October 2015

ATTACHMENT H

Part 201 Generic Exposure Assumption Values Update

TECHNICAL SUPPORT DOCUMENT

SUBJECT: SOIL-TO-AMBIENT AIR VOLATILIZATION RELATED PARAMETERS

MDEQ Introduction

MDEQ contracted SRC, Inc. to evaluate and update the exposure assumptions and fate and transport values, consistent with the Collaborative Stakeholder Advisory (CSA) recommendations. This work is a component of the MDEQ's comprehensive cleanup criteria update and is incorporated in the calculation of the health-based cleanup values. The CSA recommendations pertinent to exposure assumptions and fate and transport factors are presented in the Decision Framework for Determination of Exposure Values (CSA, 2014). The SRC followed the Framework's process for identifying values and evaluating data against the Data Quality Objectives (DQOs). Refer to the CSA Report (2014) and Cleanup Criteria and Screening Levels Development and Application Resource Materials (Resource Materials) Section 3.2.1.

The MDEQ has adopted the SRC recommendation for the mean soil temperature used to derive the existing Temperature Adjustment Factor (TAF). The TAF is not incorporated in the calculation of the vapor intrusion screening levels including those derived at 10° C; an alternative method is used to address soil temperatures other than 25°C. Refer to Resource Materials Attachment I for the derivation of the TAF.

The MDEQ completed a comprehensive evaluation on the availability of Michigan-specific soil types data and was able to establish that sand is the appropriate default soil type because it is the predominant soil type in Michigan. Sand is present at over 30% of the state. As a result, the MDEQ used sand associated soil type-based inputs (e.g. soil dry bulk density, porosities, water content, and fraction of organic carbon content) in calculating the health-based values for indoor air, ambient air, groundwater protection, and Csat.

Because of the MDEQ evaluation noted above, the MDEQ did not use the fraction of organic carbon content and other soil parameters recommended by SRC in this TSD. For soil types and related soil inputs, refer to the Resource Materials Sections 4.4 and 12.7. For fraction of organic carbon content, refer to Resource Materials Attachment M.

Background

This Technical Support Document (TSD) describes the process used to update generic exposure assumption values for parameters used by Michigan Department of Environmental Quality (MDEQ) in deriving the soil-to-air volatilization factor (VF) used in Part 201 Volatile Soil Inhalation Criteria (VSIC) for Ambient Air. The TSD follows the Decision Framework for Updating the Michigan Part 201 Generic Cleanup Criteria Exposure Assumptions (TAG, 2014). As outlined in the Decision Framework, the update process involves searching for Michigan-specific data pertinent to each exposure assumption, revised U.S. Environmental Protection Agency (EPA) exposure assumptions, and other sources of relevant data (e.g., state and federal government agencies, published literature), and evaluating both the existing and any new information against the Data Quality Objectives (DQOs) provided in the Decision Framework.

To identify new information pertinent to each exposure assumption, the following search process was followed. First, Michigan government agencies and select research universities were contacted to determine if relevant data could be provided. Second, soil property parameters recommended by U.S. EPA's Soil Screening Guidance (1996a,b; 2002) were considered. Third, searches of the published scientific literature for data or analyses specific to Michigan or to the U.S. as a whole were conducted. For the purpose of this TSD, searches of the published literature were restricted to papers published in 2009 or later. Fourth, websites for U.S. governmental organizations were searched for readily accessible data relevant to the exposure assumptions. Fifth, selected state (including Illinois, Indiana, Minnesota, Ohio, Wisconsin, California, Oregon, Washington, Texas, and Massachusetts) and international (Health Canada and Environment Canada, Ontario Ministry of the Environment, European Commission Joint Research Centre [ECJRC], and the European Centre for Ecotoxicology and Toxicology of Chemicals [ECETOC]) environmental agency websites were searched to identify default exposure assumptions used by these agencies.

The TSD describes the results of each of the searches and the evaluation of new, relevant information against the DQOs. The DQOs in the framework (TAG, 2014) address the following:

- Relevant and applicable to Michigan;
- Clear and comprehensive;
- Sound and credible;
- Transparent and objective; and
- Certainty.

The current Part 201 generic exposure assumptions (MDEQ, 2007) and new relevant information were evaluated against the DQOs and given a rating of high, medium, or low; an explanation of the ratings is provided as Appendix A of this document. Based on the ratings, the data or information that best meets the DQOs, are recommended as the basis for updated values.

The MDEQ Part 201 VSIC algorithm addresses the soil to ambient air pathway by incorporating volatilization factors (VF) that account for volatilization of a hazardous chemical from soil, and a dispersion model that accounts for subsequent dispersion of the contaminants in ambient air. The soil-to-air VF defines the relationship between the concentration of a contaminant in soil and the concentration of the volatilized contaminant in ambient air. The VF is calculated using meteorological data, chemical-specific properties, and default values for soil properties that are representative of conditions for Michigan.

Introduction

Soil properties included in the calculation of VF include the following:

- Dry soil bulk density (ρ_b)
- Soil air-filled porosity (θ_a)
- Soil water-filled porosity (θ_w)
- Total soil porosity (n)
- Organic carbon content of soil (f_{oc})
- Temperature adjustment factor (TAF)

MDEQ uses a TAF to adjust chemical-specific dimensionless Henry's Law Constants (H') which are typically reported under the standard temperature of 25 degrees Celsius (°C), to account for reduced volatility under the lower Michigan soil temperatures.

This TSD consists of one section that presents recommendations for default values for each of these parameters for use in the MDEQ Part 201 VF equations. Table 1 below provides a comparison of the MDEQ (2007) and 2015 updated values.

Table 1. Summary of Existing and Updated MDEQ Values for Soil-to-Air Volatilization Parameters

Parameter	MDEQ (2007) Value	2015 Updated Value
ρ_b = Dry soil bulk density (g/cm^3)	1.5	1.5
θ_a = Air-filled soil porosity (L_{air}/L_{soil})	0.28	0.20
θ_w = Water-filled soil porosity (L_{water}/L_{soil})	0.15	0.23
n = Total soil porosity (L_{pore}/L_{soil})	0.43	0.43
f_{oc} = Organic carbon content of soil (g/g)	0.006	0.006
TAF = Temperature adjustment factor (unitless)	0.5	0.5

Section 1. Soil Properties Related to Volatilization from Soil to Ambient Air

1.1. Introduction

Soil types vary across Michigan. The western and northern portions of the Lower Peninsula are dominated by sandy soils, while clays and loams are predominant in the southern portion of the Lower Peninsula. The Upper Peninsula is largely sandy soils and soils with predominantly organic material (histosols). The U.S. EPA uses loam as a default soil texture, based on nationwide data (U.S. EPA 1996a,b).

1.2. MDEQ (2007) Value

1.2.1. Description of MDEQ (2007) Value

MDEQ (2007) recommended the default soil properties presented in Table 2.

Table 2. Summary of MDEQ (2007) Default Soil Properties for the VF

Parameter	Value
ρ_b = Dry soil bulk density (g/cm^3)	1.5
θ_a = Air-filled soil porosity (L_{air}/L_{soil})	0.28
θ_w = Water-filled soil porosity (L_{water}/L_{soil})	0.15
n = Total soil porosity (L_{pore}/L_{soil})	0.43
f_{oc} = Organic carbon content of soil (g/g)	0.006
TAF = Temperature adjustment factor (unitless)	0.5

For all of these parameters except TAF, the MDEQ (2007) recommendations were based on U.S. EPA's 1996 Soil Screening Guidance (SSG) (U.S. EPA 1996a,b). These values were considered representative of generic conditions for Michigan (MDEQ, 2007).

U.S. EPA (1996b) reported that the value of 1.5 g/cm^3 for ρ_b represents the mode of the range given for U.S. soils in the *Superfund Exposure Assessment Manual* (U.S. EPA, 1988). U.S. EPA (1988) referenced the U.S. Soil Conservation Service (USCS) as a data source for the basis of this value. The recommended value of 1.5 g/cm^3 is supported by data presented by Carsel et al. (1988) for a sandy loam soil texture which was also derived from evaluation of USCS data. U.S. EPA (1996a,b) recommended a default value for ρ_s of 2.65 g/cm^3 based on the value presented by U.S. EPA (1988) for particle density for most soil mineral material.

U.S. EPA (1996a,b) calculated the default value for n (0.43 Lpore/Lsoil) using recommended default values for ρ_b and ρ_s and the equation below (U.S. EPA, 1996b):

$$\text{Equation 1:} \quad n = 1 - (\rho_b / \rho_s)$$

It was noted that the mean porosity for loam soil was reported by Carsel and Parrish (1988, as cited in U.S. EPA, 1996b) was also 0.43.

U.S. EPA (1996b) described θ_a as the most significant soil parameter affecting the final steady-state flux of volatile contaminants from soil: the higher the θ_a, the greater the emission flux of volatile constituents. Air-filled soil porosity is a function of n and θ_w as follows (U.S. EPA, 1996b):

$$\text{Equation 2:} \quad \theta_a = n - \theta_w$$

U.S. EPA (1996b) indicated that, because surface soil bulk densities vary over a relatively small range (from about 1.3 to 1.7 g/cm^3), ρ_b does not affect θ_a with nearly the significance of θ_w.

U.S. EPA (1996a,b) recommended a default f_{oc} of 0.006 (g/g) or 0.6% based on the mean value for the top 0.3 m of Class B soils from Carsel et al. (1988)[1]. U.S. EPA (1996b) described Class B soils as soils well represented by a loam soil type reflective of moderate hydrologic characteristics. Carsel et al. (1988) developed probability density functions for soil characteristics including bulk density, organic matter, field capacity, and wilting point as a function of depth. The underlying data used to inform these distributions came from nearly 3,000 soil series in 40 states from the USCS; the sample size for organic matter for the 0-3 m stratum for Class B soils was 1,135 samples.

U.S. EPA's (1996a,b) recommended value of θ_w (0.15) corresponds to an average annual soil water content of 10 weight percent. U.S. EPA (1996b) described this value as "a conservative compromise between that required to achieve a monomolecular layer of water on soil particles (approximately 2 to 5 weight percent) and that required to reduce the air-filled porosity to zero (approximately 29 weight percent)". Additionally, U.S. EPA (1996b) noted that a θ_w of 0.15 falls between the mean wilting point (0.09) and mean field capacity (0.20) reported for Class B soils by Carsel et al. (1988).

The U.S. EPA (1996a,b) recommended value for θ_a (0.28 Lair/Lsoil) was calculated as the difference between the recommended default values for n and θ_w (0.43 Lpore/Lsoil and 0.15 Lwater/Lsoil, respectively), as shown in Equation 2 above.

MDEQ (2007) recommended a TAF of one half (0.5) to account for reduced volatility of a contaminant under the annual average soil temperatures in Michigan of 10°C. The value of 10 °C was based on soil temperature data obtained from the Agricultural Weather Office and the

[1] The value of 0.6% could not be verified by review of Carsel et al. (1988).

Michigan Department of Agriculture/State Climatologist at Michigan State University (MSU). At that time, soil temperature data had been collected from the MSU agricultural station during the Michigan growing season. No data were available for the colder months, but available data indicated that soil temperatures paralleled air temperatures with a lag time of a few hours, so air temperatures were used as a surrogate for soil temperatures. Using the data from MSU, MDEQ (2007) estimated that 10°C was the average annual air temperature for Michigan as a whole and that this temperature was a reasonable surrogate for average annual soil temperature. MDEQ (2007) cited Howe (1987) as the basis for the TAF but did not provide further detail as to its calculation.

1.2.2. Evaluation of Data Quality Objectives

The default soil property values recommended by MDEQ (2007) as described above were evaluated using the Part 201 DQOs. MDEQ (2007) recommended values for ρ_b, ρ_s, n, θ_A, θ_w, and f_{oc} were based on U.S. EPA (1996a,b), whereas the value for TAF was based on Michigan-specific data obtained by the Agency for the purposes of developing a default recommendation. Therefore, the following DQO summary presents separate ratings based on the two separate sources of information.

Relevance and applicability to Michigan (g*eographic, temporal, and demographic representativeness*). The default soil property values for ρ_b, ρ_s, θ_w, and f_{oc} recommended by MDEQ (2007) are based on default values recommended by U.S. EPA (1996a,b). These values are generally considered applicable for the general U. S. The value for f_{oc} is based on a study (Carsel et al., 1988) that evaluated soils from over 40 states; it is not known whether data from Michigan were included. Rating: Medium.

The value for TAF recommended by MDEQ (2007) was derived based on air temperature data for Michigan (as a surrogate for soil temperatures). Soil temperatures vary over time and location. MDEQ (2007) did not indicate the number of stations from which the air temperature data were obtained, nor how many years of data were analyzed, but did state that the data were considered to be representative of Michigan as a whole. Rating: Medium-High.

Clarity and comprehensiveness (completeness of method and data reporting, completeness of literature search). The basis for the soil property values for ρ_b, ρ_s, θ_w, and f_{oc} is clearly described in U.S. EPA (1996a,b). No information is presented in U.S. EPA (1996a,b) regarding the nature of the search for data relevant to these soil properties. Rating: Medium.

The basis for the TAF value is described in brief by MDEQ (2007). The value was derived based on air temperature data considered to be representative of Michigan as a whole, but no information on the data collection, curation, or analysis were provided. In addition, MDEQ (2007) did not describe how the TAF value was obtained from the temperature data. Rating: Low -Medium.

Soundness and credibility (*adequacy of approach; intrinsic sources of bias; sample size*). U.S. EPA (1996a,b) used data from Carsel et al. (1988) for f_{oc} and as support for θ_w. Carsel et al. (1988) presented values for Class B soils for f_{oc}, ρ_b, field capacity, and wilting point that were based on the analysis of nearly 3,000 soil series. U.S. EPA (1996a,b) values for ρ_b and ρ_s were based on data reported in U.S. EPA (1988); the approach used to obtain these data and sample sizes were not reported. Rating: Low-medium.

The basis of the TAF value is described in brief by MDEQ (2007). Details on sample size, sampling locations, sampling times, and sampling methodologies for air temperatures were not provided, nor was a description of the calculation used to obtain the TAF of 0.5. Rating: Low.
Transparency and objectivity (availability of supporting data; funding source; peer-review). U.S. EPA (1996a,b) evaluated the data available on soil properties for evaluating volatilization of contaminants from soil to air and made the report available on the internet. Prior to publication, the report was reviewed internally by U.S. EPA staff, and also reviewed by a Science Advisory Board Panel and an external Peer Review Panel. Carsel et al. (1988) was published in a peer-reviewed journal. Rating: High.

The data obtained by MDEQ and used as the basis for the TAF were collected by MSU, presumably to provide weather information for agricultural purposes in Michigan. No information was provided by MDEQ (2007) to evaluate funding or peer-review of these data. Rating: Low.

Certainty (number and agreement of studies). The soil property values recommended by U.S. EPA (1996a,b) provide generalized conservative recommendations and/or reference a single study (Carsel et al., 1988), albeit a study of significant size. Rating: Low-medium.
For TAF, no other studies were available to compare with the data from MSU reported by MDEQ (2007). Rating: Low.

1.3. Evaluation of New Information Using Decision Framework

1.3.1. Michigan-Specific Data

1.3.1.1. Summary of Search Results

The MDEQ Remediation and Redevelopment Division (RRD) was contacted by email and phone to determine if the Department was aware of research or could provide data pertinent to Michigan-specific soil properties; however, the Agency was not aware of research or data relevant to this exposure parameter. The following research universities were contacted by email and phone to determine if each was aware of research or could provide data: University of Michigan, Michigan State University, Western Michigan University, and Michigan Technological University. MSU offered data relevant to soil temperature and soil moisture.

MSU Extension collects daily minimum and maximum soil temperature at two inches and four inches below the surface, and soil moisture at four and ten inches below the surface from more than 80 weather stations across the state. This program is managed by Dr. Jeff Andresen,

Associate Professor of Meteorology/Climatology in the Department of Geography and State Climatologist for Michigan. Dr. Andresen was contacted and asked whether these data could be used to estimate state-wide estimates of average soil temperature and average soil moisture.

Dr. Andresen selected twenty[2] of the 80+ possible weather stations as those that would best provide a reliable representation of annual soil temperature and soil moisture conditions state-wide, and recommended that at least 10 years of data be used in order to capture information regarding the variability of these parameters with year and location. For the 20 stations selected by Dr. Andresen, data from the last 10 full years (e.g., 2005 through 2014 inclusive) were downloaded from the Enviro-weather database and analyzed to obtain estimates of an annual average soil temperature in Michigan and average state-wide soil moisture content. Specifically, minimum and maximum soil temperature at two inches below grade, and minimum and maximum soil moisture at four and ten inches below grade were downloaded for each day and station from January 1, 2005 through December 31, 2014. The resulting data contained 365 days per year of data for 10 years for each of 20 monitoring station (a total of nearly 73,000 possible data points).

The data were analyzed as follows. A total of 1,191 daily minimum or maximum measurements were not available for one or more of the measurement endpoints. However, this is a very small percentage of the total of ~73,000 possible data points (<2%), so the missing data would have minimal impact on the overall averages. For each daily measurement, an average value across the minimum and maximum reported values was calculated. An average soil temperature and average soil moisture content were then calculated by averaging across all stations and years. For soil moisture, average values were calculated based on the four-inch depth data, the ten-inch depth data, and on both datasets combined.

Table 3 presents the mean, standard deviation, and count for each endpoint.

Table 3. Summary Statistics for MSU 10-year Soil Temperature and Moisture Data

Parameter	Summary Statistics		
	N	Mean	SD
Soil temperature (°F)	71,727	51.5	16.3
Soil moisture at 4 inches (in^3/in^3)	71,591	0.22	1.15
Soil moisture at 10 inches (in^3/in^3)	71,297	0.23	0.72
Soil moisture (in^3/in^3)	71,810	0.23	0.69

[2] Stations at the following locations were selected: Albion, Bear Lake, Benton Harbor, Chatham, Dundee, East Lansing, Eastport, Escanaba, Fairgrove, Fremont, Hart, Hawks, Ithaca, Kawkawlin, Lakeview, Mendon, Sandusky, Sparta, Stephenson, and Traverse City. Station locations and data are provided online at: http://www.agweather.geo.msu.edu/mawn/.

This analysis suggests that 51.5 °F (10.8°C) is a reasonable estimate of an average soil temperature for Michigan, and 0.23 (v/v) is a reasonable estimate of average soil moisture for Michigan. The average state-wide soil temperature of 10.8°C is consistent with the estimated average soil temperature of 10°C used to derive the TAF of 0.5 in MDEQ (2007). As such, the existing TAF is retained.

Table 4 summarizes the updated θ_a, θ_w, and TAF values based on analysis of the MSU soil temperature and moisture data.

Table 4. Updated Soil Properties Based on MSU Soil Temperature and Moisture Data

Parameter	Value
$\boldsymbol{\theta_a}$ = Air-filled soil porosity (L_{air}/L_{soil})	0.20
$\boldsymbol{\theta_w}$ = Water-filled soil porosity (L_{water}/L_{soil})	0.23
TAF = Temperature adjustment factor (unitless)	0.5

1.3.1.2. Evaluation of Data Quality Objectives

The data obtained from MSU were evaluated using the Part 201 DQOs. A summary of the evaluation follows.

Relevance and applicability to Michigan (g*eographic, temporal, and demographic representativeness*). MSU provided daily soil temperature and moisture measurements between January 1, 2005 and December 31, 2014 for 20 monitoring stations in Michigan. The stations were selected by State Climatologist Dr. Jeff Andresen to provide data representative of the entire state. These data are both current and specific to Michigan. Rating: High.

Clarity and comprehensiveness (completeness of method and data reporting, completeness of literature search). Data provided by MSU were not complete, with missing data points for several stations and years. However, given that <2% of the data were missing, the influence of the missing data on the averages is not expected to be significant. Rating: Medium-High.
Soundness and credibility (*adequacy of approach; intrinsic sources of bias; sample size*). According to Dr. Andresen, the methods for data collection employed by MSU are modeled after those of the National Oceanic and Atmospheric Administration (NOAA). The sample size (~73,000 over 10 recent years) was recommended by Dr. Andresen and is deemed adequate to the purpose. Rating: High.

Transparency and objectivity (availability of supporting data; funding source; peer-review). The data collected by MSU were collected to provide weather information for agricultural and natural resource management purposes in Michigan. Based on the limited information available on the website, funding for the data collection is provided by MSU and support from contributions. The MSU data and analysis described above have not undergone peer review. Rating: Medium.

Certainty (number and agreement of studies). The analysis of soil temperatures in Michigan over the past 10 years yielded a value (10.8ºC) consistent with the average Michigan air temperature (10 ºC) cited by MDEQ (2007). No other data were available for comparison. Rating: Medium.

1.3.2. Most Recent EPA Recommended Value(s)

In 2002, the U.S. EPA (2002) released a companion guidance document to the 1996 SSG (U.S. EPA, 1996a,b) that presented the same recommended values for the default soil properties used to derive a VF as were recommended by U.S. EPA (1996a,b). As there were no changes in the U.S. EPA recommended values based on the updated SSG guidance, no additional DQO assessment was conducted.

1.3.3. New Scientific Literature

A search of the open scientific literature (PubMed and ToxLine) for data on soil properties used to derive a VF from studies published since 2009 was conducted. This search did not yield any potentially relevant studies.

1.3.4. New Federal Information

A search of federal sources of data on soil properties was conducted. The search included evaluating publicly available databases, reports, data briefs, and publications from federal agencies including the U.S. Geological Survey (USGS) and the U.S. Department of Agriculture (USDA). Additional relevant information was not identified.

1.3.5. Other State and/or International Searches

1.3.5.1. Summary of Search Results

State and international agencies listed in the background to this TSD were searched for recommended soil properties. Table 5 below summarizes the recommended soil properties identified in the searches. As the table shows, all states besides Indiana and Texas recommend the same values as U.S. EPA (1996a,b). The Indiana values for θ_a and θ_w and f_{oc} were derived for calculating migration to groundwater screening levels (IDEM, 2012), not VF. No basis for the Texas default values is given in the state guidance (TCEQ, 2009). The Canadian Council of Ministers of the Environment (CCME) recommended soil densities and moisture contents to be representative of typical sand (coarse-grained) and clay (fine-grained) soils (CCME, 2006). The Canada default f_{oc} is based on a review of the organic carbon contents of various Canadian subsoils undertaken in support of the Canada-Wide Standard for Petroleum Hydrocarbons in Soil (CCME, 2000). Because the state and international values were either based on U.S. EPA recommendations or based on assumptions specific to the location, further evaluation of DQOs for these values was not conducted.

Table 5. Comparison of state and international default soil parameters.

Parameter	MI	IL	CA	MA	MN	WA	WI	IN	OH	OR	TX	Canada	EU JRC	EU ECETOC
ρ_b (gm/cm^3)	1.5	1.5	1.5	ND	1.5	1.5	1.5	1.5	1.5	1.5	1.67	1.7 1.4	ND	ND
θ_a (L_{air}/L_{soil})	0.28	0.28	0.28	ND	0.28	0.28	0.28	0.13[a]	0.28	ND	0.21[b]	0.31 0.303	ND	ND
θ_w (L_{water}/L_{soil})	0.15	0.15	0.15	ND	0.15	0.15	0.15	0.3[a]	0.15	ND	0.16[c]	0.05 0.167	ND	ND
n (L_{pore}/L_{soil})	0.43	0.43	0.43	ND	0.43	0.43	0.43	ND	0.43	0.38	0.37	0.36 0.47	ND	ND
f_{oc} (g/g)	0.006	0.006	0.006	ND	0.006	0.006	0.006	0.002[a]	ND	0.005	0.008	0.005	ND	ND
TAF (unitless)	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = No data;
[a]Values used to calculate migration to ground water screening levels (IDEM, 2012), not for VF calculation.
[b]Value represents the volumetric air content of vadose zone soils.
[c]Value represents the volumetric water content of vadose zone soils.
[d]The first value represents coarse-grained soil; the second represents fine-grained soil.

1.3.6. Comparison of Results of DQO Evaluations.

Table 6 provides a comparison of the DQO evaluations for the MDEQ (2007) and the alternate estimates from key studies considered in this review. For each DQO, the assessments have been compiled and rated from low to high.

Table 6. Summary of DQO evaluation for Soil Properties Related to VF

Parameter	MDEQ (2007) values based on U.S. EPA (1996a,b); same as U.S. EPA (2002)	MDEQ (2007) values based on MSU Data	New Michigan data	New scientific literature
ρ_b (g/cm^3)	1.5	NV	ND	ND
θ_a (L_{air}/L_{soil})	0.28	NV	0.20	
θ_w (L_{water}/L_{soil})	0.15	NV	0.23	
n (L_{pore}/L_{soil})	0.43	NV	ND	
f_{oc} (g/g)	0.006	NV	ND	
TAF (unitless)	NV	0.5	0.5	
Data Quality Objective Scoring				
Relevance and applicability to Michigan	M	M-H	H	NA
Clarity and comprehensiveness	M	L-M	M-H	
Soundness and credibility	L-M	L	H	
Transparency and objectivity	H	L	M	
Certainty	L-M	L	M	

ND = No data; NV = No value; NA = Not analyzed; H = high; M = medium; L = low; M-H = Medium to High; L-M = Low to Medium.

1.4. Conclusion

No new data have been identified to provide alternative recommendations for ρ_b, n, or f_{oc}. Thus, the existing values should continue to be used.

Available soil moisture data from MSU suggest that the average soil moisture content for Michigan ranges from about 0.10 (v/v) to 0.61 (v/v) with an average of 0.23 (v/v). Using this value for θ_w results in a value of 0.2 Lair/Lsoil for θ_a based on the default value for n (0.43 Lpore/Lsoil) and Equation 2 above (0.43 – 0.23 = 0.2).

Available soil temperature data from MSU suggest that the average soil temperature for Michigan ranges from 47.6°F to 55.0°F (8.6°C to 12.8°C) with a mean value of 51.5°F (10.8°C). This mean soil temperature is consistent with the temperature used to derive the existing TAF. Thus, the existing TAF of 0.5 is retained for this update. Table 7 presents the updated recommendations.

Table 7. Summary of 2015 Updated MDEQ Values for Soil-to-Air Volatilization Parameters

Parameter	2015 Updated Value
ρ_b = Dry soil bulk density (g/cm^3)	1.5
θ_a = Air-filled soil porosity (L_{air}/L_{soil})	0.20
θ_w = Water-filled soil porosity (L_{water}/L_{soil})	0.23
n = Total soil porosity (L_{pore}/L_{soil})	0.43
f_{oc} = Organic carbon content of soil (g/g)	0.006
TAF = Temperature adjustment factor (unitless)	0.5

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APPENDIX A

EXPLANATION OF RELATIVE DQO RATINGS

This appendix provides a broad outline of how the DQO ratings were applied. To some extent, professional judgment was used in the application of the ratings, as a set of rating characteristics that would apply to the many different data sources used to develop exposure assumptions was not feasible. The ratings should be considered relative rather than absolute. In other words, the ratings may be compared across sources of data for a single exposure assumption, but a rating of high for one exposure assumption may not be equivalent to a rating of high for another exposure assumption.

Relevance and applicability to Michigan (g*eographic, temporal, and demographic representativeness*).

High: Based on recent data obtained in Michigan, in members of its population, or developed based on data specific to Michigan (e.g., exposure frequency based on climate conditions in Michigan).

Medium: Based on recent data obtained outside Michigan or its population, but in an area or population with comparable geographic, temporal, and demographic conditions.

Low: Based on data obtained outside Michigan or its population, in an area or population with different geographic, temporal, and demographic conditions, or with unknown geographic, temporal, and demographic conditions.

Clarity and comprehensiveness (completeness of method and data reporting, completeness of literature search).

High: Derived value with complete documentation of the selection process, and based on known or apparently thorough literature search, OR, single study with thorough description of methods and results.

Medium: Derived value with incomplete documentation of the selection process, and/or based on limited literature search, OR, single study with some noncritical information missing from methods and results.

Low: Derived value with little or no documentation of the selection process, and/or without accompanying literature search, OR, single study lacking critical information from method or results.

Soundness and credibility (adequacy of approach; intrinsic sources of bias; sample size).

High: Using an established method to estimate the parameter, without intrinsic sources of bias, and with adequate sample size(s).

Medium: Using an established method to estimate the parameter, with some known or expected intrinsic sources of bias, and with adequate sample size(s).

Low: Using a novel or uncertain method to estimate the parameter, with or without intrinsic sources of bias, and with inadequate sample size(s).

Transparency and objectivity (availability of supporting data; funding source; peer-review).

High: Based on peer-reviewed study(s) performed by researcher(s) without demonstrable conflict of interest and supported by other studies.

Medium: Based on peer-reviewed study(s) performed by researcher(s) without demonstrable conflict of interest but without support from other studies.

Low: Based on unpublished study(s) and/or performed by researcher(s) with potential conflict of interest and/or based on professional judgment, without support from other studies.

Certainty (number and agreement of studies).

High: Based on > 3 studies with values ranging up to ±50% from the selected value.

Medium: Based on at least 2 or 3 studies with values ranging up to ±100% from the selected value.

Low: Based on a single study or more than one study with variability ranging >±100% from the selected value, or based on professional judgment.