PART 201
GENERIC SOIL INHALATION CRITERIA FOR AMBIENT AIR: TECHNICAL SUPPORT DOCUMENT

Environmental Response Division
Michigan Department of Environmental Quality
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This document provides the technical basis for the development of generic soil inhalation criteria (SIC) for ambient air that may be used to address inhalation exposures to soil contaminants under residential, industrial, and commercial land use scenarios. This technical support document (TSD) supercedes the generic SIC TSD dated April 1, 1998. The generic SIC are presented in the Environmental Response Division Interim Operational Memorandum #18: Part 201 Generic Cleanup Criteria Tables. They are located in columns #15-18 of the Soil: Residential and Commercial I Table and columns #23-26 of the Soil: Industrial and Commercial II, III, and IV Table.

These criteria have been developed pursuant to Sections 20120a(1)(a), (b) and (d) and 20120(a)(3) of Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Section 20120a(3) requires the department to develop cleanup criteria based on human health risk assessment assumptions utilizing reasonable and relevant exposure pathways. Current soil direct contact criteria presented in the Part 201 Cleanup Criteria Tables are only protective of chronic, systemic health effects which may result from incidental ingestion of soil or direct dermal contact with soil. For some chemicals, the inhalation route of exposure may present a greater risk of harm. Therefore, the generic SIC have been developed to assess the potential for human health effects from exposure to airborne soil contaminants in ambient air.

Emissions from Part 201 facilities are not normally subject to the permit requirements of the Air Toxics Rules of Part 55, Air Pollution Control, of Act 451 with the exception of some periods of active remediation. However, compliance with ambient air screening levels developed under the authority of the Air Toxics Rules has been determined to be one way of demonstrating that soils at Part 201 facilities will not result in unacceptable emissions to ambient air. Therefore, the methods used to develop Air Quality Division (AQD) screening values and the regulations governing application of those values have been considered and employed in the development of SIC for ambient air where appropriate. Some modifications in AQD methods and applications were made in the development of Part 201 SIC.

The generic SIC are not protective of indoor inhalation exposures resulting from migration of vapors from groundwater or soil into indoor air space. Consult the “Generic Groundwater and Soil Volatilization to Indoor Air Inhalation Criteria: Technical Support Document” (August 31, 1998a) for guidance to address these pathways.

The generic SIC are intended to be protective of chronic human health effects which may result from exposure to ambient airborne contaminants. The allowable levels in soil developed under this scenario do not completely account for and may not be protective of other endpoints such as acute human health effects, odors, ocular irritation, dermal irritation or sensitization, physical hazards such as reactivity, corrosivity, or ignitability, nuisance dust conditions, and/or ecological impacts. The potential for these effects to occur must be considered to determine if more restrictive criteria are needed to ensure protection for these endpoints.

TECHNICAL DEVELOPMENT OF SIC

GENERIC RESIDENTIAL ALGORITHMS

The generic residential SIC algorithms presented below are consistent with those presented in the United States Environmental Protection Agency (EPA) Soil Screening Guidance (SSG): Technical Background Document (EPA, 1996). These algorithms yield criteria which represent concentrations of contaminants in soil in units of micrograms per kilogram (ug/kg or ppb). All exposure assumptions represent current EPA guidance. A discussion of the default exposure assumptions for residential land use may be found in the Generic Soil Direct Contact Criteria: Technical Support Document (MDEQ, 1998c). Discussion of parameters which are specific to the soil to air inhalation pathway is presented below.

The inhalation toxicity values used in the calculation of the SIC are presented in Attachment B of Operational Memorandum #18 (MDEQ, 1998d). Please note that the reference concentration (RfC) for noncarcinogens and the inhalation unit risk factor (IURF) for carcinogens are presented in micrograms per cubic meter of air [ug/m^3 and $(ug/m^3)^{-1}$, respectively]. The RfC and the IURF differ from oral toxicity values in that they represent a concentration in the media of concern (i.e., air) rather than a dose to the receptor in units of mg/kg-day. These values are presumed to be protective of most human receptors, therefore, it is unnecessary to include either body weight or inhalation rate (intake) in the generic equation. AQD screening values developed under the authority of Part 55 of Act 451 are used in lieu of EPA developed RfC's where those values are not available. Please consult the Part 55 Air Toxics Rules for information regarding development of AQD screening values.

Generic Residential SIC Algorithms Protective of Ambient Air Exposures

Carcinogens:

$$\text{Volatile Soil Inhalation Criteria} = \frac{10^{-5} \times AT}{IURF \times EF \times ED \times (1/VF)} \qquad (1)$$

where,

10^{-5} cancer risk	=	target risk
AT (averaging time)	=	25,550 days (70 x 365)
IURF (inhalation unit risk factor)	=	chemical-specific $(ug/m^3)^{-1}$
EF (exposure frequency)	=	350 days/year
ED (exposure duration)	=	30 years
VF (volatilization factor)	=	chemical-specific in m^3/kg

$$\text{Particulate Soil Inhalation Criteria} = \frac{10^{-5} \times AT}{IURF \times EF \times ED \times (1/PEF)} \qquad (2)$$

where,

10^{-5} cancer risk	=	target risk
AT (averaging time)	=	25,550 days (70 x 365)
IURF (inhalation unit risk factor)	=	chemical-specific $(ug/m^3)^{-1}$
EF (exposure frequency)	=	350 days/year

ED (exposure duration) = 30 years
PEF (particulate emission factor) = chemical-specific in m^3/kg

Noncarcinogens:

$$\text{Volatile Soil Inhalation Criteria} = \frac{THQ \times AT}{EF \times ED \times (1/RfC \times 1/VF)} \qquad (3)$$

where,

THQ (target hazard quotient) = 1
AT (averaging time) = 10,950 days (30 x 365)
EF (exposure frequency) = 350 days/year
ED (exposure duration) = 30 years
RfC (reference concentration) = chemical-specific in mg/m^3
VF (volatilization factor) = chemical-specific in m^3/kg

$$\text{Particulate Soil Inhalation Criteria} = \frac{THQ \times AT}{EF \times ED \times (1/RfC \times 1/PEF)} \qquad (4)$$

where,

THQ (target hazard quotient) = 1
AT (averaging time) = 10,950 days (30 x 365)
EF (exposure frequency) = 350 days/year
ED (exposure duration) = 30 years
RfC (reference concentration) = chemical-specific in mg/m^3
PEF (particulate emission factor) = chemical-specific in m^3/kg

The volatilization factor (VF) and the particulate emission factor (PEF) in the equations above are used to define the relationship of the acceptable level of contaminant in air to a corresponding concentration of contaminant in soil. This relationship is dependent upon the emission of contaminant from soil and the subsequent dispersion of the airborne contaminant. Emission of volatile contaminants from soil will be discussed in the Soil to Air Volatilization Factor section below. Emission of particulates from soil will be discussed in the Particulate Emission Factor section, also below. Since the dispersion of airborne contaminants in ambient air affects both the VF and the PEF, this parameter will be discussed separately under the heading of Q/C: Air Dispersion Factor.

SOIL TO AIR VOLATILIZATION FACTOR

The soil to air volatilization factor (VF) relates the acceptable concentration of a volatile contaminant in ambient air to the corresponding concentration of contaminant in soil. VF is calculated from equation (5) below using chemical-specific properties and default values for soil properties that are representative of generic conditions for Michigan.

$$VF = (Q/C) \times (1/J_s^{ave}) \qquad (5)$$

J_s^{ave}, using the Jury infinite source model is calculated as:

$$J_s^{ave} = \rho_b (4D_A/\pi t)^{1/2} \times 10^4 \, cm^2/m^2 \qquad (6)$$

The apparent diffusivity, D_A, of a chemical accounts for partitioning of contaminants between phases (liquid, solid, and gas) and is calculated as:

$$D_A = \frac{[(\Theta_a^{3.33} D_a (H' \times TAF) + \Theta_w^{3.33} D_w)/n^2]}{\rho_b K_d + + \Theta_w + \Theta_a (H' \times TAF)} \qquad (7)$$

where,

VF	Volatilization Factor	= chemical-specific in m^3/kg
J_s^{ave}	Normalized Average Flux from Soil	= chemical-specific in g/m^2-s
D_A	Apparent Diffusivity	= chemical-specific in cm^2/s
Q/C	Dispersion Factor	= source size-specific in g/m^2-s per kg/m^3
t	Exposure Time	= seconds (ED x 3.1536E+7 sec/yr)
Θ_a	Air-filled Soil Porosity	= 0.28 L_{air}/L_{soil}
n	Total Soil Porosity	= 0.43 L_{pore}/L_{soil}
Θ_w	Water-filled Soil Porosity	= 0.15 L_{water}/L_{soil}
ρ_b	Dry Soil Bulk Density	= 1.5 g/cm^3
D_a	Diffusivity in Air	= chemical-specific in cm^2/s
D_w	Diffusivity in Water	= chemical-specific in cm^2/s
H′	Dimensionless Henry's Law Constant, where H′ = HLC x 41	= unitless, chemical-specific
HLC	Henry's Law constant at 25^0 C	= chemical-specific in atm-m^3/mol
TAF	Temperature Adjustment Factor	= 0.5
K_{oc}	Soil Organic Partition Coefficient	= chemical-specific in cm^3/g (equivalent to L/Kg)
f_{oc}	Organic Carbon Content of Soil	= 0.006 in g/g (0.6%)
K_d	Soil-water Partition Coefficient	= chemical-specific in cm^3/g
	Organic Compounds	= K_{oc} (cm^3/g) x f_{oc} (g/g)
	Inorganic Compounds	= calculated value (EPA, 1996)

The VF equation (5) above is based on the assumption of an infinite source of contamination. In effect, it is assumed that the concentration of contaminant in the soil remains constant throughout the entire exposure duration. Also, that the contaminant flux from soil predicted by this model is unchanging and that air concentrations will remain constant throughout the exposure duration. Under these assumptions, exposure to airborne contaminants on the last day of the exposure duration would be the same as on the first.

The VF may also be calculated based on a known mass of contaminant using a finite source model. Both the infinite and finite source models assume that the contamination exists from ground surface to a subsurface depth. The infinite model assumes an unlimited thickness of contaminated soil, however, the finite model is based on a discrete, measured source thickness. The vertical extent of the contaminant source must, therefore, be adequately characterized throughout the facility to apply the finite source mode. The application of finite volatile SIC (VSIC), therefore, requires additional site information beyond that which is required for the application of the infinite VSIC.

Finite Source VF

The finite source model for calculation of the VF incorporates two concepts which are not included in the infinite source model. First, the vertical extent of the contamination is assumed to be a discreet, measured thickness. Second, as volatile contaminants are emitted from soil to air, an ever larger zone of depletion is assumed to be created at the soil surface. This zone (as its name implies) is depleted of contaminants over time and serves to retard volatilization of contaminants present at lower depths.

The simplified finite source model equation for VF is:

$$VF = (Q/C) \times (C_0 / \rho_b) \times (1 / J_s^{ave}) \qquad (8)$$

and

$$J_s = C_0 (D_A / \pi t))^{1/2} [1 - e^{(-d_s 2 / 4 D_A t)}] \qquad (9)$$

where,

VF	Volatilization Factor	= chemical-specific in m^3/kg
Q/C	Dispersion Factor	= source size-specific in g/m^2-s per kg/m^3
C_0	Uniform Contaminant Concentration at t=0	= 1.5 E-6 g/cm^3
ρ_b	Dry Soil Bulk Density	= 1.5 g/cm^3
J_s^{ave}	Normalized Average Flux from Soil	= chemical-specific in g/m^2-s
J_s	Instantaneous Flux from Soil at time t	= chemical-specific in g/m^2-s
D_A	Apparent Diffusivity (as above)	= chemical-specific in cm^2/s
t	Time	= seconds (s)
d_s	Thickness of Source	= site-specific in meters

In order to back calculate a normalized average flux for finite source VSIC, a uniform contaminant concentration at time zero must be assumed. This value is set equal to 1 ppm (0.001 mg/g) and adjusted using the default dry soil bulk density of 1.5 g/cm^2. This yields a contaminant concentration at time zero of 1.5E-6 g/cm^2 when converted to the appropriate units (Jury, 1983).

To calculate J_s^{ave}, the finite equation for J_s is solved iteratively for time dependent volatile emissions and the results are averaged over 30 years for residential land use and 21 years for industrial/commercial land uses. The EPA has developed the Exposure Model for Soil Organic

Fate and Transport (EMSOFT) which provides an integral solution for these calculations. The EMSOFT model eliminates mass balance violations (discussed below) previously associated with both the infinite and finite Jury models.

EMSOFT has been used to predict average flux rates for the two and five meter source thickness VSIC provided in the Part 201 Integrated Tables. This approach may be used to develop generic facility-specific SIC for source thicknesses other than those provided. The EMSOFT program also permits calculation of emission rates from contaminant sources where an overlying layer of clean soil is present or where several soil layers of differing contaminant concentrations are present at a facility. The EMSOFT computer model and user manual may be obtained from the EPA Office of Research and Development.

Since the finite VSIC are based upon a limited volume of contaminated soil, these criteria are generally less restrictive than the infinite source VSIC for the same contaminant (i.e., finite VSIC permit a higher level of contaminant to be left in place). However, for chemicals which exhibit a combination of low volatility, high affinity for soil particles and/or a molecular weight approaching or greater than 200 g/mol, the finite model may produce VSIC which are slightly more restrictive than the infinite model. This difference is a calculation artifact and becomes more probable as the source thickness is increased. Under these circumstances the infinite source VSIC is considered to be protective and is substituted for the finite VSIC where appropriate.

Mass Balance VF

The Jury model under both the infinite and finite assumption may result in mass balance violations under some conditions (i.e., the model may predict loss from soil of more contaminant than was initially present). This problem is more likely to occur for infinite source VSIC developed for very volatile chemicals which may be depleted from the soil in a shorter time period than the assumed exposure duration. To prevent mass balance violations, an alternative VF may be calculated using the mass balance model equation presented below:

$$VF = Q/C \times \frac{AT \times (3.15E-7 s/yr)}{\rho_b \times d_s \times 10^6 g/Mg} \qquad (10)$$

where,

VF	Volatilization Factor	= chemical-specific in m^3/kg
Q/C	Dispersion Factor	= source size-specific in g/m^2-s per kg/m^3
AT	Exposure Period	= scenario specific in years
ρ_b	Dry Soil Bulk Density	= 1.5 Mg/m^3
d_s	Average Source Depth	= site specific in meters

The mass balance model cannot be calculated without knowledge of the depth of the contaminant source (d_s). This check for mass balance violations cannot, therefore, be applied to the infinite source model without facility-specific information regarding the vertical extent

(i.e., thickness) of contaminated soils. A mass balance VSIC greater than the infinite source VSIC and/or a finite source VSIC indicates that the Jury model is over predicting volatile flux from soil. When this occurs, the mass balance VSIC may be used in place of either the infinite or finite VSIC. As discussed above, finite VSIC generated using the EMSOFT model are not subject to mass balance violations.

Soil Properties for the VF

The default values for the soil properties in the VF equations above are representative of generic conditions for Michigan. The air-filled soil porosity property has the most significant effect on the emission of contaminants from soil and is dependent upon the assumed moisture content of the soil. The Jury model adjusts the air-filled ($\Theta_a^{3.33}$) and water-filled porosity ($\Theta_w^{3.33}$) values to account for the difference between total and effective porosity. Effective porosity is that portion of the total porosity that is actively engaged in transport of contaminants through the soil pore space. The EPA default values given in the SSG will therefore be used for these soil properties without the adjustment for effective porosity used to generate generic soil saturation screening concentrations (C_{sat}) (MDEQ, 1998b). The EPA default value of 0.006 g/g or 0.6 percent for the fraction of organic content (f_{oc}) in the soil is the mean value for the top 0.3 meters of Class B soils from Carsel et al., (1988) and is consistent with the range of f_{oc} for Michigan.

Due to wide variation in site-specific soil characteristics, it is possible that the generic soil assumptions may not accurately represent the conditions at certain properties. For these cases, facility-specific soil values may be used in place of the generic assumptions and still allow for generic closures under Section. 20120a(1). This type of closure is referred to as a “generic facility-specific” closure. Any of the following three soil parameters may be substituted in place of the generic default values: soil dry bulk density, soil organic carbon content, and soil porosity.

Dry soil bulk density (ρ_b) can be determined by weighing a thin-walled tube soil sample (e.g., Shelby tube) of known volume and subtracting the tube weight to estimate “field” bulk density (ASTM, 1994; D2937). A moisture content determination (ASTM, 1992; D2216) is then performed on a subsample of the tube sample to adjust field bulk density to dry bulk density. Soil organic carbon content (f_{oc}) is determined by burning off soil carbon in a controlled-temperature oven (Nelson and Summers, 1982). Sieve and hydrometer analyses must be performed to verify field soil classifications (e.g.,, clay) to support the use of published values from the scientific literature (ASTM, 1983; D2487).

Temperature Adjustment Factor (TAF)

Henry’s Law Constants are typically reported in the literature under the standard temperature of 25^0 C. The chemical-specific dimensionless Henry’s Law Constant (H’) contained in equation 7 is multiplied by the TAF of one-half (0.5) to account for reduced volatility of the contaminant under the annual average soil temperatures in Michigan of 10^0 C. Support for the TAF may be found in Howe et al., (1987). This approach is consistent with the use of annual average meteorological data in the development of the VF as will be discussed below for the Q/C dispersion factor.

Data to support the calculation of an annual average soil temperature in Michigan was obtained from the Agricultural Weather Office and the Michigan Department of Agriculture/State Climatologist at Michigan State University (MSU) (East Lansing, Michigan). Soil temperatures are routinely gathered at the MSU agricultural station during the Michigan growing season. While no data is available for the colder months, examination of the existing data indicates that soil temperatures parallel air temperatures with a lag time of a few hours. This effect was confirmed by Dr. Fred V. Nurnberger, State Climatologist (Nurnberger, 1997). Therefore, it may be assumed that an annual average *air* temperature will approximate an annual average *soil* temperature. While temperatures vary between years and from the upper peninsula to the lower, 10^0 C is consistent with an average annual air temperature for the state as a whole and this value was, therefore, chosen to represent an annual average soil temperature for SIC development.

Decay Constants

Many contaminants will decay or degrade over time through various mechanisms such as hydrolysis, photolysis and microbial degradation. However, environmental degradation is a complex process and is dependent upon several site-specific conditions which are not amenable to a generic approach. MDEQ may consider methods to incorporate decay constants into the generic VSIC and this issue may be addressed in future guidance. In the interim, no degradation will be assumed in the calculation of generic VSIC. The party proposing a plan (PPP) has the option of demonstrating a site-specific rate of decay which can be used to adjust the generic VSIC. Use of site-specific decay rates will not preclude closure under a generic land use category.

Soil Saturation Limit

The development of soil saturation screening concentrations (C_{sat}) is discussed in the Generic Soil Saturation Screening Concentrations: Technical Support Document" (MDEQ, 1998b). C_{sat} is defined as the level in soil at which the soil pore water, pore air and surface sorption sites are saturated with contaminant. At or above this level, free phase contaminant may be present in soil. Under these conditions, the Jury model can no longer predict an accurate VSIC because Henry's law constants which predict partitioning of a chemical between the vapor phase and water are not applicable to free phase contaminants. However, at C_{sat}, the emission of a volatile contaminant from soil to ambient air reaches a plateau and does not increase even when more chemical is added to the soil matrix (EPA, 1996). Target risk levels for ambient air are not exceeded at C_{sat} or greater concentrations for those chemicals with calculated VSIC which exceed C_{sat}. Therefore, the soil to ambient air pathway does not appear to be a human health concern for those chemicals with calculated VSIC greater than C_{sat}.

Chemical-Specific Parameter Values

The EPA SSG contains guidance on the collection and handling of chemical-specific values reported in the scientific literature. The values presented in the SSG Technical Support Document were derived for EPA under contract with Research Triangle Institute (RTI). Since reported values for some chemical parameters vary widely, RTI conducted a qualitative review of the available values and geometric means were calculated as appropriate (EPA, 1996). EPA chemical-specific values were used in the development of Part 201 cleanup criteria, including the SIC, for those chemicals presented in the SSG. For chemicals not in the SSG, chemical-specific parameter values were obtained through a search of the scientific literature and geometric means were developed following the procedures employed by RTI (MDEQ, 1997).

Reported organic carbon partition coefficient (Koc) values were found to vary widely and no values are reported for many chemicals. Therefore, EPA relied upon the relationship of octanol water partition coefficient (Kow) values to Koc values to predict Koc values by employing a regression analysis (EPA, 1996). The regression equation is presented below.

$$\log Koc_{(L/kg)} = 0.00028 + (0.983 \times \log Kow) \quad (11)$$

This equation performs well for most chemicals but consistently over predicts Koc values for volatile organic compounds, chlorinated benzenes and some chlorinated pesticides. For these compounds the following equation is used to calculate Koc.

$$\log Koc_{(L/kg)} = 0.0784 + (0.7919 \times \log Kow) \quad (12)$$

Chemical-physical parameters required for the calculation of VSIC are presented in Attachment B of Operational Memorandum #18 (MDEQ, 1998d). VSIC cannot be calculated for all chemicals on the Part 201 list due to the lack of values for one or more chemical parameters. Additional VSIC will be developed as more chemical-specific values are identified. Chemicals that are designated as "ID" (insufficient data) for the SIC pathways are lacking either chemical-specific data or toxicological data necessary to calculate a criterion.

PARTICULATE EMISSION FACTOR

The soil to air particulate emission factor (PEF) relates the acceptable concentration of a particulate contaminant in ambient air to the corresponding concentration of contaminant in soil. The PEF equation incorporates factors which account both for emission of particulates from soil and dispersion after the particulates become airborne. Emission is assumed to occur due to both wind erosion and vehicle traffic. The general equation is presented below. Default values for PEF parameters are identified in Attachment A.

$$PEF = (Q/C) \times 1/[(Ew \times (1-V)) + Ev] \quad (13)$$

where,

PEF	Particulate Emission Factor	= chemical-specific in m^3/kg
Q/C	Dispersion Factor	= source size-specific in g/m^2-s per kg/m^3
Ew	Emission due to wind	= g/m^2 per s
Ev	Emission due to vehicle traffic	= g/m^2 per s
V	Vegetative Cover (unitless)	= 0.5 (50%)

Particulate Emission Due to Wind Erosion (Ew)

Ew represents the emission of a chemical from soil due to wind erosion. Parameters which influence this value include meteorological factors such as the annual average wind speed and the equivalent threshold value of wind speed at 7 meters. Default values for meteorological factors have been obtained from the data set selected to model the Q/C dispersion factor discussed below. Attachment A, the PEF Worksheet, presents the assumptions and calculations used in developing the generic Ew values.

Ew may be adjusted to account for vegetative cover at a facility. No data are available to estimate the distribution of vegetative cover values for Michigan. In the absence of data, the mid-range value of 0.5 (50 percent) was chosen as a central tendency value. If vegetative cover at a facility differs significantly from this value, a facility-specific evaluation may be necessary.

Meteorological data characteristic of a specific location may be used to generate alternative cleanup criteria. However, it is not appropriate to combine facility-specific meteorological data with the defaults used to calculate generic criteria. It may not be necessary to generate data for a particular location, rather data from an existing monitoring location more appropriate for a facility may be used in place of the defaults presented in Attachment A. Please contact an ERD toxicologist for further information concerning location-specific meteorological analysis. Use of location-specific meteorological data does not preclude closure under a generic land use category.

Particulate Emission due to Vehicle Traffic (Ev)
Ev accounts for emission of chemicals from soil due to passenger vehicle traffic. This source of emission was not considered by the EPA in the Soil Screening Guidance, therefore, the vehicle traffic emissions equation presented in EPA's Compilation of Air Pollution Emission Factors (1995) was used to generate default vehicle emission rates. Attachment B contains the default assumptions and equations used to calculate Ev's for residential and industrial/commercial scenarios. Note that the value for Ev is directly proportional to the number of passenger vehicle trips per day assumed for each scenario (e.g., the residential Ev for 10 round trips per day is twice that for 5 round trips per day). A party proposing the plan (PPP) may use this relationship to adjust the Ev value if it can be demonstrated that vehicle traffic at a facility differs from the default assumptions. The Ev values assume that vehicles at the facility are primarily passenger automobiles. At facilities where trucks and other heavy equipment are expected to be present, a facility-specific assessment of particulate emission due to vehicle traffic may be required.

Q/C: AIR DISPERSION FACTOR

The Q/C factor accounts for dispersion of airborne contaminants. The SSG presents a default value for this parameter which represents the 90th percentile of the distribution of nationally modeled Q/C values from 29 locations. No Michigan locations were included in these modeling efforts, therefore, air dispersion modeling was used to develop a Michigan-specific default dispersion factor for Part 201 SIC. A half-acre (0.5) default source size is considered to be representative of a residential property and is consistent with current EPA recommendations for residential facilities. Adaptation of the generic half-acre SIC for other source sizes will be discussed under "Application of SIC" below.

Location Selection of Q/C Modeling Data
A half-acre source was modeled with 15 sets of meteorological data routinely used in Michigan air dispersion modeling. The most recent year of available data for each location was chosen (in most cases this was 1991). Maximum, annual average concentrations were obtained using EPA's ISCST3 model assuming a standard emission rate of contaminant from soil of 1 g/m^2-sec.

From these results, three meteorological locations were selected and modeled with the most recent 5 years of data (in all 3 cases this was 1987-1991). These datasets were selected based on location within an area of the state that is both agricultural and industrial, availability of 5 years of recent meteorological data and the conservativeness of the 1991 data. However, the three locations selected do not represent "worst case" meteorological conditions for the state. The 5-year analysis was necessary to ensure that the year of data chosen to calculate the Q/C values was representative of general weather conditions for that area (i.e., the year did not represent unusual weather events). The three meteorological locations selected were Midland-Bay City-Saginaw (MBS), Grand Rapids (GRR), and South Bend (SBN). While SBN does not lie within the geographical boundaries of the state of Michigan, the dataset from this location is considered representative of southwest Michigan and is routinely used in air modeling by AQD. SBN was chosen as the default location for conducting the air dispersion modeling for the generic SIC. This location represents roughly the 50th percentile of the 15 Michigan meteorological monitoring locations originally modeled.

Air Dispersion Model

The EPA ISCST3 area source model is used with rural dispersion coefficients and several default assumptions to estimate the generic dispersion of airborne contaminants. For some locations, urban dispersion coefficients may be more appropriate and may be used in the development of generic facility-specific Q/C dispersion factors. The emission height in the ISCST# model was set at zero (0) since contaminants are assumed to be emitted directly from the soil surface. Additional assumptions are discussed below.

Receptor Height - The Source Receptor Analysis Branch of the EPA Office of Air Quality Planning Standards (OAQPS) has historically recommended a receptor height of zero for air dispersion modeling. MDEQ AQD policy agrees with this position and supports the use of a receptor height of zero to represent a ground level receptor.

The appropriate receptor height for the ISCST3 area source model for ground level receptors and emissions was investigated by Environmental Quality Management (EQM) under contract with EPA. In a technical memorandum dated November 6, 1996, Mr. Craig Mann conveyed EQM's findings to the EPA. The wind tunnel experiments conducted to verify the ISCST3 area source algorithm indicate that the model performs well in the horizontal direction and accurately predicts down-wind concentrations. However, the model algorithm does not account for phenomena such as ground turbulence and temperature cycles which act to mix air concentrations in the first few feet above the ground surface. As a result, the model overpredicts the concentration gradient in the vertical direction resulting in an underestimation of concentrations at elevated heights. Algorithms which account for ground level phenomena may be available but have not been incorporated into the ISCST3 area source model or any other available program.

In consideration of the above discussion, EPA recommends a zero foot receptor height be used to assess ground level exposures to soil emissions and acknowledges this to be a conservative assumption. Therefore, in keeping with both EPA and MDEQ AQD recommendations, a zero foot receptor height was used to represent a ground level receptor in the calculations of the air dispersion factor for the SIC. The use of a zero-foot receptor height will be reconsidered as revised air dispersion models become available for on-source, ground level receptors.

Modeled Air Concentration - Dispersion analysis for SIC development requires modeling of predicted air concentrations based on an assumed uniform emission rate from the source area of 1 g/m^2-sec. A receptor grid is imposed on the half-acre source area and annual average air concentrations are estimated for each discrete receptor location based on meteorological data. The Q/C for Part 201 SIC development is the 90th percentile of the distribution of modeled annual average air concentrations for all on-property receptor locations.

Short-term Emission and Dispersion of Volatiles and Particulates

While some variation in the emission of *volatile* contaminants from soil as a result of changing air temperature and meteorological conditions may occur, these variations are not expected to result in significant fluctuations in ambient air concentrations. Therefore, all VSIC are based on annual average air dispersion modeling. Since both the emission and dispersion of *particulates* are dependent upon meteorological conditions, day-to-day variations may have significant effects on the resulting ambient air concentration. The particulate SIC (PSIC) must, therefore, be adjusted to protect against likely short-term peaks in particulate ambient air concentrations.

The formula for PEF represents annual average emission and dispersion of PM-10 particulates. It is not appropriate for evaluating short-term exposures. However, the available models for predicting short-term particulate emission rates are very conservative and not intended for the currently proposed use. Therefore, AQD field monitoring data are used to characterize the likely variation between annual and short-term ambient air particulate levels for Michigan.

Data are available for several land use categories at various locations in Michigan for both PM-10 levels and total suspended particulates (TSP). PM-10 is that fraction of the total suspended particulate matter less than or equal to 10 microns in diameter. Particles of this size are considered to be fine enough to enter the respiratory system and to become lodged in the alveoli. PM-10 levels were chosen as the appropriate standard for comparison to the particulate levels predicted by the annual PEF equation. The data indicate that Wayne County has high particulate levels relative to the remainder of the state. However, levels are consistent for the remainder of the state across all land uses and settings. These data, excluding those datasets from Wayne County, are used to establish average annual and 24-hour PM-10 concentrations for Michigan.

The annual average PM-10 level is based on a dataset of 24-hour averages. This allows for the construction of a distribution of 24-hour values and associated percentiles. The average PM-10 level from this distribution (equivalent to an annual average) is 20 ug/m^3 and the 90th percentile is 40 ug/m^3. This suggests that peak particulate levels for a given 24-hour period are likely to be twice as high as an annual average. This assumption is used to adjust the PSIC for the subset of chemicals for which short-term levels may pose a human health risk. PSIC were adjusted by a factor of 2 for all chemicals which are associated with quarterly, 24-hour, 8-hour or 1-hour averaging times under the Air Toxics Rules. No Michigan-specific particulate data are available for less than 24-hour time periods. However, data are available from several other states which indicates that the ratio of annual to 1 hour or 8 hour particulate levels is not greatly different from the annual to 24-hour ratio.

SIC FOR INDUSTRIAL/COMMERCIAL FACILITIES

Two distinct receptor populations must be considered in the development of SIC for industrial and commercial facilities: on-property workers and off-property, near-by residents. Since both Part 201 and Part 55 rules require compliance with residential criteria at the property boundary of a facility, industrial/commercial SIC must consider the need to protect off-property receptors if they represent the more highly impacted receptor group.

Off-property Residential Receptor

In order to assess which of these two receptor populations would control development of industrial/commercial SIC, additional dispersion modeling was conducted to predict air impacts to off-property, near-by receptors. Inputs to the ISCST3 model were identical to those used to predict on-property impacts (i.e., the SBN dataset), however, the Q/C values for off-property impacts are based on the 90th percentile of the concentrations predicted by the model for the perimeter of the source area. SIC protective of off-property exposures were developed using the perimeter Q/C and the residential default exposure values described previously.

On-property Worker

Calculation of industrial/commercial SIC for on-property workers relied upon the initial modeling efforts for the generic residential SIC to predict the Q/C values. Several parameters were adjusted in the generic equation, however, to characterize the worker population. Consistent with the default exposure values discussed in MDEQ, 1998c, the exposure duration (ED) was adjusted to 21 years and the exposure frequency (EF) to 245 days.

Intake rate (i.e., inhalation rate) is not explicitly included in the generic residential equations. It is, however, implicit in development of the inhalation toxicity values. The default intake rate for adults is assumed to be 20 m^3/day. Because continuous exposure is not characteristic of worker exposures in commercial and industrial settings, an adjusted intake rate (AIR) of 20 m^3/day /10 m^3/day (i.e., a factor of 2) was added to the equation. The AIR is applied only to carcinogenic chemicals for consistency with currently proposed AQD administrative rules. The 10 m^3/day intake rate for workers is consistent with both EPA and Occupational Safety and Health Administration (OSHA) standard default values and assumes that a worker engaged in moderate activity will respire more heavily while on the job than during light activity and resting portions of a day.

Adjustments to the VF and PEF for On-property Workers

The VF for the on-property worker scenario is different than that for the residential scenario since the exposure period used in the calculation for the J_s^{ave} corresponds to the ED of 21 years (see discussion of the J_s^{ave} equation).

The PEF is adjusted to account for the greater level of vehicular traffic at industrial or commercial facilities (see attachment B). The residential default of 50 percent vegetative cover was retained for this calculation, however, it is anticipated that some industrial facilities may not be as heavily vegetated. Therefore, this value must be evaluated for its appropriateness to the facility in question.

Results

A comparison of SIC generated under these two scenarios indicates that the on-property worker scenario generates more restrictive industrial/commercial PSIC than the off-property residential scenario. Conversely, the off-property residential scenario produces more restrictive industrial/commercial VSIC. However, the disparity between the on-property worker VSIC and the off-property residential VSIC is minimal. Given the level of uncertainty surrounding the SIC and the conservativeness of perimeter modeling to develop the VF for the off-property scenario, this disparity does not appear to be significant. Therefore, both the VSIC and the PSIC for industrial/commercial sites will be based on protection of the on-property worker.

Generic Industrial/Commercial SIC Algorithms Protective of Ambient Air Exposures

Generic industrial/commercial SIC equations with worker exposure default values are presented below. Default exposure assumptions for industrial and commercial land uses are discussed in Generic Soil Direct Contact Criteria: Technical Support Document (MDEQ, 1998c).

Carcinogens:

$$\text{Volatile Soil Inhalation Criteria} = \frac{10^{-5} \times \text{AT} \times \text{AIR}}{\text{IURF} \times \text{EF} \times \text{ED} \times (1/\text{VF})} \qquad (14)$$

where,

10^{-5} cancer risk	= target risk
AT (averaging time)	= 25,550 days (70 x 365)
AIR (adjusted inhalation rate)	= 20 m^3/d /10 m^3/d
IURF (inhalation unit risk factor)	= chemical-specific $(ug/m^3)^{-1}$
EF (exposure frequency)	= 245 days/year
ED (exposure duration)	= 21 years
VF (volatilization factor)	= chemical-specific in m^3/kg

$$\text{Particulate Soil Inhalation Criteria} = \frac{10^{-5} \times \text{AT} \times \text{AIR}}{\text{IURF} \times \text{EF} \times \text{ED} \times (1/\text{PEF})} \qquad (15)$$

where,

10^{-5} cancer risk	= target risk
AT (averaging time)	= 25,550 days (70 x 365)
AIR (adjusted inhalation rate)	= 20 m^3/d /10 m^3/d
IURF (inhalation unit risk factor)	= chemical-specific $(ug/m^3)^{-1}$
EF (exposure frequency)	= 245 days/year
ED (exposure duration)	= 21 years
PEF (particulate emission factor)	= chemical-specific in m^3/kg

Noncarcinogens:

$$\text{Volatile Soil Inhalation Criteria} = \frac{THQ \times AT}{EF \times ED \times (1/RfC \times 1/VF)} \qquad (16)$$

where,

THQ (target hazard quotient)	=	1
AT (averaging time)	=	7,665 days (21 x 365)
EF (exposure frequency)	=	245 days/year
ED (exposure duration)	=	21 years
RfC (reference concentration)	=	chemical-specific in ug/m^3
VF (volatilization factor)	=	chemical-specific in m^3/kg

$$\text{Particulate Soil Inhalation Criteria} = \frac{THQ \times AT}{EF \times ED \times (1/RfC \times 1/PEF)} \qquad (17)$$

where,

THQ (target hazard quotient)	=	1
AT (averaging time)	=	7,665 days (21 x 365)
EF (exposure frequency)	=	245 days/year
ED (exposure duration)	=	21 years
RfC (reference concentration)	=	chemical-specific in ug/m^3
PEF (particulate emission factor)	=	chemical-specific in m^3/kg

APPLICATION OF SIC

As indicated by the discussion above, separate criteria are provided for volatile and particulate emissions. To determine overall compliance with soil cleanup criteria for the soil to ambient air pathway, compliance must be demonstrated for both the VSIC and PSIC for each chemical of concern.

Statistical evaluation of soil data may be conducted to demonstrate compliance with both the VSIC and PSIC. Generally, the 95 percent UCL is the appropriate statistic to compare to the criteria, but a PPP has the option of proposing other approaches for MDEQ review

The SIC are protective of long-term, systemic health effects only. A PPP has the responsibility to demonstrate that soil contaminants left in place will not result in unacceptable acute exposures or other health effects such as ocular irritation, dermal irritation or sensitization, physical hazards such as reactivity, corrosivity, or ignitability, nuisance dust conditions, and/or ecological impacts.

Closure Options

The SIC are developed using generic default assumptions for meteorological conditions, soil characteristics and human exposure parameters. Compliance with the SIC for the relevant land use provides for a generic closure under Part 201 Section 20120a(1)(a), (b), and (d) for the soil to ambient air pathway. Other options for compliance with the SIC include: a generic facility-specific closure under Part 201 Section 20120a(1)(a), (b), and (d), a limited closure under Part 201 Section 20120a(1)(f), (g), and (i), or a site-specific closure under Part 201 Section 20120a(2). Facility-specific and limited closures are discussed separately for the VSIC and PSIC below.

Site-Specific Closures

A site-specific closure is required if facility-specific values for exposure parameters (e.g., exposure duration and exposure frequency) are substituted for the default values used to develop the generic SIC. Site-specific closures are provided for in Part 201 Section 20120a(2). A restrictive covenant for the facility must ensure that future exposures will remain consistent with the exposure assumptions used to generate the site-specific SIC values.

Air Monitoring to Determine Compliance

Ambient air monitoring may be used to determine that contaminant concentrations in facility soils will not result in unacceptable inhalation exposures at Part 201 facilities. Monitoring results must be compared to AQD Initial Threshold Screening Levels (ITSLs) for noncarcinogens and Secondary Risk Screening Levels (SRSLs) for carcinogens. Monitoring plans must be designed to adequately characterize both current and future facility conditions. For a generic closure, facility conditions during air monitoring must be consistent with the assumptions which are used in the development of the otherwise applicable SIC for the appropriate land use. In some cases, the use of ambient air monitoring to determine compliance may necessitate a limited rather than a generic closure. For example, if a source area is subsurface and is covered by soil exhibiting lesser contaminant concentrations, land use restrictions are required to ensure that the more highly contaminated soils are not brought to the surface where their impact on ambient air may be greater.

VOLATILE SOIL INHALATION CRITERIA (VSIC)

Chemicals of Concern for the VSIC

Generic VSIC are not presented in the Integrated Table for all hazardous substances currently regulated under Part 201. Some substances do not volatilize (e.g., elemental inorganics) or volatilize at such low levels that their vapor phase concentration will not reach a level which would pose a health risk via this pathway. Chemicals of concern for this pathway are generally identified as those having a Henry's Law Constant equal to or greater than 1E-5 atm-m^3/mol at standard temperature and pressure (MDEQ, 1998a). Chemicals **not** of concern for the volatilization to ambient air pathway are designated as "NLV" (not likely to volatilize). Those compounds lacking sufficient data for VSIC calculation are indicated as "ID."

The volatilization from soil to ambient air pathway is not a concern for chemicals with calculated VSIC greater than their respective C_{sat} screening values. Please see the Part 201 Generic Soil Saturation Screening Concentrations: Technical Support Document (August 31, 1998b) for guidance on how to address soil concentrations which exceed C_{sat} screening concentrations. Note that VSIC which exceed the respective chemical-specific C_{sat} have been presented as calculated in the Part 201 Integrated Table. This was done to ensure that the appropriate value is used to adjust the half-acre VSIC for other source sizes as will be discussed below.

VSIC Generic Closures

A generic closure is acceptable under Part 201 Section 20120a(1)(a), (b), and (d) for facilities where concentrations in soil, both surface and subsurface, do not exceed the generic VSIC. The generic criteria are applicable to the entire soil column since both surface and subsurface soil concentrations may contribute to volatile emissions. Compliance with the generic criteria may be demonstrated by comparing facility soil concentrations to the infinite source VSIC, the finite source VSIC or the mass balance VSIC as described below.

Infinite Source VSIC

Generic infinite source VSIC are to be used as a "first cut" screening tool. These criteria may be used as a screen at facilities where the vertical extent of contamination is not well characterized (e.g., Baseline Environmental Assessments, determination of facility status). If contaminant concentrations **do not** exceed these criteria, the soil to ambient air pathway is not a concern for the facility. If contaminant concentrations **do** exceed infinite source VSIC, the vertical extent of contamination must be characterized before application of either the finite source VSIC or the mass balance VSIC.

Finite Source VSIC

Generic finite VSIC are provided in the Part 201 Integrated Tables for 2 and 5 meter source thicknesses. These criteria may be applied where the vertical extent (i.e., thickness) of the contaminant source is no greater than the thickness assumed for these scenarios.

Finite source VSIC may be used to determine the need for a response action to address soil contamination or to verify the adequacy of soil remediation when the soil-to-air pathway is the most restrictive and relevant pathway.

Mass Balance VSIC

Mass balance VSIC may be calculated using equation (10) as discussed above where the vertical extent of the contaminant source (d_s) is characterized. A mass balance VSIC greater than the infinite source VSIC and/or a finite source VSIC indicates that the Jury model is over predicting volatile emission from soil. When this occurs, the mass balance VSIC may be used in place of either the infinite or finite VSIC.

VSIC Generic Facility-Specific Closure

A generic facility-specific closure is acceptable under Part 201 Section 20120a(1)(a), (b), and (d) where local meteorological data is used to develop the Q/C (dispersion factor) or where facility-specific data are substituted for the generic soil characteristics used to develop the VF. Any of the following three soil parameters shown in equation (7) may be substituted in place of the generic default values: dry soil bulk density, soil organic carbon content, and soil porosity. Refer to the discussion of soil properties for the VF equation above for guidance on facility-specific determination for these parameters. MDEQ AQD may be consulted to perform air dispersion modeling based on local meteorological data.

A generic facility-specific closure may also be appropriate where finite source VSIC or mass balance VSIC are developed based on facility characteristics. For example, development of VSIC for source thicknesses other than the 2 and 5 meter values provided in the Integrated Tables would provide for a generic facility-specific closure.

VSIC Limited Closures

A limited closure is acceptable under Part 201 Section 20120a(1)(f), (g), and (I) if volatilization of soil contaminants to the ambient air is determined by the department to be prevented by an engineered exposure barrier. A limited closure is also appropriate when emissions from a subsurface source are limited or prevented by an overlying layer of clean (or cleaner) soils. A restrictive covenant is required to ensure that exposure barriers remain in place and that subsurface soils which exceed the applicable VSIC are not brought to the surface.

PARTICULATE SOIL INHALATION CRITERIA (PSIC)

Chemicals of Concern for the PSIC

Since all chemicals may be emitted as particulates from soil, PSIC have been calculated for all compounds on Part 201 Integrated Tables where sufficient toxicological inhalation data were available. Those compounds lacking sufficient data are indicated as “ID.”

Note that all PSIC have been presented as calculated in the Part 201 Integrated Table. This was done to ensure that the appropriate value is used to adjust the half-acre PSIC for other source sizes as will be discussed below.

A 50 percent vegetative cover is assumed for all land uses and is used in the PEF equation to adjust the expected emission of particulates from soil due to wind erosion. Professional judgment must be used to determine if the vegetative cover at a facility is consistent with this value, particularly at industrial facilities where activities may prevent vegetative growth. Additionally, professional judgment must be used in situations where vehicle traffic at a facility will be greater than that assumed for the generic scenarios. Consult an ERD toxicologist for further guidance on facilities where these conditions are noted.

PSIC Generic Closures

A generic closure is acceptable under Part 201 Section 20120a(1)(a), (b), and (d) for sites where concentrations in soil, both surface and subsurface, do not exceed the generic PSIC.

For generic closures, the PSIC will apply to the entire soil column since no restriction prevents subsurface soils from being brought to the surface where they will be subject to emission forces of wind and vehicle traffic.

PSIC Generic Facility-Specific Closures
A generic facility-specific closure is acceptable under Part 201 Section 20120a(1)(a), (b), and (d) where local meteorological data is used to develop the Q/C dispersion factor and the E_w wind erosion factor. Since the same dataset is used to develop both these parameters in the PEF equation (13), it is not appropriate to use a mix of facility-specific data and the default values used to develop the generic PSIC.

PSIC Limited Closures
A limited closure is acceptable under Part 201 Section 20120a(1)(f), (g), and (I) if emission of particulate contaminants from soil to the ambient air is determined by the department to be prevented by an engineered exposure barrier. A limited closure is also appropriate when emissions from a subsurface source are limited or prevented by an overlying layer of clean (or cleaner) soils. A restrictive covenant is required to ensure that exposure barriers remain in place and that subsurface soils which exceed the applicable PSIC are not brought to the surface where they will be subject to emission forces of wind and vehicle traffic.

APPLICATION OF SIC FOR OTHER SOURCE SIZES

An underlying assumption of the generic SIC is that the area of soil contamination is equal to half-acre. The source size is defined as the areal extent of contaminated soil and is specified as an input to the ISCST3 model. In order to adapt the generic SIC for a half-acre source to larger and smaller source sizes, air dispersion modeling was used to provide a set of modifiers to adjust the criteria presented in the Part 201 Integrated Tables. The modifier corresponding to a source size which is at least as large as the source size of the facility in question should be chosen. For example, if the source size at a facility is 8 acres, the generic SIC for half-acre is multiplied by the modifier for 10 acres to provide generic SIC for a 10-acre facility. The PPP retains the option to conduct facility-specific meteorological modeling for other source sizes. Criteria for a half-acre source size in the Part 201 Integrated Tables which exceed 100 percent (i.e., 1.0E+9) have been presented as calculated to ensure that the correct value is used to adapt the half-acre criteria for larger or smaller source sizes. Modifiers are presented below.

Modifiers		
Source Size (sq. feet or acres)	Q/C (g/m^2-s per kg/m^3)	Modifier
400 sq feet	261.26	3.17
1000 sq feet	180.76	2.2
2000 sq feet	144.91	1.76
½ acre	82.33	1
1 acre	71.74	0.87
5 acre	54.62	0.66
10 acre	49.13	0.6
32 acre	41.55	0.5
100 acre	35.66	0.43

Source Size Characterization

Characterization of the source size need not be precise to determine compliance with screening criteria. For example, if the source size is estimated to be greater than 1 acre but less than 5 acres, the 5-acre SIC may be applied as a conservative screen. The soil to ambient air pathway would not be a concern at this facility if soil concentrations do not exceed the 5-acre SIC. If exceedances are noted, the PPP may then refine the source size characterization to more accurately define the applicable criteria.

Land Use Categories

Generic exposure assumptions (e.g.,, exposure duration and exposure frequency) for residential, industrial and commercial land use are discussed in Part 201 Operational Memorandum #18 (MDEQ, 1998d). Consistent with the discussion in Memorandum #18, Commercial Subcategory I land use requires the application of residential criteria. This land use category may include but is not limited to day care centers, any form of educational use, hospitals, elder care centers, and nursing homes. Industrial/Commercial SIC are applicable under the Industrial and Commercial II through IV land use categories. A demonstration that facility activities are consistent with the assumed exposure assumptions used in the development of generic land use based cleanup criteria is required.

SIC Application Example

An additional underlying assumption of the generic SIC is that soil contaminants are homogeneous throughout the source area and that this homogeneous source produces a modeled concentration in air. A homogeneous pattern of contamination is unlikely at most Part 201 facilities with the possible exception of uniform fill material. It is not feasible to address all possible scenarios under the generic approach, however, consider the following example of a multiacre facility with several small source areas. The entire facility covers 10 acres. There are 5 source areas at the facility which cover 1 acre each and have been impacted with similar contaminants. It is not acceptable to compare the concentration in each source area to the SIC for 1 acre without consideration of the combined effect of all 5 source areas. The contamination emitted from all 5 source areas will commingle in ambient air at the facility to produce an air concentration greater than would be expected from a single 1 acre source. Two questions are foremost: which SIC to apply and to what extent must the source areas be characterized? The answers are interrelated.

If the portion of the facility which is outside of the 5 source areas is sampled and demonstrated to be non-detect, the sizes of the source areas can be added together and the detected concentrations within the source areas can be compared to the criteria which best fits the sum of those areas. In this example, the SIC for a 5 acre source size could be used as a first cut screen for ambient air impacts. This is a conservative screen since the airborne contamination emitted from these 5 noncontiguous source areas would be more greatly dispersed over the 10-acre facility than would be the case if all 5 areas of contaminated soil were contiguous. Professional judgment and information concerning site activities should be used to determine the extent of sampling required to characterize the areas between sources. Only samples taken from within the source areas should be included in statistical analysis of the data. Sampling results from the area outside of the source areas cannot be included since this would, in effect, dilute the 95 percent UCL concentration to be compared to the SIC.

Another possible scenario is that soils outside of and between the 5 source areas are also impacted, but to a lesser extent than the source areas themselves. Since all areas of soil contamination contribute to ambient air levels, the expected air concentration would be somewhat greater than in the example above but may not be as high as predicted by the generic air dispersion modeling for a 10-acre facility. As a conservative screen for this scenario, facility concentrations are compared to the SIC for 10 acres. Careful professional judgment should be used to determine if the variability in the data indicates that source areas must be considered separately from the remainder of the facility. If variability in the data is reasonable, facility-wide averaging may be acceptable. Consult an ERD toxicologist for further guidance on statistical analysis of source areas. As always, the PPP retains the option to conduct a facility-specific analysis of the soil to ambient air pathway.

This guidance is intended to provide guidance to ERD staff to foster consistent application of Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, and associated Administrative Rules. This document and matters addressed herein are subject to revision.

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Attachment A

PEF WORKSHEET

Ew – emissions due to wind erosion

$$Ew = (0.036(Um/Ut_{adj})^3 F(x))/3600$$

where:

Um(z) = mean windspeed (m/s) = 4.56 for South Bend (at 6.4m)
Um = Um(z) adjusted to 7 meters (m/s) = $Um(z)(7.0/6.4)^{.15}$ = 4.62
assume: z_0 = 0.005 m
assume: U*t = 0.42 m/s for 0.35 mm aggregate mode
Ut = threshold friction velocity at 7 m (adjust U*t to 7m) = 0.42/0.4*ln(7.0/0.005)) = 7.61 m/s
Ut_{adj} = 7.61 m/s (1.25) = 9.51 m/s
X = 0.886*Ut_{adj}/Um = 1.824 (unitless)
F(x) = 0.48 (unitless)

Ew = $(0.036(4.62/9.51)^3\ 0.48)/3600$ = 5.5E-7 g/m^2-s

Ev- emissions due to vehicle traffic

See attachment B.

PEF – particulate emission factor for annual averaging

$$PEF = (Q/C) \times 1/(Ew((1-V)) + Ev)$$

where:

PEF = Particulate Emission Factor	
Residential	= 1.28E+8 m^3/kg
Industrial/Commercial	= 3.95E+7 m^3/kg
Q/C = (Dispersion Factor)	= 82.33 g/m^2-s per kg/m^3
Ew (Emission due to wind erosion)	= 5.5E-7 g/m^2-s
V (Assumed vegetative cover)	= 50% (0.5)
Ev (Emission due to vehicle traffic)	
Residential	= 3.68E-7 g/m^2-s
Industrial/Commercial	= 1.81E-6 g/m^2-s

NOTE: The PEF is divided by 2 as discussed on page 12 above to account for short-term peak particulate levels for all chemicals which are associated with quarterly, 24-hour, 8-hour, or 1-hour averaging times under the Air Toxics Rules.

Attachment B

TO DERIVE A VEHICLE EMISSIONS RATE FOR INCLUSION IN EQN. 7 OF SSG FOR PEF:

For vehicle emissions, use Eqn. 1 in Compilation of Air Pollutant Emission Factors, Jan. 1995

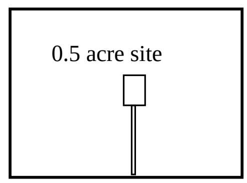
$$E_{10} = k * 1.7 * (s/12) * (S/48) * (W/2.7)^{0.7} * (w/4)^{0.5} * ((365-p)/365)$$

Where			Cowherd Residential Default Nos.
E_{10}	=	PM_{10} emissions per vehicle-kilometer of travel, (kg/VKT)	
k	=	particle size multiplier (number for 10 um is used in this calculation)	0.36
s	=	silt content of road surface material, (%)	15
		(Cowherd, 1985 shows a range of 5-68%, with default s = 15%)	
S	=	mean vehicle speed, (km/hr)	20
		(Cowherd, 1985 default of S = 48 km/hr. was not used for this driveway scenario)	
W	=	mean vehicle weight, (Mg)	2
w	=	mean number of wheels	4
p	=	number of days with at least 0.254 mm (0.01 inch) of precipitation per year (Figure 4-4 of Cowherd).	135

ASSUMPTIONS: These parameters may be changed if site specific information is available.

Units must be in (grams/m^2-sec) for use in the SSG equation 7.

Size of site	=	0.5	acres
Size of home	=	25	feet per side
Round trips/day	=	**10**	trips away from home/day
Length of driveway	=	20	metres (**unpaved**)
Time period	=	350	days



CALCULATIONS:

Area of home	=	58.06	square metres
Dimension of site	=	44.98	metres per side
Area of site	=	1965	square metres, excluding area of the house
Dist. travelled/day	=	0.40	Kilometres/day
	=	140.00	Kilometres/year
Vehicle emission	**=**	**0.1628**	**kg/VKT**
	=	0.0651	kg/day
	=	22.792	kg/year at 10 round trips per day

Vehicle emis. at	**5**	round trips per day	=	11.396	Kg/year
Vehicle emis. at	**2**	round trips per day	=	4.558	Kg/year

NOTE: **The emissions from the vehicle traffic is averaged over the area of the entire site rather than just the area of the driveway (excluding the area of the house).**

(I) For ANNUAL averaging time,

Vehicle emissions in grams per square metre per second (10 round trips per day)

$$= 22.792 \frac{Kg}{year} \times \frac{1000\ gm}{Kg} \times \frac{1}{31{,}536{,}000} \frac{year}{sec} \times \frac{1}{1965\ m^2}$$

= **3.68E-07** grams per square metre per second for 0.5 acre site with one home

For comparison:

Vehicle emission rate at	5	round trip per day	=	**1.839E-07**	grams/sq. metre/second for 0.5 acre site with one home
Vehicle emission rate at	2	round trip per day	=	**7.355E-08**	grams/sq. metre/second for 0.5 acre site with one home

VEHICLE EMISSIONS FOR SITE WITH COMMERCIAL ACTIVITIES:

Attachment B

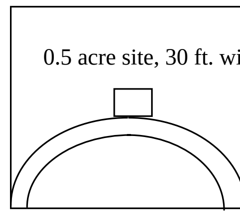
For customers' vehicle emissions, use Eqn. 1 in Compilation of Air Pollutant Emission Factors, Jan. 1995

$$E_{10} = k * 1.7 * (s/12) * (S/48) * (W/2.7)^{0.7} * (w/4)^{0.5} * ((365-p)/365)$$

Where			Nos. Applied
E_{10}	=	PM_{10} emissions per vehicle-kilometer of travel, (kg/VKT)	
k	=	particle size multiplier (number for 10 um is used in this calculation)	0.36
s	=	silt content of road surface material, (%)	15
S	=	mean vehicle speed, (km/hr)	20
W	=	mean vehicle weight, (Mg)	2
w	=	mean number of wheels	4
p	=	number of days with at least 0.254 mm (0.01 inch) of precipitation per year (Figure 4-4 of Cowherd).	135

ASSUMPTIONS: These parameters may be changed if site specific information is available.

Size of site	=	0.5	acres
Size of building	=	25	feet per side
Round trips/day	=	50	vehicles/day
Length of driveway	=	45.0	metres (**unpaved**)
Time period	=	307	days (6 days/wk, - 5 holidays)



CALCULATIONS:

Area of building	=	58.06	square metres
Dimension of site	=	44.98	metres per side
Area of site	=	1965	square metres, excluding area of the building
Dist. travelled/day	=	2.25	Kilometres

Vehicle emission = 0.1628 kg/VKT * 690.75 Kilometres/year
= 112.454 Kg/year

NOTE: **The emissions from the vehicle traffic is averaged over the area of the entire site rather than just the area of the driveway (excluding the area of the building).**

(I) For ANNUAL averaging time,

Vehicle emissions in grams per square metre per second

$$= 112.454 \frac{\text{Kg}}{\text{year}} \times \frac{1000\ \text{gm}}{\text{Kg}} \times \frac{1}{31{,}536{,}000} \quad \frac{\text{year}}{\text{sec}} \times \frac{1}{1965} \text{m}^2$$

= **1.81E-06** grams per square metre per second for 0.5 acre "commercial" site with one building

This "commercial" site has 4.93 times the emission rate of a residential scenario of 10 trips per day.