration rate was calculated by assuming 70 percent of the precipitation evaporates.

Table A-6.2. Annual Average Meteorological Parameters for Case F

Ave. annual evapotranspiration (cm/yr)	Ave. annual runoff [a] (cm/yr)	Ave. annual precipitation[b] (cm/yr)	Ambient air temperature[b] (K)	Mean annual windspeed[b] (m/s)
51.2	12.7	73.2	279.1	4.1

[a] *Water Atlas* (Geraghty et al., 1973)
[b] International Station Meteorological Climate Summary CD-ROM (U. S. Department of Commerce, 1992).

C. Characterization of Exposed Populations

Table A-6.3 presents the locations of exposed populations identified for Case F. Information regarding the location of the residence and farms likely to be most impacted by Case F was obtained through telephone interviews with local planning offices and local agricultural extension agents. The local officials were asked to identify farms near the facility where subsistence activities would be likely. Farms identified by local officials were assessed to determine which would be most impacted by the facility emissions, and the maximally impacted farms were assumed to represent the location of the subsistence farmers.

Table A-6.3. Location of Receptors Identified for Case F

Receptor	Location (Distance (km)/Direction)	Source
Residence of home gardener	0.7 km west	City Engineering
Subsistence beef farm	16 km northwest	County Extension Office
Subsistence dairy farm	16 km southwest	County Extension Office
Subsistence poultry farm	16 km northwest[a]	County Extension Office
Subsistence pork farm	16 km northwest[a]	County Extension Office
Subsistence fisher location (inhalation and soil ingestion) Thunder Bay River Mud and Devils Lake Long Lake	 3 km northwest 7.5 km west 10.5 km north	Location of maximum air concentration of vapors within the watershed
Waterbody identified as surface drinking water source	Thunder Bay	Michigan State University

[a] Default assumption based on location of subsistence beef farmer.

The waterbodies were selected from USGS topographical maps as those that would be large enough to support fish yet would reflect the highest impact from the facility. Phone calls to local officials verified that individuals might consume fish caught in the selected waterbodies. The topographic maps were also used to identify the watersheds associated with each waterbody and to estimate waterbody and watershed surface areas. Table A-6.4 lists the surface areas and other surface water parameters for Case F. References for the surface water parameters are also listed in the table.

As noted in Table A-6.3, Thunder Bay was used as a drinking water source for the residents surrounding Facility F. Because the impact of emissions from one facility would be indiscernible on a waterbody the size of the Great Lakes, Thunder Bay was not used. Instead, Thunder Bay River, which flows into Thunder Bay, was used to represent the drinking water source.

The fraction of food contaminated was varied depending on the scenario. In this analysis, the fraction contaminated is defined as the fraction of what is consumed that is contaminated by facility emissions. The fraction contaminated is independent of the level of contamination, which is dependent upon the production location. Contamination levels calculated for a subsistence farm located near the facility would be higher than those calculated for the typical farm (air concentrations and deposition rates averaged to 20 kilometers over the land only). The terms "subsistence level of contamination" and "typical level of contamination" are used to reflect the different levels.

Central tendency and high-end contaminated fractions were developed based on an economic analysis of regional production and processing capacity and the fraction home- produced recommendations from the *Exposure Factors Handbook* (U.S. EPA, 1990). The fractions were developed using data from counties within 50 kilometers of the site. The economic analysis is discussed in Section II.E.2 of the main report. The commodity with the highest fraction locally produced and processed was assumed to be the commodity produced by the typical farmer. Local agricultural production indicated that the typical farmer for Case F was a dairy farmer. The fractions assumed to be locally produced and processed for Case F are as follows:

Beef	0.01	Pork	0.01
Dairy	0.01	Poultry	0.01
Produce	0.01	Eggs	0.01
Fish	0.01		

The subsistence farmers considered for Case F were beef, dairy, poultry, and pork farmers. The locations of the subsistence farmers, listed in Table A-6.3, were used for estimating exposures from direct inhalation and soil ingestion. The fraction contaminated is assumed to be 1 for the livestock the subsistence farmer is identified as producing. He was also assumed to grow all the fruits and vegetables he consumed. For example, the subsistence beef farmer was assumed to produce all the beef, vegetables, and fruits that he ingested and to purchase all other dietary items -- such as milk, pork, fish, etc. -- from local markets. The items raised on the subsistence farms had higher levels of contamination than the items available in the local market.

Table A-6.4. Surface Water Parameters for Case F

Waterbody	Surface Area (m^2) [a]	Watershed Area (m^2) [a]	Impervious Watershed Area (m^2)[b]	Average Volumetric Flow Rate (m^3/yr)[c]	Current Velocity (m/s)[d]	Depth of Water Column (m)[e]	USLE Rainfall/ Erosivity Factor [f]
Mud/Devils Lake	3.0E+06	5.1E+07	2.0E+06	6.4E+06	NA	3.1	75
Thunder Bay River	4.6E+06	4.0E+08	2.0E+06	5.0E+07	0.1	1	75
Long Lake	2.6E+07	9.7E+07	4.9E+05	1.2E+07	NA	6.1	75

[a] Surface areas for the watersheds and waterbodies were determined from the USGS 1.25 000-scale Topographic 7.5 min X 15 min quadrangles.

[b] Impervious watershed areas were estimated from USGS quadrangles, site-specific land use, and a study of percent imperviousness for different land uses conducted by Camp, Dresser, and McKee (1989).

[c] Flow rates for the waterbodies were calculated from the watershed area and average annual surface runoff.

[d] Current velocity calculated from the volumetric flow rate and the cross-sectional area. Current velocities for lakes were not required and are listed as NA (Not Applicable).

[e] Depths for Long Lake and Mud/Devils Lake from information obtained in telephone surveys. Default depth of 1 meter used for Thunder Bay River.

[f] USLE Erosivity/Rainfall Factor was obtained from Edwards (1993) and was used in the universal soil loss equation (USLE).

The local items purchased in the market were contaminated at levels that reflected the average impact from the stack out to 20 kilometers over land from the facility. Subsistence farmers consuming fish from the Thunder Bay River were also assumed to drink contaminated water from the Thunder Bay River. Tables A-6.5 through A-6.8 list the locations of contamination and the contaminated fraction by pathway for the subsistence farmer scenarios.

Table A-6.5. Exposure Scenario for Subsistence Beef Farmer, Case F

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence beef farm (16 km northwest)	1.0
Soil ingestion	Location of subsistence beef farm (16 km northwest)	1.0
Belowground vegetables	Location of subsistence beef farm (16 km northwest)	1.0
Aboveground produce	Location of subsistence beef farm (16 km northwest)	1.0
Beef ingestion	Location of subsistence beef farm (16 km northwest)	1.0
Milk ingestion	Average over land to 20 km	0.01
Chicken meat ingestion	Average over land to 20 km	0.01
Egg ingestion	Average over land to 20 km	0.01
Pork ingestion	Average over land to 20 km	0.01
Fish ingestion	Each watershed	0.01

Table A-6.6. Exposure Scenario for Subsistence Dairy Farmer and Child, Case F

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence dairy farm (16 km southwest)	1.0
Soil ingestion	Location of subsistence dairy farm (16 km southwest)	1.0
Belowground vegetables	Location of subsistence dairy farm (16 km southwest)	1.0
Aboveground produce	Location of subsistence dairy farm (16 km southwest)	1.0
Beef ingestion	Average over land to 20 km	0.01
Milk ingestion	Location of subsistence dairy farm (16 km southwest)	1.0
Chicken meat ingestion	Average over land to 20 km	0.01
Egg ingestion	Average over land to 20 km	0.01
Pork ingestion	Average over land to 20 km	0.01
Fish ingestion	Each watershed	0.01

Table A-6.7. Exposure Scenario for Subsistence Pork Farmer, Case F

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence pork farm (16 km northwest)[a]	1.0
Soil ingestion	Location of subsistence pork farm (16 km northwest)[a]	1.0
Belowground vegetables	Location of subsistence pork farm (16 km northwest)[a]	1.0
Aboveground produce	Location of subsistence pork farm (16 km northwest)[a]	1.0
Beef ingestion	Average over land to 20 km	0.01
Milk ingestion	Average over land to 20 km	0.01
Chicken meat ingestion	Average over land to 20 km	0.01
Egg ingestion	Average over land to 20 km	0.01
Pork ingestion	Location of subsistence pork farm (16 km northwest)[a]	1.0
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence beef farmer.

Table A-6.8. Exposure Scenario for Subsistence Poultry Farmer, Case F

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of subsistence poultry farm (16 km northwest)[a]	1.0
Soil ingestion	Location of subsistence poultry farm (16 km northwest)[a]	1.0
Belowground vegetables	Location of subsistence poultry farm (16 km northwest)[a]	1.0
Aboveground produce	Location of subsistence poultry farm (16 km northwest)[a]	1.0
Beef ingestion	Average over land to 20 km	0.01
Milk ingestion	Average over land to 20 km	0.01
Chicken meat ingestion	Location of subsistence poultry farm (16 km northwest)[a]	1.0
Egg ingestion	Location of subsistence poultry farm (16 km northwest)[a]	1.0
Pork ingestion	Average over land to 20 km	0.01
Fish ingestion	Each watershed	0.01

[a] Default assumption based on location of subsistence beef farmer.

A subsistence fisher was modeled for each watershed. The fish consumption rate for the subsistence fisher was 60 g/d, rather than the 1.64-g/d rate of the general population. The locations of the residences of the subsistence fishers were assumed to be the site of highest vapor air concentration within the affected watershed. The residence location was used for estimating exposures from direct inhalation and soil ingestion. All fish in the diet was assumed to be from the watershed where the subsistence fisher resided. All other dietary items were assumed purchased from the local market and to contain typical levels of contamination. The subsistence fisher residing in the Thunder Bay River watershed and consuming fish from the river was also assumed to drink contaminated water from the Thunder Bay River. Table A-6.9 lists the locations of contamination and the contaminated fraction by pathway for the subsistence fisher scenario.

Table A-6.9. Exposure Scenario for Subsistence Fisher, Case F

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Location of maximum vapor air concentration in each watershed	1.0
Soil ingestion	Location of maximum vapor air concentration in each watershed	1.0
Belowground vegetables	Average over land to 20 km	0.01
Aboveground produce	Average over land to 20 km	0.01
Beef ingestion	Average over land to 20 km	0.01
Milk ingestion	Average over land to 20 km	0.01
Chicken meat ingestion	Average over land to 20 km	0.01
Egg ingestion	Average over land to 20 km	0.01
Pork ingestion	Average over land to 20 km	0.01
Fish ingestion (60 g/d)	Each watershed	1.0

The location of the home gardener and child was derived from the location of the closest actual residence to the facility. This residential location was used to estimate exposures from direct inhalation and soil ingestion. The fractions contaminated for the aboveground produce and belowground vegetables were determined by adding the fraction contaminated in the local market to the fraction that the gardener home-raised and consumed, as cited in the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.26 by adding the homegrown fraction of 0.25 to 1 percent of the remaining 0.75 purchased from local markets. All other dietary items were assumed purchased from local markets and to contain typical levels of contamination derived from air concentrations and deposition rates averaged over land out to 20 kilometers from the facility. The home gardener consuming fish from the Thunder Bay River was also assumed to drink contaminated water from the Thunder Bay River. Table A-6.10 lists the locations of contamination and the contaminated fraction by pathway for the home gardener scenarios.

Table A-6.10. Exposure Scenario for Home Gardener and Child, Case F

Exposure Pathway	Location for Calculating Contamination	Percent Contaminated	
Direct inhalation	Location of closest residence (0.7 km west)	1.0	
Soil ingestion	Location of closest residence (0.7 km west)	1.0	
		Central Tendency	**High End**
Belowground vegetables	Location of closest residence (0.7 km west)	0.25 Typical farmer + 0.75 x Local market = 0.26	0.40 Typical farmer + 0.60 x Local market = 0.41
Aboveground produce	Location of closest residence (0.7 km west)	0.25 Typical farmer + 0.75 x Local market = 0.26	0.40 Typical farmer + 0.60 x Local market = 0.41
Beef ingestion	Average over land to 20 km	0.01	0.01
Milk ingestion	Average over land to 20 km	0.01	0.01
Chicken meat ingestion	Average over land to 20 km	0.01	0.01
Egg ingestion	Average over land to 20 km	0.01	0.01
Pork ingestion	Average over land to 20 km	0.01	0.01
Fish ingestion	Each watershed	0.01	0.01

The typical adult resident and child exposures were based on air concentrations and deposition rates averaged over land out to 20 km. The averages were used for estimating exposures from direct inhalation and soil ingestion. All dietary items were assumed purchased from the local market and to contain typical levels of contamination. The typical resident consuming fish from the Thunder Bay River was assumed to drink contaminated water from the Thunder Bay River. Table A-6.11 lists the locations of contamination and the contaminated fraction by pathway for the typical resident scenarios.

Table A-6.11. Exposure Scenario for Typical Adult Resident and Child, Case F

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average over land to 20 km	1.0
Soil ingestion	Average over land to 20 km	1.0
Belowground vegetables	Average over land to 20 km	0.01
Aboveground produce	Average over land to 20 km	0.01
Beef ingestion	Average over land to 20 km	0.01
Milk ingestion	Average over land to 20 km	0.01
Chicken meat ingestion	Average over land to 20 km	0.01
Egg ingestion	Average over land to 20 km	0.01
Pork ingestion	Average over land to 20 km	0.01
Fish ingestion	Each watershed	0.01

The typical farmer for this site was assumed to be a dairy farmer because the fraction of dairy locally produced was higher than the fractions for the other commodities in the analysis. The typical dairy farmer was assumed to produce a fraction of the dairy, vegetables, and fruits he consumed and to purchase all other dietary items from the local market. The fractions contaminated for each pathway were determined by adding the fraction contaminated in the local market to the fraction that the farmer home-raised and consumed from the *Exposure Factors Handbook* (U.S. EPA, 1990). For example, the central tendency contaminated fraction for belowground vegetables was calculated as 0.26 by adding the homegrown fraction of 0.25 to 1 percent of the remaining 0.75 purchased from local markets. Both the items raised on the typical farm and the items purchased from local markets had typical levels of contamination. The typical dairy farmer's exposures from direct inhalation and soil ingestion were estimated to be at levels derived from averages of air dispersion and deposition outputs to 20 kilometers over land. The typical farmer consuming fish from Thunder Bay River was also assumed to drink contaminated water from Thunder Bay River. Table A-6.12 lists the locations of contamination and the contaminated fraction by pathway for the typical farmer scenario.

Table A-6.12. Exposure Scenario for Typical Farmer, Case F

Exposure Pathway	Location for Calculating Contamination	Percent Contaminated	
Direct inhalation	Average over land to 20 km	1.0	
Soil ingestion	Average over land to 20 km	1.0	
		Central tendency	**High-end**
Belowground vegetables	Average over land to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.26	0.40 Typical farmer + 0.60 x Local market = 0.41
Aboveground produce	Average over land to 20 km	0.25 Typical farmer + 0.75 x Local market = 0.26	0.40 Typical farmer + 0.60 x Local market = 0.41
Beef ingestion	Average over land to 20 km	0.01	0.01
Milk ingestion	Average over land to 20 km	0.40 Typical farmer + 0.60 x Local market = 0.41	0.75 Typical farmer + 0.25 x Local market = 0.76
Chicken meat ingestion	Average over land to 20 km	0.01	0.01
Egg ingestion	Average over land to 20 km	0.01	0.01
Pork ingestion	Average over land to 20 km	0.01	0.01
Fish ingestion	Each waterbody	0.01	0.01

Recreational fishers were modeled for each waterbody by combining the typical resident scenario with an increased consumption of contaminated fish recreationally caught (30 g/d). The recreational fisher's exposures from direct inhalation and soil ingestion were derived from averages of air dispersion and deposition output to 20 kilometers over land. All fish in the diet was assumed to be from a single waterbody. For instance, the recreational fisher identified for Long Lake ate only fish caught in Long Lake. All other dietary items were assumed to be purchased from the local market and to contain typical levels of contamination. The recreational fisher consuming fish from Thunder Bay River was also assumed to drink contaminated water from Thunder Bay River. Table A-6.13 lists the location of contamination and the contaminated fraction by pathway for the recreational fisher scenario.

Table A-6.13. Exposure Scenario for Recreational Fisher, Case F

Exposure Pathway	Location for Calculating Contamination	Fraction Contaminated
Direct inhalation	Average over land to 20 km	1.0
Soil ingestion	Average over land to 20 km	1.0
Belowground vegetables	Average over land to 20 km	0.01
Aboveground produce	Average over land to 20 km	0.01
Beef ingestion	Average over land to 20 km	0.01
Milk ingestion	Average over land to 20 km	0.01
Chicken meat ingestion	Average over land to 20 km	0.01
Egg ingestion	Average over land to 20 km	0.01
Pork ingestion	Average over land to 20 km	0.01
Fish ingestion (30 g/d)	Each watershed	1.0

D. Air Modeling and Air Modeling Results

A test version of ISCSTDFT was the air dispersion and deposition model used to estimate air concentrations and deposition rates for Case F. Source inputs used in the modeling are listed in Table A-6.1. The meteorologic data required for the air modeling were created using PCRAMMET, DEPMET, and PMERGE preprocessors. Table A.6-14 lists site-specific data needed for the DEPMET preprocessor. The actual anemometer height was used as a DEPMET input. For the other inputs, recommendations from the DEPMET User's Guide (U.S. EPA, 1994) based on the site-specific land use data were used. Land use information for Case F was obtained from telephone surveys and assessed through topographic maps.

The ISCSTDFT model was run using 5 years of meteorological data concatenated into a multiple-year meteorological file (U.S. EPA, 1995b). Therefore, results of the ISCSTDFT modeling conducted with this multiple-year meteorological file represent a 5 year average.

The ISCSTDFT model was run using the "default" model options. The terrain option was not used because this site is an area of flat terrain, and the effects of terrain on air dispersion would not be significant for this site. Additionally, the good engineering practices (GEP) stack height was calculated using EPA's Building Profile Input Program (BPIP) to determine if building downwash should be considered for this site. Inputs to BPIP -- site-specific information on the building height, width, and location -- were available for several buildings with the potential to influence the plume dispersion from the stack. Based on this site-specific information, the actual stack height exceeded the GEP stack height as calculated by BPIP. Therefore, downwash was not used in the air dispersion modeling for Case F.

Specific receptor locations evenly spaced every 1,000 meters were identified for each watershed and waterbody using USGS topographic maps. The 5 year averages of air dispersions and deposition rates were then areally averaged over each specific watershed and waterbody.

The point of maximum combined deposition and the point of maximum vapor air concentration were used for "bounding" estimates. For a given scenario, the point of maximum concentration was used in calculating bounding risks for direct inhalation, while the maximum combined deposition or maximum concentration was used in estimating risks for other pathways. However, bounding exposure was considered only for the pathways involved in the subsistence activities for a given scenario. For example, bounding exposure for the subsistence poultry farmer was due to ingestion of soil, produce, poultry, and eggs (based on the point of maximum deposition) and to direct inhalation (based on the point of maximum concentration). The other exposure routes -- ingestion of beef, pork, milk, fish, and drinking water -- were not bounding but were, instead, based on the location of the subsistence poultry farmer. For the subsistence fisher scenario, a default watershed, which lies at the high end of the distribution of watersheds (Van der Leeden, 1990), was centered at the point of maximum combined deposition. Parameters for the bounding watershed are contained in the body of the document (Section II).

The ISCSTDFT air modeling results are presented in Figures A-6.1 through A-6.4. Figure A-6.1 shows the combined deposition of particles within 20 kilometers of Case F; Figure A-6.2 shows the air concentration of vapors within 20 kilometers of Case F; and Figures A-6.3 and A-6.4 show the wet and dry deposition of particles, respectively, within 3 kilometers of Facility F. The results are also presented in tabular form in Table A-6.15.

Table A-6.14. Air Modeling Inputs Used in ISCSTDFT Modeling

Meteorological location	
Surface / upper air	Alpena, MI / St. Marie, MI
Anemometer height (m)	6.7
DEPMET Preprocessor Inputs	
Land use within 5 km	Forest / water
Min. M-O length (m)	50.
Roughness height (m)	0.34[a]
Displacement height (m)	1.68
Noontime albedo (fraction)	0.18
Soil moisture available (fraction)	0.9
Net radiation absorbed in ground (fraction)	0.15
Anthropogenic heat flux (W/m^2)	0.0

[a] Based on a maximum roughness height of 1/20th of the anemometer height.

Table A-6.15. Results of ISCSTDFT Air Modeling for Case F[a]

Scenario	Location Distance (m)/ Direction	Particles				Vapors	
		Combined Deposition (g/m²-yr)/(g/s)	Wet Deposition (g/m²-yr)/(g/s)	Dry Deposition (g/m²-yr)/(g/s)	Air Concentration (μg/m³)/(g/s)	Wet Deposition (g/m²-yr)/(g/s)	Air Concentration (μg/m³)/(g/s)
Point of maximum combined deposition	100/WNW	0.12	0.12	0	0	0.016	0
Point of maximum vapor concentration	10,000/ESE	0.0014	0.00028	0.0011	0.0034	0.00044	0.0038
Home gardener (closest resident)	700/W	0.011	0.011	0	1.4E-05	0.015	1.4E-05
General population	--	6.7E-04	3.3E-04	3.6E-04	0.0014	5.3E-04	0.0015
Subsistence farmer - beef / pork/ poultry	16,000/NW	0.00057	0.00021	0.00036	0.0018	0.00035	0.0019
Subsistence farmer - dairy	16,000/SW	0.00037	0.00017	0.00020	0.00094	0.00030	0.0010
Subsistence fisher - Thunder Bay River	3,000/NW	0.0038	--	--	0.0037	0.0038	0.0041
Subsistence fisher - Mud /Devil's Lake	7,500/W	0.0011	--	--	0.0017	0.00083	0.0019
Subsistence fisher - Long Lake	10,500/N	0.0011	--	--	0.0028	0.00053	0.0031
		Averages over Watershed			Averages over Waterbody		
		Combined Deposition of Particles (g/m²-yr)/(g/s)	Wet Deposition of Vapors (g/m²-yr)/(g/s)	Air Concentration of Vapors (μg/m³)/(g/s)	Combined Deposition of Particles (g/m²-yr)/(g/s)	Wet Deposition of Vapors (g/m²-yr)/(g/s)	Air Concentration of Vapors (μg/m³)/(g/s)
Thunder Bay River	--	0.00076	0.00061	0.0014	0.0009	0.00076	0.0015
Mud and Devil's Lake	--	0.00062	0.00055	0.0012	0.00079	0.00079	0.0012
Long Lake	--	0.00052	0.00033	0.0019	0.00053	0.00020	0.0019

[a] The air modeling results in the table are based on an emission rate of 1 g/s from the stack.

Figure A.6.1 Combined deposition of particles within 20 kilometers of Facility F. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

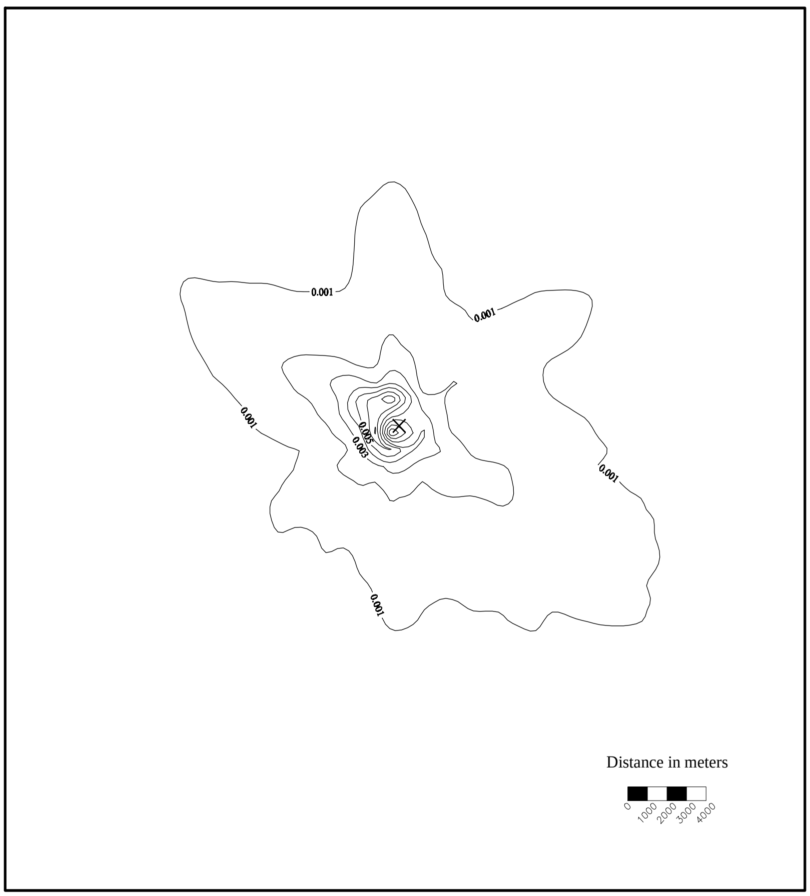


Figure A.6.2 Air concentration of vapors within 20 kilometers of facility F. Air concentration in units of micrograms per cubic meter, resulting from a unit emission rate of 1 gram per second.

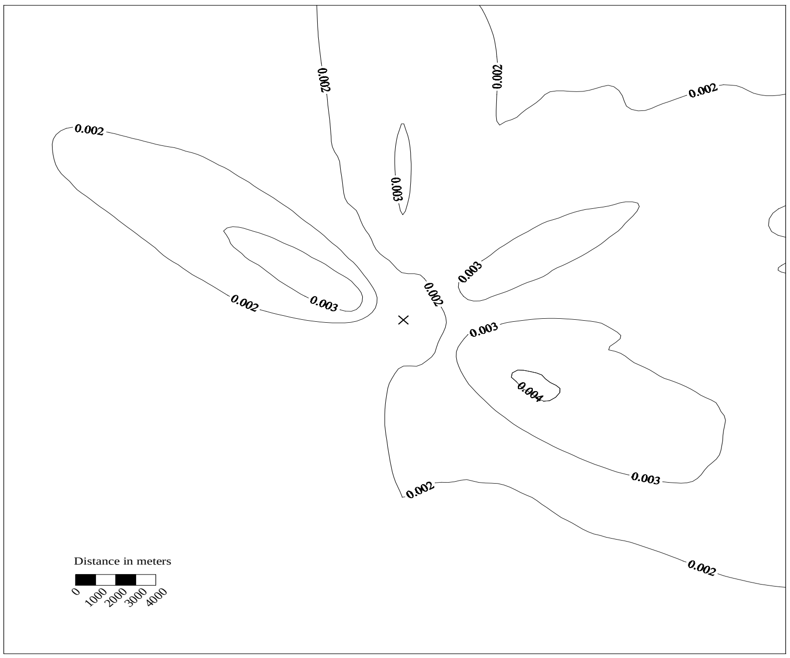


Figure A.6.3 Wet deposition of particles within 3 kilometers of Facility F. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.

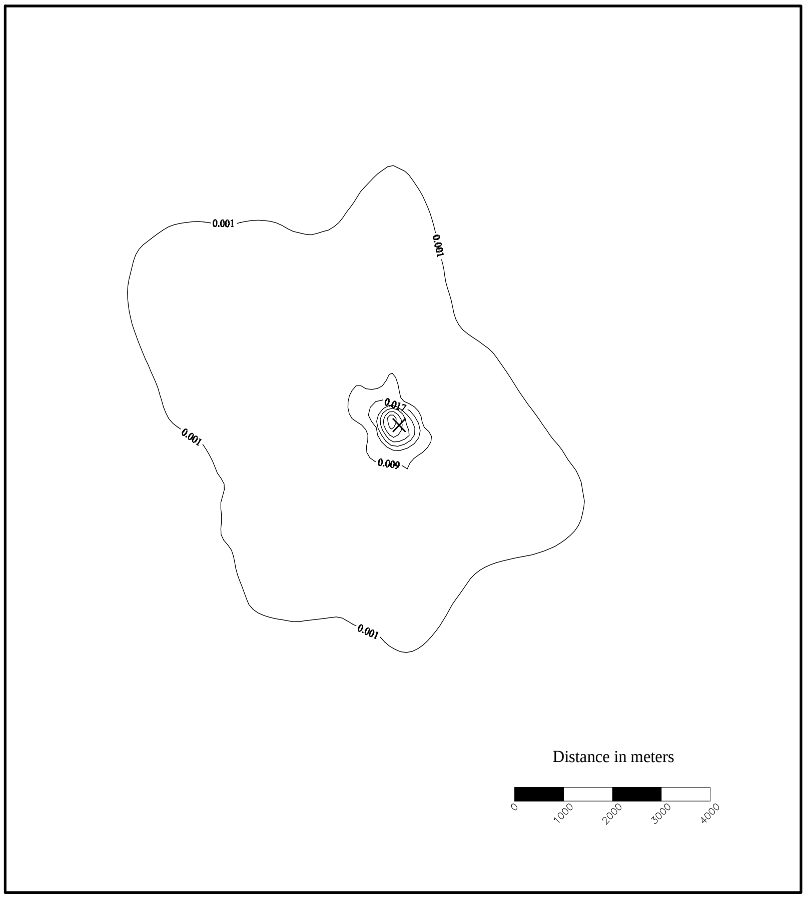


Figure A.6.4 Dry deposition of particles within 3 kilometers of Facility F. Deposition in units of grams per meter squared per year, resulting from a unit emission rate of 1 gram per second.