Residual Risk Assessment for Pulp Mill Combustion Sources in Support of the December, 2016 Risk and Technology Review Proposed Rule

EPA's Office of Air Quality Planning and Standards
Office of Air and Radiation
December, 2016

Table of Contents

Index of Tables

Appendices

Appendix 1	Emissions Inventory Support Documents
Appendix 2	Technical Support Document for HEM3 Modeling
Appendix 3	Meteorological Data for HEM3 Modeling
Appendix 4	Dispersion Model Receptor Revisions and Additions
Appendix 5	Analysis of short-term emission rates relative to long-term emission rates
Appendix 6	Technical Support Document for TRIM-Based Multipathway Tiered Screening Methodology for RTR
Appendix 7	Protocol for Developing a TRIM.FaTE Model Scenario to Support a Site-Specific Risk Assessment in the RTR Program
Appendix 8	Dose-Response Values Used in the RTR Risk Assessments
Appendix 9	Environmental Risk Screen
Appendix 10	Detailed Risk Modeling Results
Appendix 11	Site-Specific Human Health Multipathway Residual Risk Assessment Report

Index of Acronyms

AERMOD	American Meteorological Society/EPA Regulatory Model
AEGL	Acute exposure guideline level
ASTDR	US Agency for Toxic Substances and Disease Registry
CalEPA	California Environmental Agency
CTE	Central Tendency Estimate
ERPG	Emergency Response Planning Guideline
HAP	Hazardous Air Pollutant
HEM	Human Exposure Model
HI	Hazard index
HQ	Hazard quotient
IRIS	Integrated Risk Information System
MACT	Maximum Achievable Control Technology
MIR	Maximum Individual Risk
MOA	Mode of action
NAC	National Advisory Committee
NAAQS	National Ambient Air Quality Standards
NATA	National Air Toxics Assessment
NEI	National Emissions Inventory
NPRM	Notice of Proposed Rulemaking
PB-HAP	Persistent and Bioaccumulative – HAP
PAH	Polycyclic aromatic hydrocarbon
POM	Polycyclic organic matter
REL	Reference exposure level
RfC	Reference concentration
RfD	Reference dose
RTR	Risk and Technology Review

TOSHI	Target-organ-specific hazard index
TRIM	Total Risk Integrated Methodology
TRIM.FaTE	TRIM Environmental Fate, Transport, and Ecological Exposure
URE	Unit risk estimate

1 Introduction

Section 112 of the Clean Air Act (CAA) establishes a two-stage regulatory process for addressing emissions of hazardous air pollutants (HAP) from stationary sources. In the first stage, section 112(d) requires the Environmental Protection Agency (EPA, or the Agency) to develop technology-based National Emission Standards for Hazardous Air Pollutants (NESHAP) for categories of sources (e.g., petroleum refineries, pulp and paper mills, etc.). EPA has largely completed the initial Maximum Achievable Control Technology (MACT) standards as required under this provision. In the second stage, EPA is required under section 112(f)(2) to assess the health and environmental risks that remain after implementation of the MACT standards. If additional risk reductions are necessary to protect public health with an ample margin of safety or to prevent an adverse environmental effect, EPA must develop standards to address these remaining risks. This second stage of the regulatory process is known as the residual risk stage. For each source category for which EPA issued MACT standards, the residual risk stage must be completed within eight years of promulgation of the initial technology-based standard.

Also, under section 112(d)(6), EPA must review each of the technology-based standards at least every eight years and revise it, as necessary, taking into account developments in practices, processes and control technologies. For efficiency, the Agency includes the 112(f) and 112(d) analyses in the same regulatory package and calls the rulemakings the Risk and Technology Review (RTR).

In December of 2006 we consulted with a panel from the EPA's Science Advisory Board (SAB) on the “Risk and Technology Review (RTR) Assessment Plan,” and in June of 2007, we received a letter with the results of that consultation. Subsequent to the consultation, in June of 2009, EPA met with an SAB panel for a formal peer review of the “Risk and Technology Review (RTR) Assessment Methodologies” (USEPA, 2009a). We received the final SAB report on this review in May of 2010 (USEPA, 2010a). Where appropriate, we have responded to the key messages from this review in developing our current risk assessments and we will be continuing our efforts to improve our assessments by incorporating updates based on the SAB recommendations as they are developed and become available. Our responses to the key recommendations of the SAB are outlined in a memo entitled, “EPA’s Actions in Response to Key Recommendations from the SAB Review of RTR risk Assessment Methodologies” (USEPA, 2010b).

This document contains the methods used to conduct the risk assessment, the results of the residual risk assessment performed for the pulp mill combustion source (Subpart MM source category), and associated uncertainties. Methods described in Section 2 include those used to develop refined estimates of chronic inhalation exposures and human health risks for cancer and noncancer endpoints, as well as those used to screen for acute health risks, chronic non-inhalation health risks, and adverse environmental effects. The source category specific results for the risks are presented in Section 3. Section 4 contains a discussion of the uncertainties of the risk assessment, including uncertainties in the exposure assessment and in the dose-response values.

2 Methods

A risk assessment consists of four steps. The first step, hazard identification, determines whether the pollutants of concern can be linked to the health effects in question (cancer and/or non-cancer). This step has been accomplished via Section 112 of the CAA which identifies the HAP included in the risk assessment for this source category. The second step is the dose-response assessment, which quantifies the relationship between the dose of a pollutant and the resultant health effects. Dose-response assessments are performed by EPA through the Integrated Risk Information System (IRIS) process as well as by other agencies, such as the Agency for Toxic Substances and Disease Registry (ATSDR). See Section 2.7 of this document for more information on dose-response assessments. The third and fourth steps in the risk assessment process are the exposure assessment and the risk characterization, respectively. These final two steps are specific to the source category and are described throughout this report. The exposure assessment includes characterization of HAP emissions, environmental fate and transport, and population exposure for both inhalation and non-inhalation pathways. The fourth and final step, risk characterization, integrates all the information from the previous steps and describes the outcome of the analysis. This four-step approach to risk assessment was endorsed by the National Academy of Sciences in its publication “Science and Judgment in Risk Assessment” (NAS, 1994) and subsequently was adopted in the EPA’s “Residual Risk Report to Congress” (USEPA, 1999).

The EPA conducts a risk assessment that provides estimates of the maximum individual risks (MIR) posed by the HAP emissions from each source in the source category, the hazard index (HI) for chronic exposures to HAP with potential to cause chronic (or long-term) non-cancer health effects and the hazard quotient (HQ) for acute exposures to HAP with the potential to cause acute (or short-term) non-cancer health effects. The MIR is defined as the risk associated with a lifetime of exposure at the highest concentration of HAP where people are likely to live. The HQ is the ratio of the potential exposure to the HAP and the level at which no adverse effects are expected; and the HI is the sum of hazard quotients for HAP that affect the same target organ or organ system. The risk assessment also provides estimates of the distribution of cancer risks within the exposed populations, cancer incidence and an evaluation of the potential for adverse environmental effects. The following sections describe how we estimate HAP emissions and conduct steps three and four of the risk assessment. The methods used to assess risks are consistent with those peer-reviewed by a panel of the EPA’s Science Advisory Board (SAB) in 2009 and described in their peer review report issued in 2010 (USEPA 2010a).

2.1 Emissions and source data

To conduct the exposure assessment, EPA gathers the best available data on emissions, emissions release parameters, other source category-specific data as needed. EPA determines the HAP emissions levels from emission points in the source category and identifies the emissions-release characteristics of these emission points (e.g., stack height). EPA often begins with the NEI database as the starting point for emissions and emissions-release characteristics for the source category. The NEI database contains information about sources that emit HAP and it contains annual air pollutant emissions estimates. EPA's industry experts review the source category data for consistency and completeness. This includes an evaluation of facilities contained in the source category, the emissions units expected to be included for the processes in the source category, and the HAP compounds and emissions levels typically seen. If necessary, EPA will conduct a formal information collection request (CAA, Section 114) for emissions data and other data from the industry associated with the source category under review. Following the creation of the initial dataset, the technology review, and the residual risk analysis, the EPA proposes regulatory action for the source category in a Notice of Proposed Rulemaking (NPRM) published in a Federal Register Notice. The NPRM datasets are available for public review in the rulemaking docket. Industry, state and local agencies, as well as the public have an opportunity to provide comments on the data, analyses, and results used to support the proposed action. EPA incorporates the comments, as appropriate, conducts any re-analysis, and summarizes and responds to comments before finalizing the action. Through source category-specific engineering reviews, information collection efforts, and public comment, EPA ensures that the quality of the data used to conduct risk assessments in support of the RTR rulemakings is adequate for its intended purpose.

Details on the development of the emissions and source data for the pulp mill combustion source category can be found in Appendix 1 (*Emissions Inventory Support Documents*). Section 3 provides a summary of the processes and emissions associated with this source category.

2.2 Dispersion modeling for inhalation exposure assessment

Both long- and short-term inhalation exposure concentrations and associated health risks from each facility in the source category were estimated using the Human Exposure Model (HEM) in combination with the American Meteorological Society/EPA Regulatory Model dispersion modeling system (HEM-AERMOD, or HEM3). The approach used in applying this modeling system is outlined below, and further details are provided in Appendix 2 to this document (*Technical Support Document for HEM3 Modeling*). The HEM3 performs three main operations: atmospheric dispersion modeling, estimation of individual human exposures and health risks, and estimation of population risks. This section focuses on the dispersion modeling component.

The dispersion model in the HEM3 system, AERMOD version 15181, is a state-of-the-science Gaussian plume dispersion model that is preferred by EPA for modeling point, area, and volume sources of continuous air emissions from facility applications (USEPA, 2005a). Further details on AERMOD can be found in the AERMOD Users Guide (USEPA, 2004). The model is used to develop annual average ambient concentrations through the simulation of hour-by-hour dispersion from the emission sources into the surrounding atmosphere. Default hourly emission rates used for this simulation are generated by evenly dividing the total annual emission rate from the inventory into the 8,760 hours of the year.

The first step in the application of the HEM3 modeling system is to predict ambient concentrations at locations of interest. The AERMOD model options employed are summarized in Table 2.2-1 and are discussed further below.

Table 2.2-1. AERMOD version 15181 Model Options for RTR Modeling

Modeling Option	*Selected Parameter for chronic exposure*
Type of calculations	Hourly Ambient Concentration
Source type	Point Area represented as pseudo point source
Receptor orientation	Polar (13 rings and 16 radials) Discrete (census block centroids) and user-supplied receptors
Terrain characterization	Actual from USGS 1-degree DEM data
Building downwash	Not Included
Plume deposition/depletion	Not Included
Urban source option	Yes
Meteorology	1 year representative NWS from nearest site (823 stations) for year 2014

In HEM3, meteorological data are ordinarily selected from a list of more than 800 National Weather Service (NWS) surface observation stations across the continental United States, Alaska, Hawaii, and Puerto Rico. In most cases the nearest station is selected as representative of the conditions at the subject facility. When considering off-site meteorological data, most site specific dispersion modeling efforts employ up to five years of data to capture variability in weather patterns from year to year. However, because dispersion model runtimes using five years of meteorological data would be too long for RTR source categories with many sources, we modeled only a single year, 2014. While the selection of a single year may result in under-prediction of long-term ambient levels at some locations, it may result in over-prediction at others. For each facility identified by its characteristic latitude and longitude coordinates, the closest meteorological station was used in the dispersion modeling. In this analysis, the average distance between a modeled facility and the applicable meteorological station was 39 miles (63 km). The sensitivity of model results to the selection of the nearest weather station and the use of one year of meteorological data is discussed in “Risk and Technology Review (RTR) Risk Assessment Methodologies” (USEPA 2009a).

We generated nationwide surface and profile files for input into AERMOD stations using the AERMET meteorological data preprocessor, and the Automated Surface Observing System (ASOS) surface data and Forecast Systems Laboratory (FSL) upper air. EPA has posted the AERMET meteorological data used in the analysis on the EPA’s Fate, Exposure, and Risk Analysis (FERA) website under the Human Exposure Model (HEM) page. The Agency released to the public on the EPA’s Support Center for Regulatory Atmospheric Modeling

(SCRAM) website both AERMET and AERMOD (version 15181) in 2015. Appendix 3 to this document (*Meteorological Data for HEM3 Modeling*) provides a complete listing of stations and assumptions along with further details used in processing the data through the AERMOD meteorological data processing program.

The HEM3 system estimates ambient concentrations at the geographic centroids of census blocks (using the 2010 Census) and at other receptor locations that can be specified by the user. See Appendix 4 of this document (*Dispersion Model Receptor Revisions and Additions*) for a discussion of user receptors and centroid location changes specific to this source category. The model accounts for the effects of multiple facilities when estimating concentration impacts at each block centroid. In this assessment we combined the impacts of all facilities within the same source category, and assessed chronic exposure and risk for all census blocks[1] with at least one resident (i.e., locations where people may reasonably be assumed to reside rather than receptor points at the fenceline of a facility). We then calculated ambient concentrations as the annual average of all estimated short-term (one-hour) concentrations at each block centroid. We did not consider possible future residential use of currently uninhabited areas.

To assess the potential impacts from short-term exposures, we estimated worst-case one-hour concentrations both at the census block centroids and at points nearer the facility that represent locations where people may be present for short periods[2]. Note that this is in contrast to the development of ambient concentrations for evaluating long-term exposures, which we performed only for occupied census block. Since short-term emission rates are needed to screen for the potential for hazard via acute exposures, and since the emissions data typically contain only annual emission totals, we generally apply the assumption to all source categories that the maximum one-hour emission rate from any source is ten times the average annual hourly emission rate for that source. However, sources may emit on a more intermittent basis and source category specific data may support the use of engineering judgement to determine peak hourly emissions for any given process. Further information on the factor used to estimate short-term emissions for this source category is provided in Appendix 1 and further discussion of the acute risk assessment can be found in Section 2.4.

We determined census block elevations for HEM3 modeling nationally from the US Geological Service 1/3 Arc Second National Elevation Dataset, which have a spatial resolution of about 10 meters. Elevations of polar grid points used in estimating short- and long-term ambient concentrations were assumed to be equal to the highest elevation of any census block falling within the polar grid sector corresponding to the grid point. If a sector does not contain any blocks, the model defaults the elevation to that of the nearest block. If an elevation is not provided for the emission source, the model uses the average elevation of all sectors within the innermost model ring. In addition to using receptor elevation to determine plume height, AERMOD adjusts the plume's flow if nearby elevated hills are

---

[1] Census blocks, the finest resolution available in the census data, are typically comprised of approximately 50 people or about 20 households.

[2] Generally we estimate these concentrations at locations no nearer than 100 meters from the center of the facility (note that for large facilities, this 100-meter ring could still contain locations inside the facility property).

expected to influence the wind patterns. For details on how hill heights were estimated and used in the AERMOD modeling see Appendix 2 of this document.

2.3 Estimating chronic human inhalation exposure

We used the estimated annual average ambient air concentration of each HAP at each census block centroid or user defined receptor as a surrogate for the lifetime inhalation exposure concentration of all the people who reside in the census block. The risk analysis did not consider either the short-term or long-term behavior (mobility) of the exposed populations and its potential influence on their exposure.

We did not address short-term human activity, including indoor air concentrations, for two reasons. First, our experience with the National Air Toxics Assessment (NATA), which models daily activity using EPA's HAPEM model, suggests that, given our current understanding of microenvironment concentrations and daily activities, modeling short-term activity would, on average, reduce risk estimates about 25 percent for particulate HAP. It will also reduce risk estimates for gaseous HAP, but typically by much less. Second, basing exposure estimates on average ambient concentrations at census block centroids may underestimate or overestimate actual exposure concentrations at some residences. Further reducing exposure estimates for the most highly exposed residents by modeling their short-term behavior could add a systematic low bias to these results.

We did not address long-term migration nor population growth or decrease over 70 year. Instead we, assumed that each person's predicted exposure is constant over the course of their lifetime, which is assumed to be 70 years. The assumption of not considering short or long-term population mobility does not bias the estimate of the theoretical MIR (assumes a person stays in one location for 70 years) nor does it affect the estimate of cancer incidence since the total population number remains the same. It does, however, affect the shape of the distribution of individual risks across the affected population, shifting it toward higher estimated individual risks at the upper end and reducing the number of people estimated to be at lower risks, thereby increasing the estimated number of people at specific risk levels.

2.4 Acute risk screening and refined assessments

In establishing a scientifically defensible approach for the assessment of potential health risks due to acute exposures to HAP, we followed the same general approach that has been used for developing chronic health risk assessments under the residual risk program, which is a tiered, iterative approach. To implement this approach, we designed an assessment methodology to eliminate from further consideration those facilities for which we have confidence that no acute adverse health effects of concern will occur. We began with a screening assessment, which relies on readily available data and uses conservative assumptions that in combination approximate a worst-case exposure. The result of this screening process is that either the facility being assessed poses no potential acute health risks (i.e., it "screens out"), or that it requires further, more refined assessment. A more refined acute assessment could use industry- or site-specific data on the temporal pattern of emissions, the layout of emission points at the facility, the boundaries of the facility, and/or the local meteorology. In some cases, all of these site-specific data are used to refine the assessment; in others, lesser amounts of site-specific data can be used to determine that acute exposures are not a concern, and significant additional data collection is not necessary.

To develop a more robust peak-to-mean emissions factor, and in response to one of the key messages from the SAB consultation on our RTR Assessment Plan, we performed an analysis using a short-term emissions dataset from a number of sources located in Texas (originally reported on by Allen *et al.* 2004). In that report, the Texas Environmental Research Consortium Project compared hourly and annual emissions data for volatile organic compounds for all facilities in a heavily-industrialized 4-county area (Harris, Galveston, Chambers, and Brazoria Counties) over an 11-month time period in 2001. We obtained the dataset and performed our own analysis, focusing on sources which reported emitting high quantities of HAP over short periods of time (see Appendix 5 of this document, *Analysis of Data on Short-term Emission Rates Relative to Long-term Emission Rates*). Most peak emission events were less than twice the annual average, the highest was a factor of 74 times the annual average, and the 99th percentile ratio of peak hourly emission rate to the annual hourly emission rate was 9. Based on these results, we generally chose the factor of ten for all initial screening. This factor is intended to cover all possible hourly peaks associated with routinely- variable emissions. While there have been some documented emission excursions above this level, our analysis of the data from the Texas Environmental Research Consortium suggests that this factor should cover more than 99 percent of the short-term peak gaseous or volatile HAP emissions from typical industrial sources. We have no data relating specifically to peak short-term emissions of particulate HAP. In the absence of source category-specific data, we use this same default approach for particulate emissions as well. When screening for potentially significant acute exposures, we used an estimate of the highest hourly ambient concentration at any off-site location as the surrogate for the maximum potential acute exposure concentration for any individual.

When we identify acute impacts which exceed their relevant benchmarks, we pursue refining our acute screening estimates to the extent possible. In some cases, this may include the use of a facility-specific emissions multiplier to estimate the peak hourly emission rates from the average rates (rather than the default factor of 10). In some cases, this may also entail determining the actual physical layout and boundaries of a facility to more accurately gauge where people might reasonably be exposed for an hour. See Section 3 of this document for the approach used for this source category.

In summary, we used conservative assumptions for emission rates, meteorology, and exposure location. We used the following worst-case assumptions in our screening approach:

- Peak 1-hour emissions are obtained from the data collection effort or estimated based on the operating characteristics and engineering judgement of facility emission sources.
- We assumed that the peak emissions occur at all emission points at the same time.
- For facilities with multiple emission points, 1-hour concentrations at each receptor were assumed to be the sum of the maximum concentrations due to each emission

point, regardless of whether those maximum concentrations occurred during the same hour.
- Worst-case meteorology (from one year of local meteorology) was assumed to occur at the same time the peak emission rates occur. The recommended EPA local-scale dispersion model, AERMOD, is used for simulating atmospheric dispersion.
- A person was assumed to be located downwind at the point of maximum modeled impact during this same worst-case 1-hour period, but no nearer to the source than 100 meters.
- The maximum impact was compared to multiple short-term health benchmarks for the HAP being assessed to determine if a possible acute health risk might exist. These benchmarks are described in section 2.6 of this report.

2.5 Multipathway human health risk analysis

The potential for significant human health risks due to exposures via routes other than inhalation (i.e., multipathway exposures) was screened by first determining whether any sources emitted HAP known to be persistent and bioaccumulative in the environment (PB-HAP).[3] The initial set of PB-HAP compounds or compound classes were identified for screening from EPA's Air Toxics Risk Assessment (ATRA) Library. The PB-HAP listed in the ATRA library include: cadmium compounds, chlordane, chlorinated dibenzodioxins and furans (dioxins), 1,1-Dichloro-2,2-bis(p-chlorophenyl) ethylene (DDE) heptachlor, hexachlorobenzene, hexachlorocyclohexane, lead compounds, mercury compounds, methoxychlor, polychlorinated biphenyls (PCB), polycyclic organic matter (POM), toxaphene, and trifluralin. From among these 14 identified PB-HAP, EPA identified cadmium compounds, dioxins, mercury compounds and POM as PB-HAP of primary concern. EPA identified these by assessing national emission totals, toxicity considerations, and bioaccumulation potential.

PB-HAP emissions were evaluated for potential non-inhalation risks using a tiered screening approach. The approach was developed for use with EPA's peer-reviewed Total Risk Integrated Methodology: Fate, Transport, and Ecological Exposure (TRIM.FaTE) model. Using this approach, we first determined whether the facility-specific emission rates for each emitted PB–HAP were large enough to create the potential for significant non-inhalation human health risks under reasonable worst-case conditions. To facilitate this step, we developed emission rate screening values for each PB-HAP using a hypothetical upper-end screening exposure scenario developed for use in conjunction with TRIM.FaTE. The exposure scenario was developed to simulate a generic subsistence farming and fishing lifestyles. We conducted a sensitivity analysis on the screening scenario to ensure that its key design parameters would represent the upper end of the range of possible values, such that it would represent a conservative but not impossible scenario. We then derived an emission level for each carcinogenic PB-HAP at which the maximum excess lifetime cancer risk would be 1-in-

---

[3] Although the two-letter chemical symbol for lead is Pb, in this assessment PB-HAP refers to the many air pollutants known to be persistent and bioaccumulative in the environment. When this report is specifically referring to lead, the term is spelled out (i.e., the two-letter chemical symbol for lead is not used in this document).

1 million. For PB-HAP that cause non-cancer health effects, we derived an emission level for which the maximum hazard quotient (HQ) would be 1. An exceedance of a screening value in any of the tiered screening methods cannot be equated with a risk value or a hazard quotient (or hazard index). Rather, it represents a high-end estimate of what the risk or hazard may be. For example, an exceedance of 2 for a non-carcinogen can be interpreted to mean that we are confident that the non-cancer hazard would be lower than 2. Similarly, an exceedance of 30 for a carcinogen means that we are confident that the cancer risk is lower than 30-in-1 million. This application of the TRIM.FaTE model represents a Tier 1 Screen. See Appendix 6 (*Technical Support Document for TRIM-Based Multipathway Tiered Screening Methodology for RTR*) for a complete discussion of the development and testing of the screening scenario and the facility-level emission rate screening values.

If the PB-HAP emissions for a facility exceed the Tier 1 screening value, we can conduct a Tier 2 multipathway screen. In the Tier 2 screen, the locations of the facilities with emissions that exceed the Tier 1 screening value can be used to refine some of the assumptions associated with the environmental scenario while maintaining the exposure scenario assumptions. We then adjust the risk-based Tier 1 screening value for each PB-HAP for each facility, based on an understanding of how exposure concentrations estimated for the screening scenario change with use of the local meteorology and environmental assumptions. Whereas the hypothetical human receptor in Tier 1 is exposed through subsistence fishing and subsistence farming together, Tier 2 more realistically considers the fishing and farming as two separate exposure scenarios. This step creates a facility-specific screening value for each PB-HAP (i.e., the threshold for cadmium could differ across facilities) and for each fisher receptor and farmer receptor, unlike the Tier 1 screening value which is constant at different facilities for the same PB-HAP (i.e., the threshold for cadmium is the same for every facility) and includes combined subsistence fisher and farmer receptors.

The subsistence fisher scenario assumes a high-end fish consumption rate of 373 g/day for adults (Burger, 2002); fish consumption rates for other age groups are presented in Appendix 6. In addition, the subsistence fisher scenario uses the assumption that the biological productivity limitation of each lake is 1 gram of fish per acre of water per day. Thus, to fulfill the adult ingestion rate, we might need to model more than one lake to reach a cumulative total of 373 acres. Refer to Appendix 6 of this document for a complete discussion of the bioassay studies used to support this assumption. This occurs only in Tier 2 and Tier 3; the Tier 1 subsistence fisher consumes the full ingestion rate of fish from a single lake.

If we need to include more than one lake to achieve the 373-g/day ingestion rate, we begin with the lake with highest modeled chemical concentration of a given PB-HAP group, and “fish” up to the lake’s biological productivity. We then systematically proceed to other lakes based on concentration, until the 373-g/day target is met. A maximum travel radius of 50 km relative to the facility is used to maintain a realistic scenario. The final Tier 2 screening result for the fisher can be expressed as the sum of the screening result from each lake that is fished (which is based on the amount of fish ingested from each lake multiplied by the fish concentration). If the highest-concentration lake is at least 373 acres, the adult fisher catches and consumes 373 g/d of fish from that lake. If the cumulative size of multiple visited lakes exceeds 373 acres, the model includes from the final lake only the amount of fish necessary to satisfy the ingestion rate (i.e., to reach 373 g/d). If the total acreage of lakes within 50 km is less than 373, the screening result reflects a reduced ingestion rate based on the lake acreage.

The farmer scenario involves an individual that lives for a 70-year lifetime on a farm near the source and consumes produce grown, and meat and animal products raised, on the farm. The ingestion rates used for these food groups, and for incidental soil ingestion, are set at the 90th percentile of EPA's Exposure Factors Handbook: 2011 Edition (USEPA, 2011) and are considered upper-bound levels.

Tier 2 screening values are then evaluated for the source category to determine if further refinement is necessary for those facilities that may pose a significant risk. A finding that a facility's emissions exceed Tier 2 screening values does not mean that multipathway impacts are significant, only that we cannot rule out that possibility based on the results of the screen. See Appendix 6 of this document for a complete discussion of the Tier 2 screen.

For facilities for which the Tier 2 screening value(s) indicate a potential health risk to the public, we can conduct a Tier 3 multipathway screen. Tier 3 has three individual stages, and we progress through Tier 3 until the facility's screening values indicate that emissions are unlikely to pose health risks to the public, or until all three stages are complete.

In the first stage of Tier 3, the lake-assessment stage, we examine the fished lakes from Tier 2 and evaluate the existence, the potential purpose, the accessibility and fishability, and the suitability of the lakes for the models and methods used in the screening assessments. We do not reasonably expect a subsistence fisher to catch and consume fish from lakes or ponds that are for industrial or wastewater disposal; are covered in thick plant growth (e.g., swamps or marshes); are clearly closed to public use; or no longer exist (i.e., filled or drained). TRIM.FaTE is not configured to model chemical processes and environmental fate and transport mechanisms in saltwater or brackish waters, nor is it configured to model the very large watersheds and water dynamics of rivers or very large lakes (e.g., larger than 100,000 acres). We use aerial imagery and web inquires to evaluate whether any Tier 2 fished lakes meet these disqualifying criteria and, if so, remove those lakes from all future screening. If we remove a lake from a facility's assessment, and the total acres of fished lakes drops below the target of 373 acres, we evaluate the previously unfished lake with the highest chemical concentration, and so on, until the sizes of the qualifying lakes collectively comprise at least 373 acres or all lakes have been evaluated. We then rerun the fisher screen with the revised lake dataset. If the PB-HAP emissions for a facility exceed the screening value based on the revised lake dataset, we can conduct the next stage of the Tier 3 screen (i.e., the plume-rise screen); otherwise, the emissions are considered unlikely to pose significant risks.

In the second stage of Tier 3, the plume-rise stage, we use site-specific hourly meteorology and facility-specific emission-point characteristics to estimate the fraction of annual emissions that stay within TRIM.FaTE's mixing layer where exposure occurs (i.e., that do not exit the mixing layer). In Tiers 1 and 2, all chemicals are emitted inside the mixing layer and are available for ground-level exposure. In reality, meteorological conditions and emission-point characteristics can cause emissions occasionally to reach higher than the mixing layer. In TRIM.FaTE, any emissions exiting the mixing layer do not reenter the mixing layer, resulting in no ground-level exposure for those emissions. In this Tier 3 stage, we use thermodynamic equations with local hourly meteorology and facility stack parameters to calculate hourly plume-rise heights. The fraction of annual hours during which the plume-rise height is less than the mixing-layer height equals the fraction of annual emissions available for human exposure in the screen. We calculate these fractions for the location of each fished lake and for each relevant farm because lakes and farms can be in different directions from the facility; thus, these calculations are conditional on wind direction. The results of this stage of Tier 3 are revised fisher and/or farmer screening values for each relevant PB-HAP and facility, accounting for emissions deposited above the mixing layer. If the revised screening value still indicates potential health risks to the public, we can proceed to the final stage of the Tier 3 screen (i.e., the time-series screen); otherwise, the PB-HAP emissions are considered unlikely to pose significant risks.

The final stage of Tier 3, if warranted, is the time-series assessment. In this stage, we can conduct new runs of TRIM.FaTE for each relevant lake and/or farm location for a facility for every PB-HAP that represents a risk concern based on the Tier 3 plume-rise assessment. For these model runs, we start with the screening configuration corresponding to the lake and/or farm location and we use site-specific hourly meteorology and the hourly plume-rise values calculated in the Tier 3 plume-rise assessment. Allowing TRIM.FaTE to model chemical fate and transport with hour-by-hour changes in meteorology and plume rise produces a more accurate estimate of chemical concentrations in media of interest, as compared to the static values used in Tier 2 and the post-processing adjustments made in the Tier 3 plume-rise assessment. If a facility's PB-HAP emissions are lower than the Tier 3 time-series screening value, the emissions are considered unlikely to pose significant risk.

If a facility's PB-HAP Tier 3 time-series screening values still indicate potential health risk to the public and data are available, we could elect to conduct a more refined multipathway assessment. A refined assessment replaces some of the assumptions made in the Tier 2 screen with site-specific data. The refined assessment also uses the TRIM.FaTE model and facility-specific emission rates for each PB-HAP. Many variables are available to consider in a refined multipathway assessment, and we have developed a protocol to maintain consistency across source categories. This protocol can be found in Appendix 7 of this document (*Protocol for Developing a TRIM.FaTE Model Scenario to Support a Site-Specific Risk Assessment in the RTR Program*).

Lead

In evaluating the potential multipathway risks from emissions of lead compounds, rather than developing a screening emission rate for them, we compared maximum estimated chronic atmospheric concentrations with the current National Ambient Air Quality Standard (NAAQS) for lead. Values below the NAAQS were considered to have a low potential for multipathway risks.

The NAAQS value, a public health policy judgment, incorporated the Agency's most recent health evaluation of air effects of lead exposure for the purposes of setting a national ambient air quality standard. In setting this value, the Administrator promulgated a standard that was requisite to protect public health with an adequate margin of safety. We consider values below the level of the primary NAAQS to protect against multipathway risks because as mentioned above, the primary NAAQS is set as to protect public health with an adequate margin of safety. However, ambient air lead concentrations above the NAAQS are considered to pose the potential for increased risk to public health. We consider this NAAQS assessment to be a refined analysis given: 1) the numerous health studies, detailed risk and exposure analyses, and level of external peer and public review that went into the development of the primary NAAQS for lead, combined with: 2) the site-specific dispersion modeling used in this assessment to estimated ambient lead concentrations due to the source category emissions. It should be noted, however, that this comparison does not account for possible population exposures to lead from sources other than the one being modeled; for example, via consumption of water from untreated local sources or ingestion of locally grown food. Nevertheless, the Administrator judged that such a standard would protect, with an adequate margin of safety, the health of children and other at-risk populations against an array of adverse health effects, most notably including neurological effects, particularly neurobehavioral and neurocognitive effects, in children (73 FR 67007). The Administrator, in setting the standard, also recognized that no evidence-or risk based bright line indicated a single appropriate level. Instead a collection of scientific evidence and other information was used to select the standard from a range of reasonable values (73 FR 67006).

We further note that comparing ambient lead concentrations to the NAAQS for lead, considering the level, averaging time, form and indicator, also informs whether there is the potential for adverse environmental effects. This is because the secondary lead NAAQS, set to protect against adverse welfare effects (including adverse environmental effects), has the same averaging time, form, and level as the primary standard. Thus, ambient lead concentrations above the NAAQS for lead also indicate the potential for adverse environmental effects.

2.6 Environmental risk analysis

The EPA has developed a screening approach to examine the potential for adverse environmental effects as required under section 112(f)(2)(A) of the CAA. The environmental screen focuses on the following seven environmental HAP:

- Five persistent bioaccumulative HAP (PB-HAP) – cadmium, dioxins/furans, POM, mercury (both inorganic mercury and methyl mercury), and lead;
- Two acid gases – hydrogen chloride (HCl) and hydrogen fluoride (HF).

HAP that persist and bioaccumulate are of particular environmental concern because they accumulate in the soil, sediment, and water. The acid gases – HCl and HF – were included due to their well-documented potential to cause direct damage to terrestrial plants. See Appendix 9 of this document (*Environmental Risk Screen*) for the PB-HAP and acid gas benchmarks included in the environmental risk screen.

For the environmental risk screening analysis, EPA first determined whether any facilities in the source category emitted any of the eight environmental HAP. If one or more of the environmental HAP evaluated are emitted by at least one facility in the source category we proceed to the second step of the environmental risk screen.

For cadmium, mercury, POM, and dioxins/furans, the environmental screening analysis consists of two tiers. In the first tier, TRIM.FaTE modeling was conducted under worst-case environmental conditions to determine whether the facility-specific off-site emission rates of each of the emitted environmental HAP exceeded ecological benchmarks represented as emissions screening values. If off-site emissions from a facility do not exceed the Tier 1 screening values the facility "passes" the screen, and therefore, is not evaluated further under the screening approach. If off-site emissions from a facility exceed the Tier 1 screening values, we evaluate the facility further in Tier 2.

In Tier 2 of the environmental screening analysis, the screening emission levels are adjusted to account for local meteorology and the actual location of lakes in the vicinity of facilities that did not pass the Tier 1 screen. If off-site emissions from a facility do not exceed the Tier 2 screening values, the facility passes the screen, and is typically not evaluated further. If off- site emissions from a facility exceed the Tier 2 screening values, the facility does not pass the screen, and, we evaluate it further in Tier 3. In Tier 3 of the environmental screening analysis, we further examine the suitability of the lakes around the facilities to support life (e.g., remove lakes that have been filled in or are industrial ponds), adjust emissions for plume-rise, and conduct hour-by-hour time-series assessments.

If after conducting the Tier 3 assessment screening values still indicate the potential for adverse environmental effects, we could elect to conduct a more refined assessment using more site specific information. If after additional refinement, the facility still exceeds the environmental screening thresholds, the facility may have the potential to cause adverse environmental effects.

For acid gases, the environmental screening analysis evaluates the potential phytotoxicity and reduced productivity of plants due to chronic exposure to acid gases. The environmental risk screening methodology for acid gases is a single-tier screen that compares the average off-site ambient air concentration over the modeling domain to ecological benchmarks for each of the acid gases. For purposes of ecological risk screening, EPA identifies a potential for adverse environmental effects to plant communities from exposure to acid gases when the average concentration of the HAP around a facility exceeds the lowest-observed-adverse-effect-level (LOAEL) ecological benchmark. In such cases, we further investigate factors such as the magnitude and characteristics of the area of exceedance (e.g., land use of exceedance area, size of exceedance area) to determine if there is an adverse environmental effect.

For lead compounds, we currently do not have the ability to calculate media concentrations using the TRIM.FaTE model. However, air concentrations of lead are already calculated as part of the human health exposure and risk analysis using HEM3. To evaluate the potential for adverse environmental effects from lead, we compare the average modeled air emission concentrations of lead from each facility in the source category emissions to the level of the secondary NAAQS for lead. The secondary lead NAAQS is a reasonable means of evaluating environmental risk because it is set to provide substantial protection against adverse welfare effects which can include "effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being." [4]

2.7 Dose-response assessment

2.7.1 Sources of chronic dose-response information

Dose-response assessment (carcinogenic and non-carcinogenic) for chronic exposure (either by inhalation or ingestion) for the HAP reported in the emissions inventory for this source category were based on the EPA Office of Air Quality Planning and Standards' (OAQPS) existing recommendations for HAP (USEPA, 2014a). This information has been obtained from various sources and prioritized according to (1) conceptual consistency with EPA risk assessment guidelines and (2) level of peer review received. The prioritization process was aimed at incorporating into our assessments the best available science with respect to dose-response information. The recommendations are based on the following sources, in order of priority:

1) **US Environmental Protection Agency (EPA).** EPA has developed dose-response assessments for chronic exposure for many of the pollutants in this study. These assessments typically provide a qualitative statement regarding the strength of scientific data and specify a reference concentration (RfC, for inhalation) or reference dose (RfD, for ingestion) to protect against effects other than cancer and/or a unit risk estimate (URE, for inhalation) or slope factor (SF, for ingestion) to estimate the probability of developing cancer. The RfC is defined as an "estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." The RfD is "an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." The URE is defined as "the upper-bound excess cancer risk estimated to result from continuous lifetime exposure to an agent at a concentration of 1 $\mu g/m^3$ in air." The SF is "an upper bound, approximating a 95 percent confidence limit, on the increased cancer risk from a lifetime exposure to an agent. This estimate, [is] usually expressed in units of proportion (of a population) affected per mg/kg-day…"

   EPA disseminates dose-response assessment information in several forms, based on the level of review. The Integrated Risk Information System (IRIS) is an EPA database that contains scientific health assessment information, including dose-response information.

---

[4] A secondary standard, as defined in Section 109(b)(2), must "specify a level of air quality the attainment and maintenance of which, in the judgment of the Administrator, based on criteria, is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air." Welfare effects as defined in section 302(h) (42 U.S.C. 7602(h)) include, but are not limited to, "effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being."

All IRIS assessments since 1996 have also undergone independent external peer review. The current IRIS process includes review by EPA scientists, interagency reviewers from other federal agencies, and the public, and peer review by independent scientists external to EPA. New IRIS values are developed and old IRIS values are updated as new health effects data become available. Refer to the IRIS Agenda for detailed information on status and scheduling of current individual IRIS assessments and updates. EPA's science policy approach, under the current carcinogen guidelines, is to use linear low-dose extrapolation as a default option for carcinogens for which the mode of action (MOA) has not been identified. We expect future EPA dose-response assessments to identify nonlinear MOAs where appropriate, and we will use those analyses (once they are peer reviewed) in our risk assessments. At this time, however, there are no available carcinogen dose-response assessments for inhalation exposure that are based on a nonlinear MOA.

2) **US Agency for Toxic Substances and Disease Registry (ATSDR).** ATSDR, which is part of the US Department of Health and Human Services, develops and publishes Minimum Risk Levels (MRLs) for inhalation and oral exposure to many toxic substances. As stated on the ATSDR web site: "Following discussions with scientists within the Department of Health and Human Services (HHS) and the EPA, ATSDR chose to adopt a practice similar to that of the EPA's Reference Dose (RfD) and Reference Concentration (RfC) for deriving substance specific health guidance levels for non-neoplastic endpoints." The MRL is defined as "an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (other than cancer) over a specified duration of exposure." ATSDR describes MRLs as substance-specific estimates to be used by health assessors to select environmental contaminants for further evaluation.

3) **California Environmental Protection Agency (CalEPA).** The CalEPA Office of Environmental Health Hazard Assessment has developed dose-response assessments for many substances, based both on carcinogenicity and health effects other than cancer. The process for developing these assessments is similar to that used by EPA to develop IRIS values and incorporates significant external scientific peer review. As stated in the CalEPA Technical Support Document for developing their chronic assessments, the guidelines for developing chronic inhalation exposure levels incorporate many recommendations of the U.S. EPA (USEPA, 1994a) and NAS (NAS, 1994). The non-cancer information includes available inhalation health risk guidance values expressed as chronic inhalation reference exposure levels (RELs). CalEPA defines the REL as "the concentration level at or below which no health effects are anticipated in the general human population." CalEPA's quantitative dose-response information on carcinogenicity by inhalation exposure is expressed in terms of the URE, defined similarly to EPA's URE.

After the dose-response information was prioritized, we made additional changes to some of the chronic inhalation exposure values to address data gaps, increase accuracy, and avoid underestimating risk. Important changes made are outlined below and are reflected in Appendix 8 (*Dose-Response Values Used in the RTR Risk Assessments*) to this document and are as follows:

1) **Manganese**. The EPA considers the ATSDR MRL for manganese (Mn) the most appropriate value to be used in RTR assessments. There is an existing IRIS RfC for Mn (USEPA, 1993a), and ATSDR published an assessment of Mn toxicity which includes a chronic inhalation reference value (i.e., an ATSDR Minimal Risk Level, MRL). (ATSDR, 2012). Both the 1993 IRIS RfC and the 2012 ATSDR MRL were based on the same study (Roels et al., 1992), however, ATSDR used updated dose-response modeling methodology (benchmark dose approach) and considered recent pharmacokinetic findings to support their MRL derivation. Because of the updated methods, EPA has determined that the ATSDR MRL is the appropriate health value to use in RTR risk assessments.

2) **Polycyclic Organic Matter.** EPA has identified appropriate UREs for many individual compounds of POM, published in the sources used for RTR risk assessments. When an individual POM compound is reported in the emission inventory for the source category, we use the appropriate URE for that compound. However, if in the emission inventory for the source category, a POM compound is reported for which EPA has not identified a URE, or when POM are not speciated into individual compounds, then EPA applies simplifying assumptions so that cancer risk can be quantitatively evaluated without substantially under- or over-estimating risk (which can occur if all reported POM emissions were assigned the same URE). To accomplish this, EPA places each POM compound into one of eight POM groups, generally defined by toxicity and the estimated emission profile of POM compounds. POM Groups 1 and 2 include unspeciated POM (emissions reported as “polycyclic organic matter”) and individual POM compounds with no URE assigned from the sources used in RTR risk assessments. With two exceptions, both Groups 1 and 2 are assigned a URE equal to 5 percent of that for pure benzo[a]pyrene; the two exceptions are benzo[a]fluoranthene and generic “benzofluoranthenes”, which received the URE of benzo[b]fluoranthene. POM Groups 3 through 7 comprise POM compounds for which UREs are available from the sources used for RTR risk assessments, except for benz[b+k]fluoranthene and benzo[g,h,i]fluoranthene which receive the URE of benzo[b]fluoranthene. If reported emissions are for a specific compound in these groups, then EPA evaluates the cancer risk of the compound using its unique URE if one has been derived or its group URE if one has not been specifically derived. If the reported emissions are for a specific POM group rather than a compound within the group, then EPA evaluates the cancer risk of the POM group using a URE value that is close to the average of the UREs of the individual compounds within the group. POM Group 8 is composed of unspeciated polycyclic aromatic hydrocarbons (PAH) reported as 7-PAH and are assigned a URE equal to approximately 18 percent of that for pure benzo[a]pyrene. In addition, we concluded that three PAHs—anthracene, phenanthrene and pyrene—are not carcinogenic and therefore no URE is assigned. Details of the analysis that led to this conclusion can be found in the document titled Development of a Relative Potency Factor (RPF) Approach for Polycyclic Aromatic Hydrocarbon (PAH) Mixtures: In Support of Summary Information of the Integrated Risk Information System (IRIS).

3) **Glycol Ethers.** Often in an emission inventory, the glycol ethers are reported only as the total mass for the entire group without distinguishing among individual glycol ether compounds. In other cases, emissions of individual glycol ether compounds that had not been assigned dose-response values were reported. To avoid underestimating the health hazard associated with glycol ethers, we protectively applied the RfC for ethylene glycol methyl ether (the most toxic glycol ether for which an assessment exists) to glycol ether emissions of unspecified composition.

4) **Lead.** We consider the primary NAAQS for lead, which incorporates an adequate margin of safety, to be protective of all potential health effects for the most susceptible populations. The NAAQS, developed using the EPA Integrated Exposure, Uptake, Biokinetic Model, was preferred over the RfC for noncancer adverse effects because the NAAQS for lead was developed using more recent toxicity and dose-response information on the noncancer adverse impacts of lead. The NAAQS for lead was set to protect the health of the most susceptible children and other potentially at-risk populations against an array of adverse health effects, most notably including neurological effects, particularly neurobehavioral and neurocognitive effects (which are the effects to which children are most sensitive). The lead NAAQS, a rolling 3-month average level of lead in total suspended particles, was used as a long-term value in the RTR risk assessment.

5) **Nickel compounds.** To provide a conservative estimate of the potential cancer risks, the EPA considers the IRIS URE value for nickel subsulfide (which is considered the most potent carcinogen among all nickel compounds) to be the most appropriate value to be used in RTR assessments. Based on consistent views of major scientific bodies, such as the National Toxicology Program (NTP) in their 13th Report of the Carcinogens (RoC) (NTP, 2014), the International Agency for Research on Cancer (IARC, 1990), and other international agencies (WHO, 1991) that consider all nickel compounds to be carcinogenic, we currently consider all nickel compounds to have the potential of being carcinogenic to humans. The 13th RoC states that "the combined results of epidemiological studies, mechanistic studies, and carcinogenic studies in rodents support the concept that nickel compounds generate nickel ions in target cells at sites critical for carcinogenesis, thus allowing consideration and evaluation of these compounds as a single group." Although the precise nickel compound (or compounds) responsible for carcinogenic effects in humans is not always clear, studies indicate that nickel sulfate and the combinations of nickel sulfides and oxides encountered in industrial emissions of nickel mixtures cause cancer in humans (these studies are summarized in a review by Grimsrud et al., 2010). The major scientific bodies mentioned above have also recognized that there may be differences in the toxicity and/or carcinogenic potential across the different nickel compounds. For this reason, and given that there are two additional URE values[5] derived for exposure to mixtures

---

[5] Two UREs (other than the current IRIS values) have been derived for nickel compounds as a group: one developed by the California Department of Health Services (http://www.arb.ca.gov/toxics/id/summary/nickel_tech_b.pdf) and the other by the Texas Commission on Environmental Quality (http://www.tceq.state.tx.us/assets/public/implementation/tox/dsd/final/june11/nickel_&_compounds.pdf).

of nickel compounds (as a group) that are 2-3 fold lower than the IRIS URE for nickel subsulfide, the EPA considers it reasonable, in some instances (e.g., when high quality data is available on the composition of nickel emissions from a specific source category), to use a value that is 50 percent of the IRIS URE for nickel subsulfide for providing an estimate of the lower end of the plausible range of cancer potency values for different mixtures of nickel compounds.

6) **Carbonyl Sulfide.** Although the health effects data for carbonyl sulfide (COS) are very limited, a series of studies (Morgan et. al., 2004; Herr et. al., 2007; Sills et. al., 2004) conducted by the National Toxicology Program have shown that the major concern regarding exposure to COS is its potential for neurotoxicity. These studies have shown consistently and at the same range of COS concentrations that the brain is a target organ for COS toxicity. Since health appropriate effects benchmarks have not been derived by our preferred sources of dose-response data including IRIS, ATSDR, and Cal EPA, the EPA has used the data from the above referenced studies to derive a chronic screening benchmark level for COS. A chronic screening level of 163 ug/m^3 was developed for COS from a No Observed Adverse Effects Level (NOAEL) of 200 ppm based on brain lesions and neurophysiological alterations in rodents. Additional details on the derivation of the chronic screening level for COS can be found in Appendix 8.

7) **Pollutant Groups.** In the case of HAP groups such as cyanide compounds, mercury compounds, antimony compounds and others, the most conservative dose-response value in the chemical group is used as a surrogate for other compounds in the group for which dose-response values are not available. This is done to examine, under conservative assumptions, whether those HAP that lack dose-response values may pose an unacceptable risk and require further examination.

8) **Mutagenic Mode of Action.** For carcinogenic chemicals acting via a mutagenic mode of action (i.e., chemicals that cause cancer by damaging genes), we estimated risks to reflect the increased carcinogenicity of such chemicals during childhood. This approach is explained in detail in the Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Where available data do not support a chemical-specific evaluation of differences between adults and children, the Supplemental Guidance recommends using the following default adjustment factors for early-life exposures: increase the carcinogenic potency by 10-fold for children up to 2 years old and by 3-fold for children 2 to 15 years old. These adjustments have the aggregate effects of increasing by about 60 percent the estimated risk (a 1.6-fold increase) for a lifetime of constant inhalation exposure. EPA uses these default adjustments only for carcinogens known to be mutagenic for which data to evaluate adult and juvenile differences in toxicity are not available. The UREs for several HAP (see Appendix 8) were adjusted upward, by multiplying by a factor of 1.6, to account for the increased risk during childhood exposures. Although trichloroethylene is carcinogenic by a mutagenic mode of action, the age-dependent adjustment factor for the URE only applies to the portion of the slope factor reflecting risk of kidney cancer. For full lifetime exposure to a constant level of trichloroethylene exposure, the URE

was adjusted upward by a factor of 1.12 (rather than 1.6 as discussed above). For more information on applying age-dependent adjustment factors in cases where exposure varies over the lifetime, see Toxicological Review of Trichloroethylene. The URE for vinyl chloride includes exposure from birth, although the IRIS assessment contains UREs for both exposure from birth and exposure during adulthood. This value already accounts for childhood exposure; thus, no additional factor was applied.

2.7.2 Sources of acute dose-response information

Hazard identification and dose-response assessment information for preliminary acute inhalation exposure assessments are based on the existing recommendations of OAQPS for HAP (USEPA, 2014b). Depending on availability, the results from screening acute assessments are compared to both "no effects" reference levels for the general public, such as the California Reference Exposure Levels (RELs), as well as emergency response levels, such as Acute Exposure Guideline Levels (AEGLs) and Emergency Response Planning Guidelines (ERPGs), with the recognition that the ultimate interpretation of any potential risks associated with an estimated exceedance of a particular reference level depends on the definition of that level and any limitations expressed therein. Comparisons among different available inhalation health effect reference values (both acute and chronic) for selected HAP can be found in an EPA document of graphical arrays (USEPA, 2009b).

California Acute Reference Exposure Levels (RELs). The California Environmental Protection Agency (CalEPA) has developed acute dose-response reference values for many substances, expressing the results as acute inhalation RELs.

> The acute REL is defined by CalEPA as "the concentration level at or below which no adverse health effects are anticipated for a specified exposure duration (OEHHA, 2015). RELs are based on the most sensitive, relevant, adverse health effect reported in the medical and toxicological literature. RELs are designed to protect the most sensitive individuals in the population by the inclusion of margins of safety. Since margins of safety are incorporated to address data gaps and uncertainties, exceeding the REL does not automatically indicate an adverse health impact." Acute RELs are developed for 1-hour (and 8-hour) exposures. The values incorporate uncertainty factors similar to those used in deriving EPA's inhalation RfCs for chronic exposures (and, in fact, California also has developed chronic RELs).

Acute Exposure Guideline Levels (AEGLs). AEGLs are developed by the National Advisory Committee (NAC) on Acute Exposure Guideline Levels (NAC/AEGL) for Hazardous Substances, and then reviewed and published by the National Research Council. As described in the Committee's Standing Operating Procedures, AEGLs "represent threshold exposure limits for the general public and are applicable to emergency exposures ranging from 10 min to 8 h." Their intended application is "for conducting risk assessments to aid in the development of emergency preparedness and prevention plans, as well as real time emergency response actions, for accidental chemical releases at fixed facilities and from transport carriers." The document states that "the primary purpose of the AEGL program and the NAC/AEGL Committee is to develop guideline levels for once-in-a-lifetime, short-term exposures to airborne concentrations of acutely toxic, high-priority chemicals." In detailing the intended application of AEGL values, the document states that, "It is anticipated that the AEGL values will be used for regulatory and nonregulatory purposes by U.S. Federal and State agencies, and possibly the international community in conjunction with chemical emergency response, planning, and prevention programs. More specifically, the AEGL values will be used for conducting various risk assessments to aid in the development of emergency preparedness and prevention plans, as well as real-time emergency response actions, for accidental chemical releases at fixed facilities and from transport carriers."

The NAC/AEGL defines AEGL-1 and AEGL-2 as:

> "AEGL-1 is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure."
>
> "AEGL-2 is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape."
>
> "Airborne concentrations below AEGL-1 represent exposure levels that can produce mild and progressively increasing but transient and nondisabling odor, taste, and sensory irritation or certain asymptomatic, nonsensory effects. With increasing airborne concentrations above each AEGL, there is a progressive increase in the likelihood of occurrence and the severity of effects described for each corresponding AEGL. Although the AEGL values represent threshold levels for the general public, including susceptible subpopulations, such as infants, children, the elderly, persons with asthma, and those with other illnesses, it is recognized that individuals, subject to unique or idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL."

Emergency Response Planning Guidelines (ERPGs). The American Industrial Hygiene Association (AIHA) has developed ERPGs for acute exposures at three different levels of severity. These guidelines represent concentrations for exposure of the general population (but not particularly sensitive persons) for up to 1 hour associated with effects expected to be mild or transient (ERPG-1), irreversible or serious (ERPG-2), and potentially life-threatening (ERPG-3).

ERPG values are described in their supporting documentation as follows: "ERPGs are air concentration guidelines for single exposures to agents and are intended for use as tools to assess the adequacy of accident prevention and emergency response plans, including transportation emergency planning, community emergency response plans, and incident prevention and mitigation."

ERPG-1 and ERPG-2 values are defined by AIHA's Standard Operating Procedures as follows:

> "ERPG-1 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient health effects or without perceiving a clearly defined objectionable odor."
>
> "ERPG-2 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious adverse health effects or symptoms that could impair an individual's ability to take protective action."

2.8 Risk characterization

2.8.1 General

The final product of the risk assessment is the risk characterization, in which the information from the previous steps is integrated and an overall conclusion about risk is synthesized that is complete, informative, and useful for decision makers. In general, the nature of this risk characterization depends on the information available, the application of the risk information and the resources available. In all cases, major issues associated with determining the nature and extent of the risk are identified and discussed. Further, it is EPA's policy that a risk characterization be prepared in a manner that is clear, transparent, reasonable, and consistent with other risk characterizations of similar scope prepared across programs in the Agency. These principles of transparency and consistency have been reinforced by the Agency's *Risk Characterization Handbook* (USEPA, 2000a), in the Agency's information quality guidelines (USEPA, 2002a), and in the Office of Management and Budget (OMB) Memorandum on Updated Principles for Risk Analysis (OMB, 2007), and are incorporated in these assessments.

Estimates of health risk are presented in the context of uncertainties and limitations in the data and methodology. Through our tiered, iterative analytical approach, we have attempted to reduce both uncertainty and bias to the greatest degree possible in these assessments, within the limitations of available time and resources. We provide summaries of risk metrics (including maximum individual cancer risks and noncancer hazards, as well as cancer incidence estimates) along with a discussion of the major uncertainties associated with their derivation to provide decision makers with the fullest picture of the assessment and its limitations.

For each carcinogenic HAP included in an assessment that has a potency estimate available, individual and population cancer risks were calculated by multiplying the corresponding lifetime average exposure estimate by the appropriate URE. This calculated cancer risk is defined as the upper-bound probability of developing cancer over a 70-yr period (i.e., the assumed human lifespan) at that exposure. Because UREs for most HAP are upper-bound estimates, actual risks at a given exposure level may be lower than predicted, and could be zero.

Increased cancer incidence for the entire population within the area of analysis was estimated by multiplying the estimated lifetime cancer risk for each census block by the number of people residing in that block, then summing the results for the entire modeled domain. This lifetime population incidence estimate was divided by 70 years to obtain an estimate of the number of cancer cases per year.

Unlike linear dose-response assessments for cancer, noncancer health hazards generally are not expressed as a probability of an adverse occurrence. Instead, "risk" for noncancer effects is expressed by comparing an exposure to a reference level as a ratio. The "hazard quotient" (HQ) is the estimated exposure divided by a reference level (e.g., the RfC). For a given HAP, exposures at or below the reference level ($HQ \leq 1$) are not likely to cause adverse health effects. As exposures increase above the reference level (HQs increasingly greater than 1), the potential for adverse effects increases. For exposures predicted to be above the RfC, the risk characterization includes the degree of confidence ascribed to the RfC values for the compound(s) of concern (i.e., high, medium, or low confidence) and discusses the impact of this on possible health interpretations.

The risk characterization for chronic effects other than cancer is expressed in terms of the HQ for inhalation, calculated for each HAP at each census block centroid. As discussed above, RfCs incorporate generally conservative uncertainty factors in the face of uncertain extrapolations, such that an HQ greater than one does not necessarily suggest the onset of adverse effects. The HQ cannot be translated to a probability that adverse effects will occur, and is unlikely to be proportional to adverse health effect outcomes in a population.

Screening for potentially significant acute inhalation exposures also followed the HQ approach. We divided the maximum estimated acute exposure by each available short-term threshold value to develop an array of HQ values relative to the various acute endpoints and thresholds. In general, when none of these HQ values are greater than one, there is no potential for acute risk. In those cases where HQ values above one are seen, additional information is used to determine if there is a potential for significant acute risks.

2.8.2 Mixtures

Since most or all receptors in these assessments receive exposures to multiple pollutants rather than a single pollutant, we estimated the aggregate health risks associated with all the exposures from a particular source category combined.

To combine risks across multiple carcinogens, our assessments use the mixtures guidelines' default assumption of additivity of effects, and combine risks by summing them using the independence formula in the mixtures guidelines (USEPA, 1986; USEPA, 2000b).

In assessing noncancer hazard from chronic exposures, in cases where different pollutants cause adverse health effects via completely different modes of action, it may be inappropriate to aggregate HQs. In consideration of these mode-of-action differences, the mixtures guidelines support aggregating effects of different substances in specific and limited ways.

To conform to these guidelines, we aggregated non-cancer HQs of HAP that act by similar toxic modes of action, or (where this information is absent) that affect the same target organ. This process creates, for each target organ, a target organ specific hazard index (TOSHI), defined as the sum of hazard quotients for individual HAP that affect the same organ or organ system. All TOSHI calculations presented here were based exclusively on effects occurring at the "critical dose" (i.e., the lowest dose that produces adverse health effects). Although HQs associated with some pollutants have been aggregated into more than one TOSHI, this has been done only in cases where the critical dose affects more than one target organ. Because impacts on organs or systems that occur above the critical dose have not been included in the TOSHI calculations, some TOSHIs may have been underestimated. As with the HQ, the TOSHI should not be interpreted as a probability of adverse effects, or as strict delineation of "safe" and "unsafe" levels. Rather, the TOSHI is another measure of the potential for adverse health outcomes associated with pollutant exposure, and needs to be interpreted carefully by health scientists and risk managers.

Because of the conservative nature of the acute inhalation screening and the variable nature of emissions and potential exposures, acute impacts were screened on an individual pollutant basis, not using the TOSHI approach.

3 Risk results for the pulp mill combustion sources (Subpart MM source category)

3.1 Source category description and emissions

The pulp mill combustion sources category includes any facility engaged in the production of chemical pulp and includes, but is not limited to, integrated mills (where pulp and paper or paperboard are manufactured on-site) and non-integrated mills (where only pulp is produced). Examples of chemical pulping methods include kraft, soda, sulfite, and semichemical processes.

The MACT standards for the pulp and paper production source category were developed in three parts; this report regards the risks from the MACT II source category (with standards contained in 40 CFR 63, Subpart MM: National Emission Standards for Hazardous Air Pollutants for Chemical Recovery Combustion Sources at Kraft, Soda, Sulfite, and Stand-Alone Semichemical Pulp Mills). The chemical recovery process at pulp mills involves the recovery of chemicals in the spent cooking liquor, reconstitution of those chemicals, and the generation of energy from the incineration of the organic residuals. This subpart regulates the emissions from pulp mill combustion sources, which are recovery furnaces, smelt dissolving tanks, lime kilns, semichemical combustion units, and sulfite combustion units. These standards do not address emissions from the chemical pulping processes which are referred to as MACT I sources. Mills that mechanically pulp wood, or that pulp secondary fiber or non-wood fibers, or that produce paper or paperboard from purchased pulp are referred to as MACT III sources, and these two MACTs are regulated under a separate NESHAP (40 CFR

63, Subpart S). A complete description of the pulp and paper mill~~s~~ source category can be found in the text of the NPRM.

The emissions data for this source category was obtained from a 2011 information collection request (ICR) survey, updated with more recent data from industry stakeholders, and reviewed to ensure quality control of facility and emission locations. We estimate that there are 108 facilities with pulp mill combustion sources operating in the U.S. and all of these facilities are identified as major sources of HAP. Emissions from the pulp mill combustion source category are summarized in Table 3.1-1. The total HAP emissions for the source category are approximately 11,600 tons per year. Based on these data, the HAP emitted in the largest quantities are methanol, hydrochloric acid, acetaldehyde, formaldehyde, phenol, methyl chloride, propionaldehyde, cresols (mixed), acetophenone, naphthalene, benzene, cumene, carbon disulfide, xylenes (mixed), n-hexane, methylene chloride, methyl isobutyl ketone, hexachloroethane, toluene, o-cresol, carbonyl sulfide, ethyl benzene, 1,2,4-trichlorobenzene, acrolein and phenanthrene. Emissions of these 25 HAP make up 99 percent of the total emissions by mass. The PB-HAP reported as emissions from these facilities include polycyclic organic matter (POM), lead compounds, cadmium compounds, mercury compounds, and dioxins/furans. The following environmental HAP are emitted from the pulp mill combustion source category and are included in the environmental risk screen: POM, cadmium, mercury, dioxins/furans, hydrogen chloride, and hydrofluoric acid.

The emissions data for this source category are estimates of actual emissions on an annual basis. The risk results presented in the following sections are based on these actual emissions. MACT-allowable and facility-wide emissions were also estimated and the risk results based on those emissions are presented below as well. Details on the development of the actual, allowable, and facility-wide and the source of the data for this source category can be found in Appendix 1.

For the chronic inhalation risk assessment, the emissions inventory for the pulp mill combustion source category includes emissions of 109 HAP with available chronic inhalation dose-response values. Of these, 68 are classified as known, probable, or possible carcinogens, with quantitative cancer dose-response values available and 84 HAP have quantitative noncancer dose-response values available. These HAP, their emissions and toxicity values are listed in Table 3.1-1 and the source of each toxicity value is listed in Appendix 8.

For the acute inhalation risk assessment, for the pulp mill combustion source category, maximum hourly emissions estimates were available, so we did not use the default emissions multiplier of 10 as described in Section 2.4. In general, hourly emissions estimates were based on the median of the peak-to-mean ratio for 14 emission process groups ranging from a factor of 1.3 to 4.7, with emissions from the semichemical recovery process having the highest hourly peak emissions at a factor of 4.7 times the annual average. See Appendix 1 to this document for a detailed description of how the maximum hourly emissions were developed for this source category.

The emissions inventory for the pulp mill combustion source category includes emissions of 44 HAP with relevant and available quantitative acute dose-response threshold values. These

HAP, their emissions and toxicity values are listed in Table 3.1-1 and the source of each toxicity value is listed in Appendix 8.

As mentioned previously, when we identify acute impacts which exceed their relevant benchmarks, we pursue refining our acute screening estimates to the extent possible. For the pulp mill combustion source category, the acute screening results indicated the peak emissions are considered unlikely to pose significant risk and further refinement was not warranted. The acute results for the source category are summarized in the following section and detailed information is contained in Appendix 10 to this document (*Detailed Risk Modeling Results*).

For the multipathway risk assessment, PB-HAP identified in the emissions inventory for the pulp mill combustion source category includes POM (of which PAH is a subset), lead compounds, cadmium compounds, mercury compounds, and dioxins/furans. Of these, all but lead have quantitative chronic oral cancer or noncancer threshold values available, which are presented in Table 3.1-1, and were screened for non-inhalation risks using a tiered screening approach described in Section 2.5. In evaluating the potential multipathway risks from emission of lead compounds, we compared maximum estimated chronic atmospheric concentrations with the current NAAQS for lead, also as described in Section 2.5.

As mentioned previously, when we identify multipathway impacts which exceed their relevant benchmarks, we pursue refining our multipathway estimates. For the pulp mill combustion source category, we conducted a screening multipathway assessment for all of the facilities in this category and determined that a refined site-specific multipathway assessment was not warranted. A detailed discussion of the approach for this refined site-specific assessment can typically be found in Appendix 11 of this document (*Site-Specific Human Health Multipathway Residual Risk Assessment Report*); however, since this type of analysis was not warranted, Appendix 11 is intentionally left blank. The results of the screening multipathway assessment for the source category are summarized in the following section and detailed information is contained in Appendix 10 to this document.

For the environmental risk assessment, the PB-HAP identified above as well as two acid gases (hydrogen chloride and hydrogen fluoride) were screened for potential adverse environmental effects as described in Section 2.6. The benchmark values and a detailed discussion of the approach for this assessment can be found in Appendix 9. The results of the environmental assessment for the source category are summarized in the following section and detailed information is contained in Appendix 10 to this document.

Table 3.1-1 Summary of Emissions from the Pulp Mill Combustion Sources and Dose-Response Values Used in the Residual Risk Assessment

HAP	**Emissions (tpy)**	**Number of Facilities Reporting HAP (108 facilities in source category)**	**Prioritized Inhalation Dose-Response Value Identified by OAQPS**			**PB-HAP Oral Benchmark Values for Cancer (1/(mg/kg/d)) and/or Noncancer (mg/kg/d)[a]**
			Unit Risk Estimate for Cancer (1/(μg/m^3))	**Reference Concentration for Noncancer (mg/m^3)**	**Health Benchmark Values for Acute Noncancer (mg/m^3)**	
Methanol	6,056	106		20	28 (REL)	
Hydrochloric Acid	3,304	102		0.02	2.1 (REL)	
Acetaldehyde	470	105	0.0000022	0.009	0.47 (REL)	
Formaldehyde	332	106	0.000013	0.0098	0.055 (REL)	
Phenol	327	93		0.2	5.8 (REL)	
Methyl Chloride	255	81		0.09	310 (ERPG-1	
Propionaldehyde	135	70		0.008	110 (AEGL-1 (1-hr))	
Cresols (mixed)	93	30		0.6		
Acetophenone	71	25				
Naphthalene	60	95	0.000034	0.003		
Benzene	51	101	0.0000078[d]	0.03	1.3 (REL)[g]	
Cumene	39	82		0.4	250 (AEGL-1 (1-hr))	
Carbon Disulfide	36	82		0.7	3.1 (ERPG-1)	
Xylenes (mixed)	36	88		0.1	22 (REL)	
n-Hexane	35	86		0.7	10000 (AEGL-2 (1-hr))	
Methylene Chloride	31	81	0.000000016	0.6	14 (REL)	
Methyl Isobutyl Ketone	24	85		3		
Hexachloroethane	23	5		0.03		
Toluene	20	99		5	37 (REL)	
o-Cresol	20	12		0.6		
Carbonyl Sulfide	19	19		0.163[f]	140 (AEGL-2 (1-hr))	
Ethyl Benzene	16	71	0.0000025	1	140 (AEGL-1 (1-hr))	
1,2,4-Trichlorobenzene	16	83		0.2		
Acrolein	14	91		0.00002	0.07 (AEGL-1 (1-hr))	
Polycyclic Organic Matter						
Phenanthrene	13	93				b
Acenaphthylene	5	86	0.000088			0.5 (cancer)
2-Methylnaphthalene	4	51	0.000088			0.5 (cancer)
Fluoranthene	3	97	0.000088			0.5 (cancer)
Pyrene	2	93				b
Acenaphthene	1	84	0.000088			0.5 (cancer)
Anthracene	1	86				b

Table 3.1-1 Summary of Emissions from the Pulp Mill Combustion Sources and Dose-Response Values Used in the Residual Risk Assessment

HAP	Emissions (tpy)	Number of Facilities Reporting HAP (108 facilities in source category)	Prioritized Inhalation Dose-Response Value Identified by OAQPS			PB-HAP Oral Benchmark Values for Cancer (1/(mg/kg/d)) and/or Noncancer (mg/kg/d)[a]
			Unit Risk Estimate for Cancer (1/(µg/m^3))	Reference Concentration for Noncancer (mg/m^3)	Health Benchmark Values for Acute Noncancer (mg/m^3)	
Fluorene	0.5	93	0.000088			0.5 (cancer)
1-Methylnaphthalene	0.4	32	0.000088			0.5 (cancer)
Chrysene	0.4	86	0.0000176			0.12 (cancer)
Benz[a]anthracene	0.2	90	0.000176			1.2 (cancer)
Benzo[b]fluoranthene	0.07	90	0.000176			1.2 (cancer)
Benzo(ghi)perylene	0.07	90	0.000088			0.5 (cancer)
3-methylcholanthrene	0.07	43	0.01008			22 (cancer)
Benzo[k]fluoranthene	0.06	90	0.000176			1.2 (cancer)
Benzo(e)pyrene	0.04	81	0.000088			0.5 (cancer)
Benzo[a]pyrene	0.02	90	0.00176			7.3 (cancer)
Dibenzo[a,h]anthracene	0.02	90	0.00192			4.1 (cancer)
Polycyclic Organic Matter	0.01	2	0.000088			0.5 (cancer)
Indeno[1,2,3-c,d]pyrene	0.01	91	0.000176			1.2 (cancer)
Benzo(c)phenanthrene	0.005	3	0.000088			0.5 (cancer)
7,12-Dimethylbenz[a]anthracene	0.003	35	0.1136			250 (cancer)
Perylene	0.002	69	0.000088			0.5 (cancer)
Benzo[j]fluoranthene	0.0006	2	0.000176			1.2 (cancer)
Benzo(g,h,i)fluoranthene	0.0002	1	0.000176			1 (cancer)
Benzo[b+k]fluoranthene	0.000007	12	0.000176			1 (cancer)
Benzofluoranthenes	0.0000006	1	0.000176			0.5 (cancer)
Styrene	12	97		1	21 (REL)	
o-Xylene	11	37		0.1	22 (REL)	
Hydrofluoric Acid	8	33		0.014	0.24 (REL)	
Tetrachloroethene	7	78	0.00000026	0.04	20 (REL)	
Manganese Compounds	6	104		0.0003		
m-Cresol (3-methylphenol)	6	3		0.6		
Chloroform	5	86		0.098	0.15 (REL)	
Lead Compounds	4	103		0.00015[e]		
Dibutylphthalate	4	50				
Methyl Bromide	3	50		0.005	3.9 (REL)	
Nickel Compounds	3	101	0.00048	0.00009		
Trichloroethylene	3	77	0.0000048	0.002	540 (ERPG-1)	
Methyl Iodide	2	18			150 (ERPG-1)	
Chlorine	2	6		0.00015	0.21 (REL)	
1,1,2-Trichloroethane	2	74	0.000016	0.4		

Table 3.1-1 Summary of Emissions from the Pulp Mill Combustion Sources and Dose-Response Values Used in the Residual Risk Assessment

HAP	Emissions (tpy)	Number of Facilities Reporting HAP (108 facilities in source category)	Prioritized Inhalation Dose-Response Value Identified by OAQPS			PB-HAP Oral Benchmark Values for Cancer (1/(mg/kg/d)) and/or Noncancer (mg/kg/d)[a]
			Unit Risk Estimate for Cancer (1/(µg/m^3))	Reference Concentration for Noncancer (mg/m^3)	Health Benchmark Values for Acute Noncancer (mg/m^3)	
Carbon Tetrachloride	2	68	0.000006	0.1	1.9 (REL)	
Biphenyl	2	48			61 (AEGL-2 (1-hr))	
1,2-Dimethoxyethane	1	29		0.02	0.09 (REL)	
1,3-Butadiene	1	36	0.00003	0.002	22 (ERPG-1)	
1,1,1-Trichloroethane	1	73		5	68 (REL)	
Ethylene Dichloride	1	53	0.000026	2.4	200 (ERPG-1)	
Chlorobenzene	1	70		1	46 (AEGL-1 (1-hr))	
Chromium Compounds						
Chromium (III) Compounds	1	96				
Chromium (VI) Compounds	0.5	102	0.012	0.0001		
2,2,4-Trimethylpentane	0.9	26				
Vinyl Acetate	0.8	47		0.2	18 (ERPG-1)	
Selenium Compounds	0.6	84		0.02		
m-Xylene	0.5	5		0.1	22 (REL)	
Cadmium Compounds	0.4	95	0.0018	0.00001		0.001 (noncancer)
Chloroprene	0.2	33	0.00048	0.02		
Bis(2-ethylhexyl)phthalate	0.2	47	0.0000024	0.01		
Arsenic Compounds	0.2	101	0.0043	0.000015		
Cobalt Compounds	0.2	83		0.0001		
Di(ethylene Glycol Monobutyl Ether) Phthalate	0.2	3		0.02	0.09 (REL)	
Antimony Compounds	0.2	76		0.0002		
Aniline	0.1	18	0.0000016	0.001	30 (AEGL-1 (1-hr))	
Acrylonitrile	0.09	20	0.000068	0.002	10 (AEGL-1 (1-hr))	
p-Xylene	0.09	2		0.1	22 (REL)	
Mercury Compounds						
Mercury (elemental)	0.08	101		0.0003	1.7 (AEGL-2 (1-hr))	c
Gaseous Divalent Mercury	0.04	100		0.0003		0.0001 (noncancer)
Particulate Divalent Mercury	0.03	100		0.0003		0.0001 (noncancer)
Phosphorus, White	0.05	2				

Table 3.1-1 Summary of Emissions from the Pulp Mill Combustion Sources and Dose-Response Values Used in the Residual Risk Assessment

HAP	Emissions (tpy)	Number of Facilities Reporting HAP (108 facilities in source category)	Prioritized Inhalation Dose-Response Value Identified by OAQPS			PB-HAP Oral Benchmark Values for Cancer (1/(mg/kg/d)) and/or Noncancer (mg/kg/d)[a]
			Unit Risk Estimate for Cancer (1/(µg/m^3))	Reference Concentration for Noncancer (mg/m^3)	Health Benchmark Values for Acute Noncancer (mg/m^3)	
Vinyl Chloride	0.04	43	0.0000088	0.1	180 (REL)	
Beryllium Compounds	0.04	90	0.0024	0.00002	0.03 (ERPG-2)	
Hexachlorobutadiene	0.03	2	0.000022	0.09	11 (ERPG-1)	
p-Dichlorobenzene	0.01	9	0.000011	0.8		
Isophorone	0.008	17		2		
Bromoform	0.007	1	0.0000011			
Dimethyl Phthalate	0.001	1				
1,2-Dibromo-3-chloropropane	0.0004	2	0.002	0.0002		
Thorium-232	0.0004	8				
Ethylene Dibromide	0.0002	1	0.0006	0.009	130 (AEGL-1 (1-hr))	
Uranium Compounds	0.00007	11		0.0008		
Thallium	0.00003	1				
Dibenzofuran	0.0000003	1				
Dioxins and Furans						
2,3,7,8-Tetrachlorodibenzofuran	0.0000002	93	3.3	0.0000004		15000 (cancer)
2,3,4,7,8-Pentachlorodibenzofuran	0.0000002	93	9.9	0.00000013		45000 (cancer)
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.0000001	100	0.33	0.000004		1500 (cancer)
1,2,3,4,7,8-Hexachlorodibenzofuran	0.0000001	93	3.3	0.0000004		15000 (cancer)
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.0000001	84	33	0.00000004		150000 (cancer)
2,3,4,6,7,8-Hexachlorodibenzofuran	0.0000001	93	3.3	0.0000004		15000 (cancer)
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.00000008	100	3.3	0.0000004		6200 (cancer)
1,2,3,4,6,7,8,9-Octochlorodibenzo-p-dioxin	0.00000007	100	0.0099	0.00013		45 (cancer)
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.00000007	98	3.3	0.0000004		15000 (cancer)
1,2,3,6,7,8-Hexachlorodibenzofuran	0.00000006	93	3.3	0.0000004		15000 (cancer)
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.00000003	97	3.3	0.0000004		15000 (cancer)
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.00000003	94	0.33	0.000004		1500 (cancer)

Table 3.1-1 Summary of Emissions from the Pulp Mill Combustion Sources and Dose-Response Values Used in the Residual Risk Assessment

HAP	Emissions (tpy)	Number of Facilities Reporting HAP (108 facilities in source category)	Prioritized Inhalation Dose-Response Value Identified by OAQPS			PB-HAP Oral Benchmark Values for Cancer (1/(mg/kg/d)) and/or Noncancer (mg/kg/d)[a]
			Unit Risk Estimate for Cancer $(1/(\mu g/m^3))$	Reference Concentration for Noncancer (mg/m^3)	Health Benchmark Values for Acute Noncancer (mg/m^3)	
1,2,3,7,8,9-Hexachlorodibenzofuran	0.00000002	90	3.3	0.0000004		15000 (cancer)
1,2,3,7,8-Pentachlorodibenzofuran	0.00000002	93	0.99	0.0000013		4500 (cancer)
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.000000009	85	0.33	0.000004		1500 (cancer)
1,2,3,4,6,7,8,9-Octochlorodibenzofuran	0.000000007	92	0.0099	0.00013		45 (cancer)
Hexachlorobenzene	0.0000002	40	0.00046	0.003		

Notes:

[a] Benchmark values are provided only for those PB-HAPs for which multipathway risk is assessed (via TRIM). There may be other PB-HAPs in this table, even though no benchmark is presented.

[b] IRIS has determined this POM to be not carcinogenic.

[c] The predominant form of mercury assessed in our multipathway risk screening is methyl mercury, which is a transformation product of divalent mercury and accumulates in fish. While elemental mercury emissions can convert to divalent mercury in the atmosphere, such transformations generally occur beyond the 50 km modeling domain around the emissions sources in our assessment. *Emissions reported as "mercury compounds" is speciated into elemental, particulate divalent, and gaseous divalent and modeled accordingly in the multipathway screening assessment.

[d] The EPA IRIS assessment for benzene provides a range of plausible UREs. This assessment used the highest value in that range, 7.8E-06 $\mu g/m^3$. The low end of the range is 2.2E-06 $\mu g/m^3$.

[e] There is no reference concentration for lead. In considering noncancer hazards for lead in this assessment, we compared rolling three-month average exposure estimates to the National Ambient Air Quality Standard (NAAQS) for lead (0.15 µg/m3). The primary (health-based) standard is a maximum or not-to-be-exceeded, rolling three-month average, measured as total suspended particles (TSP). The secondary (welfare-based) standard is identical to the primary standard.

[f] A chronic screening level of 0.163 mg/m3 was developed for carbonyl sulfide by EPA ORD from a No Observed Adverse Effects Level of 200 ppm based on brain lesions and neurophysiological alterations in rodents.

[g] The acute REL for benzene used in our risk assessment does not reflect the latest 1-hour value developed by California OEHHA. EPA is evaluating the derivation of the OEHHA value to determine whether it is appropriate for use in the RTR program.

3.2 Baseline risk characterization

This section presents the results of the risk assessment for the pulp mill combustion source category based on the modeling methods described in the previous sections. All baseline risk results are developed using the best estimates of actual HAP emissions summarized in the previous section. The basic chronic inhalation risk estimates presented here are the maximum individual lifetime cancer risk, the maximum chronic hazard index, and the cancer incidence. We also present results from our acute inhalation impact screening assessment in the form of maximum hazard quotients, as well as the results of our preliminary screen for potential non-inhalation risks and environmental risk from PB-HAP. Also presented are the HAP "drivers," which are the HAP that collectively contribute 90 percent of the maximum cancer risk or maximum hazard at the highest exposure location. A detailed summary of the facility-specific inhalation and multipathway risk assessment results is available in Appendix 10 of this document.

3.2.1 Risk assessment results based on actual emissions

Inhalation

Table 3.2-1 summarizes the chronic and acute inhalation risk results for this source category based upon baseline actual emissions. The results of the chronic inhalation cancer risk assessment are that the maximum lifetime individual cancer risk posed by the 108 facilities could be as high as 4-in-1 million, with naphthalene and acetaldehyde from the black liquor oxidation process as the major contributors to the risk. The total estimated cancer incidence from this source category is 0.01 excess cancer cases per year, or one excess case in every 100 years. Approximately 7,600 people were estimated to have cancer risks above 1-in-1 million from exposure to HAP emitted from 11 facilities in this source category. The maximum chronic noncancer hazard index value for the source category could be up to 0.3 (respiratory) driven by emissions of acrolein from lime kilns and no one is exposed to TOSHI levels above 1.

Worst-case acute hazard quotients (HQs) were calculated for every HAP that has an acute benchmark, as shown in Table 3.1-1. Since none of the screening HQ were greater than 1, further refinement of the estimates was not warranted. Acute estimates for each plant and pollutant are provided in Appendix 10 of this document.

Table 3.2-1. Source Category Level Inhalation Risks for Pulp Mill Combustion Sources Based on Actual Emissions

Result		HAP "Drivers"
Facilities in Source Category		
Number of Facilities Estimated to be in Source Category	108	n/a
Number of Facilities Modeled in Risk Assessment	108	n/a
Cancer Risks		
Maximum Individual Lifetime Cancer Risk (in 1 million)	4	naphthalene, acetaldehyde
Number of Facilities with Maximum Individual Lifetime Cancer Risk:		
Greater than or equal to 100 in 1 million	0	n/a
Greater than or equal to 10 in 1 million	0	n/a
Greater than or equal to 1 in 1 million	11	naphthalene, acetaldehyde, chromium (VI) compounds, formaldehyde, 3-methylcholanthrene, arsenic compounds,

Table 3.2-1. Source Category Level Inhalation Risks for Pulp Mill Combustion Sources Based on Actual Emissions

Result		HAP "Drivers"
		nickel compounds, benzene, 2-methylnaphthalene, cadmium compounds, acenaphthylene, 7,12-demethylbenz[a]anthracene, chloroprene, fluoranthene, acenaphthene
Chronic Noncancer Risks		
Maximum Respiratory Hazard Index	0.3	acrolein
Number of Facilities with Maximum Respiratory Hazard Index:		
Greater than 1	0	n/a
Acute Noncancer Screening Results		
Maximum Acute Hazard Quotient	0.3	acrolein (REL)
Number of Facilities With Potential for Acute Effects	0	n/a
Population Exposure		
Number of People Living Within 50 Kilometers of Facilities Modeled	30,000,000	n/a
Number of People Exposed to Cancer Risk:		
Greater than or equal to 100 in 1 million	0	n/a
Greater than or equal to 10 in 1 million	0	n/a
Greater than or equal to 1 in 1 million	7,600	n/a
Number of People Exposed to Noncancer Respiratory Hazard Index:		
Greater than 1	0	n/a
Estimated Cancer Incidence (excess cancer cases per year)	0.01	n/a
Contribution of HAP to Cancer Incidence		
chromium (VI) compounds	31%	n/a
formaldehyde	18%	n/a
naphthalene	13%	n/a
nickel compounds	8%	n/a
acetaldehyde	7%	n/a
arsenic compounds	6%	n/a
cadmium compounds	3%	n/a
2-methylnaphthalene	3%	n/a
3-methylcholanthrene	2%	n/a

Facility-wide Inhalation

The facility-wide chronic MIR and TOSHI, available in Appendix 10, are based on emissions from all sources at the identified facilities (both MACT and non-MACT sources). The results of the facility-wide assessment for cancer risks are summarized in Table 3.2-5. The results indicate that 81 facilities have a facility-wide cancer MIR greater than or equal to 1-in-1 million. The maximum facility-wide cancer MIR is 20-in-1 million, mainly driven by arsenic and chromium (VI) compounds from industrial boilers. The total estimated cancer incidence from the whole facility is 0.05 excess cancer cases per year, or one excess case in every 20 years. Approximately 443,000 people were estimated to have cancer risks above 1-in-1 million from exposure to HAP emitted from 81 facilities in this source category. The maximum facility-wide TOSHI for the source category is estimated to be less than 1, mainly driven by emissions of acrolein from industrial boilers.

Table 3.2-5 Source Category Contribution to Facility-Wide Cancer Risks Based on Actual Emissions

Pulp Mill Combustion Sources	**Number of Facilities Binned by Facility-Wide MIR (in 1 million)**				
Source Category MIR Contribution to Facility-Wide MIR	<1	1≤ MIR<10	10≤ MIR<100	≥ 100	**Total**
> 90%	0	1	0	0	1
50-90%	5	6	0	0	11
10-50%	14	44	0	0	58
< 10%	8	28	2	0	38
Total	27	79	2	0	108

Multipathway

Table 3.2-2 summarizes the multipathway risk results for this source category based on baseline actual emissions. The PB-HAP emitted by facilities in this source category include POM (of which PAH is a subset), lead compounds, cadmium compounds, mercury compounds, and dioxins/furans. To identify potential multipathway health risks from PB-HAP other than lead, we first performed a tiered screening analysis (Tiers 1, 2, and 3) based on emissions of PB-HAP emitted from each facility in the source category (see section 2.5).

Of the 108 facilities in the source category, 85 facilities reported emissions of carcinogenic PB-HAP (dioxins and POM) and 59 facilities reported emissions of non-carcinogenic PB-HAP (cadmium and mercury) that exceed the Tier 1 screening value of 1. One facility's emission rates of dioxin exceeded the screening value by a factor of 5 while another facility's emission rates of POM exceeded the screening value by a factor of 80. For the non-carcinogens, mercury was the only PB-HAP emitted at rates that exceeded the screening value with the maximum exceedance by a factor of 20. Due to the theoretical construct of the screening model, these factors are not directly translatable into estimates of risk or hazard quotients for these facilities; rather they indicate that the initial multipathway screening does not rule out the potential for multipathway impacts of concern. Table 3.2-2 summarizes the results of the Tier 1 screen.

For the PB-HAP and facilities that exceeded the Tier 1 multipathway screening value, we used facility site-specific information to refine some of the assumptions associated with the local area around the facilities. While maintaining the exposure assumptions, we refine the scenario to examine a subsistence fisher and a subsistence farmer in separately to develop a Tier 2 screening value. (See Section 2.5 and Appendix 6 of this document for more information on the Tier 2 screen.) The additional site-specific information included the land use around the facilities, the location of fishable lakes, and local wind direction and speed. The result of this analysis was the development of site-specific emission screening values for each of the PB-HAP. Based on this Tier 2 screening analysis, the dioxin emission rates for all facilities were below levels of concern. POM emissions exceeded the screening value by a factor of 10 for the fisher scenario and a factor of 9 for the farmer scenario. For mercury, 9 facility's emissions exceeded the screening value, with the maximum exceeding by a factor of 5. Table 3.2-2 summarizes the results of the Tier 2 screen.

For the PB-HAP and facilities that exceeded the Tier 2 multipathway screening values, we conducted a Tier 3 multipathway screen. Tier 3 has three individual stages, and we progressed through each of those stages until the facility's PB-HAP emissions did not exceed the screening value, or until all three stages were complete. These stages included lake, plume rise, and time-series assessments. (See Section 2.5 and Appendix 6 of this document for more information on Tier 3.) Based on this Tier 3 screening analysis, none of the facilities had PB-HAP emissions that exceeded its screening value. Table 3.2-2 summarizes the results of the Tier 3 screen.

An exceedance of a screening value in any of the tiers cannot be equated with a risk value or a hazard quotient (or hazard index). Rather, it represents a high-end estimate of what the risk or hazard may be. For example, facility emissions exceeding the screening value by a factor of 2 for a non-carcinogen can be interpreted to mean that we are confident that the HQ would be lower than 2. Similarly, facility emissions exceeding the screening value by a factor of 30 for a carcinogen means that we are confident that the risk is lower than 30-in-1 million. Our confidence comes from the conservative, or health-protective, assumptions that are in the screens: we choose inputs from the upper end of the range of possible values for the influential parameters used in the screens; and we assume that the exposed individual exhibits ingestion behavior that would lead to a high total exposure.

Table 3.2-2. Source Category Level Multipathway Screening Assessment Risk Results for Pulp Mill Combustion Sources

		Tiered Multipathway Maximum Screening Values (SV) SV (# facilities above SV = 1)			
		Tier 1	**Tier 2**		**Tier 3**
PB-HAP	**Facilities Emitting PBHAP**	**Fisher and Farmer**	**Fisher**	**Farmer**	**Fisher or Farmer**
Carcinogens[a]					
Dioxins/furans as 2,3,7,8-TCDD	101	5 (64)	1 (0)	0.3 (0)	NA
Polycyclic Organic Matter as Benzo(a)pyrene TEQ	103	80 (44)	10 (13)	9 (17)	NA
Dioxins + POM	99	80 (85)	10 (19)	10 (19)	NA
Non-carcinogens					
Cadmium Compounds	95	1 (0)	1 (0)	0.01 (0)	NA
Mercury Compounds	100	20 (59)	5 (9)	0 (0)	1 (0)

Notes:

[a] POM and dioxin emissions were normalized to BaP and 2,3,7,8-TCDD, respectively, for oral toxicity and modeled for environmental fate and transport.

When tiered screening values for any facility indicate a potential health risk to the public, we can conduct a more refined multipathway assessment for a specific facility. A refined assessment replaces some of the assumptions made in the tiered screening with facility-specific information. Since none of the facilities in this source emitted hazardous air pollutants at a rate that exceeded all of the tiered screening levels, a facility-specific multipathway assessment was not warranted. As such, Appendices 7 and 11 of this document are intentionally blank.

In evaluating the potential for multipathway effects from emissions of lead, modeled maximum annual lead concentrations were compared to the NAAQS for lead (0.15 µg/m^3). Lead emissions were reported from 103 facilities. Results of this analysis estimate that the NAAQS for lead would not be exceeded by any facility.

Environmental

We conducted a screening-level evaluation of the potential adverse environmental risks associated with emissions of the following environmental HAP for the pulp mill combustion sources: cadmium, dioxins/furans, hydrogen chloride, hydrofluoric acid, lead, mercury, and POM (for which PAHs are a subset). The results of the environmental screening analysis are summarized in Table 3.2-4.

In the Tier 1 screening analysis for PB-HAP (other than lead, which was evaluated differently), one modeled soil parcel for one facility in the source category exceeded a surface soil – threshold level benchmark (invertebrates) for mercuric chloride by 2. There were no Tier 1 exceedances of any benchmarks for the other pollutants. Therefore, we conducted a Tier 2 screen for mercuric chloride. In the Tier 2 screen for mercuric chloride, none of the individual modeled concentrations for any facility in the source category exceeded any of the ecological benchmarks.

For HCl and HF, each individual concentration (i.e., each off-site data point in the modeling domain) was below the ecological benchmarks for all facilities.

Table 3.2-4. Source Category Level Environmental Risk Screening Results for Pulp Mill Combustion Sources

Environmental HAP		Number of Facilities in the Source Category Exceeding				Percent of Modeled Area in Source Category Exceeding[2]	
		Tier I Screen		Tier II Screen[1]		NOAEL	LOAEL
		NOAEL	LOAEL	NOAEL	LOAEL		
PB-HAP	Lead	0	0	0	0	0%	0%
	Mercuric chloride	NB	2	NB	0	NA	0%
	Methyl mercury	0	0	0	0	0%	0%
	PAH	0	0	0	0	0%	0%
	Dioxins	0	0	0	0	0%	0%
Acid Gases	Hydrogen fluoride[3]	NB	0	-	-	NB	0%
	Hydrogen chloride[4]	NB	0	-	-	NB	0%

NB – No benchmark available.

1- Tier II screen is performed for PB-HAP when there are exceedances of the Tier I screen. The acid gas screen is a one tier screen, therefore, there are no Tier II results for acid gases.

2 - A value of 0% indicates that none of the modeled data points exceeded the benchmark. For PB-HAP the percent area is based on the Tier II results, if a Tier II analysis is performed. Otherwise, the percent area is based on the Tier I results.

3 – For hydrogen fluoride, we evaluated two benchmarks, one from Canada and the other from the State of Washington. Although, they are both considered to be LOELs - the level between a NOAEL and a LOAEL, we have listed the results under the LOAEL column.

4 – For hydrogen chloride, we evaluated one benchmark at the LOAEL level.

3.2.2 Risk assessment results based on allowable emissions

Inhalation

Analysis of potential differences between actual emissions levels and the maximum emissions allowable under the MACT standards (i.e., MACT-allowable emissions) were also calculated for the facilities. Risk estimates based on the actual emissions were then scaled up using these factors. See Appendix 1 of this document for a discussion of the development of the allowable factors. Risk results from the inhalation risk assessment using the MACT-allowable emissions indicate that the maximum lifetime individual cancer risk could be as high as 4-in-1 million with naphthalene and acetaldehyde emissions driving the risks, and that the maximum chronic noncancer TOSHI value could be as high as 0.3 at the MACT-allowable emissions level with acrolein emissions driving the TOSHI value. The total estimated cancer incidence from this source category considering allowable emissions is expected to be about 0.02 excess cancer cases per year or one excess case in every 50 years. Based on allowable emission rates approximately 15,000 people were estimated to have cancer risks above 1-in-1 million.

3.3 Post-control risk characterization

In light of the low cancer and non-cancer risk posed to individuals exposed to HAP emitted from this source category, no post-control risk assessment was warranted.

4 General discussion of uncertainties and how they have been addressed

4.1 Exposure modeling uncertainties

Although every effort has been made to identify all the relevant facilities and emission points, as well as to develop accurate estimates of the annual emission rates for all relevant HAP, the uncertainties in our emission inventory likely dominate the uncertainties in the exposure analysis. The chronic ambient modeling uncertainties are considered relatively small in comparison, since we are using EPA’s refined local dispersion model with site-specific parameters and reasonably representative meteorology. If anything, the population exposure estimates are biased high by not accounting for short- or long-term population mobility, and by neglecting processes like deposition, plume depletion, and atmospheric degradation. Additionally, estimates of the MIR contain uncertainty, because they are derived at census block centroid locations rather than actual residences. This uncertainty is known to create potential underestimates and overestimates of the actual MIR values for individual facilities, but, overall, it is not thought to have a significant impact on the estimated MIR for a source category. Finally, we did not factor in the possibility of a source closure occurring during the 70-year chronic exposure period, leading to a potential upward bias in both the MIR and population risk estimates; nor did we factor in the possibility of population growth during the 70-year chronic exposure period, leading to a potential downward bias in both the MIR and population risk estimates.

A sensitivity analysis performed for the 1999 NATA found that the selection of the meteorology dataset location could result in a range of chronic ambient concentrations which varied from as much as 17 percent below the predicted value to as much as 84 percent higher than the predicted value. This variability translates directly to the predicted exposures and risks in our assessment, indicating that the actual risks could vary from 17 percent lower to 84 percent higher than the predicted values.

We have purposely biased the acute screening results high, considering that they depend upon the joint occurrence of independent factors, such as hourly emissions rates, meteorology and human activity patterns. Furthermore, in cases where multiple acute threshold values are considered scientifically acceptable we have chosen the most conservative of these threshold values, erring on the side of overestimating potential health risks from acute exposures. In the cases where these results indicated the potential for exceeding short-term health thresholds, we refined our assessment by developing a better understanding of the geography of the facility relative to potential exposure locations.

4.2 Uncertainties in the dose-response relationships

In the sections that follow, separate discussions are provided on uncertainty associated with cancer potency factors and for noncancer reference values. Cancer potency values are derived for chronic (lifetime) exposures. Noncancer reference values are generally derived for chronic exposures (up to a lifetime), but may also be derived for acute (less than 24 hours), short-term (from24 hours up to 30 days), and subchronic (30 days up to 10 percent of lifetime) exposure durations, all of which are derived based on an assumption of continuous exposure throughout the duration specified. For the purposes of assessing all potential health risks associated with the emissions included in an assessment, we rely on both chronic (cancer and noncancer) and acute (noncancer) benchmarks, which are described in more detail below.

Although every effort is made to identify peer-reviewed dose-response values for all HAP emitted by the source category included in an assessment, some HAP have no peer-reviewed values. Since exposures to these pollutants cannot be included in a quantitative risk estimate, an understatement of risk for these pollutants at environmental exposure levels is possible.

Additionally, chronic dose-response values for certain compounds included in the assessment may be under EPA IRIS review and revised assessments may determine that these pollutants are more or less potent than currently thought. We will re-evaluate risks if, as a result of these reviews, a dose-response metric changes enough to indicate that the risk assessment may significantly mischaracterize human health risk

Cancer assessment

The discussion of dose-response uncertainties in the estimation of cancer risk below focuses on the uncertainties associated with the specific approach currently used by the EPA to develop cancer potency factors. In general, these same uncertainties attend the development of cancer potency factors by CalEPA, the source of peer-reviewed cancer potency factors used where EPA-developed values are not yet available. To place this discussion in context, we provide a quote from the EPA's *Guidelines for Carcinogen Risk Assessment* (herein referred to as *Cancer Guidelines*). (USEPA, 2005d) "The primary goal of EPA actions is protection of human health; accordingly, as an Agency policy, risk assessment procedures, including default options that are used in the absence of scientific data to the contrary, should be health protective." The approach adopted in this document is consistent with this approach as described in the *Cancer Guidelines*.

For cancer endpoints EPA usually derives an oral slope factor for ingestion and a unit risk value for inhalation exposures. These values allow estimation of a lifetime probability of developing cancer given long-term exposures to the pollutant. Depending on the pollutant being evaluated, EPA relies on both animal bioassay and epidemiological studies to characterize cancer risk. As a science policy approach, consistent with the *Cancer Guidelines*, EPA uses animal cancer bioassays as indicators of potential human health risk when other human cancer risk data are unavailable.

Extrapolation of study data to estimate potential risks to human populations is based upon EPA's assessment of the scientific database for a pollutant using EPA's guidance documents and other peer-reviewed methodologies. The EPA *Cancer Guidelines* describes the Agency's recommendations for methodologies for cancer risk assessment. EPA believes that cancer risk estimates developed following the procedures described in the *Cancer Guidelines* and outlined below generally provide an upper bound estimate of risk. That is, EPA's upper bound estimates represent a plausible upper limit to the true value of a quantity (although this is usually not a true statistical confidence limit). In some circumstances, the true risk could be as low as zero; however, in other circumstances the risk could also be greater.[6] When developing an upper bound estimate of risk and to provide risk values that do not underestimate risk, EPA generally relies on conservative default approaches.[7] EPA also uses the upper bound (rather than lower bound or central tendency) estimates in its assessments, although it is noted that this approach can have limitations for some uses (e.g. priority setting, expected benefits analysis).

Such health risk assessments have associated uncertainties, some which may be considered quantitatively, and others which generally are expressed qualitatively. Uncertainties may vary substantially among cancer risk assessments associated with exposures to different pollutants, since the assessments employ different databases with different strengths and limitations and the procedures employed may differ in how well they represent actual biological processes for the assessed substance. EPA's *Risk Characterization Handbook* also recommends that risk characterizations present estimates demonstrating the impact on the assessment of alternative choices, data, models and assumptions (USEPA, 2000a). Some of the major sources of uncertainty and variability in deriving cancer risk values are described more fully below.

(1) The qualitative similarities or differences between tumor responses observed in experimental animal bioassays and those which would occur in humans are a source of

---

[6] The exception to this is the URE for benzene, which is considered to cover a range of values, each end of which is considered to be equally plausible, and which is based on maximum likelihood estimates.

[7] According to the NRC report Science and Judgment in Risk Assessment (NRC, 1994) "[Default] options are generic approaches, based on general scientific knowledge and policy judgment, that are applied to various elements of the risk-assessment process when the correct scientific model is unknown or uncertain." The 1983 NRC report Risk Assessment in the Federal Government: Managing the Process defined default option as "the option chosen on the basis of risk assessment policy that appears to be the best choice in the absence of data to the contrary" (NRC, 1983a, p. 63). Therefore, default options are not rules that bind the agency; rather, the agency may depart from them in evaluating the risks posed by a specific substance when it believes this to be appropriate. In keeping with EPA's goal of protecting public health and the environment, default assumptions are used to ensure that risk to chemicals is not underestimated (although defaults are not intended to overtly overestimate risk). See EPA 2004 An Examination of EPA Risk Assessment Principles and Practices, EPA/100/B-04/001.

uncertainty in cancer risk assessment. In general, EPA does not assume that tumor sites observed in an experimental animal bioassay are necessarily predictive of the sites at which tumors would occur in humans.[8] However, unless scientific support is available to show otherwise, EPA assumes that tumors in animals are relevant in humans, regardless of target organ concordance. For a specific pollutant, qualitative differences in species responses can lead to either under-estimation or over-estimation of human cancer risks.

(2) Uncertainties regarding the most appropriate dose metric for an assessment can also lead to differences in risk predictions. For example, the measure of dose is commonly expressed in units of mg/kg/d ingested or the inhaled concentration of the pollutant. However, data may support development of a pharmacokinetic model for the absorption, distribution, metabolism and excretion of an agent, which may result in improved dose metrics (e.g., average blood concentration of the pollutant or the quantity of agent metabolized in the body). Quantitative uncertainties result when the appropriate choice of a dose metric is uncertain or when dose metric estimates are themselves uncertain (e.g., as can occur when alternative pharmacokinetic models are available for a compound). Uncertainty in dose estimates may lead to either over or underestimation of risk.

(3) For the quantitative extrapolation of cancer risk estimates from experimental animals to humans, EPA uses scaling methodologies (relating expected response to differences in physical size of the species), which introduce another source of uncertainty. These methodologies are based on both biological data on differences in rates of process according to species size and empirical comparisons of toxicity between experimental animals and humans. For a particular pollutant, the quantitative difference in cancer potency between experimental animals and humans may be either greater than or less than that estimated by baseline scientific scaling predictions due to uncertainties associated with limitations in the test data and the correctness of scaled estimates.

(4) EPA cancer risk estimates, whether based on epidemiological or experimental animal data, are generally developed using a benchmark dose (BMD) analysis to estimate a dose at which there is a specified excess risk of cancer, which is used as the point of departure (or POD) for the remainder of the calculation. Statistical uncertainty in developing a POD using a benchmark dose (BMD) approach is generally addressed though use of the 95 percent lower confidence limit on the dose at which the specified excess risk occurs (the BMDL), decreasing the likelihood of understating risk. EPA has generally utilized the multistage model for estimation of the BMDL using cancer bioassay data (see further discussion below).

(5) Extrapolation from high to low doses is an important, and potentially large, source of uncertainty in cancer risk assessment. EPA uses different approaches to low dose risk assessment (i.e., developing estimates of risk for exposures to environmental doses of an agent from observations in experimental or epidemiological studies at higher dose) depending on the available data and understanding of a pollutant's mode of action (i.e., the manner in which a pollutant causes cancer). EPA's *Cancer Guidelines* express a preference for the use

---

[8] Per the EPA Cancer Guidelines: "The default option is that positive effects in animal cancer studies indicate that the agent under study can have carcinogenic potential in humans." and "Target organ concordance is not a prerequisite for evaluating the implications of animal study results for humans."

of reliable, compound-specific, biologically-based risk models when feasible; however, such models are rarely available. The mode of action for a pollutant (i.e., the manner in which a pollutant causes cancer) is a key consideration in determining how risks should be estimated for low-dose exposure. A reference value is calculated when the available mode of action data show the response to be nonlinear (e.g., as in a threshold response). A linear low-dose (straight line from POD) approach is used when available mode of action data support a linear (e.g., nonthreshold response) or as the most common default approach when a compound's mode of action is unknown. Linear extrapolation can be supported by both pollutant-specific data and broader scientific considerations. For example, EPA's *Cancer Guidelines* generally consider a linear dose-response to be appropriate for pollutants that interact with DNA and induce mutations. Pollutants whose effects are additive to background biological processes in cancer development can also be predicted to have low-dose linear responses, although the slope of this relationship may not be the same as the slope estimated by the straight line approach.

EPA most frequently utilizes a linear low-dose extrapolation approach as a baseline science-policy choice (a "default") when available data do not allow a compound-specific determination. This approach is designed to not underestimate risk in the face of uncertainty and variability. EPA believes that linear dose-response models, when appropriately applied as part of EPA's cancer risk assessment process, provide an upper bound estimate of risk and generally provide a health protective approach. Note that another source of uncertainty is the characterization of low-dose nonlinear, non-threshold relationships. The National Academy of Sciences (NAS, 1994) has encouraged the exploration of sigmoidal type functions (e.g., log-probit models) in representing dose-response relationships due to the variability in response within human populations. Another National Research Council report (NRC, 2006) suggests that models based on distributions of individual thresholds are likely to lead to sigmoidal-shaped dose-response functions for a population. This report notes sources of variability in the human population: "One might expect these individual tolerances to vary extensively in humans depending on genetics, coincident exposures, nutritional status, and various other susceptibility factors..." Thus, if a distribution of thresholds approach is considered for a carcinogen risk assessment, application would depend on ability of modeling to reflect the degree of variability in response in human populations (as opposed to responses in bioassays with genetically more uniform rodents). Note also that low dose linearity in risk can arise for reasons separate from population variability: due to the nature of a mode of action and additivity of a chemical's effect on top of background chemical exposures and biological processes.

As noted above, EPA's current approach to cancer risk assessment typically utilizes a straight line approach from the BMDL. This is equivalent to using an upper confidence limit on the slope of the straight line extrapolation. The impact of the choice of the BMDL on bottom line risk estimates can be quantified by comparing risk estimates using the BMDL value to central estimate BMD values, although these differences are generally not a large contributor to uncertainty in risk assessment (Subramaniam et. al., 2006). It is important to note that earlier EPA assessments, including the majority of those for which risk values exist today, were generally developed using the multistage model to extrapolate down to environmental dose levels and did not involve the use of a POD. Subramaniam et. al. (2006) also provide comparisons indicating that slopes based on straight line extrapolation from a POD do not show large differences from those based on the upper confidence limit of the multistage model.

(6) Cancer risk estimates do not generally make specific adjustments to reflect the variability in response within the human population — resulting in another source of uncertainty in assessments. In the diverse human population, some individuals are likely to be more sensitive to the action of a carcinogen than the typical individual, although compound-specific data to evaluate this variability are generally not available. There may also be important life stage differences in the quantitative potency of carcinogens and, with the exception of the recommendations in EPA's Supplemental Cancer Guidance for carcinogens with a mutagenic mode of action, risk assessments do not generally quantitatively address life stage differences. However, one approach used commonly in EPA assessments that may help address variability in response is to extrapolate human response from results observed in the most sensitive species and sex tested, resulting typically in the highest URE which can be supported by reliable data, thus supporting estimates that are designed not to underestimate risk in the face of uncertainty and variability.

Chronic noncancer assessment

Chronic noncancer reference values represent chronic exposure levels that are intended to be health-protective. That is, EPA and other organizations which develop noncancer reference values (e.g., the Agency for Toxic Substances and Disease Registry – ATSDR) utilize an approach that is intended not to underestimate risk in the face of uncertainty and variability. When there are gaps in the available information, uncertainty factors (UFs) are applied to derive reference values that are intended to be protective against appreciable risk of deleterious effects. Uncertainty factors are commonly default values[9] e.g., factors of 10 or 3, used in the absence of compound-specific data; where data are available, uncertainty factors may also be developed using compound-specific information. When data are limited, more assumptions are needed and more default factors are used. Thus there may be a greater tendency to overestimate risk—in the sense that further study might support development of reference values that are higher (i.e., less potent) because fewer default assumptions are needed. However, for some pollutants it is possible that risks may be underestimated.

For non-cancer endpoints related to chronic exposures, EPA derives a Reference Dose (RfD) for exposures via ingestion, and a Reference Concentration (RfC) for inhalation exposures.

---

[9] According to the NRC report *Science and Judgment in Risk Assessment* (NRC, 1994) "[Default] options are generic approaches, based on general scientific knowledge and policy judgment, that are applied to various elements of the risk-assessment process when the correct scientific model is unknown or uncertain." The 1983 NRC report *Risk Assessment in the Federal Government: Managing the Process* defined *default option* as "the option chosen on the basis of risk assessment policy that appears to be the best choice in the absence of data to the contrary" (NRC, 1983a, p. 63). Therefore, default options are not rules that bind the agency; rather, the agency may depart from them in evaluating the risks posed by a specific substance when it believes this to be appropriate. In keeping with EPA's goal of protecting public health and the environment, default assumptions are used to ensure that risk to chemicals is not underestimated (although defaults are not intended to overtly overestimate risk). See EPA 2004 *An examination of EPA Risk Assessment Principles and Practices*, EPA/100/B-04/001.

As stated in the IRIS Glossary, these values provide an estimate (with uncertainty spanning perhaps an order of magnitude) of daily oral exposure (RfD) or of a continuous inhalation exposure (RfC) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. To derive values that are intended to be "without appreciable risk," EPA's methodology relies upon an uncertainty factor (UF) approach (USEPA, 1993b; USEPA, 1994b) which includes consideration of both uncertainty and variability.

EPA begins by evaluating all of the available peer-reviewed literature to determine non-cancer endpoints of concern, evaluating the quality, strengths and limitations of the available studies. EPA typically chooses the relevant endpoint that occurs at the lowest dose, often using statistical modeling of the available data, and then determines the appropriate POD for derivation of the reference value. A POD is determined by (in order of preference): (1) a statistical estimation using the BMD approach; (2) use of the dose or concentration at which the toxic response was not significantly elevated (no observed adverse effect level—NOAEL); or (3) use of the lowest observed adverse effect level (LOAEL).

A series of downward adjustments using default UFs is then applied to the POD to estimate the reference value (USEPA, 2002b). While collectively termed "UFs", these factors account for a number of different quantitative considerations when utilizing observed animal (usually rodent) or human toxicity data in a risk assessment. The UFs are intended to account for: (1) variation in susceptibility among the members of the human population (i.e., inter-individual variability); (2) uncertainty in extrapolating from experimental animal data to humans (i.e., interspecies differences); (3) uncertainty in extrapolating from data obtained in a study with less-than-lifetime exposure (i.e., extrapolating from subchronic to chronic exposure); (4) uncertainty in extrapolating from a LOAEL in the absence of a NOAEL; and (5) uncertainty when the database is incomplete or there are problems with applicability of available studies. When scientifically sound, peer-reviewed assessment-specific data are not available, default adjustment values are selected for the individual UFs. For each type of uncertainty (when relevant to the assessment), EPA typically applies an UF value of 10 or 3 with the cumulative UF value leading to a downward adjustment of 10-3000 fold from the selected POD. An UF of 3 is used when the data do not support the use of a 10-fold factor. If an extrapolation step or adjustment is not relevant to an assessment (e.g., if applying human toxicity data and an interspecies extrapolation is not required) the associated UF is not used. The major adjustment steps are described more fully below.

1) Heterogeneity among humans is a key source of variability as well as uncertainty. Uncertainty related to human variation is considered in extrapolating doses from a subset or smaller-sized population, often of one sex or of a narrow range of life stages (typical of occupational epidemiologic studies), to a larger, more diverse population. In the absence of pollutant-specific data on human variation, a 10-fold UF is used to account for uncertainty associated with human variation. Human variation may be larger or smaller; however, data to examine the potential magnitude of human variability are often unavailable. In some situations, a smaller UF of 3 may be applied to reflect a known lack of significant variability among humans.

2) Extrapolation from results of studies in experimental animals to humans is a necessary step for the majority of chemical risk assessments. When interpreting animal data, the concentration at the POD (e.g. NOAEL, BMDL) in an animal model (e.g. rodents) is extrapolated to estimate the human response. While there is long-standing scientific support for the use of animal studies as indicators of potential toxicity to humans, there are uncertainties in such extrapolations. In the absence of data to the contrary, the typical approach is to use the most relevant endpoint from the most sensitive species and the most sensitive sex in assessing risks to the average human. Typically, compound specific data to evaluate relative sensitivity in humans versus rodents are lacking, thus leading to uncertainty in this extrapolation. Size-related differences (allometric relationships) indicate that typically humans are more sensitive than rodents when compared on a mg/kg/day basis. The default choice of 10 for the interspecies UF is consistent with these differences. For a specific chemical, differences in species responses may be greater or less than this value.

Pharmacokinetic models are useful to examine species differences in pharmacokinetic processing and associated uncertainties; however, such dosimetric adjustments are not always possible. Information may not be available to quantitatively assess toxicokinetic or toxicodynamic differences between animals and humans, and in many cases a 10-fold UF (with separate factors of 3 for toxicokinetic and toxicodynamic components) is used to account for expected species differences and associated uncertainty in extrapolating from laboratory animals to humans in the derivation of a reference value. If information on one or the other of these components is available and accounted for in the cross-species extrapolation, a UF of 3 may be used for the remaining component.

3) In the case of reference values for chronic exposures where only data from shorter durations are available (e.g., 90-day subchronic studies in rodents) or when such data are judged more appropriate for development of an RfC, an additional UF of 3 or 10-fold is typically applied unless the available scientific information supports use of a different value.

4) Toxicity data are typically limited as to the dose or exposure levels that have been tested in individual studies; in an animal study, for example, treatment groups may differ in exposure by up to an order of magnitude. The preferred approach to arrive at a POD is to use BMD analysis; however, this approach requires adequate quantitative results for a meaningful analysis, which is not always possible. Use of a NOAEL is the next preferred approach after BMD analysis in determining a POD for deriving a health effect reference value. However, many studies lack a dose or exposure level at which an adverse effect is not observed (i.e., a NOAEL is not identified). When using data limited to a LOAEL, a UF of 10 or 3-fold is often applied.

5) The database UF is intended to account for the potential for deriving an underprotective RfD/RfC due to a data gap preventing complete characterization of the chemical’s toxicity. In the absence of studies for a known or suspected endpoint of concern, a UF of 10 or 3-fold is typically applied.

There is no RfD or other comparable chronic health benchmark value for lead compounds. Thus, to address multipathway human health and environmental risks associated with emissions of lead from this facility, ambient lead concentrations were compared to the NAAQS for lead. In developing the NAAQS for lead, EPA considered human health evidence reporting adverse health effects associated with lead exposure, as well as an EPA conducted multipathway risk assessment that applied models to estimate human exposures to air-related lead and the associated risk (73FR at 66979). EPA also explicitly considered the uncertainties associated with both the human health evidence and the exposure and risk analyses when developing the NAAQS for lead. For example, EPA considered uncertainties in the relationship between ambient air lead and blood lead levels (73FR at 66974), as well as uncertainties between blood lead levels and loss of IQ points in children (73FR at 66981). In considering the evidence and risk analyses and their associated uncertainties, the EPA Administrator noted his view that there is no evidence- or risk-based bright line that indicates a single appropriate level. Instead, he noted, there is a collection of scientific evidence and judgments and other information, including information about the uncertainties inherent in many relevant factors, which needs to be considered together in making this public health policy judgment and in selecting a standard level from a range of reasonable values (73FR at 66998). In so doing, the Administrator decided that, a level for the primary lead standard of 0.15 $\mu g/m^3$, in combination with the specified choice of indicator, averaging time, and form, is requisite to protect public health, including the health of sensitive groups, with an adequate margin of safety (73FR at 67006). A thorough discussion of the health evidence, risk and exposure analyses, and their associated uncertainties can be found in EPA's final rule revising the lead NAAQS (73 FR 66970-66981, November 12, 2008).

We also note the uncertainties associated with the health-based (i.e., primary) NAAQS are likely less than the uncertainties associated with dose-response values developed for many of the other HAP, particularly those HAP for which no human health data exist. In 1988, EPA's IRIS program reviewed the health effects data regarding lead and its inorganic compounds and determined that it would be inappropriate to develop an RfD for these compounds, saying, "A great deal of information on the health effects of lead has been obtained through decades of medical observation and scientific research. This information has been assessed in the development of air and water quality criteria by the Agency's Office of Health and Environmental Assessment (OHEA) in support of regulatory decision-making by the Office of Air Quality Planning and Standards (OAQPS) and by the Office of Drinking Water (ODW). By comparison to most other environmental toxicants, the degree of uncertainty about the health effects of lead is quite low. It appears that some of these effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold. The Agency's RfD Work Group discussed inorganic lead (and lead compounds) at two meetings (07/08/1985 and 07/22/1985) and considered it inappropriate to develop an RfD for inorganic lead." See EPA's IRIS assessment for Lead and compounds (inorganic) (CASRN 7439-92-1).

We note further that because of the multi-pathway, multi-media impacts of lead, the risk assessment supporting the NAAQS considered direct inhalation exposures and indirect air-related multi-pathway exposures from industrial sources like primary and secondary lead smelting operations. It also considered background lead exposures from other sources (like contaminated drinking water and exposure to lead-based paints). In revising the NAAQS for lead, we note that the Administrator placed more weight on the evidence-based framework and less weight on the results from the risk assessment, although he did find the risk estimates to be roughly consistent with and generally supportive of the evidence-based framework applied in the NAAQS determination (73FR at 67004). Thus, when revising the NAAQS for lead to protect public health with an adequate margin of safety, EPA considered both the evidence-based framework and the risk assessment, albeit to different extents.

Acute noncancer assessment

Many of the UFs used to account for variability and uncertainty in the development of acute reference values are quite similar to those developed for chronic durations, but more often using individual UF values that may be less than 10. UFs are applied based on chemical-specific or health effect-specific information (e.g., simple irritation effects do not vary appreciably between human individuals, hence a value of 3 is typically used), or based on the purpose for the reference value (see the following paragraph). The UFs applied in acute reference value derivation include: 1) heterogeneity among humans; 2) uncertainty in extrapolating from animals to humans; 3) uncertainty in LOAEL to NOAEL adjustments; and 4) uncertainty in accounting for an incomplete database on toxic effects of potential concern. Additional adjustments are often applied to account for uncertainty in extrapolation from observations at one exposure duration (e.g., 4 hours) to arrive at a POD for derivation of an acute reference value at another exposure duration (e.g., 1 hour).

Not all acute reference values are developed for the same purpose and care must be taken when interpreting the results of an acute assessment of human health effects relative to the reference value or values being exceeded. Where relevant to the estimated exposures, the lack of threshold values at different levels of severity should be factored into the risk characterization as potential uncertainties.

5 References

Allen, et al., 2004. Variable Industrial VOC Emissions and their impact on ozone formation in the Houston Galveston Area. Texas Environmental Research Consortium. https://www.researchgate.net/publication/237593060_Variable_Industrial_VOC_Emissions_and_their_Impact_on_Ozone_Formation_in_the_Houston_Galveston_Area

ATSDR, 2012. Agency for Toxic Substances & Disease Registry Toxicological Profile for Manganese. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=102&tid=23

Burger, J. 2002. Daily consumption of wild fish and game: Exposures of high end recreationalists. Environmental Health Research. 12(4):343–354.

Grimsrud TK and Andersen A., 2010. Evidence of carcinogenicity in humans of water-soluble nickel salts. J Occup Med Toxicol 2010, 5:1-7. Available online at http://www.occup-med.com/content/5/1/7

Herr, D.W., Graff, J.E., Moser, V.C., Crofton, K.M., Little, P.B., Morgan, D.L., and Sills, R.C., 2007. Inhalational exposure to carbonyl sulfide produced altered brainstem auditory and somatosensory-evoked potentials in Fischer 344N rats. Toxicol. Sci. 95(1):118-135, 2007.

IARC, 1990. International Agency for Research on Cancer, 1990. IARC monographs on the evaluation of carcinogenic risks to humans. Chromium, nickel, and welding. Vol. 49. Lyons, France: International Agency for Research on Cancer, World Health Organization Vol. 49:256.

Morgan, D.L., Little, P.B., Herr, D.W., Moser, V.C., Collins, B., Herbert, R., Johnson, G.A., Maronpot, R.R., Harry, G.J., and Sills, R.C., 2004. Neurotoxicity of carbonyl sulfide in F344 rats following inhalation exposure for up to 12 weeks. Toxicol. Appl. Pharmacol. 200(2):131-145, 2004.

National Academy of Sciences, 1994. National Research Council. Science and Judgement in Risk Assessment. Washington, DC: National Academy Press.

NRC, 2006. National Research Council. Assessing the Human Health Risks of Trichloroethylene. National Academies Press, Washington DC.

NTP, 2014. National Toxicology Program. Report on Carcinogens (RoC). 13th ed. Research Triangle Park, NC: US Department of Health and Human Services (DHHS), Public Health Service. http://ntp.niehs.nih.gov/pubhealth/roc/roc13/index.html

OEHHA, 2015. California Office of Environmental Health Hazard Assessment. All Acute Reference Exposure Levels developed by OEHHA as of June 2014. http://oehha.ca.gov/air/allrels.html

OMB, 2007. Memorandum for the Heads of Executive Departments and Agencies - Updated Principles for Risk Analysis (September 19, 2007), From Susan E. Dudley, Administrator, Office of Information and Regulatory Affairs, Office of Management and Budget; and Sharon L. Hays, Associate Director and Deputy Director for Science, Office of Science and Technology Policy https://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/m07-24.pdf

R.P. Subramaniam, P. White and V.J. Cogliano. 2006. Comparison of cancer slope factors using different statistical approaches, Risk Anal. Vol 26, p. 825-830.

Roels HA, Ghyselen P, Buchet JP, et al. 1992. Assessment of the permissible exposure level to manganese in workers exposed to manganese dioxide dust. Br J Ind Med 49:25-34.

Sills, R.C., Morgan, D.L., Herr, D.W., Little, P.B., George, N.M., Ton, T.V., Love, N.E., Maronpot, R.R., and Johnson, G.A., 2004. Contribution of magnetic resonance microscopy in the 12-week neurotoxicity evaluation of carbonyl sulfide in Fischer 344 rats. Toxicol. Pathol. 32:501-510, 2004.

USEPA, 1986. Guidelines for the Health Risk Assessment of Chemical Mixtures. EPA-630-R-98-002. https://www.epa.gov/risk/guidelines-health-risk-assessment-chemical-mixtures

USEPA, 1993a. Integrated Risk Information system Review of Manganese. https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=373

USEPA, 1993b. Reference Dose (RfC): Description and Use in Health Risk Assessments. https://www.epa.gov/iris/reference-dose-rfd-description-and-use-health-risk-assessments

USEPA, 1994a. US Environmental Protection Agency. Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry. EPA/600/8-90/066F. Office of Research and Development. Washington, DC: U.S.EPA.

USEPA, 1994b. Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry. https://www.epa.gov/risk/methods-derivation-inhalation-reference-concentrations-and-application-inhalation-dosimetry

USEPA, 1999. Residual Risk Report to Congress. 453R-99-001. https://www3.epa.gov/airtoxics/rrisk/risk_rep.pdf

USEPA, 2000a. Risk Characterization Handbook. EPA 100-B-00-002. https://www.epa.gov/sites/production/files/2015-10/documents/osp_risk_characterization_handbook_2000.pdf

USEPA, 2000b. Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures. EPA-630/R-00-002. https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=20533

USEPA, 2002a. EPA's Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by the Environmental Protection Agency. EPA Office of Environmental Information. EPA/260R-02-008. https://www.epa.gov/quality/guidelines-ensuring-and-maximizing-quality-objectivity-utility-and-integrity-information

USEPA, 2002b. A Review of the Reference Dose and Reference Concentration Processes. https://www.epa.gov/osa/review-reference-dose-and-reference-concentration-processes

USEPA, 2004. Users' guide for the AMS/EPA regulatory model – AERMOD. EPA-454/B-03-001. https://www3.epa.gov/scram001/7thconf/aermod/aermodugb.pdf

USEPA, 2005a. Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule. 40 CFR Part 51. https://www3.epa.gov/scram001/guidance/guide/appw_05.pdf

USEPA, 2005b. Supplemental guidance for assessing early-life exposure to carcinogens. EPA/630/R-03003F. https://www3.epa.gov/ttn/atw/childrens_supplement_final.pdf

USEPA, 2005c. Science Policy Council Cancer Guidelines Implementation Workgroup Communication I: Memo from W.H. Farland dated 4 October 2005 to Science Policy Council. https://www.epa.gov/sites/production/files/2015-01/documents/cgiwgcommuniation_i.pdf

USEPA, 2005d. Guidelines for Carcinogen Risk Assessment. U.S. Environmental Protection Agency, Washington, DC, EPA/630/P-03/001F. https://www.epa.gov/risk/guidelines-carcinogen-risk-assessment

USEPA, 2006. Performing risk assessments that include carcinogens described in the Supplemental Guidance as having a mutagenic mode of action. Science Policy Council Cancer Guidelines Implementation Workgroup Communication II: Memo from W.H. Farland dated 14 June 2006. https://www.epa.gov/sites/production/files/2015-01/documents/cgiwg-communication_ii.pdf

USEPA, 2009a. Risk and Technology Review (RTR) Risk Assessment Methodologies: For Review by the EPA's Science Advisory Board with Case Studies – MACT I Petroleum Refining Sources and Portland Cement Manufacturing. EPA-452/R-09-006. https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryID=238928

USEPA, 2010a. SAB's Response to EPA's RTR Risk Assessment Methodologies. https://yosemite.epa.gov/sab/sabproduct.nsf/0/b031ddf79cffded38525734f00649caf!OpenDocument&TableRow=2.3#2

US EPA, 2010b. Memorandum from Dave Guinnup to Docket EPA-HQ-OAR-2010-0600, entitled, "EPA's Actions in Response to Key Recommendations of the SAB Review of RTR

Risk Assessment Methodologies”. https://yosemite.epa.gov/sab/sabproduct.nsf/3BE2C36A4ADDC85A85257B48006C88D7/$File/EPA+resp+to+SAB+on+RTR+memo.pdf

USEPA, 2011. Exposure Factors Handbook: 2011 Edition (Final). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-09/052F. https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

USEPA, 2014a. Table 1. Prioritized Chronic Dose-Response Values (5/9/14). Office of Air Quality Planning and Standards. https://www.epa.gov/fera/dose-response-assessment-assessing-health-risks-associated-exposure-hazardous-air-pollutants

USEPA, 2014b. Table 2. Acute Dose-Response Values for Screening Risk Assessments (9/18/2014). Office of Air Quality Planning and Standards. https://www.epa.gov/fera/dose-response-assessment-assessing-health-risks-associated-exposure-hazardous-air-pollutants

USEPA, 2009b. Graphical Arrays of Chemical-Specific Health Effect Reference Values for Inhalation Exposures [Final Report]. EPA/600/R-09/061, 2009. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=211003

WHO, 1991. World Health Organization and the European Union’s Scientific Committee on Health and Environmental Risks (SCHER, 2006).

Appendix 1

Emission Inventory Support Documents

Appendix 1

Emission Inventory Support Documents

Memorandum

Date: September 30, 2014

Subject: Preparation of Residual Risk Modeling Input File for Subpart MM
EPA Contract No. EP-D-11-084; Work Assignment No. 2-06

From: Katie Hanks and Thomas Holloway

To: John Bradfield, Bill Schrock, Kelley Spence, and Nick Swanson
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Background

Under section 112(f)(2) of the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) is directed to conduct risk assessments on each source category subject to maximum achievable control technology (MACT) standards and determine if additional or more stringent standards beyond those originally promulgated are needed to reduce any residual risk remaining after promulgation. The EPA is directed to conduct the section 112(f)(2) residual risk review 8 years after promulgation of the original standards. In addition, section 112(d)(6) of the CAA requires EPA to review and revise the MACT standards, as necessary, taking into account developments in practices, processes, and control technologies. The EPA completed and promulgated the residual risk and technology review (RTR) for the national emissions standards for hazardous air pollutants (NESHAP) for the pulp and paper industry (40 CFR part 63, subpart S) in the Federal Register on September 11, 2012. Another standard, the NESHAP for Chemical Recovery Combustion Sources at Kraft, Soda, Sulfite, and Stand-Alone Semichemical Pulp Mills, (40 CFR part 63, subpart MM) originally promulgated on January 12, 2001 is due for RTR review under CAA sections 112(f)(2) and 112(d)(6). The purpose of this memorandum is to document development of the section 112(f)(2) residual risk modeling input file for subpart MM.

II. Source of Inventory Data

In February 2011, the EPA initiated a three-part Information Collection Request (ICR) to gather information from U.S. pulp and paper manufacturers needed to conduct the CAA-required regulatory reviews for each of the air regulations affecting the pulp and paper industry. Parts I and III of the ICR collected equipment and process details for the pulp and paper production and chemical recovery processes, respectively. The second part of the ICR (Part II), which concluded in June 2011, was targeted towards facilities that are major sources of HAP emissions, and involved an update of pre-populated National Emissions Inventory (NEI) data spreadsheets (or creation of new NEI data sets). The response rate for Part II of EPA's ICR was 100 percent, with respondents submitting NEI spreadsheets for 171 major sources (2 of which were new NEI data sets for mills not previously included in the NEI).

Two substantial quality assurance (QA) efforts were conducted in 2011 on the Part II data prior to proposal of the subpart S RTR in order to create the modeling files needed for the residual risk assessment: (1) QA of the spreadsheets submitted by each mill prior to import into the compiled database, and (2) QA and standardization of the compiled inventory data base. These QA efforts are discussed in a November 11, 2011 memorandum entitled, *Inputs to the Pulp and Paper Industry October 2011 Residual Risk Modeling*.[1] Modeling files were needed for both the subpart S category and the whole facility, so QA efforts focused on data for all emission sources at pulp and paper facilities, including subpart MM emission sources.

The EPA requested comments on the inventory in the preamble to the December 27, 2011 subpart S proposal.2 The EPA was specifically interested in receiving corrections to the mill-specific HAP emissions data used in the risk modeling. The mill-specific NEI emissions data were available for download on EPA's Risk and Technology Review (RTR) web page.[3] Commenters on the subpart S proposal (e.g., industry, states) were asked to determine whether any of the NEI data were unrepresentative or inaccurate and to submit their comments on the data downloaded from the RTR web page. Specifically, commenters were asked to enter suggested revisions to the NEI data fields appropriate for that information, gather documentation for any suggested emissions revisions (e.g., performance test reports, material balance calculations), and send the downloaded file with suggested revisions and all accompanying documentation to the docket for the subpart S amendments (Docket ID No. EPA–HQ–OAR–2007–0544).

In 2012, the EPA received revisions to inventories for 81 facilities following proposal of the subpart S residual risk review. These revisions were reviewed to evaluate which revisions could increase or decrease the risk associated with a particular facility, and recommend whether risk remodeling for the subpart S category should be conducted for any of the facilities prior to promulgation of the subpart S residual risk review. Review of the inventory revisions performed prior to promulgation of subpart S is documented in a May 8, 2012 memorandum entitled, *Recommendations Concerning Residual Risk Remodeling for the Pulp and Paper Industry*.[4] Premised on EPA's finding in the December 27, 2011 subpart S proposed amendments that the risks from the pulp and paper source category (as modeled prior to proposal) are acceptable, remodeling was not performed for purposes of the promulgated subpart S residual risk review because it was determined that risks at individual facilities were not expected to increase

---

[1] Memorandum from Thomas Holloway, Katie Hanks, Corey Gooden, and Matt Hakos, RTI, to J. Bradfield and B. Schrock, EPA. *Inputs to the Pulp and Paper Industry October 2011 Residual Risk Modeling.* November 11, 2011.

[2] U.S. Environmental Protection Agency. *National Emission Standards for Hazardous Air Pollutants from the Pulp and Paper Industry, Proposed Rule.* 76 FR 81349-51. December 27, 2011.

[3] http://www.epa.gov/ttn/atw/rrisk/rtrpg.html

[4] Memorandum from Thomas Holloway, RTI, to J. Bradfield, B. Schrock, K.. Spence, and N. Swanson, EPA. *Recommendations Concerning Residual Risk Remodeling for the Pulp and Paper Industry.* May 8, 2012.

substantially as a result of the inventory revisions. It was noted that risk modeling focused on the subpart MM source category would be forthcoming.[5,6]

The following sections discuss revisions to the inventory and preparation of the risk modeling file for the subpart MM RTR. The individual mill revisions received and reviewed following proposal of the subpart S RTR were compiled into the pulp and paper inventory data base. Following incorporation of the mill-specific revisions, the entire file was reviewed in preparation for further risk modeling efforts including modeling focused on the subpart MM source category and remodeling of facility-wide risk (including subpart S sources).

III. Assembly of Facility-wide Modeling File for the Subpart MM Residual Risk Review

As mentioned above, following the December 2011 Subpart S proposal, 81 facilities made a variety of revisions to their NEI data, including, but not limited to:

- Deleting emission units (e.g., shutdown units, units with emissions collected and emitted elsewhere, causticizing systems using fresh water/no pulping condensates, units consolidated elsewhere in the inventory, fugitive sources changed to stack sources, paper machines reconfigured from a single emission point to wet/dry end emission points or multiple vents);
- Replacing emission units (e.g., consolidated units, stack sources changed from fugitive sources, reconfigured paper machines);
- Adding emission units omitted from previous inventory (e.g., wastewater treatment plant);
- Deleting individual records (e.g., duplicates, zero emissions);
- Correcting source classification codes (SCCs);
- Changing release point IDs;
- Correcting release point type from fugitive to stack;
- Deleting pollutants (e.g., hexachloroethane [HCE] from washers/bleach plants, chlorinated compounds at unbleached mills, biphenyl from recycle paper machines, o-xylene double-counted with total xylenes, o-cresol double-counted with total cresols);
- Adding pollutants omitted from previous inventory;
- Revising routine annual emissions data (e.g., based on updated emission factors/test data, corrected emissions calculations);
- Deleting/replacing routine annual emissions data with updated/corrected data;
- Revising maximum hourly emissions data;
- Revising MACT code;
- Providing stack parameters for newly designated stack sources;
- Correcting stack parameters;
- Replacing incorrect fugitive parameters; and
- Correcting latitudes/longitudes.

---

[5] *Ibid.*

[6] *National Emission Standards for Hazardous Air Pollutants from the Pulp and Paper Industry*. Final Rule. 77 FR 55698, September 11, 2012.

While most of the inventory revisions received following the December 2011 Subpart S proposal dealt with subpart S sources, some revisions were also made to subpart MM sources. Revisions to all process types were incorporated into the inventory for purposes of remodeling facility-wide risk and performing the complete scope of residual risk modeling for subpart MM emissions sources. The 81 individual revision files were checked to ensure they were incorporated into the main data base correctly, and then the entire data base was further reviewed as described in the remainder of this memorandum.

Acrolein and dioxin/furan were not included in the model run used for the subpart S RTR because of uncertainties in the emissions data available for these pollutants. These pollutants were not pertinent to the subpart S source category because they are primarily related to combustion sources at pulp and paper mills. Acrolein and dioxin/furan have been included in the subpart MM modeling file because these pollutants are more relevant to subpart MM sources.

A. Updates to Mill List

A total of 171 major source pulp and paper mills were included in the subpart S RTR analyses performed in 2011-2012. Some of these major sources were represented by multiple NEI IDs. Area, synthetic minor, and closed mills were excluded from the 2011 subpart S residual risk modeling file. Of the 171 major source mills included in the previous pulp and paper modeling file, 108 are pulp manufacturing facilities were subject to subpart MM. Subpart MM affected facilities are labeled with the 1626-2 MACT code (63MM regulatory code) in the NEI inventory. Subpart MM affected sources include:

- Recovery furnaces (at kraft and soda mills)
    - Non-direct contact evaporator (NDCE) recovery furnaces
    - Direct-contact evaporator (DCE) recovery furnaces and associated black liquor oxidizers (BLO)
- Chemical recovery combustion units (at sulfite and semichemical mills)
- Lime kilns
- Smelt dissolving tanks (SDTs)

Additions to the subpart MM facility list for purposes of the subpart MM RTR include mills that existed, but were not operational at the time of the 2011 ICR:

- KPAQ Industries LLC - St Francisville, LA – Kraft (NEI33043, RTI 153[7])
- International Paper – Franklin, VA (NEI7621, RTI 161)
- Cosmo Specialty Fibers, Inc – Cosmopolis, WA (formerly Weyerhaeuser)- magnesium based dissolving sulfite pulp mill (NEI42351, RTI 700)[8]

Emissions data from the 2011 Emissions Inventory System (EIS) were used to populate the risk model input file for KPAQ and Cosmo Specialty Fibers. Emissions data were

---

[7] Note that RTI created an ICR data entry (Part I and III) for this mill based on permit information.

[8] Cosmo Specialty Fiber began operating the former Weyerhaeuser Cosmopolis Pulp mill in May 2011. Subpart MM contains a site-specific rule for this mill (originally established for Weyerhaeuser). The site-specific rule involves controlling a hog fuel dryer as opposed to subpart MM equipment. Thus, the hog fuel dryer has been considered as a subpart MM emission unit in the risk model input file.

unavailable from the 2011 EIS for the International Paper (Franklin, VA) mill because it was not operational in 2011. Thus, emissions data from the 2005 NEI was used to populate the risk model input file for International Paper (Franklin, VA).

One kraft pulp and paper mill was permanently closed in early 2014, and therefore was removed from the subpart MM inventory:

- International Paper – Courtland, AL (NEI18357, RTI 600)[9]

One ammonia-based sulfite mill was deleted from the subpart MM facility list because it is no longer operational:

- Kimberly-Clark Worldwide – Everette, WA (NEI42385; RTI 158) [10]

Two paper mills were also removed from the whole facility modeling file due to permanent closure:

- Smart Papers Holdings – Hamilton, OH (NEI11600; RTI 373)[11]
- Catalyst Paper, Snowflake, AZ (NEI13216; RTI 210)[12]

Following additions and deletions, there are 109 major source facilities in the subpart MM source category represented by 110 NEI IDs,[13] and 170 major source facilities represented in the whole-facility modeling file (some of which have multiple NEI IDs). There are three chemical pulping facilities included in the facility-wide inventory that are not subject to subpart MM because they do not operate any subpart MM chemical recovery combustion equipment:

- Flambeau River Papers LLC, Park Falls WI (calcium-based sulfite) (NEI42730)
- Temple-Inland, Waverly, TN (semichemical) (NEI46866)
- Domtar Paper Company, LLC (calcium-based sulfite) (NEI54400)

All other facilities included in the facility-wide inventory do not manufacture chemical pulp, but instead are mechanical pulp, secondary fiber, or paper-only mills that are not subject to subpart MM.

B. Updates to Mill Configurations

Some mills made significant changes to equipment configurations that are relevant for purposes of the subpart MM RTR. These changes are summarized in Table 1.

---

[9] The mill permanently closed in early 2014. Source: Press release, *International Paper Announces Closure of its Courtland, Ala. Paper Mill*, 09/11/2013

[10] The mill ceased reporting under the GHGRP after reporting year 2012 and is reported to be closed in online articles. Source: *Kimberly-Clark paper mill shuts down*, KING5.com, Posted on April 16, 2012.

[11] The mill ceased reporting under the GHGRP after reporting year 2010.

[12] The mill was permanently closed in 2009. Sources: *Hackman Capital Partners Leads Consortium of Investors in Purchase of Arizona Paper Mill Assets from Catalyst*, Los Angeles, CA (PRWEB) February 19, 2013; and *Catalyst sells Snowflake, AZ paper mill assets to Hackman*, Forest Business Network, January 7, 2013. Paper

[13] One major source has two NEI IDs: NIE33135 and NEI706. Thus there are 109 major source mills subject to subpart MM, represented by 110 NEI IDs (SPPD Facility Identifiers).

Table 1. Significant Equipment Changes that Affect Subpart MM Risk Modeling

RTI ID	NEI ID	Mill Name	Description of Change	Notes Regarding Whether the Changes were Reflected in NEI Revisions
143	NEI26504	Packaging Corp. of America (Valdosta Mill) in Clyattville, GA	This mill shut down and replaced 3 DCE recovery furnaces with a No. 4 recovery furnace (NDCE) and SDT in 2012.	This mill submitted an inventory revision following promulgation of subpart S. The 3 DCE furnaces were flagged for deletion in the inventory revision.
142	NEI41552	Packaging Corp. of America, Counce, TN	According to a 6/15/10 permit, two DCE recovery furnaces (R-1 and R-2) were replaced with a new R-4 NDCE furnace and the BLO system was removed; and the mill plans to convert the R-1 and R-2 DCEs to NDCE recovery furnaces.	The two DCE furnaces (R-1 and R-2) and the BLO remain in the inventory. The new R-4 NDCE furnace is not listed.
606	NEI47091	Buckeye Florida, Limited Partnership, Perry, FL	RB3 was converted to NDCE in 2011 Comment in PIII: *Will be converted to low odor November/December 2011, PSD-FL-397, BACT for PM more restrictive than Subpart BB or Subpart MM, BLOX System to be shutdown.*	The "#3 RECOVERY BOILER W/1 dry ESP & BLOX" is still in the NEI. Permit seems to indicate that the RB3 was converted to NDCE Need to remove BLO unit from NEI

C. Emissions Data Base Year

The subpart MM compliance date for existing sources was March 13, 2004. The base year for subpart MM source emissions data included in the NEI file ranged from 2002 to 2011. Nearly all of the data were for base years after the MACT compliance date. More than 95 percent of the subpart MM data were dated 2009 or later because 2009 was the base year requested in the Part II survey. Only 16 HAP data points (from two processes, and two different mills) were dated prior to 2004 (i.e., dated 2002). Thus, the subpart MM inventory is best characterized as post-MACT data.

D. Review of Mill Identification Codes

The inventory was reviewed to ensure that each record in the inventory contains a facility ID. The EPA is moving towards use of Federal Registry System (FRS) identification (ID) codes for facilities in national emissions inventories. The formerly used NEI ID, referred to as the SPPD_Facility_Identifier in the revised data base, is included in the inventory for reference but this ID will eventually be replaced with the FRS ID. The mill identity codes were reviewed and found to be consistent (e.g., one FRS ID per SPPD_Facility_Identifier and mill). Mill addresses and FIPs codes were also reviewed to ensure each facility was labeled with consistently (e.g., same address for each SPPD_Facility_Identifier and FRS ID).

E. Review of Emission Unit and Release Point IDs, Source Classification Codes, Regulatory Codes, and Emission Process Groups

The inventory was reviewed to ensure that each record in the modeling file contains an Emission Unit ID, Process ID, and Emission Release Point ID. In addition, each record was checked to ensure it was labeled with a Source Classification Code (SCC), Regulatory Code, and Emission Process Group. Next, the SCCs, Regulatory Codes, and Emission Process Groups were compared and reviewed for consistency across all mill types.

Regulatory codes replace the former MACT codes in the revised inventory. Regulatory codes are assigned at the unit and/or process level. The legacy MACT codes (used in the subpart S risk modeling effort) were retained for review purposes, but will eventually be phased out. The regulatory codes were cross-walked with the MACT codes to ensure consistent application within the revised data set. The regulatory codes and corresponding MACT codes contained in the revised inventory are listed in Table 2.

Table 2. Regulatory Codes Including in the Pulp and Paper Facility-wide Inventory

Regulatory Code	MACT Code	Source Category
63DDDDD	0107, 0107-1, 0107-2 0107-3, 0107-4	Industrial, Commercial and Institutional Boilers and Process Heaters (Major Sources
63EEEE	0602	Organic Liquids Distribution (Non-Gasoline) (OLD)
63JJJJ	0711	Paper and Other Web Coatings: Surface Coating
63KK	0714	Printing and Publishing: Surface Coating
63MM	1626-2	Pulp and Paper Industry (Subpart MM): Chemical Recovery Combustion Sources at Kraft, Soda, Sulfite and Semichemical Pulp Mills
63R	0601	Gasoline Distribution (Stage I): Bulk Gasoline Terminals and Pipeline Breakout Stations
63S	1626-1	Pulp and Paper Industry (Subpart S): Kraft, Soda, Sulfite and Semichemical Pulping and Bleaching Processes
63S	1626-3	Pulp and Paper Industry (Subpart S): Kraft, Soda, Sulfite and Semichemical Pulping and Bleaching Processes
63YYYY	0108-1, 0108-2	Stationary Combustion Turbines
63ZZZZ	0105-1, 0105-2	Stationary Reciprocating Internal Combustion Engines (RICE)

Looking across the revised inventory, RTI cross-walked the regulatory codes, SCCs and Emission Process Groups to identify and correct any inconsistencies that may have been introduced with the inventory updates. In addition to retaining the emission process groups used in the previous subpart S modeling effort, new emission process groups were added for lime kilns at soda mills and a hogged fuel dryer used in a site-specific subpart MM compliance strategy by one mill. **Appendix A** lists the 225 SCCs reflected in the revised inventory, along with their assigned emission process groups. **Appendix B** lists all of the emission process groups used in the facility-wide modeling file and indicates the by regulatory code associated with each emission process group.

F. Review of Subpart MM Equipment

Table 3 contains a list of the chemical recovery combustion source equipment present at mills in the subpart MM inventory depending on pulping process. The subpart MM emission process groups were compared with the Part III ICR data base to ensure that all known recovery furnaces and lime kilns were included in the NEI inventory. In addition, the presence of absence of black liquor oxidation systems was reviewed (e.g., because BLO systems are only expected to be present at mills with DCE recovery furnaces). Finally, the mills were checked to ensure emission process groups included SDTs and sulfite and semichemical recovery equipment, as expected. Discrepancies were noted for investigation were explained or resolved as indicated in **Appendix C.**

Table 3. Chemical Recovery Combustion Source Equipment

Pulping Process	Subpart MM and Related Combustion Equipment	SCC	Subpart MM Emission Process Group
Kraft	Chemical recovery furnace: DCE BLO (accompanies one or more DCE)	 30700104 30700109	 DCE BLO
	Chemical recovery furnace (NDCE)	30700110	NDCE
	SDT	30700105	SDT (Kraft)
	Lime kiln or fluidized bed calciner (if no lime kiln)	30700106, 30700108	Lime Kiln Calciner
	Salt cake mix tank	30700119	Salt Cake Tank
	Miscellaneous (e.g., plant fugitives)	30700199	Kraft Misc
Soda	Chemical recovery furnace	30700351	Soda Recovery
	SDT	30700352	SDT (Soda)
	Lime kiln	30700353	Lime Kiln (Soda)
Sulfite	Recovery System: ammonia - including liquor evaporators	30700222	Sulfite Recovery
	Hogged fuel dryer (unique to one mill with a site-specific rule)	39000999	Hogged Fuel Dryer
Semi-chemical*	Non-sulfur liquor combustion	30700324	Semichem Recovery
	NSSC liquor combustion	30700305	NSSC Recovery
	SDT or ash dissolving tank	30700327	SDT (Semichem)

*Some semichemical mills have no chemical recovery system subject to subpart MM, and instead use a sulfur burner (identified by SCC 30700304).

G. Review of Pollutant Codes

The pollutant codes in the inventory were reviewed ensure the codes and descriptions matched the latest NEI lookup table used by EPA for risk model input files. Extensive QA of the pollutant codes was performed prior to the subpart S risk modeling so few updates were required.[14]

The review of the HAP category names found numerous records where the HAP category names for particular pollutants were inconsistent, with some HAP category names including both the HAP name and HAP synonym (e.g., “Methyl Chloroform (1,1,1-Trichloroethane)”) and others including just the HAP name (e.g., “Methyl Chloroform”). In such cases, the HAP category names were standardized to include just the HAP name, consistent with other records and the latest NEI guidance.

Unlike in the previous (subpart S) modeling file which contained separate HAP category names for certain polycyclic organic matter (POM) pollutants, the latest look up table contains one HAP category name of “Polycyclic Organic Matter” for the various POM pollutants. Each POM pollutant continues to be identified by its individual description and pollutant code (i.e., CAS number), but is now labeled with the “Polycyclic Organic Matter” HAP category name. This approach streamlines POM speciation, as discussed in more detail in Section H below.

As was done under the subpart S risk modeling file:

- Thallium at one mill was coded with pollutant code 605 for “Radionuclides (Including Radon)” because no other pollutant code was available for this compound in the NEI lookup table. [Note: The CAS number for thallium is 7440280.]

- Pollutant code 1330207 for “Xylenes (Mixed Isomers)” was used for m,p-xylene, and the xylene records were checked to ensure there was no double counting of individual isomers plus mixed isomers for each emission point. (Note that the combination of “Xylenes (Mixed Isomers)” and o-xylene was acceptable because m,p-xylene was previously coded as “Xylenes (Mixed Isomers).”)

- Similarly, pollutant code 1319773 for “Cresol/Cresylic Acid (Mixed Isomers)” was used for m,p-cresol and the cresol records were checked to ensure there was no double counting of individual isomers plus mixed isomers for each emission point.

- Lead was found to be double-counted at recovery furnaces at one mill using both pollutant code 195 for “Lead & Compounds” and pollutant code 7439921 for a smaller quantity of “Lead.” The emissions of “Lead” appeared to be accounted for under pollutant code 195, so the emissions for “Lead” were removed from the inventory.

One mill has pollutant code 117817 for “Bis(2-Ethylhexyl)Phthalate” listed twice for the same emission point, but with two different pollutant descriptions--“Bis(2-Ethylhexyl) Phthalate” and “Dioctyl Phthalate,” which is a synonym for “Bis(2-Ethylhexyl)Phthalate.” After a review of the NCASI emission factors on which the emissions are based, the latter pollutant has been identified as “Di-n-Octyl Phthalate,” which, while an isomer of “Bis(2-Ethylhexyl) Phthalate,” is not the same pollutant, and has a pollutant code of 117840. The pollutant code for the “Di-n-Octyl Phthalate” record has been revised accordingly.

---

[14] Memorandum from Thomas Holloway, Katie Hanks, Corey Gooden, and Matt Hakos, RTI, to J. Bradfield and B. Schrock, EPA. *Inputs to the Pulp and Paper Industry October 2011 Residual Risk Modeling.* November 11, 2011.

As in the review of the previous inventory, numerous non-HAP pollutants were included in the file. The non-HAP pollutant codes were reviewed but the non-HAP pollutants will not be included in the subpart MM risk modeling effort. For the non-HAP pollutants:

- Some records had the incorrect pollutant code "PM," which was revised to the correct pollutant code ("PM-PRI" or "PM-FIL"), consistent with the pollutant descriptions that the mills provided in their revision files. A similar change was made to the one record with the pollutant code "PM10," which was changed to "PM10-PRI," based on information from the mill's revision file.

- Numerous records were found where the HAP category name for the various classifications of PM (PM Primary, Filterable, or Condensible; PM_{10} Primary, Filterable, or Condensible; and $PM_{2.5}$ Primary, Filterable, or Condensible) was just given as "PM." This HAP category name was revised to reflect the specific classification, consistent with the pollutant code, other records, and the latest NEI guidance.

- Numerous records were found where the HAP category name was spelled out in some places—"Carbon Monoxide," "Nitrogen Oxides," "Sulfur Dioxide," and "Volatile Organic Compounds"--and abbreviated in others—"CO," "NOx," "SO_2," and "VOC." Consistent with the latest NEI guidance, all HAP category names were spelled out, where necessary.

- Some of the TRS records have pollutant codes of "TRS," while others are coded as "TRS (H_2S)" or "TRS as S." In the absence of information on the specific TRS compounds that comprise "TRS" for each of these sources, the TRS data in the inventory were not converted into a common basis because TRS data are not required for purposes of the subpart MM modeling file. Additional QA of the TRS data can be performed in the future to convert to a common basis (e.g., "TRS as S") considering the intended application for these data and to ensure there is no double counting of emissions.

H. HAP Speciation

The inventory included unspeciated data for a number of HAPs, including chromium, mercury, radionuclides, PCBs, glycol ethers, cyanide, POM, and dioxins/furans. This section describes how these data were speciated to facilitate risk modeling.

Chromium. Chromium compounds are a significant contributor to increased cancer risk, but the level of risk largely depends on the oxidation state (species) of the compounds. The two most common chromium species are hexavalent chromium (Cr^{+6}) and trivalent chromium (Cr^{+3}). The EPA has classified Cr^{+6} and its compounds as known human carcinogens, while Cr^{+3} is not classified as to its human carcinogenicity. Consequently, determining the percentage of total chromium that is Cr^{+6} vs. Cr^{+3} is an important factor in estimating the level of risk from chromium exposure.

The input file included two records of unspeciated chromium (pollutant code 7440473), one for a solid waste-fired boiler (SCC 10201201) and one for a residual oil-fired boiler (SCC

10200401). While these emission units are outside the subpart MM category being modeled, given the small number of records involved, the chromium data were speciated into hexavalent chromium (pollutant code 18540299) and trivalent chromium (pollutant code 16065831), using the SCC-specific chromium speciation profiles used in the October 2011 risk modeling of the pulp and paper sector (i.e., Cr^{+6} multipliers of 18 percent for SCC 10201201 and 56 percent for SCC 10200401, with the balance considered as Cr^{+3}).[15]

Mercury. Like chromium, the different oxidation states of mercury compounds vary in toxicity, but also in exposure pathway (e.g., inhalation, ingestion). The most common mercury species are divalent mercury (Hg^{+2}) (including both particulate and gaseous forms) and elemental gaseous mercury (Hg^0). The input file included a number of records for unspeciated mercury (pollutant code 7439976)--some for subpart MM sources (recovery furnace, SDT, lime kiln), some for boilers, and one for a hogged fuel dryer. Because of the differences in toxicity for the various mercury species, the mercury data for all sources were speciated using the NEI default multipliers of 0.2 for particulate divalent mercury (pollutant code 202), 0.3 for gaseous divalent mercury (pollutant code 201), and 0.5 for elemental gaseous mercury (pollutant code 200).

Radionuclides. The input file included records for unspeciated radionuclides (pollutant code 605), most for subpart MM sources (recovery furnaces, SDTs, lime kilns) and a couple for wood/bark boilers. Only the individual isotopes included in radionuclides will be modeled in the residual risk analysis. Records for speciated radionuclides--uranium (pollutant code 7440291) and thorium (pollutant code 7440611)--which were available in the input file for subpart MM sources at other mills--were used to develop radionuclide speciation profiles for subpart MM sources, as shown in Table 4 below.

Table 4. Radionuclide Speciation Profiles for Subpart MM Sources

Pollutant code	Radionuclide compounds	DCE recovery furnace (30700104)	NDCE recovery furnace (30700110)	SDT (30700105)	Lime kiln (30700106)
7440291	Thorium-232	80.90%	91.81%	44.31%	89.46%
7440611	Uranium-238	19.10%	8.19%	55.69%	10.54%

Where applicable, the profiles in Table 4 were used to develop speciated radionuclide data for the subpart MM sources with unspeciated data. No speciated radionuclide data for boilers were available to develop a speciation profile. In addition, boilers are outside the subpart MM category being modeled. Consequently, the radionuclide data for boilers were not speciated.

Polychlorinated biphenyls (PCBs). The input file included a number of boiler records with unspeciated PCB data (pollutant code 1336363), but only individual PCBs are modeled in the residual risk analysis. Nearly all of the mills with unspeciated PCB data also had speciated PCB data. The unspeciated data consisted of those PCBs (e.g., dichlorobiphenyl, trichlorobiphenyl) from mills' NEI revision files that did not have pollutant codes in the NEI pollutant code lookup table and were consequently assigned the default PCB pollutant code

---

[15] Memorandum from Thomas Holloway, Katie Hanks, Corey Gooden, and Matt Hakos, RTI, to J. Bradfield and B. Schrock, EPA. *Inputs to the Pulp and Paper Industry October 2011 Residual Risk Modeling.* November 11, 2011.

(1336363). Because there were no unspeciated pollutants with listed pollutant codes and because all of the PCB data were for boilers, which are outside the subpart MM category being modeled, no further action was taken.

Glycol ethers. The input file was reviewed for total glycol ethers (pollutant code 175), and no unidentified glycol ethers with pollutant code 175 were found. Each glycol ether reported in the input file was identified as a specific compound. Glycol ether compounds were reported for a variety of processes, including subpart MM sources.

Cyanide. The input file included a number of records for emissions of "Cyanide" (pollutant code 57125) and "Cyanide & Compounds" (pollutant code 144). Only cyanide will be modeled in the residual risk analysis, and the compounds included in "Cyanide & Compounds" are not known. All of these emissions are from outside the subpart MM category being modeled, mostly boilers but also a couple of emission units associated with secondary fiber pulping and wastewater processes at mechanical pulp mills. The cyanide compound data were not speciated because of the uncertainty concerning what the "Cyanide & Compounds" include and because all of the emission units with the cyanide data are outside the subpart MM category.

Polycyclic organic matter (POM). Polycyclic organic matter is comprised of a large number of individual compounds, which can be divided into the subgroups of polycyclic aromatic hydrocarbons (PAHs) and PAH-derivatives. Each compound has its own toxicity level and can vary in exposure pathway. Unit risk estimates (UREs) for individual PAHs can span five orders of magnitude. Individual PAHs are needed for both multipathway and ecological analyses. The input file included numerous records with unspeciated POM data (pollutant code 246), most for subpart MM sources and boilers (all major fuel types), and a few for engines, turbines, and paper coating operations. Our review focused on the subpart MM category sources only, given the large number of records for sources outside of the subpart MM source category that would have required speciation (e.g., addition of numerous speciated compounds, particularly for boilers).

The subpart MM sources with unspeciated POM data (pollutant code 246) included a large number of kraft DCE/NDCE recovery furnaces and lime kilns, a calciner, a few SDTs, tow emission points for the one multi-stage BLO unit (one with a regenerative thermal oxidizer (RTO) and the other uncontrolled), and a couple of semichemical combustion units. Where applicable, the unspeciated POM data for subpart MM sources were speciated using the profiles in Table 5 below. The speciation profiles for the kraft combustion sources were developed based on emissions data in NCASI Technical Bulletin No. 973, while the speciation profile for the semichemical combustion sources were developed based on Part II survey data from another semichemical combustion source.[16,17] In the absence of speciated POM data for the BLO units, the POM speciation profile for DCE recovery furnaces was used, since the BLO unit is a part of the DCE recovery furnace system.

---

[16] Someshwar, Arun V. *Compilation of 'Air Toxic' and Total Hydrocarbon Emissions Data for Pulp and Paper Mill Sources—A Second Update.* National Council for Air and Stream Improvement (NCASI). Technical Bulletin No. 973. February 2010. (NCASI 2010)

[17] Email and attachments from Peggi Davis, Sonoco, to PPSURVEY. Attachment: Part II survey response "Sonoco Part II.xls." June 6, 2011.

Table 5. POM Speciation Profiles for Subpart MM Sources

Pollutant code	POM compounds	Kraft chemical recovery combustion sources				Semi-chemical combustion unit (30700324)
		DCE recovery furnace (30700104)	NDCE recovery furnace (30700110)	SDT (30700105)	Lime kiln/ calciner (30700106/ 30700108)	
90120	1-Methylnaphthalene	0.66%	--	1.17%	--	--
91576	2-Methylnaphthalene	0.97%	--	1.73%	--	46.31%
56495	3-Methylcholanthrene	0.08%	--	0.27%	--	--
57976	7,12-Dimethylbenz[a] Anthracene	0.004%	--	0.01%	--	--
83329	Acenaphthene	72.58%	0.32%	21.03%	--	--
208968	Acenaphthylene	5.94%	8.98%	0.12%	--	--
120127	Anthracene	1.02%	1.64%	6.40%	--	--
56553	Benz[a]Anthracene	0.22%	0.43%	0.70%	7.18%	--
50328	Benzo[a]Pyrene	0.01%	0.06%	0.06%	7.18%	--
205992	Benzo[b]Fluoranthene	0.07%	0.57%	0.14%	7.18%	--
192972	Benzo[e]Pyrene	0.004%	1.19%	0.07%	7.18%	--
191242	Benzo[g,h,i]Perylene	0.03%	1.88%	0.009%	--	--
207089	Benzo[k]Fluoranthene	0.02%	1.19%	0.12%	7.18%	--
218019	Chrysene	0.10%	11.31%	1.64%	7.18%	--
53703	Dibenzo[a,h]Anthracene	0.02%	0.01%	0.006%	7.18%	--
206440	Fluoranthene	1.81%	8.74%	13.81%	7.31%	5.80%
86737	Fluorene	0.68%	1.32%	1.41%	--	5.41%
193395	Indeno[1,2,3-c,d]Pyrene	0.01%	0.07%	0.01%	7.18%	--
198550	Perylene	0.002%	0.003%	0.01%	--	--
85018	Phenanthrene	14.73%	39.21%	44.23%	7.18%	32.84%
129000	Pyrene	1.05%	23.08%	7.04%	28.09%	9.65%

Several of the subpart MM sources with unspeciated POM data also had speciated POM data. A couple of these sources had data for a large number of POM compounds (13) which were retained while the unspeciated POM records for these sources were deleted. The other subpart MM sources had data for total PAH and one POM compound (benzo[g,h,i]perylene) in addition to unspeciated POM data. In every case, the unspeciated POM value was greater than the total PAH value. The distinction between total PAH and POM for these sources suggests that the unspeciated POM value includes both PAHs and PAH-derivatives.[18] Emissions for

---

[18] "PAHs" are organic compounds which include only carbon and hydrogen with a fused ring structure containing at least two benzene (six-sided) rings. PAHs may also contain additional fused rings that are not six-sided. Like PAHs, "PAH-derivatives" also have at least two benzene rings and may contain additional fused rings that are not six-sided rings. However, PAH-derivatives also contain other elements in addition to carbon and hydrogen. PAH-derivatives include nitro-PAHs, amino-PAHs, and oxygenated PAHs (phenols, quinones, and heterocyclic aromatic compounds containing sulfur and oxygen. [Reference: California Air Resources Board. *Toxic Air Contaminant Identification List Summaries – ARB/SSD/SES. Polycyclic Organic Matter.* Available at: *www.nmenv.state.nm.us/aqb/projects/openburn/CAchemfacts/pom.pdf. September 1997.]*

benzo[g,h,i]perylene were subtracted from the total PAH emissions for those sources, the revised total PAH were speciated using the profiles in the table above (excluding the factor for benzo[g,h,i]perylene), and the unspeciated PAH and POM records were deleted. (Note: The emissions from benzo[g,h,i]perylene were sufficiently low that excluding the pollutant did not alter the speciation factors for the other POM compounds, after rounding.)

Dioxins/furans. The predominant sources of dioxin/furan emissions at pulp and paper mills are power boilers used to provide steam and electricity for the mill and the subpart MM chemical recovery combustion sources (e.g., recovery furnaces, lime kilns) at the mill. A small percentage of the dioxin/furan data in the input file was unspeciated. Individual dioxin/furan congeners, specifically those used to determine the 2,3,7,8-TCDD toxic equivalency (TEQ), are needed for multipathway and ecological analyses. The congeners of interest are listed in Table 6 below, along with the toxic equivalency factor (TEF) used to express the mass of each congener in terms of its 2,3,7,8-TCDD TEQ. This subsection explains how uspeciated dioxin/furan data were speciated, and how those speciated dioxin/furan data were converted to a TEQ basis for purposes of risk modeling.

Table 6. Dioxin/Furan Congeners and Associated Toxic Equivalency Factors

Pollutant code	Pollutant description	TEF[1]
1746016	2,3,7,8-Tetrachlorobenzo-p-Dioxin	1
40321764	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	1
39227286	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	0.1
57653857	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	0.1
19408743	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	0.1
35822469	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	0.01
3268879	Octachlorodibenzo-p-Dioxin	0.0003
51207319	2,3,7,8-Tetrachlorodibenzofuran	0.1
57117416	1,2,3,7,8-Pentachlorodibenzofuran	0.03
57117314	2,3,4,7,8-Pentachlorodibenzofuran	0.3
70648269	1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
57117449	1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
72918219	1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
60851345	2,3,4,6,7,8-Hexachlorodibenzofuran	0.1
67562394	1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01
55673897	1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01
39001020	Octachlorodibenzofuran	0.0003

[1] TEF values for 2,3,7,8-tetrachlorodibenzo-p-dioxin TEQ, published in 2005 by the World Health Organization, and adopted by EPA in 2008 for risk assessments.[19]

---

[19] U.S. Environmental Protection Agency. *Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds.* Publication No. EPA/100/R-10/005. Available at: http://www.epa.gov/raf/files/tefs-for-dioxin-epa-00-r-10-005-final.pdf. December 2010. (EPA 2010)

Because power boilers are outside the subpart MM category being modeled, we did not speciate the dioxin/furan data for boilers at pulp and paper mills, except where the unspeciated data appeared to be unreasonably out of range from expected values (e.g., 10^{-4} tpy or higher) and required additional review. For perspective, the entire U.S. inventory of dioxin/furan emissions is estimated to be on the order of 10^{-3} tpy.[20] However, it should be noted that this estimate is in terms of 2,3,7,8-TCDD TEQ, while the unspeciated dioxin/furan data are in terms of total dioxin/furan.

Consequently, dioxin/furan data were speciated for subpart MM combustion sources (e.g., recovery furnaces, lime kilns) and boilers with suspect dioxin/furan data. The unspeciated data included total CDD, total CDF, and two homologs (hexachlorodibenzo-p-dioxin and heptachlorodibenzo-p-dioxin).[21,22] Homologs represent broad groupings of dioxin/furan compounds that include the congeners with TEFs plus additional homologous compounds for which TEFs have not been developed.

One mill (NEI46931) had data for both speciated and unspeciated dioxins/furans for its subpart MM combustion sources. The unspeciated data were deleted and the speciated data were retained for this mill.

For recovery furnaces and boilers with total CDD, total CDF, or homolog data in the input file, speciation profiles were developed based on average dioxin/furan emissions data in EPA's dioxin/furan inventory report.[23] Tables 7 and 8 below present the speciation profiles and include the relevant TEF from Table 6. For some sources, data were available for both total CDD and CDD homologs. However, the sum of the CDD homolog data did not equal total CDD, indicating some homolog data were unaccounted for. In those cases, we just speciated the total CDD data.

For lime kilns with unspeciated CDD/CDF data, no speciation profile was available, so dioxin/furan emissions were recalculated using emission factors from Technical Bulletin No. 973[24] and process/operating data from the mills' Part III survey responses.

---

[20] U.S. Environmental Protection Agency. *An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000.* Publication No. EPA/600/P-03/002F. Available at: http://www.epa.gov/ncea/pdfs/dioxin/2006/dioxin.pdf. November 2006. (EPA 2006)

[21] Total CDD in the input file were identified by pollutant codes:

- 155 for "Dioxins,"
- 262124 for "Dibenzo-p-Dioxin," or
- 136677093 for "Dioxins, Total, W/O Individ. Isomers Reported {PCDDS}"

[22] Total CDF were identified by pollutant code 136677106 for "Polychlorinated Dibenzofurans, Total"

[23] EPA 2006, Tables 4-14, 4-25, and 5-13.

[24] NCASI 2010, Table 9.9.

Table 7. Dioxin/Furan Speciation Profiles for Sources with Total Dioxin/Furan Data[1]

Dioxin congeners/ homologs	Recovery furnaces		Wood-fired boilers		TEF
	Emissions, ng/kg BLS	% of total CDD or CDF	Emissions, ng/kg wood	% of total CDD or CDF	
Congeners:					
2,3,7,8-TCDD	0	0%	0.04	0.43%	1
1,2,3,7,8-PeCDD	0	0%	0.079	0.85%	1
1,2,3,4,7,8-HxCDD	0.001	0.07%	0.115	1.24%	0.1
1,2,3,6,7,8-HxCDD	0.003	0.20%	0.138	1.48%	0.1
1,2,3,7,8,9-HxCDD	0.006	0.40%	0.321	3.45%	0.1
1,2,3,4,6,7,8-HpCDD	0.108	7.16%	0.745	8.01%	0.01
OCDD	1.033	68.50%	3.329	35.78%	0.0003
Homologs:[2]					
Other TCDD	0.106	7.03%	0.929	9.99%	
Other PeCDD	0.013	0.86%	1.442	15.50%	
Other HxCDD	0.094	6.23%	1.089	11.71%	
Other HpCDD	0.144	9.55%	1.076	11.57%	
Total CDD[3]	**1.508**	**100%**	**9.303**	**100%**	
Congeners:					
2,3,7,8-TCDF	0.04	2.13%	0.684	4.61%	0.1
1,2,3,7,8-PeCDF	0.03	1.60%	0.406	2.73%	0.03
2,3,4,7,8-PeCDF	0.033	1.76%	0.389	2.62%	0.3
1,2,3,4,7,8-HxCDF	0.007	0.37%	0.375	2.52%	0.1
1,2,3,6,7,8-HxCDF	0.012	0.64%	0.418	2.81%	0.1
1,2,3,7,8,9-HxCDF	0.005	0.27%	0.178	1.20%	0.1
2,3,4,6,7,8-HxCDF	0.01	0.53%	0.192	1.29%	0.1
1,2,3,4,6,7,8-HpCDF	0.024	1.28%	1.062	7.15%	0.01
1,2,3,4,7,8,9-HpCDF	0	0%	0.113	0.76%	0.01
OCDF	0.113	6.01%	0.674	4.54%	0.0003
Homologs:[2]					
Other TCDF	1.23	65.46%	3.669	24.70%	
Other PeCDF	0.307	16.34%	4.135	27.84%	
Other HxCDF	0.068	3.62%	2.153	14.50%	
Other HpCDF	0	0%	0.405	2.73%	
Total CDF[3]	**1.879**	**100%**	**14.853**	**100%**	

[1] Source: EPA 2006, Tables 4-14 and 5-13. Non-detect set to zero consistent with EPA Method 23 guidance.

[2] The “Other” homologs were derived by subtracting the congener value from the “total” homolog value in the in EPA 2006. For example, as presented in EPA 2006 Table 4-14, Total HpCDD = 0.252 and 1,2,3,4,6,7,8-HpCDD = 0.108, so “Other” HpCDD = 0.252 – 0.108 = 0.144.

[3] Sum of the congeners and homologs.

Table 8. Speciation Profile for Sources with Only Dioxin/Furan Homolog Data[1]

Congener or Homolog	Recovery furnaces		Wood-fired boilers		Coal-fired boilers		TEF
	Emissions, ng/kg feed	%[2] of homolog	Emissions, ng/kg wood	%[2] of homolog	Emissions, ng/kg coal[3]	%[2] of homolog	
Congeners:							
1,2,3,4,7,8-HxCDD	0.001	0.96%	0.115	6.92%	0	0%	0.1
1,2,3,6,7,8-HxCDD	0.003	2.88%	0.138	8.30%	0.004	13.33%	0.1
1,2,3,7,8,9-HxCDD	0.006	5.77%	0.321	19.30%	0.004	13.33%	0.1
1,2,3,4,6,7,8-HpCDD	0.108	42.86%	0.745	40.91%	0.216	100%	0.01
Homologs:							
Total HxCDD	0.104		1.663		0.03		
Total HpCDD[3]	0.252		1.821		0.216		

[1] Source: EPA 2006, Tables 4-14, 4-25, and 5-13. Non-detect set to zero consistent with EPA Method 23 guidance.
[2] Calculated, by dividing the conger by the total homolog value. Using MM source HpCDD for example, 42.86% = 1,2,3,4,6,7,8-HpCDD / Total HpCDD = 0.108/0.252 x 100%
[3] Emissions for total HpCDD in this table were based on the value of the corresponding congener, which was greater than the total value tabulated for the homolog in EPA 2006.

For mills with total CDD or CDF data, the emissions estimates for each congener (as 2,3,7,8-TCDD TEQ) were estimated by multiplying the total CDD or CDF value in the input file by the percentage of total CDD or CDF (as applicable) and the TEF for that congener using the profile in Table 7 above. The speciated data (TEQ congeners) were then used to replace the unspeciated CDD/CDF data in the input file for those sources as shown in Table 9 below.

Table 9. Example of Dioxin/Furan Speciation for Mills with Total CDD/CDF Data

Emission Unit Description	Pollutant Code	Pollutant Description	HAP Category Name	Emissions, tpy
Unspeciated				
#2 Recovery Boiler	136677093	Dioxins, Total, W/O Individ. Isomers Reported {PCDDS}	Dioxins/Furans (total, non TEQ)	5.605E-07
Speciated TEQ*				
#2 Recovery Boiler	39227286	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	Dioxins/Furans as 2,3,7,8-TCDD TEQs	3.71684E-11
#2 Recovery Boiler	57653857	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	Dioxins/Furans as 2,3,7,8-TCDD TEQs	1.11505E-10
#2 Recovery Boiler	19408743	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	Dioxins/Furans as 2,3,7,8-TCDD TEQs	2.23011E-10
#2 Recovery Boiler	35822469	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	Dioxins/Furans as 2,3,7,8-TCDD TEQs	4.01419E-10
#2 Recovery Boiler	3268879	Octachlorodibenzo-p-Dioxin	Dioxins/Furans as 2,3,7,8-TCDD TEQs	1.15185E-10

*The 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD congeners do not appear in the speciated TEQ because they represent 0% of CDD congeners based on the speciation profile for recovery furnaces in Table 7.

For mills with only homolog CDD or CDF data, the emissions estimates for each congener (as 2,3,7,8-TCDD TEQ) were estimated by multiplying the homolog value in the input file by the percentage of that homolog corresponding to each congener using the profile in

Table 8. The speciated data (TEQ congeners) were then used to replace the unspeciated homolog data in the input file for those sources are shown in Table 10 below.

Table 10. Example of Dioxin/Furan Speciation for Mills with CDD/CDF Homolog Data

Emission Unit Description	Pollutant Code	Pollutant Description	HAP Category Name	Emissions, tpy
Unspeciated				
B&W Boiler	34465468	Hexachlorodibenzo-p-Dioxin	Dioxins/Furans (total, non TEQ)	0.000415958
Speciated TEQ				
B&W Boiler	39227286	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	Dioxins/Furans as 2,3,7,8-TCDD TEQs	2.87644E-06
B&W Boiler	57653857	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	Dioxins/Furans as 2,3,7,8-TCDD TEQs	3.45173E-06
B&W Boiler	19408743	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	Dioxins/Furans as 2,3,7,8-TCDD TEQs	8.02902E-06

I. Emissions Corrections

This section documents the emissions corrections that were conducted after the mill revisions were incorporated into the input file.

In a recent communication to EPA, a representative from one mill noted that the nickel compound emissions for the mill’s three recovery furnaces needed to be reevaluated based on more current information. The mill’s current nickel estimates were noted to be based on 25-year old data (specifically a 1989 stack test on one of the mill’s recovery furnaces)--a limited dataset which gave nickel emissions estimates over 20 times higher than the average of other mills. Recalculating the nickel emissions using the NCASI nickel emission factor for recovery furnaces gives nickel emissions an order of magnitude lower, that are more in line with the nickel emissions from other mills’ recovery furnaces. We replaced the current nickel emission estimates for this mill’s recovery furnaces with these revised estimates.

A review of the emissions data in the input file revealed that acrolein data at one mill had been inadvertently omitted when the HAP data for causticizing tanks at the mill were replaced with three separate sets of HAP data split evenly across three emission points. To correct the error, we created three new acrolein records for these emission points, splitting the acrolein emissions for the emission unit evenly across the three emission points.

There were also instances where data for acrolein, xylenes, and various non-HAPs (e.g., TRS, VOC, and acetone) for specific emission points needed to be made consistent with revisions to those emission points for similar compounds. For example, because acrolein data were reinserted into the inventory, these data needed to be split across emission points, consolidated, or removed in instances where similar adjustments were made to corresponding organic compounds for each emission unit. Similar revisions were required for other pollutants (e.g., non-HAP) that had not been updated in mills’ inventory revisions.

Dioxin/furan. As noted in the previous section, some unspeciated dioxin/furan emissions estimates in the input file appeared high (10^{-4} tpy or higher). Most of these were addressed by speciating the data and expressing the data in terms of 2,3,7,8-TCDD TEQ. However, there were also some speciated dioxin/furan data in the input file that exceeded 10^{-4} tpy, indicating that the data were in error. These data came from four mills and were addressed as follows.

- Mill 1 (regenerative thermal oxidizer): 2,3,7,8-TCDD = 0.000151 tpy. Based on the mill's Part I survey response, this incinerator controls the coating processes at the mill, subject to 40 CFR part 63, subpart JJJJ. These emissions are unreasonably high and are the only dioxin/furan data for this type of emission unit in the input file. Accordingly, these data were removed from the input file.

- Mill 2 (NDCE recovery furnace): OCDD (as 2,3,7,8-TCDD TEQ) = 0.00104 tpy. The OCDD TEQ emissions are much higher than the other dioxin/furan congener data for this emission unit. In the mill's Part II survey response, the mill indicated their dioxin/furan data were from a test report. To revise the OCDD TEQ data, we applied the ratio of OCDD/OCDF TEQ data in the test report to the OCDF TEQ data in the input file to generate a new OCDD TEQ estimate of 1.13×10^{-7} tpy, which is more in line with the other dioxin/furan congener data at this mill.

- Mill 3 (coal-fired boiler): 2,3,7,8-TCDD = 0.0002 tpy. These emissions are unreasonably high and appear to be a result of miscalculation. This is the only dioxin/furan data for this emission unit. In the mill's Part II survey response, the mill indicated that this estimate was based on an EPA emission factor. Without knowing how the emissions were miscalculated, we recalculated the TCDD value, as well as all other congeners, using the dioxin/furan emission factors for coal-fired boilers in NCASI Technical Bulletin No. 973[25] and all available process/operating data for this boiler.

- Mill 4 (multiple emission units): The dioxin/furan congener data from the wood-fired boilers, recovery furnace, and lime kiln at this mill were found to be unreasonably high, ranging from 1.09×10^{-4} to 2.56×10^{-3} tpy (as 2,3,7,8-TCDD TEQ). The elevated emissions data appear to be a result of miscalculation. Without knowing how the emissions were miscalculated, we recalculated the dioxin/furan data for these emission units. We also recalculated the dioxin/furan data for the oil-fired package boiler at the mill, which, while not unreasonably high, were also considered suspect given the high dioxin/furan estimates for the other emission units at the mill. We recalculated the emissions using the dioxin/furan emission factors for wood-fired boilers, oil-fired boilers, recovery furnaces, and lime kilns in NCASI Technical Bulletin No. 973[26] and the process/operating data for these emission units from the mill's title V permit and Part III survey response.

---

[25] NCASI 2010, Table 9.5, which cites the following EPA document as its source:

U.S. Environmental Protection Agency. *Emergency Planning and Community Right-to-Know Act—Section 313: Guidance for reporting toxic chemicals within the dioxin and dioxin-like compounds category.* Publication No. EPA/745-B-00-021. Available at: http://www2.epa.gov/sites/production/files/documents/2000dioxinguidance.pdf. December 2000.

[26] NCASI 2010, Tables 9.1, 9.6, 9.7, and 9.9.

J. Emission Release Point Information

Emissions data are presented for each emission release point in the inventory. Emission release points can be characterized as either "fugitive" or "stack" using the Emission Release Point Type Code. Table 11 lists the Emission Release Point Type codes included in the pulp and paper modeling file. Fugitive emission points have the "01" Emission Release Point Type code, while all other Emission Release Point Type codes represent "stack" emissions.

Table 11. Emission Release Point Type Codes in the Pulp and Paper Inventory

Emission Release Point Type Code	Emission Release Point Type Description
01	Fugitive
02	Vertical
03	Horizontal
04	Goose neck
05	Vertical with rain cap
06	Downward-faciing vent

Individual emission release points can be identified as having a unique concatenation of State_County_FIPS—SPPD_Facility_Identifier—Emission_Release_Point_ID.[27] For each emission release point, each record should have one set of coordinates (latitude and longitude) and one set of stack or fugitive parameters. All records were reviewed for consistency with respect to the emission release point.

Fugitive parameters. Fugitive parameters for Emission Release Point Type "01" were checked to ensure there were no blanks and the values provided were reasonable and consistent with the required national defaults or other criteria. The fugitive parameters were also reviewed to ensure only one set of parameters applied for each emission release point (e.g., each emission release point has the same length and width for every pollutant). No issues were identified. The conventions for fugitive release parameters are presented in Table 12.

Table 12. Fugitive Release Parameter Conventions for Risk Model Input Files

Parameter	Criteria
Height (ft)	Mill-specific value or pulp and paper default*; must be a whole number (i.e., 1 ft minimum)
Diameter (ft)	Always defaulted to 0.003 ft
Temperature (F)	Mill-specific value or default of 72°F
Velocity (ft/sec)	Always defaulted to 0.0003 ft/sec
Flow Rate (cu ft/sec)	Always defaulted to 0 cu ft/sec

---

[27] Similarly, each unique concatenation of SPPD_Facility_Identifier—Emission_Unit_ID—Process_ID--Emission_Release_Point_ID represents an emission release point.

Parameter	Criteria
Fugitive Release Width (ft)	Mill-specific value or pulp and paper default*
Fugitive Release Length (ft)	Mill-specific value or pulp and paper default*
Fugitive Release Angle at SW corner	Mill-specific value or defaulted to 0

*In preparation of the modeling file for the subpart S modeling effort, defaults were developed for use in place of missing data. See Appendix C in *Inputs to the Pulp and Paper Industry October 2011 Residual Risk Modeling* for details. There were no missing fugitive dimensions to populate in the inventory being reviewed for the subpart MM modeling effort.

Stack parameters. Emission points labeled as stacks were reviewed to ensure no fugitive parameters were identified. A few fugitive widths and angles that had apparently been left on stack rows by mistake were removed.

The stack release parameters include: height (ft), diameter (ft), release temperature (F), exit gas velocity (ft/sec), and exit gas flow rate (cu ft/sec). Stack parameters were reviewed to ensure all were populated with reasonable values. No issues were identified. Exit gas flow rate values were checked to determine whether they met EPA's criteria that the flow rate must be within 10 percent of the calculated value (assuming a cylindrical stack), based on the following formula:

$$\text{Flow rate} = 3.1416 \times (\text{diameter}/2)^2 \times \text{exit gas velocity (ft/sec)}$$

Several exit gas flow rate values not meeting the 10 percent criteria were revised to the calculated flow rate.

In addition, the stack release parameters were reviewed to ensure each emission point was represented by only one set of stack parameters. Any inconsistencies, such as two different stack parameters for different pollutants for a given emission point, were corrected.

Coordinates. Coordinate values (latitude and longitude) were checked to ensure only one set of coordinates appeared for each emission release point. In addition, coordinates were reviewed to determine which values changed as a result of the inventory revisions. The changed values (for about 135 process emission release points) were mapped to determine if they remained on the mill site. Coordinates for three emission points located 10 miles east of the plant were adjusted back to the plant site. In some cases, the revised values lacked the required 5 decimal digits (preferred 6 decimal digits). If 4 or fewer digits were present, previous files were reviewed to ensure the values were not truncated (no truncation was found), and coordinates were adjusted to 5 or more digits, with some slight revision where necessary (e.g., x-coordinate adjusted from -86.5087 to -86.50857).

K. Control Information

Information on control measures will be helpful to evaluate risk results and develop post-control scenario emissions. To that end, control information from the Part III ICR data base was added to the Control Measure Comments column in the input file for subpart MM sources. Any remaining gaps in control information were filled from the mills' title V permits, where necessary. Once the control information was entered, the corresponding Control Measure codes from the latest NEI look-up table were added to the Control Measure Code columns (one column per control measure). The same control measure was listed for all records for a particular emission point, with no distinction by pollutant. The control measures, organized by emission process group, are presented in **Appendix D** at the end of this memorandum.

It should be noted that the match between Part III ICR control information and NEI control measure codes was not always exact. For example, the SDT at one mill is equipped with a condensate stripper after the wet scrubber, but there was no corresponding control measure code for a condensate stripper. In that case, a generic control measure code of 099 for "Other Control Device" was assigned. In another example, the input file included dioxin/furan emissions data for three mills under a composite emission unit that included all recovery furnaces, lime kilns, and/or SDTs at the mill, each of which has its own control device. With no specific emission unit, a control measure code could not be added. However, a summary of the control measures for the various recovery furnaces, lime kilns, and SDTs in the composite emission unit was included in the Control Measure Comments column.

The most common example where there was not an exact match between control information and control measure code was the recovery furnace ESP. Nearly all recovery furnaces are equipped with ESPs, which are designed with either a wet or dry bottom. In wet-bottom ESPs, the collected PM falls directly into a pool of liquid, which may be black liquor or process water, in the bottom of the ESP. In dry-bottom ESPs, the collected PM falls to the (dry) bottom of the ESP and is transferred from the ESP bottom to a mix tank (containing black liquor) via drag-chain or screw conveyors. Black liquor is sometimes used to transport the dry collected PM to the salt cake mix tank. More recent ESP installations employ a dry PM return system to transport the PM to the mix tank. When hot recovery furnace flue gases come in contact with ESP systems, gaseous organic HAPs (primarily methanol) may be stripped from any black liquor or HAP-contaminated process water present in the ESP bottom or wet PM return system and emitted to the atmosphere.[28] While the type of ESP bottom or PM return system does not impact the level of PM (and HAP metals) emitted from the ESP, it can potentially impact the level of gaseous organic HAP emissions. However, the NEI look-up table only includes a single control measure code (128) for "Electrostatic Precipitator – Dry (DESP)," so each of these recovery furnace ESPs, regardless of design, was assigned a control measure code of 128. Therefore, in reviewing the impact of ESP design on gaseous organic HAP emissions, we recommend consulting the information in the Control Measure Comments column, which indicates the specific ESP design.

IV. Actual versus Allowable Emissions

A. Background

In addition to evaluating the residual risks associated with actual emissions, the EPA evaluates the risk associated with the emissions that would be allowed under the NESHAP, i.e., "allowable emissions," since they reflect the maximum level that sources could emit and still comply with the national standards. Actual emissions are sometimes less than allowable

---

[28] U.S. Environmental Protection Agency. *Technical Support Document: Chemical Recovery Combustion Sources at Kraft and Soda Mills*. Publication No. EPA-453/R-96-012. October 1996.

emissions due to a compliance margin, a more stringent state or local rule, or over-control due to the use of control technologies, equipment, or work practices that are significantly better than that required by MACT. Any over-control from pulp and paper chemical recovery combustion sources, e.g., for mills using the PM bubble compliance alternative, would be site-specific and not estimable. The remainder of this section documents how multipliers were estimated to calculate allowable emissions.

B. Allowable Multipliers for Subpart MM Risk Modeling

Appendix E at the end of this memorandum lists the standards in subpart MM to which chemical recovery combustion sources are subject. The sources include:

- Kraft and soda recovery furnaces (NDCE and DCE)
- Kraft and soda smelt dissolving tanks
- Kraft and soda lime kilns and calciners
- Sulfite combustion units
- Semichemical combustion units

Subpart MM includes numeric standards for HAP metals and gaseous organic HAP, with PM used as a surrogate for HAP metals and methanol or THC used as a surrogate for total gaseous organic HAP. The specific emission limits to which each source is subject vary depending on whether the source is considered existing or new (i.e., whether the source was constructed or reconstructed before or after the subpart MM proposal date of April 15, 1998).

Kraft/soda mills. To estimate the allowable multipliers for HAP metal emissions from kraft and soda sources subject to subpart MM, we calculated the ratio of subpart MM PM limits to PM stack test averages, for existing sources and for new sources. The PM stack test data were obtained from test reports submitted by mills in response to Part III of the 2011 pulp and paper industry ICR.

Under subpart MM, mills were not required to conduct stack testing or monitoring to demonstrate compliance with the gaseous organic HAP standard for new kraft and soda recovery furnaces, if the mills were equipped with NDCE recovery furnaces using a dry ESP system. Since that is the only type of recovery furnace system currently being installed at kraft and soda mills, no emissions are measured, and allowable emissions are assumed to equal actual emissions, resulting in an allowable multiplier of 1.

Sulfite mills. The allowable multiplier for HAP metal emissions from sulfite combustion units subject to subpart MM was calculated similar to kraft/soda combustion sources, based on a ratio of the subpart MM PM limit to the average PM emissions estimate for existing sulfite combustion units (there are no new sulfite combustion units), obtained from stack test reports.

The allowable multiplier for HAP metal emissions from the existing hogged fuel dryer at a sulfite mill was calculated as a ratio of the site-specific subpart MM PM limit for the dryer to the average PM emissions estimate for the dryer, obtained from the support document for the mill's title V permit.

Semichemical mills. The allowable multiplier for gaseous organic HAP emissions from semichemical combustion units was also calculated similarly, based on a ratio of the subpart MM THC limit to the average THC emissions estimate for semichemical combustion units, obtained from stack test reports.

Allowable multipliers. A summary of the allowable multipliers for each emission source type is provided in Table 13 below. Multipliers were developed for subpart MM equipment with numeric limits for a particular pollutant type (e.g., HAP metals, gaseous organic HAP),. All other equipment and pollutants received an allowable multiplier of 1. Allowable multipliers were developed for both new and existing sources, but EPA may wish to apply the higher of the two multipliers for each emission process group, referred to as the composite multiplier in Table 13. The basis for the multipliers is presented in **Appendix E** at the end of this memorandum. The allowable multipliers for existing and new sources were added to the inventory in a column labeled "RTI_Allowable_Mult" and were multiplied by the "Actual_Emissions_tpy_Final" column to populate the "Allowable_Emissions_tpy_Revised" column.

Table 13. Allowable Multipliers by Emission Source Type for Subpart MM Risk Modeling

Pollutant	Emission Process Group	Allowable multiplier for existing sources	Allowable multiplier for new sources	Composite allowable multiplier for all sources in the emission process group[1]
HAP metals (PM surrogate)	DCE NDCE Soda Recovery	3.3	2.0	3.3
	SDT (Kraft) SDT (Soda)	1.8	1.4	1.8
	Lime Kiln Lime Kiln (Soda) Calciner	1.8	1.0	1.8
	Sulfite Recovery	3.6	N/A	3.6
	Hogged Fuel Dryer	7.4	N/A	7.4
	All other subpart MM emission process groups	1	1	1
Gaseous organic HAP	Semichemical Recovery NSSC Recovery	3.1	3.1	3.1
	All other subpart MM emission process groups	1	1	1
Acid gases	All subpart MM emission process groups	1	1	1
Dioxins/furans	All subpart MM emission process groups	1	1	1

1. The composite multiplier is the higher of the new and existing multipliers where applicable and may be applied for each emission process group in the inventory without distinguishing between new and existing sources.

V. Acute Multipliers for Subpart MM Risk Modeling

In addition to the chronic, long-term exposures, EPA also considers acute, short-term exposures in its risk-based decision-making. In the absence of short-term emissions data, EPA estimates peak, short-term emissions using available annual emissions data in the NEI. In previous RTR rulemakings, EPA has assumed that a facility's peak, 1-hour emission rate could exceed its annual average hourly emission rate by as much as a factor of 10, under worst-case meteorological conditions and the presence of a human receptor at the facility boundary. (EPA 2010) Such peak-to-mean emissions ratios are also referred to as acute multipliers and can be developed by various methods.

In order to refine the default-10 assumption, the peak hourly emission rates (lb/hr) (labeled in Part II of the pulp and paper survey as "routine emissions maximum hourly rate") were collected in the Part II survey (the results for which were received on June 6, 2011). These peak hourly emission rates were reviewed as part of the Part II data review. Under ideal circumstances, these data would be used directly to evaluate acute, short-term exposures. However, the data provided by respondents had considerable inconsistencies. When compared to the annual emissions (tpy) reported in the Part II survey (assuming 8,760 hours per year [hr/yr]) the primary outliers identified were:

- Underestimate of peak hourly emission rates – The peak hourly emission rate scaled to a peak annual emission rate did not exceed actual annual emissions.
- Overestimate of peak hourly emission rates – The peak hourly emission rate scaled to a peak annual emission rate excessively exceeded actual annual emissions.
- Zero emission rates – These emission rates were discarded from the analysis.

Various reasons are expected for these outliers, including lack of understanding of the data request, decimal place errors, typos, etc. Most of the discrepancies appeared to be independent of annual operating hours (e.g., the discrepancies remained discrepancies even when tested at annual operating hours other than 8,760 hr/yr). Given the number of outliers at both the high and low end, we recommend using the Part II survey data to calculate acute multipliers for broad groupings of equipment as opposed to directly modeling of the peak hourly emission rates provided in the Part II data set. Such acute multipliers would also be needed to fill data gaps for emission units where peak hourly rates were not provided. The following approach was used to develop acute multipliers for subpart MM sources.

Part II of the pulp and paper survey requested information on annual emission rates (referred to in Part II as "routine emissions") and peak hourly emission rates (discussed above). Peak-to-mean (acute) ratios were derived from the Part II survey data as follows:

- Mean = Average annual lb/hr = Routine emissions (tpy) / (8760 hr/yr) x (2000 lb/ton)
- Peak = Routine emissions maximum hourly rate (lb/hr)
- Peak/Mean = [Routine emissions maximum hourly rate (lb/hr)] / (Average annual lb/hr)

All subpart MM HAP, PM, and VOC emissions data from the Part II survey were compiled (22,582 records excluding zero emission rates). Although not HAP, the PM and VOC data were included to maximize the amount of relevant available data given that PM is used as a surrogate for metal HAPs in subpart MM and VOC is a broad grouping of organic compounds.[29] A peak-to-mean ratio was calculated for each compound from each emission source type. All

---

[29] A sensitivity analysis showed that inclusion of PM and VOC data (1,436 records) made very little difference in the average peak/mean ratios developed for subpart MM process units.

peak-to-mean ratios less than one were removed from the data set (1,500 records). A peak-to-mean ratio less than one indicates that the peak value provided is incorrect (does not exceed the average hourly emission rate and is, therefore, not a peak). All unreasonably high peak-to-mean ratios above 100 were also considered suspect and removed (1,083 records). The average of the remaining peak-to-mean values was calculated for the remaining 19,999 records and is presented in Table 13 below.

For comparison, a second measure of central tendency (the median) was applied to evaluate the peak-to-mean ratios as well. The median peak-to-mean ratio for each general equipment type was determined from the data set excluding the peak-to-mean ratios less than one but including the excessively high peak-to-mean ratios greater than 100. The median approach is also shown in Table 13.

Table 13. Peak-to-mean Ratios for Subpart MM Processes

Emission Process Group	No. of records included in average[1]	Average of Peak-to-mean Ratio[1]	No. of records included in median[2]	Median of Peak-to-mean Ratio[2]
BLO	567	3.9	567	1.4
Calciner	58	1.3	58	1.4
DCE	3,369	3.4	3,437	1.3
Lime Kiln	4,617	4.4	4,924	1.6
Lime Kiln (Soda)	47	1.2	47	1.2
NDCE	4,698	5.3	5,236	1.3
NSSC Recovery	68	1.7	68	1.7
Salt Cake Tank	785	3.9	785	1.3
SDT (Kraft)	5,558	1.8	5,728	1.3
SDT (Semichem)	3	2.2[3]	3	1.1[3]
SDT (Soda)	71	1.3	71	1.3
Semichem Recovery	27	13[4]	27	4.7[4]
Soda Recovery	75	1.3	75	1.3
Sulfite Recovery	56	1.4	56	1.3
Total records	**19,999**	**3.6[5]**	**21,082**	**1.4[5]**

1. Excludes peak-to-mean rations below 1 and unreasonably high peak-to-mean ratios above 100.
2. Excludes peak-to-mean rations below 1, but includes high peak-to-mean ratios above 100.
3. Two emission units at two mills were included in this small data set. The peak-to-mean ratio for NEIVA00022 ranged from 1.0-1.1, while the peak-to-mean value for NEI42211 was 4.4. EPA may consider applying site-specific acute multipliers for these emission units given the small data set and range in peak-to-mean values.
4. Three semichemical recovery emission units were included in this small data set (each with multiple records for different pollutants). The peak-to-mean ratios (for all pollutants) for each of the semichemical recovery units were: 2.0 (NEI11461), 4.7 (NEI46750), and 25 (NEI33945). EPA may consider applying site-specific acute multipliers for these emission units given the small data set and range in peak-to-mean values, and applying the values in the table above for any additional Semichem Recovery units appearing in the inventory for which site-specific multipliers are not available.
5. Average/median of records across all emission process groups.

The peak-to-mean ratios in Table 13 serve as acute multipliers for use in short-term exposure modeling. It is recommended that short-term exposure modeling be performed with acute multipliers based on the average values presented in Table 13, and that the median multipliers be considered (e.g., used to scale the modeling results) if needed for additional perspective. The average peak-to-mean ratios were added to the inventory in a column labeled “RTI_Acute_Mult” and were multiplied by the “Actual_Emissions_tpy_Final” column to populate the “Acute_Emissions_tpy_Revised” column.

Two emission process groups appearing in the subpart MM source category (Kraft Misc and Hogged Fuel Dryer) do not have multipliers in Table 13 because no maximum hourly emissions data were available for these sources. The Kraft Misc sources include combustion-related emissions from various kraft recovery processes and can be represented by a composite acute multiplier for the DCE, NDCE, and Lime Kiln process groups (4.4 average, or 1.4 median) or by the composite value for all records shown in bold in Table 13. The multiplier applied for Sulfite Recovery may be applied for the Hogged Fuel Dryer because this emission source is located at a sulfite mill and is part of a site-specific compliance approach involving the mill’s sulfite recovery system.

VI. Multipathway Modeling Inputs

Actual emissions of the persistent and bioaccumulative (PB) HAPs from the subpart MM source category are used for multipathway modeling. The PB HAPs emitted from the subpart MM source category include:

- Cadmium compounds
- Dioxins/Furans as 2,3,7,8-TCDD TEQs
- Hexachlorobenzene
- Lead compounds
- Mercury compounds
- POM

Risk-based thresholds are available for Tier 1 screening for all of the above PB HAPs with the exception of hexachlorobenzene. Of the PB HAPs listed above, it appears that dioxin/furan TEQ, mercury, and POM could exceed the multipathway screening thresholds based on the average and/or maximum emissions from the following subpart MM emission process groups:

Subpart MM emission process group	**Exceeding PB threshold for....**		
	Mercury	**Dioxin/furan TEQ**	**POM**
NDCE	X	X	X
DCE		X	X
Lime Kiln		X	X
Lime Kiln (Soda)		X	
SDT (Kraft)			X
BLO*			X
Semichem Recovery			X
NSSC Recovery		X	

*Includes one BLO system located at one mill. The system has two emission points, one uncontrolled and one controlled with an RTO system.

In terms of mass emissions, dioxin/furan TEQ emissions are miniscule, mercury emissions are low (less than 0.5 percent of the PB HAP, and POM emissions from recovery furnaces and SDTs represent over 91 percent of the PB HAP from subpart MM sources. Lead emissions from lime kilns (4 percent) and recovery furnaces (1.3 percent) are also a notable percentage of the subpart MM PB HAP.

VII. Ecological HAP

Actual emissions of the ecological HAP emitted from the subpart MM source category are considered in the ecological HAP analysis. In addition to the PB HAP emitted from the subpart MM source category (except hexachlorobenzene), hydrochloric acid (HCl), hydrofluoric acid (HF), and chlorine are considered for ecological HAP modeling. Hydrochloric acid and chlorine from recovery furnaces represent 92 plus 3 percent, respectively, of the mass of ecological HAPs emitted from the subpart MM source category.

VIII. Recommendations for Further Review of the Emissions Data

The memorandum describes how emissions inventory revisions received following proposal of the subpart S RTR were incorporated into the inventory used for pulp and paper risk modeling and reviewed. This inventory will be used for forthcoming risk modeling of the subpart MM source category. Many of the revisions received following proposal of the subpart S RTR focused on subpart S sources. However, as the modeling file is developed for subpart MM sources, additional review of certain aspects of the subpart MM inventory could improve the representativeness of the risk modeling results.

Mills added. It may be beneficial for three companies to have an opportunity to review new data added to the inventory for their mills to ensure the emission units are properly identified and characterized.

> NEI33043: KPAQ Industries LLC - St Francisville, LA – This kraft mill was not included in the 2011 ICR. Emissions data from the 2011 Emissions Inventory System (EIS) were available and were used to populate the risk model input file for this mill.
>
> NEI42351: Cosmo Specialty Fibers, Cosmopolis, WA (formerly Weyerhaeuser). This magnesium based dissolving sulfite pulp mill was closed down when the ICR was conducted in 2011 but has since reopened. Emissions data from the 2011 Emissions Inventory System (EIS) were available and were used to populate the risk model input file for this mill.
>
> NEI7621: International Paper, Franklin, VA. This mill was closed down when the ICR was conducted in 2011 but has since reopened. Emissions data were unavailable from the 2011 EIS, so emissions data from the 2005 NEI was used to populate the risk model input file for International Paper (Franklin, VA). International Paper may want to review this inventory to determine if it reflects current equipment and operations.

Equipment changes. Two mills have significantly upgraded subpart MM equipment, but these changes are not reflected in the inventory. It may be beneficial for these companies to have an opportunity to review their data to update the equipment and emissions information.

> NEI47091: Buckeye, Perry, FL. The Part III ICR inventory indicated RB3 would be converted to an NDCE in 2011 and that the BLO would be shut down. However, RB3 and its BLO unit are still included in the risk input file. Buckeye may want to replace these units with data for the new NDCE.
>
> NEI41552: Packaging Corp. of America, Counce, TN. According to a 6/15/10 permit, two DCE recovery furnaces (R-1 and R-2) were replaced with a new R-4 NDCE furnace and the BLO system was removed; and the mill plans to convert the R-1 and R-2 DCEs to NDCE recovery furnaces. PCA may want to update their inventory.

Certain pollutant emissions may also benefit from additional review as described below.

Acrolein. One NDCE recovery furnace (NEI13340) accounts for 75 percent of the acrolein reported from NDCE furnaces in the data base. This value seems unusually high, especially given that acrolien emissions were all non-detect in NCASI Technical Bulletin 973 (with 20 sources tested).

Chromium VI. Lime kilns at two mills account for 40 percent of the chromium VI reported for lime kilns. These values seem uncharacteristically high.

Antimony. Antimony compounds from an SDT resulted in the maximum facility-wide TOHSI of 2 in the subpart S facility-wide modeling.[30] Some antimony values in the inventory seem unreasonably high compared to the average for across all SDTs. For example, 7 mills account for more than 80% of the SDT antimony mass in the inventory: NEI12368, NEI12411, NEI26471, NEI26526, NEI33040, NEI6057, and NEI7559. These data are recommended for further review.

PB HAP. It is recommended that the data for mercury, dioxin/furan, and POM be reviewed closely given the importance of these PB HAP for multipathway and ecological risk modeling. Some observations relative to mercury (Hg) and POM are as follows:

1. Four NDCE recovery furnaces exceeded the mill-wide PB screening thresholds for Hg (codes 201 and 202) and represent 24% of the NDCE Hg emissions combined: NEI7559--SR0001, NEI26471--D001, NEI47104--RB7A, NEI32869A--RB4.
2. The Hg emissions for the DCE recovery furnace at NEI47091 are also quite high (e.g., more than 10 times the average for other DCE furnaces). As noted above, this DCE (RB3) has been replaced with an NDCE but the inventory data have not been updated.

---

[30] U.S. EPA. *Residual Risk Assessment for the Pulp & Paper Source Category*. July 2012. (p. 40)

3. One mill (NEI40282) estimated POM emissions for their BLO system which has one emission point controlled with an RTO/scrubber and another uncontrolled emission point (2 BLO stages). The POM emissions for this unit seem very high compared to POM from other emission unit types. No other mills associated POM with BLO systems (regardless of their control status).
4. For the emission process group “Semichem Recovery,” one of the 4 mills with semichemical recovery processes reporting POM represents ~100% of the POM emissions (NEI46750--B25). This value is 1000 times the others reported.
5. POM emissions for the “SDT (Kraft)” emission process group at the following mills may need to be rechecked because they are on the high end for SDTs: NEI8186, NEI759, NEI41314, NEI33013, NEI47091, and NEI26309. A few others are also high, but the mills listed above represent 60% of the POM from kraft SDTs.
6. POM emissions for the “DCE” emission process group were quite high for: NEI41314, NEI759, NEI8278, NEI34070, NEI11172, NEI42254, NEI8560, and NEI40247. A few others were moderately high, but those listed account for 76% of the DCE POM emissions.
7. NDCEs at 4 mills made up about 80% of the NDCE POM: NEI34066 (43%), NEI7621 and NEI47091 (15% each), and NEI6057 (6%)

Dioxin/furan. Recovery furnaces and lime kilns account for 99 percent of the subpart MM dioxin/furan TEQ emissions are reported for subpart MM sources. Total TEQ emissions for the MM source category are 3.6×10^{-5}, of which 3.2×10^{-5} (89 percent) is from kraft recovery furnaces and 3.5×10^{-6} (10 percent) is from lime kilns. All of the other subpart MM processes account for the remaining 1 percent of the TEQ emissions. For comparison, EPA 2006 suggested that dioxin/furan TEQ emissions are 0.75 grams TEQ per year (g TEQ/yr) (8.3×10^{-7} tons TEQ/yr) for kraft recovery furnaces and 6.9×10^{-5} g TEQ/yr (7.6×10^{-11} tons TEQ/yr) for lime kilns. Thus, the kraft recovery furnace (DCE + NDCE) TEQ emissions included in the inventory are 2 orders of magnitude greater than expected, and the lime kiln TEQ emissions are 5 orders of magnitude greater than expected. No obvious outlying high emissions values were found to be driving the subpart MM recovery furnace and lime kiln TEQ totals. In spite of the dioxin/furan data exceeding expected values, it appears that some mills have not reported dioxin/furan emissions for their recovery furnaces or lime kilns. It is recommended that more in-depth quality assurance of the dioxin/furan emissions data be performed prior to drawing conclusions from these data.

While dioxin/furan data were included in the inventory for emission units outside of the subpart MM source category (e.g., for boilers), it is noted that these data are also suspect. Boilers are subject to the Industrial Boilers and Process Heaters MACT which is currently in the process of being implemented and will limit dioxin/furan emissions from these sources. Therefore, EPA may wish to consider removing all dioxin/furan data not associated with the subpart MM source category from the subpart MM modeling file dues to concerns regarding the representativeness of these data.

Lead. Lead (Pb) emissions at 3 NDCE recovery furnaces account for over 50% of the total lead compounds reported for NDCE furnaces (NEI26476, NEI35908, NEI8265). Lead is a PB HAP.

Cadmium. The cadmium value reported for the lime kiln at NEI12368 seems uncharacteristically high, accounting for approximately 20 percent of the cadmium emissions reported for lime kilns nationwide. The next highest value was an order of magnitude lower. Cadmium is also a PB HAP.

HF and HCl. The HCl emissions reported for the lime kiln at NEI46835 account for more than 50 percent of the HCl reported for lime kilns in the industry. The HF emissions reported for the lime kiln at NEI45206 account for more than 98 percent of the HF emissions reported for lime kilns. These values seem unreasonably high, particularly given the alkaline environment in lime kilns that would limit formation of acid gas emissions.

Nickel. Over 75 percent of the nickel emissions from DCE recovery furnaces were reported for 6 mills: NEI42254, NEI46739, NEI47091, NEI8278, NEI40282, NEI12492. The lime kiln at NEI46835 represented 17 percent of the lime kiln nickel emissions. The SDT at NEI12368 represented more than 50 percent of the nickel reported for SDTs.

Arsenic. The arsenic emissions for the NDCE at NEI7559 was more than 70 percent of the arsenic reported for NDCE recovery furnaces. This value seems unreasonably high. Two lime kilns (at NEI11338 and NEI7559) represented 44 percent of the arsenic reported for lime kilns. The SDT at NEI46599 represented more than 20 percent of the arsenic reported for kraft SDTs.

Appendix A

Emission Process Groups Assigned for Each SCC in the Pulp and Paper Facility-wide Inventory

Appendix A: Emission Process Groups Assigned for Each SCC in the Pulp and Paper Facility-wide Inventory

SCC	SCC Description	Emission Process Group
10200201	External Combustion Boilers; Industrial; Bituminous Coal; Pulverized Coal: Wet Bottom	ICI Boiler/PH
10200202	External Combustion Boilers; Industrial; Bituminous Coal; Pulverized Coal: Dry Bottom	ICI Boiler/PH
10200203	External Combustion Boilers; Industrial; Bituminous Coal; Cyclone Furnace	ICI Boiler/PH
10200204	External Combustion Boilers; Industrial; Bituminous Coal; Spreader Stoker	ICI Boiler/PH
10200205	External Combustion Boilers; Industrial; Bituminous Coal; Overfeed Stoker	ICI Boiler/PH
10200206	External Combustion Boilers; Industrial; Bituminous Coal; Underfeed Stoker	ICI Boiler/PH
10200212	External Combustion Boilers; Industrial; Bituminous Coal; Pulverized Coal: Dry Bottom (Tangential)	ICI Boiler/PH
10200218	External Combustion Boilers; Industrial; Bituminous Coal; Atmospheric Fluidized Bed Combustion: Circulating Bed	ICI Boiler/PH
10200219	External Combustion Boilers; Industrial; Bituminous Coal; Cogeneration	ICI Boiler/PH
10200224	External Combustion Boilers; Industrial; Subbituminous Coal; Spreader Stoker	ICI Boiler/PH
10200401	External Combustion Boilers; Industrial; Residual Oil - Grade 6; Boiler	ICI Boiler/PH
10200402	External Combustion Boilers; Industrial; Residual Oil; 10-100 Million BTU/hr **	ICI Boiler/PH
10200404	External Combustion Boilers; Industrial; Residual Oil; Grade 5 Oil	ICI Boiler/PH
10200405	External Combustion Boilers; Industrial; Residual Oil; Cogeneration	ICI Boiler/PH
10200501	External Combustion Boilers; Industrial; Distillate Oil - Grades 1 and 2; Boiler	ICI Boiler/PH
10200502	External Combustion Boilers; Industrial; Distillate Oil; 10-100 Million BTU/hr **	ICI Boiler/PH
10200503	External Combustion Boilers; Industrial; Distillate Oil; < 10 Million BTU/hr **	ICI Boiler/PH
10200601	External Combustion Boilers; Industrial; Natural Gas; > 100 Million BTU/hr	ICI Boiler/PH
10200602	External Combustion Boilers; Industrial; Natural Gas; 10-100 Million BTU/hr	ICI Boiler/PH
10200603	External Combustion Boilers; Industrial; Natural Gas; < 10 Million BTU/hr	ICI Boiler/PH
10200604	External Combustion Boilers; Industrial; Natural Gas; Cogeneration	ICI Boiler/PH
10200799	External Combustion Boilers; Industrial; Process Gas; Other: Specify in Comments	ICI Boiler/PH
10200802	External Combustion Boilers; Industrial; Petroleum Coke; All Boiler Sizes	ICI Boiler/PH
10200804	External Combustion Boilers; Industrial; Petroleum Coke; Cogeneration	ICI Boiler/PH
10200901	External Combustion Boilers; Industrial; Wood/Bark Waste; Bark-fired Boiler	ICI Boiler/PH
10200902	External Combustion Boilers; Industrial; Wood/Bark Waste; Wood/Bark-fired Boiler	ICI Boiler/PH
10200903	External Combustion Boilers; Industrial; Wood/Bark Waste; Wood-fired Boiler - Wet Wood (>=20% moisture)	ICI Boiler/PH
10200904	External Combustion Boilers; Industrial; Wood/Bark Waste; Bark-fired Boiler (< 50,000 Lb Steam) **	ICI Boiler/PH

SCC	SCC Description	Emission Process Group
10200905	External Combustion Boilers; Industrial; Wood/Bark Waste; Wood/Bark-fired Boiler (< 50,000 Lb Steam) **	ICI Boiler/PH
10200907	External Combustion Boilers; Industrial; Wood/Bark Waste; Wood Cogeneration	ICI Boiler/PH
10200911	External Combustion Boilers; Industrial; Wood/Bark Waste; Stoker boilers **	ICI Boiler/PH
10200912	External Combustion Boilers; Industrial; Wood/Bark Waste; Fluidized bed combustion boiler	ICI Boiler/PH
10201002	External Combustion Boilers; Industrial; Liquified Petroleum Gas (LPG); Propane	ICI Boiler/PH
10201201	External Combustion Boilers; Industrial; Solid Waste; Specify Waste Material in Comments	ICI Boiler/PH
10201202	External Combustion Boilers; Industrial; Solid Waste; Refuse Derived Fuel	ICI Boiler/PH
10201301	External Combustion Boilers; Industrial; Liquid Waste; Specify Waste Material in Comments	ICI Boiler/PH
10201302	External Combustion Boilers; Industrial; Liquid Waste; Waste Oil	ICI Boiler/PH
10201401	External Combustion Boilers; Industrial; CO Boiler; Natural Gas	ICI Boiler/PH
10500106	External Combustion Boilers; Space Heaters; Industrial; Natural Gas	ICI Boiler/PH
10500110	External Combustion Boilers; Space Heaters; Industrial; Liquified Petroleum Gas (LPG)	ICI Boiler/PH
20200101	Internal Combustion Engines; Industrial; Distillate Oil (Diesel); Turbine	Turbine
20200102	Internal Combustion Engines; Industrial; Distillate Oil (Diesel); Reciprocating	RICE
20200201	Internal Combustion Engines; Industrial; Natural Gas; Turbine	Turbine
20200202	Internal Combustion Engines; Industrial; Natural Gas; Reciprocating	RICE
20200203	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Cogeneration	Turbine
20200209	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Exhaust	Turbine
20200401	Internal Combustion Engines; Industrial; Large Bore Engine; Diesel	RICE
20201001	Internal Combustion Engines; Industrial; Liquified Petroleum Gas (LPG); Propane: Reciprocating	RICE
20201702	Internal Combustion Engines; Industrial; Gasoline; Reciprocating Engine	RICE
20300101	Internal Combustion Engines; Commercial/Institutional; Distillate Oil (Diesel); Reciprocating	RICE
30101814	Industrial Processes; Chemical Manufacturing; Plastics Production; Extruder	Chem Manuf
30101815	Industrial Processes; Chemical Manufacturing; Plastics Production; Pellet Silo	Chem Manuf
30187009	Industrial Processes; Chemical Manufacturing; Inorganic Chemical Storage (Fixed Roof Tanks); Sulfuric Acid: Breathing Loss	Chem Manuf
30187097	Industrial Processes; Chemical Manufacturing; Inorganic Chemical Storage (Fixed Roof Tanks); Specify Liquid: Breathing Loss	Chem Manuf
30190099	Industrial Processes; Chemical Manufacturing; Fuel Fired Equipment; Specify in Comments Field	Chem Manuf
30501009	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Raw Coal Storage	Coal Handling
30501010	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Crushing	Coal Handling
30501011	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Coal Transfer	Coal Handling

SCC	SCC Description	Emission Process Group
30501015	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Coal Loading (For Clean Coal Loading USE 30501016)	Coal Handling
30501031	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Scrapers: Travel Mode	Coal Handling
30501040	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Truck Unloading: End Dump - Coal	Coal Handling
30501043	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Open Storage Pile: Coal	Coal Handling
30501049	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Wind Erosion: Exposed Areas	Coal Handling
30501099	Industrial Processes; Mineral Products; Coal Mining, Cleaning, and Material Handling; Other Not Classified	Coal Handling
30502099	Industrial Processes; Mineral Products; Stone Quarrying - Processing (See also 305320); Not Classified **	Mineral Handling
30510199	Industrial Processes; Mineral Products; Bulk Materials Conveyors; Other Not Classified	Mineral Handling
30510203	Industrial Processes; Mineral Products; Bulk Materials Storage Bins; Coal	Mineral Handling
30510204	Industrial Processes; Mineral Products; Bulk Materials Storage Bins; Coke	Mineral Handling
30510205	Industrial Processes; Mineral Products; Bulk Materials Storage Bins; Limestone	Mineral Handling
30510298	Industrial Processes; Mineral Products; Bulk Materials Storage Bins; Mineral: Specify in Comments	Mineral Handling
30510299	Industrial Processes; Mineral Products; Bulk Materials Storage Bins; Other Not Classified	Mineral Handling
30510303	Industrial Processes; Mineral Products; Bulk Materials Open Stockpiles; Coal	Mineral Handling
30510499	Industrial Processes; Mineral Products; Bulk Materials Unloading Operation; Other Not Classified	Mineral Handling
30700101	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Digester System - Continuous or Batch	Kraft Pulping: Digester LVHC
30700102	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Brown Stock Washing System	Kraft Pulping: Washing
30700103	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Multiple Effect Evaporators and Concentrators	Kraft Pulping: Evaporator LVHC
30700104	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Recovery Furnace/Direct Contact Evaporator	DCE
30700105	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Smelt Dissolving Tank	SDT (Kraft)
30700106	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Lime Kiln	Lime Kiln
30700107	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Turpentine Condenser	Kraft Pulping: Turpentine LVHC
30700108	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Fluid Bed Calciner	Calciner
30700109	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Black Liquor Oxidation System	BLO
30700110	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Recovery Furnace/Indirect Contact Evaporator	NDCE
30700112	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Lime Mud Washers	Causticizing: Lime Mud
30700113	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Lime Mud Filter System	Causticizing: Lime Mud

SCC	SCC Description	Emission Process Group
30700114	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Bleach Plant	Bleaching: Kraft
30700115	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Chlorine Dioxide Generator	Bleaching: ClO2 Generator
30700116	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Turpentine Storage and Loading (incl decanting, storage and loading)	Kraft Pulping: Turpentine LVHC
30700117	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Venting of condensate stripper off-gases	Condensate Stripper
30700119	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Salt Cake Mix Tank (Boiler Ash Handling)	Salt Cake Tank
30700120	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Stock Washing/Screening	Kraft Stock Washing
30700121	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Wastewater: General	Wastewater (Kraft)
30700122	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Causticizing: Miscellaneous	Causticizing: Misc
30700123	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Lime Slaker Vent	Causticizing: Slaker
30700124	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Black Liquor Storage Tanks	Kraft Pulping: BL Tanks HVLC
30700125	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Low Volume High Concentration System Venting of Non-condensible Gases	Kraft Pulping: LVHC
30700126	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; High Volume Low Concentration System Venting of Non-condensible Gases	Kraft Pulping: HVLC
30700127	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Non-condensible Gases Incinerator	Kraft Pulping: Incinerator
30700128	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Total Reduced Sulfur Thermal Oxidizer (any supplemental fuel)	Kraft Pulping: Incinerator
30700129	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Enclosed secondary wastewater treatment system vents	Wastewater (Kraft)
30700130	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Decker System	Kraft Pulping: Decker
30700131	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Knotter / Deknotter System	Kraft Pulping: Knotter
30700132	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Green Liquor Processing	Causticizing: Green Liquor
30700133	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; White Liquor Processing	Causticizing: White Liquor
30700134	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Oxygen Delignification System	Kraft Pulping: O2 Delig HVLC
30700135	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Pulp Storage - Bleached and Unbleached	Kraft Pulp Storage
30700136	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Tall Oil System (includes tall oil reactor and tall oil storage)	Tall Oil
30700199	Industrial Processes; Pulp and Paper and Wood Products; Sulfate (Kraft) Pulping; Other Not Classified	Kraft Misc
30700211	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; Digester/Blow Pit/Dump Tank: Calcium	Sulfite Pulping (Ca)
30700214	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; Digester/Blow Pit/Dump Tank: NH3 with Process Change	Sulfite Pulping (NH3)

SCC	SCC Description	Emission Process Group
30700216	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; Bleach Plant (includes bleaching towers, filtrate tanks, vacuum pump)	Bleaching: Sulfite
30700222	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; Recovery System: NH3 including liquor evaporators	Sulfite Recovery
30700224	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; Wastewater: General	Wastewater (Sulfite)
30700231	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; Acid Plant: NH3	Sulfite Pulping (NH3)
30700233	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; Acid Plant: Ca	Sulfite Pulping (Ca)
30700234	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; Knotters/Washers/Screens/etc.	Sulfite Pulping
30700299	Industrial Processes; Pulp and Paper and Wood Products; Sulfite Pulping; See Comment **	Sulfite Pulping
30700301	Industrial Processes; Pulp and Paper and Wood Products; Neutral Sulfite Semichemical Pulping; Digester/Blow Pit/Dump Tank	NSSC Pulping
30700305	Industrial Processes; Pulp and Paper and Wood Products; Neutral Sulfite Semichemical Pulping; Liquor combustion (incl recovery furnace and fluidized bed reactors)	NSSC Recovery
30700306	Industrial Processes; Pulp and Paper and Wood Products; Neutral Sulfite Semichemical Pulping; Wastewater: General	Wastewater (NSSC)
30700307	Industrial Processes; Pulp and Paper and Wood Products; Neutral Sulfite Semichemical Pulping; Pulp washing system	NSSC Pulping
30700308	Industrial Processes; Pulp and Paper and Wood Products; Neutral Sulfite Semichemical Pulping; Pulp storage tanks/stock chests	NSSC Pulping
30700309	Industrial Processes; Pulp and Paper and Wood Products; Neutral Sulfite Semichemical Pulping; Liquor storage tanks	NSSC Misc
30700320	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Pulp washing system	Semichem Pulping
30700321	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Pulp storage tanks/stock chests	Semichem Pulping
30700322	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Liquor making system	Semichem Pulping
30700323	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Liquor evaporator system	Semichem Pulping
30700324	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Liquor combustion	Semichem Recovery
30700325	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Liquor storage tanks	Semichem Pulping
30700326	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Digesters/refiners/blow tanks/blow heat recovery system	Semichem Pulping
30700327	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Smelt tank	SDT (Semichem)
30700328	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Wastewater: General	Wastewater (Semichem)
30700329	Industrial Processes; Pulp and Paper and Wood Products; Semi-chemical (non-sulfur); Other Not Classified	Semichem Misc
30700351	Industrial Processes; Pulp and Paper and Wood Products; Soda; Recovery furnace	Soda Recovery
30700352	Industrial Processes; Pulp and Paper and Wood Products; Soda; Smelt tank	SDT (Soda)
30700353	Industrial Processes; Pulp and Paper and Wood Products; Soda; Lime kiln	Lime Kiln (Soda)

SCC	SCC Description	Emission Process Group
30700354	Industrial Processes; Pulp and Paper and Wood Products; Soda; Other Not Classified	Soda Misc
30700399	Industrial Processes; Pulp and Paper and Wood Products; Neutral Sulfite Semichemical Pulping; Other Not Classified	NSSC Misc
30700399	Industrial Processes; Pulp and Paper and Wood Products; Neutral Sulfite Semichemical Pulping; Other Not Classified	SDT (Semichem)
30700401	Industrial Processes; Pulp and Paper and Wood Products; Paper and Paperboard Manufacture; Paper Machine / Pulp Dryer	Papermaking
30700403	Industrial Processes; Pulp and Paper and Wood Products; Pulpboard Manufacture; Raw Material Storage and Handling	Paper Misc
30700404	Industrial Processes; Pulp and Paper and Wood Products; Secondary Fiber Pulping; Stock Preparation and Repulper	Paper Stock Prep
30700407	Industrial Processes; Pulp and Paper and Wood Products; Paper and Paperboard Manufacture; Coating Operations: On-Machine	Coating: On Machine
30700408	Industrial Processes; Pulp and Paper and Wood Products; Secondary Fiber Pulping; Deinking operations	Paper Stock Prep
30700409	Industrial Processes; Pulp and Paper and Wood Products; Paper and Paperboard Manufacture; Coating Operations: Off-Machine	Coating: Off Machine
30700410	Industrial Processes; Pulp and Paper and Wood Products; Secondary Fiber Pulping; Bleaching / Brightening / Decoloring	Bleaching: Sec Fiber
30700499	Industrial Processes; Pulp and Paper and Wood Products; Paper and Paperboard Manufacture; See Comment **	Paper Misc
30700501	Industrial Processes; Pulp and Paper and Wood Products; Wood Pressure Treating; Creosote	Wood Handling
30700801	Industrial Processes; Pulp and Paper and Wood Products; Sawmill Operations; Log Debarking	Wood Handling
30700820	Industrial Processes; Pulp and Paper and Wood Products; Sawmill Operations; Chipping and Screening	Wood Handling
30701199	Industrial Processes; Pulp and Paper and Wood Products; Paper Coating and Glazing; Extrusion Coating Line with Solvent Free Resin/Wax	Paper Coating
30701201	Industrial Processes; Pulp and Paper and Wood Products; Miscellaneous Paper Processes; Cyclones	Paper Misc
30701202	Industrial Processes; Pulp and Paper and Wood Products; Miscellaneous Paper Processes; Wastewater: General	Wastewater (General)
30701220	Industrial Processes; Pulp and Paper and Wood Products; Mechanical Pulping Operations; Thermomechanical Process and Chemi-thermomechanical Pulping	Mechanical Pulping
30701221	Industrial Processes; Pulp and Paper and Wood Products; Mechanical Pulping Operations; Pressurized Groundwood / Stone Groundwood Process	Mechanical Pulping
30701222	Industrial Processes; Pulp and Paper and Wood Products; Mechanical Pulping Operations; Bleaching / Brightening	Bleaching: Mechanical
30701223	Industrial Processes; Pulp and Paper and Wood Products; Mechanical Pulping Operations; Wastewater: General	Wastewater (Mechanical)
30701224	Industrial Processes; Pulp and Paper and Wood Products; Mechanical Pulping Operations; Refiner Pulping	Mechanical Pulping
30701399	Industrial Processes; Pulp and Paper and Wood Products; Miscellaneous Paper Products; Other Not Classified	Paper Misc
30704001	Industrial Processes; Pulp and Paper and Wood Products; Bulk Handling and Storage - Wood/Bark; Storage Bins	Wood Handling
30704002	Industrial Processes; Pulp and Paper and Wood Products; Bulk Handling and Storage - Wood/Bark; Stockpiles	Wood Handling

SCC	SCC Description	Emission Process Group
30704003	Industrial Processes; Pulp and Paper and Wood Products; Bulk Handling and Storage - Wood/Bark; Unloading	Wood Handling
30704004	Industrial Processes; Pulp and Paper and Wood Products; Bulk Handling and Storage - Wood/Bark; Loading	Wood Handling
30704005	Industrial Processes; Pulp and Paper and Wood Products; Bulk Handling and Storage - Wood/Bark; Conveyors	Wood Handling
30788801	Industrial Processes; Pulp and Paper and Wood Products; Fugitive Emissions; Specify in Comments Field	Fugitive Emissions - Misc
30799998	Industrial Processes; Pulp and Paper and Wood Products; Other Not Classified; Other Not Classified	Paper Misc
30799999	Industrial Processes; Pulp and Paper and Wood Products; Other Not Classified; See Comment **	ICI Boiler/PH
30900500	Industrial Processes; Fabricated Metal Products; Welding; General	Welding
31299999	Industrial Processes; Machinery, Miscellaneous; Miscellaneous Machinery; Other Not Classified	Misc Machinery Manuf
38500101	Industrial Processes; Cooling Tower; Process Cooling; Mechanical Draft	Cooling Tower
38500110	Industrial Processes; Cooling Tower; Process Cooling; Other Not Specified	Cooling Tower
39000999	Industrial Processes; In-process Fuel Use; Wood; General: Wood	Hogged Fuel Dryer
39090003	Industrial Processes; In-process Fuel Use; Fuel Storage - Fixed Roof Tanks; Distillate Oil (No. 2): Breathing Loss	Petrol Storage-Transfer
40100251	Petroleum and Solvent Evaporation; Organic Solvent Evaporation; Degreasing; Stoddard (Petroleum Solvent): General Degreasing Units	Solvent Use
40100299	Petroleum and Solvent Evaporation; Organic Solvent Evaporation; Degreasing; Other Not Classified: Open-top Vapor Degreasing	Solvent Use
40100301	Petroleum and Solvent Evaporation; Organic Solvent Evaporation; Cold Solvent Cleaning/Stripping; Methanol	Solvent Use
40100303	Petroleum and Solvent Evaporation; Organic Solvent Evaporation; Cold Solvent Cleaning/Stripping; Stoddard (Petroleum Solvent)	Solvent Use
40100307	Petroleum and Solvent Evaporation; Organic Solvent Evaporation; Cold Solvent Cleaning/Stripping; Isopropyl Alcohol	Solvent Use
40100399	Petroleum and Solvent Evaporation; Organic Solvent Evaporation; Cold Solvent Cleaning/Stripping; Other Not Classified	Solvent Use
40188898	Petroleum and Solvent Evaporation; Organic Solvent Evaporation; Fugitive Emissions; Specify in Comments Field	Solvent Use
40200101	Petroleum and Solvent Evaporation; Surface Coating Operations; Surface Coating Application - General; Paint: Solvent-base	Coating Misc
40200601	Petroleum and Solvent Evaporation; Surface Coating Operations; Surface Coating Application - General; Primer	Coating Misc
40200701	Petroleum and Solvent Evaporation; Surface Coating Operations; Surface Coating Application - General; Adhesive Application	Coating Misc
40200710	Petroleum and Solvent Evaporation; Surface Coating Operations; Surface Coating Application - General; Adhesive: General	Coating Misc
40200801	Petroleum and Solvent Evaporation; Surface Coating Operations; Coating Oven - General; General	Coating Misc
40200901	Petroleum and Solvent Evaporation; Surface Coating Operations; Thinning Solvents - General; General: Specify in Comments	Coating Misc
40201001	Petroleum and Solvent Evaporation; Surface Coating Operations; Coating Oven Heater; Natural Gas	Coating Misc
40201301	Petroleum and Solvent Evaporation; Surface Coating Operations; Paper Coating; Coating Operation	Paper Coating
40201303	Petroleum and Solvent Evaporation; Surface Coating Operations; Paper Coating; Coating Mixing	Paper Coating

SCC	SCC Description	Emission Process Group
40201304	Petroleum and Solvent Evaporation; Surface Coating Operations; Paper Coating; Coating Storage	Paper Coating
40201305	Petroleum and Solvent Evaporation; Surface Coating Operations; Paper Coating; Equipment Cleanup	Paper Coating
40201399	Petroleum and Solvent Evaporation; Surface Coating Operations; Paper Coating; Other Not Classified	Paper Coating
40202605	Petroleum and Solvent Evaporation; Surface Coating Operations; Steel Drums; Equipment Cleanup	Coating Misc
40204435	Petroleum and Solvent Evaporation; Surface Coating Operations; Fabric Coating, Transfer Coating; Lamination: Laminating Device	Coating Misc
40288824	Petroleum and Solvent Evaporation; Surface Coating Operations; Fugitive Emissions; Clean-up	Coating Misc
40299998	Petroleum and Solvent Evaporation; Surface Coating Operations; Miscellaneous; Specify in Comments Field	Coating Misc
40300103	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Deleted - Do Not Use (See 4-03-010 and 4-07); Gasoline	Petrol Storage-Transfer
40400102	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank	Petrol Storage-Transfer
40400104	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank	Petrol Storage-Transfer
40400107	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Working Loss (Diam. Independent) - Fixed Roof Tank	Petrol Storage-Transfer
40400108	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Working Loss (Diameter Independent) - Fixed Roof Tank	Petrol Storage-Transfer
40400121	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Diesel Fuel: Standing Loss (Diameter Independent) - Fixed Roof Tank	Petrol Storage-Transfer
40400199	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; See Comment **	Petrol Storage-Transfer
40400316	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Oil and Gas Field Storage and Working Tanks; Fixed Roof Tank, Diesel, working+breathing+flashing losses	Petrol Storage-Transfer
40400403	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 10: Breathing Loss	Petrol Storage-Transfer
40400404	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 10: Working Loss	Petrol Storage-Transfer
40400413	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Distillate Fuel #2: Breathing Loss	Petrol Storage-Transfer
40500201	Petroleum and Solvent Evaporation; Printing/Publishing; Letter Press; Printing	Print-Publish
40500215	Petroleum and Solvent Evaporation; Printing/Publishing; Letter Press; Cleaning Solution	Print-Publish
40500301	Petroleum and Solvent Evaporation; Printing/Publishing; Flexographic; Printing	Print-Publish

SCC	SCC Description	Emission Process Group
40600401	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Filling Vehicle Gas Tanks - Stage II; Vapor Loss w/o Controls	Petrol Storage-Transfer
40688801	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Fugitive Emissions; Specify in Comments Field	Petrol Storage-Transfer
40700814	Petroleum and Solvent Evaporation; Organic Chemical Storage; Fixed Roof Tanks - Alcohols; Isopropyl Alcohol: Working Loss	Storage Tanks - Alcohol
40700815	Petroleum and Solvent Evaporation; Organic Chemical Storage; Fixed Roof Tanks - Alcohols; Methyl Alcohol: Breathing Loss	Storage Tanks - Methanol
40700816	Petroleum and Solvent Evaporation; Organic Chemical Storage; Fixed Roof Tanks - Alcohols; Methyl Alcohol: Working Loss	Storage Tanks - Methanol
40701698	Petroleum and Solvent Evaporation; Organic Chemical Storage; Fixed Roof Tanks - Alkanes (Paraffins); Specify Alkane: Working Loss	Storage Tanks - Organic
40708098	Petroleum and Solvent Evaporation; Organic Chemical Storage; Fixed Roof Tanks - Nitro Compounds; Specify in Comments: Working Loss	Storage Tanks - Organic
40799997	Petroleum and Solvent Evaporation; Organic Chemical Storage; Miscellaneous; Specify in Comments	Storage Tanks - Organic
49099998	Petroleum and Solvent Evaporation; Organic Solvent Evaporation; Miscellaneous Volatile Organic Compound Evaporation; Identify the Process and Solvent in Comments	Solvent Use
50300101	Waste Disposal; Solid Waste Disposal - Industrial; Incineration; Multiple Chamber	Waste Disposal - Incineration
50300602	Waste Disposal; Solid Waste Disposal - Industrial; Landfill Dump; Liquid Waste Disposal	Landfill
50300801	Waste Disposal; Solid Waste Disposal - Industrial; Treatment, Storage, Disposal/TSDF; Surface Impoundment: Fugitive Emissions	Waste Disposal - Fugitive Emissions
50300810	Waste Disposal; Solid Waste Disposal - Industrial; Treatment, Storage, Disposal/TSDF; Waste Piles: Fugitive Emissions	Waste Disposal - Fugitive Emissions
50300899	Waste Disposal; Solid Waste Disposal - Industrial; Treatment, Storage, Disposal/TSDF; General: Fugitive Emissions	Landfill
50390006	Waste Disposal; Solid Waste Disposal - Industrial; Auxillary Fuel/No Emissions; Natural Gas	Waste Disposal - Incineration

Appendix B

Emission Process Groups with Regulatory Codes and Multipliers

Appendix B. Emission Process Groups

Emission Process Group	Regulatory Code
Bleaching: ClO2 Generator	63S
Bleaching: Kraft	63S
Bleaching: Mechanical	63S
Bleaching: Sec Fiber	63S
Bleaching: Sulfite	63S
BLO	63MM
Calciner	63MM
Causticizing: Green Liquor	63S
Causticizing: Lime Mud	63S
Causticizing: Misc	63S
Causticizing: Slaker	63S
Causticizing: White Liquor	63S
Chem Manuf	63S
Coal Handling	63S
Coating Misc	63JJJJ
Coating: Off Machine	63JJJJ
Coating: On Machine	63JJJJ
Condensate Stripper	63S
Cooling Tower	63S
DCE	63MM
Fugitive Emissions - Misc	63S
Hogged Fuel Dryer	63MM
ICI Boiler/PH	63DDDDD
Kraft Misc	63MM, 63S
Kraft Pulp Storage	63S
Kraft Pulping: BL Tanks HVLC	63S
Kraft Pulping: Decker	63S
Kraft Pulping: Digester LVHC	63S
Kraft Pulping: Evaporator LVHC	63S
Kraft Pulping: HVLC	63S
Kraft Pulping: Incinerator	63S
Kraft Pulping: Knotter	63S
Kraft Pulping: LVHC	63S
Kraft Pulping: O2 Delig HVLC	63S
Kraft Pulping: Turpentine LVHC	63S
Kraft Pulping: Washing	63S
Kraft Stock Washing	63S
Landfill	63S
Lime Kiln	63MM
Lime Kiln (Soda)	63MM
Mechanical Pulping	63S
Mineral Handling	63S

Emission Process Group	Regulatory Code
Misc Machinery Manuf	63S
NDCE	63MM
NSSC Misc	63S
NSSC Pulping	63S
NSSC Recovery	63MM
Paper Coating	63JJJJ
Paper Misc	63S
Paper Stock Prep	63S
Papermaking	63S
Petrol Storage-Transfer	63EEEE, 63R
Print-Publish	63KK
RICE	63ZZZZ
Salt Cake Tank	63MM
SDT (Kraft)	63MM
SDT (Semichem)	63MM
SDT (Soda)	63MM
Semichem Misc	63S
Semichem Pulping	63S
Semichem Recovery	63MM
Soda Misc	63S
Soda Recovery	63MM
Solvent Use	63S
Storage Tanks - Alcohol	63S
Storage Tanks - Methanol	63S
Storage Tanks - Organic	63EEEE
Sulfite Pulping	63S
Sulfite Pulping (Ca)	63S
Sulfite Pulping (NH3)	63S
Sulfite Recovery	63MM
Tall Oil	63S
Turbine	63YYYY
Waste Disposal - Fugitive Emissions	63S
Waste Disposal - Incineration	63S
Wastewater (General)	63S
Wastewater (Kraft)	63S
Wastewater (Mechanical)	63S
Wastewater (NSSC)	63S
Wastewater (Semichem)	63S
Wastewater (Sulfite)	63S
Welding	63S
Wood Handling	63S

Appendix C

Discrepancies Between NEI and Part III Data Bases Requiring Resolution

Appendix C. Discrepancies Between NEI and Part III Data Bases Requiring Resolution or Explanation[1]

NEI—Emission Unit ID	Issue	Resolution/Explanation
DCE and NDCE checks:		
NEI18334--RB15	Listed as DCE in NEI, and listed as NDCE in PIII. No BLO system was included in the NEI.	Revised NEI SCC and/or emission process group to reflect that the emission unit is an NDCE consistent with PIII data which have been extensively reviewed for accuracy.
NEI26309--08P012 NEI26309--08P013		
NEI34066--AA-011		
NEI42695--B14		
NEI45474--RF3		
NEI54342--SN26		
NEI8265--EU18		
NEI47091—7 (PCA Counce, TN)	Listed as a DCE in the NEI (NEI47091--RB3): but the Part III data and process flow diagrams indicate that a conversion to NDCE was performed in 2011.	The mill has two NDCE furnaces: RB2 (NEI47091--6) and RB4 (NEI47091--11). The mill also has RB3 (NEI47091--7) which was converted to NDCE technology in 2011. The Statement of Basis in the 10/29/2013 Title V permit revision files obtained from the FLDEP website indicate that RB3 is indeed an NDCE recovery furnace. Thus, the NEI needs to be revised to reflect the NDCE and to remove the associated BLO system (NEI47091--48).
NEI11338—03	Listed as NDCE in NEI, and listed as DCE in PIII. The NEI contains a BLO system.	Revised NEI SCC and/or emission process group columns to reflect that unit is a DCE consistent with PIII data which have been extensively reviewed for accuracy. Double-checked any post-subpart-S-proposal revisions submitted by mills and found no evidence of DCE->NDCE conversion.
NEI18657—2		
NEI8278--RB1 NEI8278--RB2		
NEI41599—RF	This NDCE in PIII was not included in the NEI with "NDCE" as the emission process grouping	OK as is. There is only 1 soda mill in the U.S. (NEI41599) and their NDCE has "Soda Recovery" as the emission process group instead of "NDCE."
NEI13340—634474 [NDCE] NEI13340—65 [NDCE]	NEI13340--55 (NDCE) is the only recovery furnace listed in the PIII	Cascade Pacific Pulp, Halsey, OR There were three separate emission unit IDs for the recovery furnace, with only one ID representing the furnaces HAP emissions: 65 = RFEU: RECOVERY FURNACE OIL USE 634474 = Recovery Furnace-Vents out common stack with Lime Kiln 55= Recovery Furnace-Vents out common stack with Lime Kiln Revised emission unit ID to "55" for consistency.
NEI26504—7040 (PCA Valdosta)	This is a new NDCE added to the NEI, but not yet reflected in the PIII inventory	The new NDCE needs to be reflected in the part III inventory. (RTI will note in PIII and in analyses moving forward.)

NEI—Emission Unit ID	Issue	Resolution/Explanation
NEI41552 (PCA-Counce, TN)	According to a 6/15/10 permit, two DCE recovery furnaces (R-1 and R-2) were replaced with a new R-4 NDCE furnace and the BLO system was removed; and the mill plans to convert the R-1 and R-2 DCEs to NDCE recovery furnaces.	The two DCE furnaces (R-1 and R-2) and the BLO remain in the inventory. The new R-4 NDCE furnace is not listed.
NEI41565--018	This NDCE was in the NEI but missing from PIII	Emission unit 018 is "chemical recovery" which includes weak liquor tanks, evaporators, a steam stripper, and the salt cake mix tank (which appears to be vented to HVLC in the flow diagram but is not listed as having control in PIII). Given the number of subpart S emission units, changed this emission point to 1626-1. Chemical Recovery 2700P is shown to have one emission point, but the HVLC and LVHC emission units account for most of the emissions, meaning 2700P is probably miscellaneous emissions. Relabeled as Kraft Misc, with SCC 30700199, and MACT code 1626-1.
NEI42710--02	This NDCE was in the NEI but missing from PIII	Emission unit "02" is B08 and B10 combined PAH. Split this across the two recovery boilers to eliminate this "stray" emission unit and to use consistent stack parameters.
BLO checks:		
NEI12492	This mill has two DCEs, but no corresponding BLO listed in the NEI. Mill has 3-stage BLO listed as 2 separate units in PIII (BLOX01, BLOX02, BLOX03).	OK as is. Flow diagram appears to show emission release following O2 addition from the next process unit immediately following each O2 addition stage. PIII indicates that the BLO 2nd stage exhaust is incinerated in the lime kiln or bark boiler (e.g., as NCG exiting from the evaporator). Stage 1 appears to vent from the weak liquor storage tanks. Stage 3 appears to vent through the strong black liquor tanks. The weak and strong liquor tanks are included in the NEI, so we conclude that the BLO emissions are accounted for.
NEI42254	This mill has one DCE, but no corresponding BLO listed in the NEI.	The mill has a BLO listed in PIII. PIII indicates that the BLO vents through the recovery furnace dry bottom ESP.
Lime kiln checks:		
NEI13340--62 NEI13340--634468 NEI13340--67	NEI13340--32 is the only lime kiln listed in PIII	There were three separate emission unit IDs for the lime kiln. Revised emission unit ID to "32" for consistency.
NEI46817--10 NEI46817--11 NEI46817--90	An LK1 and LK2 are listed in PIII, but 3 kilns are shown in the NEI	OK as is. "90" is lime kiln fugitive PM which is inconsequential to the risk modeling. "10" is LK1 and "11" is LK2.

NEI—Emission Unit ID	Issue	Resolution/Explanation
NEI706--001 NEI706--047 NEI706--048	Only lime kiln NEI706--001 shown in PIII	001 is the lime kiln (ok). However, 047 and 048 dealt with PM emissions from limestone or pebble lime handling. Change emission process group to Mineral Handling, SCC to 30510205, and MACT and regulatory codes to 1626-3 and 63S.
SDT checks:		
NEI11251	No SDTs shown in NEI	Ok as is. The SDT vents through the lime kiln or recovery furnace.
NEI33025		Ok as is. Not an emission point; vents to RB#3
NEI8177		Ok as is. The recovery boiler and SDT both vent to the same wet scrubber (per test report description).
NEI11461	No SDT shown in NEI for this semichemical mill	OK as is. No SDT used per Part III.
NEI33945	No SDTs shown in NEI for this semichemical mill	OK as is. No SDT used per Part III.
Mills not reflected in PIII data		
NEI7621 RTI 161	International Paper – Franklin, VA	Was not operating at the time of the 2011 ICR. Need to add to PIII using RTI 161. RTI will add major equipment to PIII and/or subpart MM analyses using permit information.
NEI42351 RTI 700	Cosmo Specialty Fibers, Inc – Cosmopolis, WA (formerly Weyerhaeuser)	Was not operating at the time of the 2011 ICR. Magnesium based dissolving sulfite pulp mill Need to add to PIII with new RTI number (RTI 700). RTI will add major equipment to PIII and/or subpart MM analyses using permit information.

1. All of the discrepancies identified were explained or resolved (to date) with the exception of the shaded rows.

Appendix D

Control Measures Added to Risk Input File

Emission process group	Control measure comment
BLO	Thermal Oxidizer; Wet Scrubber
	Uncontrolled
Calciner	Wet Scrubber
DCE	Dry-Bottom ESP
	Dry-Bottom ESP with Wet PM Return System
	Dry-Bottom ESP; Wet Scrubber
	Wet-Bottom ESP
	Wet-Bottom ESP; Wet Scrubber
Hogged Fuel Dryer	Fabric Filter / Baghouse; Mist Eliminator
Kraft Misc	Composite emission unit, which includes recovery furnaces (equipped with dry-bottom ESP and 2-sided dry- and wet-bottom ESP), lime kiln (equipped with ESP), and SDTs (equipped with wet scrubbers)
	Composite emission unit, which includes recovery furnaces (equipped with dry-bottom ESPs) and lime kilns (equipped with wet scrubbers)
	Composite emission unit, which includes recovery furnaces (equipped with wet-bottom ESPs) and lime kiln (equipped with wet scrubber)
Lime Kiln	Cyclone / Centrifugal Collector; Electrostatic Precipitator - Dry (DESP)
	Cyclone / Centrifugal Collector; Wet Scrubber
	Cyclones (Multiple); Wet Scrubber
	Electrostatic Precipitator - Dry (DESP)
	Electrostatic Precipitator - Dry (DESP); Packed-Gas Absorption Column
	Electrostatic Precipitator - Dry (DESP); Wet scrubber
	Uncontrolled
	Wet Scrubber
	Wet Scrubber (NCG Scrubbers Pre-Kiln + LK ESP]
	Wet Scrubber (NCG Scrubbers Pre-Kiln + LK Wet Scrubber]
Lime Kiln (Soda)	Electrostatic Precipitator - Dry (DESP)
NDCE	Dry-Bottom ESP
	Dry-Bottom ESP with Wet PM Return System
	Dry-Bottom ESP with Wet PM Return System; Dry-Bottom ESP; Dry-Bottom ESP
	Dry-Bottom ESP; Wet Scrubber
	Dry-Bottom/Wet-Bottom ESP [2-Sided Dry and Wet]
	Wet Scrubber
	Wet-Bottom ESP
NSSC Recovery	Thermal Oxidizer; Wet Scrubber; Absorber
Salt Cake Tank	Dry-Bottom ESP
	Incinerator_Boiler; Cyclones (Multiple); Wet Scrubber; Electrostatic Precipitator - Wet (WESP)
	Incinerator_Recovery Furnace; Electrostatic Precipitator - Dry (DESP)
	Packed-Gas Absorption Column
	Uncontrolled
	Wet Scrubber

Emission process group	Control measure comment
	Wet-Bottom ESP
SDT (Kraft)	Incinerator_Recovery Furnace; Electrostatic Precipitator - Dry (DESP)
	Mist Eliminator
	Packed-Gas Absorption Column
	Wet Scrubber
	Wet Scrubber; Condensate Stripper
	Wet Scrubber; Incinerator_Recovery Furnace; Electrostatic Precipitator - Dry (DESP)
SDT (Semichem)	Incinerator_Recovery Furnace; Electrostatic Precipitator - Dry (DESP)
	Shower Scrubber
	Uncontrolled
	Wet Scrubber
SDT (Soda)	Wet Scrubber
Semichem Recovery	Electrostatic Precipitator - Dry (DESP)
	Thermal Oxidizer; Fabric Filter / Baghouse
	Wet Scrubber; Electrostatic Precipitator - Wet (WESP); Regenerative Thermal Oxidizer
	Wet Scrubber; Regenerative Thermal Oxidizer
Soda Recovery	Wet-Bottom ESP
Sulfite Recovery	Mist Eliminator
	Wet Scrubber
	Wet Scrubber; Magnesium Oxide Scrubbing

Appendix E

Information Needed to Calculate Allowable Multipliers

Table E-1. Information Needed to Calculate Allowable Multipliers for Existing Sources for Subpart MM Risk Modeling (Regulatory Code 63MM)

Pollutant	Equipment type	Numeric standard	Standard units	Allowable multiplier calculation	Allowable emissions	Actual emissions	Allowable multiplier
HAP metals (PM surrogate)	Kraft/soda recovery furnaces	0.044	gr/dscf (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (PM test average)	0.044	0.0131	3.3
	Kraft/soda smelt dissolving tanks	0.2	lb/ton BLS (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (PM test average)	0.2	0.108	1.8
	Kraft/soda lime kilns	0.064	gr/dscf (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (PM test average)	0.064	0.0356	1.8
	Sulfite combustion units	0.04	gr/dscf (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (PM test average)	0.04	0.0110	3.6
	Hog fuel dryer (at one sulfite mill with a site-specific limit)	10	lb/hr (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (PM test average)	10	1.36	7.4
	All other subpart MM emission process groups	None		No limit; actual = allowable, so allowable multiplier = 1			1
Gaseous organic HAP	Semichemical combustion units	2.97	lb/ton BLS (THC as C)	Allowable multiplier = allowable emissions (surrogate THC limit)/actual emissions (THC test average)	2.97	0.967	3.1
	All other subpart MM emission process groups	None		No limit; actual = allowable, so allowable multiplier = 1			1
Acid gases	All subpart MM emission process groups	None		No limit; actual = allowable, so allowable multiplier = 1			1
Dioxins/furans	All subpart MM emission process groups	None		No limit; actual = allowable, so allowable multiplier = 1			1

Note: Need install date to determine whether sources are subject to existing or new source standards. Existing sources - began construction/reconstruction on or before 4/15/98.

Table E-2. Information Needed to Calculate Allowable Multipliers for New Sources for Subpart MM Risk Modeling (Regulatory Code 63MM)

Pollutant	Equipment type	Numeric standard	Standard units	Allowable multiplier calculation	Allowable emissions	Actual emissions	Allowable multiplier
HAP metals (PM surrogate)	Kraft/soda recovery furnaces	0.015	gr/dscf (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (Part III inventory)	0.015	0.0076	2.0
	Kraft/soda smelt dissolving tanks	0.12	lb/ton BLS (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (Part III inventory)	0.12	0.084	1.4
	Kraft soda lime kilns	0.01	gr/dscf (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (Part III inventory)	0.01	0.01	1.0
	Sulfite combustion units	0.02	gr/dscf (PM)	No new units	0.02	--	N/A
	Hog fuel dryer (at one sulfite mill with a site-specific limit)	10	lb/hr (PM)	Allowable multiplier = allowable emissions (surrogate PM limit)/actual emissions (PM test average)	10	1.36	7.4
	All other subpart MM emission process groups	None		No limit; actual = allowable, so allowable multiplier = 1			1
Gaseous organic HAP	Kraft/soda recovery furnaces (including BLO units)	0.025	lb/ton BLS (methanol)	Based on Note 2 below, actual = allowable, so allowable multiplier = 1			1
	Semichemical combustion units	2.97	lb/ton BLS (THC as C)	Allowable multiplier = allowable emissions (surrogate THC limit)/actual emissions (THC test average)	2.97	0.97	3.1
	All other subpart MM emission process groups	None		No limit; actual = allowable, so allowable multiplier = 1			1
Acid gases	All subpart MM emission process groups	None		No limit; actual = allowable, so allowable multiplier = 1			1
Dioxins/furans	All subpart MM emission process groups	None		No limit; actual = allowable, so allowable multiplier = 1			1

Notes:

1. Need install date to determine whether sources are subject to existing or new source standards. New sources - began construction/reconstruction after 4/15/98. See Table E-3 for a listing of new sources.
2. Mills that comply with the new source limit using an NDCE recovery furnace with a dry ESP system are not required to conduct testing or monitoring to demonstrate compliance with the standard. Since that is the only type of furnace system currently being installed, there is no emissions measurement, so allowable emissions are assumed to equal actual emissions.

Table E-3. Emission Units Constructed in 1998 or Later That Were Assigned Multipliers for New Sources

UnitOpID	EmissionUnitDesc	EmissionProcessGroup
NEI11251--EUG E7	Lime Kiln	Lime Kiln
NEI12368--EU 033	Rotary Lime Kiln	Lime Kiln
NEI26506--U800	Lime Kiln	Lime Kiln
NEI40247--G-18	No. 4 Lime Kiln	Lime Kiln
NEI6450--55	Lime Kiln	Lime Kiln
NEI759--30	No. 2 Lime Kiln (REC047)	Lime Kiln
NEI11251--EUG D6	Recovery Furnace	NDCE
NEI12368--EU 005	Recovery Furnace	NDCE
NEI18338--3	No. 3 Recovery Furnace	NDCE
NEI33025--RB3	Recovery Boiler No. 3	NDCE
NEI34064--AA-100	Recovery Furnace	NDCE
NEI41552--CU7215	Chemical recovery furnace	NDCE
NEI45206--G-44	Recovery Boiler	NDCE
NEI47077--007RF3	Recovery Furnace No. 3	NDCE
NEI11251--EUG E4b	New Smelt Dissolving Tank	SDT (Kraft)
NEI12368--EU 031	Smelt Dissolving Tank	SDT (Kraft)
NEI34064--AA-101a	Smelt Dissolving Tank Vent Scrubber	SDT (Kraft)
NEI45206--G-127	South Smelt Tank	SDT (Kraft)
NEI8261--4SDT	#4RB smelt dissolving tank vent	SDT (Kraft)

Appendix 2
Technical Support Document for HEM-AERMOD Modeling

Modeling for the Residual Risk and Technology Review Using the Human Exposure Model 3 – AERMOD Version

Updated 01/08/2014

Technical Support Document

Prepared for:

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Health and Environmental Impacts Division
Air Toxics Assessment Group
Research Triangle Park, NC 27711

Prepared by:

EC/R Incorporated
501 Eastowne Drive, Suite 250
Chapel Hill, North Carolina 27514

Disclaimer

The research described in this document has been funded by the United States Environmental Protection Agency contracts 68-D-01-076, EP-D-06-119, and currently EP-W-12-011 to EC/R Incorporated. Although it has been subject to the Agency's review, it does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

Contents

Figures

Tables

1. Introduction

This document describes the general modeling approach used to estimate the risks to human populations in support of the Residual Risk and Technology Review (RTR) currently being carried out by the U.S. Environmental Protection Agency (EPA). It is important to note that risk characterizations of individual source categories under the RTR program may not follow every item/approach noted in this document. The reader is referred to the main body of the risk assessment document for more details on source category specific approaches that may have been included in the analysis.

The model used in these risk assessments is the Human Exposure Model, Version 3 (HEM-3). HEM-3 incorporates AERMOD, a state of the art air dispersion model developed under the direction of the American Meteorological Society / Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC).

Section 2 of this report provides an overview of the HEM-3-AERMOD system; and Section 3 describes inputs and choices made in implementing the model for the RTR program. Quality assurance efforts undertaken in the modeling effort are discussed in Section 4, and uncertainties associated with the modeling effort are discussed in Section 5.

2. Overview of the HEM-3 – AERMOD System

HEM-3 performs three main operations: dispersion modeling, estimation of population exposure, and estimation of human health risks. The state-of-the-art American Meteorological Society (AMS) EPA Regulatory Model (AERMOD)[1,2] is used for dispersion modeling. AERMOD can handle a wide range of different source types which may be associated with an industrial source complex, including stack (point) sources, area and polygon sources, and volume sources.

To prepare dispersion modeling inputs and carry out risk calculations, HEM-3 draws on four data libraries, which are provided with the model. The first is a library of meteorological data for over 824 stations, which are used for dispersion calculations. A second library of Census block ("centroid") internal point locations and populations provides the basis of human exposure calculations. The Census library also includes the elevations of every Census block, which are used in the dispersion calculations for the RTR assessments. A third library of pollutant unit risk estimates and reference concentrations is used to calculate population risks. These unit risk estimates and reference concentrations are based on the latest values recommended by EPA for hazardous air pollutants (HAP) and other toxic air pollutants. The fourth data library, which provides deposition parameters for gaseous pollutants, is used only when the user opts to compute deposition and plume depletion (not computed for the RTR assessments to date).

HEM-3 has been implemented in two versions: a single facility version, and a multiple facility version ("Multi HEM-3"). Multi HEM-3 is used in the RTR risk assessment modeling. Both versions operate under the same general principles. In essence, Multi HEM-3 provides a platform for running the single facility version multiple times. In both versions, source location and emissions data are input through a set of Excel™ spreadsheets. The main difference is in the user interface for other model inputs. Single HEM-3 includes a graphical user interface (GUI) for the selection of various dispersion modeling options. In Multi HEM-3, a control file replaces many of these GUI inputs.

The model estimates cancer risks and noncancer adverse health effects due to inhalation exposure at Census block internal point locations (or "centroids"), at concentric rings surrounding the facility center, and at other receptor locations that can be specified by the user. Cancer risks are computed using EPA's recommended unit risk estimates for Hazardous Air Pollutants (HAP) and other toxic air pollutants. The resulting estimates reflect the excess cancer risk for an individual breathing the ambient air at a given receptor site 24-hours per day over a 70-year lifetime. The model estimates the numbers of people exposed to various cancer risk levels. In addition, HEM-3 estimates the total incremental cancer risks for people living within different distances of the modeled emission sources.

Potential noncancer health effects due to chronic exposures are quantified using hazard quotients and hazard indices for various target organs. The "hazard quotient" (HQ) for a given chemical and receptor site is the ratio of the ambient concentration of the chemical to the reference concentration. The "hazard index" (HI) for a given organ is the sum of hazard quotients for substances that affect that organ. HEM-3 computes target-organ-specific hazard indices (TOSHI) for HAPs and other toxic air pollutants, and estimates the numbers of people exposed to different hazard index levels. In addition, maximum short term (“acute”) concentrations are computed for all pollutants, and concentrations are compared with threshold levels for acute health effects.

The following sections outline the methodologies used in the HEM-3–AERMOD system. Section 2.1 describes the preparation of dispersion modeling inputs, Section 2.2 describes the running of AERMOD, Section 2.3 describes calculations performed by HEM-3 to calculate risks and exposures, and Section 2.4 details the sources and methods used to produce HEM-3’s data libraries. The HEM-3 User’s Manuals – for single HEM-3 and Multi HEM-3 – provide additional details on the input data and algorithms used in the model.[3] Specific model options used in the RTR assessments are discussed in Chapter 3.

2.1 Preparation of Dispersion Modeling Inputs

HEM-3 compiles data that will be needed for dispersion modeling, and prepares an input file suitable for running AERMOD. The dispersion modeling inputs can be divided into three main components: emission source data, information on the modeling domain and receptors for which impacts will be computed, and meteorological data.

2.1.1 Compiling Emission Source Data

A series of Excel™ spreadsheet files are used to specify the emissions and configuration of the facility to be modeled. At a minimum, two files are needed: a pollutant emission file, and an emission location file. The emission file includes an emission source identification code for each emission source at the facility, the names of pollutants emitted by each source, and the emission rate for each pollutant. In addition, if the model run is to incorporate deposition or plume depletion, the emission file must also specify the percentage of each pollutant that is in the form of particulate matter. The balance is assumed to be in vapor form.

The emission location file includes the coordinates of each source, as well as information on the configuration and other characteristics of the source. HEM-3 can analyze point sources, area and polygon sources, and volume sources - configurations that are described in AERMOD's documentation.[1, 2] For stack (point) sources, the location file must provide the stack height, stack diameter, emission velocity, and emission temperature. The file must also provide dimensions for each area or volume source, as well as the height of the source above the ground. For area sources, the angle of rotation from north can also be specified. The user can also provide the terrain elevation at the base of each source. (The controlling hill height is also used in AERMOD’s flow calculations. Calculation of the controlling hill height by HEM-3 is discussed in Section 2.4.2.) If the terrain elevations are not provided by the user, HEM-3 will calculate elevations and controlling hill heights based on elevations and hill heights provided by the Census database for the Census blocks nearest to the facility.

If particulate deposition and plume depletion are to be considered, then HEM-3 requires a third input file to specify the particle size distribution. This input file must include the average particle diameter, the mass fraction percentage, and the average particle density for each size range emitted. Another optional file can be used to specify building dimensions if building wake effects are to be modeled.

2.1.2 Defining the Modeling Domain and Receptors

HEM-3 defines a modeling domain for each facility that is analyzed based on parameters specified by the model user or calculated by the model. These parameters are summarized in Table 2-1. The modeling domain is circular, and is centered on the facility, with a radius specified by the user. For the RTR analysis, the radius of the modeling domain is 50 kilometers (km). HEM-3 identifies all of the Census block locations in the modeling domain from its Census database, and divides the blocks into two groups based on their distance from the facility. For the inner group of Census blocks (closest to the facility), each block location is modeled as a separate receptor in AERMOD. The cutoff distance for modeling individual Census blocks is generally set to 3 km for the RTR assessments, although it can be set differently by the model user. The model user can also provide an Excel™ spreadsheet specifying additional locations to be included as model receptors in AERMOD. These additional discrete "user receptors" may include facility boundary locations, monitoring sites, individual residences, schools, or other locations of interest.

For Census blocks in the outer group, beyond this modeling cutoff distance, emission impacts are interpolated based on modeling results for a polar receptor network. The user also specifies an "overlap" distance, within which Census block coordinates will be considered to be on facility property. The following paragraphs provide more details on the treatment of blocks near the facility, on the polar receptor network, and on the determination of receptor elevations and controlling hill heights to be used in AERMOD.

Table 2-1. Parameters Used to Delineate the Modeling Domain in HEM-3

Parameter	Typical value
Modeling domain size – maximum radial distance to be modeled from facility center	50 km
Cutoff distance for modeling of individual blocks[a]	3,000 m
Overlap distance – where receptors are considered on facility property[a]	30 m
Polar receptor network:	
Distance to the innermost ring[b]	≥100 m
Number of concentric rings	13
Number of radial directions	16

[a] Measured from each stack at the facility, and from the edges of each area or volume source

[b] Generally model-calculated to encompass all emission sources but not less than 100 meters from the facility center

Treatment of Nearby Census Blocks and Screening for Overlapping Blocks

Census block locations near the facility are modeled as separate receptors within AERMOD. The cutoff distance for modeling of individual Census blocks may be chosen by the user, but is typically 3000 meters for the RTR assessments. This distance is not measured from the center of the facility, but is the minimum distance from any source at the facility. Therefore, any Census block location that is within the cutoff distance from any emission source is treated as a discrete AERMOD receptor.

HEM-3 checks Census blocks that are very close to the facility in order to assess whether they overlap any point, area or volume emission sources. In addition, the user can specify an overlap distance, within which receptors will be considered to be on facility property. The default value for the overlap distance is 30 meters, or approximately equal to the width of a narrow buffer and a roadway. HEM-3 tests each nearby receptor to determine whether it is within this distance from any stack or from the perimeter of any area or volume source. If a receptor falls within this distance, HEM-3 will not calculate risks based on the location of that receptor, but will instead assume that the risks associated with the receptor are the same as the highest predicted value for any receptor that is not overlapping. The location for calculating the default impact may be either another Census block, one of the polar grid receptors, or one of the additional discrete user-specified receptor locations.

Polar receptor network

The polar receptor network used in HEM-3 serves three functions. First, it is used to estimate default impacts if one or more Census locations are inside the overlap cutoff distance used to represent the facility boundary. Second, it is used to evaluate potential acute effects that may occur due to short-term exposures in locations outside the facility boundary. Third, the polar receptor network is used to interpolate long-term and short-term impacts at Census block locations that are outside the cutoff distance for modeling of individual blocks.

Generally, the model calculates the inner radius (or first ring distance) for the polar receptor network to be just outside the emission source locations, but not less than 100 meters from the facility center. However, the user can override the default distance calculated by the model to fit the size and shape of the facility properties to be modeled. Likewise, the model will also use default values for the number of concentric rings to be analyzed (13 rings by default), and the number of radial directions (16 radials by default), although these default values can also be changed by the user to meet the needs of a specific modeling study. The inner radius of the polar network should be the minimum distance from the facility center that is generally outside of facility property. (For complex facility shapes, it is sometimes useful to specify an inner ring that encroaches on facility property in some directions.) HEM-3 will distribute the radial directions evenly around the facility. For the concentric rings, the model will generate a logarithmic progression of distances starting at the inner ring radium and ending at the outer radium of the modeling domain.

Elevations and hill heights for model receptors

HEM-3 includes terrain elevations by default for the RTR assessments, but the user can choose to exclude terrain effects when running AERMOD. If the default terrain option is used, HEM-3 obtains elevations and controlling hill heights for Census block receptors from its internal Census location library. Section 2.4.2 describes the derivation of these elevations and hill heights.

Elevations and controlling hill heights for the polar grid receptors are also estimated based on values from the Census library. HEM-3 divides the modeling domain into sectors based on the polar receptor network, with each Census block assigned to the sector corresponding to the closest polar grid receptor. Each polar grid receptor is then assigned an elevation based on the highest elevation for any Census block in its sector. The controlling hill height is also set to the maximum hill height within the sector. If a sector does not contain any blocks, the model defaults to the elevation and controlling hill height of the nearest block outside the sector.

2.1.3 Selection of Meteorological Data

In addition to source and receptor information, AERMOD requires surface and upper air meteorological observations in a prescribed format. The model user can select a meteorological station from the HEM-3 meteorological data library, or add new files to the library if site-specific data are available. If the user does not specify a meteorological station, HEM-3 will select the closest station to the center of the modeling domain, as is generally done for the RTR assessments.

2.2 Running of AERMOD

Based on the user input data and other data described in the previous section, HEM-3 produces an input file suitable for AERMOD. HEM-3 then runs AERMOD as a compiled executable program. No changes have been made from the version of AERMOD released to the public by EPA. The following sections give additional information on how AERMOD is used within HEM-3.

2.2.1 AERMOD Dispersion Options Used by HEM-3

AERMOD provides a wide array of options for controlling dispersion modeling calculations. In general, HEM-3 uses the regulatory default options when running AERMOD.[1] These options include the following:

- Use stack-tip downwash (except for Schulman-Scire downwash);
- Use buoyancy-induced dispersion (except for Schulman-Scire downwash);
- Do not use gradual plume rise (except for building downwash);
- Use the “calms processing” routines;
- Use upper-bound concentration estimates for sources influenced by building downwash from super-squat buildings;
- Use default wind profile exponents;
- Use low wind speed threshold;
- Use default vertical potential temperature gradients;
- Use of missing-data processing routines; and
- Consider terrain effects.

The following additional AERMOD options are available to the HEM-3 user:

- Calculation of wet and dry deposition rates for vapor and particulate matter;
- Consideration of plume depletion (due to deposition) when calculating air concentrations;
- Consideration of building wake effects;
- Calculation of short term (acute) impacts; and
- Use of the FASTALL option, which conserves model runtime by simplifying the AERMOD algorithms used to represent meander of the pollutant plume.

As noted in Section 2.1, the calculation of deposition or depletion and the consideration of building wake effects require additional user inputs.

The user can opt to analyze short term impacts on a number of different time scales (i.e., 1 hour, 6 hours, 8 hours, or 24 hours) however only one short term time scale can be selected per run. If the user chooses to analyze short term impacts, a multiplier must be specified to reflect the ratio between the maximum short term emission rate and the long term average emission rate. The default multiplier for short term emissions is a factor of 10. This means that in the default case the maximum short term emission rate is assumed to be 10 times the long term average emission rate. The multiplier can be set to 1.0 if emissions from the facility are known to be constant. For RTR assessments, acute impacts are generally included in the modeling and the default multiplier of 10 is used, unless more source-specific information is available upon which to base the acute factor for the source category being modeled.

2.2.2 Use of Dilution Factors

To save computer run time when analyzing the impacts of multiple pollutants, HEM-3 does not model each pollutant separately. Instead, AERMOD is used to compute a series of dilution factors, specific to each emission source and receptor. The dilution factor for a particular emission source and receptor is defined as the predicted ambient impact from the given source and at the given receptor, divided by the emission rate from the given source.

If the user chooses not to analyze deposition and plume depletion, the dilution factor does not vary from pollutant to pollutant. If deposition and depletion is chosen as a model option, separate dilution coefficients must be computed for each gaseous pollutant. In addition, separate dilution factors must be computed for different components of particulate matter if the components do not have the same particle size distribution. In the current version of HEM-3, this can be done by creating a separate emission record for each pollutant emitted by from each source. (Common location data and source configurations can be used for different pollutant records representing the same emission source.)

2.3 Postprocessing of AERMOD Results in HEM-3

HEM-3 estimates total excess cancer risks and potential chronic noncancer health effects for all Census block locations in the modeling domain, all user-defined receptors, and all points in the polar receptor network. Potential chronic noncancer health effects are expressed in terms of TOSHI. Based on the results for Census blocks and other receptors, HEM-3 estimates the maximum individual risk (MIR) and maximum TOSHI for populated receptors, and determines the locations of these maximum impacts. The model also determines the concentrations of different pollutants at the sites of the maximum risks, and the contributions of different emission sources to these maximum estimated risks. It should be noted that the locations may differ for the maximum individual cancer risk and for the hazard indices for different target organs.

For acute impacts, HEM-3 calculates the maximum short term concentrations for all pollutants emitted by the facility. These maximum short term concentrations are compared with various threshold levels for acute health effects (e.g., the California EPA reference exposure level [REL] for no adverse effects).

At the option of the model user, HEM-3 will also compute the long term and short term predicted ambient concentrations of all pollutants emitted by the facility at all of the receptors in the modeling domain. In addition, pollutant contributions from each emission source at the facility are computed under this option.

Section 2.3.1. describes methods used to calculate cancer risks and hazard indices for receptors that are explicitly modeled using AERMOD. Section 2.3.2 describes the interpolation approach used to estimate cancer risks and hazard indices at Census blocks that are not explicitly modeled.

2.3.1 Calculation of Impacts at Modeled Receptors

As noted in Section 2.2.2, HEM-3 does not model each pollutant separately unless deposition or depletion is being analyzed. Instead, AERMOD is used to compute a series of dilution factors, specific to each emission source and receptor. HEM-3 also conserves computer memory by computing cancer risks and hazard indices directly, without recording the concentration of each pollutant at each receptor. The following algorithms are used to compute cancer risks and TOSHI for chronic noncancer health effects.

For cancer risk:

$$CR_T = \sum_{i,j} CR_{i,j}$$

$$CR_{i,j} = DF_{i,j} \times CF \times \sum_k [E_{i,k} \times URE_k]$$

For TOSHI:

$$TOSHI_T = \sum_{i,j} TOSHI_{i,j}$$

$$TOSHI_{i,j} = DF_{i,j} \times CF \times \sum_k [E_{i,k} / RfC_k]$$

where:

CR_T = total cancer risk at a given receptor (probability for one person)

$\sum_{i,j}$ = the sum over all sources i and pollutant types j (particulate or gas)

$CR_{i,j}$ = cancer risk at the given receptor for source i and pollutant type j

$DF_{i,j}$ = dilution factor [(µg/m^3) / (g/sec)] at the given receptor for source i and pollutant type j

CF = conversion factor, 0.02877 [(g/sec) / (ton/year)]

$\sum_k$ = sum over all pollutants k within pollutant type j (particulate or gas)

$E_{i,k}$ = emissions of pollutant k from source i and in pollutant type j

URE_k = cancer unit risk factor for pollutant k

$TOSHI_T$ = total target-organ-specific hazard index at a given receptor

$TOSHI_{i,j}$ = target-organ-specific hazard index at the given receptor for source i and pollutant type j

RfC_k = non-cancer health effect reference concentration for pollutant k

The above equations are equivalent to the following simpler equations:

$$CR_T = \sum_{i,k} AC_{i,k} \times URE_k$$

$$HI_T = \sum_{i,k} AC_{i,k} / RC_k$$

where:

$AC_{i,k}$ = ambient concentration (µg/m^3) for pollutant k at the given receptor. This is the same as [$E_{i,k} \times DF_{i.j} \times CF$]

However, use of these simpler equations would require modeling all pollutants individually in AERMOD, and performing separate risk calculations for each pollutant.

If the cancer unit risk estimate is not available for a given chemical, then that chemical is not included in the calculation of cancer risk. Likewise, if the noncancer reference concentration is not available for a given chemical, that chemical is not included in the calculation of hazard indices. Note also that separate reference concentrations are used for acute and chronic hazard indices.

HEM-3 computes short term concentrations and records the highest short term concentration for each pollutant. In addition, the user can opt to compute and record the short term and long concentrations at each receptor. Concentrations are computed as follows.

Long term concentrations:

$$AC_{T,k} = \sum_i AC_{i,k}$$

$$AC_{i,k} = E_{i,k\,x} DF_{i,j} \times CF$$

Short term concentrations:

$$AC_T = \sum_i AC_{i,k}$$

$$AC_{i,k} = E_{i,k\,x} DF_{i,j} \times CF \times M$$

where:

$AC_{T,k}$ = total estimated ambient concentration for pollutant k at a given receptor
$\sum_i$ = the sum over all sources i (µg/m^3)
$AC_{i,k}$ = estimated ambient concentration of pollutant k at the given receptor as a result of emissions from source i (µg/m^3)
M = ratio between the estimated maximum short term emission rate and the long term average emission rate (dimensionless)

2.3.2 Interpolation of Impacts at Outer Census Blocks

For Census blocks outside of the cutoff distance for individual block modeling, HEM-3 estimates cancer risks and hazard indices by interpolation from the polar receptor network. Impacts at the polar grid receptors are estimated using AERMOD modeling results and the algorithms described in Section 2.3.1. If terrain elevation is part of the modeling, then an elevation is estimated for each polar receptor. HEM-3 estimates elevations and controlling hill heights for the polar grid receptors based on values from the census library. HEM-3 divides the modeling domain into sectors based on the polar grid receptor network, with each census block assigned to the sector corresponding to the closest polar grid receptor.

HEM-3 then assigns each polar grid receptor an elevation based on the highest elevation for any census block in its sector. The controlling hill height is also set to the maximum hill height within the sector. If a sector does not contain any blocks, the model defaults to the elevation and controlling hill height of the nearest block outside the sector.

The impacts at each outer Census block are interpolated from the four nearest polar grid receptors. The interpolation is linear in the angular direction, and logarithmic in the radial direction, as summarized in the following equations:

$$I_{a,r} = I_{A1,r} + (I_{A2,r} - I_{A1,r}) \times (a - A1) / (A2 - A1)$$

$$I_{A1,r} = \exp\{(\ln (I_{A1,R1}) + [(\ln (I_{A1,R2}) - \ln (I_{A1,R1})] \times [(\ln r) - \ln(R1)] / [\ln(R2) - \ln(R1)]\}$$
$$I_{A2,r} = \exp\{(\ln (I_{A2,R1}) + [(\ln (I_{A2,R2}) - \ln (I_{A2,R1})] \times [(\ln r) - \ln(R1)] / [\ln(R2) - \ln(R1)]\}$$

where:

$I_{a,r}$ = the impact (cancer risk, hazard index, or concentration) at an angle, a, from north, and radius, r, from the center of the modeling domain
a = the angle of the target receptor, from north
r = the radius of the target receptor, from the center of the modeling domain
A1 = the angle of the polar network receptors immediately counterclockwise from the target receptor
A2 = the angle of the polar network receptors immediately clockwise from the target receptor
R1 = the radius of the polar network receptors immediately inside the target receptor
R2 = the radius of the polar network receptors immediately outside the target receptor

2.3.3 Calculation of Population Exposures and Incidence

Using the predicted impacts for Census blocks, HEM-3 estimates the numbers of people exposed to various cancer risk levels and TOSHI levels. This is done by adding up the populations for receptors that have predicted cancer risks or TOSHI above the given threshold.

The model also estimates the total annual excess cancer risk (incidence) for the entire modeling region. The following equation is used:

$$TCR = \sum_m [CR_m \times P_m] / LT$$

where:

TCR = the estimated total annual cancer risk, or incidence, (cancers/year) to the population living within the modeling domain
$\sum_m$ = the sum over all Census blocks m within distance the modeling domain
CR_m = the total lifetime cancer risk (from all modeled pollutants and emission sources) at Census block m
P_m = the population at Census block m
LT = the average lifetime used to develop the cancer unit risk factor, 70 years

Furthermore, HEM-3 estimates the contributions of different chemicals and emission sources to total annual cancer incidence for the overall modeling domain using the following equations:

$$TCR_{i,j} = \sum_m [(\sum_k E_{i,k} \times URE_k) \times DF_{i,j,m} \times CF / LT]$$

$$TCR_{i,k} = TCR_{i\,j} \times E_{i,k} \times URE_k / (\sum_k E_{i,k} \times URE_k)$$

where:

$TCR_{i,j}$ = the estimated total annual cancer incidence (cancers/year) to the population in the modeling domain due to emissions from pollutant type j (1 = particulate, 2 = gas) and emission source i

$\sum_m$ = the sum over all Census blocks m within distance the modeling domain

$\sum_k$ = the sum over all pollutant k, within pollutant type j

$E_{i,k}$ = emissions of pollutant k from source i (tons/year)

URE_k = unit risk factor for pollutant k

$DF_{i,j,m}$ = dilution factor at receptor m, for emissions of pollutant type j (which includes pollutant k), from source i

CF = conversion factor, 0.02877 [(g/sec) / (ton/year)]

$TCR_{i,k}$ = the estimated annual cancer incidence (cancers/year) of the population in the modeling domain due to emissions of pollutant k (in pollutant type j) from emission source i

2.3.4 Model Outputs

The following is a summary of the outputs produced by HEM-3. These are written to a collection of files in Excel™ and dBase™ format (dbf).

- Maximum long term impacts at populated locations
    - maximum lifetime individual cancer risk (MIR)
    - maximum TOSHI for the following health effects
        - respiratory system effects
        - liver effects
        - neurological system effects
        - developmental effects
        - reproductive system effects
        - kidney effects
        - ocular system effects
        - endocrine system effects
        - hematological system effects
        - immunological system effects
        - skeletal system effects
        - spleen effects
        - thyroid effects
        - whole body effects
    - locations of the maximum cancer risk and TOSHI
    - Census block identification codes for the maximum cancer risk and TOSHI, and number of people in the Census block

    - contributions of different chemicals and emission sources to the maximum risk and TOSHI

- Maximum acute impacts
    - maximum short term ambient concentration for each chemical
    - threshold levels for acute health effects of each chemical (compared with the maximum short term concentrations)
    - locations of the maximum impacts for different chemicals (often polar receptors)
    - Census block identification codes at the locations of maximum concentration, and number of people in the block
    - contribution of each emission source at the facility to the maximum short term concentration of each chemical

- Outputs for all receptors
    - maximum individual cancer risk and TOSHI (all target organs) for each Census block and each user-specified discrete receptor (monitoring sites, etc.)
    - maximum individual cancer risk and TOSHI (all target organs) for each polar grid receptor
    - estimated deposition (optional)
    - predicted ambient concentration resulting from each emission source at each Census block and polar grid receptor (optional)

- Population exposures and total cancer risk, or incidence
    - estimated numbers of people exposed to different levels of lifetime individual cancer risk (1 in a million, 1 in 100,000, etc.)
    - estimated numbers of people exposed to different levels of TOSHI (1, 2, 10, etc.)
    - total cancer risk, or incidence, in estimated cancer deaths per year, over the entire modeling domain, and for each pollutant and source combination

2.4 Data Libraries Used in HEM-3

2.4.1 Chemical Health Effects Information

HEM-3 includes a library of available health effects data for HAPs. For each pollutant, the library includes the following parameters, where available:

- unit risk estimate (URE) for cancer
- reference concentration (RfC) for chronic noncancer health effects
- reference concentrations for acute health effects
- target organs affected by the chemical for chronic noncancer health effects

Unit risk estimates and reference concentrations included in the HEM-3 chemical library have been taken from EPA’s database of recommended dose-response factors for HAPs, which is updated periodically, consistent with continued research on these parameters.[4] The URE represents the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 microgram per cubic meter ($\mu g/m^3$) in air (e.g., if the

URE = 1.5 x 10^{-6} per µg/m^3, 1.5 excess tumors are expected to develop per 1 million people if all 1 million people were exposed daily for a lifetime to 1 microgram of the chemical in 1 cubic meter of air).[5]

The RfC is a concentration estimate of a continuous inhalation exposure to the human population that is likely to be without an appreciable "risk" of deleterious non-cancer health effects during a lifetime. No adverse effects are expected as a result of exposure if the ratio of the potential exposure concentration to the RfC, defined as the hazard quotient (HQ), is less than 1.[5]

The reference benchmark concentration for acute health effects, similar to the chronic RfC, is the concentration below which no adverse health effects are anticipated when an individual is exposed to the benchmark concentration for 1 hour (or 8 hours, depending on the specific acute benchmark used and the formulation of that benchmark). Target organs are those organs (e.g., kidney) or organ systems (e.g., respiratory) which may be impacted with chronic non-cancer health effects by exposure to the chemical in question. A more in-depth discussion of the development and use of these parameters for estimating cancer risk and non-cancer hazard may be found in the EPA's Air Toxics Risk Assessment Library.[6]

The model user can add pollutants and associated health effects to HEM-3's chemical health effects (dose-response) library, as needed.

2.4.2 Census Block Locations and Elevation Data

The HEM-3 Census library includes Census block identification codes, locations, populations, elevations, and controlling hill heights for all of the over 6 million Census blocks identified in the 2010 Census and the over 5 million Census blocks identified in the 2000 Census. The model user may choose to use either Census database according to their modeling needs. The location coordinates reflect the internal "centroid" of the block, which is a point selected by the Census to be roughly in the center of the block. For complex shapes, the internal point may not be in the geographic center of the block. Locations and population data for Census blocks in the 50 states and Puerto Rico were extracted from the LandView® database For the 2000 Census[7] and from the U.S. Census Bureau website for the 2010 Census.[8] Locations and populations for blocks in the Virgin Islands were obtained from the U.S. Census Bureau website.

U.S. Geological Survey data was used to estimate the elevation of each census block in the continental U.S. and Hawaii. The data used for the 2000 Census elevations have a resolution of 3 arc seconds, or about 90 meters.[9] The data used for the 2010 Census elevations have a resolution of 1/3 of an arc second, or about 10 meters.[10] Using analysis tools (ArcGIS® 9.1 software application for the 2000 Census, and ArcGIS® 10 for the 2010 Census), elevation was estimated for each census block in Alaska and the U.S. Virgin Islands. The point locations of the census blocks in Alaska and the U.S. Virgin Islands were overlaid with a raster layer of North American Digital Elevation Model (DEM) elevations (in meters).[9] An elevation value was assigned to each census block point based on the closest point in the ArcGIS elevation raster file.

An algorithm used in AERMAP, the AERMOD terrain processor, is used to determine controlling hill heights.[11,12] These values are used for flow calculations within AERMOD.

To save run time and resources, the HEM-3 census block elevation database is substituted for the DEM data generally used in AERMAP. As noted above, the census block elevations were originally derived from the DEM database. To determine the controlling hill height for each census block, a cone is projected away from the block centroid location, representing a 10% elevation grade. The controlling hill height is selected based on the highest elevation above that 10% grade (in accordance with the AERMAP methodology). The distance cutoff for this calculation is 100 km. (This corresponds to an elevation difference at a 10% grade of 10,000 m, which considerably exceeds the maximum elevation difference in North America.)

2.4.3 Meteorological Data

HEM-3 includes an extensive library of meteorological data to support the AERMOD dispersion model. Currently 824 meteorological stations have been preprocessed for AERMOD as part of the RTR effort. Section 3.3 includes a depiction of these meteorological stations and Appendix 2 discusses the preparation of meteorological data for the RTR in more detail.

2.4.4 Gaseous Deposition Parameters

HEM-3 provides options to compute the deposition of air pollutants, and to take into account the impacts of plume depletion due to deposition of gaseous and particulate pollutants. If the deposition and depletion option is selected by the model user for gaseous pollutants, a number of pollutant properties are required by AERMOD. (These include the diffusivity of the pollutant in air, the diffusivity of the pollutant in water, the Henry's Law constant, and a parameter reflecting the cuticular resistance to uptake of the pollutant by leaves r_{CL}).[13] HEM-3 includes a library of these parameters for most gaseous HAPs. This library is based on a compendium of gaseous deposition parameters developed by Argonne National Laboratories.[14] It should be noted, however, that the deposition and depletion option of HEM-3 and AERMOD have not been used to date for the RTR assessments.

3. Modeling for the Residual Risk Technology Review

This section discusses the general approach used to implement the HEM-3 AERMOD system for the RTR modeling analyses. Separate reports have been prepared for each of the emission source categories analyzed to date. These reports provide information on the emissions inputs and results for specific emission categories.

3.1 Emission Source Inputs

HEM-3 and AERMOD require detailed data on emissions from each emission source included in the modeling analysis. These data include:

- pollutants emitted;
- emission rate for each pollutant;
- emission source coordinates;
- stack height (or emission height for fugitive and other area sources);
- stack diameter (or configuration of fugitive and other area sources);
- emission velocity; and
- emission temperature.

Emissions data for the RTR assessments are compiled form a variety of data sources (i.e., the 2005 National Emissions Inventory (NEI)[15] ,information data requests). Each source category under the RTR program, in most cases, utilizes the latest best available data. These data include HAP emission rates, emission source coordinates, stack heights, stack diameters, flow rates, and exit temperatures. EPA performs an engineering review of the NEI data. In cases where new or better data were known to exist for a particular source category, that information is integrated into the data used in modeling for that category. For each source category, the emissions are summarized in the source category specific report. Detailed computer files containing all emission and release characteristics are available in the docket prepared for the specific RTR source category proposed or final rule.

As noted in the previous section, industrial emission sources can be characterized in AERMOD as point, area, polygon, or volume sources. Fugitive emissions are generally characterized as low point sources with minimal exit velocities. For some categories, additional information was available on the configuration of fugitive emission sources. This information was incorporated into the emissions database as part of the engineering review. Thus, fugitive emission sources were characterized as area or volume sources when sufficient configuration information was available.

3.2 Pollutant Cross-Referencing

Because the NEI is developed from a number of different data sources, a single chemical may be listed in the inventory under different names (i.e. a “common name” and one or more structure-based names). In addition, pollutant groupings such as polycyclic organic matter (POM), can be listed in the NEI under the names of individual member compounds, and under different synonyms (e.g. polynuclear aromatic hydrocarbons). HEM-3 requires an exact match in the chemical name in order to link emissions to the appropriate dose-response factors. The model will not process any pollutant that is not specifically listed in the chemical library. Therefore, all of the HAP names used in the NEI were linked to the appropriate chemical names in the HEM-3 reference file.

Pollutant-specific dose response values are used in the HEM-3 modeling whenever available, including when modeling POM pollutants. Pollutant groupings, such as POM groupings, are used for POMs without a chemical-specific unit URE's. These POMs are assigned a URE associated with various POM compounds having similar characteristics. "An Overview of Methods for EPA's National-Scale Air Toxics Assessment" 2011 document[16] provides more details regarding POM modeling, including:

> [S]ome emissions of POM were reported in [the] NEI as "7-PAH" or "16-PAH," representing subsets of certain POM, or simply as "total PAH" or "polycyclic organic matter." In other cases, individual POM compounds are reported for which no quantitative cancer dose-response value has been published in the sources used for NATA. As a result, simplifying assumptions that characterize emissions reported as POM are applied so that cancer risk can be quantitatively evaluated for these chemicals without substantially under- or overestimating risk (which can occur if all reported emissions of POM are assigned the same URE). To accomplish this, POM emissions as reported in NEI are grouped into categories. EPA assigns dose-response values based on the known or estimated toxicity for POM within each group and on information for the POM speciation of emission sources, such as wood fires and industrial processes involving combustion.

Emissions of metal compounds are also adjusted using algorithms developed for the Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP) under the National-scale Air Toxics Assessment (NATA). A mass adjustment factor was applied to the emissions of metal compounds to account for a particular portion (e.g., the lead portion of lead sulfate) or to partition them among multiple pollutant categories (e.g. chromium arsenate into chromium VI compounds and arsenic compounds). In addition, where no specific compound information was available, metals were speciated into appropriate oxidation states (e.g. chromium compounds into chrome VI and chrome III) based on factors that have been developed for specific source categories and average factors that have been developed for the inventory as a whole. The adjustment factors and speciation factors were taken from the HAP Table module of EMS-HAP.[17,18]

3.3 Meteorological Data

Nationwide meteorological data files are accessed by HEM-3 and used for the RTR modeling. The current HEM-3 AERMOD Meteorological Library includes over 800 nationwide locations, depicted in Figure 3-1. This library contains surface and upper air meteorological data from National Weather Service (NWS) observation stations, which are named beginning with the state abbreviation for the state in which the station is located. AERMOD requires surface and upper air meteorological data that meet specific format requirements.[19,20] Appendix 2 discusses the preprocessing performed on the meteorological data used by AERMOD and includes a detailed listing of the 824 meteorological station pairs.

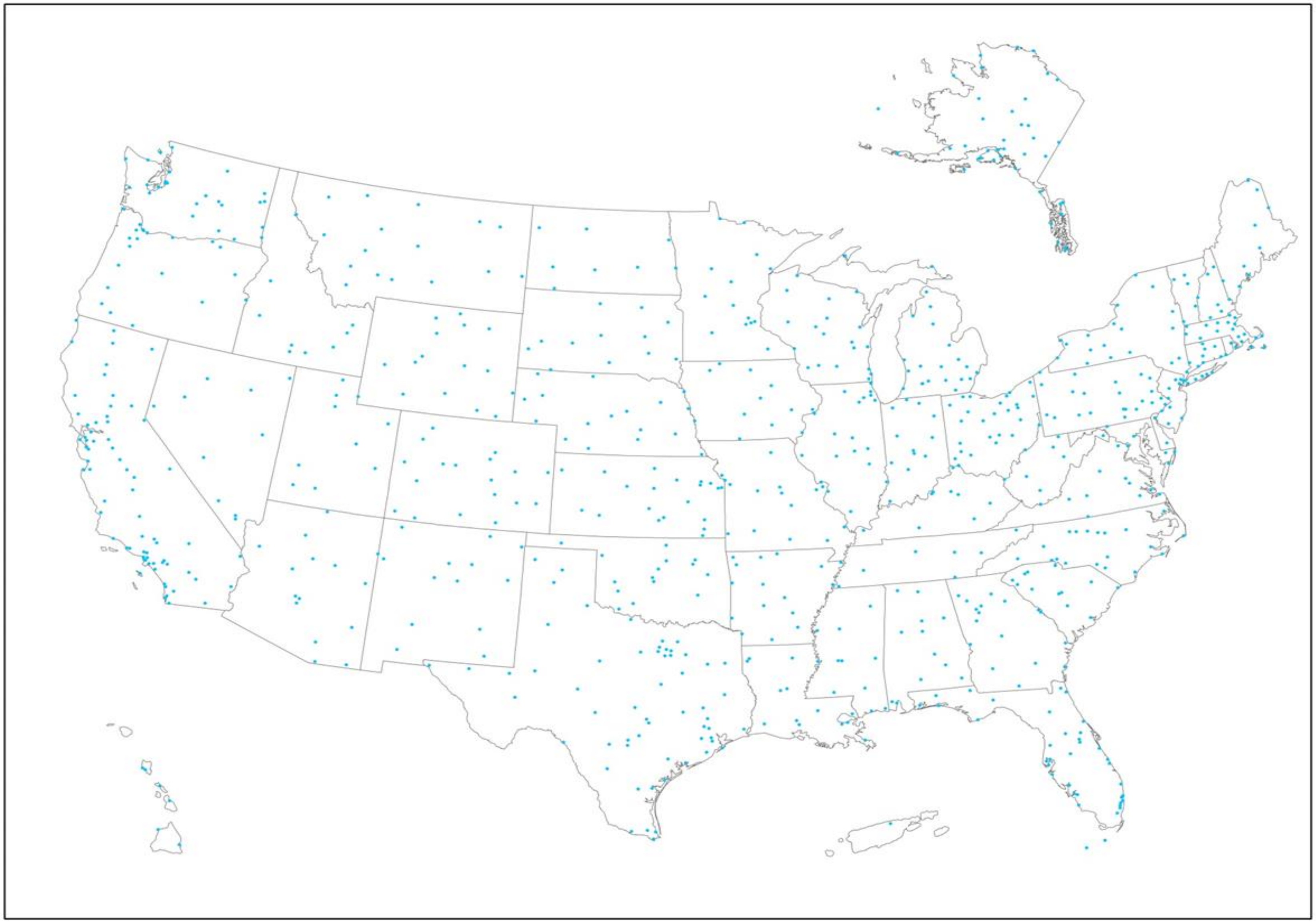


Figure 3-1. AERMOD Meteorological Stations

3.4 Model Options Selected

HEM-3 presents a number of options for characterizing the modeling domain and data sources. As many sources are generally modeled in RTR assessments, established defaults and common practices are relied on to make these choices. The choices available to a HEM-3 user and the selections that are made in most RTR assessments are presented in Table 3-1. Some of the key selections are discussed in more detail in the paragraphs below.

It should be noted that although routine emissions are not expected to vary significantly with time, nonroutine (upset) emissions can be significant relative to routine emissions. Upset emissions occur during periods of startup, shutdown, and malfunction. Upset emissions are not likely for equipment or storage tanks, but do result from malfunctioning control devices and leaks in cooling tower heat exchangers. There is some limited data on upset emissions available,[21] but no facility-specific analyses of these data were performed to characterize short-term emissions from these emission sources, and upset emissions are generally not modeled for the RTR risk assessments.

3.4.1 Urban or Rural Dispersion Characteristics

Current RTR source category assessments which use the 2010 Census are based on either urban or rural dispersion characteristics, depending on the land characteristics surrounding each modeled facility. The EPA provides guidance on whether to select urban or rural dispersion coefficients in its Guideline on Air Quality Models.[22] In general, the urban option is used if (1) the land use is classified as urban for more than 50% of the land within a 3-kilometer radius of the emission source, or (2) the population density within a 3-kilometer radius is greater than 750 people per square kilometer. Of these two criteria, the land use criterion is more definitive.

Using the 2010 Census, the HEM-3 model determines, by default, whether to use rural or urban dispersion characteristics. HEM-3 will find the nearest census block to the facility center and determine whether that census block is in an urban area, as designated by the 2010 Census.[23] The population of the designated urban area will be used to specify the population input for AERMOD's urban mode. (Alternatively, a user may select the rural or urban option to override determination by the model. If a user selects an urban dispersion environment, then the user must provide the urban population as well.)

For the 2008 and prior screening-level RTR assessments of 51 source categories, the rural option was chosen to be most conservative (i.e., more likely to overestimate risk results). The rural option is also chosen by default by the HEM-3 model whenever the 2000 Census is selected by the user.

3.4.2 Deposition and Plume Depletion

The RTR modeling analysis to date has not taken into account the depletion of pollutant concentrations in the plume due to wet or dry deposition, although HEM-3 can model deposition and depletion using AERMOD. In addition, reactivity and decay have not been considered. It is possible that this approach may overestimate air concentrations and therefore risk. However, one of the main metrics used by EPA in the residual risk program is the risk to the individual most exposed (the maximum individual risk, or MIR). Because the maximum risk usually occurs at a receptor very close to the emission source, it is unlikely to be influenced by altered plume dispersion characteristics of this type. For more refined, multipathway assessments, EPA may consider deposition and depletion.

3.4.3 Cutoff Distance for Modeling of Individual Blocks

The cutoff distance for modeling individual Census blocks is initially set to 3 km by default. This distance generally ensures that the maximum individual cancer risk and the maximum TOSHI are modeled explicitly and not interpolated. Following a modeling run, the results for each facility are checked to determine whether the maximum impacts are located inside the modeling cutoff distance. If the maximum impacts are outside the cutoff distance, and if any of the impacts are significant, then HEM-3 is rerun for the facility with a cutoff distance greater than 3 km. In general, this is done if the cancer risk exceeds 1 in 1 million or any TOSHI exceeds 1. However, the risks for such facilities are generally very low, since the maximum impacts are in most cases only interpolated when the nearest Census block is more than 3 km from the facility (i.e., in sparsely populated areas).

3.4.4 Facility Boundary Assumptions

The main input mechanisms for incorporating facility boundary information in HEM-3 are the overlap distance, the distance to the innermost polar receptor ring, and user-specified receptor locations. The NEI does not provide information on facility boundaries. However, satellite/aerial images are used to locate residential populations that are closer to a facility than the Census block centroid. User-specified receptor locations are used in such assessments to avoid underestimating risk. Conservative default assumptions are used for the overlap distance and the innermost polar receptor ring. However, these are adjusted for some categories where facility sites are known to be large. In addition, satellite imagery is used to check the facility boundary assumptions for facilities with large projected impacts. These checks are discussed further in the section on Quality Assurance (Section 4).

Table 3-1. HEM-3 Domain and Set-Up Options As Used in the Residual Risk and Technology Review Assessments

Option	Selection
Dispersion model	AERMOD
Census database: 2010 or 2000	Based on date of analysis
Type of analysis: chronic, acute, or both	Both
Averaging time for short term impacts	1-hour
Multiplier for short term emissions	10 generally, although multiple source type-specific factors are also used if available
Dispersion characteristics: urban or rural, as determined by model, based on closest 2010 Census block to each facility (when using 2010 Census). Rural by default, when using the 2000 Census.	Urban or Rural based on facility location; (Rural for 2000 Census)
Include terrain impacts	Yes
Include building wake effects	No
Calculate deposition (wet, dry, or both) & include impacts of plume depletion	No
User-specified receptor locations (for residential population locations, facility boundary sites, or other sites of interest)	Yes, for some facilities
Modeling domain size – maximum distance to be modeled	50 km
Cutoff distance for modeling of individual blocks	3 km[a]
Overlap distance where receptors are considered to be on facility property – measured from each source measured from each source	30 m[b]
Polar receptor network specifications:	
Distance from the facility center to the innermost ring	≥ 100 m[c]
Number of rings	13
Number of directions	16
Meteorology data	Closest site

[a] The individual block modeling cutoff is increased for categories and for some facilities to ensure that the maximum individual risk values are not interpolated.

[b] The overlap distance is adjusted for some facilities to avoid modeling locations that are on facility property (see section 4.2).

[c] HEM-3 sets the innermost ring distance to be just outside the emission sources but not < 100 m.

3.5 Modeling of Multiple Facilities

HEM-3 models one facility at a time. However, clusters of nearby facilities may impact the same people, resulting in higher risk to those people. To account for this situation, risks are summed at each Census block for all facilities affecting the Census block.

As described earlier (Section 2.3.4), HEM-3 produces detailed output tables containing the risk and population for every Census block in the modeling domain. These detailed tables are combined for all facilities in a source category and the risk for each Census block is summed, using the RTR Summary Program add-on module to the Multi HEM-3 model.[3] Thus, the effect of multiple facilities in the same source category on the same receptor are estimated. The resulting "combined facility" or "cluster-effect" Census block risks are used to calculate population exposure to different cancer risk levels, noncancer hazard indices, and source category incidence.

4. Quality Assurance

The National Emissions Inventory (NEI) is subject to an extensive program of quality assurance (QA) and quality control (QC). The QA/QC program for the point source component of the NEI is documented in a separate report, available from the NEI website.[24] This section describes QA activities carried out under the RTR modeling analysis.

4.1 Engineering Review

In addition to the standardized QA steps taken for the entire NEI, EPA performs an engineering review of NEI data for the emission source categories included in the RTR analysis. This engineering review includes two main components. The first component addresses the list of facilities included in each source category. EPA engineers review independent sources of information to identify all sources in the category that are included in the NEI. In addition, EPA reviews the list of sources represented as part of each category in the NEI to make sure that the facilities actually manufacture products characteristic of the source category.

The second component of the engineering review focuses on the appropriateness of facility emissions. EPA reviews the list of HAPs reportedly emitted by each facility to make sure that the pollutants are appropriate to the source category. In addition, EPA engineers review the magnitude of those HAP emissions. In cases where new or better data are known to exist for a particular source category, that information is integrated into the data used in modeling for that category. In these cases, the source category specific documents provide additional details on the emissions inputs used.

4.2 Geographic Pre-Modeling Checks

The NEI QA process includes some basic checks on location data for point sources. The coordinates for each source are checked to ensure that they are in the county that has been specified for the source. If this is not the case, or if no geographic coordinates are available for the emission source, then the coordinates are set to a default location based on the nature of the emission source category.[25] In addition, coordinates for all emission sources at a given facility are checked to ensure that they are within 3 km of one another. These QA checks happen prior to HEM-3 modeling and the results of such checks are reflected in the HEM-3 input files.

Another pre-modeling geographic QA check regards the location of the census block receptors. As noted above, to estimate ambient concentrations for evaluating long-term exposures, the HEM-3 model uses the census block centroids as dispersion model receptors. The census block centroids are often good surrogates for where people live within a census block. A census block generally encompasses about 40 people or 10-15 households. However, in cases where a block centroid is located on industrial facility property, or where a census block is large and the centroid less likely to be representative of the block's residential locations, the block centroid may not be an appropriate surrogate.

Census block centroids that are on facility property can sometimes be identified by their proximity to emission sources. In cases where a census block centroid is within 300 meters of any emission source, aerial images of the facility are reviewed to determine whether the block centroid is likely located on facility property. The selection of the 300-meter distance reflects a compromise between too few and too many blocks identified as being potentially on facility property. Distances smaller than 300 meters would identify only block centroids very near the emission sources and could exclude some block centroids that are still within facility boundaries, particularly for large facilities. Distances significantly larger than 300 meters would identify many block centroids that are outside facility boundaries, particularly for small facilities. Block centroids confirmed to be located on facility property are moved to a location that best represents the residential locations in the block.

In addition, census block centroids for blocks with large areas may not be representative of residential locations. Risk estimates based on such centroids can be understated if there are residences nearer to a facility than the centroid, and overstated if the residences are farther from the facility than the centroid. To avoid understating the maximum individual risk associated with a facility, block centroids are relocated in some cases, or additional user-specified receptors are added to a block. Aerial images of all large census blocks within one kilometer of any emission source are examined. Experience from previous risks characterizations show that in most cases the MIR is generally located within 1 km of the facility boundary. If the block centroid does not represent the residential locations, it is relocated in the HEM-3 input files to better represent them. If residential locations cannot be represented by a single receptor (that is, the residences are spread out over the block), additional user-specified receptors are included in the HEM-3 input files to represent residences nearer to the facility than the centroid.

4.3 Geographic Post-Modeling Checks

As part of the RTR modeling analysis, additional geographical QA checks are made for some facilities, after initial HEM-3 modeling results are reviewed. Facilities subjected to these additional checks include:

- cases where the initial estimates of maximum risks are particularly high
    - maximum individual cancer risk of over 1 in 10,000
    - any maximum TOSHI above 10
- cases where no Census blocks are identified by the model within 3 km of the facility

HEM-3 produces a detailed Google Earth™ map of the modeled point and area emission sources and surrounding receptors (including Census block centroids, polar receptors and user-specified receptors) overlaying Google Earth™'s satellite imagery. This map allows a QA check of the specific source locations, as well as an approximate check of the facility boundaries. The emission source coordinates are reviewed for each of these facilities and compared with the address reported for the facility. If the address and the coordinates represent the same location, then the coordinates are taken to be correct. For more recent modeling of source categories, the emission coordinates initially modeled by HEM-3 tend to be correct, as they undergo pre-modeling scrutiny and QA checks (as discussed in Section 4.2).

More rarely, the modeled emission coordinates will be determined post initial modeling not to be located on facility property. If the facility and emission coordinate locations are different, then the satellite imagery for the address and the coordinate location are reviewed to determine whether either photograph includes an industrial facility. Generally for the 2008 and prior screening-level RTR assessments of 51 source categories, where the two locations were different, the facility address was found to be correct (and the emission source coordinates required correction). In some cases, this comparison could not be made because the reported address was a Post Office box or a headquarters address. Where this occurred, the aerial photograph for the coordinate location was reviewed to determine whether an industrial facility was located at or near the location. If emission source coordinates are found to be incorrect, HEM-3 is rerun using corrected coordinates. These changes are described in the source category documents.

For the high-risk facilities, the coordinates used to represent the most impacted Census blocks are also reviewed. This review draws on detailed Census block boundary maps and satellite imagery. Large industrial facilities will frequently occupy one or more entire Census blocks. However, these blocks may also include one or more residences on the periphery of the industrial land. Generally, the centroid coordinates listed for a Census block are near the center of the block. In these cases of mixed industrial and residential blocks, the coordinates may be on facility property.

In general, block coordinates are considered to be on facility property if they are located between the different emission source locations listed for the facility. In these situations, HEM-3 is rerun with an expanded overlap distance, in order to exclude the Census block coordinates that appear to be located on facility property. The distance to the innermost polar receptor ring is also adjusted to ensure that this ring is not on facility property, but as close to the apparent facility boundaries as possible.

5. Uncertainties

The RTR risk assessments using HEM-3 and AERMOD are subject to a number of uncertainties. For instance, model verification studies for AERMOD show predicted maximum annual concentrations ranging from 0.3 to 1.6 times measured values, with an average of 0.9. Predicted maximum short term (1 to 24 hours) concentrations were 0.25 to 2.5 times measured values, with an average of 1.0.[25]

In addition, a number of simplifying assumptions are made in these modeling analyses. First, the coordinates reported by the Department of Census for Census block internal points ("centroids") have been used as a surrogate for long-term population exposures. Locations of actual residences have not been modeled. In addition, the current version of HEM-3 does not take into account the movement of people from one Census block to another during the course of their lives, or commuting patterns during a given day. Nor does the model take into account the attenuation of pollutant from outside emission sources in indoor air. Ideally, risks to individuals would be modeled as they move through their communities and undertake different activities. However, such modeling is time-and resource-intensive and can only capture a portion of the uncertainty associated with the full range of human activities. In general, it is expected that long-term exposures will be overstated for high-end estimates (as most individuals will not spend all their time at their highly affected residences), but may understate the total population exposed (as some individuals living outside the modeled area may regularly commute into the area for work or school).

When considering long-term or lifetime exposures, it should be noted that relatively few people in the United States reside in one place for their entire lives. For the purposes of this assessment, cancer risk estimates are based on a lifetime exposure at the Census-identified place of residence. While it is impossible to know how this assumption affects the risk experiences by a particular individual (as people can move into higher- or lower-risk areas), it is likely that this assumption will overstate the exposure to those most exposed (i.e., people already living in high exposure areas are unlikely to move to yet higher exposure areas). However, this assumption will also tend to underestimate the total number of people exposed and population risk (i.e., incidence) because population levels are generally increasing.

In the current analyses, only direct inhalation is modeled. Other pathways such as the deposition of pollutants to drinking water, and to bioaccumulation of deposited pollutants in the food supply may be a significant source of exposure for persistent and bioaccumulative hazardous air pollutants (PB HAP). Screening level evaluations of the potential human health risks associated with emissions of PB HAP from the modeled facilities are used to determine if additional analyses are needed, but these analyses are outside the scope of this document. Because the HEM-3 AERMOD analyses are restricted to the inhalation pathway, the impacts of plume depletion due to deposition are not taken into account. Thus, inhalation impacts may be overestimated for some pollutants, but exposures through other pathways would be underestimated.

A number of other simplifications are made in the dispersion modeling analyses, as noted in Table 3-1. For instance, building wake effects are not considered. In addition, meteorological observations are based on the closest station in the HEM-3 meteorological library (see Figure 3-1). Alternative meteorological stations may be more appropriate for some facilities. Ideally, facility-specific meteorological observations would be used. A single year of meteorological data (2011) is currently used for AERMOD's dispersion modeling. (The 2008 and prior screening-level RTR assessments of 51 source categories used meteorological data based on the year 1991.) When considering off-site meteorological data most site specific dispersion modeling efforts will employ up to five years of data to capture variability in weather patterns from year to year. However, because of the large number of facilities in the analyses and the extent of the dispersion modeling analysis (national scale), it is not practical to model five years of data. Other national studies such as NATA also consider only a single year of meteorological data. A sensitivity analyses performed by the NATA assessment found that variability attributable to the selection of the meteorology location/time (both temporal and spatial) resulted in a 17-84% variation in predicted concentrations at a given station.[26]

Finally, risk and exposure factors are also subject to uncertainty. Not all individuals experience the same degree of exposure or internal dose of a given pollutant due to individual-specific parameters such as weight, age, and gender. While the health benchmarks used in the analyses crudely account for sensitive populations, a prototypical human (e.g., body weight, ventilation rate) is used to define the benchmark. Because of the variability of these parameters in the population, this factor will result in a degree of uncertainty in the resulting risk estimate.

Table 5-1 summarizes the general sources of uncertainty for the RTR modeling analyses. The table also gives a qualitative indication of the potential direction of bias on risk estimates. The sources of uncertainty in Table 5-1 are divided into four categories, based on the major components of the analyses:

- emissions inventory;
- fate and transport modeling;
- exposure assessment; and
- toxicity assessment.

It must also be noted that individual source categories may be subject to additional uncertainties. These are discussed in separate reports which are prepared for each emission source category included in the RTR assessments.

Table 5-1. Summary of General Uncertainties Associated with Risk and Technology Review Risk Assessments

Parameter	Assumption	Uncertainty/Variability Discussion	Potential Direction of Bias on Risk Estimates
Emissions Inventory			
Individual HAP emissions rates and facility characteristics (stack parameters, property boundaries)	Emissions and facility characteristics from the NEI provide an accurate characterization of actual source emissions.	Our current emissions inventory is based on the 2005 NEI, our internal review, and public comments received. The degree to which the data in our inventory represents actual emissions is likely to vary across sources. For the 2008 screening level assessments, nearly half of the sources in a given source category submitted a review of their emissions and facility characteristics data. Some detailed data, such as property boundary information is not available for most facilities. This is an important consideration in determining acute impacts.	Unbiased overall, magnitude variable
Multiplier for short-term emission rates	Generally, maximum short term emission rates are estimated by applying a simple multiplier (a factor of 10) to average annual emissions.	The ratio between short-term and long-term average emission rates may vary among the different emission sources at a facility. In addition, the use of a simple multiplier means that impacts of maximum short term emissions are modeled for all meteorological conditions, including the worst-case conditions for population exposure.	Potential overestimate due to the fact that worst-case emissions are assumed to occasionally coincide with worst-case meteorology. Overestimate due to lack of actual information on short-term emission rates.
Fate and Transport Modeling			
Atmospheric dispersion model choice	AERMOD is EPA's recommended dispersion model for assessing pollutant concentrations from industrial facilities	Field testing of dispersion models, including AERMOD, have shown results to generally be within a factor of 2 of measured concentrations.	Unbiased overall
Building downwash	Not included in assessments	Use of this algorithm in AERMOD could improve the dispersion calculations at individual facilities. However, data are not readily available to utilize this option.	Potential underestimate of maximum risks near facility. No effect on risks further out.
Plume deposition and depletion	Not included in assessments	Ignoring these impacts for pollutants that deposit minimally, and whose risks derive predominantly from inhalation, should have minimal effect on risk estimates.	Unbiased or minimal overestimate.

Table 5-1. Summary of General Uncertainties Associated with Risk and Technology Review Risk Assessments (continued)

Parameter	Assumption	Uncertainty/Variability Discussion	Potential Direction of Bias on Risk Estimates
Meteorology	One year of meteorological data from the nearest weather station (selected from 824 nationwide) is representative of long-term weather conditions at the facility.	The use of one year of data rather than the five or more adds uncertainty based on whether that year is representative of each location's climatology. Use of weather station data rather than on-site data can add to uncertainty. Additionally, the use of default surface parameters in the generation of the meteorological datasets imparts uncertainty to the results from any individual facility.	Minimal underestimate or overestimate.
Reactivity	Not included in the assessments	Chemical reactions and transformations of individual HAP into other compounds due to solar radiation and reactions with other chemicals happens in the atmosphere. However, in general, the HAP in this assessment do not react quickly enough for these transformations to be important near the sources, where the highest individual risks are estimated. Further, most of the HAP do not react quickly enough for these transformations to be important to risk estimates in the entire modeled domain (i.e., within 50 km of the source).	No impact on maximum risk estimates. Minimal impact on population risks and incidence.
Maximum modeling distance	50 kilometers from center of facility	This distance is considered to be the maximum downwind distance for a Gaussian plume model such as AERMOD. This is because, in general, winds cannot be considered to follow straight line trajectories beyond this distance.	No effect on maximum individual risks. Minimal underestimation of incidence.
Exposure Assessment			
Locations and short-term movements of individuals	Ambient concentration at centroid of each off-site census block is equal to the exposure concentration for all people living in that census block. Effect of human activity patterns on exposures is not included in the assessment.	People live at different areas within block that may have higher or lower exposures than at the centroid. Individuals also move from outdoors to indoors and from home to school/work to recreation, etc., and this can affect their total exposure from these sources.	Unbiased across population for most pollutants and individuals, likely overestimate for most exposed and underestimate for least exposed persons.

Table 5-1. Summary of General Uncertainties Associated with Risk and Technology Review Risk Assessments (continued)

Parameter	Assumption	Uncertainty/Variability Discussion	Potential Direction of Bias on Risk Estimates
Long-term movements of individuals	MIR individual is exposed continuously to the highest exposure concentration for a 70-year lifetime.	Maximum individual risk (MIR) is defined in this way to be a maximum theoretical risk at a point where a person can actually reside.	Unbiased for most individuals, likely overestimate for the actual individual most exposed and likely underestimate for the least exposed. Incidence remains unbiased unless population around facilities increases or decreases over 70 years.
Toxicity Assessment			
Reference concentrations (RfC)	Consistent with EPA guidance, RfCs are developed including uncertainty factors to be protective of sensitive subpopulations. Additionally, RfCs are developed based on the level producing an effect in the most sensitive target organ or system.	While other organ systems may be impacted at concentrations above the RfC, these are not included in the calculation of target organ-specific hazard indices.	In general, EPA derives RfCs using procedures whose goal is to avoid underestimating risks in light of uncertainty and variability. The greater the uncertainties, the greater the potential for overestimating risks.
Unit Risk Estimate (URE)	Use of unit risk estimates developed from dose-response models such as linear low-dose extrapolation.	Uncertainty in extrapolating the impacts from short-duration, high-dose animal or work-related exposures to longer duration, lower-dose environmental impacts.	Overestimate of risks for nonlinear carcinogens and for linear carcinogens with sparse health effects data. In general, EPA derives URE values using procedures aimed at overestimating risks in light of uncertainty and variability.
Toxicity of mixtures	Cancer risks and noncancer hazard quotients were calculated for each HAP individually and then summed into a total risk or hazard index (assumption of additivity).	Concurrent exposures to multiple chemicals may result in either increased or decreased toxicity due to chemical interactions but the data needed to quantify these effects are generally not available.	Unbiased overall. Some mixtures may have underestimated risks, some overestimated, and some correctly estimated.

Table 5-1. Summary of General Uncertainties Associated with Risk and Technology Review Risk Assessments (continued)

Parameter	Assumption	Uncertainty/Variability Discussion	Potential Direction of Bias on Risk Estimates
Surrogate dose- response values for HAPs without values	In the case of groups of HAPs such as glycol ethers, the most conservative dose-response value of the chemical group was used as a surrogate for missing dose-response values in the group. For others, such as unspeciated metals, we have applied speciation profiles appropriate to the source category to develop a composite dose-response value for the group. For HAP which are not in a group and for which no URE's or RfC's are available from credible sources, no assessment of risk is made.	Rather than neglecting the assessment of risks from some HAPs lacking dose response values, conservative assumptions allow the examination of whether these HAPs may pose an unacceptable risk and require further examination, or whether the conservative level examination with surrogates screens out the HAPs from further assessment.	Overestimate where most conservative values used. Unbiased where category-specific profiles applied. There is the potential to underestimate risks for pollutants which are not included in the assessment.

6. References

1. EPA. 2004. *AERMOD: Description of Model Formulation*. EPA-454/R-03-004, U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/ttn/scram/7thconf/aermod/aermod_mfd.pdf

2. EPA. 2004. *User's Guide for the AMS/EPA Regulatory Model - AERMOD.* EPA-454/B-03-001, U.S. Environmental Protection Agency, Research Triangle Park, NC. www.epa.gov/scram001/dispersion_prefrec.htm#aermod

3. EPA. 2013. The Human Exposure Model (HEM): Single-facility HEM-3 User's Guide; and Multi-facility HEM-3 and RTR Summary Programs User's Guide. Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC, by EC/R Inc., Chapel Hill, NC. February 2013. http://www.epa.gov/ttn/fera/human_hem.html

4. EPA. 2012. Dose-Response Assessment for Assessing Health Risks Associated With Exposure to Hazardous Air Pollutants. U.S. Environmental Protection Agency, Research Triangle Park, NC. Available at: http://www.epa.gov/ttn/atw/toxsource/summary.html

5. EPA. 2011. *Glossary of Key Terms*. Technology Transfer Network Air Toxics, 2005 National-Scale Air Toxics Assessment. U.S. Environmental Protection Agency. http://www.epa.gov/ttn/atw/natamain/gloss1.html.

6. EPA. 2004. Air Toxics Risk Assessment Reference Library, EPA-453-K-04-001A, U.S. Environmental Protection Agency, Research Triangle Park, NC. April 2004. www.epa.gov/ttn/fera/risk_atra_vol1.html

7. Census. 2000. *LandView® 5 on DVD*. U.S. Census Bureau, Washington, DC.

8. Census. 2010. Census Summary File 1 – United States: http://www2.census.gov/census_2010/04-Summary_File_1/ prepared by the U.S. Census Bureau, Washington, DC, 2011. See also Technical Documentation for the 2010 Census Summary File 1.

9. USGS. 2006. *US GeoData Digital Elevation Models – Fact Sheet 040-00 (April 2000).* U.S. Department of the Interior - U.S. Geological Survey, Washington, DC. http://data.geocomm.com/sdts/fs04000.pdf

10. USGS. 2010. USGS Seamless Data Warehouse. U.S. Department of the Interior - U.S. Geological Survey, Washington, DC. http://nationalmap.gov/viewer.html

11. EPA. 2004. User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-03-003, U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/scram001/dispersion_related.htm#aermap

12. EPA. 2011. Addendum to the User's Guide for the AERMOD Terrain Preprocessor (AERMAP) (EPA-454/B-03-003, October 2004), U.S. Environmental Protection Agency, Research Triangle Park, NC. March 2011. http://www.epa.gov/scram001/dispersion_related.htm#aermap

13. EPA. 2012. *Addendum: User's Guide for the AMS/EPA Regulatory Model – AERMOD (EPA-454/B-03-001, September 2004)* (Section 2.2 related to deposition). U.S. Environmental Protection Agency, Research Triangle Park, NC. December 2012. http://www.epa.gov/scram001/dispersion_prefrec.htm#aermod. See also the AERMOD Deposition Algorithms – Science Document (Revised Draft)" at http://www.epa.gov/ttn/scram/7thconf/aermod/aer_scid.pdf

14. Wesely, M.L., P.V. Doskey, and J.D. Shannon. 2002. *Deposition Parameterizations for the Industrial Source Complex (ISC3) Model*. ANL/ER/TR–01/003, Argonne National Laboratory, Argonne, Illinois 60439. See "AERMOD Deposition Parameterizations Document" pdf link under "Model Supporting Documents" section of TTN's Preferred/Recommended Models webpage at http://www.epa.gov/scram001/dispersion_prefrec.htm#aermod

15. EPA. 2012. *2005 National Emissions Inventory Data & Documentation*. U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/ttn/chief/net/2005inventory.html#inventorydata

16. EPA. 2011. An Overview of Methods for EPA's National-Scale Air Toxics Assessment. Prepared for EPA's Office of Air Quality, Planning, and Standards, Research Triangle Park, NC, by ICF International, Durham, NC. January 2011, p 55. http://www.epa.gov/ttn/atw/nata2005/05pdf/nata_tmd.pdf.

17. EPA. 2004. *EMS-HAP Modeling System*. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/scram001/dispersion_related.htm#ems-hap

18. Strum, Madeleine, Richard Mason, and James Thurman. 2004. *User's Guide for the Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP) Version 3.0*. EPA-454/B-03-006, Environmental Protection Agency, Research Triangle Park, NC. August 2004. http://www.epa.gov/ttn/scram/userg/other/emshapv3ug.pdf

19. EPA. 2004. User's Guide for the AERMOD Meteorological Preprocessor (AERMET), EPA-454/B-03-002, U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/scram001/7thconf/aermod/aermetugb.pdf

20. EPA. 2012. Addendum to the User's Guide for the AERMOD Meteorological Preprocessor (AERMET) (EPA-454/B-03-002, November 2004), U.S. Environmental Protection Agency, Research Triangle Park, NC. December 2012. http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet

21. Texas Commission on Environmental Quality. 2006. Reports on Air Emission Events. http://www.tceq.texas.gov/field/eventreporting

22. EPA. 2005. Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions. Appendix W of 40 CFR Part 51. http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf

23. Federal Register, 2012. Qualifying Urban Areas for the 2010 Census. FR 77:59 (27 March 2012). p.18652. http://www.gpo.gov/fdsys/pkg/FR-2012-03-27/pdf/2012-6903.pdf

24. EPA. 2006. *NEI Quality Assurance and Data Augmentation for Point Sources*. U.S. Environmental Protection Agency, Emission Inventory Group, RTP, NC. http://www.epa.gov/ttn/atw/nata2005/05pdf/2002nei_qa_augmentation_report0206.pdf

25. EPA. 2003. *AERMOD: Latest Features and Evaluation Results.* EPA-454/R-03-003, U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/scram001/7thconf/aermod/eval.pdf

26. EPA, 2001, National-Scale Air Toxics Assessment for 1996; EPA-453/R-01-003; EPA 454/B-03-003, U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/ttn/atw/nata/peer.html

Appendix 3
Meteorological Data for HEM3 Modeling

METEOROLOGICAL DATA PROCESSING
USING AERMET
FOR HEM3

US EPA
Air Toxic Assessment Group
RTP, NC 27711

May, 2016

BACKGROUND

The AERMOD meteorological processor, AERMET, and its supporting modeling system (AERSURFACE and AERMINUTE) were used to process one year of meteorological data for over 800 observation stations across the continental United States, Alaska, Hawaii, and Puerto Rico.

METEOROLOGICAL DATA

To estimate the boundary layer parameters required by AERMOD, AERMET requires hourly surface weather observations (which may include hourly values calculated from 1-minute data) and the full (i.e., meteorological variables reported at all levels) twice-daily upper air soundings. The surface and upper air stations are paired to produce the required input data for AERMOD.

USEPA meteorologists obtained calendar year 2014 Integrated Surface Hourly Data (ISHD) for over 800 Automated Surface Observation System (ASOS) stations spanning the entire US, as well as Puerto Rico and the US Virgin Islands, from the National Climatic Data Center (NCDC). To support AERMET, ASOS 1-minute data for each surface station were also obtained from NCDC in a DSI 6405 format.

Further, upper air sounding data for the same time period for over 80 observation sites were obtained from the “NOAA/ESRL” online Radiosonde Database. These datasets were produced by ESRL in Forecast Systems Laboratory (FSL) format. Attachment 1 lists the surface and upper air stations, as well as the coordinates, ground elevation, and anemometer height for each station.

AERMET PROCESSING

Utilizing the AERMET meteorological data preprocessor, and the ASOS surface and FSL upper air stations, surface and profile files for input into AERMOD were generated nationwide. The surface stations were paired with representative upper air stations by taking the upper air station closest to each surface station. The AERSURFACE tool was used to estimate the surface characteristics for input into AERMET utilizing land cover data surrounding the surface station. In addition, the AERMINUTE preprocessor was used to process 1-minute ASOS wind data for input into AERMET. Table 1 and Attachment 1 outline the approach and site specific inputs each of the data preprocessors and tools used to generate the AERMOD meteorological data.

Table 1. AERMET Processing Options

AERMET Options	Version	15181
	ASOS Site	Yes
	Surface Data Format	NCDC TD-3505 (ISHD)
	Upper Air Data Format	FSL, all levels, tenths m/s
	Wind Speed Threshold	0.5 m/s
	Beta Option (U*)	Yes
AERMINUTE Options	Version	15272
	Include 1 minute ASOS Data	Yes, where available TD-6405 format
AERSURFACE Options	Version	Nonpublic release version[1]
	Landcover data	USGS NLC for 2011
	Radius for Surface Roughness Calculations	1 km
	Seasons	Winter – Dec, Jan, Feb Spring – Mar, Apr, May Summer – June, July, Aug Fall – Sept, Oct, Nov
	Temporal resolution	Monthly, 12 sectors
	Site Surface Moisture	See Attachment 1
	Snow Cover	See Attachment 1

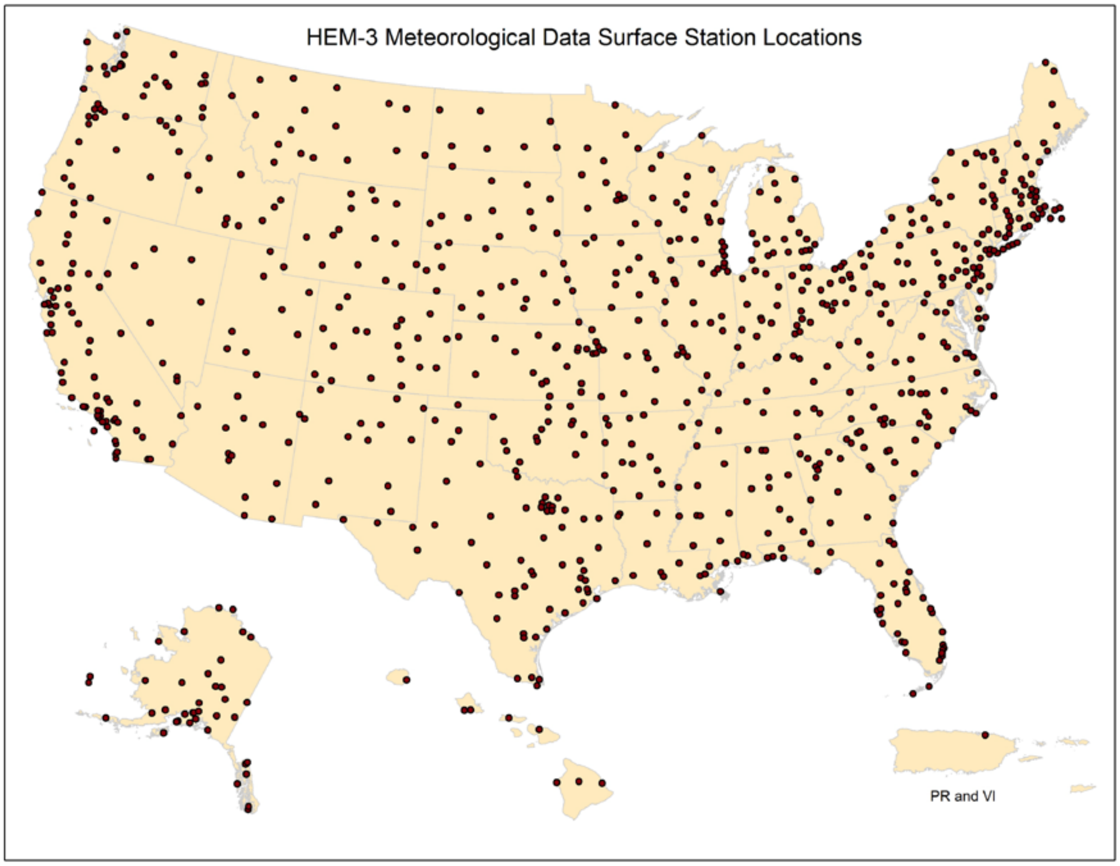
1 : generated with the pre-public release version of AERSURFACE date.

RESULTS

To assure that the data would support an AERMOD run, USEPA meteorologists ran AERMOD using a model plant with each AERMET SFC and PLF pairs. Further, the surface files were examined for completeness. If more than 10 percent of specific data including the Monin-Obukhov length, wind speed, and cloud cover were missing, the station was not considered suitable for the meteorological database.

In all, 823 met station pairs ran successfully in AERMOD and passed completeness criteria. Figure 1 is a map that shows the locations of the 823 surface stations. The processed 2014 meteorological data generated by the above approach is posted on the EPA's FERA (Fate, Exposure, and Risk Analysis) website under the HEM model page.

Figure 1. 823 HEM-3 Meteorological Stations.



Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
22551	PHJR	NA		EWA KALAELOA AP	21.31667	-158.06667	15	-10	10
21504	PHTO	ITO	062603	HILO INTL AP	19.7191	-155.053	12	-10	10
22521	PHNL	HNL	051209	HONOLULU INTL AP	21.324	-157.9294	2	-10	8
22516	PHOG	OGG	062909	KAHULUI AP	20.89972	-156.42861	16	-10	10
21510	PHKO	KOA	050809	KAILUA KONA KE-AHOLE	19.73556	-156.04889	9	-10	10
22536	PHLI	LIH	061109	LIHUE WSO AP 1020.1	21.98389	-159.34056	30	-10	10
22534	PHMK	MKK	061509	MOLOKAI AP	21.1545	-157.0961	135	-10	10
14931	KBRL	BRL	041707	BURLINGTON MUNI AP	40.78333	-91.12528	211	-6	10
14943	KSUX	SUX	043009	SIOUX CITY GATEWAY AP	42.3913	-96.3791	334	-6	10
24149	KLWS	LWS	041107	LEWISTON NEZ PERCE CO	46.3747	-117.0156	438	-8	8
24154	KMLP	MLP	070306	MULLAN PASS VOR_DME	47.45694	-115.645	1837	-8	8
3960	KCPS	CPS	051109	CAHOKIA ST LOUIS AP	38.57139	-90.15722	126	-6	10
93814	KCVG	CVG	042407	CINCINNATI NORTHERN K	39.04306	-84.67167	265	-5	10
3996	KTVR	TVR	060507	TALLULAH VICKSBURG AP	32.35	-91.02778	26	-6	10
54768	KAQW	AQW	110705	NORTH ADAMS HARRIMA	42.7	-73.16667	200	-5	10
93706	KHGR	HGR	040307	HAGERSTOWN WASHING	39.70778	-77.72972	213	-5	8
54772	KIZG	IZG	091206	FRYEBURG E SLOPES AP	43.99056	-70.9475	136	-5	10
94893	KIMT	IMT	110705	IRON MTN FORD AP	45.81833	-88.11444	338	-6	8
13988	KMKC	MKC	091306	KANSAS CITY DOWNTOW	39.1208	-94.5969	226	-6	8
53904	KSET	SET	102705	ST CHARLES CO AP	38.92861	-90.42806	133	-6	10
13993	KSTJ	STJ	030507	ST JOSEPH ROSECRANS A	39.7736	-94.9233	249	-6	10
53870	KAKH	AKH	112008	GASTONIA MUNI AP	35.19667	-81.15583	242	-5	10
14914	KFAR	FAR	092606	FARGO HECTOR INTL AP	46.92528	-96.81111	274	-6	10
14942	KOMA	OMA	091306	OMAHA EPPLEY AIRFIELD	41.3102	-95.8991	299	-6	10
94765	KLEB	LEB	011007	LEBANON MUNI AP	43.62639	-72.30472	182	-5	10
54791	KDAW	DAW	102005	ROCHESTER SKYHAVEN A	43.27806	-70.92222	96	-5	8
14792	KTTN	TTN	091708	TRENTON MERCER CO AP	40.27694	-74.81583	56	-5	8
94728	KNYC	NYC	091806	NEW YORK CNTRL PK TW	40.77889	-73.96917	40	-5	10
93812	KLUK	LUK	042007	CINCINNATI LUNKEN AP	39.10333	-84.41889	149	-5	10
24229	KPDX	PDX	020107	PORTLAND INTL AP	45.5958	-122.6093	6	-8	10
24242	KTTD	TTD	040407	PORTLAND TROUTDALE A	45.55111	-122.40889	9	-8	10
13739	KPHL	PHL	073009	PHILADELPHIA INTL AP	39.8683	-75.2311	3	-5	8

Attachment 1.

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
11641	TJSJ	SJU	012709	SAN JUAN L M MARIN AP	18.4325	-66.01083	3	-4	10
14794	KWST	WST	032107	WESTERLY STATE AP	41.34972	-71.79889	21	-5	8
94039	KIEN	IEN	102908	PINE RIDGE AP	43.02056	-102.51833	1005	-7	10
13882	KCHA	CHA	032707	CHATTANOOGA LOVELL A	35.0311	-85.2014	205	-5	10
3894	KCKV	CKV	041907	CLARKSVILLE OUTLAW AP	36.62389	-87.41944	171	-6	10
13728	KDAN	DAN	101508	DANVILLE RGNL AP	36.5728	-79.3361	174	-5	10
13743	KDCA	DCA	092606	WASHINGTON REAGAN A	38.8483	-77.0341	3	-5	8
54781	KDDH	DDH	110705	BENNINGTON MORSE ST	42.89139	-73.24694	243	-5	10
24219	KDLS	DLS	062206	THE DALLES MUNI AP	45.6194	-121.1661	72	-8	10
94298	KVUO	VUO	021306	VANCOUVER PEARSON A	45.62083	-122.65722	8	-8	8
14920	KLSE	LSE	092006	LA CROSSE MUNI AP	43.8788	-91.2527	199	-6	10
3859	KBLF	BLF	100308	BLUEFIELD MERCER CO A	37.2958	-81.2077	875	-5	8
3860	KHTS	HTS	012607	HUNTINGTON TRI STATE	38.365	-82.555	251	-5	8
14894	KHLG	HLG	022707	WHEELING OHIO CO AP	40.17639	-80.64722	359	-5	10
4111	KEVW	EVW	102005	EVANSTON BURNS FLD	41.27306	-111.03056	2175	-7	10
13714	KPOB	NA		FAYETTEVILLE POPE AFB	35.17389	-79.00889	66	-5	10
12974	KNOG	NA		ORANGE GROVE	27.9	-98.05	78	-6	10
21508	PHSF	NA		BRADSHAW AAF	19.76	-155.55361	1798	-10	10
13947	KFRI	NA		FT RILEY MARSHALL AAF	39.05	-96.76667	324	-6	10
13702	KLFI	NA		LANGLEY AFB	37.08278	-76.36028	3	-5	10
26451	PANC	ANC	091806	ANCHORAGE INTL AP	61.169	-150.0278	37	-9	8
26409	PAMR	MRI	041707	ANCHORAGE MERRILL FL	61.21694	-149.855	42	-9	5
25308	PANT	ANN	052606	ANNETTE WSO AP	55.0389	-131.5787	33	-9	10
27502	PABR	BRW	061703	BARROW POST ROGERS A	71.2834	-156.7815	9	-9	8
26615	PABE	BET	091306	BETHEL AP	60.785	-161.8293	31	-9	8
26533	PABT	BTT	051806	BETTLES AP	66.9167	-151.5186	196	-9	10
26415	PABI	BIG	100705	BIG DELTA AP	63.9944	-145.7214	389	-9	10
25624	PACD	CDB	091906	COLD BAY AP	55.22083	-162.7325	24	-9	10
26410	PACV	CDV	110705	CORDOVA M K SMITH AP	60.4888	-145.4511	9	-9	8
27406	PASC	SCC	082406	DEADHORSE AP	70.1917	-148.4772	19	-9	8
26422	PAEG	EAA	060706	EAGLE AP	64.77667	-141.14833	274	-9	10
26411	PAFA	FAI	082306	FAIRBANKS INTL AP	64.8039	-147.8761	132	-9	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
26425	PAGK	GKN	111705	GULKANA AP	62.1591	-145.4588	476	-9	10
25323	PAHN	HNS	102705	HAINES AP	59.2433	-135.5094	5	-9	10
25507	PAHO	HOM	092306	HOMER AP	59.642	-151.4908	20	-9	8
25506	PAIL	ILI	011407	ILIAMNA AP	59.7494	-154.9089	44	-9	10
25309	PAJN	JNU	082206	JUNEAU INTL AP	58.3566	-134.564	5	-9	10
26523	PAEN	ENA	092106	KENAI MUNI AP	60.5797	-151.2391	28	-9	8
25325	PAKT	KTN	011003	KETCHIKAN INTL AP	55.35667	-131.71167	23	-9	8
25503	PAKN	AKN	032107	KING SALMON AP	58.6829	-156.6563	20	-9	10
25501	PADQ	ADQ	041007	KODIAK AP	57.75111	-152.48556	24	-9	10
26616	PAOT	OTZ	083006	KOTZEBUE RALPH WEIN A	66.86667	-162.63333	9	-9	8
26510	PAMC	MCG	060106	MCGRATH AP	62.9574	-155.6103	101	-9	10
26435	PANN	ENN	102705	NENANA MUNI AP	64.55	-149.07167	110	-9	10
26617	PAOM	OME	090206	NOME MUNI AP	64.5111	-165.44	4	-9	8
26412	PAOR	ORT	082406	NORTHWAY AP	62.9617	-141.9378	522	-9	10
27515	PAQT	AQT	082206	NUIQSUT AP	70.21167	-151.00167	18	-9	8
25331	PAAQ	PAQ	091906	PALMER MUNI AP	61.5961	-149.0916	70	-9	10
26492	PATO	POR	041707	PORTAGE GLACIER V C	60.785	-148.83889	31	-9	10
25516	PASO	SOV	103005	SELDOVIA AP	59.44333	-151.70167	19	-9	10
26438	PAWD	SWD	102705	SEWARD AP	60.12833	-149.41667	15	-9	8
25333	PASI	SIT	012403	SITKA AP	57.0481	-135.3647	4	-9	8
25335	PAGY	SGY	110705	SKAGWAY AP	59.4556	-135.3239	6	-9	8
25628	PAPB	PBV	070906	ST GEORGE ISLAND AP	56.6	-169.565	27	-9	10
25713	PASN	SNP	100106	ST PAUL ISLAND AP	57.15528	-170.22222	11	-9	10
26528	PATK	TKA	070203	TALKEETNA AP	62.32	-150.095	107	-9	8
26529	PATA	TAL	111705	TANANA CALHOUN MEM	65.175	-152.1067	68	-9	10
27503	PAWI	AWI	081606	WAINWRIGHT AP	70.63917	-159.995	8	-9	8
53864	KEET	EET	010809	ALABASTER SHELBY CO A	33.17833	-86.78167	172	-6	10
13871	KANB	ANB	011409	ANNISTON METRO AP	33.5872	-85.8556	181	-6	8
13876	KBHM	BHM	030509	BIRMINGHAM AP	33.56556	-86.745	187	-6	10
53852	KDCU	DCU	051007	DECATUR PRYOR FLD	34.6525	-86.94528	179	-6	10
13839	KDHN	DHN	053007	DOTHAN RGNL AP	31.3167	-85.45	114	-6	10
53820	KGZH	GZH	032007	EVERGREEN MIDDLETON	31.41556	-87.04417	77	-6	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
3856	KHSV	HSV	050807	HUNTSVILLE INTL AP	34.64389	-86.78611	190	-6	10
13838	KBFM	BFM	041307	MOBILE DWTN AP	30.62639	-88.06806	6	-6	10
13894	KMOB	MOB	030507	MOBILE RGNL AP	30.68833	-88.24556	66	-6	10
13895	KMGM	MGM	022009	MONTGOMERY AP	32.2997	-86.4075	62	-6	10
13896	KMSL	MSL	052407	MUSCLE SHOALS RGNL A	34.7441	-87.5997	165	-6	10
3878	KTOI	TOI	012109	TROY MUNI AP	31.86056	-86.01222	120	-6	10
93806	KTCL	TCL	011209	TUSCALOOSA MUNI AP	33.2119	-87.6161	46	-6	10
53869	KHKA	HKA	092508	BLYTHEVILLE MUNI AP	35.94028	-89.83083	77	-6	10
53925	KDEQ	DEQ	042607	DE QUEEN SEVIER CO AP	34.05	-94.40083	108	-6	8
93992	KELD	ELD	071107	EL DORADO S AR RGNL A	33.22083	-92.81417	77	-6	10
93993	KFYV	FYV	042409	FAYETTEVILLE DRAKE FLD	36.0097	-94.1694	381	-6	10
53922	KXNA	XNA	103008	FAYETTEVILLE NW AR AP	36.28333	-94.3	392	-6	10
13964	KFSM	FSM	021909	FT SMITH RGNL AP	35.333	-94.3625	137	-6	10
13971	KHRO	HRO	052709	HARRISON BOONE CO AP	36.2668	-93.1566	419	-6	8
3962	KHOT	HOT	072407	HOT SPRINGS ASOS	34.479	-93.096	163	-6	8
3953	KJBR	JBR	100108	JONESBORO MUNI AP	35.83111	-90.64639	78	-6	10
13963	KLIT	LIT	052109	LITTLE ROCK AP ADAMS F	34.7273	-92.2389	79	-6	10
53919	KLLQ	LLQ	071707	MONTICELLO MUNI AP	33.6361	-91.7556	88	-6	10
53921	KMWT	MWT	060607	MOUNT IDA ASOS	34.5467	-93.57806	214	-6	10
53918	KBPK	BPK	071107	MOUNTAIN HOME BAXTE	36.36889	-92.47028	281	-6	8
93988	KPBF	PBF	061907	PINE BLUFF GRIDER FLD	34.175	-91.93472	61	-6	8
53920	KRUE	RUE	120606	RUSSELLVILLE MUNI AP	35.25778	-93.09472	116	-6	10
13977	KTXK	TXK	081607	TEXARKANA WEBB FLD	33.4536	-94.0074	110	-6	8
93026	KDUG	DUG	022706	DOUGLAS BISBEE INL AP	31.4583	-109.6061	1251	-7	10
3103	KFLG	FLG	020807	FLAGSTAFF PULLIAM AP	35.1441	-111.6663	2135	-7	10
3195	KGCN	GCN	021207	GRAND CANYON NP AP	35.94611	-112.15472	2014	-7	10
93167	KIGM	IGM	022007	KINGMAN MOHAVE CO A	35.2577	-113.933	1042	-7	10
3196	KOLS	OLS	092606	NOGALES INTL AP	31.42083	-110.84583	1194	-7	10
3162	KPGA	PGA	021507	PAGE MUNI AP	36.92611	-111.44778	1314	-7	8
3184	KDVT	DVT	022107	PHOENIX DEER VALLEY M	33.68833	-112.08167	443	-7	10
23183	KPHX	PHX	040307	PHOENIX SKY HARBOR IN	33.4277	-112.0038	337	-7	10
23184	KPRC	PRC	020907	PRESCOTT LOVE FLD	34.65167	-112.42083	1524	-7	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
93084	KSAD	SAD	030706	SAFFORD MUNI AP	32.85472	-109.63528	968	-7	10
3192	KSDL	SDL	032007	SCOTTSDALE MUNI AP	33.62278	-111.91056	449	-7	10
93027	KSJN	SJN	013006	ST JOHNS INDUSTRIAL AP	34.51833	-109.37917	1746	-7	10
23160	KTUS	TUS	041007	TUCSON INTL AP	32.1313	-110.9552	777	-7	10
3029	KRQE	RQE	013006	WINDOW ROCK AP	35.6575	-109.06139	2054	-7	8
23194	KINW	INW	013006	WINSLOW MUNI AP	35.0281	-110.7208	1489	-7	10
94299	KAAT	AAT	042406	ALTURAS MUNI AP	41.49139	-120.56444	1334	-8	10
24283	KACV	ACV	013107	ARCATA EUREKA AP	40.97806	-124.10861	61	-8	10
23191	KAVX	AVX	090507	AVALON CATALINA AP	33.405	-118.41583	472	-8	10
23155	KBFL	BFL	031407	BAKERSFIELD AP	35.4344	-119.0542	149	-8	10
23161	KDAG	DAG	013006	BARSTOW DAGGETT AP	34.8536	-116.7858	584	-8	10
23157	KBIH	BIH	102705	BISHOP AP	37.3711	-118.358	1250	-8	10
23225	KBLU	BLU	103102	BLUE CANYON AP	39.2774	-120.7102	1608	-8	8
23158	KBLH	BLH	102705	BLYTHE AP	33.6186	-114.7142	120	-8	10
23152	KBUR	BUR	020707	BURBANK GLENDALE PAS	34.20056	-118.3575	222	-8	8
23136	KCMA	CMA	012507	CAMARILLO AP	34.21667	-119.08333	25	-8	10
3177	KCRQ	CRQ	041107	CARLSBAD PALOMAR AP	33.12806	-117.27944	93	-8	8
3179	KCNO	CNO	032807	CHINO AP	33.97528	-117.63611	192	-8	8
23254	KCCR	CCR	082605	CONCORD BUCHANAN FL	37.9917	-122.055	5	-8	10
24286	KCEC	CEC	090706	CRESCENT CITY MCNAMA	41.78028	-124.23667	18	-8	8
3104	KTRM	TRM	092806	DESERT RESORTS RGNL A	33.62667	-116.15944	-39	-8	10
23199	KNJK	NA		EL CENTRO NAF	32.81667	-115.68333	-14	-8	10
93193	KFAT	FAT	040307	FRESNO YOSEMITE INTL A	36.78	-119.7194	101	-8	8
3166	KFUL	FUL	040307	FULLERTON MUNI AP	33.87194	-117.97889	29	-8	10
53119	KHJO	HJO	110705	HANFORD MUNI AP	36.31889	-119.62889	77	-8	10
3167	KHHR	HHR	012507	HAWTHORNE MUNI AP	33.92278	-118.33417	19	-8	8
93228	KHWD	HWD	020807	HAYWARD AIR TERMINAL	37.6542	-122.115	13	-8	10
93115	KNRS	NA		IMPERIAL BEACH REAM F	32.56667	-117.11667	7	-8	10
3144	KIPL	IPL	101706	IMPERIAL CO AP	32.83417	-115.57861	-18	-8	10
3159	KWJF	WJF	040507	LANCASTER WM J FOX FL	34.7411	-118.2116	713	-8	10
23285	KLVK	LVK	032307	LIVERMORE MUNI AP	37.6927	-121.8144	120	-8	8
23129	KLGB	LGB	040407	LONG BEACH DAUGHERTY	33.8116	-118.1463	9	-8	8

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
93134	KCQT	CQT	020306	LOS ANGELES DOWNTOW	34.0236	-118.2911	55	-8	6
23174	KLAX	LAX	102706	LOS ANGELES INTL AP	33.938	-118.3888	30	-8	10
93205	KMYV	MYV	021306	MARYSVILLE YUBA CO AP	39.1019	-121.5677	19	-8	10
23257	KMCE	MCE	022706	MERCED MUNI AP	37.28472	-120.51278	46	-8	8
23258	KMOD	MOD	040207	MODESTO CITY CO AP	37.6241	-120.9505	22	-8	8
24259	KSIY	SIY	102705	MONTAGUE SISKIYOU AP	41.78139	-122.46806	807	-8	10
23259	KMRY	MRY	020607	MONTEREY PENINSUL AP	36.58806	-121.84528	50	-8	8
24215	KMHS	MHS	022706	MT SHASTA	41.3325	-122.33278	1077	-8	10
93227	KAPC	APC	031808	NAPA CO AP	38.2102	-122.2847	4	-8	10
23179	KEED	EED	020507	NEEDLES AP	34.7675	-114.6188	271	-8	10
23230	KOAK	OAK	021507	OAKLAND METRO INTL A	37.72139	-122.22083	2	-8	10
53121	KOKB	OKB	020306	OCEANSIDE MUNI AP	33.21944	-117.34944	10	-8	10
3102	KONT	ONT	092407	ONTARIO INTL AP	34.05611	-117.60028	289	-8	8
93210	KOVE	OVE	021306	OROVILLE MUNI AP	39.49	-121.61833	57	-8	10
93110	KOXR	OXR	011007	OXNARD VENTURA CO A	34.20083	-119.20694	11	-8	8
93138	KPSP	PSP	092607	PALM SPRINGS RGNL AP	33.8222	-116.5043	125	-8	10
23182	KPMD	PMD	020807	PALMDALE AP	34.62944	-118.08361	769	-8	10
93209	KPRB	PRB	022706	PASO ROBLES MUNI AP	35.6697	-120.6283	247	-8	10
24216	KRBL	RBL	021306	RED BLUFF MUNI AP	40.1519	-122.2536	108	-8	10
24257	KRDD	RDD	080907	REDDING MUNI AP	40.5175	-122.2986	151	-8	10
3171	KRAL	RAL	071008	RIVERSIDE MUNI AP	33.95194	-117.43861	245	-8	10
23232	KSAC	SAC	081507	SACRAMENTO EXECUTIVE	38.5069	-121.495	5	-8	10
23233	KSNS	SNS	020607	SALINAS MUNICIPAL AP	36.6636	-121.6081	23	-8	10
23188	KSAN	SAN	082307	SAN DIEGO LINDBERGH F	32.7336	-117.1831	5	-8	10
3131	KMYF	MYF	030707	SAN DIEGO MONTGOME	32.81583	-117.13944	127	-8	8
23234	KSFO	SFO	073103	SAN FRANCISCO INTL AP	37.6197	-122.3647	2	-8	10
23293	KSJC	SJC	030807	SAN JOSE	37.3591	-121.924	16	-8	8
93206	KSBP	SBP	041707	SAN LUIS OBISPO AP	35.23722	-120.64139	61	-8	10
23187	KSDB	SDB	021306	SANDBERG	34.7436	-118.7242	1375	-8	10
93184	KSNA	SNA	081507	SANTA ANA JOHN WAYN	33.68	-117.86639	13	-8	6
23190	KSBA	SBA	062207	SANTA BARBARA MUNI A	34.4258	-119.8425	3	-8	8
23273	KSMX	SMX	060607	SANTA MARIA PUBLIC AP	34.8994	-120.4486	74	-8	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
93197	KSMO	SMO	041807	SANTA MONICA MUNI AP	34.01583	-118.45139	53	-8	10
23213	KSTS	STS	031407	SANTA ROSA SONOMA C	38.5038	-122.8102	35	-8	10
93230	KTVL	TVL	051707	SOUTH LAKE TAHOE AP	38.8983	-119.9947	1925	-8	10
23237	KSCK	SCK	081607	STOCKTON METRO AP	37.8891	-121.2258	8	-8	10
23275	KUKI	UKI	101206	UKIAH MUNI AP	39.12583	-123.20083	183	-8	6
93241	KVCB	VCB	080707	VACAVILLE NUT TREE AP	38.3775	-121.9575	33	-8	10
23130	KVNY	VNY	060707	VAN NUYS AP	34.20972	-118.48917	235	-8	8
23277	KWVI	WVI	020607	WATSONVILLE MUNI AP	36.93583	-121.78861	47	-8	10
24015	KAKO	AKO	012507	AKRON WASHINGTON CO	40.16667	-103.21667	1421	-7	10
23061	KALS	ALS	052407	ALAMOSA SAN LUIS AP	37.4389	-105.8613	2296	-7	10
93073	KASE	ASE	031507	ASPEN PITKIN CO AP	39.23	-106.87056	2353	-7	8
3026	KITR	ITR	110705	BURLINGTON CARSON AP	39.24472	-102.28417	1278	-7	10
93037	KCOS	COS	092308	COLORADO SPRINGS MU	38.81	-104.6884	1884	-7	10
93069	KCEZ	CEZ	040407	CORTEZ MONTEZUMA C	37.30694	-108.62639	1801	-7	10
24046	KCAG	CAG	032607	CRAIG MOFFAT COUNTY	40.49278	-107.52417	1887	-7	10
93067	KAPA	APA	020607	DENVER CENTENNIAL AP	39.57028	-104.84889	1793	-7	10
3017	KDEN	DEN	091205	DENVER INTL AP	39.8328	-104.6575	1650	-7	10
93005	KDRO	DRO	040307	DURANGO LA PLATA CO	37.14306	-107.76028	2033	-7	10
23066	KGJT	GJT	031307	GRAND JUNCTION WALK	39.1342	-108.54	1481	-7	10
23067	KLHX	LHX	121605	LA JUNTA MUNI AP	38.0494	-103.5122	1278	-7	10
3013	KLAA	LAA	082608	LAMAR MUNI AP	38.07	-102.68806	1124	-7	10
93009	KLXV	LXV	082808	LEADVILLE LAKE CO AP	39.22917	-106.31694	3011	-7	10
93010	KLIC	LIC	100405	LIMON WSMO	39.18944	-103.71583	1635	-7	10
94050	KEEO	EEO	031307	MEEKER AIRPORT	40.04417	-107.88861	1940	-7	10
93013	KMTJ	MTJ	102705	MONTROSE REGIONAL A	38.50583	-107.89889	1743	-7	10
93058	KPUB	PUB	040407	PUEBLO MEM AP	38.2901	-104.4983	1439	-7	10
23070	KTAD	TAD	102808	TRINIDAD PERRY STOKES	37.26222	-104.33778	1750	-7	10
94702	KBDR	BDR	061709	BRIDGEPORT SIKORSKY M	41.15833	-73.12889	2	-5	8
54734	KDXR	DXR	071509	DANBURY MUNI AP	41.37139	-73.48278	138	-5	8
14707	KGON	GON	111708	GROTON NEW LONDON	41.3275	-72.04944	3	-5	10
14740	KBDL	BDL	040907	HARTFORD BRADLEY INT	41.9381	-72.6825	58	-5	10
14752	KHFD	HFD	102308	HARTFORD BRAINARD FL	41.73611	-72.65056	6	-5	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
54788	KMMK	MMK	100708	MERIDEN MARKHAM MU	41.50972	-72.82778	30	-5	10
14758	KHVN	HVN	033109	NEW HAVEN TWEED AP	41.26389	-72.88722	1	-5	8
54767	KIJD	IJD	102705	WILLIMANTIC WINDHAM	41.74194	-72.18361	75	-5	1
13764	KGED	GED	082608	GEORGETOWN SUSSEX C	38.68917	-75.35917	15	-5	10
13781	KILG	ILG	091808	WILMINGTON NEW CAST	39.6728	-75.6008	24	-5	10
12832	KAAF	AAF	052207	APALACHICOLA AP	29.73333	-85.03333	6	-5	10
12818	KBKV	BKV	052407	BROOKSVILLE HERNAND	28.47361	-82.45444	20	-5	10
53848	KNFJ	NA		CHOCTAW NAVAL OUTLY	30.50694	-86.95972	30	-6	10
13884	KCEW	CEW	032907	CRESTVIEW BOB SIKES AP	30.77972	-86.5225	58	-6	10
12834	KDAB	DAB	013107	DAYTONA BEACH INTL AP	29.1828	-81.0483	9	-5	10
53853	KDTS	DTS	031407	DESTIN FT WALTON AP	30.4	-86.47167	4	-6	8
12885	KFXE	FXE	073009	FT LAUDERDALE EXECUTI	26.19694	-80.17083	4	-5	10
12849	KFLL	FLL	080109	FT LAUDERDALE HOLLYW	26.0719	-80.1536	3	-5	10
12835	KFMY	FMY	020609	FT MYERS PAGE FLD AP	26.585	-81.8614	5	-5	8
12894	KRSW	RSW	020909	FT MYERS SW FL RGNL AP	26.53611	-81.755	9	-5	10
12895	KFPR	FPR	041607	FT PIERCE ST LUCIE CO IN	27.49806	-80.37667	7	-5	8
12816	KGNV	GNV	030907	GAINESVILLE RGNL AP	29.6919	-82.2755	37	-5	10
92809	KHWO	HWO	080109	HOLLYWOOD NORTH PER	25.99889	-80.24111	2	-5	10
53860	KCRG	CRG	030507	JACKSONVILLE CRAIG MU	30.3361	-81.5147	12	-5	8
13889	KJAX	JAX	022707	JACKSONVILLE INTL AP	30.495	-81.6936	8	-5	10
12836	KEYW	EYW	102204	KEY WEST INTL AP	24.555	-81.75222	1	-5	10
12819	KLEE	LEE	060607	LEESBURG MUNI AP	28.82083	-81.80972	20	-5	10
12896	KMTH	MTH	022707	MARATHON AP	24.72583	-81.05167	2	-5	8
3818	KMAI	MAI	052507	MARIANNA MUNI AP	30.83556	-85.18389	33	-6	10
12838	KMLB	MLB	091506	MELBOURNE INTL AP	28.1011	-80.6439	8	-5	10
12839	KMIA	MIA	071409	MIAMI INTL AP	25.7905	-80.3163	9	-5	10
12888	KTMB	TMB	081309	MIAMI KENDALL TAMIAM	25.6475	-80.43306	2	-5	10
12882	KOPF	OPF	070809	MIAMI OPA LOCKA AP	25.90694	-80.28028	3	-5	10
12897	KAPF	APF	072809	NAPLES MUNI AP	26.1522	-81.7752	3	-5	10
12841	KORL	ORL	051007	ORLANDO EXECUTIVE AP	28.54528	-81.33306	33	-5	10
12815	KMCO	MCO	053107	ORLANDO INTL AP	28.4339	-81.325	27	-5	8
12854	KSFB	SFB	050307	ORLANDO SANFORD AP	28.77972	-81.24361	15	-5	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
13899	KPNS	PNS	032707	PENSACOLA RGNL AP	30.47806	-87.18694	34	-6	10
12812	KPGD	PGD	020409	PUNTA GORDA CHARLOTT	26.91722	-81.99139	7	-5	10
12871	KSRQ	SRQ	011409	SARASOTA BRADENTON A	27.40139	-82.55861	7	-5	10
92806	KSPG	SPG	010809	ST PETERSBURG ALBERT W	27.76472	-82.6275	2	-5	8
12873	KPIE	PIE	041607	ST PETERSBURG INTL AP	27.91056	-82.6875	2	-5	10
93805	KTLH	TLH	050907	TALLAHASSEE RGNL AP	30.39306	-84.35333	17	-5	10
12842	KTPA	TPA	012709	TAMPA INTL AP	27.96194	-82.5403	6	-5	8
12843	KVRB	VRB	030707	VERO BEACH INTL AP	27.651	-80.4199	9	-5	10
12844	KPBI	PBI	072109	WEST PALM BEACH INTL A	26.6847	-80.0994	6	-5	10
12876	KGIF	GIF	010509	WINTER HAVEN GILBERT A	28.06222	-81.75417	44	-5	10
13869	KABY	ABY	053107	ALBANY SW GA RGNL AP	31.53556	-84.19444	58	-5	10
13870	KAMG	AMG	010609	ALMA BACON CO AP	31.5358	-82.5067	59	-5	10
13873	KAHN	AHN	051007	ATHENS BEN EPPS AP	33.948	-83.3275	239	-5	8
3888	KFTY	FTY	032007	ATLANTA FULTON CO AP	33.77917	-84.52139	256	-5	8
13874	KATL	ATL	032707	ATLANTA HARTSFIELD INT	33.6301	-84.4418	308	-5	10
53863	KPDK	PDK	032107	ATLANTA PEACHTREE AP	33.875	-84.30222	303	-5	10
3820	KAGS	AGS	051209	AUGUSTA BUSH FLD AP	33.3644	-81.9633	40	-5	10
13837	KDNL	DNL	050409	AUGUSTA DANIEL FLD AP	33.46694	-82.03861	125	-5	10
13878	KSSI	SSI	030707	BRUNSWICK MALCOLM M	31.1522	-81.3908	5	-5	10
53873	KVPC	VPC	032207	CARTERSVILLE AP	34.12306	-84.84861	228	-5	10
93842	KCSG	CSG	052407	COLUMBUS METRO AP	32.5161	-84.9422	119	-5	10
53838	KGVL	GVL	041207	GAINESVILLE GILMER AP	34.27194	-83.83028	387	-5	8
3813	KMCN	MCN	072407	MACON MIDDLE GA RGN	32.6847	-83.6527	105	-5	10
53819	KFFC	FFC	020306	PEACHTREE CITY FALCON	33.35528	-84.56694	243	-5	10
93801	KRMG	RMG	051707	ROME R B RUSSELL AP	34.34778	-85.16111	195	-5	10
3822	KSAV	SAV	021209	SAVANNAH INTL AP	32.13	-81.21	14	-5	10
94989	KAMW	AMW	102705	AMES MUNICIPAL AP	41.99056	-93.61889	291	-6	10
14990	KCID	CID	041807	CEDAR RAPIDS MUNI AP	41.8833	-91.7166	265	-6	8
94982	KDVN	DVN	102005	DAVENPORT MUNI AP	41.61389	-90.59139	229	-6	10
14933	KDSM	DSM	041807	DES MOINES INTL AP	41.5338	-93.653	292	-6	10
94908	KDBQ	DBQ	042007	DUBUQUE RGNL AP	42.39778	-90.70361	322	-6	10
94971	KEST	EST	050207	ESTHERVILLE MUNICIPAL	43.40111	-94.74722	401	-6	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
14937	KIOW	IOW	102005	IOWA CITY MUNI AP	41.63278	-91.54306	198	-6	10
94991	KLWD	LWD	052907	LAMONI MUNICIPAL AP	40.6306	-93.9008	346	-6	10
94988	KMIW	MIW	102005	MARSHALLTOWN MUNIC	42.11056	-92.91611	297	-6	10
14940	KMCW	MCW	051707	MASON CITY MUNI AP	43.1544	-93.3269	373	-6	10
14950	KOTM	OTM	061307	OTTUMWA INDUSTRIAL A	41.1077	-92.4466	257	-6	10
14972	KSPW	SPW	110705	SPENCER MUNI AP	43.16444	-95.20167	407	-6	10
94910	KALO	ALO	062507	WATERLOO MUNI AP	42.5544	-92.4011	265	-6	10
24131	KBOI	BOI	010907	BOISE AIR TERMINAL	43.5666	-116.2405	858	-7	10
24133	KBYI	BYI	110705	BURLEY MUNI AP	42.5416	-113.7661	1266	-7	10
4114	KLLJ	LLJ	010203	CHALLIS AP	44.52278	-114.215	1534	-7	8
24145	KIDA	IDA	013007	IDAHO FALLS FANNING FL	43.51639	-112.06722	1441	-7	8
4110	KJER	JER	050406	JEROME CO AP	42.72667	-114.45639	1223	-7	8
94182	KMYL	MYL	060706	MCCALL AP	44.88889	-116.10167	1528	-7	10
24156	KPIH	PIH	030607	POCATELLO RGNL AP	42.9202	-112.5711	1357	-7	10
94194	KRXE	RXE	102005	REXBURG MADISON CO A	43.83389	-111.80444	1481	-7	10
94178	KTWF	TWF	071807	TWIN FALLS SUN VLY RGN	42.48194	-114.48694	1261	-7	10
93810	KMDH	MDH	052407	CARBONDALE SOUTHERN	37.77972	-89.24972	124	-6	10
94870	KCMI	CMI	051007	CHAMPAIGN WILLARD AP	40.03972	-88.27778	229	-6	8
4808	KARR	ARR	120602	CHICAGO AURORA MUNI	41.77	-88.48139	216	-6	8
14819	KMDW	MDW	061307	CHICAGO MIDWAY AP	41.78611	-87.75222	187	-6	10
94846	KORD	ORD	062707	CHICAGO OHARE INTL AP	41.995	-87.9336	202	-6	10
4838	KPWK	PWK	062607	CHICAGO PALWAUKEE AP	42.12083	-87.90472	194	-6	8
14880	KUGN	UGN	052407	CHICAGO WAUKEGAN RG	42.41667	-87.86667	216	-6	10
3887	KDEC	DEC	032007	DECATUR AP	39.83444	-88.86556	206	-6	10
13809	KLWV	LWV	110705	LAWRENCEVILLE INTL AP	38.76417	-87.60556	131	-6	10
53802	KMTO	MTO	102005	MATTOON COLES CO AP	39.47806	-88.28028	217	-6	8
14923	KMLI	MLI	041607	MOLINE QUAD CITY INTL	41.46528	-90.52333	180	-6	10
14842	KPIA	PIA	091806	PEORIA GTR PEORIA AP	40.6675	-89.6839	198	-6	10
93989	KUIN	UIN	092006	QUINCY RGNL AP	39.93694	-91.19194	234	-6	8
94822	KRFD	RFD	052207	ROCKFORD GTR ROCKFOR	42.1927	-89.093	223	-6	10
93822	KSPI	SPI	092506	SPRINGFIELD CAPITAL AP	39.8447	-89.6839	181	-6	10
94892	KDPA	DPA	062907	WEST CHICAGO DUPAGE	41.91444	-88.24639	230	-6	8

Attachment 1.

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
3893	KBMG	BMG	052507	BLOOMINGTON MONROE	39.13333	-86.61667	257	-5	8
93817	KEVV	EVV	092606	EVANSVILLE REGIONAL AP	38.0441	-87.5205	122	-6	8
14827	KFWA	FWA	092106	FT WAYNE INTL AP	40.9705	-85.2063	241	-5	10
14829	KGSH	GSH	121605	GOSHEN MUNI AP	41.5333	-85.7833	253	-5	10
53842	KEYE	EYE	100405	INDIANAPOLIS EAGLE CRE	39.825	-86.29583	249	-5	10
93819	KIND	IND	052207	INDIANAPOLIS INTL AP	39.7318	-86.2788	241	-5	10
14835	KLAF	LAF	091406	LAFAYETTE PURDUE UNIV	40.41222	-86.93694	183	-5	10
94895	KMIE	MIE	052907	MUNCIE DELAWARE CO A	40.23417	-85.39361	286	-5	10
14848	KSBN	SBN	092706	S BEND AP	41.7072	-86.3163	236	-5	10
53866	KGEZ	GEZ	100405	SHELBYVILLE MUNI AP	39.57806	-85.80333	245	-5	10
3868	KHUF	HUF	011603	TERRE HAUTE HULMAN R	39.45194	-87.30889	175	-5	8
4846	KVPZ	VPZ	110705	VALPARAISO PORTER CO	41.4525	-87.00583	232	-6	8
13981	KCNU	CNU	060706	CHANUTE MARTIN JOHNS	37.67028	-95.48417	300	-6	10
13984	KCNK	CNK	011007	CONCORDIA MUNI AP	39.5514	-97.6508	448	-6	10
13989	KEMP	EMP	040207	EMPORIA MUNI AP	38.32917	-96.19472	365	-6	10
23064	KGCK	GCK	012407	GARDEN CITY RGNL AP	37.92722	-100.72472	878	-6	8
23065	KGLD	GLD	102705	GOODLAND RENNER FLD	39.36722	-101.69333	1114	-7	10
93990	KHLC	HLC	020607	HILL CITY MUNI AP	39.37556	-99.82972	667	-6	10
13986	KHUT	HUT	012907	HUTCHINSON MUNI AP	38.06528	-97.86056	463	-6	10
3997	KLWC	LWC	100705	LAWRENCE MUNI AP	39.00778	-95.21167	254	-6	10
3936	KMHK	MHK	022107	MANHATTAN MUNI AP	39.1346	-96.6788	322	-6	8
93909	KIXD	IXD	012607	OLATHE JOHNSON CO AP	38.83167	-94.88972	327	-6	10
3967	KOJC	OJC	042007	OLATHE JOHNSON CO EXE	38.85	-94.73917	326	-6	10
3998	KPPF	PPF	040307	PARSONS TRI CITY AP	37.32778	-95.50417	265	-6	8
93997	KRSL	RSL	090606	RUSSELL MUNI AP	38.87611	-98.80917	568	-6	10
13920	KFOE	FOE	090706	TOPEKA FORBES FLD	38.95028	-95.66389	325	-6	10
13996	KTOP	TOP	101702	TOPEKA MUNI AP	39.0725	-95.6261	267	-6	8
3974	KAAO	AAO	102005	WICHITA COLONEL JAMES	37.74611	-97.22111	431	-6	10
3928	KICT	ICT	100605	WICHITA DWIGHT D EISEN	37.6475	-97.43	403	-6	10
13932	KWLD	WLD	101305	WINFIELD STROTHER FLD	37.16806	-97.03694	351	-6	8
93808	KBWG	BWG	110705	BOWLING GREEN WARRE	36.9647	-86.4238	161	-6	8
53841	KFFT	FFT	102005	FRANKFORT CAPITAL CITY	38.18472	-84.90333	238	-5	10

Attachment 1.

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
3889	KJKL	JKL	102005	JACKSON JULIAN CARROL	37.59139	-83.31444	416	-5	10
93820	KLEX	LEX	092706	LEXINGTON BLUEGRASS A	38.0408	-84.6058	299	-5	10
3849	KLOZ	LOZ	110705	LONDON CORBIN AP	37.08722	-84.07694	362	-5	10
13810	KLOU	LOU	052307	LOUISVILLE BOWMAN FL	38.22806	-85.66361	165	-5	10
93821	KSDF	SDF	061407	LOUISVILLE INTL AP	38.1811	-85.7391	149	-5	10
3816	KPAH	PAH	022207	PADUCAH BARKLEY RGNL	37.0563	-88.7744	126	-6	10
93915	KAEX	AEX	042607	ALEXANDRIA INTL AP	31.33472	-92.55861	26	-6	8
13970	KBTR	BTR	092606	BATON ROUGE RYAN AP	30.5372	-91.1469	20	-6	10
12884	KBVE	BVE	041807	BOOTHVILLE ASOS	29.333	-89.4075	1	-6	10
13976	KLFT	LFT	060107	LAFAYETTE RGNL AP	30.205	-91.9875	12	-6	8
3937	KLCH	LCH	041907	LAKE CHARLES RGNL AP	30.12472	-93.22833	3	-6	10
13942	KMLU	MLU	100908	MONROE REGIONAL AP	32.5155	-92.0405	24	-6	8
53915	KARA	ARA	061207	NEW IBERIA AP - ACADIA	30.0375	-91.8839	7	-6	8
12916	KMSY	MSY	032307	NEW ORLEANS INTL AP	29.9933	-90.2511	1	-6	10
53917	KNEW	NEW	010803	NEW ORLEANS LAKEFRON	30.0494	-90.0288	3	-6	8
53905	KDTN	DTN	041907	SHREVEPORT DWTN AP	32.54278	-93.745	55	-6	10
13957	KSHV	SHV	060707	SHREVEPORT RGNL AP	32.4472	-93.8244	77	-6	10
53865	KASD	ASD	030207	SLIDELL AP	30.34333	-89.82222	8	-6	10
14702	KBED	BED	052907	BEDFORD HANSCOM FLD	42.47	-71.28944	38	-5	10
54733	KBVY	BVY	100808	BEVERLY MUNI AP	42.58417	-70.9175	29	-5	10
14739	KBOS	BOS	100506	BOSTON LOGAN INTL AP	42.3606	-71.0106	4	-5	8
94624	KCQX	CQX	030107	CHATHAM MUNI AP	41.6875	-69.99333	17	-5	10
4780	KFIT	FIT	102005	FITCHBURG MUNI AP	42.55194	-71.75583	101	-5	10
94720	KHYA	HYA	043009	HYANNIS BARNSTABLE M	41.66861	-70.28	14	-5	8
94723	KLWM	LWM	110408	LAWRENCE MUNI AP	42.71722	-71.12389	42	-5	10
14756	KACK	ACK	051909	NANTUCKET MEM AP	41.25306	-70.06083	10	-5	10
94726	KEWB	EWB	103008	NEW BEDFORD MUNI AP	41.67639	-70.95833	22	-5	8
54704	KOWD	OWD	111808	NORWOOD MEM AP	42.19083	-71.17361	15	-5	8
14763	KPSF	PSF	102705	PITTSFIELD MUNI AP	42.42722	-73.28917	351	-5	10
54769	KPYM	PYM	102005	PLYMOUTH MUNI AP	41.90972	-70.72944	44	-5	10
54777	KTAN	TAN	100206	TAUNTON MUNI AP	41.87556	-71.02111	9	-5	10
94724	KMVY	MVY	051109	VINEYARD HAVEN AP	41.39306	-70.615	19	-5	10

Attachment 1.

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
14775	KBAF	BAF	100208	WESTFIELD BARNES MUN	42.15778	-72.71611	80	-5	10
94746	KORH	ORH	032807	WORCESTER RGNL AP	42.2706	-71.8731	305	-5	10
93721	KBWI	BWI	092006	BALTIMORE WASH INTL A	39.1666	-76.6833	48	-5	10
93786	KOXB	OXB	040507	OCEAN CITY MUNI AP	38.30833	-75.12389	4	-5	10
93720	KSBY	SBY	041107	SALISBURY WICOMICO R	38.34056	-75.51028	15	-5	8
14605	KAUG	AUG	102705	AUGUSTA STATE AP	44.3155	-69.7972	107	-5	8
14606	KBGR	BGR	092706	BANGOR INTL AP	44.7978	-68.8185	45	-5	10
14607	KCAR	CAR	092602	CARIBOU MUNI AP	46.8705	-68.0173	190	-5	8
4836	KFVE	FVE	121605	FRENCHVILLE AROOSTOO	47.28556	-68.31333	302	-5	10
14610	KMLT	MLT	101305	MILLINOCKET MUNI AP	45.6477	-68.6925	124	-5	10
14764	KPWM	PWM	100606	PORTLAND INTL JETPORT	43.6497	-70.3002	14	-5	8
94623	KIWI	IWI	091306	WISCASSET AP	43.96361	-69.71167	13	-5	10
94849	KAPN	APN	050407	ALPENA CO RGNL AP	45.0716	-83.5644	208	-5	10
94889	KARB	ARB	092408	ANN ARBOR MUNI AP	42.22278	-83.74444	253	-5	10
14815	KBTL	BTL	022007	BATTLE CREEK KELLOGG	42.3075	-85.25111	283	-5	10
94871	KBEH	BEH	121605	BENTON HARBOR AIRPO	42.1256	-86.4284	196	-5	10
14822	KDET	DET	101206	DETROIT CITY AP	42.40917	-83.01	191	-5	10
94847	KDTW	DTW	060707	DETROIT METRO AP	42.2313	-83.3308	192	-5	10
14853	KYIP	YIP	092608	DETROIT WILLOW RUN A	42.23333	-83.53333	237	-5	10
14826	KFNT	FNT	091808	FLINT BISHOP INTL AP	42.9666	-83.7494	235	-5	10
4854	KGLR	GLR	100705	GAYLORD OTSEGO CO AP	45.01333	-84.70139	407	-5	10
94860	KGRR	GRR	022107	GRAND RAPIDS INTL AP	42.8825	-85.52389	245	-5	10
14858	KCMX	CMX	112602	HANCOCK HOUGHTON C	47.16861	-88.48889	325	-5	8
4839	KBIV	BIV	111705	HOLLAND TULIP CITY AP	42.74611	-86.09667	206	-5	10
94814	KHTL	HTL	032907	HOUGHTON LK ROSCOMM	44.3591	-84.6738	351	-5	10
14833	KJXN	JXN	041607	JACKSON REYNOLDS FLD	42.2667	-84.4667	304	-5	8
94815	KAZO	AZO	083106	KALAMAZOO BATTLE CK	42.23472	-85.55194	265	-5	10
14836	KLAN	LAN	090706	LANSING CAPITAL CITY A	42.78028	-84.57889	256	-5	10
14840	KMKG	MKG	032007	MUSKEGON CO AP	43.17111	-86.23667	191	-5	10
14841	KPLN	PLN	100705	PELLSTON RGNL AP	45.5644	-84.7927	215	-5	8
94817	KPTK	PTK	042407	PONTIAC OAKLAND CO I	42.665	-83.41806	297	-5	10
14845	KMBS	MBS	053107	SAGINAW MBS INTL AP	43.53306	-84.07972	201	-5	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
14850	KTVC	TVC	051707	TRAVERSE CITY CHERRY C	44.74083	-85.5825	188	-5	8
14910	KAXN	AXN	102705	ALEXANDRIA MUNI AP	45.8679	-95.3941	432	-6	10
94938	KBRD	BRD	102705	BRAINERD CROW WING C	46.40472	-94.13083	372	-6	10
14913	KDLH	DLH	072507	DULUTH INTL AP	46.8369	-92.1833	437	-6	10
94931	KHIB	HIB	102005	HIBBING CHISHOLM HIBB	47.38639	-92.83889	411	-6	10
14918	KINL	INL	090706	INTL FALLS INTL AP	48.5614	-93.3981	361	-6	10
14922	KMSP	MSP	091306	MINNEAPOLIS_ST PAUL A	44.8831	-93.2289	266	-6	10
94960	KMIC	MIC	041807	MPLS CRYSTAL AP	45.06194	-93.35083	262	-6	10
94963	KFCM	FCM	042507	MPLS FLYING CLOUD AP	44.8321	-93.4705	276	-6	10
94967	KPKD	PKD	041807	PARK RAPIDS MUNI AP	46.90056	-95.06778	437	-6	10
14992	KRWF	RWF	102005	REDWOOD FALLS MUNI A	44.5483	-95.0804	311	-6	10
14925	KRST	RST	053007	ROCHESTER INTL AP	43.9041	-92.4916	397	-6	10
14926	KSTC	STC	070306	ST CLOUD RGNL AP	45.5433	-94.0513	308	-6	10
14927	KSTP	STP	091206	ST PAUL DOWNTOWN AP	44.93194	-93.05556	213	-6	10
3935	KCGI	CGI	121605	CAPE GIRARDEAU MUNI A	37.2252	-89.5705	102	-6	8
3945	KCOU	COU	062007	COLUMBIA RGNL AP	38.8169	-92.2183	272	-6	10
3963	KJEF	JEF	071107	JEFFERSON CITY MEM AP	38.59111	-92.15583	175	-6	10
13987	KJLN	JLN	092706	JOPLIN REGIONAL AIRPO	37.1466	-94.5022	299	-6	10
3947	KMCI	MCI	091906	KANSAS CITY INTL AP	39.2972	-94.7306	306	-6	10
14938	KIRK	IRK	100705	KIRKSVILLE RGNL AP	40.09722	-92.54333	293	-6	10
53879	KLXT	LXT	041805	LEES SUMMIT MUNI AP	38.95972	-94.37139	304	-6	10
3975	KPOF	POF	121605	POPLAR BLUFF MUNI AP	36.7725	-90.32472	100	-6	8
3994	KDMO	DMO	081406	SEDALIA MEM AP	38.70417	-93.18333	274	-6	10
13995	KSGF	SGF	092006	SPRINGFIELD RGNL AP	37.2397	-93.3897	384	-6	10
13994	KSTL	STL	092606	ST LOUIS LAMBERT INTL A	38.7525	-90.3736	162	-6	10
3966	KSUS	SUS	043007	ST LOUIS SPRT OF S L AP	38.65722	-90.65583	141	-6	8
13997	KVIH	VIH	012407	VICHY ROLLA NATIONAL A	38.13111	-91.76833	344	-6	10
53901	KUNO	UNO	101305	WEST PLAINS MUNI AP	36.87806	-91.9025	373	-6	10
13939	KGLH	GLH	013007	GREENVILLE ASOS	33.4825	-90.98528	39	-6	10
13978	KGWO	GWO	030607	GREENWOOD LEFLORE AI	33.4963	-90.0866	41	-6	10
93874	KGPT	GPT	030607	GULFPORT - BILOXI AP	30.4119	-89.0808	13	-6	10
13833	KHBG	HBG	022707	HATTIESBURG CHAIN MU	31.28194	-89.25306	46	-6	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
13927	KHKS	HKS	022807	JACKSON HAWKINS FLD	32.33667	-90.22139	104	-6	10
3940	KJAN	JAN	052207	JACKSON INTL AP	32.3205	-90.0777	101	-6	10
93919	KMCB	MCB	041607	MCCOMB_PIKE CO_JOHN	31.1827	-90.4708	126	-6	10
13865	KMEI	MEI	060607	MERIDIAN KEY FLD	32.3347	-88.7442	90	-6	10
53858	KPQL	PQL	032607	PASCAGOULA LOTT INTL A	30.46361	-88.53194	5	-6	8
93862	KTUP	TUP	091708	TUPELO RGNL AP	34.2622	-88.7713	110	-6	10
94055	KBHK	BHK	102705	BAKER MUNI AP	46.3583	-104.25	906	-7	10
24033	KBIL	BIL	090506	BILLINGS INTL AP	45.8069	-108.5422	1091	-7	10
24132	KBZN	BZN	042507	BOZEMAN GALLATIN FLD	45.788	-111.1608	1349	-7	10
24135	KBTM	BTM	021306	BUTTE BERT MOONEY AP	45.9647	-112.5006	1678	-7	10
24137	KCTB	CTB	020306	CUT BANK MUNI AP	48.6033	-112.3752	1170	-7	10
24138	KDLN	DLN	013006	DILLON AP	45.2575	-112.5544	1585	-7	10
94008	KGGW	GGW	041405	GLASGOW INTL AP	48.2138	-106.6214	696	-7	10
24143	KGTF	GTF	032607	GREAT FALLS INTL AP	47.4733	-111.3822	1117	-7	10
94012	KHVR	HVR	110705	HAVRE CITY CO AP	48.5428	-109.7633	788	-7	10
24144	KHLN	HLN	053107	HELENA RGNL AP	46.6056	-111.9636	1167	-7	10
24146	KGPI	GPI	091306	KALISPELL GLACIER AP	48.3042	-114.2636	901	-7	8
24036	KLWT	LWT	041706	LEWISTOWN MUNI AP	47.0492	-109.4578	1263	-7	10
24150	KLVM	LVM	102005	LIVINGSTON AP	45.6983	-110.4408	1415	-7	10
24037	KMLS	MLS	102705	MILES CITY AP	46.4266	-105.8825	800	-7	10
24153	KMSO	MSO	053107	MISSOULA INTL AP	46.9208	-114.0925	973	-7	10
94017	KOLF	OLF	102005	WOLF POINT INTL AP	48.09444	-105.57444	605	-7	10
3812	KAVL	AVL	101608	ASHEVILLE RGNL AP	35.43194	-82.5375	645	-5	8
93765	KMRH	MRH	020807	BEAUFORT MICHAEL J SM	34.73361	-76.66056	2	-5	10
93783	KBUY	BUY	060507	BURLINGTON ALAMANCE	36.04667	-79.47694	187	-5	10
93729	KHSE	HSE	031907	CAPE HATTERAS AP	35.2326	-75.6219	3	-5	10
93785	KIGX	IGX	042905	CHAPEL HILL WILLIAMS A	35.93333	-79.06417	152	-5	10
13881	KCLT	CLT	060209	CHARLOTTE DOUGLAS AP	35.2236	-80.9552	222	-5	10
13754	KNKT	NA		CHERRY POINT MCAS	34.88333	-76.86667	30	-5	10
13786	KECG	ECG	032607	ELIZABETH CITY CGAS	36.26056	-76.175	4	-5	10
93740	KFAY	FAY	060209	FAYETTEVILLE RGNL AP	34.99139	-78.88028	57	-5	10
3810	KHKY	HKY	110608	HICKORY FAA AP	35.7425	-81.3819	348	-5	8

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
93782	KMEB	MEB	060209	LAURINBURG MAXTON A	34.79167	-79.36611	66	-5	10
13776	KLBT	LBT	041907	LUBERTION REGIONAL AP	34.608	-79.0591	37	-5	10
53872	KEQY	EQY	052009	MONROE AP	35.01694	-80.62056	204	-5	10
93719	KEWN	EWN	092206	NEW BERN CRAVEN CO A	35.0677	-77.048	6	-5	8
13723	KGSO	GSO	063009	PIEDMONT TRIAD INTL AI	36.0969	-79.9432	271	-5	10
13722	KRDU	RDU	070809	RALEIGH DURHAM INTL A	35.8923	-78.7819	127	-5	10
93759	KRWI	RWI	051507	ROCKY MT WILSON AP	35.855	-77.89306	45	-5	8
13748	KILM	ILM	041307	WILMINGTON INTL AP	34.2675	-77.8997	10	-5	10
24011	KBIS	BIS	050107	BISMARCK MUNI AP	46.7825	-100.7572	503	-6	10
14916	KGFK	GFK	101702	GRAND FORKS INTL AP	47.9428	-97.1839	257	-6	8
94038	KHEI	HEI	100405	HETTINGER MUNI AP	46.01389	-102.65472	824	-7	10
14919	KJMS	JMS	011007	JAMESTOWN MUNI AP	46.9258	-98.6691	455	-6	8
24013	KMOT	MOT	090606	MINOT INTL AP	48.2552	-101.2733	507	-6	8
24012	KDIK	DIK	011707	THEODORE ROOSEVELT A	46.7994	-102.7972	786	-7	10
94014	KISN	ISN	040407	WILLISTON SLOULIN INTL	48.1738	-103.6366	580	-6	10
24044	KAIA	AIA	092908	ALLIANCE MUNI AP	42.0573	-102.8017	1198	-7	10
94946	KBBW	BBW	100705	BROKEN BOW MUNI AP	41.43333	-99.63333	771	-6	10
24017	KCDR	CDR	100708	CHADRON MUNI AP	42.8374	-103.0981	1004	-7	10
94957	KFNB	FNB	091406	FALLS CITY BRENNER FLD	40.08028	-95.59194	299	-6	10
14935	KGRI	GRI	091906	GRAND ISLAND AP	40.9611	-98.3136	561	-6	8
94949	KHSI	HSI	110705	HASTINGS MUNI AP	40.6005	-98.4258	598	-6	8
24091	KIML	IML	060507	IMPERIAL MUNI AP	40.51	-101.62	996	-7	10
14939	KLNK	LNK	032607	LINCOLN MUNI AP	40.8508	-96.7475	363	-6	10
94040	KMCK	MCK	022107	MCCOOK MUNI AP	40.20639	-100.59139	779	-6	10
14941	KOFK	OFK	102005	NORFOLK KARL STEFAN A	41.9855	-97.4352	473	-6	10
24023	KLBF	LBF	102005	NORTH PLATTE RGNL AP	41.1213	-100.6694	847	-6	8
94958	KODX	ODX	100405	ORD EVELYN SHARP FLD	41.62333	-98.94833	629	-6	8
24028	KBFF	BFF	022003	SCOTTSBLUFF HEILIG AP	41.8705	-103.593	1202	-7	8
24030	KSNY	SNY	092508	SIDNEY MUNI AP	41.0993	-102.9863	1309	-7	10
94978	KTQE	TQE	102005	TEKAMAH MUNI AP	41.76361	-96.17778	313	-6	10
24032	KVTN	VTN	091306	VALENTINE MILLER FLD	42.8783	-100.55	789	-6	10
94700	KBML	BML	102705	BERLIN MUNI AP	44.57611	-71.17861	342	-5	10

Attachment 1.

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
14745	KCON	CON	102005	CONCORD MUNI AP	43.1952	-71.5011	105	-5	8
54770	KAFN	AFN	111705	JAFFREY MUNI AP	42.805	-72.00361	317	-5	10
14710	KMHT	MHT	051309	MANCHESTER AP	42.93333	-71.43833	69	-5	10
93730	KACY	ACY	112906	ATLANTIC CITY INTL AP	39.4494	-74.5672	18	-5	8
54743	KCDW	CDW	060909	CALDWELL ESSEX CO AP	40.87639	-74.28306	53	-5	8
13735	KMIV	MIV	092606	MILLVILLE MUNI AP	39.3667	-75.0667	21	-5	8
93780	KVAY	VAY	091206	MT HOLLY S JERSEY AP	39.94917	-74.84167	14	-5	10
14734	KEWR	EWR	070809	NEWARK INTL AP	40.6825	-74.16944	2	-5	10
54785	KSMQ	SMQ	100708	SOMERVILLE SOMERSET	40.62389	-74.66944	33	-5	10
54793	KFWN	FWN	092408	SUSSEX AP	41.20028	-74.62306	123	-5	10
94741	KTEB	TEB	051909	TETERBORO AP	40.85	-74.06139	2	-5	8
23050	KABQ	ABQ	052207	ALBUQUERQUE INTL AP	35.0419	-106.6155	1618	-7	10
93033	KCNM	CNM	051007	CARLSBAD CAVERN CITY	32.3335	-104.258	985	-7	10
23051	KCAO	CAO	050307	CLAYTON MUNI AIR PK	36.4486	-103.1539	1512	-7	10
3027	KCQC	CQC	032007	CLINES CORNERS	35.00278	-105.66278	2160	-7	10
23078	KDMN	DMN	092706	DEMING MUNI AP	32.26222	-107.72056	1311	-7	10
23090	KFMN	FMN	040407	FARMINGTON RGNL AP	36.74361	-108.22917	1675	-7	10
23081	KGUP	GUP	051507	GALLUP MUNI AP	35.5144	-108.794	1972	-7	10
23054	KLVS	LVS	042607	LAS VEGAS MUNI AP	35.65417	-105.14194	2092	-7	10
23052	KRTN	RTN	031407	RATON MUNI CREWS AP	36.74139	-104.50222	1934	-7	10
23009	KROW	ROW	041607	ROSWELL IND AIR PK	33.3075	-104.5083	1112	-7	8
23049	KSAF	SAF	052307	SANTA FE CO MUNI AP	35.61694	-106.08889	1923	-7	8
93045	KTCS	TCS	031907	TRUTH OR CONSEQUENC	33.23667	-107.26806	1470	-7	8
23048	KTCC	TCC	040507	TUCUMCARI MUNI AP	35.18222	-103.60306	1234	-7	10
24121	KEKO	EKO	062807	ELKO RGNL AP	40.8288	-115.7886	1533	-8	10
23154	KELY	ELY	121605	ELY YELLAND FLD AP	39.2952	-114.8466	1909	-8	10
53123	KVGT	VGT	042607	LAS VEGAS AIR TERMINAL	36.21167	-115.19583	670	-8	10
23169	KLAS	LAS	042507	LAS VEGAS MCCARRAN A	36.0719	-115.1634	664	-8	10
24172	KLOL	LOL	101305	LOVELOCK DERBY FLD	40.0681	-118.5692	1189	-8	10
3160	KDRA	DRA	013006	MERCURY DESERT ROCK	36.6206	-116.0278	985	-8	10
23185	KRNO	RNO	051507	RENO TAHOE INTL AP	39.4838	-119.7711	1344	-8	10
23153	KTPH	TPH	020306	TONOPAH	38.0511	-117.0902	1644	-8	10

Attachment 1.

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
24128	KWMC	WMC	111705	WINNEMUCCA MUNI AP	40.9017	-117.808	1309	-8	10
14735	KALB	ALB	090806	ALBANY AP	42.7431	-73.8092	95	-5	10
4725	KBGM	BGM	021307	BINGHAMTON GREATER	42.2068	-75.98	486	-5	8
14733	KBUF	BUF	060409	BUFFALO NIAGARA INTL	42.9408	-78.7358	218	-5	10
94704	KDSV	DSV	092408	DANSVILLE MUNI AP	42.57083	-77.71333	196	-5	10
14747	KDKK	DKK	091908	DUNKIRK CHAUTAUQUA	42.49333	-79.27222	203	-5	10
14748	KELM	ELM	042507	ELMIRA CORNING RGNL	42.15944	-76.89194	288	-5	10
54787	KFRG	FRG	051809	FARMINGDALE AP	40.73417	-73.41694	24	-5	10
54773	KFZY	FZY	102705	FULTON OSWEGO CO AP	43.34972	-76.38472	141	-5	8
14750	KGFL	GFL	102705	GLENS FALLS AP	43.35	-73.6167	98	-5	10
4781	KISP	ISP		ISLIP LONG IS MACARTHU	40.79389	-73.10167	26	-5	8
94725	KMSS	MSS	111705	MASSENA INTL AP	44.93583	-74.84583	65	-5	10
4789	KMGJ	MGJ	071509	MONTGOMERY ORANGE	41.50917	-74.265	106	-5	10
94789	KJFK	JFK	063009	NEW YORK JFK INTL AP	40.63861	-73.76222	3	-5	10
14732	KLGA	LGA	070609	NEW YORK LAGUARDIA A	40.77944	-73.88028	3	-5	10
54778	KPEO	PEO	110705	PENN YAN AP	42.6425	-77.05639	263	-5	10
64776	KPBG	PBG	110705	PLATTSBURGH INTL AP	44.65	-73.46667	71	-5	10
14757	KPOU	POU	091206	POUGHKEEPSIE DUTCHES	41.6266	-73.8842	51	-5	8
14768	KROC	ROC	102008	ROCHESTER GTR INTL AP	43.1167	-77.6767	164	-5	10
64775	KRME	RME	032807	ROME GRIFFISS AIRFIELD	43.23389	-75.41167	147	-5	10
94740	KSLK	SLK	111805	SARANAC RGNL AP	44.38528	-74.20667	501	-5	8
54790	KHWV	HWV	120308	SHIRLEY BROOKHAVEN A	40.82167	-72.86889	20	-5	10
14771	KSYR	SYR	020107	SYRACUSE HANCOCK INTL	43.1111	-76.1038	126	-5	10
94790	KART	ART	110705	WATERTOWN INTL AP	43.9922	-76.0217	97	-5	8
54757	KELZ	ELZ	110705	WELLSVILLE MUNI AP	42.10944	-77.99194	647	-5	10
14719	KFOK	FOK	021109	WESTHAMPTN GABRESKI	40.84361	-72.63222	18	-5	10
14895	KCAK	CAK	070709	AKRON CANTON RGNL A	40.91667	-81.43333	368	-5	10
14813	KAKR	AKR	100306	AKRON FULTON INTL AP	41.0375	-81.46417	318	-5	10
4857	KHZY	HZY	100606	ASHTABULA CO AP	41.77806	-80.69583	278	-5	10
4853	KBKL	BKL	081808	CLEVELAND BURKE AP	41.5175	-81.68361	177	-5	8
14820	KCLE	CLE	052207	CLEVELAND HOPKINS INT	41.405	-81.85278	235	-5	10
4804	KOSU	OSU	061107	COLUMBUS OHIO STATE	40.07806	-83.07806	276	-5	8

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
14821	KCMH	CMH	053007	COLUMBUS PORT COLUM	39.99139	-82.88083	247	-5	10
93815	KDAY	DAY	050907	DAYTON INTL AP	39.90611	-84.21861	305	-5	10
53859	KMGY	MGY	043007	DAYTON WRIGHT BROS A	39.59361	-84.22639	290	-5	8
4851	KDFI	DFI	042407	DEFIANCE AP	41.3375	-84.42889	215	-5	10
4849	KLPR	LPR	120606	ELYRIA LORAIN CO AP	41.34611	-82.17944	241	-5	10
14825	KFDY	FDY	100506	FINDLAY AP	41.01361	-83.66861	244	-5	10
53855	KHAO	HAO	050807	HAMILTON BUTLER CO R	39.36444	-84.52472	189	-5	10
53844	KLHQ	LHQ	061207	LANCASTER FAIRFIELD AP	39.75556	-82.65722	259	-5	10
4850	KAOH	AOH	091906	LIMA ALLEN COUNTY AP	40.7075	-84.02722	297	-5	10
14891	KMFD	MFD	052307	MANSFIELD LAHM MUNI	40.82028	-82.51778	395	-5	10
4855	KMNN	MNN	120606	MARION MUNI AP	40.61611	-83.06361	301	-5	10
4852	KPHD	PHD	090706	NEW PHILADELPHIA FLD	40.47194	-81.42361	272	-5	10
4858	KVTA	VTA	120606	NEWARK HEATH AP	40.02278	-82.4625	267	-5	10
94830	KTOL	TOL	012007	TOLEDO EXPRESS AP	41.58861	-83.80139	204	-5	10
4848	KTDZ	TDZ	082008	TOLEDO METCALF FLD	41.56306	-83.47639	189	-5	10
13841	KILN	ILN	102005	WILMINGTON AIRBORNE	39.42028	-83.82167	321	-5	10
4842	KBJJ	BJJ	100406	WOOSTER WAYNE CO AP	40.87306	-81.88667	336	-5	10
14852	KYNG	YNG	090808	YOUNGSTOWN RGNL AP	41.25444	-80.67389	360	-5	10
93824	KZZV	ZZV	030907	ZANESVILLE MUNI AP	39.94444	-81.89222	268	-5	8
3959	KBVO	BVO	021309	BARTLESVILLE F P FLD	36.7683	-96.0261	218	-6	10
3932	KCSM	CSM	012209	CLINTON-SHERMAN AP	35.3568	-99.2042	586	-6	10
3981	KFDR	FDR	021809	FREDERICK MUNI AP	34.21	-98.59	383	-6	10
13975	KGAG	GAG	012109	GAGE AP	36.2967	-99.7689	668	-6	10
53913	KGOK	GOK	072607	GUTHRIE MUNI AP	35.8517	-97.4142	326	-6	10
3030	KGUY	GUY	090606	GUYMON MUNI AP	36.68167	-101.50528	950	-6	8
93986	KHBR	HBR	080107	HOBART MUNI AP	34.9894	-99.0525	474	-6	10
3950	KLAW	LAW	022509	LAWTON MUNI AP	34.5584	-98.4172	326	-6	10
93950	KMLC	MLC	043009	MCALESTER RGNL AP	34.8822	-95.783	235	-6	10
93953	KMKO	MKO	020907	MUSKOGEE DAVIS FLD	35.65667	-95.36139	184	-6	10
3954	KPWA	PWA	010709	OKLAHOMA CITY POST A	35.53417	-97.64694	395	-6	8
13967	KOKC	OKC	011409	OKLAHOMA CITY WILL R	35.3889	-97.6006	392	-6	8
13969	KPNC	PNC	020609	PONCA CITY MUNI AP	36.73667	-97.10194	305	-6	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
3965	KSWO	SWO	012009	STILLWATER RGNL AP	36.1624	-97.0894	300	-6	10
13968	KTUL	TUL	042209	TULSA INTL AP	36.1994	-95.8872	198	-6	10
53908	KRVS	RVS	021209	TULSA R L JONES JR AP	36.03944	-95.98444	190	-6	10
94224	KAST	AST	032006	ASTORIA RGNL AP	46.1569	-123.8825	3	-8	10
94281	KUAO	UAO	011503	AURORA STATE AP	45.24861	-122.76861	60	-8	8
24130	KBKE	BKE	050806	BAKER CITY MUNI AP	44.8428	-117.8086	1024	-8	10
94185	KBNO	BNO	050806	BURNS MUNI AP	43.595	-118.9564	1262	-8	10
24221	KEUG	EUG	040507	EUGENE MAHLON SWEET	44.1278	-123.2206	108	-8	10
4113	KHRI	HRI	041907	HERMISTON MUNI AP	45.82583	-119.26111	196	-8	10
94236	KLMT	LMT	052507	KLAMATH FALLS INTL AP	42.14694	-121.72417	1245	-8	10
94273	KMMV	MMV	040306	MCMINNVILLE MUNI AP	45.19472	-123.13389	48	-8	10
24152	KMEH	MEH	092806	MEACHAM	45.51139	-118.42472	1135	-8	10
24225	KMFR	MFR	040607	MEDFORD ROGUE VLY AP	42.3811	-122.8722	395	-8	10
24162	KONO	ONO	050806	ONTARIO MUNI AP	44.02056	-117.01278	668	-7	10
24155	KPDT	PDT	042607	PENDLETON E OR RGNL A	45.6983	-118.8547	453	-8	10
94261	KHIO	HIO	031607	PORTLAND-HILLSBORO A	45.54056	-122.94861	63	-8	10
24230	KRDM	RDM	032207	REDMOND ROBERTS FLD	44.2558	-121.1392	928	-8	10
24231	KRBG	RBG	022706	ROSEBURG RGNL AP	43.23889	-123.35472	158	-8	10
24232	KSLE	SLE	051507	SALEM MCNARY FLD	44.905	-123.0011	62	-8	10
4201	KSPB	SPB	022706	SCAPPOOSE IND AP	45.77278	-122.86111	16	-8	10
24235	KSXT	SXT	121605	SEXTON SUMMIT	42.6003	-123.3641	1168	-8	10
14737	KABE	ABE	093008	ALLENTOWN INTL AP	40.65083	-75.4492	119	-5	8
14736	KAOO	AOO	082108	ALTOONA BLAIR CO AP	40.29639	-78.32028	451	-5	8
4751	KBFD	BFD	111705	BRADFORD RGNL AP	41.8	-78.6333	653	-5	8
54792	KFIG	FIG	102705	CLEARFIELD LAWRENCE A	41.04667	-78.41167	462	-5	10
54786	KDYL	DYL	090208	DOYLESTOWN AP	40.33	-75.1225	119	-5	10
4787	KDUJ	DUJ	040207	DUBOIS JEFFERSON CO A	41.17833	-78.89889	553	-5	8
14860	KERI	ERI	082108	ERIE INTL AP	42.08	-80.1825	223	-5	10
14751	KCXY	CXY	071207	HARRISBURG CPTL CY AP	40.21722	-76.85139	104	-5	8
4726	KJST	JST	082506	JOHNSTOWN CAMBRIA C	40.31611	-78.83389	695	-5	8
54737	KLNS	LNS	081508	LANCASTER AP	40.12028	-76.29444	122	-5	8
14711	KMDT	MDT	082208	MIDDLETOWN HARRISBU	40.1962	-76.7724	95	-5	8

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
54789	KMPO	MPO	091908	MT POCONO MOUNTAIN	41.13889	-75.37944	578	-5	10
94732	KPNE	PNE	071207	PHILADELPHIA NE AP	40.08194	-75.01111	30	-5	10
14762	KAGC	AGC	040307	PITTSBURGH ALLEGHENY	40.35472	-79.92167	380	-5	8
94823	KPIT	PIT	072809	PITTSBURGH INTL AP	40.4846	-80.2144	367	-5	10
4843	KGKJ	GKJ	010606	PORT MEADVILLE AP	41.62639	-80.215	426	-5	10
54782	KPTW	PTW	090408	POTTSTOWN LIMERICK A	40.23833	-75.55722	90	-5	8
14712	KRDG	RDG	111908	READING SPAATZ FLD	40.36667	-75.96667	87	-5	8
14770	KSEG	SEG	081808	SELINSGROVE PENN VLY A	40.82056	-76.86417	135	-5	10
14777	KAVP	AVP	032807	WILKES-BARRE INTL AP	41.3336	-75.7269	283	-5	10
14778	KIPT	IPT	053007	WILLIAMSPORT	41.2433	-76.9217	158	-5	8
93778	KTHV	THV	031505	YORK AP	39.91806	-76.87417	141	-5	10
14787	KUUU	UUU	092606	NEWPORT STATE AP	41.53333	-71.28333	43	-5	8
14765	KPVD	PVD	071709	PROVIDENCE T F GREEN A	41.7219	-71.4325	18	-5	10
93846	KAND	AND	102108	ANDERSON CO AP	34.4977	-82.7097	232	-5	10
13880	KCHS	CHS	061009	CHARLESTON INTL AP	32.8986	-80.0402	12	-5	10
53850	KCEU	CEU	100208	CLEMSON OCONEE CO A	34.67194	-82.88639	265	-5	8
13883	KCAE	CAE	051209	COLUMBIA METRO AP	33.9419	-81.1181	69	-5	10
53867	KCUB	CUB	042809	COLUMBIA OWENS DWT	33.97056	-80.99583	55	-5	8
13744	KFLO	FLO	041707	FLORENCE RGNL AP	34.1852	-79.7238	45	-5	10
13886	KGMU	GMU	102808	GREENVILLE DWTN AP	34.84611	-82.34611	309	-5	8
53874	KGRD	GRD	101508	GREENWOOD CO AP	34.24861	-82.15917	192	-5	10
3870	KGSP	GSP	110508	GRNVL SPART AP	34.8842	-82.2209	287	-5	8
93718	KCRE	CRE	042007	N MYRTLE BCH AP	33.81167	-78.72389	10	-5	10
53854	KOGB	OGB	042909	ORANGEBURG MUNI AP	33.46167	-80.85806	55	-5	10
53871	KUZA	UZA	051909	ROCK HILL YORK CO AP	34.98694	-81.0575	200	-5	10
14929	KABR	ABR	102705	ABERDEEN RGNL AP	45.4433	-98.413	395	-6	8
94032	KCUT	CUT	102005	CUSTER CO AP	43.73306	-103.61139	1690	-7	10
14936	KHON	HON	042809	HURON RGNL AP	44.3981	-98.2231	390	-6	10
94950	KMHE	MHE	020306	MITCHELL MUNI AP	43.7743	-98.0384	396	-6	8
94052	KMBG	MBG	010907	MOBRIDGE MUNI AP	45.54639	-100.40778	517	-6	10
24024	KPHP	PHP	051507	PHILIP AP	44.05111	-101.60111	672	-7	10
24025	KPIR	PIR	111705	PIERRE RGNL AP	44.3813	-100.2855	531	-6	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
24090	KRAP	RAP	092806	RAPID CITY REGIONAL AP	44.0433	-103.0536	963	-7	10
14944	KFSD	FSD	060706	SIOUX FALLS FOSS FLD	43.5778	-96.7539	435	-6	10
14946	KATY	ATY	110705	WATERTOWN RGNL AP	44.9047	-97.1494	533	-6	8
94990	KICR	ICR	082108	WINNER WILEY FLD	43.39056	-99.84222	619	-6	10
13877	KTRI	TRI	042307	BRISTOL TRI CITY AP	36.4731	-82.4044	457	-5	10
3847	KCSV	CSV	041007	CROSSVILLE MEM AP	35.9509	-85.0813	569	-6	8
3811	KMKL	MKL	093008	JACKSON MCKELLAR AP	35.593	-88.9167	132	-6	10
13891	KTYS	TYS	041707	KNOXVILLE MCGHEE TYSC	35.8181	-83.9858	293	-5	10
13893	KMEM	MEM	100608	MEMPHIS INTL AP	35.0564	-89.9865	77	-6	10
13897	KBNA	BNA	040507	NASHVILLE INTL AP	36.11889	-86.68917	183	-6	10
53868	KOQT	OQT	032207	OAK RIDGE ASOS	36.0236	-84.2375	277	-5	10
13962	KABI	ABI	012909	ABILENE RGNL AP	32.4105	-99.6822	546	-6	10
12932	KALI	ALI	022707	ALICE INTL AP	27.74111	-98.02472	53	-6	10
23047	KAMA	AMA	082506	AMARILLO INTL AP	35.2295	-101.7042	1098	-6	10
12976	KLBX	LBX	062107	ANGLETON BRAZORIA AP	29.10972	-95.46194	8	-6	10
53907	KGKY	GKY	022607	ARLINGTON MUNI AP	32.66361	-97.09389	188	-6	10
13904	KAUS	AUS	103008	AUSTIN BERGSTROM AP	30.1831	-97.6799	146	-6	10
13958	KATT	ATT	030807	AUSTIN-CAMP MABRY	30.3208	-97.7604	204	-6	10
3024	KBGD	BGD	090506	BORGER HUTCHINSON CC	35.695	-101.395	925	-6	10
12919	KBRO	BRO	040607	BROWNSVILLE INTL AP	25.9141	-97.423	7	-6	10
3999	KBMQ	BMQ	090308	BURNET MUNI AP	30.7406	-98.2354	393	-6	10
23007	KCDS	CDS	042607	CHILDRESS MUNI AP	34.4272	-100.2831	595	-6	10
3904	KCLL	CLL	062309	COLLEGE STN	30.58917	-96.36472	93	-6	8
53902	KCXO	CXO	052609	CONROE MONTGOMERY	30.35667	-95.41389	71	-6	8
12924	KCRP	CRP	021306	CORPUS CHRISTI INTL AP	27.7742	-97.5122	13	-6	10
53912	KCRS	CRS	022207	CORSICANA CAMPBELL FL	32.03111	-96.39889	136	-6	10
12947	KCOT	COT	022607	COTULLA LA SALLE CO AP	28.45667	-99.21833	145	-6	10
3927	KDFW	DFW	052709	DAL-FTW WSCMO AP	32.8978	-97.0189	171	-6	10
93042	KDHT	DHT	090506	DALHART FAA AP	36.0167	-102.55	1216	-6	10
13960	KDAL	DAL	052809	DALLAS FAA AP	32.8519	-96.8555	134	-6	10
3971	KRBD	RBD	030707	DALLAS REDBIRD AP	32.68083	-96.86806	201	-6	10
22010	KDRT	DRT	060707	DEL RIO INTL AP	29.3784	-100.927	304	-6	10

Attachment 1.

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
3991	KDTO	DTO	022707	DENTON MUNI AP	33.20611	-97.19889	197	-6	10
23044	KELP	ELP	111308	EL PASO INTL AP	31.81111	-106.37583	1194	-7	10
23091	KFST	FST	050107	FT STOCKTON PECOS AP	30.91194	-102.91667	917	-6	10
53909	KAFW	AFW	022007	FT WORTH ALLIANCE AP	32.97333	-97.31806	209	-6	10
13961	KFTW	FTW	021003	FT WORTH MEACHAM FL	32.81917	-97.36139	209	-6	8
12923	KGLS	GLS	053007	GALVESTON SCHOLES FLD	29.2733	-94.8592	2	-6	8
12904	KHRL	HRL	050907	HARLINGEN RIO GRANDE	26.22806	-97.65417	10	-6	10
12962	KHDO	HDO	050207	HONDO MUNI AP	29.3601	-99.1742	280	-6	10
12975	KLVJ	LVJ	060607	HOUSTON CLOVER FLD	29.51889	-95.24167	13	-6	8
12918	KHOU	HOU	062707	HOUSTON HOBBY AP	29.63806	-95.28194	13	-6	10
53910	KDWH	DWH	073107	HOUSTON HOOKS MEM A	30.0675	-95.55611	47	-6	10
12960	KIAH	IAH	061109	HOUSTON INTERCONT AP	29.98	-95.36	29	-6	10
12977	KSGR	SGR	062207	HOUSTON SUGARLAND M	29.62194	-95.65667	26	-6	8
53903	KUTS	UTS	061909	HUNTSVILLE MUNI AP	30.74389	-95.58611	106	-6	10
13973	KJCT	JCT	032807	JUNCTION KIMBLE CO AP	30.51083	-99.76639	524	-6	10
3901	KGGG	GGG	100808	LONGVIEW E TX RGNL AP	32.38472	-94.71167	111	-6	10
23042	KLBB	LBB	041107	LUBBOCK INTL AP	33.6656	-101.8231	992	-6	10
93987	KLFK	LFK	112008	LUFKIN ANGELINA CO AP	31.23611	-94.75444	88	-6	8
12959	KMFE	MFE	051507	MCALLEN MILLER INTL AP	26.18389	-98.25389	30	-6	10
53914	KTKI	TKI	030507	MCKINNEY MUNI AP	33.19028	-96.59139	179	-6	10
23023	KMAF	MAF	041107	MIDLAND INTL AP	31.9475	-102.2086	872	-6	8
93985	KMWL	MWL	022106	MINERAL WELLS AP	32.7816	-98.0602	283	-6	10
12971	KBAZ	BAZ	051305	NEW BRAUNFELS MUNI A	29.7089	-98.0458	197	-6	10
12935	KPSX	PSX	061107	PALACIOS MUNI AP	28.72472	-96.25361	4	-6	10
23055	KGDP	GDP	052207	PINE SPRINGS NP	31.83111	-104.80889	1663	-6	6
12917	KBPT	BPT	062007	PORT ARTHUR SE TX AP	29.95056	-94.02056	5	-6	10
12957	KPIL	PIL	040307	PORT ISABEL CAMERON A	26.16583	-97.34583	4	-6	10
12972	KRKP	RKP	030107	ROCKPORT ARANSAS CO	28.08361	-97.04639	7	-6	10
23034	KSJT	SJT	052307	SAN ANGELO MATHIS FLD	31.35167	-100.495	584	-6	10
12921	KSAT	SAT	102208	SAN ANTONIO INTL AP	29.5443	-98.4839	240	-6	10
12970	KSSF	SSF	090908	SAN ANTONIO STINSON A	29.3389	-98.472	174	-6	10
53911	KTRL	TRL	030607	TERRELL MUNI AP	32.71	-96.26722	144	-6	8

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
13972	KTYR	TYR	103008	TYLER POUNDS FLD	32.35417	-95.4025	166	-6	10
12912	KVCT	VCT	022307	VICTORIA RGNL AP	28.8614	-96.9303	35	-6	10
13959	KACT	ACT	030207	WACO RGNL AP	31.61889	-97.22833	152	-6	10
13966	KSPS	SPS	032409	WICHITA FALLS MUNI AP	33.9786	-98.4928	310	-6	10
23040	KINK	INK	040307	WINKLER CO AP	31.7801	-103.2018	856	-6	10
23159	KBCE	BCE	091906	BRYCE CANYON AP	37.70639	-112.14556	2307	-7	10
93129	KCDC	CDC	120606	CEDAR CITY MUNI AP	37.7086	-113.0944	1703	-7	8
94128	KLGU	LGU	110705	LOGAN CACHE AP	41.78722	-111.85333	1356	-7	10
23176	KMLF	MLF	021306	MILFORD MUNI AP	38.41667	-113.01667	1538	-7	10
93075	KCNY	CNY	050307	MOAB CANYONLAND AP	38.75	-109.76278	1390	-7	10
93141	KPUC	PUC	110705	PRICE CARBON CO AP	39.60917	-110.75472	1779	-7	10
24127	KSLC	SLC	052307	SALT LAKE CITY INTL AP	40.7781	-111.9694	1288	-7	10
94030	KVEL	VEL	032707	VERNAL MUNI AP	40.44278	-109.51278	1606	-7	10
93775	KOFP	OFP	032907	ASHLAND HANOVER CO M	37.70806	-77.43444	63	-5	10
93736	KCHO	CHO	042307	CHARLOTTESVILLE AP	38.13861	-78.45306	188	-5	8
13733	KLYH	LYH	103008	LYNCHBURG RGNL AP	37.3208	-79.2067	287	-5	10
93741	KPHF	PHF	032007	NEWPORT NEWS INTL AP	37.13194	-76.49306	11	-5	10
13737	KORF	ORF	032707	NORFOLK INTL AP	36.9033	-76.1922	9	-5	10
13740	KRIC	RIC	032807	RICHMOND INTL AP	37.505	-77.3202	50	-5	10
13741	KROA	ROA	102308	ROANOKE RGNL AP	37.3169	-79.9741	358	-5	10
93773	KAKQ	AKQ	031307	WAKEFIELD MUNI AP	36.98389	-77.00722	33	-5	8
93739	KWAL	WAL	041107	WALLOPS ISLAND FLIGHT	37.9372	-75.4708	14	-5	10
93738	KIAD	IAD	100306	WASHINGTON DC DULLES	38.9408	-77.4636	88	-5	10
94705	KMPV	MPV	102705	BARRE MONTPELIER AP	44.2035	-72.5623	343	-5	8
14742	KBTV	BTV	092402	BURLINGTON INTL AP	44.4683	-73.1499	101	-5	8
54771	KMVL	MVL	110705	MORRISVILLE STOWE STA	44.53444	-72.61444	225	-5	8
54740	KVSF	VSF	110705	SPRINGFIELD HARTNESS A	43.34361	-72.51778	176	-5	8
24217	KBLI	BLI	040307	BELLINGHAM INTL AP	48.79389	-122.53722	45	-8	10
94119	KDEW	DEW	091206	DEER PARK AP	47.97417	-117.42833	668	-8	10
24220	KELN	ELN	071107	ELLENSBURG BOWERS FL	47.03389	-120.53028	535	-8	10
24141	KEPH	EPH	111705	EPHRATA MUNI AP	47.3078	-119.5154	382	-8	10
24222	KPAE	PAE	032907	EVERETT SNOHOMISH AP	47.90778	-122.28028	181	-8	10

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
94276	KFHR	FHR	121605	FRIDAY HARBOR AP	48.52222	-123.02306	27	-8	8
94225	KHQM	HQM	041006	HOQUIAM BOWERMAN A	46.9727	-123.9302	4	-8	10
24110	KMWH	MWH	081507	MOSES LAKE GRANT CO A	47.20778	-119.31917	357	-8	10
24227	KOLM	OLM	051007	OLYMPIA AP	46.9733	-122.9033	57	-8	8
94197	KOMK	OMK	062707	OMAK	48.464444	-119.51694	396	-8	10
94129	KPUW	PUW	110705	PULLMAN MOSCOW RGN	46.74389	-117.10861	772	-8	10
94240	KUIL	UIL	052506	QUILLAYUTE STATE AP	47.9375	-124.555	56	-8	10
94248	KRNT	RNT	033007	RENTON MUNI AP	47.49333	-122.21444	7	-8	8
24234	KBFI	BFI	051707	SEATTLE BOEING FLD	47.53028	-122.30083	5	-8	8
24233	KSEA	SEA	051707	SEATTLE TACOMA INTL A	47.4444	-122.3138	113	-8	10
94227	KSHN	SHN	111705	SHELTON SANDERSON FL	47.238	-123.1408	83	-8	10
94176	KSFF	SFF	062607	SPOKANE FELTS FLD	47.68306	-117.32139	595	-8	10
24157	KGEG	GEG	061407	SPOKANE INTL AP	47.6216	-117.528	717	-8	10
94274	KTIW	TIW	051607	TACOMA NARROWS AP	47.2675	-122.57611	89	-8	8
24160	KALW	ALW	082207	WALLA WALLA RGNL AP	46.09472	-118.28694	355	-8	10
94239	KEAT	EAT	121605	WENATCHEE PANGBORN	47.3977	-120.2013	375	-8	10
24243	KYKM	YKM	080807	YAKIMA AIR TERMINAL	46.5683	-120.5428	324	-8	10
94929	KASX	ASX	111705	ASHLAND KENNEDY MEM	46.54861	-90.91889	251	-6	10
94994	KOVS	OVS	100705	BOSCOBEL AP	43.15611	-90.6775	203	-6	10
14991	KEAU	EAU	032007	EAU CLAIRE RGNL AP	44.8665	-91.4879	270	-6	10
4840	KFLD	FLD	102005	FOND DU LAC CO AP	43.76944	-88.49083	246	-6	10
14898	KGRB	GRB	082605	GREEN BAY A S INTL AP	44.4794	-88.1366	209	-6	10
94973	KHYR	HYR	110705	HAYWARD MUNI AP	46.02611	-91.44417	367	-6	10
4845	KENW	ENW	032607	KENOSHA RGNL AP	42.595	-87.93806	225	-6	10
14921	KLNR	LNR	050907	LONE ROCK TRI CO AP	43.21194	-90.18139	219	-6	10
14837	KMSN	MSN	051007	MADISON DANE RGNL AP	43.1405	-89.3452	264	-6	10
94985	KMFI	MFI	100405	MARSHFIELD MUNI AP	44.63806	-90.1875	383	-6	10
14839	KMKE	MKE	091406	MILWAUKEE MITCHELL A	42.955	-87.9044	204	-6	10
94855	KOSH	OSH	110402	OSHKOSH WITTMAN AP	43.98444	-88.55694	238	-6	8
94818	KRAC	RAC	102705	RACINE BATTEN AP	42.76111	-87.81361	202	-6	10
4803	KRHI	RHI	100705	RHINELANDER ONEIDA AP	45.6314	-89.4823	495	-6	8
4841	KSBM	SBM	100405	SHEBOYGAN CO MEM AP	43.76944	-87.85056	227	-6	10

Attachment 1.

Surface WBAN	Surface CALL	Ice Free Call	Ice Free Date	Name	Surface Latitude	Surface Longitude	Surface Elevation	Surface UTC	Aneno Height (m)
14897	KAUW	AUW	100405	WAUSAU ASOS	44.9288	-89.6277	366	-6	10
4826	KISW	ISW	100405	WISCONSIN RAPIDS ALEX	44.35917	-89.83694	311	-6	10
3872	KBKW	BKW	030907	BECKLEY RALEIGH CO AP	37.7836	-81.123	766	-5	10
13866	KCRW	CRW	091906	CHARLESTON YEAGER AP	38.3794	-81.59	277	-5	8
3802	KCKB	CKB	052207	CLARKSBURG BENEDUM	39.29556	-80.22889	361	-5	8
13729	KEKN	EKN	092206	ELKINS RANDOLPH CO AP	38.8853	-79.8528	603	-5	8
13734	KMRB	MRB	031407	MARTINSBURG E WV RGN	39.4019	-77.9844	163	-5	8
13736	KMGW	MGW	022807	MORGANTOWN HART FL	39.64278	-79.91639	378	-5	8
24164	KBPI	BPI	061107	BIG PINEY MARBLETON A	42.58444	-110.1075	2124	-7	10
94054	KBYG	BYG	090606	BUFFALO JOHNSON CO A	44.38139	-106.72111	1506	-7	10
24089	KCPR	CPR	041107	CASPER NATRONA CO AP	42.8977	-106.4739	1619	-7	10
24018	KCYS	CYS	092606	CHEYENNE MUNI AP	41.15	-104.8167	1868	-7	10
94057	KDGW	DGW	092308	CONVERSE CO AP ASOS	42.79611	-105.38028	1504	-7	10
94023	KGCC	GCC	012407	GILLETTE CAMPBELL AP	44.33944	-105.54194	1327	-7	8
24048	KGEY	GEY	071807	GREYBULL S BIG HORN A	44.51694	-108.08222	1194	-7	10
24021	KLND	LND	111705	LANDER HUNT FLD AP	42.8154	-108.7261	1704	-7	10
24022	KLAR	LAR	092806	LARAMIE AP	41.3167	-105.6833	2215	-7	10
24057	KRWL	RWL	090408	RAWLINS AP	41.8025	-107.2056	2053	-7	10
24061	KRIW	RIW	110705	RIVERTON RGNL AP	43.06417	-108.45889	1660	-7	10
24027	KRKS	RKS	052907	ROCK SPRINGS AP	41.5944	-109.0529	2055	-7	10
24029	KSHR	SHR	083006	SHERIDAN AP	44.7694	-106.9688	1202	-7	10
94053	KTOR	TOR	091306	TORRINGTON MUNI AP	42.0613	-104.1584	1280	-7	10
24062	KWRL	WRL	053107	WORLAND	43.96583	-107.95083	1272	-7	10

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
22551	AIRWAYS,ASOS	HI	N	N	A	HI	Y	HI22551	91165	-10
21504	ASOS,COOP	HI	N	N	A	HI	Y	HI21504	91285	-10
22521	ASOS,COOP	HI	N	N	A	HI	Y	HI22521	91165	-10
22516	AIRWAYS,ASOS,CO	HI	N	N	A	HI	Y	HI22516	91285	-10
21510	AIRWAYS,ASOS	HI	N	N	A	HI	Y	HI21510	91285	-10
22536	ASOS,COOP	HI	N	N	A	HI	Y	HI22536	91165	-10
22534	ASOS,COOP	HI	N	N	A	HI	Y	HI22534	91165	-10
14931	ASOS	IA, IL	Y	N	A	IA	Y	IA14931	74455	-6
14943	AIRWAYS,ASOS,CO	IA, NE	Y	N	A	IA	Y	IA14943	72558	-6
24149	AIRSAMPLE,ASOS,C	WA, ID	N	N	A	ID	Y	ID24149	72786	-8
24154	AIRWAYS,ASOS	MT, ID	Y	N	A	ID	N	ID24154	72786	-8
3960	AIRWAYS,ASOS	IL, MO	N	N	A	IL	Y	IL3960	74560	-6
93814	ASOS,COOP	OH, KY	Y	N	A	KY	Y	KY93814	72426	-5
3996	AIRWAYS,ASOS,CO	MS, LA	N	N	A	LA	Y	LA3996	72235	-6
54768	AIRWAYS,ASOS,CO	VT, MA	Y	N	A	MA	Y	MA54768	72518	-5
93706	AIRWAYS,ASOS	PA, MD	N	N	A	MD	Y	MD93706	72403	-5
54772	AIRWAYS,ASOS	ME, NH	Y	N	A	ME	Y	ME54772	74389	-5
94893	AIRWAYS,ASOS	WI, MI	Y	N	A	MI	Y	MI94893	72645	-6
13988	AIRWAYS,ASOS,CO	KS, MO	Y	N	A	MO	Y	MO13988	72456	-6
53904	AIRWAYS,ASOS	IL, MO	N	N	A	MO	Y	MO53904	74560	-6
13993	AIRWAYS,ASOS,CO	KS, MO	Y	N	A	MO	Y	MO13993	72456	-6
53870	AIRWAYS,ASOS	NC, SC	N	N	A	NC	Y	NC53870	72317	-5
14914	AIRWAYS,ASOS,CO	ND, MN	Y	N	A	ND	Y	ND14914	72659	-6
14942	AIRWAYS,ASOS,CO	IA, NE	Y	N	A	NE	Y	NE14942	72558	-6
94765	AIRWAYS,ASOS	VT, NH	Y	N	A	NH	Y	NH94765	72518	-5
54791	AIRWAYS,ASOS	ME, NH	Y	N	A	NH	Y	NH54791	74389	-5
14792	AIRWAYS,ASOS	PA, NJ	Y	N	A	NJ	Y	NJ14792	72501	-5
94728	ASOS,COOP,USHCN	NY, NJ	Y	N	A	NY	N	NY94728	72501	-5
93812	AIRWAYS,ASOS,CO	OH, KY	Y	N	A	OH	Y	OH93812	72426	-5
24229	ASOS,COOP	WA, OR	N	N	A	OR	Y	OR24229	72694	-8
24242	AIRWAYS,ASOS	WA, OR	N	N	A	OR	Y	OR24242	72694	-8
13739	ASOS,COOP	PA, NJ	Y	N	A	PA	Y	PA13739	72403	-5

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
11641	ASOS,COOP	PR	N	N	A	PR	Y	PR11641	78526	-4
14794	AIRWAYS,ASOS	CT, RI	Y	N	A	RI	Y	RI14794	72501	-5
94039	AIRWAYS,ASOS	SD, NE	N	Y	A	SD	Y	SD94039	72662	-7
13882	AIRSAMPLE,AIRWA	TN, GA	N	N	A	TN	Y	TN13882	72215	-5
3894	ASOS,COOP	KY, TN	N	N	A	TN	Y	TN3894	72327	-6
13728	ASOS,COOP	VA, NC	N	N	A	VA	Y	VA13728	72317	-5
13743	ASOS,COOP	MD, DC, VA	N	N	A	VA	Y	VA13743	72403	-5
54781	AIRWAYS,ASOS	VT, NY	Y	N	A	VT	Y	VT54781	72518	-5
24219	AIRWAYS,ASOS,CO	WA, OR	Y	N	A	WA	Y	WA24219	72694	-8
94298	AIRWAYS,ASOS	WA, OR	N	N	A	WA	Y	WA94298	72694	-8
14920	AIRWAYS,ASOS,CO	WI, MN	Y	N	A	WI	Y	WI14920	74455	-6
3859	ASOS,COOP	WV, VA	Y	N	A	WV	Y	WV3859	72318	-5
3860	ASOS,COOP	WV, OH, KY	N	N	A	WV	Y	WV3860	72426	-5
14894	AIRWAYS,ASOS	OH, WV	N	N	A	WV	Y	WV14894	72520	-5
4111	AIRWAYS,ASOS	WY, UT	N	Y	A	WY	Y	WY4111	72572	-7
13714	ASOS,COOP,WXSV	NC	N	N	A	NC	Y	NC13714	72317	-5
12974	ASOS,COOP,WXSV	TX	N	N	A	TX	Y	TX12974	72251	-6
21508	ASOS,COOP,WXSV	HI	N	N	A	HI	Y	HI21508	91285	-10
13947	ASOS,COOP,WXSV	KS	Y	N	A	KS	Y	KS13947	72456	-6
13702	ASOS,COOP,WXSV	VA	N	N	A	VA	Y	VA13702	72402	-5
26451	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26451	70273	-9
26409	AIRWAYS,ASOS	AK	Y	N	A	AK	Y	AK26409	70273	-9
25308	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25308	70398	-9
27502	ASOS,COOP	AK	Y	N	A	AK	Y	AK27502	70026	-9
26615	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26615	70219	-9
26533	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26533	70261	-9
26415	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26415	70261	-9
25624	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25624	70316	-9
26410	ASOS,COOP	AK	Y	N	A	AK	Y	AK26410	70273	-9
27406	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK27406	70261	-9
26422	AIRWAYS,ASOS	AK	Y	N	A	AK	Y	AK26422	70361	-9
26411	ASOS,COOP	AK	Y	N	A	AK	Y	AK26411	70261	-9

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
26425	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26425	70261	-9
25323	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25323	71964	-8
25507	ASOS,COOP	AK	Y	N	A	AK	Y	AK25507	70273	-9
25506	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25506	70326	-9
25309	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25309	71964	-8
26523	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26523	70273	-9
25325	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25325	70398	-9
25503	ASOS,COOP	AK	Y	N	A	AK	Y	AK25503	70326	-9
25501	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25501	70350	-9
26616	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26616	70133	-9
26510	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26510	70231	-9
26435	ASOS	AK	Y	N	A	AK	Y	AK26435	70261	-9
26617	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26617	70200	-9
26412	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26412	70361	-9
27515	AIRWAYS,ASOS	AK	Y	N	A	AK	Y	AK27515	70026	-9
25331	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25331	70273	-9
26492	ASOS,COOP,WXSV	AK	Y	N	A	AK	N	AK26492	70273	-9
25516	AIRWAYS,ASOS	AK	Y	N	A	AK	Y	AK25516	70350	-9
26438	AIRWAYS,ASOS	AK	Y	N	A	AK	Y	AK26438	70273	-9
25333	ASOS,COOP	AK	Y	N	A	AK	Y	AK25333	71964	-8
25335	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25335	71964	-8
25628	AIRWAYS,ASOS	AK	Y	N	A	AK	Y	AK25628	70308	-9
25713	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK25713	70308	-9
26528	ASOS,COOP	AK	Y	N	A	AK	Y	AK26528	70273	-9
26529	AIRWAYS,ASOS,CO	AK	Y	N	A	AK	Y	AK26529	70231	-9
27503	AIRWAYS,ASOS	AK	Y	N	A	AK	Y	AK27503	70026	-9
53864	ASOS,COOP,UPPER	AL	N	N	A	AL	Y	AL53864	72230	-6
13871	AIRWAYS,ASOS,CO	AL	N	N	A	AL	Y	AL13871	72230	-6
13876	AIRSAMPLE,AIRWA	AL	N	N	A	AL	Y	AL13876	72230	-6
53852	AIRWAYS,ASOS	AL	N	N	A	AL	Y	AL53852	72230	-6
13839	AIRWAYS,ASOS,CO	AL	N	N	A	AL	Y	AL13839	72214	-5
53820	AIRWAYS,ASOS	AL	N	N	A	AL	Y	AL53820	72230	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
3856	ASOS,COOP	AL	N	N	A	AL	Y	AL3856	72230	-6
13838	AIRWAYS,ASOS	AL	N	N	A	AL	Y	AL13838	72233	-6
13894	ASOS,COOP,UPPER	AL	N	N	A	AL	Y	AL13894	72233	-6
13895	AIRSAMPLE,ASOS,	AL	N	N	A	AL	Y	AL13895	72230	-6
13896	AIRWAYS,ASOS,CO	AL	N	N	A	AL	Y	AL13896	72230	-6
3878	ASOS	AL	N	N	A	AL	Y	AL3878	72230	-6
93806	AIRWAYS,ASOS,CO	AL	N	N	A	AL	Y	AL93806	72230	-6
53869	AIRWAYS,ASOS	AR	N	N	A	AR	Y	AR53869	72340	-6
53925	ASOS,COOP	AR	N	N	A	AR	Y	AR53925	72248	-6
93992	AIRWAYS,ASOS,CO	AR	N	N	A	AR	Y	AR93992	72248	-6
93993	ASOS,COOP	AR	N	N	A	AR	Y	AR93993	72440	-6
53922	AIRWAYS,ASOS	AR	N	N	A	AR	Y	AR53922	72440	-6
13964	AIRSAMPLE,ASOS,	AR	N	N	A	AR	Y	AR13964	72440	-6
13971	ASOS,COOP	AR	N	N	A	AR	Y	AR13971	72440	-6
3962	ASOS,COOP	AR	N	N	A	AR	Y	AR3962	72340	-6
3953	AIRWAYS,ASOS	AR	N	N	A	AR	Y	AR3953	72340	-6
13963	AIRWAYS,ASOS,CO	AR	N	N	A	AR	Y	AR13963	72340	-6
53919	ASOS,COOP	AR	N	N	A	AR	Y	AR53919	72340	-6
53921	AIRWAYS,ASOS,CO	AR	N	N	A	AR	N	AR53921	72340	-6
53918	AIRWAYS,ASOS	AR	N	N	A	AR	Y	AR53918	72440	-6
93988	ASOS	AR	N	N	A	AR	Y	AR93988	72340	-6
53920	AIRWAYS,ASOS	AR	N	N	A	AR	Y	AR53920	72340	-6
13977	ASOS,COOP	TX, AR	N	N	A	AR	Y	AR13977	72248	-6
93026	ASOS,COOP	AZ	N	Y	A	AZ	Y	AZ93026	72274	-7
3103	ASOS,COOP	AZ	N	Y	A	AZ	Y	AZ3103	72376	-7
3195	AIRWAYS,ASOS	AZ	N	Y	A	AZ	Y	AZ3195	72376	-7
93167	ASOS,COOP	AZ	N	Y	A	AZ	Y	AZ93167	72388	-8
3196	AIRWAYS,ASOS	AZ	N	Y	A	AZ	Y	AZ3196	72274	-7
3162	ASOS	AZ	N	Y	A	AZ	Y	AZ3162	72376	-7
3184	AIRWAYS,ASOS	AZ	N	Y	A	AZ	Y	AZ3184	72376	-7
23183	ASOS,COOP	AZ	N	Y	A	AZ	Y	AZ23183	72274	-7
23184	AIRWAYS,ASOS	AZ	N	Y	A	AZ	Y	AZ23184	72376	-7

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
93084	AIRWAYS,ASOS	AZ	N	Y	A	AZ	Y	AZ93084	72274	-7
3192	AIRWAYS,ASOS	AZ	N	Y	A	AZ	Y	AZ3192	72376	-7
93027	AIRWAYS,ASOS	AZ	N	Y	A	AZ	Y	AZ93027	72376	-7
23160	ASOS,COOP	AZ	N	Y	A	AZ	Y	AZ23160	72274	-7
3029	ASOS	AZ, NM	N	Y	A	AZ	Y	AZ3029	72365	-7
23194	ASOS,COOP	AZ	N	Y	A	AZ	Y	AZ23194	72376	-7
94299	ASOS	CA	N	Y	A	CA	Y	CA94299	72489	-8
24283	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA24283	72597	-8
23191	ASOS	CA	N	N	A	CA	Y	CA23191	72293	-8
23155	ASOS,COOP	CA	N	N	A	CA	Y	CA23155	72293	-8
23161	ASOS,COOP	CA	N	N	A	CA	Y	CA23161	72388	-8
23157	ASOS,COOP	CA	N	N	A	CA	Y	CA23157	72489	-8
23225	ASOS,COOP	CA	N	Y	A	CA	Y	CA23225	72489	-8
23158	ASOS,COOP	CA	N	Y	A	CA	Y	CA23158	72293	-8
23152	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA23152	72293	-8
23136	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA23136	72293	-8
3177	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA3177	72293	-8
3179	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA3179	72293	-8
23254	AIRWAYS,ASOS,CO	CA	N	N	A	CA	Y	CA23254	72493	-8
24286	ASOS	CA	N	N	A	CA	Y	CA24286	72597	-8
3104	ASOS	CA	N	N	A	CA	Y	CA3104	72293	-8
23199	ASOS	CA	N	Y	A	CA	N	CA23199	72293	-8
93193	ASOS,COOP,USHCN	CA	N	N	A	CA	Y	CA93193	72493	-8
3166	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA3166	72293	-8
53119	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA53119	72493	-8
3167	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA3167	72293	-8
93228	AIRWAYS,ASOS,CO	CA	N	N	A	CA	Y	CA93228	72493	-8
93115	ASOS	CA	N	N	A	CA	Y	CA93115	72293	-8
3144	ASOS	CA	N	Y	A	CA	Y	CA3144	72293	-8
3159	ASOS,COOP	CA	N	N	A	CA	Y	CA3159	72293	-8
23285	AIRWAYS,ASOS,CO	CA	N	N	A	CA	Y	CA23285	72493	-8
23129	ASOS,COOP	CA	N	N	A	CA	Y	CA23129	72293	-8

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
93134	ASOS,COOP	CA	N	N	A	CA	N	CA93134	72293	-8
23174	ASOS,COOP	CA	N	N	A	CA	Y	CA23174	72293	-8
93205	ASOS,COOP	CA	N	N	A	CA	Y	CA93205	72493	-8
23257	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA23257	72493	-8
23258	AIRWAYS,ASOS,CO	CA	N	N	A	CA	Y	CA23258	72493	-8
24259	ASOS	CA	N	N	A	CA	Y	CA24259	72597	-8
23259	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA23259	72493	-8
24215	ASOS	CA	N	N	A	CA	N	CA24215	72597	-8
93227	AIRWAYS,ASOS,CO	CA	N	N	A	CA	Y	CA93227	72493	-8
23179	ASOS,COOP,USHCN	CA	N	Y	A	CA	Y	CA23179	72388	-8
23230	ASOS,UPPERAIR	CA	N	N	A	CA	Y	CA23230	72493	-8
53121	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA53121	72293	-8
3102	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA3102	72293	-8
93210	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA93210	72489	-8
93110	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA93110	72293	-8
93138	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA93138	72293	-8
23182	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA23182	72293	-8
93209	ASOS,COOP	CA	N	N	A	CA	Y	CA93209	72493	-8
24216	ASOS,COOP	CA	N	N	A	CA	Y	CA24216	72597	-8
24257	ASOS,COOP,USHCN	CA	N	N	A	CA	Y	CA24257	72597	-8
3171	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA3171	72293	-8
23232	AIRWAYS,ASOS,CO	CA	N	N	A	CA	Y	CA23232	72493	-8
23233	ASOS,COOP	CA	N	N	A	CA	Y	CA23233	72493	-8
23188	ASOS,COOP	CA	N	N	A	CA	Y	CA23188	72293	-8
3131	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA3131	72293	-8
23234	ASOS,COOP	CA	N	N	A	CA	Y	CA23234	72493	-8
23293	ASOS,COOP	CA	N	N	A	CA	Y	CA23293	72493	-8
93206	ASOS	CA	N	N	A	CA	Y	CA93206	72493	-8
23187	ASOS,COOP	CA	N	N	A	CA	N	CA23187	72293	-8
93184	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA93184	72293	-8
23190	AIRWAYS,ASOS,CO	CA	N	N	A	CA	Y	CA23190	72293	-8
23273	ASOS,COOP	CA	N	N	A	CA	Y	CA23273	72493	-8

Attachment 1.

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
93197	ASOS	CA	N	N	A	CA	Y	CA93197	72293	-8
23213	AIRWAYS,ASOS,CO	CA	N	N	A	CA	Y	CA23213	72493	-8
93230	ASOS,COOP	CA	N	Y	A	CA	Y	CA93230	72489	-8
23237	ASOS,COOP	CA	N	N	A	CA	Y	CA23237	72493	-8
23275	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA23275	72493	-8
93241	ASOS,COOP	CA	N	N	A	CA	Y	CA93241	72493	-8
23130	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA23130	72293	-8
23277	AIRWAYS,ASOS	CA	N	N	A	CA	Y	CA23277	72493	-8
24015	AIRWAYS,ASOS	CO	Y	N	A	CO	Y	CO24015	72469	-7
23061	ASOS,COOP,WXSV	CO	N	Y	A	CO	Y	CO23061	72365	-7
93073	AIRWAYS,ASOS,CO	CO	N	Y	A	CO	Y	CO93073	72476	-7
3026	AIRWAYS,ASOS	CO	N	Y	A	CO	Y	CO3026	72562	-6
93037	ASOS,COOP	CO	N	N	A	CO	Y	CO93037	72469	-7
93069	AIRWAYS,ASOS,CO	CO	N	Y	A	CO	Y	CO93069	72476	-7
24046	AIRWAYS,ASOS,CO	CO	N	Y	A	CO	Y	CO24046	72476	-7
93067	AIRWAYS,ASOS	CO	N	N	A	CO	Y	CO93067	72469	-7
3017	ASOS,COOP	CO	N	N	A	CO	Y	CO3017	72469	-7
93005	AIRWAYS,ASOS,CO	CO	N	Y	A	CO	Y	CO93005	72476	-7
23066	ASOS,COOP	CO	N	Y	A	CO	Y	CO23066	72476	-7
23067	AIRWAYS,ASOS,CO	CO	N	N	A	CO	Y	CO23067	72469	-7
3013	AIRWAYS,ASOS	CO	N	Y	A	CO	Y	CO3013	72451	-6
93009	ASOS	CO	Y	N	A	CO	Y	CO93009	72469	-7
93010	ASOS	CO	N	N	A	CO	N	CO93010	72469	-7
94050	AIRWAYS,ASOS,CO	CO	N	Y	A	CO	Y	CO94050	72476	-7
93013	AIRWAYS,ASOS,CO	CO	N	Y	A	CO	Y	CO93013	72476	-7
93058	ASOS,COOP,WXSV	CO	N	N	A	CO	Y	CO93058	72469	-7
23070	AIRWAYS,ASOS,CO	CO	N	N	A	CO	Y	CO23070	72469	-7
94702	ASOS,COOP	CT	Y	N	A	CT	Y	CT94702	72501	-5
54734	AIRWAYS,ASOS	CT	Y	N	A	CT	Y	CT54734	72501	-5
14707	ASOS	CT	Y	N	A	CT	Y	CT14707	72501	-5
14740	ASOS,COOP	CT	Y	N	A	CT	Y	CT14740	72501	-5
14752	ASOS	CT	Y	N	A	CT	Y	CT14752	72501	-5

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
54788	AIRWAYS,ASOS	CT	Y	N	A	CT	Y	CT54788	72501	-5
14758	AIRWAYS,ASOS	CT	Y	N	A	CT	Y	CT14758	72501	-5
54767	AIRWAYS,ASOS	CT	Y	N	A	CT	Y	CT54767	72501	-5
13764	AIRWAYS,ASOS	DE	N	N	A	DE	Y	DE13764	72402	-5
13781	ASOS,COOP	DE	Y	N	A	DE	Y	DE13781	72403	-5
12832	ASOS	FL	N	N	A	FL	Y	FL12832	72214	-5
12818	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12818	72210	-5
53848	ASOS	FL	N	N	A	FL	Y	FL53848	72214	-5
13884	AIRWAYS,ASOS,CO	FL	N	N	A	FL	Y	FL13884	72214	-5
12834	ASOS,COOP	FL	N	N	A	FL	Y	FL12834	72206	-5
53853	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL53853	72214	-5
12885	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12885	72202	-5
12849	AIRWAYS,ASOS,CO	FL	N	N	A	FL	Y	FL12849	72202	-5
12835	AIRWAYS,ASOS,CO	FL	N	N	A	FL	Y	FL12835	72210	-5
12894	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12894	72210	-5
12895	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12895	72210	-5
12816	AIRWAYS,ASOS,CO	FL	N	N	A	FL	Y	FL12816	72206	-5
92809	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL92809	72202	-5
53860	AIRWAYS,ASOS,CO	FL	N	N	A	FL	Y	FL53860	72206	-5
13889	ASOS,COOP	FL	N	N	A	FL	Y	FL13889	72206	-5
12836	AIRSAMPLE,AIRWA	FL	N	N	A	FL	Y	FL12836	72201	-5
12819	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12819	72210	-5
12896	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12896	72201	-5
3818	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL3818	72214	-5
12838	ASOS,COOP	FL	N	N	A	FL	Y	FL12838	72210	-5
12839	ASOS,COOP	FL	N	N	A	FL	Y	FL12839	72202	-5
12888	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12888	72202	-5
12882	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12882	72202	-5
12897	AIRWAYS,ASOS,CO	FL	N	N	A	FL	Y	FL12897	72202	-5
12841	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12841	72210	-5
12815	ASOS,COOP	FL	N	N	A	FL	Y	FL12815	72210	-5
12854	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12854	72210	-5

Attachment 1.

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
13899	AIRWAYS,ASOS,CO	FL	N	N	A	FL	Y	FL13899	72233	-6
12812	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12812	72210	-5
12871	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12871	72210	-5
92806	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL92806	72210	-5
12873	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12873	72210	-5
93805	ASOS,COOP,USHCN	FL	N	N	A	FL	Y	FL93805	72214	-5
12842	ASOS,COOP	FL	N	N	A	FL	Y	FL12842	72210	-5
12843	ASOS,COOP	FL	N	N	A	FL	Y	FL12843	72210	-5
12844	ASOS,COOP,UPPER	FL	N	N	A	FL	Y	FL12844	72202	-5
12876	AIRWAYS,ASOS	FL	N	N	A	FL	Y	FL12876	72210	-5
13869	ASOS	GA	N	N	A	GA	Y	GA13869	72214	-5
13870	AIRWAYS,ASOS,CO	GA	N	N	A	GA	Y	GA13870	72206	-5
13873	AIRSAMPLE,AIRWA	GA	N	N	A	GA	Y	GA13873	72215	-5
3888	AIRWAYS,ASOS	GA	N	N	A	GA	Y	GA3888	72215	-5
13874	ASOS,COOP	GA	N	N	A	GA	Y	GA13874	72215	-5
53863	AIRWAYS,ASOS	GA	N	N	A	GA	Y	GA53863	72215	-5
3820	ASOS,COOP	GA, SC	N	N	A	GA	Y	GA3820	72208	-5
13837	ASOS	GA	N	N	A	GA	Y	GA13837	72208	-5
13878	ASOS,COOP	GA	N	N	A	GA	Y	GA13878	72206	-5
53873	ASOS	GA	N	N	A	GA	Y	GA53873	72215	-5
93842	AIRSAMPLE,AIRWA	AL, GA	N	N	A	GA	Y	GA93842	72215	-5
53838	AIRWAYS,ASOS	GA	N	N	A	GA	Y	GA53838	72215	-5
3813	ASOS,COOP	GA	N	N	A	GA	Y	GA3813	72215	-5
53819	AIRWAYS,ASOS,UP	GA	N	N	A	GA	Y	GA53819	72215	-5
93801	AIRWAYS,ASOS	GA	N	N	A	GA	Y	GA93801	72215	-5
3822	ASOS,COOP,USHCN	GA	N	N	A	GA	Y	GA3822	72208	-5
94989	AIRWAYS,ASOS,CO	IA	Y	N	A	IA	Y	IA94989	72558	-6
14990	AIRWAYS,ASOS,CO	IA	Y	N	A	IA	Y	IA14990	74455	-6
94982	AIRWAYS,ASOS	IA	Y	N	A	IA	Y	IA94982	74455	-6
14933	ASOS,COOP	IA	Y	N	A	IA	Y	IA14933	72558	-6
94908	ASOS,COOP	IA	Y	N	A	IA	Y	IA94908	74455	-6
94971	AIRWAYS,ASOS,CO	IA	Y	N	A	IA	Y	IA94971	72649	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
14937	AIRWAYS,ASOS	IA	Y	N	A	IA	Y	IA14937	74455	-6
94991	AIRWAYS,ASOS,CO	IA	Y	N	A	IA	Y	IA94991	72456	-6
94988	AIRWAYS,ASOS,CO	IA	Y	N	A	IA	Y	IA94988	74455	-6
14940	ASOS,COOP	IA	Y	N	A	IA	Y	IA14940	72649	-6
14950	ASOS,COOP	IA	Y	N	A	IA	Y	IA14950	74455	-6
14972	AIRWAYS,ASOS	IA	Y	N	A	IA	Y	IA14972	72558	-6
94910	AIRWAYS,ASOS,CO	IA	Y	N	A	IA	Y	IA94910	74455	-6
24131	ASOS,COOP	ID	N	N	A	ID	Y	ID24131	72681	-7
24133	ASOS,COOP	ID	N	Y	A	ID	Y	ID24133	72572	-7
4114	ASOS	ID	Y	N	A	ID	Y	ID4114	72681	-7
24145	AIRWAYS,ASOS	ID	N	Y	A	ID	Y	ID24145	72572	-7
4110	AIRWAYS,ASOS	ID	N	Y	A	ID	Y	ID4110	72681	-7
94182	AIRWAYS,ASOS	ID	Y	N	A	ID	Y	ID94182	72681	-7
24156	ASOS,COOP	ID	N	Y	A	ID	Y	ID24156	72572	-7
94194	AIRWAYS,ASOS	ID	N	Y	A	ID	Y	ID94194	72572	-7
94178	AIRWAYS,ASOS	ID	N	Y	A	ID	Y	ID94178	72681	-7
93810	AIRWAYS,ASOS	IL	N	N	A	IL	Y	IL93810	74560	-6
94870	AIRWAYS,ASOS	IL	Y	N	A	IL	Y	IL94870	74560	-6
4808	AIRWAYS,ASOS	IL	Y	N	A	IL	Y	IL4808	74560	-6
14819	AIRWAYS,ASOS,WX	IL	Y	N	A	IL	Y	IL14819	74560	-6
94846	ASOS,COOP,WXSV	IL	Y	N	A	IL	Y	IL94846	74560	-6
4838	AIRWAYS,ASOS	IL	Y	N	A	IL	Y	IL4838	72645	-6
14880	ASOS	IL	Y	N	A	IL	Y	IL14880	72645	-6
3887	AIRWAYS,ASOS	IL	Y	N	A	IL	Y	IL3887	74560	-6
13809	AIRWAYS,ASOS	IL	Y	N	A	IL	Y	IL13809	74560	-6
53802	AIRWAYS,ASOS	IL	Y	N	A	IL	Y	IL53802	74560	-6
14923	ASOS,COOP,WXSV	IL	Y	N	A	IL	Y	IL14923	74455	-6
14842	AIRSAMPLE,ASOS,C	IL	Y	N	A	IL	Y	IL14842	74560	-6
93989	ASOS,COOP	IL	N	N	A	IL	Y	IL93989	74455	-6
94822	ASOS,COOP,WXSV	IL	Y	N	A	IL	Y	IL94822	74455	-6
93822	AIRSAMPLE,AIRWA	IL	Y	N	A	IL	Y	IL93822	74560	-6
94892	AIRWAYS,ASOS	IL	Y	N	A	IL	Y	IL94892	74560	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
3893	AIRWAYS,ASOS	IN	Y	N	A	IN	Y	IN3893	72426	-5
93817	AIRSAMPLE,AIRWA	IN	N	N	A	IN	Y	IN93817	72327	-6
14827	AIRWAYS,ASOS,CO	IN	Y	N	A	IN	Y	IN14827	72426	-5
14829	AIRWAYS,ASOS,CO	IN	Y	N	A	IN	Y	IN14829	72632	-5
53842	AIRWAYS,ASOS	IN	Y	N	A	IN	Y	IN53842	72426	-5
93819	ASOS,COOP,WXSV	IN	Y	N	A	IN	Y	IN93819	72426	-5
14835	AIRWAYS,ASOS,WX	IN	Y	N	A	IN	Y	IN14835	74560	-6
94895	AIRWAYS,ASOS	IN	Y	N	A	IN	Y	IN94895	72426	-5
14848	AIRWAYS,ASOS,CO	IN	Y	N	A	IN	Y	IN14848	72632	-5
53866	AIRWAYS,ASOS	IN	Y	N	A	IN	Y	IN53866	72426	-5
3868	AIRWAYS,ASOS	IN	Y	N	A	IN	Y	IN3868	74560	-6
4846	AIRWAYS,ASOS	IN	Y	N	A	IN	Y	IN4846	74560	-6
13981	ASOS	KS	Y	N	A	KS	Y	KS13981	72456	-6
13984	ASOS,COOP	KS	Y	N	A	KS	Y	KS13984	72456	-6
13989	AIRWAYS,ASOS,BA	KS	N	N	A	KS	Y	KS13989	72456	-6
23064	AIRWAYS,ASOS	KS	N	N	A	KS	Y	KS23064	72451	-6
23065	ASOS,COOP,WXSV	KS	N	Y	A	KS	Y	KS23065	72562	-6
93990	AIRWAYS,ASOS	KS	Y	N	A	KS	Y	KS93990	72451	-6
13986	ASOS	KS	N	N	A	KS	Y	KS13986	74646	-6
3997	AIRWAYS,ASOS,CO	KS	Y	N	A	KS	Y	KS3997	72456	-6
3936	AIRWAYS,ASOS,CO	KS	Y	N	A	KS	Y	KS3936	72456	-6
93909	AIRWAYS,ASOS	KS	N	N	A	KS	Y	KS93909	72456	-6
3967	AIRWAYS,ASOS	KS	N	N	A	KS	Y	KS3967	72456	-6
3998	AIRWAYS,ASOS	KS	Y	N	A	KS	Y	KS3998	72456	-6
93997	ASOS	KS	N	N	A	KS	Y	KS93997	72451	-6
13920	AIRWAYS,ASOS	KS	N	N	A	KS	Y	KS13920	72456	-6
13996	ASOS,COOP,WXSV	KS	N	N	A	KS	Y	KS13996	72456	-6
3974	ASOS	KS	N	N	A	KS	Y	KS3974	74646	-6
3928	ASOS,COOP,WXSV	KS	N	N	A	KS	Y	KS3928	74646	-6
13932	AIRWAYS,ASOS	KS	N	N	A	KS	Y	KS13932	74646	-6
93808	AIRWAYS,ASOS,CO	KY	N	N	A	KY	Y	KY93808	72327	-6
53841	AIRWAYS,ASOS	KY	Y	N	A	KY	Y	KY53841	72426	-5

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
3889	ASOS,COOP	KY	N	N	A	KY	Y	KY3889	72426	-5
93820	ASOS,COOP,WXSV	KY	Y	N	A	KY	Y	KY93820	72426	-5
3849	AIRWAYS,ASOS,CO	KY	N	N	A	KY	Y	KY3849	72426	-5
13810	AIRWAYS,ASOS	KY	Y	N	A	KY	Y	KY13810	72327	-6
93821	ASOS,COOP,WXSV	KY	Y	N	A	KY	Y	KY93821	72327	-6
3816	AIRSAMPLE,ASOS,	KY	Y	N	A	KY	Y	KY3816	72327	-6
93915	AIRWAYS,ASOS	LA	N	N	A	LA	Y	LA93915	72240	-6
13970	ASOS,COOP,USHCN	LA	N	N	A	LA	Y	LA13970	72233	-6
12884	ASOS,COOP	LA	N	N	A	LA	N	LA12884	72233	-6
13976	AIRWAYS,ASOS,CO	LA	N	N	A	LA	Y	LA13976	72240	-6
3937	ASOS,COOP,UPPER	LA	N	N	A	LA	Y	LA3937	72240	-6
13942	ASOS,COOP	LA	N	N	A	LA	Y	LA13942	72248	-6
53915	AIRWAYS,ASOS,CO	LA	N	N	A	LA	Y	LA53915	72240	-6
12916	ASOS,COOP	LA	N	N	A	LA	Y	LA12916	72233	-6
53917	AIRWAYS,ASOS,CO	LA	N	N	A	LA	Y	LA53917	72233	-6
53905	AIRWAYS,ASOS,CO	LA	N	N	A	LA	Y	LA53905	72248	-6
13957	AIRSAMPLE,ASOS,	LA	N	N	A	LA	Y	LA13957	72248	-6
53865	ASOS,COOP	LA	N	N	A	LA	Y	LA53865	72233	-6
14702	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA14702	74494	-5
54733	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA54733	74494	-5
14739	ASOS,COOP	MA	Y	N	A	MA	Y	MA14739	74494	-5
94624	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA94624	74494	-5
4780	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA4780	72518	-5
94720	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA94720	74494	-5
94723	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA94723	74389	-5
14756	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA14756	74494	-5
94726	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA94726	74494	-5
54704	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA54704	74494	-5
14763	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA14763	72518	-5
54769	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA54769	74494	-5
54777	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA54777	74494	-5
94724	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA94724	74494	-5

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
14775	AIRWAYS,ASOS	MA	Y	N	A	MA	Y	MA14775	72518	-5
94746	ASOS,COOP	MA	Y	N	A	MA	Y	MA94746	72518	-5
93721	ASOS,COOP	MD	N	N	A	MD	Y	MD93721	72403	-5
93786	AIRWAYS,ASOS	MD	N	N	A	MD	Y	MD93786	72402	-5
93720	AIRWAYS,ASOS,CO	MD	N	N	A	MD	Y	MD93720	72402	-5
14605	ASOS,COOP	ME	Y	N	A	ME	Y	ME14605	74389	-5
14606	AIRWAYS,ASOS,CO	ME	Y	N	A	ME	Y	ME14606	74389	-5
14607	ASOS,COOP	ME	Y	N	A	ME	Y	ME14607	72712	-5
4836	AIRWAYS,ASOS	ME	Y	N	A	ME	Y	ME4836	72712	-5
14610	AIRWAYS,ASOS	ME	Y	N	A	ME	Y	ME14610	72712	-5
14764	ASOS,COOP,USHCN	ME	Y	N	A	ME	Y	ME14764	74389	-5
94623	AIRWAYS,ASOS	ME	Y	N	A	ME	Y	ME94623	74389	-5
94849	ASOS,COOP	MI	Y	N	A	MI	Y	MI94849	72634	-5
94889	AIRWAYS,ASOS	MI	Y	N	A	MI	Y	MI94889	72632	-5
14815	AIRWAYS,ASOS	MI	Y	N	A	MI	Y	MI14815	72632	-5
94871	ASOS,COOP	MI	Y	N	A	MI	Y	MI94871	72645	-6
14822	ASOS	MI	Y	N	A	MI	Y	MI14822	72632	-5
94847	ASOS,COOP,WXSV	MI	Y	N	A	MI	Y	MI94847	72632	-5
14853	AIRWAYS,ASOS	MI	Y	N	A	MI	Y	MI14853	72632	-5
14826	ASOS,COOP,WXSV	MI	Y	N	A	MI	Y	MI14826	72632	-5
4854	AIRWAYS,ASOS	MI	Y	N	A	MI	Y	MI4854	72634	-5
94860	ASOS,COOP,WXSV	MI	Y	N	A	MI	Y	MI94860	72632	-5
14858	ASOS	MI	Y	N	A	MI	Y	MI14858	72645	-6
4839	AIRWAYS,ASOS	MI	Y	N	A	MI	Y	MI4839	72634	-5
94814	ASOS,COOP,WXSV	MI	Y	N	A	MI	Y	MI94814	72634	-5
14833	ASOS,COOP	MI	Y	N	A	MI	Y	MI14833	72632	-5
94815	AIRWAYS,ASOS,WX	MI	Y	N	A	MI	Y	MI94815	72632	-5
14836	ASOS,COOP,WXSV	MI	Y	N	A	MI	Y	MI14836	72632	-5
14840	ASOS,COOP,WXSV	MI	Y	N	A	MI	Y	MI14840	72634	-5
14841	AIRWAYS,ASOS,CO	MI	Y	N	A	MI	Y	MI14841	72634	-5
94817	AIRWAYS,ASOS	MI	Y	N	A	MI	Y	MI94817	72632	-5
14845	ASOS	MI	Y	N	A	MI	Y	MI14845	72632	-5

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
14850	AIRWAYS,ASOS,CO	MI	Y	N	A	MI	Y	MI14850	72634	-5
14910	AIRWAYS,ASOS,CO	MN	Y	N	A	MN	Y	MN14910	72649	-6
94938	AIRWAYS,ASOS	MN	Y	N	A	MN	Y	MN94938	72649	-6
14913	AIRWAYS,ASOS,CO	MN	Y	N	A	MN	Y	MN14913	72747	-6
94931	ASOS	MN	Y	N	A	MN	Y	MN94931	72747	-6
14918	ASOS,COOP,WXSV	MN	Y	N	A	MN	Y	MN14918	72747	-6
14922	ASOS,COOP,USHCN	MN	Y	N	A	MN	Y	MN14922	72649	-6
94960	AIRWAYS,ASOS,CO	MN	Y	N	A	MN	Y	MN94960	72649	-6
94963	ASOS,COOP	MN	Y	N	A	MN	Y	MN94963	72649	-6
94967	AIRWAYS,ASOS	MN	Y	N	A	MN	Y	MN94967	72747	-6
14992	ASOS,COOP	MN	Y	N	A	MN	Y	MN14992	72649	-6
14925	ASOS,COOP,WXSV	MN	Y	N	A	MN	Y	MN14925	72649	-6
14926	AIRWAYS,ASOS,CO	MN	Y	N	A	MN	Y	MN14926	72649	-6
14927	ASOS,COOP	MN	Y	N	A	MN	Y	MN14927	72649	-6
3935	AIRWAYS,ASOS,CO	MO	N	N	A	MO	Y	MO3935	74560	-6
3945	AIRWAYS,ASOS,CO	MO	Y	N	A	MO	Y	MO3945	72440	-6
3963	AIRWAYS,ASOS	MO	Y	N	A	MO	Y	MO3963	72440	-6
13987	ASOS,COOP	MO	N	N	A	MO	Y	MO13987	72440	-6
3947	AIRWAYS,ASOS,CO	MO	Y	N	A	MO	Y	MO3947	72456	-6
14938	ASOS	MO	Y	N	A	MO	Y	MO14938	74455	-6
53879	AIRWAYS,ASOS	MO	Y	N	A	MO	Y	MO53879	72456	-6
3975	AIRWAYS,ASOS	MO	N	N	A	MO	Y	MO3975	72340	-6
3994	AIRWAYS,ASOS	MO	N	N	A	MO	Y	MO3994	72440	-6
13995	ASOS,COOP,WXSV	MO	N	N	A	MO	Y	MO13995	72440	-6
13994	ASOS,COOP,WXSV	MO	N	N	A	MO	Y	MO13994	74560	-6
3966	AIRWAYS,ASOS	MO	N	N	A	MO	Y	MO3966	74560	-6
13997	ASOS,COOP	MO	N	N	A	MO	Y	MO13997	72440	-6
53901	AIRWAYS,ASOS	MO	N	N	A	MO	Y	MO53901	72440	-6
13939	ASOS,COOP	MS	N	N	A	MS	Y	MS13939	72235	-6
13978	AIRWAYS,ASOS,CO	MS	N	N	A	MS	Y	MS13978	72235	-6
93874	AIRWAYS,ASOS,CO	MS	N	N	A	MS	Y	MS93874	72233	-6
13833	ASOS,COOP	MS	N	N	A	MS	Y	MS13833	72233	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
13927	ASOS,COOP	MS	N	N	A	MS	Y	MS13927	72235	-6
3940	ASOS,COOP,UPPER	MS	N	N	A	MS	Y	MS3940	72235	-6
93919	AIRWAYS,ASOS,CO	MS	N	N	A	MS	Y	MS93919	72233	-6
13865	ASOS,COOP	MS	N	N	A	MS	Y	MS13865	72235	-6
53858	AIRWAYS,ASOS	MS	N	N	A	MS	Y	MS53858	72233	-6
93862	AIRSAMPLE,ASOS,C	MS	N	N	A	MS	Y	MS93862	72230	-6
94055	ASOS,COOP	MT	Y	N	A	MT	Y	MT94055	72662	-7
24033	ASOS,COOP	MT	N	Y	A	MT	Y	MT24033	72672	-7
24132	AIRWAYS,ASOS,CO	MT	N	Y	A	MT	Y	MT24132	72776	-7
24135	ASOS,COOP	MT	N	Y	A	MT	Y	MT24135	72776	-7
24137	ASOS,COOP,USHCN	MT	Y	N	A	MT	Y	MT24137	72776	-7
24138	AIRWAYS,ASOS,CO	MT	N	Y	A	MT	Y	MT24138	72776	-7
94008	ASOS,COOP,USHCN	MT	N	Y	A	MT	Y	MT94008	72768	-7
24143	ASOS,COOP,USHCN	MT	Y	N	A	MT	Y	MT24143	72776	-7
94012	ASOS,COOP	MT	Y	N	A	MT	Y	MT94012	72776	-7
24144	ASOS,COOP,USHCN	MT	N	Y	A	MT	Y	MT24144	72776	-7
24146	ASOS,COOP,USHCN	MT	Y	N	A	MT	Y	MT24146	72776	-7
24036	AIRWAYS,ASOS,CO	MT	N	Y	A	MT	Y	MT24036	72776	-7
24150	ASOS,COOP	MT	N	Y	A	MT	Y	MT24150	72776	-7
24037	ASOS,COOP,USHCN	MT	N	Y	A	MT	Y	MT24037	72768	-7
24153	ASOS,COOP	MT	N	Y	A	MT	Y	MT24153	72776	-7
94017	AIRWAYS,ASOS	MT	N	Y	A	MT	Y	MT94017	72768	-7
3812	ASOS,COOP,WXSV	NC	N	N	A	NC	Y	NC3812	72317	-5
93765	ASOS	NC	N	N	A	NC	Y	NC93765	72305	-5
93783	AIRWAYS,ASOS	NC	N	N	A	NC	Y	NC93783	72317	-5
93729	ASOS,COOP,USHCN	NC	N	N	A	NC	Y	NC93729	72305	-5
93785	AIRWAYS,ASOS	NC	N	N	A	NC	Y	NC93785	72317	-5
13881	ASOS,COOP	NC	N	N	A	NC	Y	NC13881	72317	-5
13754	ASOS	NC	N	N	A	NC	Y	NC13754	72305	-5
13786	AIRWAYS,ASOS	NC	N	N	A	NC	Y	NC13786	72305	-5
93740	AIRWAYS,ASOS	NC	N	N	A	NC	Y	NC93740	72317	-5
3810	AIRWAYS,ASOS,CO	NC	N	N	A	NC	Y	NC3810	72317	-5

Attachment 1.

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
93782	AIRWAYS,ASOS	NC	N	N	A	NC	Y	NC93782	72317	-5
13776	AIRWAYS,ASOS,CO	NC	N	N	A	NC	Y	NC13776	72317	-5
53872	AIRWAYS,ASOS	NC	N	N	A	NC	Y	NC53872	72317	-5
93719	AIRWAYS,ASOS,CO	NC	N	N	A	NC	Y	NC93719	72305	-5
13723	ASOS,COOP	NC	N	N	A	NC	Y	NC13723	72317	-5
13722	ASOS,COOP	NC	N	N	A	NC	Y	NC13722	72317	-5
93759	ASOS	NC	N	N	A	NC	Y	NC93759	72305	-5
13748	ASOS,COOP	NC	N	N	A	NC	Y	NC13748	72305	-5
24011	ASOS,COOP,WXSV	ND	Y	N	A	ND	Y	ND24011	72764	-6
14916	AIRWAYS,ASOS,CO	ND	Y	N	A	ND	Y	ND14916	72659	-6
94038	AIRWAYS,ASOS	ND	Y	N	A	ND	Y	ND94038	72662	-7
14919	ASOS,COOP,WXSV	ND	Y	N	A	ND	Y	ND14919	72659	-6
24013	AIRWAYS,ASOS,CO	ND	Y	N	A	ND	Y	ND24013	72764	-6
24012	ASOS,COOP,WXSV	ND	Y	N	A	ND	Y	ND24012	72764	-6
94014	ASOS,COOP,WXSV	ND	Y	N	A	ND	Y	ND94014	72768	-7
24044	AIRWAYS,ASOS,CO	NE	Y	N	A	NE	Y	NE24044	72662	-7
94946	AIRWAYS,ASOS	NE	N	N	A	NE	Y	NE94946	72562	-6
24017	ASOS,COOP	NE	N	Y	A	NE	Y	NE24017	72662	-7
94957	ASOS	NE	Y	N	A	NE	Y	NE94957	72456	-6
14935	AIRWAYS,ASOS,CO	NE	Y	N	A	NE	Y	NE14935	72558	-6
94949	AIRWAYS,ASOS,CO	NE	N	N	A	NE	Y	NE94949	72558	-6
24091	ASOS	NE	Y	N	A	NE	Y	NE24091	72562	-6
14939	AIRWAYS,ASOS,CO	NE	N	N	A	NE	Y	NE14939	72558	-6
94040	AIRWAYS,ASOS	NE	Y	N	A	NE	Y	NE94040	72562	-6
14941	ASOS,COOP,WXSV	NE	N	Y	A	NE	Y	NE14941	72558	-6
24023	ASOS,COOP,WXSV	NE	Y	N	A	NE	Y	NE24023	72562	-6
94958	ASOS,COOP	NE	Y	N	A	NE	Y	NE94958	72562	-6
24028	ASOS,COOP,WXSV	NE	Y	N	A	NE	Y	NE24028	72662	-7
24030	AIRWAYS,ASOS,CO	NE	Y	N	A	NE	Y	NE24030	72562	-6
94978	AIRWAYS,ASOS	NE	Y	N	A	NE	Y	NE94978	72558	-6
24032	ASOS,COOP,WXSV	NE	N	Y	A	NE	Y	NE24032	72562	-6
94700	AIRWAYS,ASOS	NH	Y	N	A	NH	Y	NH94700	74389	-5

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
14745	ASOS,COOP	NH	Y	N	A	NH	Y	NH14745	74389	-5
54770	AIRWAYS,ASOS	NH	Y	N	A	NH	Y	NH54770	72518	-5
14710	AIRWAYS,ASOS	NH	Y	N	A	NH	Y	NH14710	74389	-5
93730	ASOS,COOP	NJ	N	N	A	NJ	Y	NJ93730	72402	-5
54743	ASOS	NJ	Y	N	A	NJ	Y	NJ54743	72501	-5
13735	AIRWAYS,ASOS,CO	NJ	Y	N	A	NJ	Y	NJ13735	72402	-5
93780	AIRWAYS,ASOS	NJ	Y	N	A	NJ	Y	NJ93780	72501	-5
14734	ASOS,COOP	NJ	Y	N	A	NJ	Y	NJ14734	72501	-5
54785	ASOS	NJ	Y	N	A	NJ	Y	NJ54785	72501	-5
54793	ASOS	NJ	Y	N	A	NJ	Y	NJ54793	72501	-5
94741	ASOS	NJ	Y	N	A	NJ	Y	NJ94741	72501	-5
23050	AIRSAMPLE,AIRWA	NM	N	Y	A	NM	Y	NM23050	72365	-7
93033	AIRWAYS,ASOS,CO	NM	N	Y	A	NM	Y	NM93033	72265	-6
23051	AIRSAMPLE,ASOS,C	NM	N	Y	A	NM	Y	NM23051	72363	-6
3027	ASOS	NM	N	Y	A	NM	N	NM3027	72365	-7
23078	AIRWAYS,ASOS	NM	N	Y	A	NM	Y	NM23078	72364	-7
23090	AIRWAYS,ASOS	NM	N	Y	A	NM	Y	NM23090	72365	-7
23081	ASOS,COOP	NM	N	Y	A	NM	Y	NM23081	72365	-7
23054	ASOS	NM	N	Y	A	NM	Y	NM23054	72365	-7
23052	ASOS	NM	N	Y	A	NM	Y	NM23052	72365	-7
23009	AIRSAMPLE,AIRWA	NM	N	Y	A	NM	Y	NM23009	72364	-7
23049	AIRWAYS,ASOS	NM	N	Y	A	NM	Y	NM23049	72365	-7
93045	ASOS	NM	N	Y	A	NM	Y	NM93045	72364	-7
23048	ASOS	NM	N	Y	A	NM	Y	NM23048	72363	-6
24121	AIRWAYS,ASOS,CO	NV	N	Y	A	NV	Y	NV24121	72582	-8
23154	AIRWAYS,ASOS,CO	NV	N	Y	A	NV	Y	NV23154	72582	-8
53123	ASOS	NV	N	Y	A	NV	Y	NV53123	72388	-8
23169	AIRSAMPLE,AIRWA	NV	N	Y	A	NV	Y	NV23169	72388	-8
24172	ASOS,COOP	NV	N	Y	A	NV	Y	NV24172	72489	-8
3160	ASOS,COOP	NV	N	Y	A	NV	Y	NV3160	72388	-8
23185	ASOS,COOP,USHCN	NV	N	Y	A	NV	Y	NV23185	72489	-8
23153	AIRWAYS,ASOS,CO	NV	N	Y	A	NV	Y	NV23153	72388	-8

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
24128	AIRWAYS,ASOS,CO	NV	N	Y	A	NV	Y	NV24128	72582	-8
14735	ASOS,COOP,USHCN	NY	Y	N	A	NY	Y	NY14735	72518	-5
4725	AIRWAYS,ASOS,CO	NY	Y	N	A	NY	Y	NY4725	72518	-5
14733	ASOS,COOP,USHCN	NY	Y	N	A	NY	Y	NY14733	72528	-5
94704	ASOS	NY	Y	N	A	NY	Y	NY94704	72528	-5
14747	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY14747	72528	-5
14748	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY14748	72528	-5
54787	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY54787	72501	-5
54773	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY54773	72528	-5
14750	ASOS,COOP	NY	Y	N	A	NY	Y	NY14750	72518	-5
4781	AIRWAYS,ASOS,CO	NY	Y	N	A	NY	Y	NY4781	72501	-5
94725	ASOS	NY	Y	N	A	NY	Y	NY94725	71722	-5
4789	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY4789	72501	-5
94789	ASOS,COOP	NY	Y	N	A	NY	Y	NY94789	72501	-5
14732	ASOS,COOP	NY	Y	N	A	NY	Y	NY14732	72501	-5
54778	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY54778	72528	-5
64776	ASOS	NY	Y	N	A	NY	Y	NY64776	72518	-5
14757	ASOS,COOP	NY	Y	N	A	NY	Y	NY14757	72501	-5
14768	ASOS,COOP,USHCN	NY	Y	N	A	NY	Y	NY14768	72528	-5
64775	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY64775	72518	-5
94740	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY94740	72518	-5
54790	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY54790	72501	-5
14771	ASOS,COOP,USHCN	NY	Y	N	A	NY	Y	NY14771	72518	-5
94790	ASOS,COOP	NY	Y	N	A	NY	Y	NY94790	71722	-5
54757	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY54757	72528	-5
14719	AIRWAYS,ASOS	NY	Y	N	A	NY	Y	NY14719	72501	-5
14895	ASOS,COOP	OH	Y	N	A	OH	Y	OH14895	72520	-5
14813	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH14813	72520	-5
4857	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH4857	72520	-5
4853	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH4853	72520	-5
14820	ASOS,COOP	OH	Y	N	A	OH	Y	OH14820	72520	-5
4804	ASOS	OH	Y	N	A	OH	Y	OH4804	72426	-5

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
14821	ASOS,COOP	OH	Y	N	A	OH	Y	OH14821	72426	-5
93815	ASOS,COOP	OH	Y	N	A	OH	Y	OH93815	72426	-5
53859	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH53859	72426	-5
4851	ASOS,COOP	OH	Y	N	A	OH	Y	OH4851	72632	-5
4849	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH4849	72632	-5
14825	ASOS,COOP	OH	Y	N	A	OH	Y	OH14825	72426	-5
53855	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH53855	72426	-5
53844	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH53844	72426	-5
4850	AIRWAYS,ASOS,CO	OH	Y	N	A	OH	Y	OH4850	72426	-5
14891	ASOS,COOP	OH	Y	N	A	OH	Y	OH14891	72426	-5
4855	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH4855	72426	-5
4852	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH4852	72520	-5
4858	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH4858	72426	-5
94830	ASOS,COOP	OH	Y	N	A	OH	Y	OH94830	72632	-5
4848	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH4848	72632	-5
13841	ASOS	OH	Y	N	A	OH	Y	OH13841	72426	-5
4842	AIRWAYS,ASOS	OH	Y	N	A	OH	Y	OH4842	72520	-5
14852	ASOS,COOP	OH	Y	N	A	OH	Y	OH14852	72520	-5
93824	ASOS,COOP	OH	Y	N	A	OH	Y	OH93824	72520	-5
3959	AIRWAYS,ASOS,CO	OK	N	N	A	OK	Y	OK3959	74646	-6
3932	ASOS,COOP	OK	N	N	A	OK	Y	OK3932	72357	-6
3981	ASOS,COOP	OK	N	N	A	OK	Y	OK3981	72357	-6
13975	AIRWAYS,ASOS,CO	OK	N	N	A	OK	Y	OK13975	72451	-6
53913	AIRWAYS,ASOS,CO	OK	N	N	A	OK	Y	OK53913	72357	-6
3030	ASOS	OK	N	Y	A	OK	Y	OK3030	72363	-6
93986	AIRWAYS,ASOS,CO	OK	N	N	A	OK	Y	OK93986	72357	-6
3950	AIRWAYS,ASOS,CO	OK	N	N	A	OK	Y	OK3950	72357	-6
93950	AIRWAYS,ASOS,CO	OK	N	N	A	OK	Y	OK93950	72357	-6
93953	AIRWAYS,ASOS	OK	N	N	A	OK	Y	OK93953	72357	-6
3954	AIRWAYS,ASOS	OK	N	N	A	OK	Y	OK3954	72357	-6
13967	ASOS,COOP	OK	N	N	A	OK	Y	OK13967	72357	-6
13969	ASOS,COOP	OK	N	N	A	OK	Y	OK13969	74646	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
3965	ASOS,COOP	OK	N	N	A	OK	Y	OK3965	74646	-6
13968	AIRSAMPLE,ASOS,C	OK	N	N	A	OK	Y	OK13968	74646	-6
53908	AIRWAYS,ASOS	OK	N	N	A	OK	Y	OK53908	74646	-6
94224	ASOS,COOP,USHCN	OR	N	N	A	OR	Y	OR94224	72694	-8
94281	AIRWAYS,ASOS	OR	N	N	A	OR	Y	OR94281	72694	-8
24130	AIRWAYS,ASOS,CO	OR	Y	N	A	OR	Y	OR24130	72681	-7
94185	ASOS,COOP	OR	N	N	A	OR	Y	OR94185	72681	-7
24221	ASOS,COOP	OR	N	N	A	OR	Y	OR24221	72694	-8
4113	AIRWAYS,ASOS	OR	N	N	A	OR	Y	OR4113	72786	-8
94236	AIRWAYS,ASOS,CO	OR	N	N	A	OR	Y	OR94236	72597	-8
94273	AIRWAYS,ASOS	OR	N	N	A	OR	Y	OR94273	72694	-8
24152	ASOS	OR	Y	N	A	OR	N	OR24152	72786	-8
24225	ASOS,COOP	OR	N	N	A	OR	Y	OR24225	72597	-8
24162	AIRWAYS,ASOS,CO	OR	N	N	A	OR	Y	OR24162	72681	-7
24155	ASOS,COOP	OR	N	N	A	OR	Y	OR24155	72786	-8
94261	AIRWAYS,ASOS	OR	N	N	A	OR	Y	OR94261	72694	-8
24230	AIRWAYS,ASOS,CO	OR	N	N	A	OR	Y	OR24230	72694	-8
24231	AIRWAYS,ASOS	OR	N	N	A	OR	Y	OR24231	72597	-8
24232	ASOS,COOP	OR	N	N	A	OR	Y	OR24232	72694	-8
4201	AIRWAYS,ASOS	OR	N	N	A	OR	Y	OR4201	72694	-8
24235	ASOS,COOP	OR	N	N	A	OR	N	OR24235	72597	-8
14737	ASOS,COOP,USHCN	PA	Y	N	A	PA	Y	PA14737	72501	-5
14736	ASOS	PA	Y	N	A	PA	Y	PA14736	72403	-5
4751	AIRWAYS,ASOS,CO	PA	Y	N	A	PA	Y	PA4751	72528	-5
54792	ASOS	PA	Y	N	A	PA	Y	PA54792	72520	-5
54786	AIRWAYS,ASOS	PA	Y	N	A	PA	Y	PA54786	72501	-5
4787	ASOS,COOP	PA	Y	N	A	PA	Y	PA4787	72520	-5
14860	ASOS,COOP,USHCN	PA	Y	N	A	PA	Y	PA14860	72520	-5
14751	AIRWAYS,ASOS	PA	Y	N	A	PA	Y	PA14751	72403	-5
4726	ASOS	PA	Y	N	A	PA	Y	PA4726	72520	-5
54737	AIRWAYS,ASOS	PA	Y	N	A	PA	Y	PA54737	72403	-5
14711	AIRWAYS,ASOS,CO	PA	Y	N	A	PA	Y	PA14711	72403	-5

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
54789	AIRWAYS,ASOS	PA	Y	N	A	PA	Y	PA54789	72501	-5
94732	ASOS	PA	Y	N	A	PA	Y	PA94732	72501	-5
14762	AIRWAYS,ASOS,WX	PA	N	N	A	PA	Y	PA14762	72520	-5
94823	ASOS,COOP	PA	Y	N	A	PA	Y	PA94823	72520	-5
4843	AIRWAYS,ASOS	PA	Y	N	A	PA	Y	PA4843	72520	-5
54782	AIRWAYS,ASOS	PA	Y	N	A	PA	Y	PA54782	72403	-5
14712	ASOS	PA	Y	N	A	PA	Y	PA14712	72403	-5
14770	AIRWAYS,ASOS	PA	Y	N	A	PA	Y	PA14770	72403	-5
14777	ASOS,COOP	PA	Y	N	A	PA	Y	PA14777	72518	-5
14778	ASOS,COOP,USHCN	PA	Y	N	A	PA	Y	PA14778	72528	-5
93778	AIRWAYS,ASOS	PA	Y	N	A	PA	Y	PA93778	72403	-5
14787	AIRWAYS,ASOS	RI	Y	N	A	RI	Y	RI14787	74494	-5
14765	ASOS,COOP,USHCN	RI	Y	N	A	RI	Y	RI14765	74494	-5
93846	AIRWAYS,ASOS,CO	SC	N	N	A	SC	Y	SC93846	72215	-5
13880	ASOS,COOP,UPPER	SC	N	N	A	SC	Y	SC13880	72208	-5
53850	ASOS	SC	N	N	A	SC	Y	SC53850	72215	-5
13883	ASOS,COOP	SC	N	N	A	SC	Y	SC13883	72208	-5
53867	AIRWAYS,ASOS	SC	N	N	A	SC	Y	SC53867	72208	-5
13744	AIRWAYS,ASOS,CO	SC	N	N	A	SC	Y	SC13744	72208	-5
13886	AIRWAYS,ASOS	SC	N	N	A	SC	Y	SC13886	72215	-5
53874	ASOS	SC	N	N	A	SC	Y	SC53874	72208	-5
3870	ASOS,COOP,USHCN	SC	N	N	A	SC	Y	SC3870	72317	-5
93718	ASOS,COOP	SC	N	N	A	SC	Y	SC93718	72208	-5
53854	AIRWAYS,ASOS	SC	N	N	A	SC	Y	SC53854	72208	-5
53871	AIRWAYS,ASOS	SC	N	N	A	SC	Y	SC53871	72317	-5
14929	ASOS,COOP,USHCN	SD	Y	N	A	SD	Y	SD14929	72659	-6
94032	ASOS	SD	N	Y	A	SD	Y	SD94032	72662	-7
14936	ASOS,COOP,WXSV	SD	Y	N	A	SD	Y	SD14936	72659	-6
94950	AIRWAYS,ASOS,CO	SD	Y	N	A	SD	Y	SD94950	72659	-6
94052	AIRWAYS,ASOS	SD	Y	N	A	SD	Y	SD94052	72764	-6
24024	ASOS	SD	N	Y	A	SD	Y	SD24024	72662	-7
24025	AIRWAYS,ASOS,CO	SD	N	Y	A	SD	Y	SD24025	72659	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
24090	ASOS,COOP	SD	N	Y	A	SD	Y	SD24090	72662	-7
14944	ASOS,COOP,WXSV	SD	Y	N	A	SD	Y	SD14944	72558	-6
14946	AIRWAYS,ASOS,CO	SD	Y	N	A	SD	Y	SD14946	72659	-6
94990	AIRWAYS,ASOS	SD	N	Y	A	SD	Y	SD94990	72562	-6
13877	AIRSAMPLE,ASOS,	TN	N	N	A	TN	Y	TN13877	72318	-5
3847	ASOS,COOP	TN	N	N	A	TN	Y	TN3847	72327	-6
3811	AIRWAYS,ASOS,CO	TN	N	N	A	TN	Y	TN3811	72327	-6
13891	AIRSAMPLE,AIRWA	TN	N	N	A	TN	Y	TN13891	72215	-5
13893	AIRSAMPLE,ASOS,	TN	N	N	A	TN	Y	TN13893	72340	-6
13897	AIRSAMPLE,ASOS,	TN	N	N	A	TN	Y	TN13897	72327	-6
53868	AIRSAMPLE,ASOS,	TN	N	N	A	TN	N	TN53868	72327	-6
13962	AIRSAMPLE,ASOS,	TX	N	Y	A	TX	Y	TX13962	72249	-6
12932	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX12932	72251	-6
23047	ASOS,COOP	TX	N	Y	A	TX	Y	TX23047	72363	-6
12976	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX12976	72251	-6
53907	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX53907	72249	-6
13904	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX13904	72251	-6
13958	ASOS,COOP	TX	N	N	A	TX	N	TX13958	72249	-6
3024	AIRWAYS,ASOS	TX	N	Y	A	TX	Y	TX3024	72363	-6
12919	AIRWAYS,ASOS,CO	TX	N	Y	A	TX	Y	TX12919	72250	-6
3999	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX3999	72249	-6
23007	AIRWAYS,ASOS,CO	TX	N	Y	A	TX	Y	TX23007	72363	-6
3904	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX3904	72249	-6
53902	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX53902	72240	-6
12924	ASOS,COOP,USHCN	TX	N	N	A	TX	Y	TX12924	72251	-6
53912	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX53912	72249	-6
12947	ASOS,COOP	TX	N	N	A	TX	Y	TX12947	72251	-6
3927	ASOS,COOP	TX	N	N	A	TX	Y	TX3927	72249	-6
93042	ASOS,COOP	TX	N	Y	A	TX	Y	TX93042	72363	-6
13960	ASOS,COOP	TX	N	N	A	TX	Y	TX13960	72249	-6
3971	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX3971	72249	-6
22010	ASOS,COOP	TX	N	Y	A	TX	Y	TX22010	72261	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
3991	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX3991	72249	-6
23044	ASOS,COOP,USHCN	TX	N	Y	A	TX	Y	TX23044	72364	-7
23091	AIRWAYS,ASOS	TX	N	Y	A	TX	Y	TX23091	72265	-6
53909	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX53909	72249	-6
13961	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX13961	72249	-6
12923	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX12923	72240	-6
12904	AIRWAYS,ASOS	TX	N	Y	A	TX	Y	TX12904	72250	-6
12962	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX12962	72261	-6
12975	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX12975	72240	-6
12918	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX12918	72240	-6
53910	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX53910	72240	-6
12960	ASOS,COOP	TX	N	N	A	TX	Y	TX12960	72240	-6
12977	ASOS,COOP	TX	N	N	A	TX	Y	TX12977	72240	-6
53903	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX53903	72240	-6
13973	AIRWAYS,ASOS	TX	N	Y	A	TX	Y	TX13973	72261	-6
3901	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX3901	72248	-6
23042	AIRWAYS,ASOS,CO	TX	N	Y	A	TX	Y	TX23042	72363	-6
93987	ASOS,COOP	TX	N	N	A	TX	Y	TX93987	72248	-6
12959	AIRWAYS,ASOS,CO	TX	N	Y	A	TX	Y	TX12959	72250	-6
53914	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX53914	72249	-6
23023	ASOS,COOP,WXSV	TX	N	Y	A	TX	Y	TX23023	72265	-6
93985	ASOS,COOP	TX	N	Y	A	TX	Y	TX93985	72249	-6
12971	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX12971	72251	-6
12935	ASOS,COOP	TX	N	N	A	TX	Y	TX12935	72251	-6
23055	ASOS	TX	N	Y	A	TX	N	TX23055	72364	-7
12917	ASOS,COOP	TX	N	N	A	TX	Y	TX12917	72240	-6
12957	AIRWAYS,ASOS	TX	N	Y	A	TX	Y	TX12957	72250	-6
12972	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX12972	72251	-6
23034	AIRSAMPLE,ASOS,C	TX	N	Y	A	TX	Y	TX23034	72265	-6
12921	ASOS,COOP,USHCN	TX	N	N	A	TX	Y	TX12921	72251	-6
12970	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX12970	72251	-6
53911	AIRWAYS,ASOS	TX	N	N	A	TX	Y	TX53911	72249	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
13972	AIRWAYS,ASOS,CO	TX	N	N	A	TX	Y	TX13972	72248	-6
12912	ASOS,COOP	TX	N	N	A	TX	Y	TX12912	72251	-6
13959	ASOS,COOP	TX	N	N	A	TX	Y	TX13959	72249	-6
13966	ASOS,COOP	TX	N	N	A	TX	Y	TX13966	72357	-6
23040	ASOS,COOP,WXSV	TX	N	Y	A	TX	Y	TX23040	72265	-6
23159	ASOS	UT	N	Y	A	UT	Y	UT23159	72376	-7
93129	AIRWAYS,ASOS,CO	UT	N	Y	A	UT	Y	UT93129	72388	-8
94128	AIRWAYS,ASOS	UT	N	Y	A	UT	Y	UT94128	72572	-7
23176	ASOS	UT	N	Y	A	UT	Y	UT23176	72572	-7
93075	AIRWAYS,ASOS,CO	UT	N	Y	A	UT	Y	UT93075	72476	-7
93141	AIRWAYS,ASOS	UT	N	Y	A	UT	Y	UT93141	72572	-7
24127	ASOS,COOP	UT	N	Y	A	UT	Y	UT24127	72572	-7
94030	ASOS,COOP	UT	N	Y	A	UT	Y	UT94030	72476	-7
93775	AIRWAYS,ASOS	VA	Y	N	A	VA	Y	VA93775	72403	-5
93736	AIRWAYS,ASOS	VA	N	N	A	VA	Y	VA93736	72403	-5
13733	ASOS,COOP	VA	N	N	A	VA	Y	VA13733	72318	-5
93741	ASOS	VA	N	N	A	VA	Y	VA93741	72402	-5
13737	ASOS,COOP,USHCN	VA	N	N	A	VA	Y	VA13737	72402	-5
13740	ASOS,COOP	VA	N	N	A	VA	Y	VA13740	72403	-5
13741	ASOS,COOP	VA	N	N	A	VA	Y	VA13741	72318	-5
93773	AIRWAYS,ASOS	VA	N	N	A	VA	Y	VA93773	72402	-5
93739	ASOS,COOP	VA	N	N	A	VA	Y	VA93739	72402	-5
93738	ASOS,COOP	VA	N	N	A	VA	Y	VA93738	72403	-5
94705	AIRWAYS,ASOS,CO	VT	Y	N	A	VT	Y	VT94705	72518	-5
14742	ASOS,COOP,USHCN	VT	Y	N	A	VT	Y	VT14742	72518	-5
54771	AIRWAYS,ASOS	VT	Y	N	A	VT	Y	VT54771	72518	-5
54740	AIRWAYS,ASOS	VT	Y	N	A	VT	Y	VT54740	72518	-5
24217	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA24217	72797	-8
94119	AIRWAYS,ASOS,CO	WA	Y	N	A	WA	Y	WA94119	72786	-8
24220	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA24220	72786	-8
24141	AIRWAYS,ASOS,CO	WA	Y	N	A	WA	Y	WA24141	72786	-8
24222	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA24222	72797	-8

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
94276	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA94276	72797	-8
94225	ASOS,COOP	WA	N	N	A	WA	Y	WA94225	72797	-8
24110	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA24110	72786	-8
24227	ASOS,COOP	WA	N	N	A	WA	Y	WA24227	72797	-8
94197	ASOS	WA	Y	N	A	WA	N	WA94197	71203	-8
94129	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA94129	72786	-8
94240	ASOS,COOP	WA	N	N	A	WA	Y	WA94240	72797	-8
94248	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA94248	72797	-8
24234	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA24234	72797	-8
24233	ASOS,COOP	WA	N	N	A	WA	Y	WA24233	72797	-8
94227	ASOS,COOP	WA	N	N	A	WA	Y	WA94227	72797	-8
94176	AIRWAYS,ASOS	WA	Y	N	A	WA	Y	WA94176	72786	-8
24157	AIRSAMPLE,ASOS,C	WA	Y	N	A	WA	Y	WA24157	72786	-8
94274	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA94274	72797	-8
24160	AIRWAYS,ASOS	WA	N	N	A	WA	Y	WA24160	72786	-8
94239	ASOS,COOP	WA	Y	N	A	WA	Y	WA94239	72786	-8
24243	ASOS,COOP	WA	N	N	A	WA	Y	WA24243	72694	-8
94929	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI94929	72649	-6
94994	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI94994	74455	-6
14991	ASOS,COOP,WXSVC	WI	Y	N	A	WI	Y	WI14991	72649	-6
4840	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI4840	72645	-6
14898	ASOS,COOP,WXSVC	WI	Y	N	A	WI	Y	WI14898	72645	-6
94973	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI94973	72649	-6
4845	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI4845	72645	-6
14921	ASOS	WI	Y	N	A	WI	Y	WI14921	74455	-6
14837	ASOS,COOP,WXSVC	WI	Y	N	A	WI	Y	WI14837	72645	-6
94985	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI94985	72645	-6
14839	AIRSAMPLE,ASOS,C	WI	Y	N	A	WI	Y	WI14839	72645	-6
94855	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI94855	72645	-6
94818	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI94818	72645	-6
4803	AIRWAYS,ASOS,CO	WI	Y	N	A	WI	Y	WI4803	72645	-6
4841	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI4841	72645	-6

Surface WBAN	Type Station	State tif file	snow	arid	moisture	state	Airport	AERMOD File	Upper Air WMO	Upper Air UTC
14897	ASOS,COOP	WI	Y	N	A	WI	Y	WI14897	72645	-6
4826	AIRWAYS,ASOS	WI	Y	N	A	WI	Y	WI4826	72645	-6
3872	ASOS,COOP	WV	Y	N	A	WV	Y	WV3872	72318	-5
13866	ASOS,COOP	WV	Y	N	A	WV	Y	WV13866	72318	-5
3802	AIRWAYS,ASOS	WV	Y	N	A	WV	Y	WV3802	72520	-5
13729	ASOS,COOP	WV	Y	N	A	WV	Y	WV13729	72520	-5
13734	ASOS,COOP,USHCN	WV	N	N	A	WV	Y	WV13734	72403	-5
13736	AIRWAYS,ASOS,CO	WV	Y	N	A	WV	Y	WV13736	72520	-5
24164	AIRWAYS,ASOS	WY	N	Y	A	WY	Y	WY24164	72672	-7
94054	AIRWAYS,ASOS	WY	N	Y	A	WY	Y	WY94054	72672	-7
24089	AIRWAYS,ASOS,CO	WY	N	Y	A	WY	Y	WY24089	72672	-7
24018	ASOS,COOP,USHCN	WY	Y	N	A	WY	Y	WY24018	72469	-7
94057	AIRWAYS,ASOS,CO	WY	N	Y	A	WY	Y	WY94057	72662	-7
94023	AIRWAYS,ASOS	WY	N	Y	A	WY	Y	WY94023	72662	-7
24048	AIRWAYS,ASOS	WY	N	Y	A	WY	Y	WY24048	72672	-7
24021	ASOS,COOP,WXSV	WY	N	Y	A	WY	Y	WY24021	72672	-7
24022	ASOS,COOP,USHCN	WY	Y	N	A	WY	Y	WY24022	72469	-7
24057	ASOS,COOP	WY	N	Y	A	WY	Y	WY24057	72672	-7
24061	AIRWAYS,ASOS,WX	WY	Y	N	A	WY	Y	WY24061	72672	-7
24027	AIRWAYS,ASOS,AW	WY	N	Y	A	WY	Y	WY24027	72672	-7
24029	ASOS,COOP	WY	N	Y	A	WY	Y	WY24029	72672	-7
94053	AIRWAYS,ASOS,CO	WY	N	N	A	WY	Y	WY94053	72662	-7
24062	AIRWAYS,ASOS	WY	Y	N	A	WY	Y	WY24062	72672	-7

Appendix 4

Dispersion Model Receptor Revisions and Additions

Dispersion Model Receptor Revisions and Additions
Pulp Mill Combustion Sources
(Subpart MM) Source Category

To estimate ambient concentrations for evaluating long-term exposures, the HEM-3 model uses the geographic centroids of census blocks (currently utilizing the 2010 Census) as dispersion model receptors. The census block centroids are generally good surrogates for where people live within a census block. A census block generally encompasses about 40 people or 10-15 households. However, in cases where a block centroid is located on industrial property, or where a census block is large and the centroid less likely to be representative of the block's residential locations, the block centroid may not be an appropriate surrogate.

Census block centroids that are on facility property can sometimes be identified by their proximity to emission sources. In cases where a census block centroid was within 300 meters of any emission source, we viewed aerial images of the facility to determine whether the block centroid was likely located on facility property. The selection of the 300-meter distance reflects a compromise between too few and too many blocks identified as being potentially on facility property. Distances smaller than 300 meters would identify only block centroids near the emission sources and could exclude some block centroids that are still within facility boundaries, particularly for large facilities. Distances significantly larger than 300 meters would identify many block centroids that are outside facility boundaries, particularly for small facilities. Where we confirmed a block centroid on facility property, we moved the block centroid to a location that best represents the residential locations in the block.

In addition, census block centroids for blocks with large areas may not be representative of residential locations. Risk estimates based on such centroids can be understated if there are residences nearer to a facility than the centroid, and overstated if the residences are farther from the facility than the centroid. To avoid understating the maximum individual risk associated with a facility, in some cases we relocated block centroids, or added dispersion model receptors other than the block centroid. We examined aerial images of all large census blocks within one kilometer of any emission source. Experience from previous risks characterizations show that in most cases the MIR is generally located within 1 km of the facility boundary. If the block centroid did not represent the residential locations, we relocated it to better represent them. If residential locations could not be represented by a single receptor (that is, the residences were spread out over the block), we added additional receptors for residences nearer to the facility than the centroid.

For these source categories, the table below contains each census block for which we changed the centroid location because it was on facility property or was otherwise not representative of the residential locations in the block. The table also contains the locations of additional receptors that were included to represent residential locations nearer to the facility than the block centroid.

Dispersion Model Receptor Revisions:

FRS ID	NEI ID	CENSUS Block	Orig-Site Lat	Orig-Site Long	Rec Lat	Rec Long	Note
53031110000490326	NEI42357	530319505002003	48.0933	-122.8036	48.0923	-122.8065	HEM Centroid on-site, replace w/rec
1001110011734930	NEI8560	10010208011006	32.4193	-86.4954	32.4308	-86.4909	HEM Centroid moved, replace w/rec
1023110017428770	NEI18334	10239567004082	32.2168	-88.0192	32.2140	-88.0253	HEM Centroid on-site, replace w/rec
1025110000369280	NEI8601	10259579025033	31.4628	-87.8990	31.4753	-87.8932	HEM Centroid off-site, replace w/rec
1099110000589610	NEI18373	10990757001077	31.6150	-87.4700	31.6321	-87.4642	HEM Centroid moved, replace w/rec
1131110007233300	NEI8619	11310351002097	31.9637	-87.4787	31.9648	-87.4844	HEM Centroid moved, replace w/rec
05069110000450752		50690005023014	34.2689	-92.0292	34.2750	-92.0316	HEM Centroid moved, replace w/rec
05069110000450752		50690005023029	34.2467	-92.0392	34.2527	-92.0284	HEM Centroid moved, replace w/rec
12033110000400000	NEI26309	120330037001007	30.6022	-87.3267	30.6056	-87.3291	HEM Centroid on-site, replace w/rec
12033110000400000	NEI26309	120330037001010	30.6010	-87.3167	30.5991	-87.3147	HEM Centroid moved, replace w/rec
12107110000600000	NEI8265	121079506003007	29.6693	-81.6731	29.6628	-81.6796	HEM Centroid moved, replace w/rec
12107110000600000	NEI8265	121079501003075	29.6977	-81.7032	29.7115	-81.7163	HEM Centroid on-site, replace w/rec
12107110000600000	NEI8265	121079501002107	29.6867	-81.7196	29.6886	-81.7215	HEM Centroid off-site, replace w/rec
13127110000600000	NEI8196	131270007006011	31.1797	-81.5158	31.1778	-81.5123	HEM Centroid on-site, replace w/rec
23007110000600000	NEI6261	230079714004036	44.5104	-70.2352	44.5109	-70.2341	HEM Centroid off-site, replace w/rec
23007110000600000	NEI6261	230079714004072	44.4813	-70.2350	44.4903	-70.2267	HEM Centroid off-site, replace w/rec
23019110000600000	NEI33103	230190071004000	44.9160	-68.6522	44.9137	-68.6402	HEM Centroid off-site, replace w/rec

23029110013400000	NEI46835	230299554001031	45.1582	-67.4065	45.1542	-67.3975	HEM Centroid off-site, replace w/rec
28077110017400000	NEI11172	280779601003004	31.6471	-90.0882	31.6390	-90.0774	HEM Centroid off-site, replace w/rec
28149110000600000	NEI34070	281499501002008	32.5626	-90.7539	32.5037	-90.7934	HEM Centroid off-site, replace w/rec
37087110009800000	NEI40282	370879202002036	35.5374	-82.8403	35.5371	-82.8377	HEM Centroid off-site, replace w/rec
39031110000400000	NEI11461	390319613002005	40.2789	-81.8526	40.2784	-81.8588	HEM Centroid off-site, replace w/rec
39141110000400000	NEI40488	391419568001001	39.3144	-82.9693	39.3164	-82.9745	HEM Centroid off-site, replace w/rec
41039110000500000	NEI45182	410390019032014	44.0493	-122.9557	44.0476	-122.9589	HEM Centroid off-site, replace w/rec
42013110000300000	NEI7104	420130114002020	40.3357	-78.4063	40.3349	-78.4041	HEM Centroid off-site, replace w/rec
42047110000300000	NEI40686	420479502001194	41.5092	-78.6692	41.5053	-78.6785	HEM Centroid off-site, replace w/rec
45031110000600000	NEI43472	450310103003018	34.3911	-80.0595	34.3948	-80.0602	HEM Centroid off-site, replace w/rec
47071110017400000	NEI41552	470719206002055	35.0510	-88.2556	35.0484	-88.2533	HEM Centroid off-site, replace w/rec
47107110000600000	NEI41565	471079708004081	35.2933	-84.7513	35.2965	-84.7499	HEM Centroid off-site, replace w/rec
51019110000300000	NEI42211	510190303002147	37.5291	-79.3558	37.5311	-79.3577	HEM Centroid off-site, replace w/rec
51580110012500000	NEI759	515800601001052	37.8012	-79.9912	37.8033	-79.9913	HEM Centroid off-site, replace w/rec
53011110000600000	NEI46599	530110414002023	45.5866	-122.4113	45.5883	-122.4113	HEM Centroid off-site, replace w/rec
55069110000400000	NEI46750	550699604001008	45.4449	-89.7419	45.4352	-89.7466	HEM Centroid off-site, replace w/rec
55141110000700000	NEI42695	551410117004034	44.3145	-89.8992	44.3142	-89.9000	HEM Centroid off-site, replace w/rec
23007110000600000	NEI6261	230079714004059	44.5023	-70.2319	44.4997	-70.2246	HEM Centroid on-site, replace w/rec
28087110000600000	NEI34064	280870011001012	33.3613	-88.4703	33.3701	-88.4801	HEM Centroid on-site, replace w/rec
45031110000600000	NEI43472	450310103003021	34.3890	-80.0690	34.3910	-80.0685	HEM Centroid on-site, replace w/rec
45043110000400000	NEI41314	450439206001052	33.3726	-79.3071	33.3798	-79.3148	HEM Centroid on-site, replace w/rec
51101110007300000	NEI42254	511019503002017	37.5450	-76.8056	37.5458	-76.8061	HEM Centroid on-site, replace w/rec
53031110000500000	NEI42357	530319505002003	48.0933	-122.8036	48.0922	-122.8060	HEM Centroid on-site, replace w/rec

22073110017800000	NEI6057	220730058001025	32.4880	-92.1486			Make Zero Population and Remove
39141110000400000	NEI40488	391419565004032	39.3251	-82.9699			Make Zero Population and Remove
51580110012500000	NEI759	515800601001053	37.8048	-79.9919			Make Zero Population and Remove
55141110000700000	NEI42695	551410117004035	44.3159	-89.8964			Make Zero Population and Remove

Additional Receptors for Pulp Mill Combustion Sources (Subpart MM) Source Category

Source Category	NEI ID	Latitude	Longitude	Note
Pulp and Paper MACT 2	NEI8261	30.6776	-81.4550	Add User Defined Receptor
Pulp and Paper MACT 2	NEI8261	30.6885	-81.4532	Add User Defined Receptor
Pulp and Paper MACT 2	NEI47091	30.0719	-83.5372	Add User Defined Receptor
Pulp and Paper MACT 2	NEI47091	30.0551	-83.5287	Add User Defined Receptor
Pulp and Paper MACT 2	NEI7559	30.8579	-93.3868	Add User Defined Receptor
Pulp and Paper MACT 2	NEI7559	30.8582	-93.3542	Add User Defined Receptor
Pulp and Paper MACT 2	NEI46599	45.5828	-122.4151	Add User Defined Receptor
Pulp and Paper MACT 2	NEI42357	48.0913	-122.8052	Add User Defined Receptor
Pulp and Paper MACT 2	NEI26504	30.7075	-83.3018	Add User Defined Receptor
Pulp and Paper MACT 2	NEI26504	30.6888	-83.3089	Add User Defined Receptor
Pulp and Paper MACT 2	NEI6057	32.4789	-92.1565	Add User Defined Receptor
Pulp and Paper MACT 2	NEI6261	44.4954	-70.2285	Add User Defined Receptor
Pulp and Paper MACT 2	NEI33103	44.9183	-68.6374	Add User Defined Receptor
Pulp and Paper MACT 2	NEI40600	44.6143	-123.9311	Add User Defined Receptor
Pulp and Paper MACT 2	NEI42254	37.5447	-76.8033	Add User Defined Receptor
Pulp and Paper MACT 2	NEI42689	44.7852	-89.6914	Add User Defined Receptor
Pulp and Paper MACT 2	NEI42689	44.7838	-89.6921	Add User Defined Receptor

Appendix 5:

Analysis of data on short-term emission rates relative to long-term emission rates

Analysis of data on short-term emission rates relative to long-term emission rates

Ted Palma
Roy Smith
EPA/OAQPS/SBAG

1. Introduction

1.1. The problem

The process of listing hazardous air pollutants (HAPs) provided by the Clean Air Act (CAA, section 112(b)(2)) explicitly includes acute toxicity as a listing criterion. For this reason, in addition to chronic exposures, EPA considers acute exposures in risk-based decision-making for the HAP regulatory program. Estimating acute exposures via dispersion modeling requires input data on hourly meteorological conditions (available for most areas of the US) and short-term emission rates of individual facilities (almost universally absent from the National Emissions Inventory (NEI), the Toxic Release Inventory (TRI), and state emission databases).

Lacking short-term emission rates, we must estimate peak short-term rates based on annual average rates, which are available. For Risk and Technology Review (RTR) rulemakings, we have assumed that the 1-hour emission rate for each facility could exceed the annual average hourly emission rate by as much as tenfold, and further assumed that this tenfold emission spike could coincide with worst-case meteorological conditions and the presence of a human receptor at the facility boundary, as a means of screening for potentially significant acute exposures.

In a consultation on the "RTR Assessment Plan", a panel of the EPA's Science Advisory Board (SAB), several reviewers questioned the appropriateness of the factor of ten; some even suggested that this tenfold assumption may underestimate actual maximum short-term emissions for some facilities, and thereby also underestimate maximum acute risks. The SAB recommended an analysis of available short-term emissions data for HAP to test this assumption. This analysis responds to that SAB recommendation and attempts to test the protectiveness of the tenfold assumption using a database of "event emissions" collected from facilities in the Houston-Galveston area, to compare events representative of HAP releases to long-term release rates. We welcome comments from the public on the methods used and the conclusions reached by this analysis.

2. Methods

2.1. Texas Commission on Environmental Quality event emissions database

The Texas Commission on Environmental Quality (TCEQ) collects emissions data using online reporting required of any facility releasing 100 pounds or more of a listed chemical (primarily ozone-forming VOCs) during a non-routine event. The TCEQ data are intended to improve the state's knowledge of how short-term releases affect tropospheric ozone levels in that area. The database we utilized in our analysis was a subset of the TCEQ data covering emission events that occurred in an eight-county area in eastern Texas during a 756-day period between January 31, 2003 and February 25, 2005.

The complete emissions event data were obtained in April 2007 from Cynthia Folsom Murphy, a research scientists with the University of Texas at Austin (UTA) Center for Energy and Environmental Resources. The data were provided in four Excel spreadsheets generated from an original MS Access file. We used these Excel files to reconstruct a MS Access database in order to facilitate selection of a representative subset of records for this analysis.

Although some of the released substances were HAPs, this was incidental to the database's primary purpose of enhancing the TCEQ's knowledge of photochemical activity. Thus, more than 80% of the released mass was ethene and propene, neither of which are HAPs. The database included release events caused by accidents, equipment failures, maintenance, startup, and shutdown. It also contained facility names, information on amounts of individual compounds released. To provide a basis for comparing the event releases with "typical" emissions, the UTA staff included total VOC emissions data for each facility for calendar year 2004, obtained from the EPA Toxic Release Inventory (TRI). The database did *not* contain any records for facilities that did not experience any reportable events during this period.

2.2. Data filtering

Because the event release data were intended for modeling short-term releases of ozone-producing VOCs, the database includes releases from accidents (which are regulated under section 112(r) of the CAA and are therefore not considered in residual risk assessments) and releases of light hydrocarbon compounds that are not HAPs and are much more volatile than most HAPs. This intent of this analysis, on the other hand, was to evaluate short-term releases of HAPs due to normal process variability or scheduled startups, shutdowns, and maintenance, relative to long-term release rates. Because the full emission events database was not representative of likely HAP emissions normally considered under the residual risk program, we filtered the release data as follows in an attempt to improve its representativeness:

1. Hydrocarbons of C5 or less were dropped, except that all HAPs (including non-VOCs) were retained regardless of molecular structure;

2. Accidental releases were dropped, but all others (including startup, shutdown, and maintenance) were retained;

3. Only facilities whose long-term VOC releases exceeded 0.068 tons per day (25 tons per year) were retained, to approximate the population of facilities likely to be subject to residual risk standards (i.e., major facilities);

4. A few release records had to be dropped because their facility numbers did not link to any facility in the database;

5. A few facilities had to be dropped because the database did not include their 2004 TRI VOC release information.

2.3. Analysis

Annual VOC emissions and emission event release data were both converted to lb/hr. In order to conform to our atmospheric dispersion models, which estimate ambient concentrations for periods of 1 hour or more, amounts released during events shorter than 1 hour were assigned to the whole hour. For example, a release of 100 lb in ten minutes was converted to 100 lb/hr. Events longer than 1 hour were converted normally, e.g., a release of 100 lb in 120 minutes was converted to 50 lb/hr. The event release rates for individual compounds were summed, yielding a total release rate for each event. This total release rate for each event was divided by the annual VOC release rate for the facility to derive the ratio of peak-to-mean emission rate for the event.

3. Results and Discussion

3.1. Database filtering

The original database contained 505 individual contaminants, including multiple redundancies. These redundancies did not affect this analysis, so we did not resolve them. After filtering out light, non-HAP, VOCs, 317 contaminants remained (Table 1).

The database contained release records for 150 unique facilities. Of these, 48 facilities (Table 2) were major VOC emitters that reported releases of at least one of the contaminants in Table 1.

The database contained 3641 individual release events reported by the original 150 facilities. Of these, 319 events involved a Table 1 contaminant released by a Table 2 facility during startup, shutdown, or maintenance. For evaluating short-term releases for residual risk assessments, these 319 events comprise the most representative subset of the full database.

3.2. Descriptive statistics

For this subset of emission events, ratios of event release rate to long-term release rate varied from 0.00000004 to 74. Distribution statistics appear in Tables 3 and 4. The 99th percentile ratio was 9 (i.e., an event release rate nine times the long-term average). Only 3 ratios exceeded our default assumption of 10, and of these only one exceeded 11. The full cumulative probability density of the ratios is shown in Figure 1.

Figure 2 shows the relationship between ratio and event duration. As expected, the ratio declined as duration increased. Only 18 events lasted less than 2 hours, but these events produced the three highest ratios. Figure 3 is a similar ratio vs. duration plot, but with duration as a percentage of total time. Only 35 events exceeded 1% of the total period covered by the database. Figure 4 shows the relationship between ratio and total amount released, and suggests that the highest ratios were produced by facilities whose routine VOC emissions were relatively small. Thus, the events themselves also tended to be relatively small in absolute terms.

3.3. Discussion

These results suggest that the tenfold ratio assumption for short-term releases is protective, and that the facilities for which it may underestimate event releases may tend to be smaller emitters.

However, this analysis is limited in the following ways by the nature of the database and the filtering that we applied:

1. The only long-term release data available from the database were total VOC emissions for 2004. Ideally, we would have preferred to have routine release rates for each individual contaminant. However, retrieving these data from other sources and linking them to this database was not feasible.

2. Removing VOCs that are not representative of HAPs, and comparing the releases against all VOCs, would tend to underestimate the true ratios. This effect could be quantitatively large.

3. Retaining HAPs that are not VOCs (such as toxic metals), and including them in the total to be compared against all VOCs, would tend to overestimate the true ratios. The size of this effect is not known, but seems likely to be less than for (2) above.

4. The database contains only facilities that had at least one release event during the reporting period. The number of facilities in the statistical population that did not experience an event is not known. The lack of data for these facilities (whose ratios in this analysis would have been zero) would cause the descriptive statistics to be skewed toward an overestimate. The size of this effect is unknown.

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
2-Methyloctane	No	3221-61-2	90008
2-Methylpentane	No	107-83-5	43229
2-methylhexane	No	591-76-4	43263
2-Methylpentane	No	107-83-5	43229
2,2,3-Trimethylpentane	No	564-02-3	
2,2,4-Trimethylpentane	Yes	540-84-1	43250
dimethyl butane	No	75-83-2	43291
2,3-Dimethylbutane	No	79-29-8	43276
2,3,4-Trimethylpentane	No	565-75-3	43252
2,3-Dimethylbutane	No	79-29-8	43276
2,4-Dimethylpentane	No	108-08-7	43247
2-methylheptane	No	592-27-8	43296
2-methylhexane	No	591-76-4	43263
2-Methylpentane	No	107-83-5	43229
3-Methylhexane	No	589-34-4	43295
3-Methylpentane	No	96-14-0	43230
3-Methylhexane	No	589-34-4	43295
3-Methylpentane	No	96-14-0	43230
3-Methylheptane	No	589-81-1	43253
3-Methylhexane	No	589-34-4	43295
3-Methylpentane	No	96-14-0	43230

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
Acetaldehyde	Yes	75-07-0	43503
Acetic Acid	No	64-19-7	43404
Acetonitrile	Yes	75-05-8	70016
Acetophenone	Yes	98-86-2	
Acrolein	Yes	107-02-8	43505
Acrylic acid	Yes	79-10-7	43407
Acrylonitrile	Yes	107-13-1	43704
alkylphenol	No	none	
Benzene	Yes	71-43-2	45201
Benzo[a]anthracene	Yes	56-55-3	46716
Benzo[a]pyrene	Yes	50-32-8	46719
Benzo[b]fluoranthene	Yes	205-99-2	46717
Biphenyl	Yes	92-52-4	45226
Butanol	No	35296-72-1	
Butyl Acrylate	No	141-32-2	43440
t-Butyl Alcohol	No	75-65-0	43309
butylcyclohexane	No	1678-93-9	90101
Butyraldehyde	No	123-72-8	43510
C9 Aromatics	No	none	
Naphthalene	Yes	91-20-3	46701
Nonane	No	111-84-2	43235
C9+	No	none	
Carbon tetrachloride	Yes	56-23-5	43804
Carbonyl Sulfide	Yes	463-58-1	43933
Chloral	No	75-87-6	
Trichloromethane	Yes	67-66-3	43803
Chlorothalonil	No	1897-45-6	
Petroleum	No	8002-05-9	
Petroleum	No	8002-05-9	
Cumene	Yes	98-82-8	45210
Cyclohexane	No	110-82-7	43248
Cyclohexanol	No	108-93-0	43317
Cyclohexanone	No	108-94-1	43561
Cyclohexanone	No	108-94-1	43561
Decane	No	124-18-5	43238
Decane	No	124-18-5	43238
1,2-Dichloroethane	No	107-06-2	43815
Diethylbenzene (mixture)	No	25340-17-4	45106
Methyl Ether	No	115-10-6	43350
Dimethylcyclohexane	No	27195-67-1	98059
Dimethylcyclopentane	No	28729-52-4	90064

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
Dimethylcyclopentane	No	28729-52-4	90064
Dimethyl formamide	Yes	68-12-2	43450
Dimethylhexane	No	28777-67-5	90067
Dimethyl pentane	No	38815-29-1	90063
Epichlorohydrin	Yes	106-89-8	43863
Ethyl Alcohol	No	64-17-5	43302
Ethyl Acrylate	Yes	140-88-5	43438
Ethyl Alcohol	No	64-17-5	43302
Ethyl Benzene	Yes	100-41-4	45203
Ethyl Chloride	Yes	75-00-3	43812
Ethylcyclohexane	No	1678-91-7	43288
ethylacetylene	No	107-00-6	43281
Ethyl Benzene	Yes	100-41-4	45203
Ethylene Oxide	Yes	75-21-8	43601
ethylmethylbenzene	No	25550-14-5	45104
formaldehyde	Yes	50-00-0	43502
Furfural	No	98-01-1	45503
straight-run middle distillate	No	64741-44-2	
Gasoline	No	86290-81-5	
Gasoline	No	86290-81-5	
Heavy Olefins	No	none	
n-Heptane	No	142-82-5	43232
n-Heptane	No	142-82-5	43232
Heptylene	No	25339-56-4	
hexane	Yes	110-54-3	43231
hexane	Yes	110-54-3	43231
2-Methylpentane	No	107-83-5	43229
hexane	Yes	110-54-3	43231
Hexene	No	25264-93-1	43289
Indeno[1,2,3-cd]pyrene	Yes	193-39-5	46720
Isobutyraldehyde	No	78-84-2	43511
2-Methyl-1-propanol	No	78-83-1	43306
2-Methyl-1-propanol	No	78-83-1	43306
Isobutyraldehyde	No	78-84-2	43511
Isoheptanes (mixture)	No	31394-54-4	43106
2-Methylpentane	No	107-83-5	43229
2,2,4-Trimethylpentane	No	540-84-1	43250
2,2,4-Trimethylpentane	No	540-84-1	43250
Isopar E	No		
Isoprene	No	78-79-5	43243
2-Propanol	No	67-63-0	43304

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
2-Propanol	No	67-63-0	43304
Cumene	Yes	98-82-8	45210
Isopropylcyclohexane	No	696-29-7	90128
Diisopropyl ether	No	108-20-3	85005
Kerosene	No	64742-81-0	
Methyl ethyl ketone	No	78-93-3	43552
Methyl isobutenyl ketone	Yes	141-79-7	
Methanol	Yes	67-56-1	43301
Methyl Acetylene	No	74-99-7	43209
Cresol	Yes	1319-77-3	45605
Methyl Chloride	Yes	74-87-3	43801
methyl cyclohexane	No	108-87-2	43261
Methyl ethyl ketone	No	78-93-3	43552
Iodomethane	No	74-88-4	86025
Methyl Mercaptan	No	74-93-1	43901
methyl cyclohexane	No	108-87-2	43261
Methylcyclopentane	No	96-37-7	43262
2-Methyldecane	No	6975-98-0	98155
Methylheptane	No	50985-84-7	90045
2-methylheptane	No	592-27-8	43296
2-Methyl nonane	No	871-83-0	90047
Tert-butyl methyl ether	No	1634-04-4	43376
meta-xylene	No	108-38-3	45205
Nonane	No	111-84-2	43235
Naphtha	No	8030-30-6	45101
Naphthalene	Yes	91-20-3	46701
Naphtha	No	8030-30-6	45101
Naphthalene	No	91-20-3	46701
Butyl acetate	No	123-86-4	43435
Butyraldehyde	No	123-72-8	43510
Nonane	No	111-84-2	43235
Nonane	No	111-84-2	43235
Octadecene	No	27070-58-2	
n-Octane	No	111-65-9	43233
Octene (mixed isomers)	No	25377-83-7	
ortho-xylene	No	95-47-6	45204
Parathion	Yes	56-38-2	
4-Aminohippuric Acid	No	61-78-9	
Phenol	Yes	108-95-2	45300
Silicone	No	63148-62-9	
Naphtha	No	8030-30-6	45101

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
Naphtha	No	8030-30-6	45101
Polyethylene	No	9002-88-4	
Poly(Isobutylene)	No	9003-27-4	
Chloromethyl pivalate	No	18997-19-8	
Process fuel gas	No	none	
Propionic Acid	No	79-09-4	43405
Propylene oxide	No	75-56-9	43602
para-xylene	No	106-42-3	45206
Styrene	Yes	100-42-5	45220
Sulfolane	No	126-33-0	
t-Butyl Alcohol	No	75-65-0	43309
t-Butyl Alcohol	No	75-65-0	43309
tert-butyl hydroperoxide	No	75-91-2	
Toluene	Yes	108-88-3	45202
Aqualyte(TM), LSC cocktail	No	25551-13-7	45107
1,3,4-Trimethylbenzene	No	95-63-6	45208
trimethylcyclopentane	No	30498-64-7	98058
trimethylpentane	No	29222-48-8	90092
Undecane	No	1120-21-4	43241
Vinyl acetate	Yes	108-05-4	43453
Vinyl acetate	Yes	108-05-4	43453
Vinyl chloride	Yes	75-01-4	43860
vinyl resin	No	none	
Vinylcyclohexane	No	695-12-5	
xylenes	Yes	1330-20-7	45102
xylenes	Yes	1330-20-7	45102
meta-xylene	Yes	108-38-3	45205
ortho-xylene	Yes	95-47-6	45204
para-xylene	Yes	106-42-3	45206
Mineral spirits	No	64475-85-0	43118
Propylene glycol	No	57-55-6	43369
Vinyl chloride	Yes	75-01-4	43860
1-Decene	No	872-05-9	90014
2-Ethyl-1-hexanol	No	104-76-7	43318
2-Pyrrolidone	No	616-45-5	
Aromatic	No	none	
Decene	No	25339-53-1	90014
2-N,N-Dibutylaminoethanol	No	102-81-8	86007
Diisopropanolamine	No	110-97-4	86004
N,N-Dimethylethanolamine	No	108-01-0	84004
trifluoroethane	No	27987-06-0	

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
2,2'-Oxybisethanol	No	111-46-6	43367
Hydrocarbons	No	none	
Methyl Formate	No	107-31-3	43430
Isopropylamine	No	75-31-0	86014
n-Butanol	No	71-36-3	43305
Polypropylene glycol ether	No		
N-Vinyl-2-Pyrrolidinone	No	88-12-0	
1,1-Di(t-Amylperoxy) Cyclohexane	No	15667-10-4	
1,2,3-Trimethyl-4-ethylbenzene	No	none	
2-Methyldecane	No	6975-98-0	98155
2-methylheptane	No	592-27-8	43296
2-Methyl nonane	No	871-83-0	90047
2,5-Dimethylhexane-2,5-dihydroperoxide	No	3025-88-5	
Butyl ether	No	142-96-1	43372
1,2-Dichloroethane	Yes	107-06-2	43815
Hydrindene	No	496-11-7	98044
Methylheptane	No	50985-84-7	90045
methyl methacrylate	No	80-62-6	43441
Naphtha	No	8030-30-6	45101
hexane	Yes	110-54-3	43231
tert-amyl hydroperoxide	No	3425-61-4	
1,3,4-Trimethylbenzene	No	95-63-6	45208
n-Butanol	No	71-36-3	43305
2-Butoxy ethanol	Yes	111-76-2	43308
hexane	Yes	110-54-3	43231
cycloheptane	No	291-64-5	43115
n-Heptane	No	142-82-5	43232
n-Octane	No	111-65-9	43233
Hexyl Carbitol	No	112-59-4	
Nonene	No	27215-95-8	
Silane, ethenyltrimethoxy	No	2768-02-7	
tetrahydrofuran	No	109-99-9	70014
Vinyl chloride	Yes	75-01-4	43860
Methyl Formate	No	107-31-3	43430
Phenyl ether	No	101-84-8	
phosgene	Yes	75-44-5	
1,2-Dichloroethane	No	107-06-2	43815
2-Butoxy ethanol	Yes	111-76-2	43308
Gasoline	No	86290-81-5	
1-Tridecanol	No	112-70-9	

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
1,2,4-Trichlorobenzene	Yes	120-82-1	45208
2-(2-Butoxyethoxy)ethanol	Yes	112-34-5	43312
2,3,4-trihydroxybenzophenone Ester	No	1143-72-2	
Methyl n-amyl ketone	No	110-43-0	43562
4,4-Cyclohexylidenebis[phenol]	No	843-55-0	
Anisole	No	100-66-3	
2-Butoxy ethanol	Yes	111-76-2	43308
Cresol-Formaldehyde novolac Resin	No	proprietary	
Decane	No	124-18-5	43238
gamma-Butyrolactone	No	96-48-0	
Dimethyl pentane	No	38815-29-1	90063
Dodecyl Benzenesulfonic Acid	No	27176-87-0	
Ethanol Amine	No	141-43-5	43777
ethyl lactate	No	687-47-8	
Hexamethyldisilazane	No	999-97-3	
Methyl ethyl ketone	No	78-93-3	43552
Cresol	Yes	1319-77-3	45605
Naphthalene Sulfonic Acid Resin	No		
Naphthalene Sulfonic Acid Resin	No		
n-Butanol	No	71-36-3	43305
Decane	No	124-18-5	43238
1-Methyl-2-pyrrolidinone	No	872-50-4	70008
Pentyl Ester Acetic Acid	No		
Phenol Formaldehyde Resin, Novolac	No		
Phenol Formaldehyde Resin, Novolac	No		
Propylene Glycol Monomethyl Ether	No	107-98-2	70011
Pyrocatechol	No	120-80-9	
Carbon Disulfide	Yes	75-15-0	43934
Hexene	No	592-41-6	43245
VOC	No	none	
Methacrylic acid	No	79-41-4	84009
Methyl 3-hydroxybutyrate	No	1487-49-6	
t-Butyl Alcohol	No	75-65-0	43309
methyl valeraldehyde	No	123-15-9	
Butyl Methacrylate	No	97-88-1	85008
dipropyl ether	No	111-43-3	
n-Propanol	No	71-23-8	43303
Propyl propionate	No	106-36-5	86052

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
1,2-Epoxybutane	Yes	106-88-7	
Methylamine	No	74-89-5	
1,1-Dimethylcyclohexane	No	590-66-9	
1,1-Dimethylcyclopentane	No	1638-26-2	
2-Methylpentane	No	107-83-5	43229
dimethyl butane	No	75-83-2	43291
2,3,3-Trimethylpentane	No	560-21-4	
2,3-Dimethylhexane	No	584-94-1	
2,3-Dimethylpentane	No	565-59-3	
2,4-Dimethylhexane	No	589-43-5	
2,5-Dimethyl-hexane	No	592-13-2	
2-Butoxy ethanol	Yes	111-76-2	43308
2-mercaptoethanol	No	60-24-2	
Bisphenol A	No	80-05-7	
straight-run middle distillate	No	64741-44-2	
4-Vinylcyclohexene	No	100-40-3	
straight-run middle distillate	No	64741-44-2	
Allyl alcohol	No	107-18-6	
xylenes	Yes	1330-20-7	45102
Naphthalene	Yes	91-20-3	46701
3-Methylethylcyclohexane	No		
VOC	No	none	
Gasoline	No	86290-81-5	
Butyl ether	No	142-96-1	
dimethyl butane	No	75-83-2	
Dodecene	No	25378-22-7	
Styrene	Yes	100-42-5	45220
tetrahydrofuran	No	109-99-9	70014
hexane	Yes	110-54-3	43231
2-Propanol	No	67-63-0	43304
liquified petroleum gas	No	68476-85-7	
Methyl acetylene propadiene	No		
methyl isobutyl ketone	Yes	108-10-1	
Methyl n-amyl ketone	No	110-43-0	43562
Methylpentane	No	43133-95-5	
Tert-butyl methyl ether	Yes	1634-04-4	43376
Toluene	Yes	108-88-3	45202
Mineral oil	No	8012-95-1	
Gasoline	No	86290-81-5	
2,2-Dimethylpropane	No	463-82-1	43222
n-propylbenzene	No	103-65-1	

Table 1. Event emissions in the Houston-Galveston area. Representative contaminants included in the analysis, selected because they are either HAPs or VOCs with more than 5 carbon atoms. (These data were retrieved directly from the original database, which included multiple redundancies that did not affect the analysis and were left intact.)

Contaminant	*HAP*	*CAS*	*SAROAD*
propylcyclohexane	No	1678-92-8	
n-Octane	No	111-65-9	43233
ortho-xylene	No	95-47-6	45204
Gasoline	No	86290-81-5	
propylenimine	No	75-55-8	
Gasoline	No	86290-81-5	
Technical White Oil	No		
Total Alkylate - non-speciated	No		
Trichloroethylene	Yes	79-01-6	
Di(2-ethylhexyl) peroxydicarbonate	No	16111-62-9	
trimethylcyclopentane	No	30498-64-7	98058
Ultraformate	No		
4-Vinylcyclohexene	No	100-40-3	

Table 2. Event emissions in the Houston-Galveston area. Major emitters reporting at least one release event of a representative substance.

Company Name	*2004 VOC Emission Rate (lb/h)*
ATOFINA PETROCHEMICALS LA PORTE PLANT	47.88
BALL METAL BEVERAGE CONTAINER CONROE FACILITY	24.18
BASF FREEPORT SITE	46.47
BELVIEU ENVIRONMENTAL FUELS	112.3
BOC GROUP CLEAR LAKE BOC GASES PLANT	9.52
BP AMOCO CHEMICAL CHOCOLATE BAYOU PLANT	130.4
BP AMOCO CHEMICAL PASADENA PLANT	36.92
BP AMOCO POLYMERS	57.18
BP PRODUCTS NORTH AMERICA TEXAS CITY	737.4
BP TEXAS CITY CHEMICAL PLANT B	112.2
CELANESE BAY CITY PLANT	17.12
CELANESE CLEAR LAKE PLANT	53.11
CELANESE PASADENA PLANT	5.934
CHEVRON PHILLIPS CEDAR BAYOU PLANT	105.3
CHEVRON PHILLIPS CHEMICAL SWEENY COMPLEX	106.7
CHEVRON PHILLIPS HOUSTON CHEMICAL COMPLEX	215.7
CROWN BEVERAGE PACKAGING	18.05
CROWN CENTRAL PETROLEUM PASADENA PLANT	114.3
CROWN CORK & SEAL	18.10
DEER PARK LIQUID STORAGE TERMINAL	124.8
DOW CHEMICAL LA PORTE SITE	5.902
DOW TEXAS OPERATIONS FREEPORT	203.2
E I DUPONT DE NEMOURS AND COMPANY - LA PORTE PLANT	51.30
EQUISTAR CHEMICALS CHANNELVIEW COMPLEX	275.4
EQUISTAR CHEMICALS CHOCOLATE BAYOU COMPLEX	84.87
EQUISTAR CHEMICALS LA PORTE COMPLEX	90.97
EXXON MOBIL CHEMICAL BAYTOWN OLEFINS PLANT	84.73
EXXONMOBIL CHEMICAL BAYTOWN CHEMICAL PLANT	313.7
EXXONMOBIL CHEMICAL MONT BELVIEU PLASTICS PLANT	40.64
GOODYEAR HOUSTON CHEMICAL PLANT	85.68
ISP TECHNOLOGIES TEXAS CITY PLANT	22.12
KANEKA TEXAS CORPORATION	20.55
KINDER MORGAN LIQUID TERMINALS PASADENA	913.9
KINDER MORGAN LIQUIDS TERMINALS	132.7
LBC HOUSTON BAYPORT TERMINAL	12.83
LYONDELL CHEMICAL BAYPORT PLANT	30.04
LYONDELL CHEMICAL CHANNELVIEW	74.15
MARATHON ASHLAND PETROLEUM TEXAS CITY REFINERY	111.8
MOBIL CHEMICAL HOUSTON OLEFINS PLANT	26.29
MORGANS POINT PLANT	31.03
PASADENA PLANT	13.40

Table 2. Event emissions in the Houston-Galveston area. Major emitters reporting at least one release event of a representative substance.	
Company Name	*2004 VOC Emission Rate (lb/h)*
SHELL OIL DEER PARK	405.2
SOLUTIA CHOCOLATE BAYOU PLANT	53.09
STOLTHAVEN HOUSTON TERMINAL	7.347
SWEENY COMPLEX	157.1
UNION CARBIDE TEXAS CITY OPERATIONS	174.4
VALERO REFINING TEXAS CITY	260.1
WHARTON GAS PLANT	7.552

Table 3. Frequency distribution for ratio of event emission rate to long-term emission rate		
Bin	*Frequency*	*Cumulative Frequency*
1.00E-08	0	0
3.16E-08	0	0
1.00E-07	2	2
3.16E-07	1	3
1.00E-06	0	3
3.16E-06	2	5
1.00E-05	1	6
3.16E-05	2	8
1.00E-04	5	13
3.16E-04	9	22
1.00E-03	15	37
3.16E-03	28	65
1.00E-02	33	98
3.16E-02	41	139
1.00E-01	59	198
3.16E-01	38	236
1.00E+00	33	269
3.16E+00	31	300
1.00E+01	16	316
3.16E+01	2	318
1.00E+02	1	319
3.16E+02	0	319

Table 4. Statistics for ratio of event emission rate to long-term emission rate

Statistic for Ratio	*Value*
Median	0.043923
75th %ile	0.342655
90th %ile	2.204754
95th %ile	3.344422
96th %ile	3.400832
97th %ile	3.8126
98th %ile	4.790098
99th %ile	8.973897
Max	74.37138
Average	0.815352

Figure 1. Cumulative probability density for ratio of event to routine emission rates.

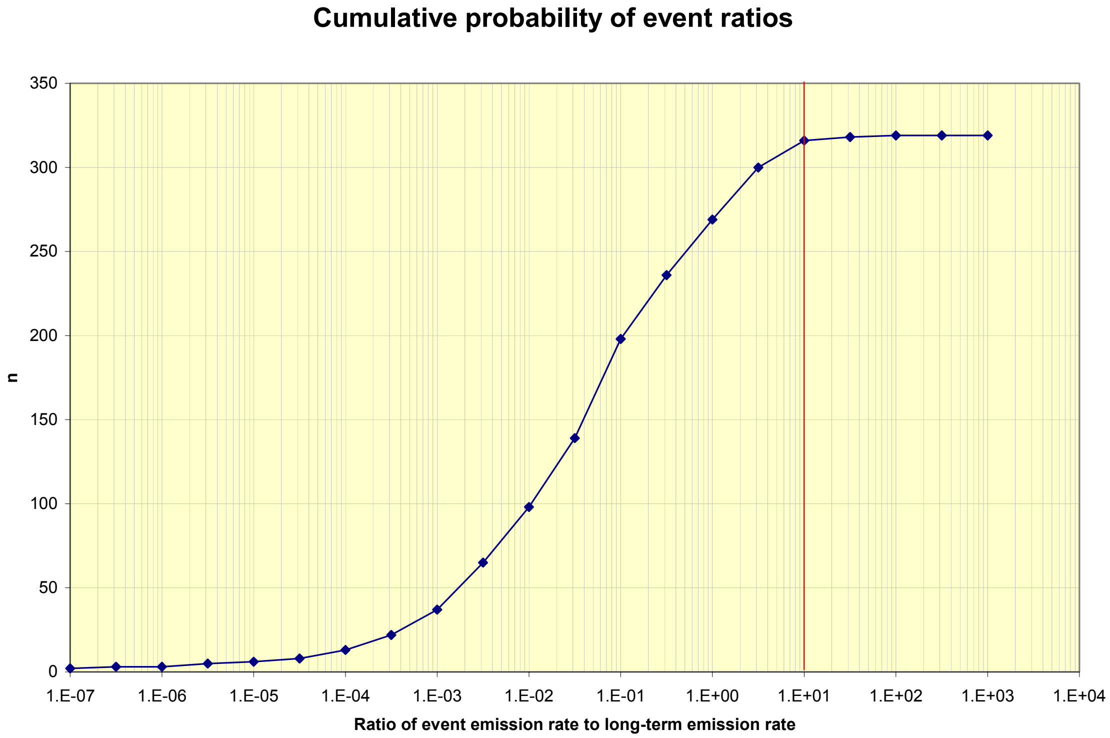


Figure 2. Relationship between ratio of event to duration emission rate and emission duration.

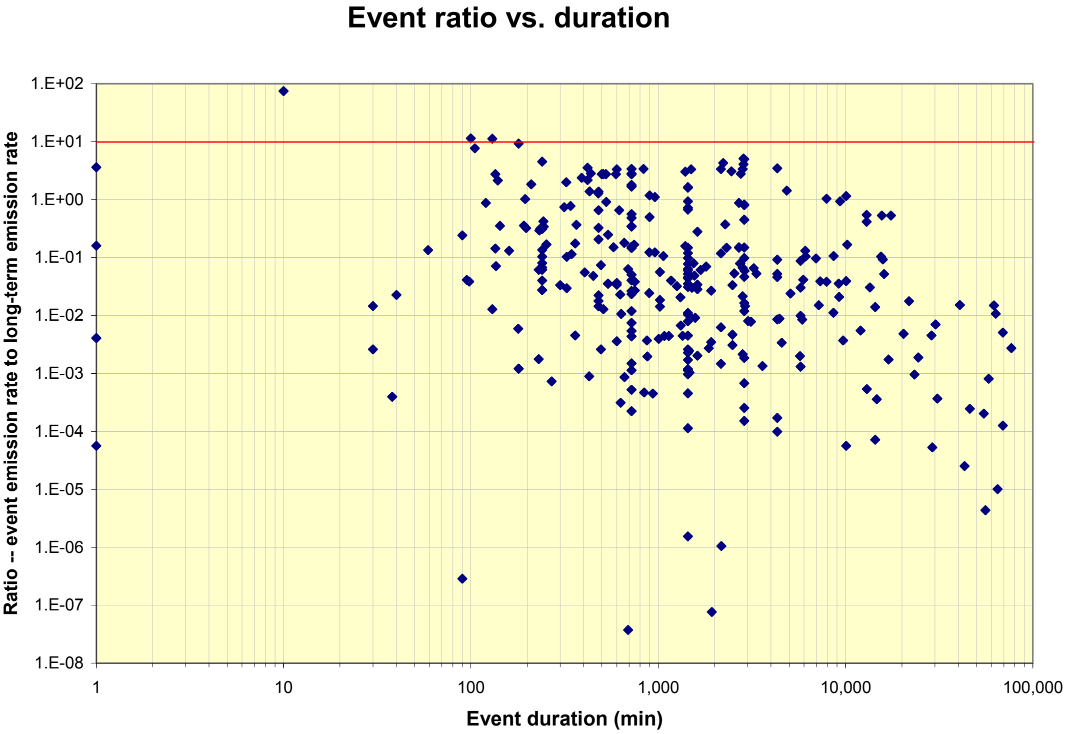


Figure 3. Relationship between ratio of event to duration emission rate and emission duration, as percentage of total time.

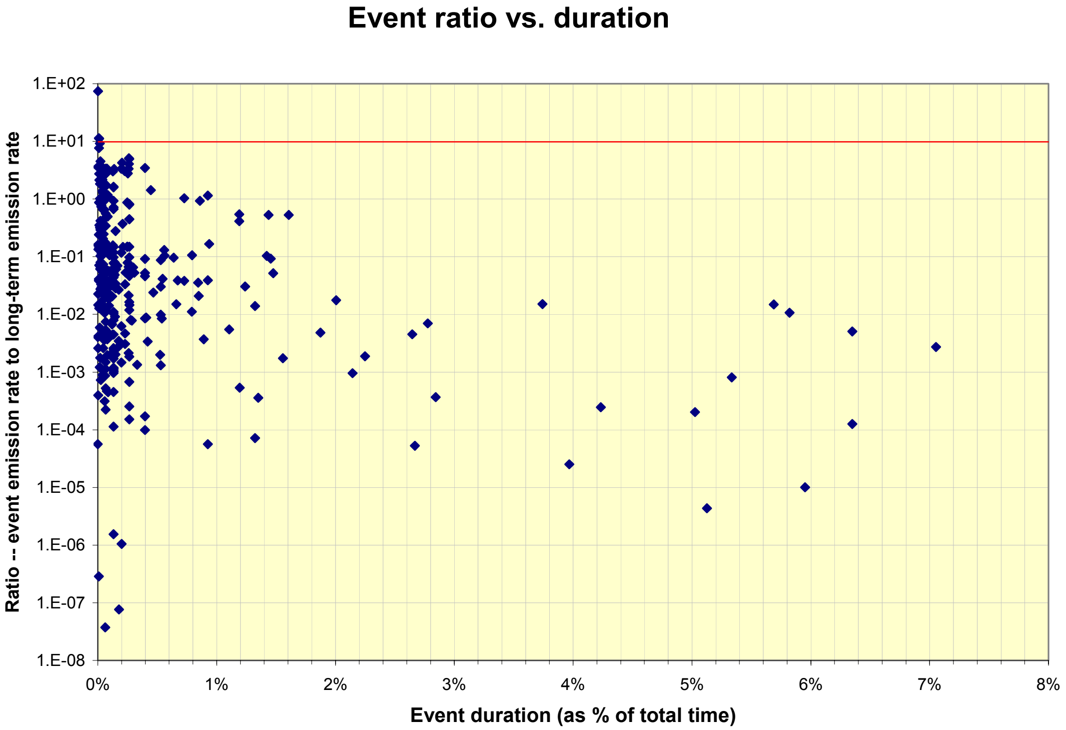
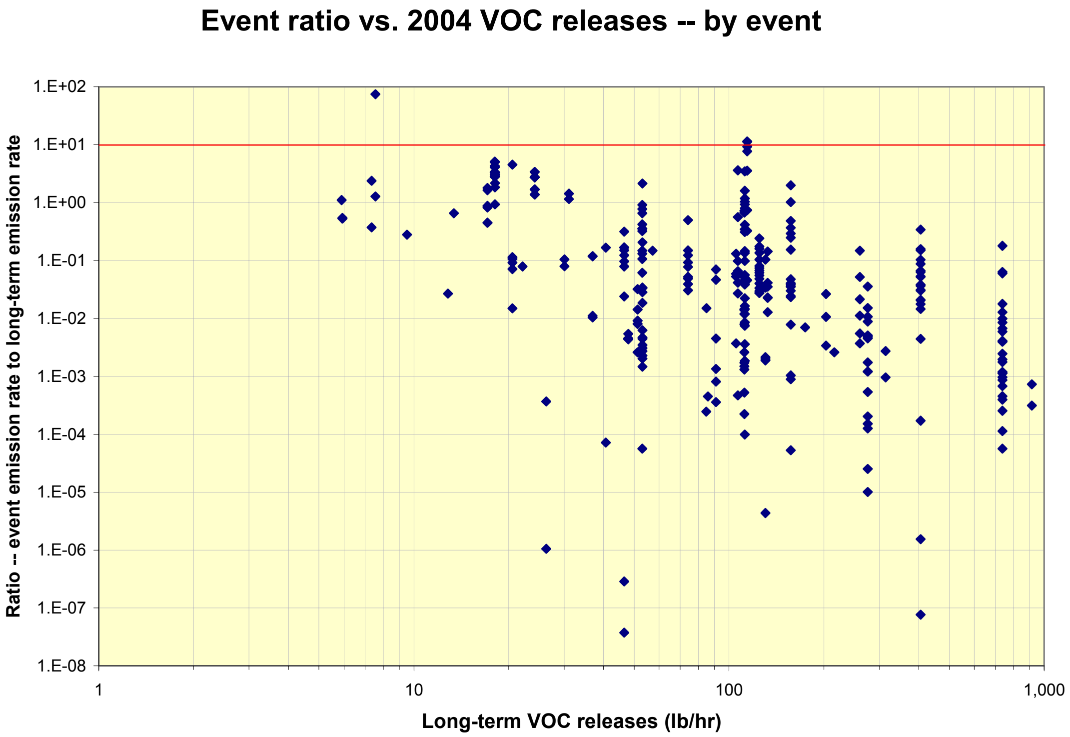


Figure 4. Relationship between ratio of event to duration emission rate and total amount emitted during the event.



Technical Memorandum

TO: EPA Docket No. EPA-HQ-OAR-2010-0682

FROM: Brenda Shine, Environmental Engineer
Refining and Chemicals Group, SPPD (E143-01)

DATE: March 15, 2012

SUBJECT: Derivation of Hourly Emission Rates for Petroleum Refinery Emission Sources Used in the Acute Risk Analysis

I. Purpose:

This memorandum documents the assumptions used to derive the hourly emission rates used to estimate acute risks from emissions of petroleum refinery emission sources. In past Risk and Technology (RTR) rulemakings, when we have lacked hourly emissions data or other specific information about the source category processes, we assumed that the 1-hour emission rate for any emission point could be 10 times higher than its average hourly emissions, calculated by dividing annual emissions by 8760 hours per year. The basis for this assumption was derived from an analysis of short term release information collected from facilities in the Houston-Galveston area and a comparison against routine emission rates for an entire facility. The conclusions of this analysis were that the hourly emissions from any single release event to the average annual VOC release rate for an entire facility was seldom greater than a factor of 10. For the petroleum refinery source category, we have additional knowledge of the emission point release characteristics that enable us to refine the default factor of 10 to something more realistic for this source category.

II. Acute Factors for the Petroleum Refinery Source Category:

Instead of using the default factor of 10 described above, we estimated variability of hourly emissions based on the operating characteristics of refinery emission sources in the following manner:

a. For many sources that are associated with continuous operations and are essentially steady state, such as Fluid Catalytic Cracking Units (FCCU), and sulfur recovery plants (SRU), we would not expect significant variability in hourly emissions. Typical source test variablility is typically ±30 to 50%. We have applied an hourly multiplier of 2 to estimate maximum hourly rates as an upper range of the expected variability. This assumption was used for the following types of sources: FCCU, SRU, Chemical Processes, miscellaneous process vents, refinery processes (not specified) and incinerators.

b. For delayed cokers, we considered the average venting cycle time in calculating our hourly emission rate. The process cycle for delayed cokers is 1 day (24 hours), with the depressurization vent having an average venting cycle time of, on average, 2 to 3 hours per cycle. Since the depressurization vent opens for 730 to 1,095 hours per year, a factor of 8 to 12 times the annual average emission rate could be used to account for this emission process. The emissions are expected to be somewhat variable, with higher emissions at the start of the venting cycle. We therefore applied an hourly multiplier of 20 to estimate maximum hourly rates for delayed coker emissions.

c. There are three types of catalytic reformers: Continuous, cyclic, and semi-regenerative. Continuous reformers (SCC 30601602) are expected to have stable operations (much like the FCCU and SRU), so a factor of 2 is appropriate for estimating the maximum hourly emissions rate. Cyclic reformers (SCC 30601603) typically vent for 2,000 to 4,000 hours per year, suggesting a factor of 2 to 4 for these units. However, their emissions over the venting period are expected to be somewhat variable, so a factor of 10 is applied as a conservative estimate. Semi-regenerative reformers (SCC 30601604) are expected to vent approximately 10-15 days per year, suggesting a factor of 30 or 40. The venting is not expected to be uniform over this period, so a factor of 60 is applied for these units.

d. For evaporative loss sources such as wastewater, we expect moderate variability in maximum hourly emissions from annual average emissions. Emissions from wastewater are dependent on organic loading to the unit and on the mass transfer (volatilization) rate from the wastewater surface (which is dependent on the wastewater temperature and air wind speed). The loading rates are expected to vary by a factor of 2 during normal operations and the mass transfer rates are expected to vary by a factor of 2 due to seasonal/meterological variations. We therefore applied an hourly multiplier of 4 to estimate maximum hourly rates from wastewater sources.

e. For fugitives from equipment leaks, we note that the current methods of estimating emissions make use of correlation equations in conjunction with Method 21 readings that ultimately provide an hourly emission rate for the monitoring period in question. The actual emission rates estimated based on the direct Method 21 readings are commonly divided by two to estimate the average emission rate between monitoring intervals (i.e., assuming the leak started mid-way between monitoring intervals as described in the emissions protocol). We expect the emission estimates from the direct Method 21 readings to provide a direct measure of the maximum hourly emissions (as leak repair will be applied to reduce hourly emissions immediately after a monitoring cycle). Therefore, we applied an hourly multiplier of 2 to estimate maximum hourly rates from the annual average emission rates.

f. For storage vessels, higher hourly rates from loading operations can occur; however, the majority of tanks are floating roof tanks; emissions from these tanks are associated with wind-driven losses from fitting controls and clingage from exposure of external floating roof tank shells. These emissions would not be expected to vary as significantly as fixed roof tanks, but the emissions from floating roof tanks are expected to be dependent on temperature (seasonal variability) and, in the case of external floating roofs, wind speed.

There may also be variability in the crude oil processed or the intermediates and products stored in a given tank. As with wastewater sources, each of these factors is expected to cause a factor of 2 variability. We therefore applied an hourly multiplier of 4 to estimate maximum hourly rates from storage tanks.

g. For other transfer and loading operations, maximum hourly rates can be approximated from pumping rates; a factor of 2 for these sources would not adequately account for higher maximum hourly emissions in most cases. Considering the hours of actual product loading during the year (commonly 1,000 to 2,000 hours per year), we applied a factor of 10 to these emission sources.

APPENDIX 6

Technical Support Document for the TRIM-Based Multipathway Tiered Screening Methodology for RTR

Technical Support Document for the TRIM-Based Multipathway Tiered Screening Methodology for RTR

November 2015

Prepared For:

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Prepared By:

ICF International
2635 Meridian Parkway
Suite 200
Durham, NC 27713

[This page intentionally left blank.]

CONTENTS

1. Introduction and Background

Section 112 of the Clean Air Act (CAA) directs the U.S. Environmental Protection Agency (EPA) to assess the risk remaining (i.e., residual risk) from emissions of hazardous air pollutants (HAPs) following the implementation of maximum achievable control technology (MACT) standards for emission sources. This risk assessment is a major component of EPA's Risk and Technology Review (RTR) program. As part of this program, EPA must consider additional emission standards for a source category if the current emission standards—with MACT regulations in place—do not provide an "ample margin of safety" for human health. One aspect of human health that EPA must consider under RTR is the potential for health effects resulting from exposures to persistent and bioaccumulative HAPs (PB-HAPs) via non-inhalation pathways, namely ingestion and dermal exposure. EPA's assessment for RTR focuses on specific PB-HAPs that the Office of Air Quality Planning and Standards (OAQPS) has identified as candidates for multipathway risk assessments (selection of the PB-HAPs is discussed in Section 2.2.2). These non-inhalation human health risks are considered in combination with estimated inhalation human health risks, potential ecological impacts, and other factors to support decisions about residual risk for RTR source categories. For PB-HAPs, exposures via ingestion are anticipated to be significantly higher than any dermal exposures that might occur as a result of the same emissions (see Attachment C). Consequently, a methodology has been developed to evaluate ingestion exposure and risk for PB-HAPs efficiently in the context of EPA's RTR program.

To evaluate ingestion exposures and human health risks for RTR on a source category basis, an iterative approach was developed that enables EPA to confidently screen out PB-HAP emissions unlikely to pose health risks above levels of concern (i.e., a cancer risk of 1 in 1 million or a noncancer hazard of 1.0) and to focus additional resources on sources of greater concern within the category. To estimate exposure and risk, two models are used: the Fate, Transport, and Ecological Exposure module of EPA's Total Risk Integrated Methodology (TRIM.FaTE) to model the fate and transport of pollutants released to the environment and the Multimedia Ingestion Risk Calculator (MIRC) to estimate transfer and uptake into the food chain and exposure to receptors consuming contaminated food products and soil. This approach is divided into three tiers of increasing refinement, as follows.

- Tier 1 of the approach begins by identifying the facility-level emissions of PB-HAPs within a source category and comparing them to risk-based emission thresholds. The risk-based thresholds are derived using the aforementioned models applied for a hypothetical environmental and exposure scenario, assuming ingestion of locally caught fish, locally grown produce and livestock, and local soil. This hypothetical "screening scenario" is intended to represent a situation in which the ingestion exposure is unlikely to be exceeded at any actual facility evaluated through the RTR program. The thresholds for Tier 1 are derived by estimating the emission rate that corresponds to a lifetime cancer risk of 1 in 1 million or a chronic non-cancer hazard quotient (HQ) of 1 for an individual exposed according to the characteristics associated with the screening scenario. For a facility, if the emission rate of each PB-HAP is less than the Tier 1 threshold emission rate, risks are assumed to be low and no additional multipathway screening is done. If, however, the emission rate of any PB-HAP exceeds the Tier 1 threshold emission rate, the facility can be evaluated further in Tier 2.
- In Tier 2, the actual location of the facility is used to refine some assumptions associated with the environmental scenario while maintaining the Tier 1 ingestion exposure scenario assumptions. The environmental scenario assumptions are refined by incorporating binned site-specific meteorological data and locations of fishable lakes near the facility (see below). The risk-based threshold for each PB-HAP is then adjusted for that facility

based on an understanding of how exposure concentrations estimated for the screening scenario change with meteorology and lake location. PB-HAP emissions that do not exceed the adjusted threshold are assumed to pose risks below levels of concern and no additional multipathway assessment is required. Facilities having emissions that exceed the adjusted thresholds for Tier 2 may require additional analysis.

- A Tier 3 screening assessment can be conducted on facilities that do not screen out with the Tier 2 assessment, at the discretion of the risk assessor. The Tier 3 screening approach consists of three individual assessments that further refine the Tier 2 screening scenario based on additional site-specific data and evaluations. One of the Tier 3 assessments (i.e., the lake assessment) results in the rescreening of the facility's emissions using the Tier 2 methods and using a revised lake database. The other two assessments (i.e., the plume-rise and time-series assessments) each result in an adjustment factor to be applied to the screening result reflecting the Tier 3 lake assessment. Facilities having emissions that exceed the adjusted thresholds for Tier 3 may require additional analysis.

- For facilities emitting PB-HAPs at levels that cannot be ruled out as being above levels of concern based on the screening assessments, a refined, site-specific, multipathway risk assessment can be conducted. Such an assessment would incorporate location- or facility-specific characteristics regarding the environment to which PB-HAPs are emitted, relevant exposure pathways, ingestion rates or other exposure factors, and other parameters. A range of exposure scenarios could be evaluated as part of a site-specific assessment, resulting in a range of risk estimates.

The key processes and decisions that make up this approach are summarized in Exhibit 1. In the remainder of this document, each of the tiers in the multipathway assessment approach is described in additional detail. The attachments provide a comprehensive record of the characteristics and methods associated with Tier 1 and Tier 2 assessments. If a site-specific assessment is conducted, a separate report detailing that assessment will be prepared.

1.1 Tier 1

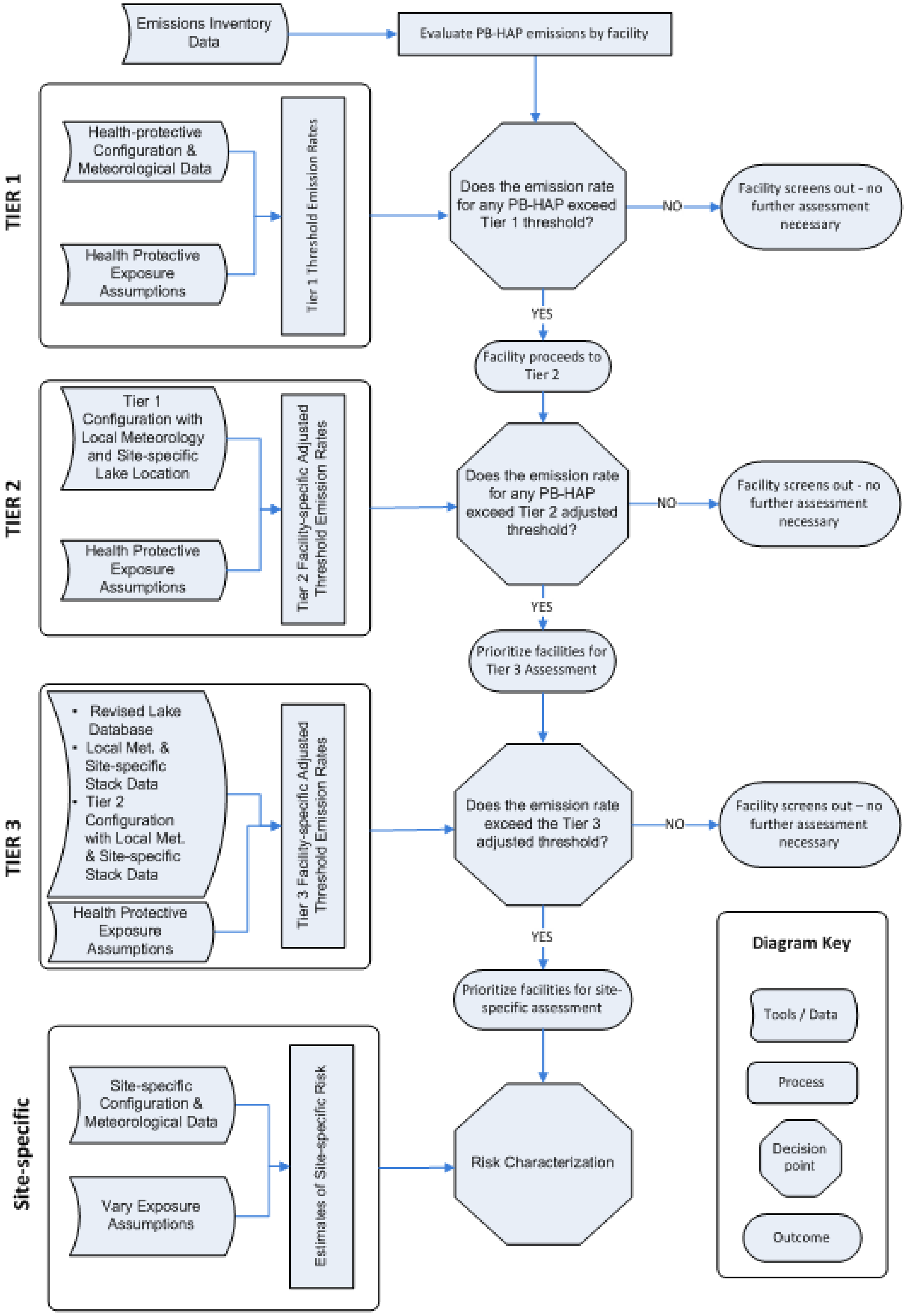
The methods used in Tier 1 are intended to enable EPA to evaluate PB-HAP emissions from multiple facilities in a source category quickly and efficiently and to remove from consideration those that are unlikely to pose risks above levels of concern, while also minimizing the possibility of EPA's failing to identify risks that exceed levels of concern. The hypothetical scenario used to estimate Tier 1 thresholds is designed to be health-protective in estimating exposures and risks; specifically, it is intended to avoid underestimating exposures to PB-HAPS that might be encountered for any location throughout the United States. The scenario also is intended to avoid grossly overestimating risk to the point where no emissions screen out (i.e., overprotective, resulting in too many "false positives").

1.1.1 Chemicals of Concern

The assessment of risk from multipathway exposures begins with a review of data for sources in a particular category to determine if emissions of any of the following PB-HAPs are reported:

- Cadmium compounds,
- Chlorinated dibenzodioxins and furans (dioxins),
- Mercury compounds, and
- Polycyclic organic matter (POM).

Exhibit 1. Conceptual Decision Tree for Evaluating Non-Inhalation Exposures for PB-HAPs



Based on current emissions, bioaccumulation potential, and toxicity considerations, emissions of these four PB-HAPs are expected to pose the majority of the non-inhalation risks to humans from air emissions at sources subject to residual risk provisions of the CAA[1] Thus, although EPA has identified nine other PB-HAPs that should be evaluated as part of residual risk assessments, the methods for multipathway assessment described here encompass only these four at this time.

If emissions of any of the four PB-HAPs listed above are reported for a facility, the emission rate for that PB-HAP is compared to the threshold emissions rate derived for that chemical using the hypothetical TRIM-based screening scenario. This threshold is the emission rate that, when input to the models used in evaluating multipathway risk for RTR, results in a specified cancer risk or non-cancer HQ threshold level of concern. For the screening scenario, threshold emission rates were calculated for a cancer risk of 1 in 1 million or an HQ of 1.0, depending on the more sensitive health effect of the PB-HAP. However, due to the hypothetical nature of the screening scenario, exceeding the threshold emissions rate by 60 times, for dioxins for example, does not imply a resulting cancer risk of 60 in 1 million. Rather, exceeding the threshold emissions rate by 60 times for dioxin implies that it is highly unlikely that the actual risk would exceed 60 in 1 million.

Important to note for dioxins and POM is that the screening methodology assesses individual congeners, taking into account differences in both the fate and transport and the toxicity among the various congeners. The details of the methods for assessing dioxins and POM are provided in Section 2.

1.1.2 Development of Emission Thresholds

Generally, the approach used to assess ingestion exposures and resulting risks for RTR has four components (Exhibit 2):

1. **Fate and transport modeling** of PB-HAPs emitted to air that partition into soil, water, and other environmental media (including fish uptake);
2. **Modeling of uptake** of PB-HAPs by farm food chain media from soil and air;
3. **Estimating ingestion exposures** in terms of average daily dose for consumption of farm food items by a hypothetical exposed human; and
4. **Calculating lifetime cancer risk estimates or chronic non-cancer HQs** for each HAP and corresponding screening threshold emission rates.

The TRIM.FaTE model is used in the first component, and the MIRC model is used to conduct calculations for the other three components.[2] To derive the emission thresholds used in Tier 1, these models are used to estimate the emission rate corresponding to a cancer risk of 1 in

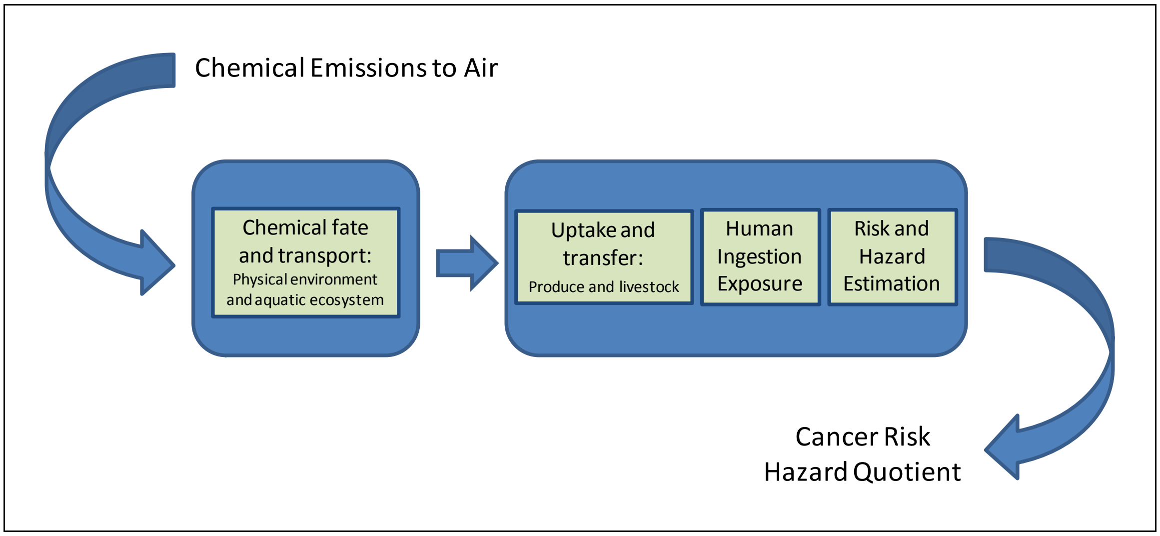
---

[1] Potential impacts on human health from non-inhalation exposures to lead are evaluated for RTR using the National Ambient Air Quality Standard for lead, which takes into account multipathway risks.

[2] EPA's TRIM methodology was conceived as a comprehensive modeling framework for evaluating risks from air toxics. It was designed to address each of the four steps in screening ingestion risk; however, only the fate and transport module currently is available for use. For the RTR screening scenario, the Multimedia Ingestion Risk Calculator (MIRC) was constructed to complete the calculations required for estimating PB-HAP concentrations in farm food chain media, average daily ingestion doses, and cancer risks and chronic non-cancer HQs. The framework is conceptually identical to the ingestion exposure and risk analyses that TRIM intended to cover. Information about the current status of TRIM modules and documentation of modules developed thus far can be accessed on EPA's Technology Transfer Network (TTN) on the Fate, Exposure, and Risk Analysis website (http://www2.epa.gov/fera).

1 million or a noncancer HQ of 1 (depending on the PB-HAP) for each PB-HAP within the hypothetical environmental scenario, as described in more detail in the following sections.

Exhibit 2. Overview of Ingestion Exposure and Risk Screening Evaluation Method



1.1.2.1 Modeling Fate and Transport

To model chemical fate and transport in the environment when deriving emission thresholds for Tier 1, the TRIM.FaTE module of the TRIM system was used.[3] The two main components of the fate and transport modeling are (1) the modeled domain, including the meteorological data and (2) the environmental and chemical-specific properties associated with fate and transport through the environment. The hypothetical modeled domain includes a farm homestead and a fishable lake near (i.e., 2 km) an emissions source, which are assumed to be the primary food sources for exposed individuals. The spatial layout and other physical aspects of the modeled domain configuration are designed to be health-protective, which results in an ingestion exposure situation that is unlikely to be exceeded at any actual facility evaluated under the RTR program. The environmental and chemical-specific properties governing fate and transport of PB-HAPs are parameterized with either conservative (i.e., health protective) values or central-tendency values. The mix of health protective and central-tendency assumptions and parameterization is expected to result in a scenario configuration that, on average, is likely to overpredict environmental concentrations of PB-HAPs in media of interest for this evaluation. The inclusion of central-tendency values where warranted is intended to minimize the number of false positives.

Based on sensitivity analyses and model testing it is generally recognized that the spatial layout of the modeled domain (e.g., distance to a fishable lake) and the meteorological data used (or a combination of these two factors) are more influential than physical/chemical parameters in dictating the resulting chemical concentrations in air, soil, water, sediment, and fish within TRIM.FaTE. The Tier 1 assumptions about these two components of fate and transport modeling are refined with relatively more site-specific data in subsequent tiers. The spatial layout used to develop the threshold emission levels in Tier 1 and other details of the Tier 1 methodology are presented in Section 2.

---

[3] http://www2.epa.gov/fera

1.1.2.2 Modeling Transfer and Uptake

MIRC was developed to conduct the required calculations involving farm food chain transfer, ingestion exposure, and risk. TRIM.FaTE outputs that are used as inputs to MIRC include:

- PB-HAP concentrations in air,
- Air-to-surface deposition rates for PB-HAPs in both particle and vapor phases,
- PB-HAP concentrations in fish tissue for fish consumed, and
- PB-HAP concentrations in surface soil and root zone soil.

From these inputs, MIRC calculates the transfer and uptake of PB-HAPs through the farm food chain using algorithms based on those included in EPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (EPA 2005) and biotransfer factors (e.g., soil-to-plant factors, which are the ratios of the concentrations in plants to concentrations in soil). The outputs of MIRC are PB-HAP concentrations in contaminated food items.

1.1.2.3 Estimating Ingestion Exposure

MIRC is also used to estimate exposure in terms of average daily doses (ADDs), normalized to body weight for the following exposure pathways:

- Incidental ingestion of soil
- Ingestion of homegrown produce
- Ingestion of homegrown beef
- Ingestion of milk from homegrown cows
- Ingestion of homegrown poultry/eggs
- Ingestion of homegrown pork
- Ingestion of fish
- Ingestion of breast milk (children <1 year old; dioxins only)[4]

Chemicals are modeled separately to evaluate the potential for risks, with exposures (in terms of ADD) for each PB-HAP summed across all ingestion exposure pathways. For the screening scenario used in Tiers 1 and 2, exposure characteristics were selected that result in a highly health protective estimate of total exposure. The ingestion rate for each exposure pathway listed above was set (as feasible) equal to an upper percentile value (99th percentile for fish and 90th percentile for all other food types) based on EPA's *Exposure Factors Handbook* (EPA 2011a) or other sources as appropriate. All media were assumed to be obtained from a location impacted by the modeled source. This approach results in an overestimate of total chemical exposure for a hypothetical exposure scenario. For example, the resulting total food ingestion rate is extremely high for a hypothetical consumer, with ingestion rates at the 99th percentile for fish and the 90th percentile for every other farm food type. These health protective exposure assumptions can be replaced in a site-specific assessment as appropriate (e.g., with distributions of the data for key exposure factors).

Dermal absorption of chemicals that are originally airborne is generally relatively minor and this pathway was not included in the scenario used to calculate Tier 1 emission thresholds (this topic is discussed further in Section 2 and Attachment C).

---

[4] Breast milk ingestion is an important exposure pathway for lipophilic compounds like dioxins and has been shown not to contribute meaningfully for exposures to mercury, cadmium, and POM. See Section 2.4.2.3 and Section 3.4 of Attachment B for full discussions of infant exposures via breast milk ingestion.

1.1.2.4 Calculating Lifetime Cancer Risk and Non-Cancer HQs

Lifetime cancer risks and the potential for chronic non-cancer effects are estimated using chemical-specific oral cancer slope factors and oral reference doses. Lifetime cancer risk estimates are calculated separately for each PB-HAP. As provided in Section 5.1 of Attachment B, age-group specific cancer risk estimates are calculated and the estimated lifetime cancer risk equals the sum of these age-group specific risks. Similarly, HQs are calculated separately for each PB-HAP and for each age group. However, as detailed in Section 5.2 of Attachment B, the HQ for the most sensitive age group is used to determine the screening threshold emission rate.

1.1.2.5 Determining Threshold Emission Rates

Tier 1 emission thresholds were calculated by conducting iterative model simulations in TRIM.FaTE and MIRC using the screening scenario described above to determine emission rates for cadmium, mercury, dioxins, and POM that correspond to a cancer risk of 1 in 1 million or a chronic non-cancer HQ of 1. Given the generally health protective nature of the scenario inputs, these thresholds are assumed to be appropriate for screening facilities emitting these PB-HAPs.

1.2 Tier 2

The Tier 1 screening approach is, by design, generic and health protective. It was constructed for quick application to a large number of facilities in a source category with the least chance of returning false negatives for risk potential. Once the Tier 1 screen is complete, however, facilities whose emissions exceed the emission screening threshold for any PB-HAP can be scrutinized further. Based on screening assessments conducted for RTR to date, many facilities might not screen out of the Tier 1 assessment for some source categories. However, conducting a full site-specific assessment of all facilities that cannot be screened out in Tier 1 would not be practical.

Site-specific values for some influential variables, however, can be determined without intensive effort during the assessment. The use of some site-specific characteristics instead of the generic characteristics used in Tier 1 can justify adjusting the threshold emission rate for a given PB-HAP at that facility, potentially screening out the facility while maintaining a high degree of confidence that risks above levels of concern have not been overlooked. In addition, using a scenario in which a fisher fishes from multiple nearby lakes, catching an amount of fish from each lake that is limited by the lake's theoretical fish productivity, creates a more site-specific approach while also maintaining health protectiveness.

In selecting the scenario characteristics to modify in Tier 2, a balance was struck between the degree of impact on the risk estimate, the ease of implementation, and the ease of obtaining relatively certain site-specific values for all facilities that might be evaluated under the RTR program. As discussed in the remainder of this section, some of these characteristics affect the PB-HAP concentrations in environmental media estimated by TRIM.FaTE. Other characteristics affect the sources of ingested fish and, potentially, the fish ingestion rates.

1.2.1.1 Site Specific Considerations

For Tier 2, location-specific data on two types of variables are taken into account:

- Meteorological characteristics, including the fraction of time the wind blows toward each farm and lake (using wind direction), wind speed, precipitation rate, and mixing height; and
- Locations of fishable lake(s) relative to the facility[5] (including the absence of a fishable lake).

For efficient Tier 2 evaluation of the impacts these parameters could have on specific facilities, a series of TRIM.FaTE simulations was performed that systematically varied the values used in the screening scenario for four of the five selected variables (lake location, wind speed, precipitation rate, and mixing height). Wind direction affects only whether the chemical mass advects toward the farms and lakes, so the effect of site-specific wind directions can be evaluated outside of the TRIM.FaTE simulations. The values of each of the four variables were changed, independent of any other changes. The values (four to six for each variable, including the original, Tier 1 scenario values) were selected using statistics on U.S. meteorological data or professional judgment to capture the expected range in the data. Four to six values were selected to result in a total number of runs that was reasonable.

Based on the TRIM.FaTE results of these simulations (and the subsequent exposure and risk characterization, conducted using MIRC), threshold adjustment factors were calculated for each unique combination of the five parameters, for each PB-HAP. These adjustment factors represent the ratio between the risk metric (i.e., cancer risk or HQ) obtained using the Tier 1 screening scenario and the risk metric obtained from the Tier 2 run. For a given facility, for each PB-HAP it emits and each nearby lake evaluated, an adjusted Tier 2 emission threshold can be estimated by dividing the Tier 1 emission threshold by the adjustment factor that best corresponds to the meteorological conditions present at the site and the location of the lake (hypothetical farms are assessed for every facility, at a constant distance from the facility). The contribution of each exposure media toward each scenario's Tier 2 risk metric (i.e., the individual contributions of fish ingestion, soil ingestion, beef ingestion, etc. toward the total Tier 2 risk metric) was included in the matrix because the Tier 2 assessment separates chemical exposure from fish ingestion from exposure from farm food chain ingestion.

To facilitate the implementation of this approach without requiring facility-specific data searches for each new source category evaluated, databases of the relevant U.S. meteorological and lake data were created that could be accessed readily during a Tier 2 evaluation. These databases are described in more detail in Section 3.4. The meteorological database is based on the same hourly meteorology data used for RTR inhalation assessments. The meteorology database includes annual summary statistics on wind direction, wind speed, precipitation, and mixing heights for more than 800 surface stations, paired with their closest upper-air station with available data, located throughout the United States (data available from the National Oceanic and Atmospheric Administration). The lake database, based on U.S. Geological Survey (USGS) data and including location and size information, consists of hundreds of thousands of water bodies classified as "Lake/Pond" or "Reservoir" but not designated for disposal, evaporation, or treatment. To focus on lakes that can support fishing of upper trophic level fish, a minimum lake surface area of 25 acres is recommended. Very large lakes and bays (i.e., those larger than 100,000 acres) are not included because their watersheds are too large and

---

[5] The lake size also was changed for each lake distance allowing for a constant ratio between watershed and erosion area compared with lake area within the TRIM modeling structure.

their lake dynamics are too complex to realistically model in the TRIM.FaTE system. Lakes and bays larger than 100,000 acres include the Great Lakes, the Great Salt Lake, Lake Okeechobee, Lake Pontchartrain, Lake Champlain, Green Bay, and Galveston Bay.

When the Tier 2 screening is conducted, three additional processing steps are completed for each facility and PB-HAP that will be analyzed in Tier 2 before looking up the appropriate adjustment factors. First, a proximity analysis for each lake is conducted, whereby each relevant lake within 50 km of the facility is identified and matched to its respective directional "octant" relative to the facility. For the purposes of Tier 2, a "relevant" lake meets the size and designation criteria discussed in the previous paragraph. Second, the lakes are manually evaluated to remove lakes whose names suggest uses related to disposal, evaporation, or treatment (sometimes the name indicates one of these uses while the USGS designations do not; for example, the Gavin Fly Ash Impoundment would not be included in the screening process). Third, the lakes around the facility that remain after the first two processing steps are ranked in order of highest to lowest PB-HAP concentrations in fish. These rankings are then used to refine the Tier 2 risk metric for the fisher, as discussed in the next section.

To perform Tier 2 assessments, a Microsoft® Access™ tool was created that merges Tier 1 screening results with the Tier 2 adjustment factors and the lake and meteorology information relevant to a specific facility. In the tool, each facility is matched with the same meteorology station used in RTR inhalation assessments, and the values for the four relevant meteorological parameters at that station are recorded. The distances from the facility to relevant lakes are computed in the tool as well. These five parameter values become the set of facility-specific inputs in Tier 2. Then, the Tier 2 adjustment factors are determined for each PB-HAP for the combination of these five variables. As described above, the Tier 1 screening emission threshold is then divided by the appropriate adjustment factor to obtain a revised, Tier 2 emission threshold for that PB-HAP. More information about Tier 2 assessment methods can be found in Section 3.

1.2.1.2 Refined Tier 2 Fisher Assessment

The refined fisher scenario is based on the idea that an adult fisher might travel to multiple lakes if the first lake (i.e., the lake with the highest concentrations in fish for a given PB-HAP) is unable to provide him an adequate catch to satisfy the assumed ingestion rate (i.e., 373 g/d for adults). This refined fisher assessment uses the assumption that the biological productivity limitation of each lake is 1 gram of fish (wet weight) per acre of lake; meaning that in order to fulfill the adult ingestion rate, the fisher will need to fish from 373 total acres of lakes.

In the refined fisher scenario, a fisher travels to each relevant lake in order of highest to lowest chemical concentration in fish (of a given PB-HAP) and catches fish up to the lake's assumed biological productivity limitation. A maximum travel radius of 50 km relative to the facility is used to maintain a realistic scenario. The final Tier 2 screening result for the fisher can be expressed as the sum of the screening result from each lake that is fished (which is based on the amount of fish ingested for each lake multiplied by the PB-HAP concentration in fish). If the highest-concentration lake is at least 373 acres, the ingestion rate is not altered (i.e., remains 373 g/d for adults). If the cumulative size of multiple visited lakes exceeds 373 acres, the fisher catches from the final lake only the amount of fish necessary to satisfy the ingestion rate (i.e., to reach the 373 g/d). If there are not 373 total acres of lakes, the risk reflects a reduced ingestion rate based on the cumulative lake acreage.

1.3 Tier 3

A Tier 3 screening assessment can be conducted on facilities that do not screen out with the Tier 2 assessment, at the discretion of the risk assessor. The Tier 3 screening approach consists of three individual assessments that further refine the screening scenario (beyond the refinements in Tier 2) based on additional site-specific data and evaluations. Because the Tier 3 assessment introduces additional site-specificity to the screening scenario, it requires a potentially higher level of effort than the Tier 2 assessment, but still a much lower level of effort than the full site-specific assessment (discussed in Section 1.4). One of the Tier 3 assessments (i.e., the lake assessment) potentially results in the rescreening of the facility's emissions using the Tier 2 methods described in Section 1.2 and using a revised lake dataset. The other two assessments (i.e., the plume-rise and time-series assessments) each result in an adjustment factor to be applied to the screening result reflecting the Tier 3 lake assessment. The adjustment factors of the plume-rise and time-series assessments cannot be compounded (i.e., the time-series assessment, if conducted, supplants the plume-rise assessment already conducted).

One component of the Tier 3 assessment is evaluating the fishability of the lakes used in Tier 2. The USGS dataset occasionally includes lakes that appear to be misclassified, no longer exist, or are estuarine by nature. These lakes are removed from the Tier 3 assessment after evaluating their validity using aerial imagery and other available data. These additional data sources are not used in the Tier 2 screening. Examples of lakes removed from Tier 3 source category assessments are provided in Section 4.2. If one or more lakes are removed from a facility's assessment, the facility's emissions are rescreened using the revised lake database and the Tier 2 methods described in Section 1.2. If removing a lake(s) causes the originally-fished lakes to sum to less than 373 total acres, then in the rescreening, the fisher will catch and consume fish from an additional lake(s) if available. In this situation, the Tier 3 lake assessment is conducted on the newly added lake(s), and another rescreening is conducted, and so on until no further lakes are removed or added to the assessment. The Tier 3 lake assessment is more thoroughly described in Section 4.2.

If, after the lake assessment, the Tier 3 screening result is still above a level of concern, the risk assessor may choose to conduct a plume-rise assessment. Atmospheric conditions coupled with the physical parameters of the chemical release point can cause the chemical plume to rise substantially beyond the physical release height. This process is not explicitly modeled by TRIM.FaTE but can substantially reduce ground-level chemical exposure if the plume frequently rises above the mixing height. This assessment uses a scenario in which the chemical release height varies over time due to hourly meteorological conditions and the parameters associated with the chemical release point (i.e., physical release height and diameter, exit velocity, and gas temperature). If the resulting "effective release height" is above the mixing height for a given hour, then in the TRIM.FaTE modeling system there is no chemical deposition or exposure for that hour. If this occurs across many hours, it will substantially reduce total PB-HAP exposure and reduce the screening result. The plume-rise adjustment factor—the number of hours when the effective release height remains below the mixing height, divided by the number of total modeled hours—is multiplied by the Tier 2 screening result, thus lowering the screening result. A more thorough description is described in Section 4.3.

If the Tier 3 screening result after the lake and plume-rise assessments still is above a level of concern, the risk assessor may choose to conduct a time-series assessment. This assessment utilizes hourly effective release heights (computed in the plume-rise assessment above) along with the hourly meteorology data associated with the facility (i.e., the meteorology data that was summarized and used in Tier 2). Using hourly meteorology data adds additional site-specificity compared to the summarized, binned meteorology statistics used in Tier 2. Using these data in combination with hourly effective release heights is a more complete evaluation of hourly chemical losses due to plume rise compared with the Tier 3 plume-rise assessment described above. These time-varying release height and meteorology files are used in a run of TRIM.FaTE that also uses the facility's PB-HAP emissions and the Tier 2 spatial scenario associated with the lake being assessed. The TRIM.FaTE modeling, and subsequent exposure and risk characterization conducted using MIRC, leads directly to a screening-level cancer risk or HQ (i.e., a revised screening result). For simplicity in the software implementation of the Tiers 2 and 3 screening assessments, the result of this Tier 3 time-series assessment is converted to a time-series adjustment factor—the revised screening result divided by the screening result after the Tier 3 lake assessment. This ratio can then be multiplied by the screening result after the Tier 3 lake assessment, yielding the revised screening result accounting for the time-series assessment.

1.4 Site-Specific Assessment

If, based on results of the screening assessments, a risk assessor concludes that there is a reasonable probability that individuals could be adversely affected by the facility emissions, a refined site-specific multipathway assessment might be performed. Examples of recent refined multipathway assessments include residual risk assessments of a ferroalloys production facility (EPA 2014a), petroleum refinery facility (EPA 2014b), two secondary lead smelting facilities (EPA 2011b), assessments of two coal-fired electric utility units conducted in support of EPA's utility rule (EPA 2011c), and a case study evaluation of a Portland cement facility included with other RTR materials presented to the Science Advisory Board for review (Appendix I of EPA 2009).

Whereas Tier 2 and Tier 3 assessments incorporate some site-specific and regional information on meteorology and water bodies, a refined multipathway assessment uses detailed site-specific data to parameterize more accurately (to the extent possible) each important parameter that affects pollutant fate and transport. These site-specific properties are incorporated into model scenarios configured in TRIM.FaTE and MIRC. Important site-specific data likely would include emission release height and plume buoyancy, hourly meteorology (e.g., wind flow, temperature, mixing height, and precipitation), surface compartments based on watershed and terrain data, local farms and water bodies, land use, soil properties, erosion and runoff rates, surface water and sediment properties, water transfer rates, and aquatic ecosystem information.

The outputs from the site-specific run of TRIM.FaTE (i.e., chemical concentrations in environmental media and fish) are used in MIRC to produce estimates of exposure and health risk (i.e., risk and/or HQ values). Additional analyses of the media concentrations, exposure estimates, and risk estimates for the various ingested media using a range of ingestion rates for each modeled PB-HAP allows the risk assessor to understand, based on TRIM.FaTE and MIRC, the sources and pathways of possible human health risk from emissions of PB-HAPs.

[This page intentionally left blank.]

2. Tier 1 Methodology

2.1 Introduction

As discussed in Section 1, the U.S. Environmental Protection Agency (EPA) implements a tiered approach to evaluate multipathway exposures and human health risks for the Risk and Technology Review (RTR) program. EPA's assessment for RTR focuses on persistent and bioaccumulative hazardous air pollutants (PB-HAPs) that the Office of Air Quality Planning and Standards (OAQPS) has identified as candidates for multipathway risk assessments (selection of the PB-HAPs is discussed in Section 2.2.2). In the first tier, a screen is conducted that focuses on the identity and magnitude of emissions of PB-HAPs from a given facility to determine whether a facility passes certain human health risk-based criteria. Sources that are "screened out" in the Tier 1 assessment are assumed to pose no risks to human health above levels of concern and are not considered in further assessments. For sources that do not pass the Tier 1 screen, more refined assessments, up to and including site-specific multipathway assessments, can be conducted as appropriate.

This section describes the technical basis for the first screening-level tier of EPA's multipathway human health evaluation of PB-HAP emissions from RTR sources. Specifically, the scenarios, models, configurations, and inputs used to derive screening threshold emission rates in the first tier of the approach are described in detail in the following sections.

- Section 2.2 presents an overview of how screening is conducted in Tier 1, the chemicals and exposure scenario evaluated in Tier 1, and the models and methods used to conduct the screen.
- Sections 2.3 and 2.4 present technical descriptions of the hypothetical environmental setting and the exposure modeling scenario used in Tier 1 as well as the models used in the screen.
- Section 2.5 provides a brief discussion of the screening threshold emissions for each of the chemicals assessed.

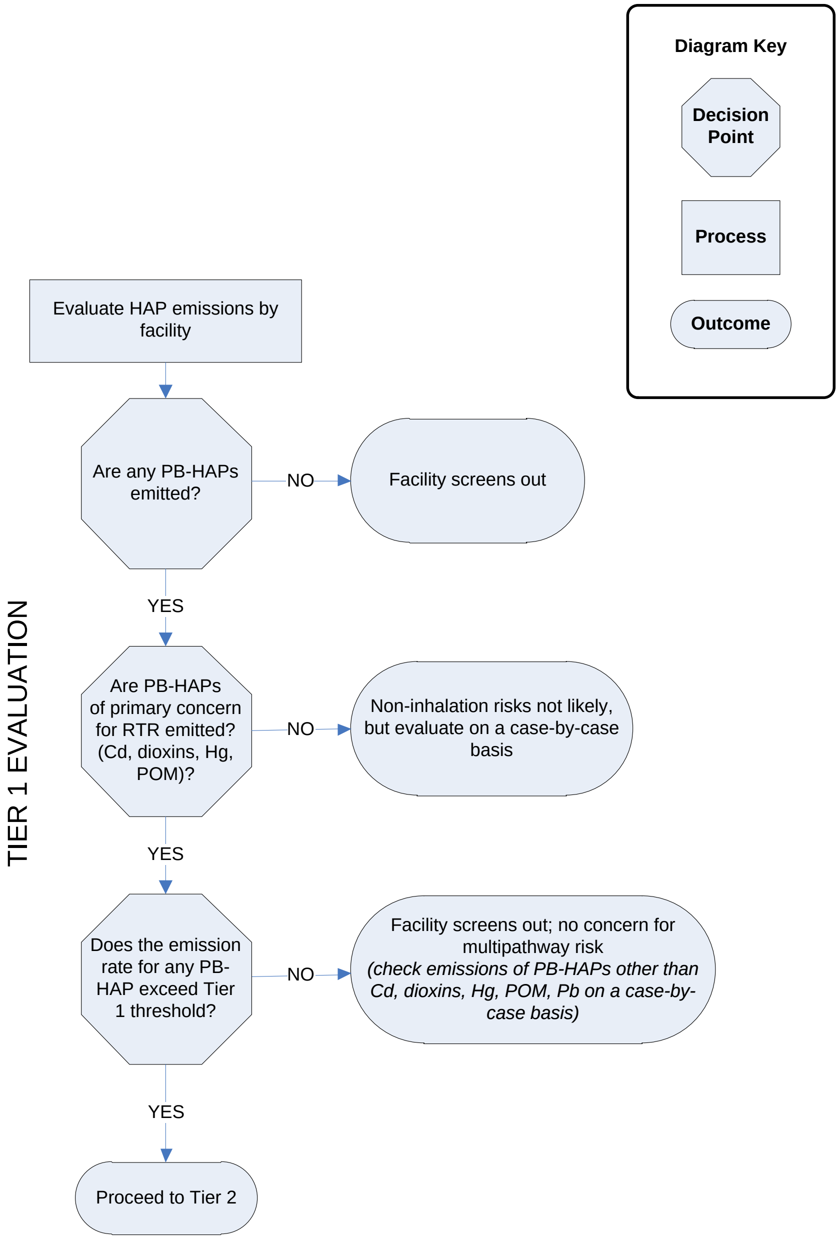
The Tier 2 and Tier 3 screening methods are discussed in Sections 3 and 4, respectively, and references cited are provided in Section 5.

2.2 Summary of Approach

2.2.1 Overview

The Tier 1 approach for evaluating non-inhalation, multipathway exposures to PB-HAPs for RTR is diagrammed in Exhibit 3. Air toxics emitted by a source under consideration are reviewed to determine, first, whether emissions are reported for any of the four PB-HAPs of concern for non-inhalation pathways. If such emissions are reported, the emission rates are compared to Tier 1 threshold-screening emission rates that have been derived using the TRIM-based Tier 1 scenario described in this document (see Exhibit 4 for threshold screening emission rates).

Exhibit 3. Conceptual Decision Tree for Tier 1 Evaluation of Non-Inhalation Exposures of PB-HAPs



The TRIM-based multipathway modeling configuration, referred to in this document as the Tier 1 scenario, forms the technical basis for determining the Tier 1 emission thresholds. The term, Tier 1 scenario, is used to refer collectively to the specific TRIM.FaTE and exposure modeling configuration described herein, including the set of assumptions and input values associated with a hypothetical watershed and the exposure and risk scenarios evaluated for this watershed. The Tier 1 scenario is a static configuration, and its primary purpose is as a modeling tool to calculate the Tier 1 emission rate thresholds for PB-HAPs of concern.

The two potential outcomes of the Tier 1 evaluation are:

- Non-inhalation exposures are unlikely to pose a human health problem (i.e., the emissions evaluated “pass” the screen); or
- Risks above the levels of concern from non-inhalation exposures cannot be ruled out.

An ideal screening approach strikes a balance between being *health-protective*—to ensure that risks above levels of concern are identified, and being *accurate*—to minimize results suggesting that additional analysis is required when in fact the actual risk is low. Typically, gains in accuracy in environmental modeling are accompanied by additional resource requirements. Stated another way, a suitable approach minimizes both false negatives and false positives. False negatives (i.e., results that suggest that the risk is acceptable when in fact the actual risk is high) can lead to inappropriate and non-protective health or environmental policy decisions. False positives (i.e., results that suggest more assessment is required when in fact the actual risk is low) can result in wasted resources by leading to additional, unnecessary analysis. For the evaluation of multipathway human health exposures to PB-HAPs, the methods for screening described in this document are intended to achieve this balance.

Because the Tier 1 evaluation enables EPA to confidently eliminate from consideration those facilities where risks from non-inhalation exposures are projected to be minimal, resources can be targeted toward those facilities that do not pass the screening test. For facilities that do not pass the Tier 1 screening, in additional tiers of analysis, some of the Tier 1 parameters are reassessed, and if appropriate, are changed to more accurately reflect site-specific characteristics. With each successive tier of the assessment, additional Tier 1 assumptions are evaluated and refined to better reflect site-specific characteristics of the facility being modeled.

The Tier 1 screening evaluation for RTR compares reported air emission rates of PB-HAPs (summed by PB-HAP for each facility) to screening threshold emission rates derived using the Tier 1 scenario. A threshold emission rate is the level that, when input to a risk model using emissions as a parameter, corresponds to a specified cancer risk or non-cancer hazard quotient (HQ) that, for the purposes of the evaluation being conducted, is assumed to be below a level of concern. Tier 1 threshold emission rates were calculated for a cancer risk of 1 in 1 million or an HQ of 1.0 and are presented in Exhibit 4.[6] Conceptually, a threshold level for the RTR multipathway screening evaluation could be obtained by back-calculating the emission rate that results in the specified cancer risk or HQ level, taking into account the exposure and fate and transport calculations included in the model. Because the models used in this assessment are not designed to run “backwards,” the rates instead were derived from regression equations established following a series of TRIM.FaTE and exposure/risk model runs spanning a wide

---

[6] For chemicals known to cause both cancer and chronic non-cancer impacts, *and* for which acceptable quantitative dose-response values are available for both cancer and non-cancer endpoints, the endpoint that results in the lower threshold emission level is used for screening (i.e., the threshold will be based on the effect that occurs at the lower exposure level). For the set of PB-HAPs for which screening threshold levels have been derived, only chlorinated dibenzo-dioxins and -furans meet both criteria. Because the cancer dose-response value is lower than that for non-cancer effects, the screening threshold value is based on the cancer endpoint.

range of emission rates for each chemical. The estimated screening-level emission rates are verified by performing model runs using the estimated threshold emission rate to confirm that the emission rates result in a cancer risk of 1 in 1 million or an HQ of 1.0.

Exhibit 4. Emission Thresholds for Screening of Multipathway Exposures

Chemical	Screening Threshold Emission Rate (TPY)	Basis of Threshold (Type of Health Endpoint)
POM (as benzo(a)pyrene equivalents)[a]	2.58E-03	Cancer
Dioxins (as 2,3,7,8-TCDD equivalents)[a]	2.81E-09	Cancer
Cadmium	1.18E-02	Non-cancer
Mercury (as divalent mercury emissions)	3.16E-04	Non-cancer

TPY = U.S. short tons per year
[a]See Section 2.2.7 for a discussion on the derivation of equivalent emissions.

The more probable risk for each emission rate would be lower than the level corresponding to the screening threshold risk quantities in nearly all circumstances, given the health protective and hypothetical nature of the Tier 1 screening configuration. It is considered very unlikely that the estimated risk at a real site would be greater than the estimated risk for the simulated Tier 1 scenario at equivalent emission rates. This is because the Tier 1 scenario assumes, for many of the most risk influential parameters in the model, parameter values that result in high-end risk estimates. In the real world, the probability of such risk-maximizing conditions prevailing across multiple parameters is very low. For example, the Tier 1 scenario assumes a fishable lake approximately 2 km from any given facility, when in reality, a lake may be more than 50 km away. Additional conservative assumptions used in the Tier 1 screen are described in Section 2.4.4.

Tier 1 emission thresholds were developed individually for elemental and divalent mercury. Both were based on the lower of the thresholds associated with multipathway exposures to divalent mercury and methyl mercury.[7] Only speciated emissions of divalent mercury are screened because the sum of elemental mercury emissions across all National Emission Inventory (NEI) facilities is less than the elemental mercury screening threshold level. See Section 2.5.3 for a detailed discussion of mercury.

2.2.2 Chemicals of Potential Concern

EPA's assessment of multipathway human exposures for RTR focuses on PB-HAPs [8] that the Office of Air Quality Planning and Standards (OAQPS) has identified as candidates for multipathway risk assessments. OAQPS developed a list of 14 chemicals and chemical groups that are PB-HAPs based on a two-step process taking into account the following (EPA 2004a):

---

[7] Note that TRIM.FaTE models the transformation of mercury within the environment; thus, emissions of both divalent and elemental mercury will result in multipathway exposures to elemental mercury, methyl mercury, and divalent mercury.

[8] Although POM (polycyclic organic matter) is the name of the HAP listed in the Clean Air Act, the term "polycyclic aromatic hydrocarbons" or PAHs is used in many cases. Much of the literature regarding toxicity and fate and transport of this chemical group refers to PAHs rather than POM. In addition, the individual POM species that are of concern with respect to health risk for RTR evaluations are all PAHs (i.e., there are no POM species explicitly evaluated for RTR that do not include an aromatic ring). The terms are used interchangeably throughout this text.

- their presence on three existing EPA lists of persistent, bioaccumulative, and toxic substances, and
- a semiquantitative ranking of toxicity and bioaccumulation potential of the entire list of HAPs.

The list's development and utility in hazard identification for multipathway risk assessment are explained further in Chapter 14 and Appendix D of Volume I of EPA's *Air Toxics Risk Assessment (ATRA) Reference Library* (EPA 2004a). Exhibit 5 presents the 14 chemicals and groups that are PB-HAPs.

Exhibit 5. OAQPS PB-HAP Compounds

PB-HAP Compound[a]	Addressed by Screening Scenario?
Cadmium compounds	Yes
Chlordane	No
Chlorinated dibenzodioxins and furans	Yes
DDE (1,1-dichloro-2,2-bis(p-chlorophenyl) ethylene)	No
Heptachlor	No
Hexachlorobenzene	No
Hexachlorocyclohexane (all isomers)	No
Lead compounds	No
Mercury compounds	Yes
Methoxychlor	No
Polychlorinated biphenyls	No
Polycyclic organic matter (POM)	Yes
Toxaphene	No
Trifluralin	No

[a] Source of list: EPA (2004a).

The screening scenario described in this document is not configured for evaluating the risk potential for all 14 PB-HAPs on the list. Currently, the scenario can only be used to estimate exposures and risks quantitatively for 4 of the 14 PB-HAPs (as indicated in Exhibit 5). These four PB-HAPs are the focus of the current scenario because, based on current emissions, bioaccumulation potential, and toxicity considerations, they are expected to pose the vast majority of the non-inhalation risks to humans from air emissions at sources subject to residual risk provisions of the Clean Air Act.[9]

2.2.3 Conceptual Exposure Scenario

A conceptual exposure scenario was developed that encompasses the specific exposure routes and pathways of interest for the four PB-HAPs that are assessed in the Tier 1 assessment. Exposure routes and pathways describe the movement of air toxics from the point of release to the point where exposure occurs and generally consist of the following elements:

- Release to the environment (i.e., emissions);

---

[9] Potential impacts on human health from non-inhalation exposures to lead are evaluated for RTR using the National Ambient Air Quality Standard for lead, which takes into account multipathway risks. Non-inhalation exposures to the other nine PB-HAPs not addressed by the modeling scenario discussed in this report will be evaluated on an individual facility or source category basis as appropriate.

- A retention medium, or a transport mechanism and subsequent retention medium in cases involving media transfer of chemicals;
- A point of potential human contact with the contaminated medium; and
- An exposure route.

An exposure route is the particular means of entry into the body. Receptors are exposed to chemicals emitted to the atmosphere via two primary routes: either directly via inhalation, or indirectly via ingestion or dermal contact with various media that have been contaminated with the emitted PB-HAPs. (Inhalation pathways are assessed separately and are not considered in the Tier 1 assessment presented here.)

PB-HAPs can persist in the environment for long periods of time and also build up in soil and in the food chain, including fish, fruits and vegetables, and animal products (e.g., meat, dairy, eggs). For this reason, ingestion of foods grown within an area impacted by RTR sources can be an important source of exposure to PB-HAPs.

To assess risks from hazardous waste combustion facilities, EPA identified several hypothetical receptor scenarios, noting that these scenarios are considered appropriate for a broad range of situations, rather than to represent any actual scenario. These scenarios are described in EPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities,* or HHRAP (EPA 2005a). In this document, EPA recommends assessment of the following hypothetical receptors: a Farmer, Farmer Child, Resident, Resident Child, Fisher, Fisher Child, Acute Receptor, and Nursing Infant. These receptors are distinguished by their pathways of exposures. EPA further notes in HHRAP that some exposure settings might warrant including additional exposure pathways; such as including exposure through fish ingestion for the farmer receptor. For the RTR screening scenario, risks are assessed for a single hypothetical receptor. Based on the guidance provided in HHRAP, a health protective exposure scenario was developed whereby the hypothetical receptor receives ingestion exposure via both the farm food chain and the fish ingestion pathways. The exposure scenario for the RTR Tier 1 assessment includes the following ingestion pathways:

- Incidental ingestion of soil,
- Ingestion of homegrown fruits and vegetables,
- Ingestion of homegrown beef,
- Ingestion of dairy products from homegrown cows,
- Ingestion of homegrown poultry and eggs,
- Ingestion of homegrown pork,
- Ingestion of locally caught fish, and
- Ingestion of breast milk (for children less than 1 year old and for dioxins only).[10]

As discussed in detail in Section 2.4.2, exposure via these pathways is assessed for adults, various age categories for children, and nursing infants (for dioxins only).

---

[10] Breast milk ingestion is an important exposure pathway for lipophilic compounds like dioxins and has been shown not to contribute meaningfully for exposures to mercury, cadmium, and POM. See Section 2.4.2.3 below and Section 3.4 of Attachment B for full discussions of infant exposures via breast milk ingestion.

Other non-inhalation exposure routes of possible concern for PB-HAPs discussed in HHRAP include the use of surface waters as a drinking water source and dermal exposure. These exposure routes, however, are not evaluated in the current assessment. The drinking water exposure pathway is not likely for the modeling scenario developed for this assessment because the likelihood that humans would use a lake as a drinking water source was assumed to be low.[11] Dermal absorption of chemicals that are originally airborne has been shown to a relatively minor pathway of exposure compared to other exposure pathways (EPA 2006, Cal/EPA 2000). Preliminary calculations of estimated dermal exposure and risk of PB-HAPs, presented in Attachment C, showed that the dermal exposure route is not a significant risk pathway relative to ingestion exposures.

2.2.4 Approach to Development of the Tier 1 Scenario

The TRIM-based Tier 1 scenario described in this document is used to provide a means to qualitatively estimate the potential for non-inhalation risks above the levels of concern for PB-HAPs emissions from facilities in the context of residual risk assessments conducted as part of RTR. The Tier 1 scenario used to derive the threshold emission rates is not intended to be representative of any particular situation. Rather, it was developed for the purpose of RTR to portray a hypothetical exposure scenario that will generate emissions screening levels that are health protective for any potential exposure situation that might plausibly be encountered in the United States. A range of conditions was assessed when conceptualizing and developing the screening scenario. The final configuration was chosen so that for a given individual, any potential long-term exposure levels for a given geographic region would be reasonably unlikely to exceed those of the Tier 1 configuration. These criteria were met by constructing a hypothetical scenario that would be health-protective in key aspects, including spatial orientation, meteorology, types of exposures, and ingestion rates. The overall result is a scenario that is unlikely to occur at any one location but has a high likelihood of representing the upper end of all potential exposures. This latter aspect accomplishes the goal of striking a balance between health protectiveness and the level of accuracy called for in the ideal screening approach previously discussed.

The development and application of the Tier 1 scenario for residual risk evaluations considered EPA's technical and policy guidelines presented in the *Residual Risk Report to Congress* (EPA 1999); Volumes I and II of the *Air Toxics Risk Assessment Reference Library* (EPA 2004a, 2005a); and other EPA publications. The scenario described herein is the culmination of assessments completed since 2005; it provides the basis for an efficient and scientifically defensible method for screening multipathway human health risk and provides a solid baseline from which to perform Tier 2 and Tier 3 assessments, as described in Sections 3 and 4, respectively. Nevertheless, this scenario should not be considered "final" but rather a product that can continue to evolve based on feedback from the scientific community and Agency reviewers, lessons learned as the scenario is further applied for RTR, variations in EPA's needs and requirements, and other factors.

2.2.4.1 Modeling Framework

The approach for multipathway risk screening and evaluation for RTR can be divided into four steps:

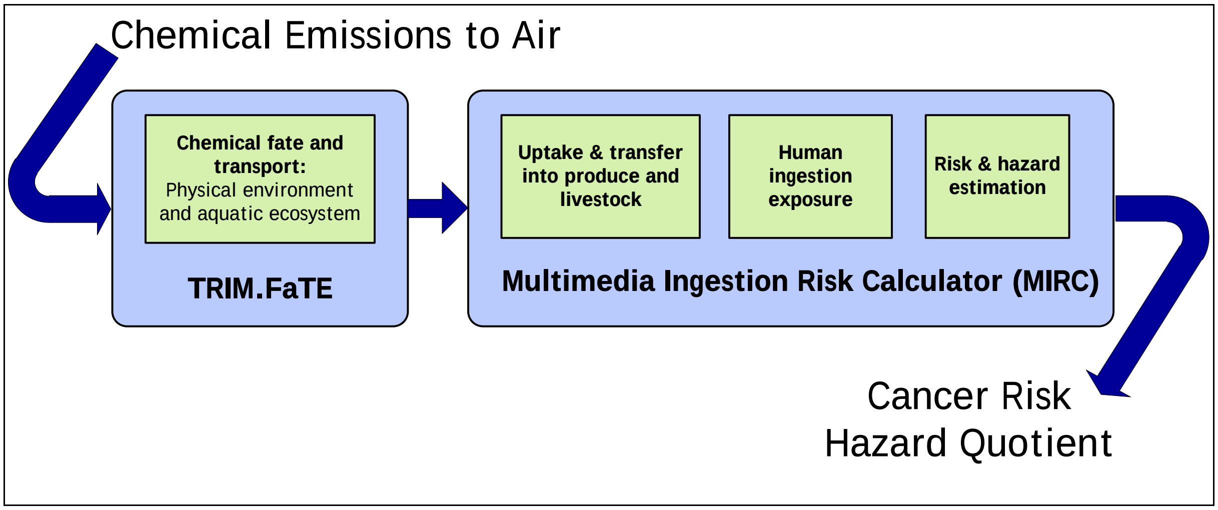
---

[11] An exception to this generality would be reservoirs used for drinking water supplies. This situation might be worthy of additional analysis, if warranted by the characteristics of a given assessment (e.g., to estimate PB-HAP concentrations in treated drinking water derived from reservoirs).

1. Fate and transport modeling of PB-HAPs emitted to air by the source that partition into soil, water, and other environmental media (including fish[12]);
2. Modeling of transfer and uptake of PB-HAPs into farm food chain media (e.g., produce, livestock, dairy products) from soil and air, and calculation of FFC media concentrations;
3. Estimating exposures from ingestion of selected media and estimating average daily ingestion doses for a hypothetical human receptor; and
4. Calculating lifetime cancer risk estimates or chronic non-cancer HQs, as appropriate, for each PB-HAP and comparing these to selected evaluation criteria.

The relationship among these four processes is shown in Exhibit 6.

Exhibit 6. Overview of Ingestion Exposure and Risk Screening Evaluation Method



As shown in Exhibit 6, two models are used to evaluate the four steps outlined above. EPA's TRIM methodology was conceived as a comprehensive modeling framework for evaluating risks from air toxics, and the TRIM system was designed to address each of the four steps involved in screening ingestion risk.[13] Currently, however, only one component corresponding to the first step included in Exhibit 6—the fate and transport module—is available for application in an ingestion risk assessment. EPA has completed some development activities for TRIM.Expo-Ingestion and TRIM.Risk-Human Health, two additional modules that cover the other three steps. Modeling software, however, is not currently available for these modules. For the RTR screening scenario, the Multimedia Ingestion Risk Calculator (MIRC), a Microsoft® Excel™-based computing framework, was constructed to complete the calculations required for estimating PB-HAP concentrations in farm food chain media, average daily ingestion doses, and

---

[12] As discussed below, concentrations in fish calculated by the TRIM.FaTE model were used to estimate ingestion exposures for humans consuming fish. Modeling of fish concentrations is therefore discussed herein as part of the fate and transport modeling. Uptake of PB-HAPs into all other biotic media assumed to be ingested is modeled in the second step of the modeling framework.

[13] Information about the current status of TRIM modules and comprehensive documentation of modules developed thus far can be accessed on EPA's Technology Transfer Network (TTN) on the Fate, Exposure, and Risk Analysis website (http://www2.epa.gov/fera).

cancer risks and chronic non-cancer HQs. This framework is conceptually identical to the ingestion exposure and risk assessments that TRIM is intended to cover.

2.2.4.2 Model Configuration and Parameterization

The Tier 1 scenario is intended to reduce the possibility that EPA would underestimate potential multipathway human health risks. Although the health protective approach likely overestimates risk, EPA determined that this approach is appropriate for the purposes of an initial multipathway screening assessment. As was done with the preliminary multipathway screening for RTR conducted in 2006 (EPA 2006), exposures were modeled for a hypothetical farm homestead and fishable lake located adjacent to an emissions source. The hypothetical individual for which exposures were calculated was assumed to derive all potentially contaminated foodstuffs from adjacent locations, and many of the exposure/activity assumptions (e.g., amount of food consumed per day) were selected from the upper ends of representative exposure parameter distributions.

The physical/chemical environment represented in the screening scenario was parameterized with two types of values. One type is typical values, such as national averages. The second type is health-protective values, or values that would tend to overestimate concentrations in media driving ingestion exposures for humans, based on knowledge of exposure patterns. In general, the spatial and temporal aspects of the scenario and the components of the scenario that influence air concentrations and deposition rates (which in turn affect all other exposures) were defined to be health protective. Chemical-specific and non-chemical-specific properties of the environmental media were parameterized with either typical or health protective values; properties having greater uncertainty were assigned a greater level of health protective bias. The spatial layout of the Tier 1 scenario and the meteorological data (or a combination of these two factors) are generally more influential than physical/chemical parameters in dictating the screening model outcomes, taking into account the potential range of variation in possible values. For example, where and how the layout is spatially oriented relative to the dominant wind direction can dramatically affect the concentrations in air, thereby driving estimated concentrations of PB-HAPs in soil, water, and biota. In contrast, relatively large changes in soil characteristics within the range of possible values (e.g., organic carbon content, water content) typically result in relatively small changes in media concentrations.

The mix of health protective and central-tendency assumptions and parameterization is expected to result in a scenario configuration that, on average, is likely to overpredict environmental concentrations of PB-HAPs in media of interest for this evaluation. Given the intended application of this scenario as a screening tool, this health protective bias was deliberate, because of the desire to ensure that risks above levels of potential concern are not overlooked (i.e., to minimize false negatives). Although the inclusion of central-tendency values where warranted is intended to minimize the number of false positives, some false positives are to be expected from a screening scenario. False positives are addressed in subsequent tiers of the screening evaluation for a particular source.

2.2.5 Fate and Transport Modeling (TRIM.FaTE)

The fate and transport modeling step depicted in the first box in Exhibit 6 is implemented for RTR using the Fate, Transport, and Ecological Exposure module of the TRIM modeling system (TRIM.FaTE).[14] In developing the Tier 1 scenario, Version 3.6.2 of TRIM.FaTE was used to

---

[14] TRIM.FaTE is a spatially explicit, compartmental mass balance model that describes movement and transformation of pollutants over time, through a user-defined, bounded system that includes both biotic and abiotic compartments. Outputs include pollutant concentrations in multiple environmental media and biota.

model the fate and transport of emitted PB-HAPs and to estimate concentrations in relevant media. Additional information about TRIM.FaTE, including support documentation, software, and the TRIM.FaTE public reference library, is available at http://www.epa.gov/ttn/fera/.

The algorithms used to model mercury species and polycyclic aromatic hydrocarbons (PAHs) are described in Volume II of the *TRIM.FaTE Technical Support Document* (EPA 2002a). A comprehensive evaluation of the performance of TRIM.FaTE for modeling mercury was documented in Volumes I and II of the T*RIM.FaTE Evaluation Report* (EPA 2002b, 2005b). Algorithms specific to the fate and transport of chlorinated dibenzo-dioxin and -furan congeners were added following the addition of those for mercury and PAHs. Documentation of the application of TRIM.FaTE for dioxin emissions is contained in the third volume of the *TRIM.FaTE Evaluation Report* (EPA 2004). More recently, the TRIM.FaTE public reference library was updated to include information on modeling for cadmium. In general, many of the algorithms and properties included in the public reference library that are used to model mercury (except for the mercury transformation algorithms) are also applicable to cadmium. Comprehensive technical documentation of TRIM.FaTE algorithms specific to cadmium has not yet been compiled; however, all chemical-specific properties used by TRIM.FaTE to model cadmium (as well as PAHs, mercury, and dioxins) are documented in Attachment A. Based on a thorough 2011 evaluation of TRIM.FaTE performance in modeling mercury's fate, transport, and transformation in the aquatic food web, a zooplankton compartment was added to TRIM.FaTE's aquatic compartment to increase the resolution and accuracy of the aquatic food web modeling. Parameterization of the TRIM.FaTE scenario used for RTR screening is described in more detail in Section 2.3.

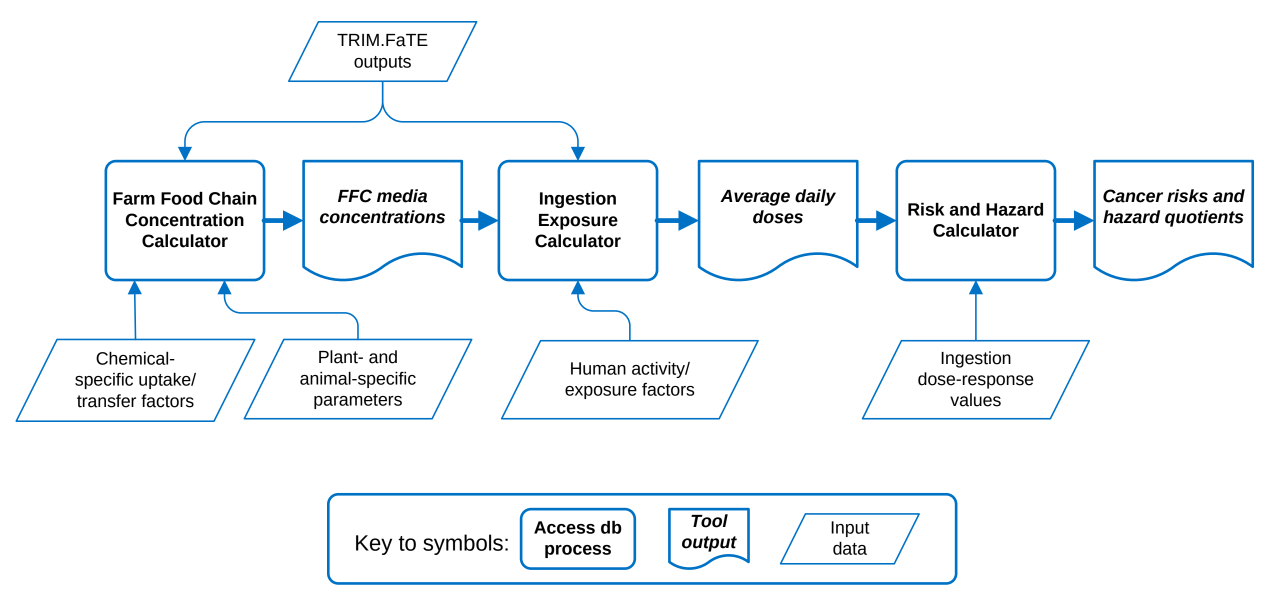
2.2.6 Exposure Modeling and Risk Characterization (MIRC)

The algorithms included in MIRC that calculate chemical concentrations in farm food chain media and ingestion exposures for hypothetical individuals were obtained from EPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities,* or HHRAP (EPA 2005a).[15] These algorithms, and the required exposure factors and other parameter values, were compiled into a database. An overview of the computational processes this tool carries out and the types of input data it requires is presented in Exhibit 7. This exhibit demonstrates the general relationships between the relevant TRIM.FaTE outputs (i.e., chemical concentrations in environmental media and fish) and the ingestion exposure and risk calculations carried out using MIRC. Additional discussion of exposure and risk calculations for the Tier 1 scenario is presented in Section 2.4 and Attachment B, and all inputs required by these calculations are documented in Attachment B.

---

[15] The farm food chain calculations and ingestion exposure equations to be included in the TRIM.Expo software are expected to be very similar to those included in HHRAP.

Exhibit 7. Overview of Process Carried Out in the Multimedia Ingestion Risk Calculator



2.2.7 Implementation of Risk-based Emission Scaling Factors for POM and Dioxin Emissions

Two of the four PB-HAPs for which screening emission thresholds have been developed for RTR—POM and dioxins—are chemical groups comprising numerous individual entities. The members of these categories reported in NEI include both specific chemicals and groups containing multiple chemicals. For example, for POM, emissions reported in NEI include various species, such as benz[a]anthracene, 2-methylnaphthalene, and chrysene, as well as non-specific entries, such as “PAH, total.” The constituents included in the POM and dioxin PB-HAP categories are grouped together not only because they are types of the “same” HAP, but also because members of these groups are assumed to have similar characteristics with respect to toxicity and behavior in the environment.

To facilitate a practical application of the multipathway screening methods for RTR, reported emissions of POM and dioxins are normalized or scaled to a single reference chemical for each group. The reference chemicals used in RTR for POM and dioxins are benzo[a]pyrene and 2,3,7,8-TCDD, respectively. These compounds were selected because they are relatively well-studied among the members of the two groups and are also among the most toxic species within each group.

Derivation of appropriate scaling factors begins with an evaluation of the basic relationship used to characterize health risk:

$$\mathit{Risk} \propto (\mathit{Exposure\ Concentration}) \times (\mathit{Toxicity})$$

For a given air pollutant, the incremental exposure concentration is directly proportional to the emissions of that substance. That is, as the emissions increase, so too does the exposure to that substance. Furthermore, toxicity is assumed to increase linearly with concentration. Consequently, emissions of one substance (e.g., chrysene) can be scaled proportional to a reference compound (e.g., benzo(a)pyrene or BaP) by applying weighting factors corresponding to the relative differences in exposure behavior and toxicity. Using the POM group as an example and BaP as the reference compound, this scaling can be expressed through an equation as follows:

$$Emiss_{PAHi:BaP} = Emiss_{PAHi} \times EEF_{PAHi:BaP} \times TEF_{PAHi:BaP}$$

where:

$Emiss_{PAHi:BaP}$ = Risk-weighted emissions of PAH_i (weighted according to cancer risk relative to BaP for oral exposures)

$Emiss_{PAHi}$ = Emission rate of PAH_i

$EEF_{PAHi:BaP}$ = Exposure equivalency (weighting) factor accounting for difference in relative oral exposure between PAH_i and BaP

$TEF_{PAHi:BaP}$ = Toxicity equivalency (weighting) factor accounting for difference in relative toxicity via oral route between PAH_i and BaP

In combination, the product of the EEF and TEF for a given substance is considered to be a “risk equivalency factor” for the purposes of RTR evaluations that enables scaling of emissions of a given substance for a given exposure scenario.

The TEF for each PAH and dioxin species can be calculated on the basis of relative toxicities. Toxicities were not evaluated separately for RTR but are based on analyses conducted by EPA elsewhere. For PAHs, oral toxicity values for individual species have been derived following the same approach used to develop inhalation toxicity values. For dioxins, TEFs are based on the relative toxicities developed by EPA recently and are ultimately based on the values developed by the World Health Organization (van den Berg et al. 2006). Refer to Section 4 of Attachment B for more information on these values.

The EEFs can be calculated directly for each individual chemical that can be modeled in TRIM.FaTE and MIRC. TRIM.FaTE is configured for 14 POM congeners and 17 dioxin/furan congeners. For these substances, EEFs were calculated directly using the modeling approach and parameterization scheme for the Tier 1 scenario described in this document. Several other POM and dioxin emissions, however, are reported in the NEI. For these, exposure surrogates must be assigned after evaluating the correlation between chemical properties of the POM or dioxin congener and exposure quantified as lifetime average daily dose. The specific calculations for EEFs and exposure surrogates for each chemical group are discussed in the sections that follow.

2.2.7.1 Calculation of Scaling Factors for POM Congeners

The calculated EEFs, TEFs, and total REFs for the 14 POM congeners that are configured in TRIM.FaTE, plus 15 others not configured in TRIM.FaTE, are shown in Exhibit 8. To determine appropriate exposure surrogates for chemicals not parameterized in TRIM.FaTE, EPA evaluated the relationships between chemical-specific properties (e.g., K_{ow} and Henry’s law constant, k_h) and intermediate modeled values (e.g., deposition, soil concentration) and exposure in terms of lifetime average daily dose (LADDs) where the average daily doses (ADDs) for the youngest two age groups were adjusted by the age-dependent adjustment factors (ADAFs) to account for the mutagenic mode of action of PAHs. The correlation between K_{ow} and exposure is stronger than for any other chemical-specific property. Exposure surrogates were thus identified for each congener by calculating Total Lifetime Average Daily Dose (Age Adjusted) for each based on the congener's K_{ow} and the power regression of the modeled PAHs. Exhibit 9 shows that as K_{ow} increases, so too does exposure.

Exhibit 8. Exposure, Toxicity, and Risk Equivalency Factors Relative to BaP for POM Congeners Currently Evaluated in Tiers 1 and 2 Assessments

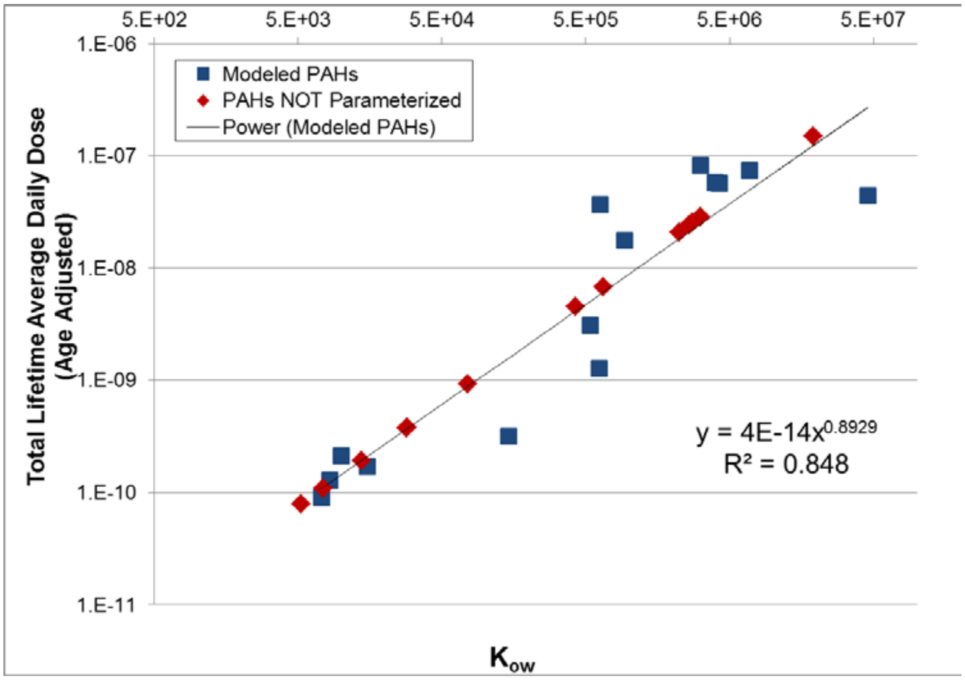
Chemical	Fully Parameterized in TRIM.FaTE?	Exposure Equivalency Factor (EEF)	Toxicity Equivalency Factor (TEF)[a]	Risk Equivalency Factor (REF)
Dibenzo(a,i)pyrene	n	27.5	16.4	452
7,12-Dimethylbenz(a)anthracene	Y	5.4	34.2	186
3-Methylcholanthrene	n	4.3	3.0	12.9
Dibenz(a,h)anthracene	Y	8.0	0.6	4.5
Benzo(k)fluoranthene	Y	18.0	0.2	3.0
Benzo(a)pyrene	Y	1.0	1.00	1.00
Benzo(b)fluoranthene	Y	11.4	0.2	1.9
Indeno(1,2,3-cd)pyrene	Y	4.5	0.2	0.7
PAH, total	n	5.1	0.07	0.3
Polycyclic Organic Matter	n	5.1	0.07	0.3
Benzo(g,h,i)perylene	Y	4.3	0.07	0.3
Benzo(e)pyrene	n	4.5	0.07	0.3
Retene	n	3.7	0.07	0.3
Dibenzo(a,j)acridine	n	0.78	0.2	0.1
Perylene	n	1.2	0.07	0.08
Benzo(a)anthracene	Y	0.09	0.16	0.01
Chrysene	Y	0.25	0.02	0.004
2-Acetylaminofluorene	n	0.005	1.4	0.01
Fluoranthene	Y	0.04	0.07	0.003
Acenaphthylene	Y	0.04	0.07	0.003
2-Chloronaphthalene	n	0.03	0.07	0.002
Fluorene	Y	0.03	0.07	0.002
Acenaphthene	Y	0.02	0.07	0.002
1-Methylnaphthalene	n	0.02	0.07	0.001
2-Methylnaphthalene	Y	0.02	0.07	0.001
Carbazole	n	0.01	0.003	0.00003
Anthracene	n	0.06	0[b]	0
Phenanthrene	n	0.06	0[b]	0
Pyrene	n	0.15	0[b]	0

[a] TEFs are calculated as the ratio of the cancer slope factor (CSF) for each specific POM congener to the CSF for benzo(a)pyrene. Dose response values, including CSFs, that are used in the screening assessment are discussed in Section 4 of Attachment B.

[b] Weight of evidence evaluations indicated that the available data were adequate to determine that three PAHs (anthracene, phenanthrene, and pyrene) were not carcinogenic (EPA 2010a),

For POMs reported as unspeciated groups (i.e., "PAH, total" and "Polycyclic Organic Matter") EPA assigned surrogates with K_{ow} values near the upper end of the range of all of the K_{ow} values, corresponding to an exposure near the upper end of the range (log $K_{ow} = 6.5$). This assignment is assumed to be health protective and likely will not under predict exposure.

Exhibit 9. Relationship between Exposure and K_{ow} for POM Congeners



It is worthy of noting that naphthalene is not included in the POM category for the RTR multipathway (i.e., non-inhalation) analyses. Naphthalene is listed individually as a HAP under Section 112(b) of the Clean Air Act. POM also is listed as a HAP under Section 112(b) and is defined as organic compounds with more than one benzene ring and a boiling point greater than or equal to 100° C (see http://www.epa.gov/ttn/atw/orig189.html). While naphthalene is a POM, as defined in the Clean Air Act, unlike the other POM chemicals modeled in the multipathway assessment, naphthalene is short-lived in environmental media due to its tendency to volatilize and biodegrade and, consequently, will not build up in environmental media over time (ATSDR 2005). Additionally, based on a log Kow of 3.29, it has a moderate affinity for lipids and will undergo short-term bioaccumulation in tissues; however, biochemical processes lead to its biodegradation and elimination. For the reasons stated above, and to avoid a less accurate and less meaningful estimate of media concentrations and multipathway risk, EPA is not including naphthalene in its multipathway risk assessment.

2.2.7.2 Calculation of Scaling Factors for Dioxin Congeners

The calculated EEFs, TEFs, and REFs for the 17 dioxin congeners that are configured in TRIM.FaTE are presented in Exhibit 10. Although there are many dioxins reported in the NEI other than the 17 configured for TRIM.FaTE, to date, none of them have been included in emissions datasets that have been screened. Therefore, no surrogate EEF's have been developed for dioxins. In future screening assessments, if surrogate EEFs are needed, an approach similar to that used for POM will be used to develop surrogate EEFs for dioxins.

Many facilities report dioxins as “Dioxins, Total, without Individual Isomers Reported,” “Dioxins,” or as “2,3,7,8-TCDD TEQ,” and in these cases, we do not adjust or scale the emissions. That is, we assume that they behave like and possess the toxic characteristics of TCDD. This approach could be improved by obtaining information on the speciation of dioxin emissions for each facility or an average speciation profile that could be assumed to apply to all facilities in a source category.

Exhibit 10. Exposure and Toxicity Equivalency Factors Relative to TCDD for Modeled Dioxin Congeners

Chemical	Exposure Equivalency Factor (EEF)	Toxicity Equivalency Factor (TEF)[a]	Risk Equivalency Factor (REF)
PentaCDD, 1,2,3,7,8-	3.8	1	3.8
TetraCDD, 2,3,7,8-	1	1	1
Dioxins, Total, w/o Indiv. Isomers Rptd.	1	1	1
Dioxins	1	1	1
2,3,7,8-TCDD TEQ	1	1	1
HexaCDD, 1,2,3,4,7,8-	1.6	0.1	0.2
PentaCDF, 2,3,4,7,8-	0.4	0.3	0.1
HexaCDD, 1,2,3,6,7,8-	1.0	0.1	0.1
HexaCDF, 1,2,3,7,8,9-	0.5	0.1	0.05
HexaCDF, 1,2,3,6,7,8-	0.5	0.1	0.05
HexaCDD, 1,2,3,7,8,9 -	1.0	0.04	0.04
HexaCDF, 1,2,3,4,7,8-	0.3	0.1	0.03
HexaCDF, 2,3,4,6,7,8-	0.2	0.1	0.02
PentaCDF, 1,2,3,7,8-	0.4	0.03	0.01
TetraCDF, 2,3,7,8-	0.1	0.1	0.01
HeptaCDD, 1,2,3,4,6,7,8-	1.0	0.01	0.01
HeptaCDF, 1,2,3,4,6,7,8-	0.2	0.01	0.002
HeptaCDF, 1,2,3,4,7,8,9-	0.2	0.01	0.002
OctaCDD, 1,2,3,4,6,7,8,9-	1.1	0.0003	0.0003
OctaCDF, 1,2,3,4,6,7,8,9-	0.2	0.0003	0.0001

[a] Values from Van den Berg et al. (2006), except for 1,2,3,7,8,9-hexaCDD, which is calculated based on the ratio of the IRIS-based CSF for 1,2,3,7,8,9-hexaCDD to the IRIS-based CSF for 2,3,7,8-TCDD. Dose response values, including CSFs, that are used in the screening assessment are discussed in Section 4 of Attachment B.

2.3 Description of Environmental Modeling Scenario

As described in Section 2.2.4.2, the physical configuration of the RTR Screening Scenario was designed to encompass the upper end of potential long-term PB-HAP exposures, and the environmental and chemical-specific properties were parameterized with either health protective or central-tendency values. Information regarding the scenario configuration and important aspects of the parameterization process, justifications for selecting particular property values, and model uncertainties is presented in the sections that follow. Comprehensive documentation of TRIM.FaTE property values for this scenario is provided in Attachment A.

2.3.1 Chemical Properties

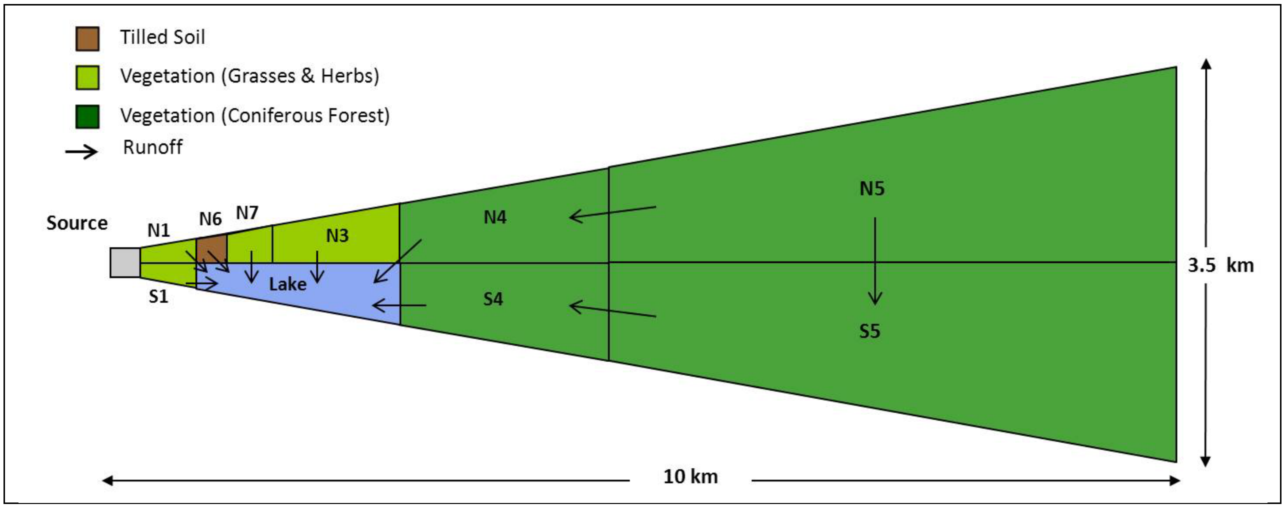
The general chemical/physical properties that TRIM.FaTE requires, such as Henry's law constant, molecular weight, and melting point, were obtained from peer-reviewed and standard reference sources. Numerous other chemical-specific properties are related more specifically to a particular abiotic or biotic compartment type; these properties are discussed generally in the sections that follow and are documented in Attachment A.

2.3.2 Spatial Layout

For the purpose of estimating media concentrations, the TRIM.FaTE scenario is intended to represent a farm homestead and a fishable lake (and its surrounding watershed) located near the emissions source of interest. A diagram of the surface parcel layout is presented in Exhibit 11. The source parcel is parameterized as a square with sides of 250 m, which is assumed to be a fair estimation for the size of a relatively small-to-medium facility at the fence line. With a predominant wind direction toward the east, the modeled layout is generally symmetric about an east-west line and is wedge-shaped to reflect Gaussian dispersion of the emission plume.

A lateral, downwind distance of 10 km was established for the watershed included in the scenario. Based on the results of dispersion modeling, the location of the maximum air concentration and deposition rate is expected to occur relatively close to the facility (probably within a few hundred meters, with the exact location varying with stack height and other parameters) and well within a 10-km radius. Additionally, deposition rates for the PB-HAPs for which this screening scenario is applicable is expected to decrease by about two orders of magnitude relative to the predicted maximum rate within a 10-km radius. Extending the modeling layout beyond a 10-km downwind distance would increase the amount of deposition "captured" by the modeled watershed, but the incremental chemical mass expected to accumulate in the watershed diminishes rapidly with distance. In addition, the impact of this additional deposited mass on ingestion exposures is expected to be negligible.[16] Given these conditions, a downwind length of 10 km was determined to be appropriate for the screening scenario.

Exhibit 11. TRIM.FaTE Surface Parcel Layout



---

[16] Mass deposited at the outer edge of the watershed is expected to result in only a very small increase in estimated exposure via fish consumption by increasing the chemical mass transported to the lake through erosion and runoff. The distance from these more distant locations to the lake would attenuate transport of chemical mass by erosion and runoff, dampening the effect of including additional deposition beyond 10 km. (Other exposure pathways largely would be unaffected; the soil concentrations used to calculate exposures for the farm food scenario are derived from soil parcels located close to the source and unaffected by deposition to the far reaches of the watershed.)

The north-south width of the wedge-shaped watershed was set based on the observed behavior of chemicals emitted to the ambient air. If meteorological stability is known or can be assumed, the lateral spread of the plume (σ_y, measured from the centerline) at a certain distance from the source can be estimated using the Pasquill-Gifford curves. Turner (1970) derived the equations for these curves, which can be found in the Industrial Source Complex 3 Dispersion Model Manual (among other sources).[17] For a relatively neutral atmosphere (stability class D), σ at 10km is about 550 m using this estimation. In a Gaussian distribution, about 99.6 percent of the plume spread area is contained within 3σ of the median line. Therefore, the plume σ was set at 3 times 550 m, or approximately 1.75 km from the centerline at a distance of 10 km. The plume width for these conditions is expected to be about twice this distance, or 3.5 km. These dimensions were used to define the dimensions of the overall air and surface parcel layouts for the screening scenario.

The surface (land and surface water) modeling area was initially divided into five pairs of parcels the areas of which increase with distance from the source, which approximately corresponds to the spatial gradient that is expected in the downwind direction from the source. The second north parcel from the source was divided further into two parts; one of them tilled soil (Parcel N6) to represent agricultural conditions and the other (Parcel N7) untilled to represent pasture.

The depth of the surface soil compartments was set to 1 cm, except for Parcel N6, for which the depth was set to 20 cm to simulate the effect of tillage. Characteristics of the soil layers (e.g., organic carbon content, air and water content, and subsoil depth) generally were set to represent typical or national averages as summarized by McKone et al. (2001).

The overall shape and boundaries of the air parcel layout mirror those of the surface parcel layout. A single air parcel (N2) overlies surface Parcels N6 and N7, and the air over the lake is divided into air Parcels S2 and S3 (mirroring the analogous parcels on the north side of the lake).

2.3.3 Watershed and Water Body Parameterization

Properties associated with the watershed soil and lake determine how pollutants in the system are transported through and accumulate in various media compartments. These properties describe the physical characteristics of the environmental media included in the modeled region, as well as the assumed connections and relationships between media types and modeled spatial components that in turn affect chemical transport via water runoff, ground infiltration, deposition of suspended sediments in the water column, and other processes. This section presents the justification for setting the key properties of the soil, water, and sediment compartments. Also discussed are some of the chemical properties related to watershed and waterbody processes (chemical-specific compartment properties in TRIM.FaTE) and the configuration of terrestrial plants included in the scenario.

2.3.3.1 Water Balance

Water-related properties of the lake and related watershed characteristics (e.g., runoff rates from each surface soil compartment) were set so that a simplified water balance is achieved. Although TRIM.FaTE maintains a chemical mass balance, the model does not calculate or maintain media mass balances (e.g., for water) except where specified in certain formulas. For the Tier 1 scenario, the parameters were set to satisfy two equations relating water volume. The first equation maintains a balance of water entering and leaving the terrestrial portion of the scenario:

---

[17] http://www.epa.gov/scram001/userg/regmod/isc3v2.pdf

[total precipitation] = [evapotranspiration] + [total runoff]

In this equation, total runoff is equal to the sum of overland runoff to the lake and seepage to the lake via groundwater.

The second equation describes the volumetric balance of transfers of water to and from the lake:

[total runoff] + [direct precipitation to the lake] = [evaporation from the lake surface] + [outflow from the lake]

Note that TRIM.FaTE actually uses only some of these properties (e.g., precipitation rate and surface runoff, but not evapotranspiration). The water characteristics assumed for the Tier 1 scenario are meant to represent a relatively wet and moderately warm location in the United States (USGS 1987). Following are the assumptions for this scenario:

- 35 percent of the total precipitation leaves the scenario through evapotranspiration.
- 25 percent of total precipitation infiltrates into the groundwater and eventually flows into the lake.
- 40 percent of total precipitation contributes to overland runoff.

For these calculations, the source parcel was considered to be outside the watershed and therefore was not included in the water balance. The evaporation rate from the lake was assumed to be 700 mm/yr based on data reported by Morton (1986) for various lakes. The runoff rate was defined to be spatially constant and temporally constant (i.e., it is not linked to precipitation events) throughout the modeled domain. Based on these assumptions, the outflow of water from the lake is about 18 million m^3/yr, which translates to a volumetric turnover rate of about 12.2 lake volumes per year.

Other quantitative water body and watershed characteristics TRIM.FaTE uses are listed in Attachment A.

2.3.3.2 Sediment Balance

A simplified balance of sediment transfers between the watershed and the lake was also maintained for the screening scenario via the parameterization of sediment-related properties. As with water, the model does not internally balance sediment mass; these calculations were performed externally for the purposes of setting parameter values. The sediment balance maintained is described by the following equation, where terms represent mass of sediment:

[total surface soil transfers to the lake via erosion] = [removal of sediment from the water column via outflow] + [sediment burial]

where the second term (removal of sediment from the water column via outflow) is accounted for in TRIM.FaTE by lake flushing rate and the third term (sediment burial) is the transfer of sediment from the unconsolidated benthic sediment compartment to the consolidated sediment layer.

To maintain the sediment balance, erosion rates were calculated for each surface soil compartment using the universal soil loss equation (USLE, Wischmeier and Smith 1978), assuming a relatively high rate of erosion. The total suspended sediment concentration is assumed to remain constant in TRIM.FaTE, and the flushing rate of the lake (calculated via the water balance approach described above) was then used to estimate the removal of sediment from the modeling domain via lake water outflow. The difference between these sediment fluxes was taken to be the sediment burial rate. The sediment burial rate is the rate at which sediment particles in the unconsolidated benthic sediment layer are transported to the consolidated sediment, where the particles can no longer freely interact with the water column.

In TRIM.FaTE, the consolidated sediment layer is represented with a sediment sink; as with all sinks in TRIM.FaTE, chemical mass sorbed to buried sediment that is transported to the sink cannot be returned to the modeling domain. The burial rate is a formula property calculated by the model according to the difference between user-specified values for sediment deposition velocity (from the water column to the benthic sediment) and sediment resuspension velocity (back into the water column from the benthic sediments). These formula properties assume a constant volume of particles in the sediment layer (because the densities for benthic and suspended sediment particles were defined to the same value, the mass of particles in the sediment is also constant).

For the Tier 1 scenario described here, the average sediment delivery rate (i.e., transfer of sediment mass from watershed surface soil to the lake due to erosion) for the entire watershed was estimated to be about 0.0036 kg/m^2-day, based on calculations using the USLE. The HHRAP documentation notes that using the USLE to calculate sediment load to a lake from the surrounding watershed sometimes leads to overestimates (EPA 2005a). For the Tier 1 scenario, however, this approach was considered to be appropriate in that health protective assumptions are a goal of the screening scenario.[18] Surface soil compartments adjacent to the lake are linked directly to the lake for the purposes of estimating erosion and runoff transfers (see layout in Exhibit 11). Erosion and runoff from the source parcel are linked directly to a sink and do not enter the Tier 1 scenario lake. The transport of sediment to the lake via overland is thus assumed to be efficient. Note that erosion from parcels not directly adjacent to the lake is assumed to be somewhat attenuated, effected by using a lower sediment delivery ratio in the USLE.

Using the calculated surface soil erosion rates for the scenario, the total average daily sediment load to the lake from the watershed is about 16,600 kg/day. About 15 percent of this load is removed from the lake via outflow of suspended sediments (based on a calculated flush rate of 12.2 volume turnovers per year) with the remainder of the sediment input to the lake transferred to the sediment burial sink.

2.3.4 Meteorology

Meteorological properties used in TRIM.FaTE algorithms include air temperature, mixing height, wind speed and direction, and precipitation rate. These properties, which can vary significantly among geographic locations, and seasonally and hourly for a single location, greatly influence the chemical concentrations predicted in media of interest. Because the screening scenario is intended to be generally applicable for any U.S. location, and to minimize the frequency of false negatives, a health protective configuration was used. The meteorology of the screening scenario was defined to ensure that (when used in combination with the selected spatial layout) the maximum exposures that might be encountered for the scenarios of interest would be encompassed (i.e., consumption of home-grown farm foodstuffs and self-caught fish, with all farm foods and fish obtained from locations impacted by chemicals emitted from the local

---

[18] Based on sensitivity analysis, a higher erosion rate will both increase surface water concentrations and decrease surface soil concentrations; the relative impact on resulting concentrations, however, will be proportionally greater in the waterbody.

source). Ensuring that the meteorological parameters were not overly protective of health, such as *always* having the wind blow toward the location of interest, however, was also important to avoid too many false positives.

The meteorological data for the screening scenario are intended to be representative of a location with a low wind speed, a wind direction that strongly favors the watershed, and a relatively high amount of total precipitation falling on the watershed. The values used were based on actual data trends for U.S. locations as specified in Exhibit 12 but an artificial data set was compiled for this assessment (for example, temporally variable meteorological parameters were made to vary only on a daily basis). This simplified approach allowed for greater control (relative to selecting a data set for an actual location) so that desired trends or outcomes could be specified. Also, using a meteorological data set with values varying on a daily basis rather than a shorter period (such as hourly, which is the typical temporal interval for meteorological measurements) reduced required model run time. Meteorological inputs are summarized in Exhibit 12.

The sensitivity of modeled PB-HAPs to changes in these meteorological variables was tested. Lower wind speeds and mixing heights affected concentrations the most. This sensitivity is not unexpected because lower wind speeds should increase pollutant deposition onto the soil and lower mixing heights should reduce the volume through which pollutants disperse. The wind speed used for the screening scenario was 2.8 m/s, the 5th percentile of the annual averages among 239 stations; by comparison, the mean annual average wind speed is approximately 4 m/s in the contiguous United States). The mixing height (mean heights from 4 states) used was 710 m (the 5th percentile of annual averages among all 40 states in the SCRAM database).

Exhibit 12. Summary of Key Meteorological Inputs

Meteorological Property	Selected Value	Justification
Air temperature	Constant at 298 Kelvin	Recommended default value listed in HHRAP (EPA 2005a). Value is similar to the mean daily June temperature in much of the U.S. Southern Plains and Southeast.[a]
Mixing height	Constant at 710 m	Value is 5th percentile of annual average mixing heights for 75 U.S. locations, using data obtained from EPA's SCRAM Web site.[b] Value is the approximate U.S. median for periods without precipitation, based on data compiled by Holzworth (1972). Value is conservative compared to the 1- to 2-km typical mid-latitude daytime value (Stull 1988).
Wind direction	Blows from source parcel into scenario domain (west to east) 3 days per week; during other times does not blow into domain	A wind direction that favors the location of interest (for example, a watershed downwind of a source of concern) will tend to result in more emitted mass accumulating in the location of interest. For much of the U.S. mid-Atlantic and western regions, the wind tends to favor the eastward direction.[a] Among the NCDC 1981–2010 normalized wind vector data, the average wind direction had a strong eastward component at over one-third of the stations.[c] For the hypothetical RTR scenario, a more extreme example of this pattern is represented by conditions in Yakima, Washington, where the wind blows eastward approximately 40 percent of the time based on a review of wind direction data compiled by the National Weather Service (NCDC 1995). This pattern was approximated in the RTR scenario with a configuration in which the modeled domain is downwind of the source 3 out of 7 days.
Horizontal wind speed	Constant at 2.8 m/sec	Set to 5th percentile of annual average speed for 239 stations across the contiguous United States (about 50 years of data per station). Value is similar to the annual average wind speeds of

Meteorological Property	Selected Value	Justification
		many areas of the U.S. east coast and west coast.[a]
Precipitation frequency	Precipitation occurs 3 days per week; wind direction blows into domain 2 of these days	This value was selected so that two-thirds of the total precipitation occurs when the domain is downwind of the modeled source. This pattern approximates that for rainy U.S. locations, where precipitation occurs 35–40% of the time (Holzworth 1972). These locations include parts of the U.S. Northeast and Northwest.[a]
Total Precipitation	1.5 m/yr	Assumed to represent rainy conditions for the United States. This annual precipitation amount is experienced in parts of the U.S. Deep South and parts of the U.S. northwest coast.[a] Conditional precipitation rate (rainfall rate when precipitation is occurring) is 9.59 mm/d, which is similar to conditions in many areas along the U.S. east coast and in the Midwest and Plains.[a]

[a] National Climatic Data Center CliMaps (NCDC-CliMaps) (2007). https://www.ncdc.noaa.gov/cgi-bin/climaps/climaps.pl.
[b] Support Center for Regulatory Atmospheric Modeling; http://www.epa.gov/ttn/scram/.
[c] National Climatic Data Center 1981-2010 Climate Normals; http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

2.3.5 Aquatic Food Web

The aquatic food web is an important part of the screening scenario because the chemical concentrations modeled in fish are used to calculate human ingestion exposure and risks associated with eating contaminated local fish. A biokinetic approach to modeling bioaccumulation in fish is used in the RTR screening scenario. The primary producers (first trophic level) in the TRIM.FaTE aquatic ecosystems are algae and macrophytes in the water column and detritus in the sediments (the latter simulated as sediment particles). Zooplankton feed on algae in the water column, while benthic invertebrates, represented as a single compartment, consume detritus that settles to the sediment compartment. In the water column, small young-of-the-year fish and minnows feed on zooplankton and phytoplankton. The small fish are in turn consumed by larger or “pan” fish (e.g., bluegills, white perch), which are in turn consumed by the top consumers (e.g., gar, pickerel). The invertebrates in the sediments of the benthic environment support small bottom-feeding fish (young-of-the-year fish for many species), which in turn are consumed by larger bottom-feeding fish (e.g., catfish). For TRIM.FaTE to provide reasonable predictions of the distribution of a chemical across biotic and abiotic compartments in aquatic systems, the biomass of the aquatic biotic compartments must represent all biota in the system and the distribution of biomass among the trophic levels and groups must be as realistic as possible.

To support the development of a relatively generic freshwater aquatic ecosystem in which to model bioaccumulation in fish, a literature search, review, and analysis was conducted (ICF 2005). This research demonstrated that the diversity of species and food webs across U.S. aquatic ecosystems is substantial, reflecting the wide range of sizes, locations, and physical/chemical attributes of both flowing (rivers, streams) and low-flow water bodies (ponds, lakes, reservoirs). In general, lentic bodies of water (lakes and ponds) can accumulate higher levels of contaminants in both sediments and biota than lotic systems (rivers, streams). Also, that initial research (ICF 2005) suggests that a lake of at least 60 hectares (ha) or 150 acres could support higher trophic level predatory fish, with some fraction of their diet comprising smaller fish.

The RTR Tier 1 scenario includes a generic aquatic ecosystem with a 47-hectare (116-acre) lake. Although slightly smaller than the size suggested by the previous review (ICF 2005), a 47-ha lake is large enough to support higher trophic level fish given appropriate conditions (e.g., high productivity given a sufficient nutrient base and average temperature and growing season). Also, this size was compatible with the overall size of the defined watershed in the screening scenario. The fish types, biomass, diet fractions, and body weights recommended for fish compartments for the Tier 1 scenario are listed in Exhibit 13. Biomass is based on an assumption that the total fish biomass (wet-weight) for the aquatic ecosystem is 5.7 grams per square meter (g_w/m^2, ICF 2005). That assumption yields health protective (i.e., higher) estimates of chemical concentrations in fish than would the assumption of higher standing biomass and fish productivity.

In general, the food web implemented in the Tier 1 scenario is consistent with aquatic food webs that support trophic level 4 fish (to maximize bioaccumulation), and is intended to be generally health protective.

Exhibit 13. Aquatic Biota Parameters for the TRIM.FaTE Screening Scenario

TRIM.FaTE Compartment Type	Organisms Represented by Compartment	Biomass		Diet	Average Body Weight (kg)
		Areal density (g_w/m^2)	Fraction of Total Fish Biomass		
Algae	green algae, diatoms, blue-green algae	7.95	–	Autotrophic	–
Zooplankton	crustaceans, rotifers, protozoans	6.36	–	100% algae[a]	5.7 E−8
Macrophyte	hydrilla, milfoil	500	–	–	–
Water column planktivore	young-of-the-year, minnows	2.0	35.1%	100% zooplankton	0.025
Water column omnivore	bluegill, white perch	0.5	8.8%	100% water column planktivore	0.25
Water column carnivore	largemouth bass, walleye	0.2	3.5%	100% water column omnivore	2.0
Benthic invertebrate	aquatic insect larvae, crustaceans, mollusks[b]	20	–	detritus in sediments	0.000255
Benthic omnivore	small catfish, rock bass	2.0	35.1%	100% benthic invert.	0.25
Benthic carnivore	large catfish, sculpins	1.0	17.5%	50% benthic invert. 50% benthic omniv.	2.0
Total Fish Biomass[c]		**5.7**			

[a] Algae is modeled as a phase of surface water in TRIM.FaTE.

[b] Benthic invertebrates include aquatic insects (e.g., nymphs of mayflies, caddisflies, dragonflies, and other species that emerge from the water when they become adults), crustaceans (e.g., amphipods, crayfish), and mollusks (e.g., snails, mussels).

[c] Total fish biomass does not include algae, macrophytes, zooplankton, or benthic invertebrates.

2.3.6 Using TRIM.FaTE Media Concentrations

The Tier 1 scenario outputs include average PB-HAP concentrations and deposition rates for each year and for each parcel of the model scenario. In each surface parcel, deposition rates to the soil are provided as are soil concentrations for the surface, root, and vadose zones and grass or leaf concentrations as appropriate for the plants. For each air parcel, air concentrations are provided. For the lake, surface water concentrations and concentrations in the various levels of the aquatic food chain are provided. For the ingestion exposure calculations, some concentrations are used to calculate direct exposure (e.g., soil ingestion), and some are used to perform the farm food chain concentration calculations in the various media that humans can ingest.

The locations that determine exposures were selected to be health protective. Decisions regarding which TRIM.FaTE outputs to use in calculating exposures for the Tier 1 scenario assume exposure at locations very close to the modeled source. These locations are predicted to have amongst the highest media concentrations consistent with the specified spatial layout, thereby resulting in higher exposures to the emitted chemicals. These assumptions are summarized in Exhibit 14.

Exhibit 14. Spatial Considerations – TRIM.FaTE Results Selected for Calculating Farm Food Chain Media Concentrations and Receptor Exposures

TRIM.FaTE Output Used in Exposure Calculations	Representative Compartment
Concentration in air, for uptake by plants via vapor transfer	Air compartment in air Parcel N2 (air over tilled soil)
Deposition rates, for uptake by farm produce	Deposition to surface soil compartment in surface Parcel N6 (tilled soil)
Concentration in surface soil, for incidental ingestion by humans and farm animals	Surface soil compartment in surface Parcel N1 (untilled soil, closest to facility)
Concentration in soil, for uptake by farm produce and animal feed	Surface soil compartment in surface Parcel N6 (tilled soil)
Concentration in fish consumed by fisher	Water column carnivore compartment in lake (50% of fish consumed) and benthic carnivore in lake (50% of fish consumed)

TRIM.FaTE can output instantaneous chemical concentrations for a user-specified time step and also can be configured to calculate temporal averages (e.g., annual averages). For the Tier 1 scenario, the model is set up to output results on a daily basis, largely because daily is the smallest time step over which input data change (i.e., wind direction and precipitation rate). Daily concentration results were averaged to obtain annual average concentrations. The default assumption is annual average concentrations for media during the fiftieth year of emissions.

For the chemicals modeled in this scenario, long-term concentrations in environmental media will be relatively constant at 50 years. Aside from mercury, chemicals modeled for RTR approach steady state before 50 years. And, although mercury concentrations do not achieve steady state after 50 years in the modeled screening scenario configuration, the rate of change in mercury concentrations shows a decreasing trend.

2.4 Description of Exposure and Risk Modeling Scenario

This section describes the approach for modeling chemical concentrations in farm food chain (FFC) media (Section 2.4.1); estimating human exposures associated with ingestion of FFC media, incidental ingestion of soil, ingestion of fish, and infant consumption of breast milk (Section 2.4.2); and calculating human health screening risk metrics associated with these exposure pathways (Section 2.4.3). All of these calculations are conducted using MIRC. For this multipathway screening evaluation, partitioning of PB-HAPs into FFC media is modeled with MIRC, not as a part of the TRIM.FaTE modeling. Consequently, processes and inputs related to estimating chemical levels in FFC media are summarized in this section and discussed in detail in Attachment B.

2.4.1 Calculating Concentrations in Farm Food Chain Media

As was shown in Exhibit 7, MIRC was compiled to calculate concentrations of PB-HAPs in foodstuffs that are part of the farm food chain. The FFC media included in this screening scenario include:

- exposed and protected fruit,
- exposed and protected vegetables,
- root vegetables,
- beef,
- dairy products,
- pork, and
- poultry and eggs.

The algorithms used in MIRC were obtained from EPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (HHRAP; EPA 2005a). These algorithms model the transfer of concentrations of PB-HAPs in FFC media using biotransfer factors. Environmental media concentrations (i.e., the chemical source terms in these algorithms) are obtained from TRIM.FaTE. As noted in Section 1.1.2.2, the TRIM.FaTE outputs included as inputs to MIRC are the following:

- PB-HAP concentrations in air;
- air-to-surface deposition rates for PB-HAPs in both particle and vapor phases;
- PB-HAP concentrations in fish tissue for water column carnivores and benthic carnivores; and
- PB-HAP concentrations in surface soil and root zone soil.

In general, plant- and animal-specific parameter values, including chemical-specific transfer factors for FFC media, were obtained from the Hazardous Waste Companion Database included in HHRAP (EPA 2005a). Attachment B provides parameter values used in MIRC for the Tier 1 assessment.

2.4.2 Ingestion Exposure

MIRC was used to estimate ingestion rates as ADDs, normalized to body weight for a range of exposure pathways. Exposure pathways included are incidental ingestion of soil, consumption of fish, produce, farm animals and related products, and ingestion of breast milk by infants. The ingestion exposure pathways included in the screening evaluation and the environmental media through which these exposures occur are summarized in Exhibit 15.

2.4.2.1 Exposure Scenarios and Corresponding Inputs

Specific exposure scenarios are developed by defining the ingestion activity patterns (i.e., estimating how much of each medium is consumed and the fraction of the consumed medium that is grown in or obtained from contaminated areas) and the characteristics of the hypothetical human exposed (e.g., age and body weight). MIRC computes exposure doses and risks for each ingestion pathway separately, enabling the pathway(s) of interest for each PB-HAP to be determined. Data related to exposure factors and receptor characteristics were obtained primarily from EPA's *Exposure Factors Handbook* (EPA 2011).

Exhibit 15. Summary of Ingestion Exposure Pathways and Routes of Uptake

Ingestion Exposure Pathway	Medium Ingested	Intermediate Exposure Pathway – Farm Animals[a]	Environmental Uptake Route	
			Medium	Process[b]
Incidental ingestion of soil	Untilled surface soil	N/A	Surface soil	Deposition; transfer via erosion and runoff [c]
Consumption of fish	Fish from local water body	N/A	Fish tissue	Direct uptake from water and consumption of food compartments modeled in TRIM.FaTE[c]
Consumption of breast milk[d]	Breast milk	N/A	Breast milk	Contaminant ingested by mother partitions to breast milk
Consumption of produce	Aboveground produce, exposed fruits and vegetables	N/A	Air Air Soil	Deposition to leaves/plants Vapor transfer Root uptake
	Aboveground produce, protected fruits and vegetables	N/A	Soil	Root uptake
	Belowground produce	N/A	Soil	Root uptake
Consumption of farm animals and related food products	Beef	Ingestion of forage	Air Air Soil	Direct deposition to plant Vapor transfer to plant Root uptake
		Ingestion of silage		
		Ingestion of grain	Soil	Root uptake
		Ingestion of soil	Soil	Ingestion from surface
	Dairy (milk)	Ingestion of forage	Air Air Soil	Direct deposition to plant Vapor transfer to plant Root uptake
		Ingestion of silage		
		Ingestion of grain	Soil	Root uptake
		Ingestion of soil	Soil	Ingestion from surface
	Pork	Ingestion of silage	Air Air Soil	Direct deposition to plant Vapor transfer to plant Root uptake
		Ingestion of grain	Soil	Root uptake
		Ingestion of soil	Soil	Ingestion from surface
	Poultry	Ingestion of grain	Soil	Root uptake
		Ingestion of soil	Soil	Ingestion from surface
	Eggs	Ingestion of grain	Soil	Root uptake
		Ingestion of soil	Soil	Ingestion from surface

[a] Calculation of intermediate exposure concentrations were required only for the farm animal/animal product ingestion pathways.
[b] Process by which HAP enters medium ingested by humans.
[c] Modeled in TRIM.FaTE.
[d] The consumption of breast milk exposure scenario is discussed in Section 2.4.2.3.

For the Tier 1 scenario described here, exposure characteristics that would result in a highly health protective estimate of total exposure were selected. The ingestion rate for each medium was set at high-end values (equal to the 90th percentile values for all food types except for fish, which was set at 99th percentile values). All media were assumed to be obtained from locations impacted by the modeled source. Although this approach could result in an overestimate of total chemical exposure for a hypothetical exposure scenario (for example, note that the total food ingestion rate that results is extremely high for a hypothetical consumer with ingestion rates in the upper percentile for every food type), it was selected to avoid underestimating exposure for any single farm food type. The exposure characteristics selected for the Tier 1 scenario are summarized in Exhibit 16.

Exhibit 16. Overview of Exposure Factors Used for RTR Multipathway Screening[a,b]

Exposure Factor	Selection for Screening Assessment
Age group evaluated	Infants under 1 year (breast milk only) Children 1–2 years of age Children 3–5 years of age Children 6–11 years of age Children 12–19 years of age Adult (20–70 years)
Body weight (BW; varies by age)	Weighted mean of national distribution or recommended value
Ingestion rate (IR) for farm produce and animal products other than fish (varies by age and medium)	90th percentile of distribution of consumers who produce own food
Ingestion rate for fish	For adults, 99th percentile *as-prepared* ingestion rate representative of subsistence fisher woman. For children, based on 99th percentile, *as-prepared*, consumer-only, national ingestion rates – adjusted.
Exposure frequency (EF)	365 days/year
Exposure duration	Lifetime, for estimating cancer risk; varies by chemical for chronic non-cancer evaluation
Fraction contaminated (FC) (varies by media consumed)[c]	1
Cooking loss[d]	Assumed to be "typical"; varies depending on food product (see Attachment B). Cooking losses were not considered for fish consumption because intake rates represent "as prepared" values.
Food preparation/cooking adjustment factor for fish[e]	Mercury = 1.5 Cadmium = 1.5 Dioxin = 0.7 PAH = 1.0

[a] Data for exposure characteristics are presented in Attachment B. Exposure parameter values were based on data obtained primarily from the *Exposure Factors Handbook* (EPA 2011). See Attachment B for details.

[b] Exposure factor inputs are used in calculating ADD estimates for each exposure pathway. ADD equations for each pathway evaluated in this screening assessment are provided in Attachment B.

[c] Fraction contaminated represents the fraction of food product that is derived from the environment included in the screening scenario (e.g., produce grown on soil impacted by PB-HAPs). This parameter is defined separately for each FFC medium; however, for the Tier 1 scenario, all ingested media are assumed to be impacted.

[d] Cooking loss inputs were included to simulate the amount of a food product that is not ingested due to loss during preparation or cooking, or after cooking.

[e] Because "as consumed," fish consumption rates are used with whole-fish concentrations, adjustments might be appropriate to adjust the fish tissue concentrations to reflect concentrations after food preparation. See Attachment B, Section 6.4.4 for additional discussion.

2.4.2.2 Calculating Average Daily Doses

MIRC calculates chemical-specific ADDs normalized to body weight (mg PB-HAP per kg of body weight per day). Equations used to calculate ADDs were adapted from the algorithms provided in the technical documentation of EPA's *Multimedia, Multipathway, and Multireceptor Risk Assessment (3MRA) Modeling System* (EPA 2003), which derived much of its input data from the *Exposure Factors Handbook* (EPA 2011). The ingestion exposure modeling approach embodied by 3MRA is conceptually similar to that presented in HHRAP. A discussion of exposure dose estimation and the equations to calculate ADDs for each ingestion pathway are provided in Attachment B.

2.4.2.3 Infant Ingestion of Breast Milk

A nursing mother exposed to contaminants by any ingestion pathway described above can pass the contaminants to her infant through breast milk (ATSDR 1998). The nursing infant's exposure can be estimated from the levels of chemical concentrations in the breast milk, which in turn can be estimated based on the mother's chemical intake.

Reports of bioaccumulation of lipophilic compounds such as polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), and dioxins are prevalent in the scientific literature. Due to their high lipophilicity, these compounds partition almost exclusively to the milk fat of breast milk rather than the aqueous phase (EPA 1998). PCBs, PCDFs, and PCDDs are the most documented groups of contaminants found in breast milk. Other compounds with lower octanol-water partition coefficients, such as phenol, benzene, halobenzenes, and PAHs, are found in both the milk fat and the aqueous phase of breast milk. Heavy metals such as arsenic, lead, cadmium, and mercury have been found in the aqueous phase of the breast milk. However, given their chemical and physical characteristics (and the impact such qualities have on partitioning within the body and pharmacokinetics), substances that do not partition as strongly to the lipophilic phase of breast milk tend to be of lower concern with regard to exposures to nursing infants. Because of the greater concern with regard to dioxins for this exposure pathway, it is the only PB-HAP included in the breast milk exposure pathway for RTR at this time. This approach is consistent with the risk assessment procedures included in EPA's Human Health Risk Assessment Protocol (EPA 2005a).

Exposure via the breast milk consumption pathway is estimated in MIRC for dioxins only. This pathway is included in computing total exposure for developing the screening threshold for dioxins. In the absence of congener-specific data, dioxin congeners were assumed to manifest the same tendency to accumulate in breast milk as 2,3,7,8-TCDD.

2.4.3 Calculating Risk

MIRC was used to calculate excess lifetime cancer risk and non-cancer hazard (expressed as the hazard quotient or HQ) using the calculated ADDs and ingestion dose-response values. Chemical dose-response data include cancer slope factors (CSFs) for ingestion and non-cancer oral RfDs. The CSFs and RfDs for the PB-HAPs included in the Tier 1 scenario are presented in Exhibit 17 and are discussed in more detail in Attachment B. Equations used to estimate cancer risk and non-cancer hazard also are provided in Attachment B.

Exhibit 17. Dose-response Values for PB-HAPs Addressed by the Screening Scenario

PB-HAP	CSF ([mg/kg-day]$^{-1}$)	Source	RfD (mg/kg-day)	Source
Inorganics				
Cadmium compounds (as Cd)	not available		1E−3	IRIS
Elemental mercury	not available		not available	
Divalent mercury	not available		3E−4	IRIS
Methyl mercury	not available		1E−4	IRIS
Organics				
Benzo[a]pyrene[a]	7.3	IRIS	not available	
2,3,7,8-TCDD	1.5E+5	EPA ORD	7E−10	IRIS

Source: EPA (2007).

CSF = cancer slope factor; RfD = reference dose; IRIS = EPA's Integrated Risk Information System; Cal/EPA = California Environmental Protection Agency; EPA ORD = EPA's Office of Research and Development

[a] For consistency with the overall approach for dose-response assessment of PAHs, the CSF listed in IRIS for benzo[a]pyrene ([7.3 mg/kg-day]$^{-1}$) was adjusted due to its mutagenic mode of action as discussed below (see also Attachment B).

Estimated individual cancer risks for the PAHs included in the screening scenario were adjusted upward to account for the mutagenic cancer potency of these compounds during childhood, as specified by EPA in supplemental guidance for cancer risk assessment (EPA 2005c). Specifically, cancer potency for PAHs is assumed to be tenfold greater for the first 2 years of life and threefold greater for the next 14 years. These factors were incorporated into a time-weighted total increase in potency over a lifetime of 70 years. The cancer potency adjustment for chemicals with a mutagenic mode of action is discussed in Attachment B.

2.4.4 Summary of Tier 1 Assumptions

As emphasized previously, the screening scenario created for evaluating PB-HAP emissions from RTR facilities is intended to be health protective to prevent underestimating risk. The scenario also is intended to avoid grossly overestimating risk to the point where no emissions screen. The overall degree to which the scenario is health protective is the sum of the multiple assumptions that affect the outputs of the fate and transport, exposure, and risk modeling. Exhibit 18 summarizes important characteristics that influence exposure and risk estimates for this scenario and indicates the general degree of health protectiveness associated with the values for each assumption. Although this summary does not provide a quantitative estimate of the output uncertainty or the degree to which exposures and risks estimated using the scenario would be overestimated, it does demonstrate qualitatively that the scenario generally overestimates exposure and thus favors a health-protective risk output.

Exhibit 18. Summary of RTR Tier 1 Screening Scenario Assumptions

Characteristic	Value	Neutral or Health Protective?	Comments on Assumptions
General Spatial Attributes			
Farm location	375 m from source; generally downwind	Health Protective	Location dictates soil and air concentrations and deposition rates used to calculate chemical levels in farm produce.
Lake location	375 m from source; generally downwind	Health Protective	Location dictates where impacted fish population is located.

Characteristic	Value	Neutral or Health Protective?	Comments on Assumptions
Surface soil properties	Typical values or national averages	Neutral	Based on existing EPA documentation and other references.
Size of farm parcel	About 4 ha	Health Protective	Relatively small parcel size results in higher chemical concentration.
Size of lake	47 ha; about 3 m average depth	Health Protective	Lake is large enough to support an aquatic ecosystem with higher trophic-level fish, but is relatively small and shallow (thus increasing surface area-to-volume ratio).
Meteorological Inputs			
Total precipitation	1.5 m/yr	Health Protective	Intended to represent rainy U.S. location; set to highest state-wide average for the contiguous United States.
Precipitation frequency (with respect to impacted farm/lake)	2/3 of total precipitation fall on farm/lake and watershed	Health Protective	Most of total precipitation occurs when the farm/lake are downwind of the source.
Wind direction	Farm/lake are downwind 40% of the time	Health Protective	Farm/lake located in the predominantly downwind direction. Temporal dominance of wind direction based on data from Yakima, Washington, where wind is predominantly from the west.
Wind speed	2.8 m/sec	Health Protective	Low wind speed (5th percentile of long-term averages for contiguous United States); increases net deposition to lake/watershed.
Air temperature	298 K	Neutral	Typical for summer temperatures in central and southern United States.
Mixing height	710 m	Health Protective	Relatively low long-term average mixing height (5th percentile of long-term averages for contiguous United States); increases estimated air concentration.
Watershed and Water Body Characteristics			
Evaporation of lake surface water	700 mm/yr	Neutral	Based on sensitivity analyses, value is not expected to under- or overestimate concentration in surface water.
Surface runoff into lake	Equal to 40% of total precipitation	Health Protective	Based on typical water flow in wetter U.S. locations; higher runoff results in greater transfer of chemical to lake.
Surface water turnover rate in lake	About 12 turnovers per year	Neutral	Consistent with calculated water balance; reasonable in light of published values for small lakes. Might overestimate flushing rate if water inputs are also overestimated. Note that after evapotranspiration, remaining water volume added via precipitation is assumed to flow into or through lake.

Characteristic	Value	Neutral or Health Protective?	Comments on Assumptions
Soil erosion from surface soil into lake	Varies by parcel; ranges from 0.002 to 0.01 kg/m^2-day	Neutral	Erosion rates calculated using the universal soil loss equation (USLE); inputs to USLE were selected to be generally conservative with regard to concentration in the pond (i.e., higher erosion rates were favored). Might underestimate erosion for locations susceptible to high erosion rates. Note that higher erosion increases concentration in lake (and fish) but decreases levels in surface soil (and farm products).
Aquatic food web structure and components	Multilevel; includes large, upper trophic-level fish	Health Protective	Inclusion of upper trophic-level fish and absence of large-bodied herbivore/detritivore fish favor higher concentrations of bioaccumulative chemicals and result in higher concentrations in consumed fish. Linear food-chain maximizes concentration of bioaccumulative chemicals in higher trophic-level fish.
Parameters for Estimating Concentrations in Farm Food Chain Media			
Fraction of plants and soil ingested by farm animals that is contaminated	1.0 (all food and soil from contaminated areas)	Health Protective	Assumes livestock feed sources (including grains and silage) are derived from most highly impacted locations.
Soil- and air-to-plant transfer factors for produce and related parameters	Typical (see Attachment B for details)	Neutral	Obtained from peer-reviewed and standard EPA reference sources.
Biotransfer factors for efficiency of uptake by animal of chemical in food/soil	Typical (see Attachment B for details)	Neutral	Obtained from peer-reviewed and standard EPA reference sources.
Bioavailability of chemicals in soil (for soil ingested by animals)	1.0 (relative to bioavailability of chemical in plant matter)	Health Protective	Probably overestimates bioavailability in soil; many chemicals are less bioavailable in soil than in plants.
Ingestion Exposure Assumptions			
Ingestion rates for all farm produce/livestock types	Person obtains all food sources from local farm; ingestion rate is 90th percentile of rates for home-produced food items	Health Protective	All food derived from impacted farm; total food ingestion rate would exceed expected body weight-normalized ingestion rates (prevents underestimating any individual food type).
Fish ingestion rate	Adult: 373 g/day Child age groups: 1 to 2: 108 g/day 3 to 5: 159 g/day 6 to 11: 268 g/day 12 to 19: 331 g/day	Health Protective	The adult rate is the 99th percentile value for adult females from Burger (2002) and is considered representative of subsistence fishers. Rates for children are based on the 99th percentile, consumer-only fish ingestion rates from EPA 2002. Rates were adjusted

Characteristic	Value	Neutral or Health Protective?	Comments on Assumptions
			to be representative of the age groups used in the screening scenario. See Attachment B for a detailed discussion.
Exposure frequency	Consumption of contaminated food items occurs 365 days/yr	Health Protective	All meals from local farm products.
Body weight	Mean of national distribution	Neutral	Note that this does not affect the body-weight-normalized rates for produce and animal products.
Other Chemical-Specific Characteristics			
General chemical properties used in fate and transport modeling (Henry's law, K_{ow}, etc.)	Varies	Neutral	Obtained from peer-reviewed sources; intended to be representative of typical behavior and characteristics.
"General" physical properties (plant matter density, aquatic life biomass, algal growth rate, etc.)	Varies	Neutral	Obtained from peer-reviewed sources; intended to be representative of typical behavior and characteristics.
Dose-response values	Varies	Neutral to Health Protective	Values used are those determined to be appropriate for risk assessment by OAQPS; values are developed to be health protective.

2.5 Evaluation of Screening Scenario

2.5.1 Introduction

The screening scenario developed for assessing multipathway human health risk for EPA's Risk and Technology Review has been subjected to a series of evaluations. As described previously the major PB-HAP categories of concern for this assessment are cadmium compounds (Section 2.5.2), mercury compounds (Section 2.5.3), dioxins (Section 2.5.4), and POM (Section 2.5.5). The scenario evaluations were focused primarily on assessing the behavior of these HAP categories in the environment, the accumulation of these chemicals in ingestible food products, and the predominant pathways of human exposure.

2.5.2 Cadmium Compounds

Some of the largest anthropogenic sources of cadmium to air are facilities that process, mine, or smelt cadmium-zinc ores or cadmium-zinc-lead ores, coal- and oil-fired boilers, other urban and industrial facilities, phosphate fertilizer manufacturing facilities, road dust, and municipal sewage sludge incinerators (ATSDR 2008).

2.5.2.1 Behavior in the Environment

Once emitted into the environment, airborne cadmium particles can be transported over long distances before being deposited. Cadmium has been observed to partition primarily to soil when released to the environment (ATSDR 2008). The mobility of cadmium in soil depends strongly on soil pH, clay content, and availability of organic matter—factors that determine whether the cadmium is dissolved or sorbed in surface soil. In general, cadmium adsorbs to soil particles in the surface layers of the soil profile, but to a lesser degree than many other heavy metals (HSDB 2005). Cadmium also binds strongly to organic matter, rendering the metal relatively immobile in some soils. Nonetheless, some plants still can take up cadmium efficiently, thus providing an entry point for cadmium into the food chain (ATSDR 2008).

Cadmium also enters surface waters, which can occur via atmospheric deposition, runoff and erosion, or wastewater streams. Most cadmium compounds entering the water column are quickly removed through adsorption to organic matter in sediment or to other suspended compounds. Cadmium that remains in the water column is expected to exist primarily in the dissolved state where it is available for uptake by aquatic organisms.

Freshwater fish accumulate cadmium primarily through direct uptake of the dissolved form through the gills and secondarily through the diet, which plays a variable role in total cadmium uptake (Reinfelder et al. 1998; Chen et al. 2000; Saiki et al. 1995). Although some biomagnification of cadmium has been reported for aquatic food chains in saltwater systems, biomagnification in freshwater systems appears to be present only at lower trophic levels (Chen et al. 2000) and in narrowly defined niches (e.g., plankton/macroinvertebrate food chains; Croteau et al. 2005). Biomagnification factors (BMFs) of less than 1 generally have been reported for fish at higher trophic levels, indicating that cadmium concentrations generally biodiminish from lower to higher trophic levels (Chen et al. 2000; Mason et al. 2000).

For the RTR screening scenario, the partitioning behavior modeled in TRIM.FaTE was consistent with the behavior of cadmium expected in the natural environment.

2.5.2.2 Concentrations in Ingestible Products

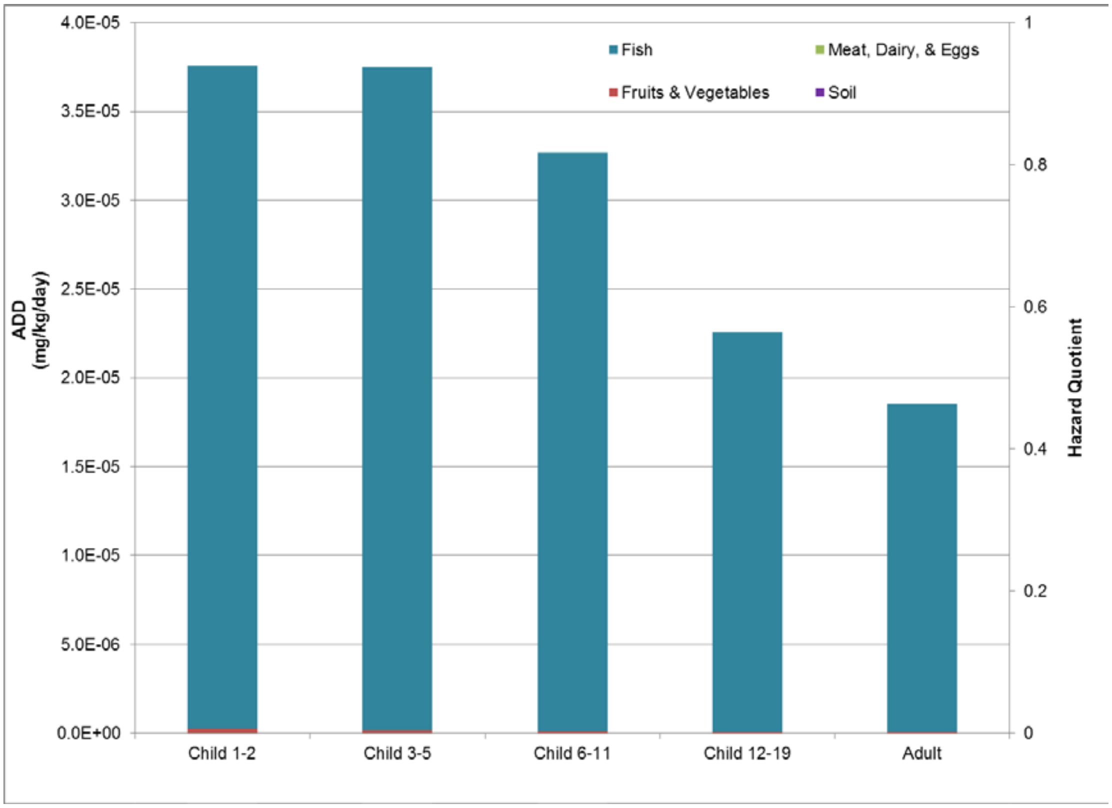
Most non-inhalation exposure to cadmium outside of occupational settings is through dietary intake. Available data indicate that cadmium accumulates in plants, aquatic organisms, and terrestrial animals, offering multiple ingestion exposure pathways (ATSDR 2008). Actual cadmium levels in ingestible products, however, varies based on type of food, agricultural and cultivation practices, atmospheric deposition rates, characteristics of environmental media, and presence of other anthropogenic pollutants. Meat and fish generally contain lower amounts of cadmium overall, but cadmium can be highly concentrated in certain organ meats, such as kidney and liver (ATSDR 2008). In a study of cadmium concentrations in 14 food groups (including prepared foods), meat, cheese, and fruits generally contained low levels of cadmium (ATSDR 2008).

For the RTR screening scenario, the cadmium concentrations output by MIRC were consistent with reported values in all ingestible media products. The products with higher reported cadmium levels in the literature, including soil, plants, and fish, also contained the higher modeled concentrations.

2.5.2.3 Average Daily Dose (ADD)

To determine the media most relevant to exposure and risk, the ingestion exposure factors must be considered in addition to the estimated media concentrations (i.e., a higher concentration for a particular medium does not necessarily mean higher risk). In Exhibit 19, the contributions of ingestion exposure pathways to the average daily dose (ADD) (and thus the HQ) for the different age categories are presented. As shown in the exhibit, fish ingestion is the dominant exposure pathway across all age categories, accounting for nearly 100 percent of the ADD for all groups. The combined contribution from all other exposure pathways accounts for less than 0.7 percent of the total ADD for all age groups. Most of the additional exposure was from ingestion of fruits and vegetables. The highest ADD corresponds to children aged 1–2 years; thus, the exposure corresponding to this group was used to determine the emission threshold for cadmium. In other words, the threshold emissions rate for cadmium is set at the level where the HQ for this age category is equal to 1.0.

Exhibit 19. Estimated Contributions of Modeled Food Types to Cadmium Ingestion Exposures and Hazard Quotients



2.5.3 Mercury Compounds

Some of the largest anthropogenic sources of mercury to air are facilities that process, mine, or smelt mercury ores; industrial/commercial boilers; fossil fuel combustion activities (primarily coal); cement production facilities; other urban and industrial facilities; and medical and municipal waste incinerators (ATSDR 1999). These facilities can emit a mixture of elemental and divalent mercury, mostly in the gaseous phase, with some divalent forms in particle-bound phases (EPA 1997).

2.5.3.1 Behavior in the Environment

Once emitted into the environment, mercury undergoes changes in form and species as it moves through environmental media. Elemental mercury is the most prevalent species of mercury in the atmosphere. Due to the long residence time of elemental mercury in the atmosphere, this compound is relatively well distributed, even on a global scale.

Divalent mercury is removed from the atmosphere at a faster rate than elemental mercury, and it can be transferred to the surface near the emission source via wet or dry deposition where it appears to adsorb tightly to soil particles (EPA 1997) or dissolved organic carbon. Divalent mercury in soil also can be methylated by microbes or reduced to elemental mercury and revolatilized back into the atmosphere. Most divalent mercury from atmospheric deposition will remain in the soil profile, however, in the form of inorganic compounds bound to soil organic matter. Although this complexing behavior with organic matter significantly limits mercury transport, the ability of mercury to form these complexes greatly depends on soil conditions such as pH, temperature, and soil humic content. For example, mercury strongly adsorbs to humic materials and sesquioxides in soil at pH > 4 and in soils with high iron and aluminum content (ATSDR 1999). Small amounts of mercury in soil can be transported to surface water via runoff or leaching.

Mercury could also enter the water column through atmospheric fallout. Once in the water body, divalent mercury can be methylated through microbial activity. In addition, divalent and methyl mercury can be further reduced to elemental mercury, which can volatilize and reenter the atmosphere. Solid forms of inorganic mercury compounds could adsorb to particulates in the water column or partition to the sediment bed (EPA 1997).

The solubility of mercury in water depends on the species and form of mercury present as well as properties of the water such as water pH and chloride ion concentration (ATSDR 1999). Low pH favors the methylation of mercury in the water column, typically performed by sulfur-reducing bacteria in anaerobic conditions. Methyl mercury is typically of greatest concern because it readily bioaccumulates and efficiently biomagnifies in aquatic organisms. A considerable amount (25–60 percent) of both divalent mercury compounds and methyl mercury is strongly bound to particulates in the water column (EPA 1997). The remaining mercury is dissolved. Most of the elemental mercury produced as a result of reduction of divalent mercury volatilizes back into the atmosphere.

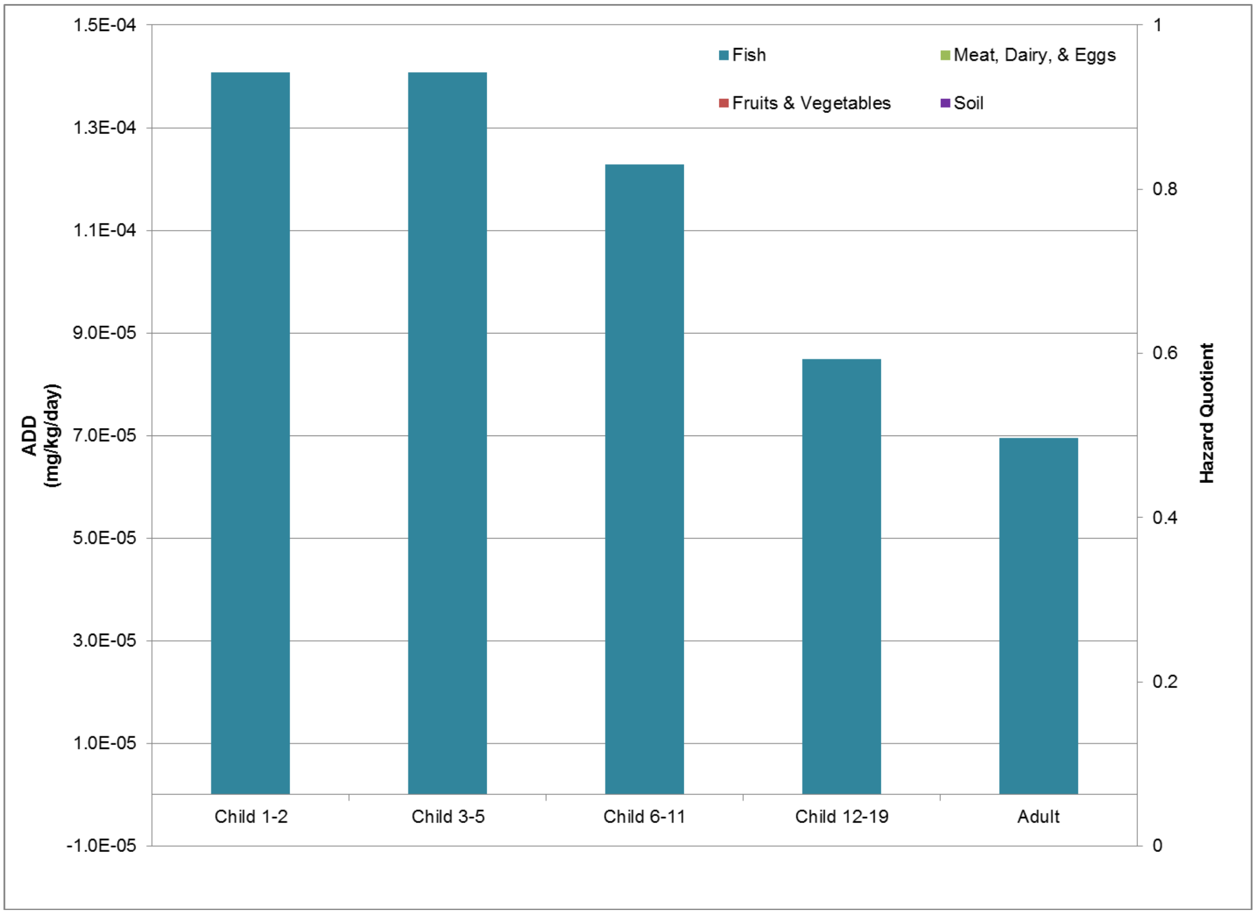
For the screening scenario, the partitioning behavior modeled in TRIM.FaTE generally was consistent with trends noted in the literature. Divalent mercury was the most prevalent species in modeled surface soil, surface water, and sediment compartments, while methyl mercury was the dominant species in fish.

2.5.3.2 Concentrations in Ingestible Products

Available data indicate that mercury bioaccumulates in plants, aquatic organisms, and terrestrial animals, providing multiple ingestion exposure pathways (EPA 1997; ATSDR 1999). Low levels of mercury are found in plants, with leafy vegetables containing higher concentrations than potatoes, grains, legumes, and other vegetables and fruits (ATSDR 1999; EPA 1997). Cattle demethylate mercury in the rumen and, therefore, store very little of the mercury they ingest by foraging or consuming silage or grain. Thus, mercury content in meat and cow's milk is low (ATSDR 1999). Concentrations of methyl mercury in fish are generally highest in larger, older specimens at the higher trophic levels (EPA 1997).

Although data on mercury in foods other than fish are not abundant in the literature, total mercury concentrations output by MIRC were generally consistent with the reported values that were available. The exposure pathways that most influenced the mercury HQs in the model are presented in Exhibit 20. As shown, the dominant exposure pathway for all age groups is ingestion of fish. Relative to divalent mercury, methyl mercury concentrations in fish were very high (approximately 95 percent of total mercury).

Exhibit 20. Estimated Contributions of Modeled Food Types to Methyl Mercury Ingestion Exposures



2.5.3.3 Average Daily Dose

In Exhibit 20, the contributions of ingestion exposure pathways to the ADD (and thus the HQ) for methyl mercury across the different age categories are presented. As shown, fish is the dominant exposure pathway across all age categories, accounting for nearly 100 percent of the ADD for each group. The combined contribution of all other exposure pathways accounts for less than 1 percent of the total ADD for all age groups. The high degree of exposure to methyl mercury through fish ingestion is attributed to the ease with which this compound bioaccumulates and biomagnifies in fish and to the health protective ingestion assumptions used in the screening scenario. The highest ADD corresponds to children aged 1–2 years; thus, the exposure corresponding to this group was used to determine the emission threshold for mercury.

2.5.4 Dioxins

Incineration and combustion processes are believed to be the primary emission sources for chlorinated dioxins (ATSDR 1998). The five stationary source categories that generate the vast majority of 2,3,7,8-TCDD emissions in the United States are municipal waste incineration, medical waste incineration, hazardous waste kilns from Portland cement manufacturing, secondary aluminum smelting, and biological incineration.

2.5.4.1 Behavior in the Environment

Dioxins emitted to the atmosphere can be transported long distances in vapor form or bound to particulates, depositing in soils and water bodies in otherwise pristine locations far from the source. Although airborne dioxins are susceptible to wet and dry deposition, most dioxins emitted to the atmosphere through incineration/combustion processes are not deposited close to the source (ATSDR 1998).

In soil, dioxins strongly adsorb to organic matter and show very little vertical movement, particularly in soils with a high organic carbon content (ATSDR 1998). Most dioxins deposited in soil are expected to remain buried in the soil profile, with erosion of contaminated soil particles the only significant mechanism for transport to water bodies.

The dry deposition of dioxins from the atmosphere to water bodies is another important transport process. Because of the hydrophobic nature of dioxins, most dioxins entering the water column are expected to adsorb to suspended organic particles or partition to bed sediment, which appears to be the primary environmental sink for this chemical group (EPA 2004c). Although dioxins bound to aquatic sediment primarily become buried in the sediment compartment, some resuspension and remobilization of congeners can occur if sediments are disturbed by benthic organisms (ATSDR 1998).

Bioaccumulation factors (BAFs) in fish are high as a result of the lipophilic nature of chlorinated dioxins. Although the processes by which freshwater fish accumulate dioxins are not well understood, both fish and invertebrates bioaccumulate congeners that have partitioned to sediment or have become suspended in water (EPA 2004c). Because most dioxins in the aquatic environment are adsorbed to suspended particles, however, direct uptake from the water is unlikely to be the primary route of exposure for most aquatic organisms at higher trophic levels (ATSDR 1998). At lower trophic levels, the primary route of exposure appears to be through uptake of water in contaminated sediment pores, and the primary route of exposure in the higher trophic levels appears to be through food chain transfer. Following ingestion, some fish can slowly metabolize certain congeners, such as 2,3,7,8-TCDD, and release the polar metabolites in bile. This process ultimately might limit bioaccumulation at higher trophic levels (ATSDR 1998).

For the RTR screening scenario, the partitioning behavior modeled in TRIM.FaTE was consistent with the behavior of 2,3,7,8-TCDD expected in the natural environment. Also of note is that dioxins readily partition into breast milk due to the lipophilic nature of these compounds.

2.5.4.2 Concentrations in Ingestible Products

The primary source of non-inhalation exposure to dioxins outside of occupational settings is through dietary intake, which accounts for more than 90 percent of daily dioxin exposure (ATSDR 1998). Available data indicate that dioxins concentrate in plants, aquatic organisms, and animals, offering multiple ingestion exposure pathways. Actual congener levels in ingestible products, however, can vary based on type of food, agricultural and cultivation practices, atmospheric deposition rates, characteristics of environmental media, and presence of other anthropogenic pollutants. Dioxins appear to enter the terrestrial food chain primarily through vapor-phase deposition onto surfaces of plants, which are then consumed by larger animals. Another major source of exposure to dioxins is through ingestion of contaminated soil by animals.

Observed trends indicate that meat, dairy, and fish consumption are the dominant exposure pathways, comprising 90 percent of dioxin dietary intake (ATSDR 1998). Consistent with the literature, the modeled concentration of 2,3,7,8-TCDD in the fish compartment for the screening scenario was at least one order of magnitude greater than concentrations in the other compartments. Among the compartments with the lowest concentrations were fruits and vegetables, which do not readily accumulate 2,3,7,8-TCDD.

Ingestion of breast milk during infancy and fish ingestion contribute to over 97 percent of lifetime dioxin exposure for 2,3,7,8-TCDD in the screening scenario. Daily intakes of 2,3,7,8-TCDD from cow's milk, produce, and fish have been reported in the literature to comprise 27 percent, 11 percent, and 10 percent, respectively, of the total daily intake in the general population. Some studies note that specific subpopulations, such as subsistence farmers and fishers, however, might have very different exposure profiles in which fish, meat, and dairy drive congener exposure (ATSDR 1998). Given the subsistence diet modeled in the RTR screening scenario, the high exposure from consumption of fish is appropriate within the context of this assessment.

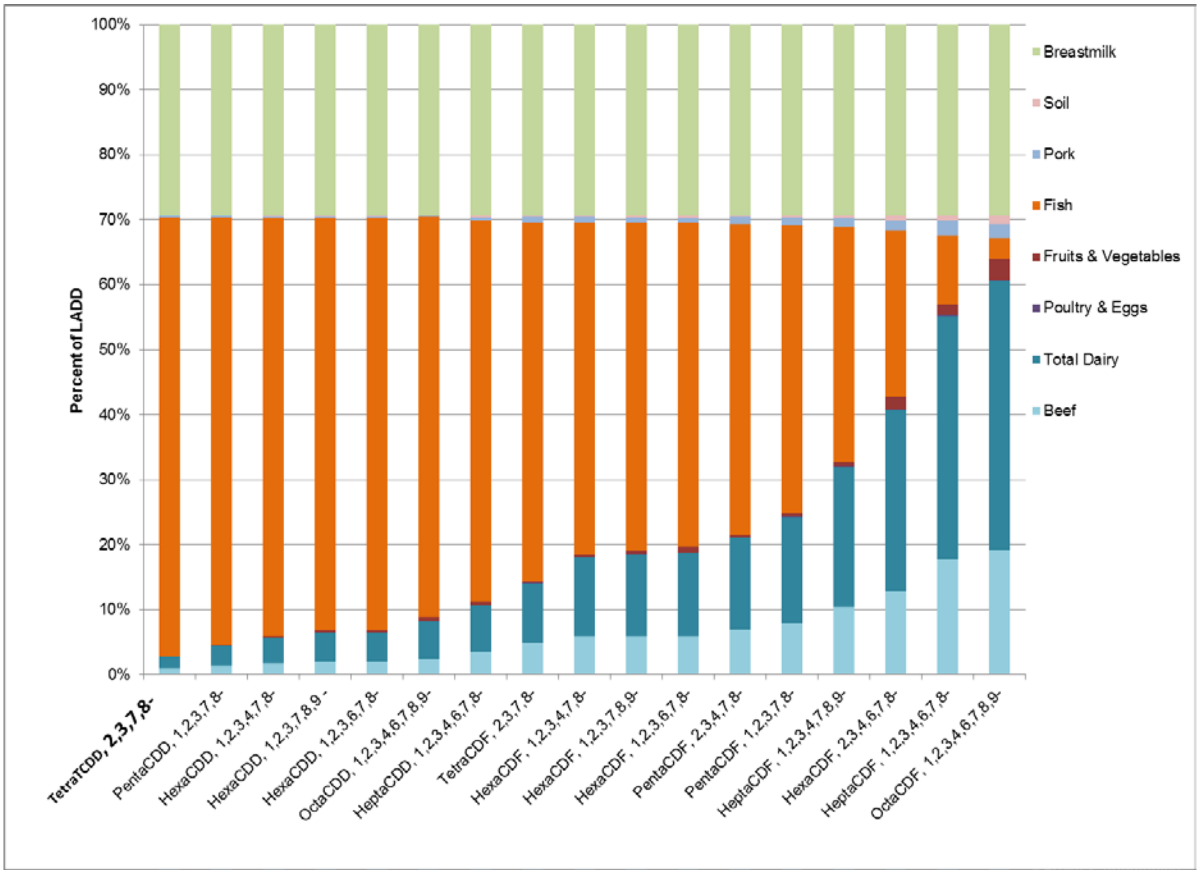
2.5.4.3 Lifetime Average Daily Dose (LADD)

The contributions of ingestion exposure pathways to the lifetime average daily dose (LADD) (and thus lifetime cancer risk) for the modeled dioxin congeners are presented in Exhibit 21. Based on the modeling methodology and assumptions used, exposures via the breast milk pathway consistently account for approximately 30 percent of the lifetime exposure for all congeners, while exposure via fish, soil, and the various farm food chain pathways is highly variable across congeners. This variability can be explained in part by differences in the physiochemical properties that drive the environmental transport processes of these congeners (e.g., K_{ow}, molecular weight). The differences are also likely attributed to differences in the congener-specific half-life in abiotic media and the degree to which the congener is metabolized in biotic media.

2.5.5 Polycyclic Aromatic Hydrocarbons

PAHs can enter the atmosphere as a result of a variety of combustion processes, both natural and anthropogenic. Stationary emission sources account for approximately 80 percent of total annual PAH emissions. Although the primary source of stationary source PAH emissions is thought to be residential wood burning, other processes such as power generation; incineration; coal tar, coke, and asphalt production; and petroleum catalytic cracking are also major contributors (ATSDR 1995).

Exhibit 21. Estimated Contributions of Modeled Food Types to Dioxin Ingestion Exposures



2.5.5.1 Behavior in the Environment

PAHs emitted to the atmosphere can travel long distances in vapor form or attached to particles, or they can deposit relatively close to an emission source via wet or dry deposition onto water, soil, and vegetation. In the atmosphere, PAHs are found primarily in the particle-bound phase, and atmospheric residence time and transport distances are highly influenced by climatic conditions and the size of the particles to which they are bound (ATSDR 1995).

As a result of sustained input from anthropogenic sources, PAHs are ubiquitous in soil. High molecular weight PAHs, such as benzo(a)pyrene, strongly adsorb to organic carbon in soil, indicating that adsorption to soil particles will limit the mobility of these compounds following deposition to soil (ATSDR 1995).

Most PAHs enter the water column directly through atmospheric deposition (ATSDR 1995). Following deposition onto surface waters, approximately two-thirds of PAHs adsorb strongly to sediment and suspended particles, while only small amounts revolatilize back to the atmosphere (ATSDR 1995). Aquatic organisms can accumulate PAHs via uptake from water, sediment, or food. Although fish and other organisms readily take up PAHs from contaminated food (e.g., aquatic insects, other benthic invertebrates, smaller fish), biomagnification generally does not occur because many organisms can rapidly metabolize PAHs (ATSDR 1995). As a result, concentrations of PAHs have generally been observed to decrease with increasing trophic levels (ATSDR 1995). Due to this ability to metabolize PAHs, BAFs in fish are not expected to be especially high. Sediment-dwelling organisms can experience increased exposure to PAHs through association (e.g., direct uptake, consumption) with contaminated sediment (ATSDR 1995).

For the screening scenario, the partitioning behavior of benzo(a)pyrene is generally consistent with trends reported in the literature.

2.5.5.2 Concentrations in Ingestible Products

The primary source of non-inhalation exposure to benzo(a)pyrene outside of occupational settings is through dietary intake. Exposure can depend on the origin of the food (higher values are often recorded at contaminated sites) and the method of food preparation (higher values have been reported for food that is smoked or grilled). PAHs have been observed to bioaccumulate in aquatic organisms and terrestrial animals through uptake of contaminated water, soil, and food. These compounds are readily metabolized by higher trophic level organisms, including humans, however, so biomagnification is not considered to be significant (ATSDR 1995). Plants accumulate PAHs primarily through atmospheric deposition, but chemical concentrations tend to be below detection levels. PAHs in meat have been observed at concentrations below detection levels up to higher concentrations when the meat is smoked. Similar concentrations have been reported for fish, with smoked fish concentrations sometimes quadruple those found in terrestrial animals. Because PAH concentrations are highest in products that are smoked or grilled, most of the available data for benzo(a)pyrene in food is for products that have been prepared using these processes. As a result, reported values might be significantly higher than those output by MIRC.

For the RTR screening scenario, concentrations output by MIRC were generally lower than the reported ranges for benzo(a)pyrene in ingestible products. This trend is likely the result of background exposure in reported measurements and available data that are skewed toward concentrations in highly contaminated products. Considering these mitigating factors, the RTR screening scenario output concentrations are within the range of plausible values for PAHs in ingestible products.

2.5.5.3 Lifetime Average Daily Dose

The contributions of ingestion exposure pathways to the LADD (and thus lifetime cancer risk) for various PAHs are presented in Exhibit 22. As shown, the variability in the driving exposure pathways across PAHs is significant, with fish, beef, dairy, fruits, and vegetables comprising between 90 and 99 percent of exposure for different PAHs.

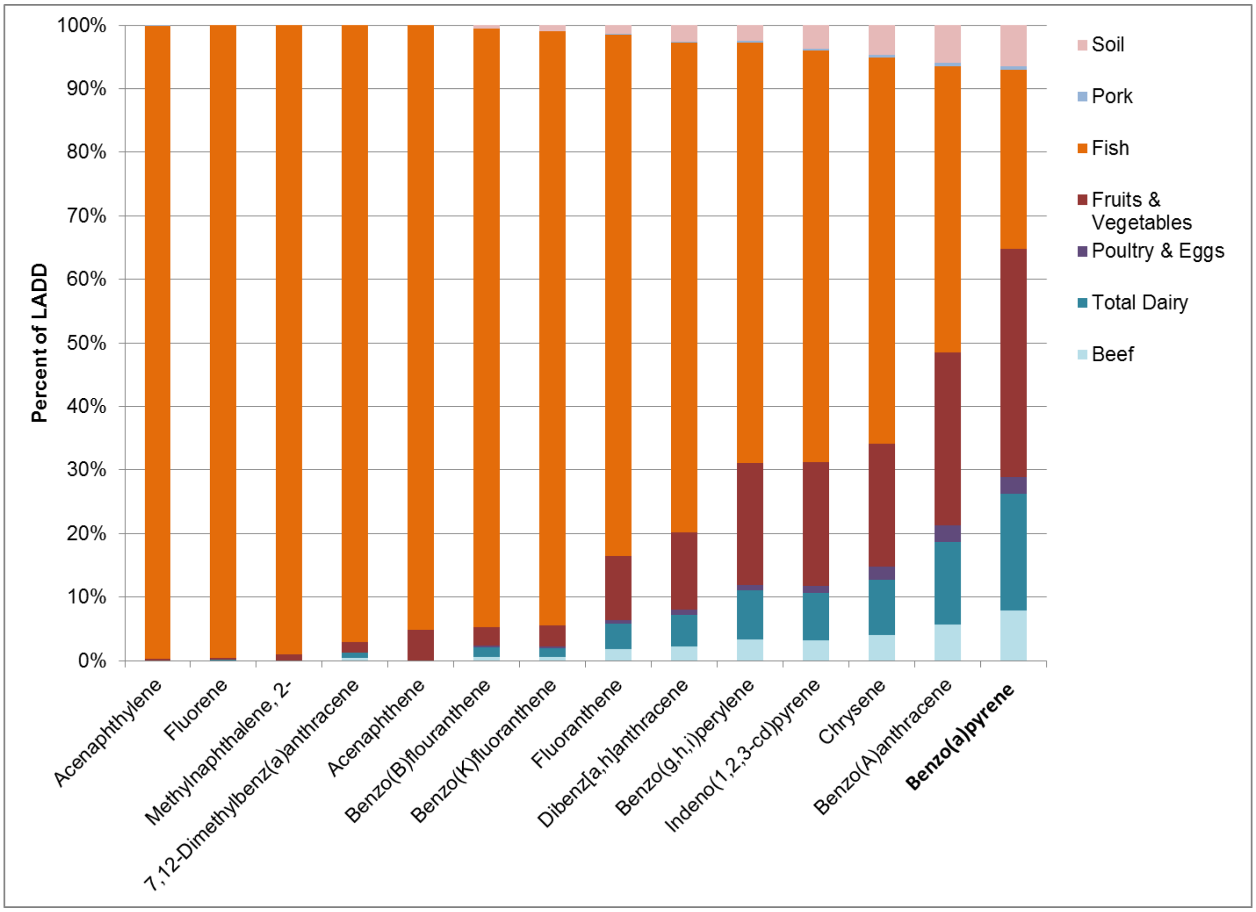
This variability can be accounted for in part by differences in the physiochemical properties that drive the environmental fate and transport processes of these PAHs (e.g., K_{ow}, molecular weight, chemical structure), differences in the PAH-specific half-life in abiotic media, and the degree to which the PAHs are metabolized in biotic media. The variability in exposure pathways is consistent with information provided in the literature.

2.5.6 Summary

This assessment provides a summary of the fate and transport processes and the major routes of exposure for the PB-HAP categories of interest to EPA’s RTR Program, as modeled in TRIM.FaTE. In general, the modeled behavior of the compounds is consistent with data found in the literature.

This assessment reveals that fish ingestion is a major route of exposure for cadmium, mercury, dioxins, and PAHs. For organics (i.e., dioxins and PAHs), the farm-food-chain also is a major route of exposure, with beef and dairy contributing significantly to the LADD.

Exhibit 22. Estimated Contributions of Modeled Food Types to PAH Ingestion Exposures



3. Tier 2 Methodology

3.1 Overview of Approach

The Tier 1 screening scenario is, by design, generic and health-protective. It was constructed to allow for quick application to a large number of facilities in a source category with a minimal chance of returning false negatives for risk. Based on screening assessments conducted for RTR to date, many facilities might not screen out of the Tier 1 assessment for some source categories. Because the Tier 1 screen uses numerous health-protective assumptions, the assessment must be refined to determine whether the facility is actually expected to pose a risk above levels of concern.

One way to refine the risk estimates is to conduct a site-specific assessment where the Tier 1 model values and layout are replaced with site-specific values and layouts wherever possible. However, this approach would not be feasible given the resource intensive nature of a site-specific assessment and the number of facilities that might not screen out of the Tier 1 assessment in some source categories.

As an intermediate approach, we instead refine our Tier 1 screening estimates to Tier 2 screening estimates. This is done by replacing some of the more health-protective assumptions in a Tier 1 screen with more site-appropriate values. Specifically, for Tier 2, the following parameter values are varied from their Tier 1 values:

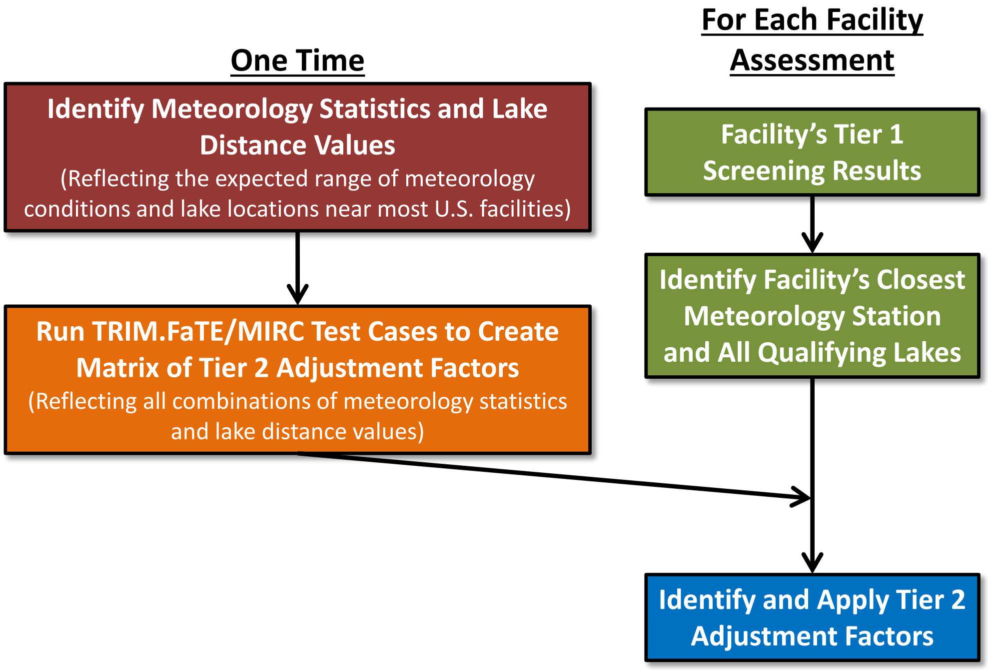
- Meteorological characteristics, including the fraction of time the wind blows in the direction of each farm and lake (using wind direction), the wind speed, the precipitation rate, and the mixing height; and
- Locations of fishable lake(s) relative to the facility (including the absence of a fishable lake).

In addition, a refined fisher scenario is used to model risks associated with nearby lakes. The refined fisher scenario is based on the idea that an adult fisher might fish from multiple lakes if the first (i.e., highest-concentration) lake is unable to provide him an adequate catch to satisfy the assumed ingestion rate (i.e., 373 g/d for adults). This assessment uses the assumption that the biological productivity limitation of each lake is 1 gram of fish per acre of water: meaning that in order to fulfill the adult ingestion rate, the fisher will need to fish from 373 total acres of lakes.

In selecting the fate and transport variables listed above to include in Tier 2 adjustments, a balance was struck between: 1) the degree of impact on the potential risk estimate; 2) the ease of implementation in TRIM.FaTE; and 3) the ease of obtaining site-specific values on a facility-by-facility basis. Because of the expected variability in exposure parameters amongst any population living around a given facility, the exposure parameters pertaining to farm ingestion pathways remain fixed at their health-protective Tier 1 levels. However, the fish ingestion rates might vary on a site-specific level using the refined fisher scenario based on the availability of lakes to fish.

Tier 2 screening assessments are performed for those facilities that do not screen out during the Tier 1 assessment. The overall implementation of Tier 2 is shown in Exhibit 23. The starting point (shown in green) is the ratio of the facility emission rate for the PB-HAP of concern to the Tier 1 threshold for that PB-HAP. Next, the facility-specific estimates of the Tier 2 meteorological and lake-location parameters listed above must be gathered for each facility (shown in red). Then, the associated TRIM.FaTE and MIRC risk estimates must be calculated (shown in orange). Because of the volume of facilities that need to be evaluated in Tier 2, the implementation focuses on estimating refined risk using pre-calculated databases (discussed below) rather than gathering the input data and performing TRIM.FaTE and MIRC modeling separately for each facility.

Exhibit 23. Basic Process for Implementing Tier 2



First, databases of the relevant U.S. meteorological and lake data were created that can be accessed during a Tier 2 evaluation (shown in red in the figure). These meteorological and lake data are discussed in more detail in Section 3.5. The meteorological database includes annual-average summary statistics on wind direction, wind speed, and precipitation for more than 800 surface stations paired with their closest upper-air stations located throughout the United States. These surface data cover year 2011 and are the same AERMOD-ready data used by EPA OAQPS for RTR inhalation modeling. As discussed below, in most cases the 2011 precipitation data were not used, and instead, the 30-year average annual precipitation data for each station were used. The database of lakes, available from ESRI® and based on U.S. Geological Survey data, includes information on the location, size, use or type designation, and name (if available) of all lakes in the United States. To focus on lakes that can support angling of upper trophic level fish, lakes used for disposal, evaporation, or treatment were excluded, and only lakes greater than 25 acres in area are included. Lakes larger than 100,000 acres in area are not included because the sizes of their watersheds and the complexity of their lake dynamics are not feasible to model with the TRIM.FaTE modeling system.

In parallel to the meteorological and lake data collection, a series of TRIM.FaTE simulations was performed that systematically varied the values for four of the five selected fate and transport variables (shown in orange in the figure, consisting of lake location, wind speed, precipitation rate, and mixing height). Wind direction affects only whether the chemical mass advects toward the farm and lake, so the effect of site-specific wind directions can be evaluated outside TRIM.FaTE simulations. These simulations do not simulate specific facilities; instead, four or five alternative values for each of the four variables were selected using statistics on U.S. meteorological data or professional judgment to capture the expected range in the facility data. TRIM.FaTE simulations were performed for every possible combination of these variable values to enable the estimation of appropriate site-specific threshold adjustment factors for scenarios with the corresponding characteristics. Based on the TRIM.FaTE results of these simulations (and the subsequent exposure and risk characterization, conducted using MIRC), a matrix of Tier 2 threshold adjustment factors was calculated, with each element of the matrix corresponding to a unique combination of values from each of the selected variables. The contribution of each exposure media toward each scenario's Tier 2 risk metric (i.e., the individual contributions of fish ingestion, soil ingestion, beef ingestion, etc. toward the total Tier 2 risk metric) was included in the matrix because the Tier 2 assessment separates chemical exposure from fish ingestion from exposure from farm food chain ingestion.

These TRIM.FaTE and MIRC simulations are used to estimate part of the Tier 2 threshold adjustment factors. Wind direction is the other part of the Tier 2 threshold adjustment factors. The wind direction adjustment for a given facility is the ratio of the frequency that winds blow toward the Tier 1 farm and lake (43 percent of the time) and the frequency that winds blow toward the facility-specific farm and lake in Tier 2. These Tier 2 threshold adjustment factors are multiplied by each other and represent the ratio between the risk metric (i.e., cancer risk or HQ) obtained using the Tier 1 screening scenario and the risk metric obtained from the Tier 2 TRIM.FaTE runs. For a given facility, an adjusted Tier 2 ratio (emissions compared to the emission threshold) can be estimated by dividing the Tier 1 emission ratio (the output of the Tier 1 screen) by the adjustment factor that best corresponds to the meteorological conditions present at the site and the presence and location of lakes at the site:

$$\textit{Tier 2 Ratio} = \textit{Tier 1 Ratio} \div \textit{Tier 2 Adjustment Factor}$$

Matrices of threshold adjustment factors from the TRIM.FaTE and MIRC simulations were separately developed for the four PB-HAPs that currently have screening emission thresholds in the Tier 1 process: benzo(a)pyrene (BaP, representative of PAHs), cadmium, divalent mercury and 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD, representative of dioxins). The wind direction threshold adjustment factors were irrespective of chemical (specific only to the facility). In implementing the Tier 2 process, a risk equivalency approach was used to convert speciated emissions of PAHs and dioxins into BaP and TCDD equivalents, respectively, similar to the Tier 1 screening approach.

Finally, to implement the Tier 2 screen, a Microsoft® Access™ tool was created that includes the database of meteorological data and lake data as well as the Tier 2 adjustment factors for the combinations of variables simulated in the Tier 2 TRIM.FaTE simulations. In the tool, each facility is matched with the same surface meteorological station used in the RTR inhalation risk assessment, and the values for the four relevant parameters at that station are recorded (wind speed, wind direction, precipitation rate, and mixing height). The tool also facilitates the identification of all qualifying lakes in the area surrounding the facility and their distances and directions relative to the facility. These five values become the set of facility-specific parameters. The threshold adjustment factor corresponding to this set of site-specific data is then estimated using the matrix of adjustment factors and the wind direction adjustment. Wind direction values are used as-is with no rounding or binning. If one of the four facility matrix variables (wind speed, precipitation rate, mixing height, or lake location) is between two of the computed levels available for that variable in the simulation matrix, the more health-protective of the two levels is selected (i.e., the level that resulted in the smaller adjustment to the Tier 1 exposure). The Tier 1 screening emission threshold for a PB-HAP is then divided by the appropriate adjustment factors to obtain an updated Tier 2 emission threshold for that PB-HAP at that facility. A facility then screens out in Tier 2 if the emissions are below the Tier 2 threshold for the fisher scenario and for the farmer scenario.

3.2 Selection of Site-Specific Characteristics for the Tier 2 Assessment

The screening scenario used to derive Tier 1 thresholds incorporates assumptions regarding meteorological conditions, the spatial configuration of the hypothetical exposure setting, physical parameters of the environment, and chemical-specific parameters that result in generally health-protective results. In Tier 2, selected assumptions used in the fate and transport modeling conducted using TRIM.FaTE are modified to reflect more site-specific information for the facilities being evaluated.[19] To determine which scenario characteristics should be incorporated into the Tier 2 assessment, the following issues were considered for TRIM.FaTE model parameters:

- How sensitive are the modeled risks to a specific user-input model parameter (e.g., wind direction, wind speed)?
- Do the plausible values for a given parameter span a large range when comparing different RTR facility locations?
- Which site-specific characteristics can be found easily and reliably for facilities with emissions exceeding Tier 1 thresholds?
- In general, is the uncertainty associated with the parameter high or low?
- How complicated or time-consuming is the incorporation of a given parameter (e.g., wind speed) into the screening scenario set-up?

Attachment D provides an exhibit showing all the TRIM.FaTE variables considered for the Tier 2 assessment. These variables were evaluated qualitatively using the criteria above to determine whether the variable was of high, medium, or low priority. The following five “high priority” variables were selected for implementation in the current Tier 2 assessment:

- Wind direction (the percent of time the wind blows toward the lake and farm),
- Wind speed,
- Precipitation,
- Mixing height, and
- Location of fishable lakes relative to the facility.

These parameters were judged to represent a balance between range of potential variability, ease of implementation within the modeling scheme used for RTR, and ease of obtaining site-specific values with a relatively high level of confidence.

3.3 Estimation of Adjustment Factors for Selected Site-Specific Parameters

The purpose of including site-specific detail for a facility evaluated in Tier 2 is to develop a more realistic estimate of risk associated with facility emissions. This purpose is achieved within the assessment by generating revised emission thresholds of potential concern specific to a given PB-HAP on a facility-by-facility basis. However, instead of performing full-fledged, site-specific model runs for each facility that does not “screen out” in Tier 1, a set of generally applicable threshold adjustment factors for each PB-HAP was developed based on a set of model runs.

---

[19] Only TRIM.FaTE parameters were considered for inclusion in Tier 2 adjustments because of the difficulty in identifying substantial ***location-related*** differences in values for exposure factors (and other inputs to MIRC). The exposure characteristics used in MIRC are considered to be generally consistent across different locations and facilities.

For each PB-HAP, these runs corresponded to unique combinations of values for wind speed, precipitation rate, mixing height, and lake location (wind direction is assessed separately). These adjustment factors were based on a set of runs in which the values for these parameters were varied systematically. The wind direction adjustment factor is the ratio of the frequency that winds blow toward the lake and farm in the Tier 1 screening scenario (43 percent) and the frequency that winds blow toward the facility's farm and lake in Tier 2, with a separate wind direction adjustment factor for each directional octant (i.e., separate factors for the farm and lakes in the northern octant, the farm and lakes in the northeastern octant, etc.). The appropriate adjustment factors are then applied to the Tier 1 threshold for that PB-HAP when evaluating a facility in Tier 2.

The analyses conducted to select the parameters to derive the threshold adjustment factors are described in this section. Section 3.3.2 also describes the development of appropriate "bins" for the selected parameters. These bins correspond to the subset of parameter values for which adjustment factors were calculated, based on the anticipated range of plausible values for facilities evaluated in RTR.

3.3.1 Selection Values for Variables of Interest

For each site-specific parameter that is assessed in the Tier 2 assessment, other than wind direction, adjustment factors were estimated that correspond to a set of four to six particular values for the parameter. The adjustment factor for wind direction directly relates Tier 1 and site-specific Tier 2 wind direction frequencies, with respect to the directions of the lake and farm. These individual adjustment factors can then be multiplied for a particular variable combination to get an overall adjustment factor. To facilitate this, bins were created for each parameter of interest and a relevant range of values, with the exception of wind direction (as described below, representative bins were not necessary for this parameter). The rationale for selecting the range for each bin for each parameter of interest is described below.

Wind Direction: Within the context of the hypothetical exposure scenario used in Tier 1 (and under actual conditions), when the frequency with which the wind blows towards the modeled domain (i.e., where the hypothetical farm and lake are located) increases, greater pollutant deposition will occur over and around the farm and lake. The percentage of time the wind blows toward the farm and lake is therefore positively correlated with ingestion exposure and risk. In the screening scenario used to estimate Tier 1 thresholds, the wind is assumed to blow toward the modeled domain 3 days a week, or 43 percent of the time. This assumption is intended to approximate an unusually consistent long-term wind pattern and is representative of wind direction patterns in Yakima, Washington (where the wind blows eastward approximately 40 percent of the time, based on a review of wind direction data compiled by the National Weather Service).

In the model runs to develop the Tier 2 bins, this factor was changed to 1, 2, and 4 days per week, corresponding to 14 percent, 29 percent, and 57 percent of the time. This range of values was chosen to obtain a good understanding of the impact of wind direction on risk for the range of wind direction patterns likely to be present at real facilities. Review of these results indicated that, within this modeling scenario, estimated ingestion exposure varies directly with percentage of time the wind blows toward the farm and lake. Given the exactly linear nature of the relationship observed in model results obtained from these runs, the adjustment of the threshold for wind direction in Tier 2 is a direct, linear adjustment **using the actual site value** rather than an incremental, bin-based approach. In other words, the Tier 1 threshold is adjusted for wind direction in direct proportion to the difference between conditions for the actual facility location and the wind direction parameters included in the Tier 1 screening scenario (i.e., blowing toward the lake/farm 43 percent of the time on average).

Wind Speed: Although the impact of wind speed on non-inhalation risks also is likely to depend on configurational parameters such as the location of farms and lakes, in general it is reasonable to assume that higher wind speeds lead to more rapid chemical transfer out of the modeled domain, allowing less time for chemical deposition and, therefore, less total near-field deposition and a lower exposure and risk. The Tier 1 screening assessment assumed a wind speed of 2.8 m/s, corresponding to the 5th percentile (i.e., slower) of annual average speed for the contiguous United States (distribution was based on data from a climate publication from the National Oceanic and Atmospheric Administration [NOAA], which used data from over 200 stations nationwide).[20] This value is similar to the annual average wind speeds of the U.S. Deep South.[21] In the model runs to develop the Tier 2 threshold adjustment factors, we calculated the change to exposure resulting from increasing this value to 3.5 m/s, 4 m/s, and 5 m/s (values also shown in Exhibit 24; 5 m/s is the 88th percentile in the NOAA data). Based on these values, the bins used to classify wind speed are: 2.8–3.5 m/s, 3.5–4 m/s, 4–5 m/s and above 5 m/s. In all modeled cases, increasing the wind speed while maintaining constant lake location, wind direction, mixing height, and precipitation led to Tier 2 estimations of high-end risk or hazard that were smaller than that of Tier 1. To ensure that the approach is health-protective, a facility was assigned the lower end value of the bin into which it was placed. Facilities with wind speeds less than 2.8 m/s were assumed to have a wind speed of 2.8 m/s.

Precipitation: Higher levels of precipitation over the modeled domain are expected to increase non-inhalation risks by increasing particulate and gaseous wet deposition near-field to the source. The screening scenario used in Tier 1 assessment assumed an annual precipitation rate of 1,500 mm/year. This level of annual precipitation was estimated to represent rainy conditions in the U.S., such as parts of the U.S. Deep South and parts of the U.S. Northwest Coast[22]. Though the rate was an estimate, it does correspond to approximately the 95th percentile (i.e., higher rate) precipitation in the National Climatic Data Center's (NCDC) 30-year (1981–2010) data from U.S. stations.[23] To estimate adjustment factors in the Tier 2 assessment, model simulations were conducted with the parameter value set to three lower values (i.e., 1,187 mm/year, 924 mm/year and 512 mm/year; values also shown in Exhibit 24), corresponding to the 75th, 50th and 25th percentiles, respectively, of the NCDC data. Locations with lower precipitation levels were assumed to have a minimum precipitation of 512 mm/year. Based on these levels, the bins used to classify precipitation were: 0-512 mm/year, 512-924 mm/year, 924-1,187 mm/year, 1,187-1,500 mm/year, and above 1,500 mm/year. In nearly all modeled cases, decreasing the precipitation rate while maintaining constant lake location, wind speed, wind direction, and mixing height led to Tier 2 estimations of high-end risk or hazard that were smaller than that of Tier 1. To be health-protective, a facility was assigned the upper end value of the bin in which it was placed. Facilities with precipitation levels above 1,500 mm/year were assumed to experience precipitation of 1,500 mm/year.

---

[20] http://ols.nndc.noaa.gov/plolstore/plsql/olstore.prodspecific?prodnum=C00095-PUB-A0001#TABLES – this website is updated yearly, so its current data may not match the data used to develop wind speeds for screening analyses.

[21] National Climatic Data Center CliMaps (NCDC-CliMaps) (2007).

[22] National Climatic Data Center Historical Climate Series (NCDC-HCS) (2007).

[23] http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

Exhibit 24. Lake Distance and Meteorological Parameter Values for which Adjustment Factors were Developed in Tier 2[a,b]

Parameter	Value
Wind Speed (m/s)	**2.8**
	3.5
	4
	5
Precipitation (mm/yr)	512
	924
	1,187
	1,500
Mixing Height (m)	**710**
	865
	1,097
	1,537
Lake Distance (km)	No lake
	2
	5
	10
	20
	40

[a] Bold indicates the value is equal to the value used in Tier 1.
[b] Wind direction is not shown here because its effect on modeled exposure and risk in TRIM.FaTE is linear.

Mixing Height: Greater mixing heights can dilute the concentration of pollutants in air, resulting in lower deposition and other transfer rates from air to surfaces and consequently also lower ingestion exposures. The Tier 1 screening assessment assumed a mixing height of 710 meters. This value is the 5th percentile (i.e., lower) of annual average mixing heights for 463 U.S. locations, based on data obtained from EPA's SCRAM Web site.[24] To estimate adjustment factors in the Tier 2 assessment, model simulations were conducted with the parameter value set to three larger values (i.e., 865 m, 1,079 m, and 1,537 m; values also shown in Exhibit 24). These values correspond to North Little Rock, Arkansas; Boise, Idaho; and Tucson, Arizona; and they are intended to encompass the range of annual average mixing heights experienced in different parts of the United States. Based on these levels, the following bins were selected for categorization of mixing height: 710–865 m, 865–1,079 m, 1,079–1,537 m, and above 1,537. In all modeled cases, increasing the mixing heights while maintaining constant lake location, wind direction, wind speed, and precipitation rate led to Tier 2 estimations of high-end risk or hazard that were smaller than that of Tier 1. To be health-protective, a facility was assigned the lower end value of the bin into which it was placed. Facilities with mixing heights above 1,537 m and those below 710 m were assumed to have mixing heights of 1,537 m and 710 m, respectively.

Lake Location: Moving the lake included in the hypothetical Tier 1 scenario to a location farther from the actual source in the modeled domain will reduce modeled (TRIM.FaTE) deposition to the lake and its watershed and consequently reduce exposures associated with

---

[24] Support Center for Regulatory Atmospheric Modeling; http://www3.epa.gov/scram001/

the fish consumption pathway. For the scenario modeled in Tier 1, the center of the lake was situated approximately 2 km from the source. To estimate lake location adjustment factors for use in Tier 2, we completed a series of model runs in which the lake was located 5 km, 10 km, 20 km, and 40 km from the source, as well as runs with no lake (values also shown in Exhibit 24). Accordingly, the bins used to classify lake location relative to the facility are: no lake, 2–5 km, 5–10 km, 10–20 km, 20–40 km, and 40–50 km (lakes farther than 50 km are not considered). To be health-protective, a facility was assigned the lower end value of the bin into which it was placed. A facility with a lake closer than 2 km was assumed to have a lake at 2 km.

In resituating the lake at these alternative locations, we maintained ratios consistent with those included in the Tier 1 screening scenario for (1) lake area to total land area in the modeled domain, (2) runoff watershed area to lake area, and (3) erosion watershed area to lake area. Exhibit 25 provides a diagram of the TRIM.FaTE layout in each of the alternate lake location simulations except no-lake. We used a “thin” lake shape (i.e., downwind width much smaller than the cross-wind length) that minimized the potential effect of declining deposition with distance from stack that might affect lakes that are long in the downwind direction. By controlling for these potentially confounding effects, we could isolate the effect of lake location on risk appropriately. Moving the lakes to increasing distances from the stack required expansion of the modeled domain. Maintaining the same overall ratio of land area to lake area in each domain resulted in scenarios with increasingly large lakes, with surface area increasing with distance from the source. This approach also was taken for reasons of modeling convenience (i.e., taking into account resource requirements associated with reconfiguring the TRIM.FaTE spatial layout). The changes in lake size between these four runs are not expected to have a substantial independent effect on exposure and risk because the effect of increased lake size is offset by greater total deposition and runoff. Furthermore, the lake depth was not changed, which might be as important a parameter as lake surface area in determining the chemical concentrations in the water column and sediment. As noted above, we set up the configurations to ensure that the lakes in the different scenarios received runoff and erosion from equivalent watersheds on a per surface area basis.

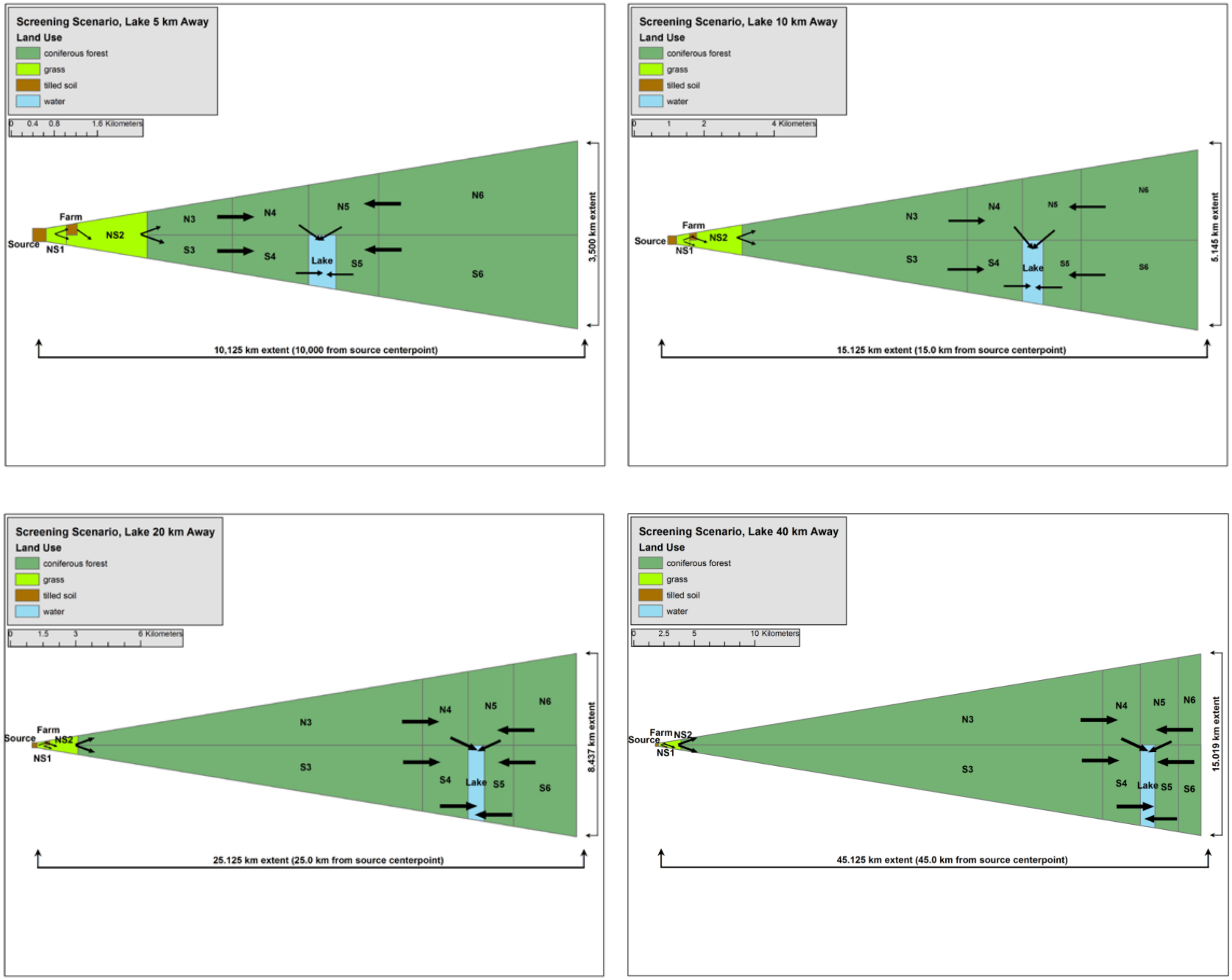
3.3.2 Estimation of Adjustment Factors

Adjustment factors were estimated for each variable described above and applied as divisors to the Tier 1 emissions thresholds. The resulting Tier 2 emissions thresholds are used to assess whether facilities with corresponding configurations carry some potential for significant multipathway health risks by comparing their actual emissions to the Tier 2 thresholds.

3.3.2.1 General Approach

The core principle in the estimation of adjustment factors is the assumption of direct proportionality of risk and emissions in the modeling approach used for RTR involving TRIM.FaTE and MIRC. Although not strictly present across all variations due to feedback mechanisms and other processes encompassed by the TRIM.FaTE model, a generally linear relationship between risk and emissions has been observed across model simulations conducted for RTR. This suggests that the ratio of total estimated exposures (and consequently risks) obtained for the screening scenario and any alternative configuration could be used as an adjustment factor to scale emissions for that specific alternative configuration. The risk in the alternative configuration following such a scaling of emissions would be equal to the risk in the screening scenario (which in Tier 1 was set at a risk level of 1E−6 incremental lifetime cancer risk or an incremental HQ of 1, depending on the toxic effect of the chemical in question).

Exhibit 25. Layouts for Tier 2 TRIM.FaTE Simulations Using Alternate Distances Between the Facility and the Fishable Lake[a]



---

[a] The no-lake scenario is not shown.

To account for potential interactions between the chosen Tier 2 variables, matrix adjustment factors were estimated by performing TRIM.FaTE runs for each unique combination of the specified variable values (that is, all permutations of the selected values for the wind speed, precipitation, mixing height, and lake location). Adjustment factors for each configuration were then estimated as the ratio of risks in the Tier 1 assessment to the estimated risk for the particular TRIM.FaTE configuration. This approach results in a large matrix of adjustment factors and has the advantage of accounting for all possible interaction effects between the variables. The contribution of each exposure media toward each scenario's Tier 2 risk metric (i.e., the individual contributions of fish ingestion, soil ingestion, beef ingestion, etc. toward the total Tier 2 risk metric) was included in the matrix because the Tier 2 assessment separates chemical exposure from fish ingestion from exposure from farm food chain ingestion.

The adjustment factor for wind direction is handled separately. Based on TRIM.FaTE test runs, the fraction of the time the wind blows in the direction of the farm and lake was observed to have a direct, linear effect on the resulting risk estimates. For this reason, it was not necessary to include this variable in the TRIM runs conducted to create the matrix of adjustment factors, as described above. Instead, the adjustment factor is calculated with a linear factor that divides the Tier 1 value (0.43, or 43% of the time in the direction of the farm and lake) by the site-specific facility value, as follows:

$$\textit{Adjustment Factor}_{\textit{Wind Direction}} = 0.43 \,/\, (\textit{fraction of time wind blows towards domain})$$

The adjustment factor for wind direction is then multiplied by the matrix adjustment factor discussed above to obtain a consolidated threshold adjustment factor that accounts for all the five variables considered in Tier 2.

3.3.2.2 Incorporation of the Risk Equivalency Approach

The adoption of a risk-equivalency approach to convert speciated emissions of PAHs and dioxins to BaP and TCDD equivalents, respectively, in Tier 1 required the development of risk equivalency factors (REFs) for each reported species in these groups. The REFs for PAHs and dioxins represent the ratio of the risk posed by a particular species to the risk posed by BaP and TCDD, respectively, at equivalent emissions rates in a given scenario.

The REFs can be represented as the product of exposure equivalency factors (EEFs) and toxicity equivalency factors (TEFs). For the PAHs, this can be expressed as:

$$REF_{PAH} = EEF_{PAH} \times TEF_{PAH}$$

The EEFs for PAHs represent the ratio of the exposure to a particular species to the exposure to BaP (and similarly for dioxins and TCDD) at equivalent emission rates. These ratios are thus specific to the TRIM.FaTE layout and input assumptions. The TEFs for PAHs and dioxins represent the ratio of the oral cancer slope factor (CSF) for a particular species to the CSF for BaP and TCDD, respectively, and are the same in Tier 1 and in Tier 2.

The EEFs depend on the TRIM.FaTE configuration, including layout and meteorological input values. For example, the exposure profile (i.e., how the different ingestion pathways contribute to total exposure and risk) is different for each PAH. For a PAH where fish is a dominant driver of risk, moving the lake will have a large effect on the overall risk; however, if produce is the dominant driver of risk, moving the lake will have a much smaller effect on overall risk. Thus, for Tier 2, EEFs were recomputed for each of the representative scenarios modeled in Tier 2 separately for the PAH species currently evaluated (some based on direct TRIM.FaTE modeling, others 15 based on K_{ow}-based regression estimates) and the dioxin species currently evaluated (most based on direct TRIM.FaTE modeling, and a small number assumed to behave like TCDD).

The following mathematical formulas demonstrate how the Tier 2 adjustment factors are estimated for the PAH and dioxin species. The formulas presented below are for a representative PAH species, but they are also applied to dioxin species.

For a given PAH congener emitted at a rate E_{PAH} at a facility, the risk-equivalent BaP emission level can be expressed as:

$$E_{BAP\ EQIV} = E_{PAH\ SPECIES} \times EEF_{PAH\ SPECIES} \times TEF_{PAH\ SPECIES}$$

Then, the Tier 1 screening result is estimated by comparing the risk-equivalent BaP emissions to the BaP emission threshold:

$$Ratio_{TIER\ 1\_PAH\ SPECIES} = \frac{E_{TIER\ 1\_BAP\ EQUIV}}{Threshold_{TIER\ 1\_BAP}}$$

If the ratio is less than 1, the facility “screens out” of the Tier 1 assessment. Similarly, for Tier 2, the ratio of risk-equivalent BaP emissions to the Tier 2 BaP threshold may be expressed as:

$$Ratio_{TIER\ 2\_PAH\ SPECIES} = \frac{E_{TIER\ 2\_BAP\ EQUIV}}{Threshold_{TIER\ 2\_BAP}}$$

Using the definition of the risk-equivalent BaP emissions, this can be re-expressed for a given PAH species as:

$$Ratio_{TIER\ 2\_PAH\ SPECIES} = \frac{E_{PAH\ SPECIES} \times EEF_{TIER\ 2\_PAH\ SPECIES} \times TEF_{PAH\ SPECIES}}{Threshold_{TIER\ 2\_BAP}}$$

This expression may be further reconfigured, after some algebraic rearrangement, in terms of the Tier 1 ratio as:

$$Ratio_{TIER\ 2\_PAH\ SPECIES} = Ratio_{TIER\ 1\_PAH\ SPECIES} \times \frac{Threshold_{TIER\ 1\_BAP}}{Threshold_{TIER\ 2\_BAP}} \times \frac{EEF_{TIER\ 2\_PAH\ SPECIES}}{EEF_{TIER\ 1\_PAH\ SPECIES}}$$

$$Tier\ 2\ Adjustment\ Factor_{PAH\ SPECIES} = \frac{Threshold_{TIER\ 1\_BAP}}{Threshold_{TIER\ 2\_BAP}} \times \frac{EEF_{TIER\ 2\_PAH\ SPECIES}}{EEF_{TIER\ 1\_PAH\ SPECIES}}$$

These equations simply state that to adjust the Tier 1 threshold to a Tier 2 threshold for a particular PAH species, the adjustment factor must include the ratio of the BaP Tier 1 and 2 thresholds (as is true for cadmium, mercury, and TCDD, as discussed above) *and* the ratio of the EEFs for the particular PAH species in Tier 2 and Tier 1. This additional EEF factor is needed to account for the fact that the EEFs are different for each Tier 2 TRIM.FaTE configuration.

Finally, the ratio of total BaP equivalents contributed by all PAH species at a given facility to the BaP Tier 2 threshold may be expressed, by summing the above expression, as:

$$Ratio_{TIER\ 2\_ALL\ PAHs} = \sum^{ALL\ PAHs} Ratio_{TIER\ 1\_PAH\ SPECIES} \times \frac{Threshold_{TIER\ 1\_BAP}}{Threshold_{TIER\ 2\_BAP}} \times \frac{EEF_{TIER\ 2\_PAH\ SPECIES}}{EEF_{TIER\ 1\_PAH\ SPECIES}}$$

If the ratio of total BaP equivalents contributed by all PAH species to the BaP Tier 2 threshold is greater than 1, the facility would not have screened out of the Tier 2 assessment for the PAH group.

3.3.2.3 Refined Fisher Scenario

The refined fisher scenario is based on the idea that an adult fisher might fish from multiple lakes if the first (i.e., highest-concentration) lake is unable to provide an adequate catch to satisfy the assumed ingestion rate (i.e., 373 g/d for adults). This assessment uses the assumption that the biological productivity limitation of each lake is 1 gram of fish per acre of water: meaning that in order to fulfill the adult ingestion rate, the fisher will need to fish from 373 total acres of lakes (see Attachment E for further discussion on lake productivity).

Under the refined fisher scenario, a fisher fishes from each surrounding lake in order of highest chemical concentration in fish to lowest concentration and catches fish up to the biological productivity limit. A maximum travel radius is used to maintain a realistic scenario. The total screening result to the fisher can be expressed as the sum of all screening results for each lake (which is based on the ingestion rate and fish concentration for each respective lake).

A 50 km radius of lakes is used to maintain a realistic scenario. Depending on the model configuration, very large modeling configurations put a strain on computing resources, and TRIM.FaTE can crash if the domain is very large or if the domain is divided into too many compartments. In most scenarios, the vast majority of chemical deposition occurs across distances smaller than 50 km, so the added computing resources needed to model a domain larger than 50 km will usually not be offset by additional, substantial chemical deposition and exposure. Indeed, wind speeds must exceed 13 m/s (approximately 29 mph) sustained across an hour in order for the chemical plume to travel farther than 50 km; those wind speeds are unlikely to occur across the many days or weeks needed to substantially affect chronic exposure. In addition, a 50-km limit also puts a reasonable constraint on the domain of lakes for the fisher scenario.

In order for the Tier 2 screening to remain health protective, it is assumed that the fisher visits lakes in order of highest to lowest with respect to risk. If the first lake is 373 acres or greater, the fisher will only travel to that lake. If the acreage is smaller than 373 acres, then the fisher will travel to the next highest risk lake, and continues to travel to subsequent lakes until a total acreage of 373 acres is achieved, or until all qualifying lakes have been visited.

The associated risk for each lake is then scaled by the total adult ingestion rate (equations 1 and 2).

$$(1)\ Scaled\ T2\ Fish\ risk = T2\ Fish\ risk\ \times \left(\frac{Lake\ SA(acs)}{373\ acs}\right)$$

Equation 1: Scaled fish risk for each lake 1 to n-1

$$(2)\ Scaled\ T2\ risk = T2\ Fish\ risk\ \times \left(\frac{373\ acs - \sum(SAs\ of\ Previously\ Visited\ Lakes\ (acs))}{373\ \text{acs}}\right)$$

Equation 2: Scaled fish risk for nth lake

The risk associated with each lake visited is then summed together for a final risk (equation 3).

$$(3)\ Total\ Scaled\ T2\ Fish\ risk = (\text{Eq.}\ 2) + \sum(\text{Eq.}\ 1)$$

Equation 3: Total fish risk for scenario

If the total acreage of fishable lakes surrounding the facility fails to exceed 373 acres, then the risk for each lake is found using equation 1, and the total risk is the sum of all scaled risks (equation 4).

$$(4)\ Total\ Scaled\ T2\ Fish\ risk = \sum(\text{Eq.}\ 1)$$

Equation 4: Total fish risk if total acreage of lakes does not reach 373 acres

3.4 Preparing National Databases of Lake and Meteorological Data

To facilitate the effective application of the Tier 2 screening procedures, databases were prepared containing national-scale information about lakes (locations and sizes) and meteorological data at available surface stations (including wind direction, wind speed, precipitation, and estimated mixing height). The development and content of these two databases are discussed in the following sections.

3.4.1 Processing Lake Data for Tier 2 Assessment

The lake database was built using a geospatial file (U.S. Water Bodies) provided by ESRI® for their ArcGIS™ products.[25] Because this geospatial file excluded water bodies in Alaska, Puerto Rico, and the U.S. Virgin Islands, it was augmented with water body information (directly from the USGS National Hydrography Dataset) for those other locations. The data generally have an estimated horizontal accuracy of 50 m. For the Tier 2 assessment, we focused on the hundreds of thousands of water bodies classified as "Lake/Pond" or "Reservoir" but not designated for disposal, evaporation, or treatment. We refer to these water bodies simply as "lakes" in the remainder of this document. The approximately 100,000 other water bodies (classified as canal/ditch, ice mass, inundation area, playa, stream/river, swamp marsh, or unclassified) were not included. In a more subjective step during the processing of the lake database for a specific source category (when Tier 2 is run "operationally"), the lake names (when provided) are scrutinized manually, and lakes are removed from the assessment when their names suggest industrial or treatment use (e.g., wastewater treatment ponds, sludge ponds, fly ash ponds, paper mill ponds, sewage pools, etc.). In this respect, the lake dataset is never truly final; lake names are scrutinized each time a new set of facilities is assessed using the Tier 2 methods and tools, which can lead to the permanent removal of some lakes from the dataset.

Early in the process of compiling this database, we encountered the question: "What size water body qualifies as a 'lake' for the purposes of this assessment?" The Tier 2 assessment must focus on lakes large enough to support relatively intensive angling pressure to be compatible

---

[25] Specifically, the geospatial file in the ESRI® Data & Maps 2009 Data Update for ArcGIS™ version 9.3.1. It was derived by the United States Geological Survey (USGS), EPA, and ESRI® from the USGS National Hydrography Dataset (USGS 2012).

with the assumed exposure scenario. To estimate the relationship between high fish consumption rates, harvest rates, and lake size, the following five key assumptions were made. Information and citations to peer-reviewed literature that support these assumptions are provided in Attachment E. Note that in the TRIM.FaTE model screening scenario, water-column carnivores (WCCs) are modeled as trophic level 4 (TL4) fish (e.g., pickerel, largemouth bass), with all of their diet consisting of smaller "prey" or "pan" fish in the water column that are simulated as trophic level 3 (TL3). The benthic carnivores (BCs) in TRIM.FaTE are modeled to represent an intermediate trophic level between 3 and 4, i.e., TL3.5. The BCs (e.g., catfish) obtain half of their diet from TL2 (benthic invertebrates that feed on detritus at the sediment surface) and half from TL3 fish in the benthic environment. For the screening scenario, we assume that fishers consume fish biomass in a ratio of 50:50 from the BC and WCC compartments, respectively. Together, these two fish compartments are referred to as piscivorous fish.

1. Piscivorous fish, when present, comprise approximately 21 percent of the standing biomass of fish. BC fish represent 17.5 percent of the standing fish biomass in natural lakes; WCC fish account for 3.5 percent of this total fish biomass. Thus, WCC (or TL4) fish represent the limiting compartment for fish harvesting and consumption.
2. Humans can harvest 10 percent of any single fish compartment without threatening the population due to overharvesting.
3. The minimum viable effective population size for a single fish species is at least 50 adult fish for a local population to survive over the short term (e.g., more than a decade).
4. Only 33 percent of the fish caught for consumption is edible fillet muscle. A 0.33 edible fraction is used to estimate total fish biomass associated with human consumption.
5. A total fish standing biomass of 40 g wet weight/m^2 represents an approximate upper bound for natural ponds and lakes in the United States.

Using the above assumptions and a series of equations (see Attachment E), the maximum fish ingestion rates as a function of standing biomass and lake size were estimated. Exhibit 26 presents these findings, where the grey shading indicating when WCC fish would probably not be present, the white (unshaded) cells represent combinations of lake size and productivity that could sustain the listed fish ingestion rates over some time, and the yellow cells represent likely long-term sustainability associated with more than 500 adult WCC fish in the lake (see Exhibit notes).

The Tier 2 assessment is intended to retain most of the health-protective attributes of the screening scenario used in Tier 1 so that no facilities of potential concern erroneously "pass" the screen. For a given facility, the smaller the lake size threshold, the greater the number of lakes and the greater the probability that a lake is closer to the facility. Lakes closer to a facility will result in higher chemical concentrations in fish compared with lakes farther from the facility. Thus, Exhibit 26 was used to determine the smallest lake size that would support a TL4 population. At the assumed upper-limit standing fish biomass of 40 g ww/m^2, this corresponds to 25 acres (the first "white" box when moving from smaller to larger lakes).

The fish ingestion rate supported by a 25-acre lake is not as high as the adult ingestion rate used in the Tier 1 and Tier 2 assessments (i.e., 373 g ww fillet per day). Exhibit 26 indicates that at a total fish biomass productivity of 40 g ww/m^2, the maximum sustainable fish harvest from the WCC compartment would correspond to an ingestion rate of only 26 g/day for those fish, with an additional 26 g/day from the benthic carnivores (which are not the limiting population), for a total of 52 g per day. However, to be health protective and to ensure that small lakes that might be more highly contaminated than estimated by the TRIM.FaTE screens were not eliminated, we selected 25 acres as the “cutoff” for the minimum size for an actual lake near a facility to be included in the Tier 2 assessment. In addition, larger lakes (larger than 100,000 acres) were not considered since they cannot be readily modeled in TRIM.FaTE. For the purposes of proximity matching lakes to emitting facilities, the location of each lake is identified as the geographic centroid inside the lake.

It should be noted that an individual lake as small as 25 acres could be stocked annually at a rate adequate to support the assumed fish ingestion rate. For stocked fish, however, we would have to assume that when introduced to the lake, the fish were uncontaminated by the chemicals of interest. Moreover, the period over which accumulation of chemical from the lake could occur would be roughly three to six months (fishing season) for the majority of the fish stocked as adults (i.e., at approximately 2 kg), instead of several years for fish hatched in the lake.

To place an upper bound on the radial distance from the source up to which lake-derived risks need to be assessed, we took into account the limitations of TRIM.FaTE. We limited the lake analysis to an outward radial bound of 50 km from the stack. For facilities with no lakes within 50 km, lake-derived risk is assumed 0.

Exhibit 26. Maximum Fish Ingestion Rate (g/day) Associated with Sustainable Fishing[a]

Standing Biomass (g ww/m^2)[b]	Size of Pond or Lake (acres)															
	1	2	3	4	5	7.5	10	15	25	35	50	75	100	150	200	400
2	0	0	0	0	0	0	1	1	1	2	3	4	5	8	10	20
3	0	0	0	0	0	1	1	1	2	3	4	6	8	12	15	31
4	0	0	0	0	1	1	1	2	3	4	5	8	10	15	20	41
5.7	0	0	0	1	1	1	1	2	4	5	7	11	15	22	29	58
10	0	1	1	1	1	2	3	4	6	9	13	19	26	38	51	102
15	0	1	1	2	2	3	4	6	10	13	19	29	38	58	77	154
20	1	1	2	2	3	4	5	8	13	18	26	38	51	77	102	205
30	1	2	2	3	4	6	8	12	19	27	38	58	77	115	154	307
35	1	2	3	4	4	7	9	13	22	31	45	67	90	134	179	359
40	1	2	3	4	5	8	10	15	26	36	51	77	102	154	205	410
50	1	3	4	5	6	10	13	19	32	45	64	96	128	192	256	512
60	2	3	5	6	8	12	15	23	38	54	77	115	154	231	307	615
70	2	4	5	7	9	13	18	27	45	63	90	134	179	269	359	717
80	2	4	6	8	10	15	20	31	51	72	102	154	205	307	410	820
90	2	5	7	9	12	17	23	35	58	81	115	173	231	346	461	922
100	3	5	8	10	13	19	26	38	64	90	128	192	256	384	512	1025
110	3	6	8	11	14	21	28	42	70	99	141	211	282	423	563	1127
120	3	6	9	12	15	23	31	46	77	108	154	231	307	461	615	1229
130	3	7	10	13	17	25	33	50	83	117	166	250	333	499	666	1332

[a] Dark gray shading indicates insufficient population size for TL4 (WCC) fish (<50 adults) to be sustainable for more than a decade; yellow-shaded cells indicate the likelihood to provide long-term sustainable fish populations with at least 500 TL4 adult fish present; white area indicates medium-term sustainability.

[b] Represents the standing biomass of TL4 fish. At the upper-limit standing biomass of 40 g ww/ m^2 estimated for natural lakes, 25 acres could support a water-column TL4 fish population, but would provide for no more than 26 grams of fillet per day for a single fisher over a full year.

3.4.2 Processing Meteorological Data for Tier 2 Assessment

In addition to the lake database, a database of U.S. surface stations with complete data was created, so that each source category facility can be paired with the closest meteorological station data. This process of pairing dozens or hundreds of facilities with meteorological data is not unprecedented. In their report to the Science Advisory Board (SAB) on the 1996 NATA, EPA described pairing each facility with the closest meteorological station in an inventory of over 350 meteorological stations nationwide, creating an average facility-to-station distance of less than 50 km in the 1996 NATA (EPA 2001b). In a separate 2009 report to the SAB on the RTR program, EPA described using 158 meteorological stations to choose from nationwide, with a standard practice of selecting the station nearest to each facility unless the facility provides onsite meteorological data (EPA 2009). Using 156 petroleum refineries as a sample data set, the average facility-to-station distance was 72 km. In both instances, the SAB accepted this matching as standard practice when modeling large numbers of sources, although they recommended providing high-level siting maps (e.g., meteorological stations overlaid with terrain gradients or regional climate regimes) to qualify some of the uncertainties related to meteorological data in air dispersion modeling (EPA 2001a; EPA 2010b). The current effort builds on this practice but increases the number of available meteorological stations as described below.

3.4.2.1 Sources of Meteorological Data

To construct a database of meteorological statistics for all available U.S. surface stations for use in multipathway screening assessments, EPA started with the same U.S. meteorology dataset used in RTR inhalation assessments. RTR inhalation assessments use data from 824 ASOS (Automated Surface Observing System) stations that record hourly and sub-hourly measurements. These data represent the year 2011, and the surface stations are paired with their closest, regularly-reporting upper-air stations. This number of stations is far greater than the 350 and 158 stations, respectively, used in the 1996 NATA report (EPA 2001b) and the 2009 RTR report (EPA 2009).

The 2011 precipitation measurements reflect 2011 weather conditions, and, like any other year, some areas of the country experienced rainfall that was significantly less than normal, and some areas received much more rainfall than normal. To reduce this bias in precipitation data, we used average annual precipitation data from the 1981−2010 National Climatic Data Center 30-year normal dataset wherever possible. If 30-year normal precipitation data were not available for a station, as was the case for a few stations in the dataset, we used the ASOS precipitation data as-is.

3.4.2.2 Coverage of Meteorological Stations Compared with Facility Locations

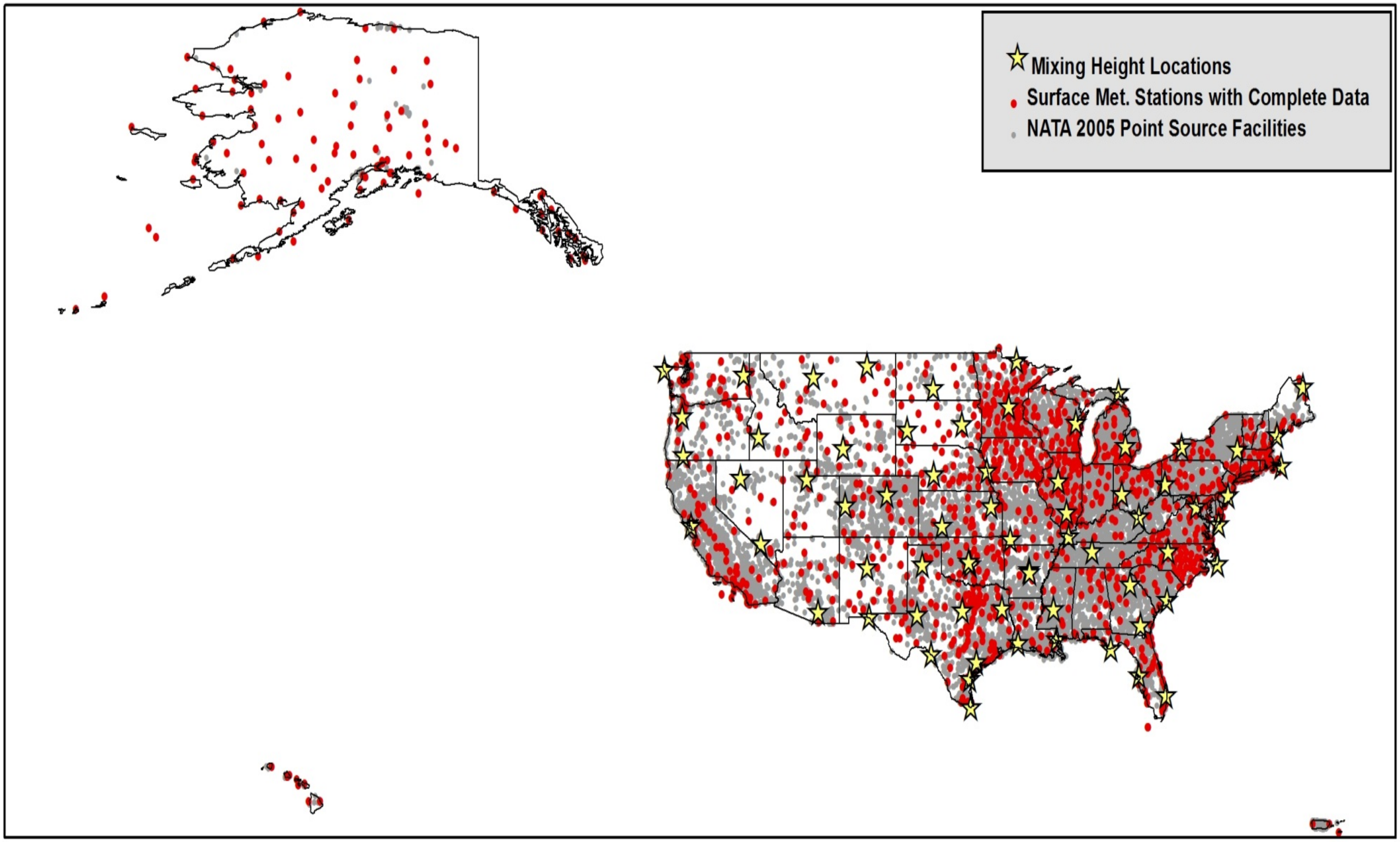
Exhibit 27 shows the proximity of the evaluated meteorology sites to the locations of U.S. point source facilities from the 2005 NATA. Generally, the spatial density of the surface meteorological stations in this dataset was similar to the spatial density of the 2005 NATA facilities. That is, the density tends to be greatest in the Great Lakes region, along the East and West Coasts, and in the Southern Plains, and tends to be lowest in the Rockies (except Colorado) and Northern Plains.

3.4.2.3 Data Processing

To facilitate application of the meteorological data to the Tier 2 assessment, EPA gathered wind information in directional octants that could be linked to the direction of the relevant lakes (see Introduction and Section 3.5). EPA divided the periphery around a meteorological station into eight octants representing the direction toward which the wind was blowing:

N: >337.5 to 22.5 degrees
NE: >22.5 to 67.5 degrees
E: >67.5 to 112.5 degrees
SE: >112.5 to 157.5 degrees
S: >157.5 to 202.5 degrees
SW: >202.5 to 247.5 degrees
W: >247.5 to 292.5 degrees
NW: >292.5 to 337.5 degrees

Exhibit 27. The Locations of Meteorological Stations and Point Source Facilities[a]



[a] The 2005 NATA was the most recent, comprehensive, finalized dataset of nationwide point source emitters of hazardous air pollutants, and it is used here only for illustrative purposes. The 2005 NATA used a meteorological dataset different from the one used in this report.

A software program was developed to calculate the following statistics for each of these stations:

- Number of hourly observations,
- Number of hours with calm winds or missing winds,
- Percentage of time the wind blows into each octant (after excluding missing wind hours),
- Median wind speed blowing into each octant,
- Median mixing height used (if heat flux > 0, convective mixing height was used, otherwise mechanical mixing height was used), and
- Average annual precipitation (irrespective of wind octant and preferring 30-year normal data if available).

Total annual precipitation data in the 2011 meteorological data included anomalies (relative to normal conditions) in areas that experienced extreme drought conditions or large rainfall surpluses. To address this, the 30-year (1981-2010) average annual precipitation was used instead.[26]

The choice of using median values for wind speed and mixing height was based on a comparison of median and mean values. For nearly all stations, the median value was smaller than the mean value; because smaller values are more health protective, we selected the median statistic for all stations.

3.5 Implementation of Tier 2 Assessment

The Tier 2 screening assessment is conducted using a Microsoft® Access™ tool that was developed specifically for this purpose. Similar to the Tier 1 screening assessment tool, the Tier 2 tool was created so that facilities that do not screen out during the Tier 1 assessment can be screened concurrently, if desired.

The Tier 2 tool requires three inputs to run: the results of the Tier 1 screening assessment, a list of facilities to model, associated meteorology stations that can be matched to using a proximity analysis, and the matrix of adjustments factors that are used to adjust the Tier 1 screening thresholds to the Tier 2 screening levels. The matrix is used to standardize the scenario based on the chemical and on the lake distance and meteorology characteristics of the assessed facility (refer to Section 3.3 for a discussion of these adjustment factors).

The tool contains procedures that match each facility to all lakes within a user-defined radius (currently 50 km) that are within user-defined size limitations (currently 25 acres to 100,000 acres), and based on water body type (e.g., they are not waste disposal or treatment facilities, retention ponds, etc.). In addition, each facility is matched to the same meteorology station used in RTR inhalation assessments, which is usually the nearest meteorology station; when the meteorology station match is not known from the RTR inhalation assessment, the tool conducts a proximity analysis. The tool allows the user to review matching lakes and exclude ones that are not considered suitable for modeling (e.g., based on names indicating industrial, waste, or treatment purposes, as discussed in Section 3.4.1.) Any excluded lakes are recorded by the tool so that they are omitted from subsequent screening assessments.

---

[26] 30-year average annual precipitation was obtained from the National Climatic Data Center (NCDC). http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html.

Per facility and PB-HAP, the tool evaluates the screening result at each lake and hypothetical farm. For each lake, the initial calculations produce screening results consistent with the full screening scenario ingestion rate (i.e., 373 g/day for adults, regardless of assumed lake fish productivity), and then additional calculations adjust the screening results for the lakes based on the initial screening results and areas of the lakes (see Section 3.3.2.3). Each modeling scenario consists of a farm and a lake (or, in some cases, no lake). Although the distance from the facility to the modeled farm remains fixed for each octant, the location of the lake affects chemical concentrations in some farm food chain media due to modeled runoff and erosion patterns that are directed mostly toward the lake. Therefore, there can be multiple different farm screening results in the same octant for the same facility, each corresponding to a different lake-distance scenario. The tool identifies the largest farm screening result from all scenarios evaluated for a facility. The tool presents the final Tier 2 screening results for the fisher and farmer separately, including results specific to individual farm food chain media, for each chemical, and then summed together for each PB-HAP group.

The tool also can incorporate the results of Tier 3 assessments. Since the tool allows the user to manually exclude lakes, if any lakes are removed from the assessment in Tier 3, those lakes can be removed in the tool and the Tier 2 screening can be repeated with the revised lake database. If Tier 3 plume-rise or time-series assessments are conducted, the resulting Tier 3 adjustment factors can be entered into the tool and it will update the Tier 2 screening results to produce Tier 3 screening results.

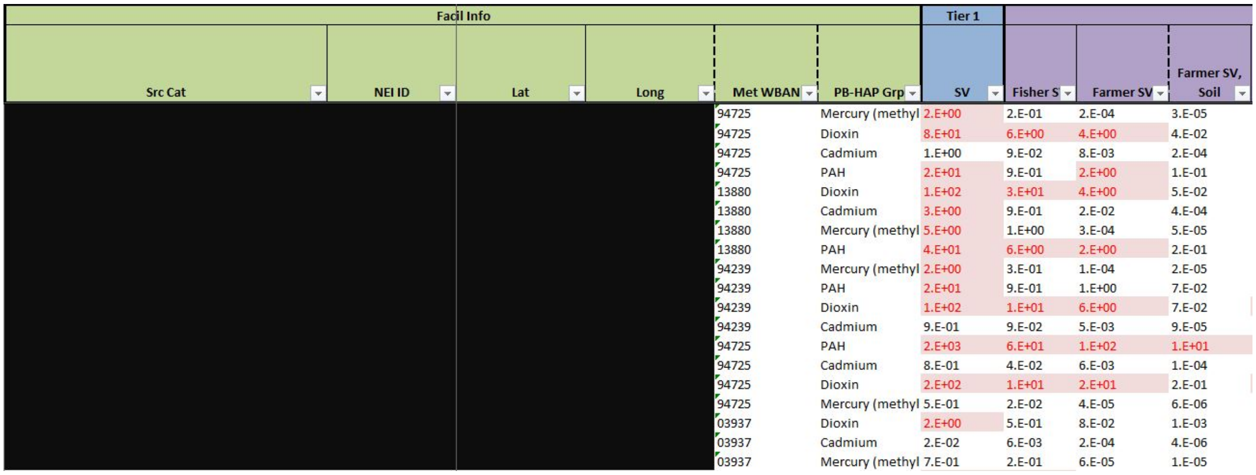
The tool outputs several results tables, including an intermediate table that provides information on each lake and farm, including the fish ingestion and screening-level risk associated with each lake. The final screening results for each facility and PB-HAP group are also output. A summary table identifies the facilities exceeding the Tier 2 emission screening threshold of each PB-HAP group (separately for the fisher and farmer) and the largest screening results. All intermediate and final results tables present the Tier 1 and Tier 2 screening results side-by-side for comparison. Exhibit 28 through Exhibit 30 provide screen shots of tool output tables.

Exhibit 28. Example of the Summary Output Table from Tier 2 Tool[a]

Src Cat Info				Tier 1			Tier 2					
Src Cat	PB-HAP Grp	Num Facil in Src Cat (Emitting Any HA	Num Facil Emitting this Gr	Num Facil SV ≥ 2	Facil with Largest S	Larges t S	Num Facil Fisher SV ≥ 2	Num Facil Farmer SV ≥ 2	Facil with Largest Fisher SV	Largest Fisher S	Facil with Largest Farmer SV	Largest Farmer
[redacted]	Cadmium	12	12	6	[redacted]	3.E+01	0	0	[redacted]	1.E+00	[redacted]	3.E-01
[redacted]	Dioxin	13	13	13	[redacted]	2.E+02	12	12	[redacted]	4.E+01	[redacted]	2.E+01
[redacted]	Mercury (methyl)	13	13	9	[redacted]	1.E+01	0	0	[redacted]	1.E+00	[redacted]	8.E-04
[redacted]	PAH	13	13	13	[redacted]	2.E+03	10	9	[redacted]	6.E+01	[redacted]	1.E+02
[redacted]	PAH + Dioxin	13	13	13	[redacted]	2.E+03	13	12	[redacted]	7.E+01	[redacted]	2.E+02
[redacted]	Cadmium	13	13	7	[redacted]	3.E+01	1	0	[redacted]	2.E+00	[redacted]	4.E-01
[redacted]	Dioxin	14	14	14	[redacted]	3.E+02	13	13	[redacted]	5.E+01	[redacted]	2.E+01
[redacted]	Mercury (methyl)	14	14	9	[redacted]	1.E+01	1	0	[redacted]	2.E+00	[redacted]	8.E-04
[redacted]	PAH	14	14	14	[redacted]	4.E+03	11	11	[redacted]	3.E+02	[redacted]	2.E+02
[redacted]	PAH + Dioxin	14	14	14	[redacted]	5.E+03	14	14	[redacted]	4.E+02	[redacted]	2.E+02

[a] The screen shot examples shown in this section are for actual facilities in actual source categories; however their source categories, NEI IDs, and coordinates have been altered or masked so the data are not linked to specific facilities. “SV” means “screening value”, which is the ratio of emissions to emission screening threshold.

Exhibit 29. Example of the Facility Output Table from Tier 2 Tool[a, b]

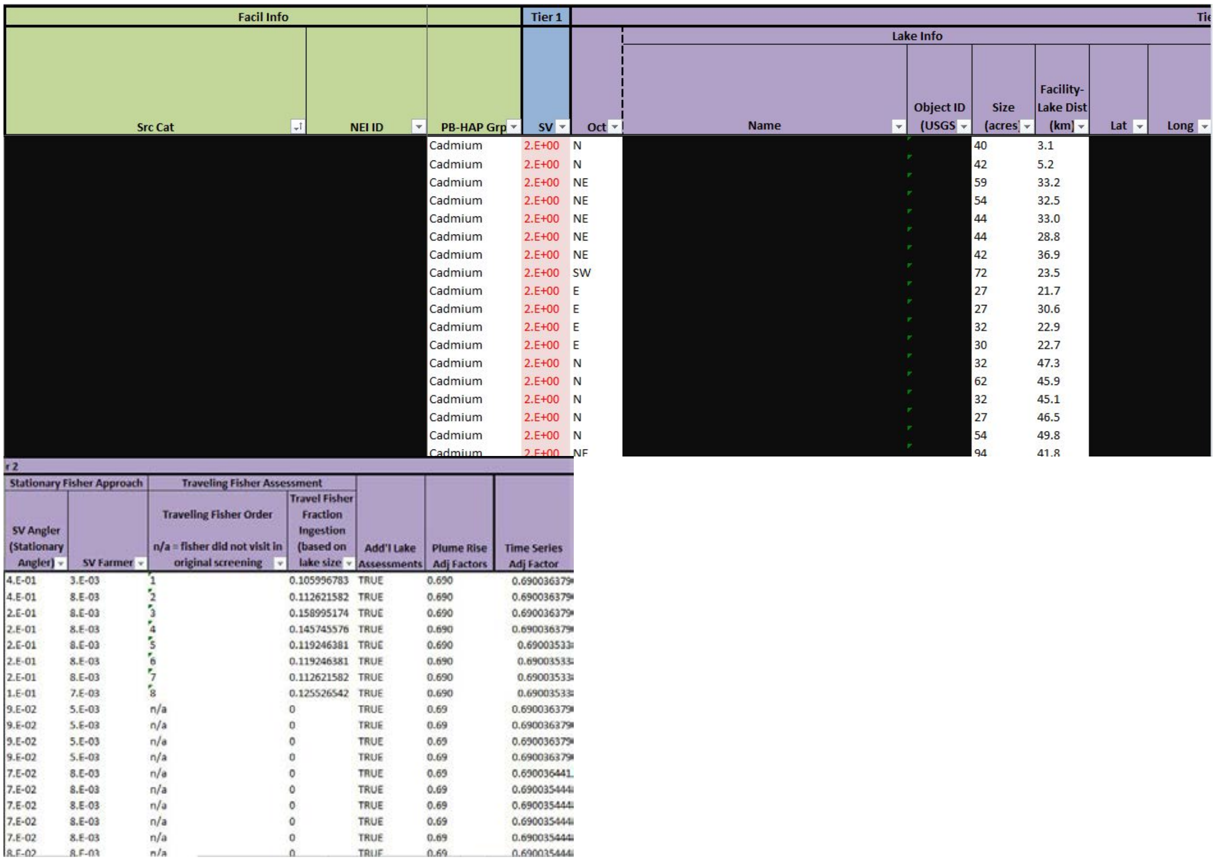


Facil Info						Tier 1			
Src Cat	NEI ID	Lat	Long	Met WBAN	PB-HAP Grp	SV	Fisher S	Farmer SV	Farmer SV, Soil
[redacted]	[redacted]	[redacted]	[redacted]	94725	Mercury (methyl	2.E+00	2.E-01	2.E-04	3.E-05
[redacted]	[redacted]	[redacted]	[redacted]	94725	Dioxin	8.E+01	6.E+00	4.E+00	4.E-02
[redacted]	[redacted]	[redacted]	[redacted]	94725	Cadmium	1.E+00	9.E-02	8.E-03	2.E-04
[redacted]	[redacted]	[redacted]	[redacted]	94725	PAH	2.E+01	9.E-01	2.E+00	1.E-01
[redacted]	[redacted]	[redacted]	[redacted]	13880	Dioxin	1.E+02	3.E+01	4.E+00	5.E-02
[redacted]	[redacted]	[redacted]	[redacted]	13880	Cadmium	3.E+00	9.E-01	2.E-02	4.E-04
[redacted]	[redacted]	[redacted]	[redacted]	13880	Mercury (methyl	5.E+00	1.E+00	3.E-04	5.E-05
[redacted]	[redacted]	[redacted]	[redacted]	13880	PAH	4.E+01	6.E+00	2.E+00	2.E-01
[redacted]	[redacted]	[redacted]	[redacted]	94239	Mercury (methyl	2.E+00	3.E-01	1.E-04	2.E-05
[redacted]	[redacted]	[redacted]	[redacted]	94239	PAH	2.E+01	9.E-01	1.E+00	7.E-02
[redacted]	[redacted]	[redacted]	[redacted]	94239	Dioxin	1.E+02	1.E+01	6.E+00	7.E-02
[redacted]	[redacted]	[redacted]	[redacted]	94239	Cadmium	9.E-01	9.E-02	5.E-03	9.E-05
[redacted]	[redacted]	[redacted]	[redacted]	94725	PAH	2.E+03	6.E+01	1.E+02	1.E+01
[redacted]	[redacted]	[redacted]	[redacted]	94725	Cadmium	8.E-01	4.E-02	6.E-03	1.E-04
[redacted]	[redacted]	[redacted]	[redacted]	94725	Dioxin	2.E+02	1.E+01	2.E+01	2.E-01
[redacted]	[redacted]	[redacted]	[redacted]	94725	Mercury (methyl	5.E-01	2.E-02	4.E-05	6.E-06
[redacted]	[redacted]	[redacted]	[redacted]	03937	Dioxin	2.E+00	5.E-01	8.E-02	1.E-03
[redacted]	[redacted]	[redacted]	[redacted]	03937	Cadmium	2.E-02	6.E-03	2.E-04	4.E-06
[redacted]	[redacted]	[redacted]	[redacted]	03937	Mercury (methyl	7.E-01	2.E-01	6.E-05	1.E-05

[a] The screen shot examples shown in this section are for actual facilities in actual source categories; however their source categories, NEI IDs, and coordinates have been altered or masked so the data are not linked to specific facilities. "SV" means "screening value", which is the ratio of emissions to emission screening threshold.

[b] Only a portion of the table is shown. Individual farm ingestion media are in the table but only "soil" is displayed for space reasons.

Exhibit 30. Example of the Lake Assessment Output Table from Tier 2 Tool[a,b]



Facil Info			Tier 1	Tier 2													
					Lake Info						Stationary Fisher Approach		Traveling Fisher Assessment				
Src Cat	NEI ID	PB-HAP Grp	SV	Oct	Name	Object ID (USGS	Size (acres	Facility-Lake Dist (km)	Lat	Long	SV Angler (Stationary Angler)	SV Farmer	Traveling Fisher Order n/a = fisher did not visit in original screening	Travel Fisher Fraction Ingestion (based on lake size	Add'l Lake Assessments	Plume Rise Adj Factors	Time Series Adj Factor
[redacted]	[redacted]	Cadmium	2.E+00	N	[redacted]	[redacted]	40	3.1	[redacted]	[redacted]	4.E-01	3.E-03	1	0.105996783	TRUE	0.690	0.690036379
[redacted]	[redacted]	Cadmium	2.E+00	N	[redacted]	[redacted]	42	5.2	[redacted]	[redacted]	4.E-01	8.E-03	2	0.112621582	TRUE	0.690	0.690036379
[redacted]	[redacted]	Cadmium	2.E+00	NE	[redacted]	[redacted]	59	33.2	[redacted]	[redacted]	2.E-01	8.E-03	3	0.158995174	TRUE	0.690	0.690036379
[redacted]	[redacted]	Cadmium	2.E+00	NE	[redacted]	[redacted]	54	32.5	[redacted]	[redacted]	2.E-01	8.E-03	4	0.145745576	TRUE	0.690	0.690036379
[redacted]	[redacted]	Cadmium	2.E+00	NE	[redacted]	[redacted]	44	33.0	[redacted]	[redacted]	2.E-01	8.E-03	5	0.119246381	TRUE	0.690	0.69003533
[redacted]	[redacted]	Cadmium	2.E+00	NE	[redacted]	[redacted]	44	28.8	[redacted]	[redacted]	2.E-01	8.E-03	6	0.119246381	TRUE	0.690	0.69003533
[redacted]	[redacted]	Cadmium	2.E+00	NE	[redacted]	[redacted]	42	36.9	[redacted]	[redacted]	2.E-01	8.E-03	7	0.112621582	TRUE	0.690	0.69003533
[redacted]	[redacted]	Cadmium	2.E+00	SW	[redacted]	[redacted]	72	23.5	[redacted]	[redacted]	1.E-01	7.E-03	8	0.125526542	TRUE	0.690	0.69003533
[redacted]	[redacted]	Cadmium	2.E+00	E	[redacted]	[redacted]	27	21.7	[redacted]	[redacted]	9.E-02	5.E-03	n/a	0	TRUE	0.69	0.690036379
[redacted]	[redacted]	Cadmium	2.E+00	E	[redacted]	[redacted]	27	30.6	[redacted]	[redacted]	9.E-02	5.E-03	n/a	0	TRUE	0.69	0.690036379
[redacted]	[redacted]	Cadmium	2.E+00	E	[redacted]	[redacted]	32	22.9	[redacted]	[redacted]	9.E-02	5.E-03	n/a	0	TRUE	0.69	0.690036379
[redacted]	[redacted]	Cadmium	2.E+00	E	[redacted]	[redacted]	30	22.7	[redacted]	[redacted]	9.E-02	5.E-03	n/a	0	TRUE	0.69	0.690036379
[redacted]	[redacted]	Cadmium	2.E+00	N	[redacted]	[redacted]	32	47.3	[redacted]	[redacted]	7.E-02	8.E-03	n/a	0	TRUE	0.69	0.690036441
[redacted]	[redacted]	Cadmium	2.E+00	N	[redacted]	[redacted]	62	45.9	[redacted]	[redacted]	7.E-02	8.E-03	n/a	0	TRUE	0.69	0.69003544
[redacted]	[redacted]	Cadmium	2.E+00	N	[redacted]	[redacted]	32	45.1	[redacted]	[redacted]	7.E-02	8.E-03	n/a	0	TRUE	0.69	0.69003544
[redacted]	[redacted]	Cadmium	2.E+00	N	[redacted]	[redacted]	27	46.5	[redacted]	[redacted]	7.E-02	8.E-03	n/a	0	TRUE	0.69	0.69003544
[redacted]	[redacted]	Cadmium	2.E+00	N	[redacted]	[redacted]	54	49.8	[redacted]	[redacted]	7.E-02	8.E-03	n/a	0	TRUE	0.69	0.69003544
[redacted]	[redacted]	Cadmium	2.E+00	NE	[redacted]	[redacted]	94	41.8	[redacted]	[redacted]	8.E-02	8.E-03	n/a	0	TRUE	0.69	0.69003544

[a] The screen shot examples shown in this section are for actual facilities; however their source categories, NEI IDs, and coordinates have been altered or masked so the data are not linked to specific facilities. Only a portion of the table might be shown. The headers "Stationary Fisher" and "Traveling Fisher" are shorthand references to the initial fisher scenario (i.e., catches and consumes 373 g/d per lake, regardless of lake area) and the refined fisher scenario (i.e., assumes a 1 g/acre/d lake productivity), respectively. "SV" means "screening value", which is the ratio of emissions to emission screening threshold.

[b] The table displayed reflects a Tier 3 Screening Assessment having been conducted. In a Tier 2 Screening Assessment, the Add'l Lake Assessment, Plume Rise Adj Factors, and Time Series Adj Factors would not be shown.

4. Tier 3 Methodology

4.1 Overview of Approach

Tier 3 screening consists of a set of assessments that can be conducted, at the discretion of the risk assessor, on facilities that do not screen out with the Tier 2 assessment. The Tier 3 screening approach consists of three individual assessments that further refine the screening scenario (beyond the refinements in Tier 2) based on additional site-specific data and evaluations. The assessments introduce additional site-specificity to the screening scenario, requiring a potentially higher level of effort than the Tier 2 assessment, but still a much lower level of effort than the full site-specific assessment. The first of the Tier 3 assessments (i.e., the lake assessment) results in the rescreening of the facility's emissions using the Tier 2 methods and using a revised lake database. The Tier 3 plume-rise assessment, which only needs to be conducted if facilities do not screen out with the Tier 3 lake assessment, results in an adjustment factor to be applied to the screening result of the Tier 3 lake assessment. The Tier 3 time-series assessment, which only needs to be conducted if facilities do not screen out with the Tier 3 plume-rise assessment, directly models in TRIM.FaTE and MIRC the effects of plume rise as well as hourly meteorology conditions, resulting in modeled screening-level risk values that replace the screening values of the Tier 3 plume-rise assessment.

The remainder of this section discusses each of these assessments.

4.2 Lake Assessment

Other than verifying a facility's emission rates, one of the simplest assessments that can be conducted (beyond the Tier 2 methods) is to assess the existence, the potential purpose, the accessibility and fishability, and the suitability of lakes for the models and methods used in Tier 2. The full USGS dataset of lakes and reservoirs nationwide that is used in Tier 2 does not contain information on lake accessibility or fishability. In addition, it occasionally identifies a lake that no longer exists (e.g., has evaporated or been drained) or it uses a classification that might not accurately reflect the lake's purpose or type. Aerial and street-view imagery and internet searches can be used to quickly ascertain if an assessed lake actually exists, if it is likely not fished (e.g., appears swampy or covered in algae), if it is likely used for industrial or waste disposal/treatment purposes, and/or if it is adjacent to or connected to a river or saltwater body (estuaries, rivers, and saltwater areas are not ideal for the assessment models and methods).

For example, the blue outline in Exhibit 31 identifies a lake from the USGS dataset that originally qualified for Tier 2 based on the information provided in that dataset, but aerial imagery shows it is likely evaporated or drained. Similarly, the outline in Exhibit 32 identifies a lake that originally qualified, but aerial imagery shows that it is directly adjacent to an industrial facility and likely used only for on-site industrial purposes.

For facilities undergoing Tier 3 screening, all lakes are assessed from which the fisher catches and consumes fish according to the refined Tier 2 fisher methods discussed in Section 3. All lakes meeting the criteria discussed in the previous paragraphs are permanently removed from the screening assessment so that they are no longer used in any screening assessment. If a lake is removed from the facility's assessment, it might be necessary for the hypothetical fisher to catch and consume fish from additional lake(s) in order to fish a total of 373 acres in order to satisfy the fisher ingestion rate 373 g-fish/d. In this case, additional lakes that were not fished previously are evaluated, using the methods discussed in Section 3, in descending order of initial Tier 2 fisher screening result and lake area.

If any lakes are removed from the screening, the screening assessment is conducted again (using the Tier 2 methods) with the revised lake dataset. Although this additional lake assessment is conducted based on the Tier 2 screening results of a particular set of facilities, lakes removed during that assessment could affect the screening results of other facilities in the source category beyond that original set. This can happen if an assessed facility is within 50 km of another assessed facility, whereby removing a lake could affect the screening results of both facilities. It should be noted, however, that screening results across different facilities are not summed.

Exhibit 31. Example of Lake Removed from Screening—Likely Evaporated or Drained

Note: Aerial imagery from ESRI World Imagery (2014).

Exhibit 32. Example of Lake Removed from Screening—Likely an Industrial Lake

Note: Aerial imagery from ESRI World Imagery (2014).

4.3 Plume-rise Assessment

If a facility's emissions do not screen out with the Tier 3 lake assessment, a Tier 3 plume-rise assessment may be conducted. In Tiers 1 and 2, all chemicals are emitted inside the mixing layer and are available for ground-level exposure. This is because the mixing height (held static) is never less than 710 m, while the physical emission source height (also held static) is always inside the mixing layer; therefore, the chemical plume is always inside the mixing layer. In reality, the physical height of an emission source, in combination with the temperature and velocity of the chemical plume as it leaves the source, can cause some of the chemical plume to reach areas above the mixing layer. In TRIM.FaTE modeling, the chemical mass deposited above the mixing layer (i.e., the model's upper-air layer) is unavailable for ground-level exposure (i.e., the upper-air layer functions as a chemical sink). Many RTR emission sources are physically taller than the actual, hourly-varying mixing height during some hours, and hot exit gas temperatures (i.e., buoyancy) and/or high exit gas velocities (i.e., momentum) can further elevate the chemical plume well above the source height and mixing layer.

The Tier 3 plume-rise methodology utilizes methods summarized by Seinfeld and Pandis (1998) to estimate how often a facility's emissions reach the upper-air sink, which decreases availability for ground-level exposure. The methods to estimate the amount of chemical lost to the upper-air sink require use of the facility's corresponding hourly meteorology data (e.g., air temperature and vertical temperature gradient, wind speed, and atmospheric stability), the mass of the PB-HAP emitted from each source, the physical characteristics of the sources (i.e., release height, inside diameter at the release point, and exit gas temperature and velocity), and an estimate of the size of the facility. The facility size is a necessary component because the emission plume can continue to rise as it travels laterally away from the emission source, and the height the plume reaches must be assessed as it leaves the facility area (where it is assumed the public is not exposed to the emissions) and enters areas where people could be exposed.

For each relevant emission source, estimates of the hourly effective release height (i.e., sum of actual release height and plume rise) are compared to the hourly mixing height to determine the mass of chemical remaining in the mixing layer. The mass of chemical remaining in the mixing layer, summed across the sources, is compared to the total emitted mass of the chemical. This results in an adjustment factor expressing the fraction of emissions remaining in the mixing layer after accounting for release height and plume rise. For the lake or hypothetical farm being assessed, the Tier 2 methods already account for how often the plume is bowing toward the lake or farm (i.e., direct chemical deposition can only occur when wind blows the plume toward those media); therefore, in the Tier 3 plume-rise assessment, the calculations of total mass emitted and mass remaining in the mixing layer are limited to only the times when winds blow toward the lake or farm. That is, the plume-rise adjustment factor is calculated as [number of hours when winds blow toward the lake or farm AND the emitted mass remains in the mixing layer] ÷ [number of hours when winds blow toward the lake or farm]. This final plume-rise adjustment factor is then applied to the Tier 2 screening results.

4.4 Assessment of Time-series Meteorology and Effective Release Heights

If a facility's emissions do not screen out with the Tier 3 plume-rise assessment, a Tier 3 time-series meteorology assessment may be conducted. As discussed in Section 3, the Tier 2 screening results are based on the average meteorological conditions prevailing at the facility being assessed. The use of time-series meteorology data, which captures hour-by-hour changes in each of the assessed meteorological parameters instead of using constant average values, increases the accuracy of the estimates of potential risk by accounting for potential statistical interactions between the meteorology parameters and by improving the method of accounting for mass advected into the modeling domain.

As noted above, Tier 2 screening results also are based on a static emission release height that is always within the mixing layer. Including hourly effective release heights along with hourly meteorology data further increases the accuracy of the screening results.

Furthermore, in the Tier 2 assessment, the emission screening thresholds for PAHs and dioxins correspond to BaP and TCDD, respectively, and a facility's emissions of the individual congeners are related to those surrogates using Risk Equivalency Factors (REFs; see Section 2.2.7) based on comparisons of toxicity and of fate and transport behavior in TRIM.FaTE. Therefore, PAH and dioxin congeners other than BaP and TCDD are assessed indirectly in the Tiers 1 and 2 screening assessments, though modeled directly in the TRIM.FaTE and MIRC model runs that used derive the equivalency factors.

For a facility undergoing a Tier 3 time-series assessment, a new TRIM.FaTE model run is conducted using the facility's emission rate of the chemical of concern, the time-series meteorological and plume-rise data developed for the Tier 3 plume-rise assessment, and the Tier 2 spatial scenario that best matches the lake or farm being assessed (e.g., the lake or farm corresponding to screening values above levels of concern in Tier 2). All other model settings are unchanged from the Tier 2 assessment. Modeling is repeated for each chemical and lake or farm of concern. This results in a screening-level risk value for each lake or farm. The screening-level risk associated with each lake is multiplied by the percent of daily ingested fish caught from the lake (i.e., the 1 g-fish/d/acre methods discussed in Section 3.3.2.3); summing those products across all modeled lakes results in the screening-level fisher risk (i.e., fisher screening result) associated with the evaluated PB-HAP emitted by the facility.

5. References

ATSDR (Agency for Toxic Substances and Disease Registry). 1995. Toxicological profile for polycyclic aromatic hydrocarbons. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

ATSDR. 1998. Toxicological profile for chlorinated dibenzo-p-dioxins. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

ATSDR. 1999. Toxicological profile for Mercury. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

ATSDR. 2008. Toxicological profile for Cadmium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Burger, J. 2002. Daily consumption of wild fish and game: Exposures of high end recreationists. *International Journal of Environmental Health Research* 12:343-354.

Cal/EPA (California Environmental Protection Agency) Office of Environmental Health Hazard Assessment (OEHHA). 2000. Air Toxics Hot Spots Program Risk Assessment Guidelines; Part IV, Exposure Assessment and Stochastic Analysis Technical Support Document. Section 6, Dermal Exposure Assessment. September. Available at: http://www.oehha.ca.gov/air/hot_spots/pdf/chap6.pdf.

Chen, C.Y., R.S. Stemberger, B. Klaue, J.D. Blum, P.C. Pickhardt, and C.L. Folt. 2000. Accumulation of heavy metals in food web components across a gradient of lakes. Limnology and Oceanography 45(7): 1525-1536.

Croteau, M., S.N. Luoma, and A.R. Stewart. 2005. Trophic transfer of metals along freshwater food webs: Evidence of cadmium biomagnification in nature. Limnology and Oceanography 50(5):1511-1519.

EPA 1997. Mercury Study Report to Congress. Volume III: Fate and Transport of Mercury in the Environment. EPA-452/R-97-005. Office of Air Quality Planning and Standards and Office of Research and Development. December.

EPA 1998. Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions. National Center for Environmental Assessment. Cincinnati, OH. EPA-600/6-90/003. December.

EPA 1999. Short Sheet: IEUBK Model Soil/Dust Ingestion Rates. EPA-540-F-00-007; OSWER-9285.7-33. Washington, D.C.: Office of Solid Waste and Emergency Response; December. Available at: http://www.epa.gov/superfund/lead/products/ssircolo.pdf.

EPA 2001a. NATA – Evaluating the National-scale Air Toxics Assessment, 1996 DATA – An SAB Advisory. U.S EPA Science Advisory Board. EPA-SAB-EC-ADV-02-001. 12/2001.

EPA 2001b. National-scale Air Toxics Assessment for 1996, Draft for EPA Science Advisory Board Review. EPA Office of Air Quality Planning and Standards. EPA-453/R-01-003. 01/18/2001.

EPA 2002a. Total Risk Integrated Methodology: TRIM.FaTE Technical Support Document. Volume II: Description of Chemical Transport and Transformation Algorithms. EPA-453/R-

02-011b. Office of Air Quality Planning and Standards: Research Triangle Park, NC. September.

EPA 2002b. Evaluation of TRIM.FaTE, Volume I: Approach and Initial Findings. EPA-453/R-02-0012. Office of Air Quality and Planning Standards: Research Triangle Park, NC. September.

EPA 2003. Multimedia, Multipathway, and Multireceptor Risk Assessment (3MRA) Modeling System, Volume II: Site-based, Regional, and National Data. SAB Review Draft. EP-530/D-03-001b. Office of Research and Development, Athens, GA, and Research Triangle Park, NC, and Office of Solid Waste, Washington, DC. July. Available at: http://www3.epa.gov/epawaste/hazard/wastetypes/wasteid/hwirwste/risk03.htm#vol3.

EPA 2004a. Air Toxics Risk Assessment Reference Library; Volume 1 – Technical Resource Document, Part III, Human Health Risk Assessment: Multipathway Chapter 14, Overview and Getting Started: Planning and Scoping the Multipathway Risk Assessment. Office of Air Quality Planning and Standards, Research Triangle Park, NC. April. Available at: http://www2.epa.gov/sites/production/files/2013-08/documents/volume_1_reflibrary.pdf.

EPA 2004b. Evaluation of TRIM.FaTE Volume III: Model Comparison Focusing on Dioxin Test Case. EPA-453/R-04-002. Available at: http://www2.epa.gov/sites/production/files/2014-01/documents/eval_rept_vol3_2005.pdf.

EPA 2004c. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. Volume 2: Properties, Environmental Levels, and Background Exposures. Dioxin Reassessment, NAS Review Draft. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/P-00/001Cb. Available at: http://www.epa.gov/ncea/pdfs/dioxin/nas-review/.

EPA 2005a. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (including the Hazardous Waste Companion Database of chemical-specific parameter values). U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC. EPA-530-R-05-006. September.

EPA 2005b. Evaluation of TRIM.FaTE, Volume II: Model Comparison Focusing on Mercury Test Case. EPA-453/R-05-002. Office of Air Quality and Planning Standards: Research Triangle Park, NC. July.

EPA 2005c. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. EPA-630/R-03-003F. Risk Assessment Forum: Washington, DC. March.

EPA 2006. Risk and Technology Review (RTR) Assessment Plan. Office of Air and Radiation. November 20, 2006. Available at: http://www.epa.gov/sab/panels/consul_risk_and_tech_assessment_plan.htm.

EPA 2007. Prioritized Chronic Dose-Response Values for Screening Risk Assessments (Table 1). Office of Air Quality Planning and Standards; June 12, 2007. Available at: http://www.epa.gov/ttn/atw/toxsource/summary.html.

EPA 2009. Risk and Technology Review (RTR) Risk Assessment Methodologies: For Review by the EPA's Science Advisory Board with Case Studies – MACT I Petroleum Refining Sources and Portland Cement Manufacturing. EPA Office of Air Quality Planning and Standards. EPA-452/R-09-006. 06/2009.

EPA 2010a Development of a Relative Potency Factor (RPF) Approach for Polycyclic Aromatic Hydrocarbon (PAH) Mixtures (External Review Draft). Washington, DC, EPA/635/R-08/012A February. Available at: http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=194584.

EPA 2010 Review of EPA's draft entitled, "Risk and Technology Review (RTR) Risk Assessment Methodologies: For Review by the EPA's Science Advisory Board with Case Studies – MACT I Petroleum Refining Sources and Portland Cement Manufacturing." EPA Science Advisory Board. EPA-SAB-10-007. 05/07/2010.

EPA 2011a Exposure Factors Handbook: 2011 edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F. Available from the National Technical Information Service, Springfield, VA, and online at http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=522996.

EPA 2011b Human Health Multipathway Residual Risk Assessment for the Secondary Lead Smelting Source Category. Draft Report. Prepared by ICF International for EPA Risk and Exposure Assessment Group. 02/15/2011.

EPA 2011c Technical Support Document: Case Study Analyses of Potential Local-scale Human Health Risks Associated with Mercury Emissions from Electric Utility Steam-generating Units. Draft. Prepared by ICF International for EPA Office of Air Quality Planning and Standards. 02/17/2011.

EPA 2014a Technical Support Document: Human Health Multipathway Residual Risk Assessment for the Ferroalloys Production Source Category. Draft. Prepared by ICF International for EPA Office of Air Quality Planning and Standards. 02/21/2014.

EPA 2014b Technical Support Document: Human Health Multipathway Residual Risk Assessment for the Petroleum Refineries Sector. Draft. Prepared by ICF International for EPA Office of Air Quality Planning and Standards. 01/31/2014.

ESRI (Environmental Systems Research Institute). 2014. World Imagery. Accessed June 03, 2014. Available at: http://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9.

Hazardous Substances Data Bank (HSDB). 2005. Bethesda, MD: National Library of Medicine, U.S. [Last Revision Date 06/23/2005]. Cadmium Compounds; Hazardous Substances Databank Number: 6922. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB.

Holzworth, G.C. 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States," AP-101, January 1972, U.S. Environmental Protection Agency, Office of Air Programs, Research Triangle Park, North Carolina.

ICF (ICF International). 2005. Memorandum: TRIM.FaTE Screening Scenario: Aquatic Food Web Analysis; submitted to Deirdre Murphy and Terri Hollingsworth, U.S. EPA, from Margaret McVey and Rebecca Kauffman, ICF Consulting. October 18.

Mason R.P., J. Laporte, and S. Andres. 2000. Factors controlling the bioaccumulation of mercury, methylmercury, arsenic, selenium, and cadmium by freshwater invertebrates and fish. Archives for Environmental Contamination and Toxicology 38(3):283-97.

McKone, T.E., A. Bodnar, and E. Hertwich. 2001. Development and evaluation of state-specific landscape data sets for multimedia source-to-dose models. University of California at Berkeley. Supported by U.S. Environmental Protection Agency (Sustainable Technology

Division, National Risk Management Research Laboratory) and Environmental Defense Fund. July. LBNL-43722.

Morton, F.I. 1986. Practical estimates of lake evaporation. Journal of Climate and Applied Meteorology 25:371-387.

NCDC (National Climatic Data Center). 1995. Hourly United States Weather Observations (HUSWO) 1990-1995.

National Climatic Data Center. (2007). Cimate Maps of the United States (CLIMAPS). Available online at https://www.ncdc.noaa.gov/cgi-bin/climaps/climaps.pl.

National Climatic Data Center (NCDC). (2012) Quality Controlled Local Climatological Data. Available online at https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/quality-controlled-local-climatological-data-qclcd.

Reinfelder, J.R., N.S. Fisher, S.N. Luoma, J.W. Nichols, and W.-X. Wang. 1998. Trace element trophic transfer in aquatic organisms: A critique of the kinetic model approach. The Science of the Total Environment 219: 117-135.

Saiki, M.K., D.T. Castleberry, T.W. May, B.A. Martin, and F.N. Bullard. 1995. Copper, cadmium, and zinc concentrations in aquatic food chains from the upper Sacramento River (California) and selected tributaries. Arch. Environ. Contam. Toxicol. 29:484-491.

Seinfeld, J.H., and S.N. Pandis. 1998. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, Wiley-Interscience, New York, pp. 931–933.

Stull, R.B. 1988. An Introduction to Boundary Layer Meteorology. Kluwer Academic Publishers, The Netherlands. 452 pp.

Turner, D.B. 1970. Workbook of Atmospheric Dispersion Estimates. PHS Publication No. 999-AP-26. U.S. Department of Health, Education, and Welfare, National Air Pollution Control Administration, Cincinnati, Ohio.

USGS (U.S. Geological Survey). (2012) National Hydrography Dataset. Available online at http://nhd.usgs.gov/.

USGS (U.S. Geological Survey). 1987. National Water Summary 1987 – Hydrologic Events and Water Supply and Use. USGS Water-Supply Paper 2350. J.E. Carr, E.B. Chase, R.W. Paulson, and D.W. Moody, Compilers.

Van den Berg, M., L.S. Birnbaum, M. Denison, M. DeVito, W. Farlans, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L.. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. Tuomisto, M. Tysklind, N. Walker, and R.E. Peterson. 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Toxicol Sci. 93(2): 223-41.

Wischmeier, W.H., and D. Smith. 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. USDA-ARS Agriculture Handbook No. 537, Washington, D.C. 58 pp.

Attachment A. TRIM.FaTE Inputs

[This page intentionally left blank.]

Exhibits, Attachment A

This attachment provides tables of the modeling inputs for the TRIM.FaTE screening scenario. Exhibit A-1 presents runtime settings for TRIM.FaTE. Exhibit A-2 and Exhibit A-3 present meteorological and air parameters, respectively, entered into the model. Exhibit A-4. , Exhibit A-5, and Exhibit A-6 present the parameters for soil and groundwater, runoff assumptions, and the USLE (universal soil loss equation) erosion parameters, respectively, for the screening scenario. Exhibit A-7 and Exhibit A-8 present terrestrial parameters. Exhibit A-9 through Exhibit A-11 present lake parameters, and Exhibit A-12 through Exhibit A-27 present parameters specific to the chemicals modeled in the scenario.

Exhibit A-1. TRIM.FaTE Simulation Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value Used	Reference
Start of simulation	date/time	1/1/1990, midnight	Consistent with met data.
End of simulation	date/time	1/1/2040, midnight	Consistent with met data set; selected to provide a 50-year modeling period.
Simulation time step	hr	1	Selected value.
Output time step[a]	hr	4	Selected value.

[a] Output time step is set in TRIM.FaTE using the scenario properties "simulationStepsPerOutputStep" and "simulationTimeStep."

.

Exhibit A-2. Meteorological Inputs for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value Used	Reference
Meteorological Inputs			
Air temperature	degrees K	298	USEPA 2005.
Horizontal wind speed	m/sec	2.8	5th percentile annual average value for contiguous United States, calculated from 30 yrs of annual normal temperature values.
Vertical wind speed	m/sec	0.0	Assumption; vertical wind speed not used by any of the algorithms in the version of the TRIM.FaTE library used for screening.
Wind direction	degrees clockwise from N (blowing from)	3-days-on 4-days-off	On is defined as time during which wind is blowing into the model domain. A conservative estimate of time during which wind should blow into the modeling domain was determined by evaluating HUSWO; it was concluded that a conservative estimate would be approximately 42% of the time.
Rainfall rate	m^3[rain]/m^2 [surface area]-day	varies daily	1.5 m/yr is the maximum statewide 30-year (1971-2000) average for the contiguous United States, excluding Rhode Island because of extreme weather conditions on Mt. Washington. Data obtained from the National Climatic Data Center at https://www.ncdc.noaa.gov/cgi-bin/climaps/climaps.pl. The precipitation frequency was 3-days-on:4-days-off based on data from Holzworth, 1972.
Mixing height (used to set air VE property named “top”)	m	710	5th percentile annual average mixing heights (calculated from daily morning and afternoon values), for all stations on SCRM (40 state, 70 stations).
isDay_SteadyState_forAir	unitless	--	Value not used in current dynamic runs (would need to be reevaluated if steady-state runs are needed).
isDay_SteadyState_forOther	unitless	--	

Exhibit A-3. Air Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value Used	Reference
Atmospheric dust load	kg[dust]/m^3[air]	6.15E-08	Bidleman 1988
Density of air	g/cm^3	0.0012	USEPA 1997b
Dust density	kg[dust]/m^3[dust]	1,400	Bidleman 1988
Fraction organic matter on particulates	unitless	0.2	Harner and Bidleman 1998

Exhibit A-4. Soil and Groundwater Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value Used	Reference
Surface Soil Compartment Type			
Air content	volume[air]/volume[compartment]	0.28	McKone et al. 2001.
Average vertical velocity of water (percolation)	m/day	8.22E-04	Assumed to be 0.2 times average precipitation for site.
Boundary layer thickness above surface soil	m	0.005	Thibodeaux 1996; McKone et al. 2001 (Table 3).
Density of soil solids (dry weight)	kg[soil]/m^3[soil]	2600	Default in McKone et al. 2001 (Table 3).
Thickness - untilled[a]	m	0.01	McKone et al. 2001 (p. 30).
Thickness - tilled[a]	m	0.20	USEPA 2005.
Erosion fraction	unitless	varies[b]	See Exhibit 5.
Fraction of area available for erosion	m^2[area available]/m^2[total]	1	Assumption ; area assumed rural.
Fraction of area available for runoff	m^2[area available]/m^2[total]	1	Assumption ; area assumed rural.
Fraction of area available for vertical diffusion	m^2[area available]/m^2[total]	1	Assumption ; area assumed rural.
Fraction sand	unitless	0.25	Assumption.
Organic carbon fraction	unitless	0.008	U.S. average in McKone et al. 2001 (Table 16 and A-3).
pH	unitless	6.8	Assumption.
Runoff fraction	unitless	varies[b]	See Exhibit A-5.
Total erosion rate	kg [soil]/m^2/day	varies[b]	See Exhibit A-6.
Total runoff rate	m^3[water]/m^2/day	1.64E-03	Calculated using scenario-specific precipitation rate and assumptions associated with water balance.
Water content	volume[water]/volume[compartment]	0.15	McKone et al. 2001
Root Zone Soil Compartment Type			
Air content	volume[air]/volume[compartment]	0.25	McKone et al 2001 (Table 16).
Average vertical velocity of water (percolation)	m/day	8.22E-04	Assumed as 0.2 times average precipitation for New England in McKone et al. 2001.
Density of soil solids (dry weight)	kg[soil]/m^3[soil]	2,600	McKone et al. 2001 (Table 3).
Fraction sand	unitless	0.25	Assumption.

Exhibit A-4. Soil and Groundwater Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value Used	Reference
Root Zone Soil Compartment Type, continued			
Thickness - untilled[a]	m	0.79	McKone et al. 2001 (Table 16 - U.S. average).
Thickness - tilled[a]	m	0.6	Adjusted from McKone et al. 2001 (Table 16).
Organic carbon fraction	unitless	0.008	McKone et al. 2001 (Tables 16 and A-3, U.S. average).
pH	unitless	6.8	Assumption.
Water content	volume[water]/volume[compartment]	0.15	McKone et al. 2001
Vadose Zone Soil Compartment Type			
Air content	volume[air]/volume[compartment]	0.22	McKone et al. 2001 (Table 17).
Average vertical velocity of water (percolation)	m/day	8.22E-04	Assumed as 0.2 times average precipitation for New England in McKone et al. 2001.
Density of soil solids (dry weight)	kg[soil]/m^3[soil]	2,600	Default in McKone et al. 2001 (Table 3).
Fraction sand	unitless	0.35	Assumption.
Thickness[a]	m	1.4	McKone et al. 2001 (Table 17).
Organic carbon fraction	unitless	0.003	McKone et al. 2001 (Tables 16 and A-3, U.S. average).
pH	unitless	6.8	Assumption.
Water content	volume[water]/volume[compartment]	0.21	McKone et al. 2001 (Table 17 - national average).
Groundwater Compartment Type			
Thickness[a]	m	3	McKone et al. 2001 (Table 3).
Fraction sand	unitless	0.4	Assumption.
Organic carbon fraction	unitless	0.004	Assumption.
pH	unitless	6.8	Assumption.
Porosity	volume[total pore space]/volume[compartment]	0.2	Default in McKone et al. 2001 (Table 3).
Density of solid material in aquifer	kg[soil]/m^3[soil]	2,600	Default in McKone et al. 2001 (Table 3).

[a] Set using the volume element properties file.

[b] See separate tables (Exhibit A-5 and Exhibit A-6) for erosion/runoff fractions and total erosion rates.

Exhibit A-5. Runoff Assumptions for the TRIM.FaTE Screening Scenario

Originating Compartment	Destination Compartment	Runoff/Erosion Fraction
SurfSoil_Source	SurfSoil_N1	0.0
	SurfSoil_S1	0.0
	sink	1.0
SurfSoil_N1	SW_Pond	1.0
	SurfSoil_Source	0.0
	SurfSoil_N6	0.0
	SurfSoil_S1	0.0
	sink	0.0
SurfSoil_S1	SW_Pond	1.0
	SurfSoil_Source	0.0
	SurfSoil_N1	0.0
	sink	0.0
SurfSoil_N6	SW_Pond	1.0
	SurfSoil_N1	0.0
	SurfSoil_N7	0.0
	sink	0.0
SurfSoil_N7	SW_Pond	1.0
	SurfSoil_N6	0.0
	SurfSoil_N3	0.0
	sink	0.0
SurfSoil_N3	SW_Pond	1.0
	SurfSoil_N7	0.0
	SurfSoil_N4	0.0
	sink	0.0
SurfSoil_N4	SW_Pond	1.0
	SurfSoil_N3	0.0
	SurfSoil_N5	0.0
	SurfSoil_S4	0.0
	sink	0.0
SurfSoil_S4	SW_Pond	1.0
	SurfSoil_N4	0.0
	SurfSoil_S5	0.0
	sink	0.0
SurfSoil_N5[a]	SW_Pond	0.0
	SurfSoil_N4	0.5
	SurfSoil_S5	0.5
	sink	0.0
SurfSoil_S5[a]	SW_Pond	0.0
	SurfSoil_N5	0.0
	SurfSoil_S4	1.0
	sink	0.0

[a] Assumes that N5 is higher ground than S5, and half of the runoff flows into N4, and the other half into S5. Assumes all runoff from S5 flows into S4.

Exhibit A-6. USLE Erosion Parameters for the TRIM.FaTE Screening Scenario

Soil Parcel	**Area**	**Rainfall/Erosivity Index**	**Soil Erodibility Index**	**Length-Slope Factor**	**Land Use**	**Cover Mgmt Factor**	**Supporting Practices Factor**	**Unit Soil Loss**		**Sediment Delivery Ratio**[a]	**Calculated (Adjusted) Erosion Rate**
Code	m^2	R (100 ft-ton/ac)	K (ton/ac/(100 ft-ton/acre))	LS (USCS)	type	C (USCS)	P	A (ton/ac/yr)	A (kg/m^2/d)	SDR[a]	kg/m^2/d
N1	5.8E+04	300	0.39	1.5	grass	0.1	1	17.55	0.010779	0.533	0.005740
N6	4.1E+04	300	0.39	1.5	crops	0.2	1	35.1	0.021557	0.557	0.012014
N7	7.3E+04	300	0.39	1.5	grass	0.1	1	17.55	0.010779	0.518	0.005580
N3	3.5E+05	300	0.39	1.5	grass	0.1	1	17.55	0.010779	0.385	0.004151
N4	2.0E+06	300	0.39	1.5	forest	0.1	1	17.55	0.010779	0.309	0.003331
N5	6.7E+06	300	0.39	1.5	forest	0.1	1	17.55	0.010779	0.196	0.002116
S1	5.8E+04	300	0.39	1.5	grass	0.1	1	17.55	0.010779	0.533	0.005740
S4	2.0E+06	300	0.39	1.5	forest	0.1	1	17.55	0.010779	0.309	0.003331
S5	6.7E+06	300	0.39	1.5	forest	0.1	1	17.55	0.010779	0.196	0.002116

[a] Calculated using SDR = $a * (AL)^{-b}$; where *a* is the empirical intercept coefficient (based on the size of the watershed), AL is the total watershed area receiving deposition (m^2), and *b* is the empirical slope coefficient (always 0.125).

Exhibit A-7. Terrestrial Plant Placement for the TRIM.FaTE Screening Scenario

Surface Soil Volume Element	Surface Soil Depth (m)	Coniferous Forest	Grasses/ Herbs	None
Source	0.01			x
N1	0.01		x	
N6	0.20 (tilled)			x
N7	0.01		x	
N3	0.01		x	
N4	0.01	x		
N5	0.01	x		
S1	0.01		x	
S4	0.01	x		
S5	0.01	x		

Exhibit A-8. Terrestrial Plant Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Coniferous[a]		Grass/Herb[a]	
		Value Used	Reference	Value Used	Reference
Leaf Compartment Type					
Allow exchange	1=yes, 0=no	1	-	Seasonal[b]	-
Average leaf area index	m^2[leaf]/ m^2[area]	5.0	Harvard Forest, dom. red oak and red maple, CDIAC website	5.0	Mid-range of 4-6 for old fields, R.J. Luxmoore, ORNL.
Calculate wet deposition interception fraction (Boolean)	1=yes, 0=no	0	Assumption.	0	Assumption.
Correction exponent, octanol to lipid	unitless	0.76	From roots, Trapp 1995.	0.76	From roots, Trapp 1995.
Degree stomatal opening	unitless	1	Assumed value of 1 for daytime (stomatal diffusion is turned off at night using a different property, IsDay).	1	Assumed value of 1 for daytime (stomatal diffusion is turned off at night using a different property, IsDay).
Density of wet leaf	kg/m^3	820	Paterson et al. 1991.	820	Paterson et al. 1991.
Leaf wetting factor	m	3.00E-04	1E-04 to 6E-04 for different crops and elements, Muller and Prohl 1993.	3.00E-04	1E-04 to 6E-04 for different crops and elements, Muller and Prohl 1993.
Length of leaf	m	0.01	Assumption.	0.05	Assumption.
Lipid content	kg/kg wet weight	0.00224	European beech, Riederer 1995.	0.00224	European beech, Riederer 1995.
Litter fall rate	1/day	0.0021	value assumes 1st-order relationship and that 99% of leaves fall over 6 years	Seasonal[c]	-
Stomatal area normalized effective diffusion path length	1/m	200	Wilmer and Fricker 1996.	200	Wilmer and Fricker 1996.
Vegetation attenuation factor	m^2/kg	2.9	Grass/hay, Baes et al. 1984.	2.9	Grass/hay, Baes et al. 1984.
Water content	unitless	0.8	Paterson et al. 1991.	0.8	Paterson et al. 1991.
Wet deposition interception fraction	unitless	0.2	Calculated based on 5 years of local met data, 1987-1991.	0.2	Calculated based on 5 years of local met data, 1987-1991.
Wet mass of leaf per soil area	kg[fresh leaf]/m^2[area]	2.0	Calculated from leaf area index, leaf thickness (Simonich and Hites, 1994), density of wet foliage.	0.6	Calculated from leaf area index and Leith 1975.
Particle on Leaf Compartment Type					
Allow exchange	1=yes, 0=no	1	-	Seasonal[b]	-

Exhibit A-8. Terrestrial Plant Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Coniferous[a]		Grass/Herb[a]	
		Value Used	Reference	Value Used	Reference
Particle on Leaf Compartment Type, continued					
Volume particle per area leaf	m^3[leaf particles]/m^2[leaf]	1.00E-09	Based on particle density and size distribution for atmospheric particles measured on an adhesive surface, Coe and Lindberg 1987.	1.00E-09	Based on particle density and size distribution for atmospheric particles measured on an adhesive surface, Coe and Lindberg 1987.
Root Compartment Type – Nonwoody Only					
Allow exchange	1=yes, 0=no			Seasonal[b]	-
Correction exponent, octanol to lipid	unitless			0.76	Trapp 1995.
Lipid content of root	kg/kg wet weight			0.011	Calculated.
Water content of root	kg/kg wet weight			0.8	Assumption.
Wet density of root	kg/m^3			820	Soybean, Paterson et al. 1991.
Wet mass per soil area	kg/m^2			1.4	Temperate grassland, Jackson et al. 1996.
Stem Compartment Type – Nonwoody Only					
Allow exchange	1=yes, 0=no			Seasonal[b]	-
Correction exponent, octanol to lipid	unitless			0.76	Trapp 1995.
Density of phloem fluid	kg/m^3			1,000	Assumption.
Density of xylem fluid	kg/cm^3			900	Assumption.
Flow rate of transpired water per leaf area	m^3[water]/m^2[leaf]			0.0048	Crank et al. 1981.
Fraction of transpiration flow rate that is phloem rate	unitless			0.05	Paterson et al. 1991.
Lipid content of stem	kg/kg wet weight			0.00224	Leaves of European beech, Riederer 1995.
Water content of stem	unitless			0.8	Paterson et al. 1991
Wet density of stem	kg/m^3			830	Assumption.
Wet mass per soil area	kg/m^2			0.24	Calculated from leaf and root biomass density.

[a] See Exhibit A-7 for assignment of plant types to surface soil compartments.

[b] Begins March 9 (set to 1), ends November 7 (set to 0). Nationwide 80th percentile.

[c] Begins November 7, ends December 6; rate = 0.15/day during this time (value assumes 99 percent of leaves fall in 30 days).

Exhibit A-9. Surface Water Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value Used	Reference
Algae carbon content (fraction)	unitless	0.465	APHA 1995.
Algae density in water column	g[algae]/L[water]	0.0025	Millard et al. 1996 as cited in ICF 2005.
Algae growth rate	1/day	0.7	Hudson et al. 1994 as cited in Mason et al. 1995b.
Algae radius	um	2.5	Mason et al. 1995b.
Algae water content (fraction)	unitless	0.9	APHA 1995.
Average algae cell density (per volume cell, not water)	g[algae]/m^3[algae]	1,000,000	Mason et al. 1995b, Mason et al. 1996.
Boundary layer thickness above sediment	m	0.02	Cal EPA 1993.
Chloride concentration	mg/L	8.0	Kaushal et al. 2005.
Chlorophyll concentration	mg/L	0.0029	ICF 2005.
Depth[a]	m	3.18	WI DNR 2007 - calculation based on relationship between drainage basin and lake area size.
Dimensionless viscous sublayer thickness	unitless	4	Ambrose et al. 1995.
Drag coefficient for water body	unitless	0.0011	Ambrose et al. 1995.
Flush rate	1/year	12.17	Calculated based on pond dimensions and flow calculations.
Fraction Sand	unitless	0.25	Assumption.
Organic carbon fraction in suspended sediments	unitless	0.02	Assumption.
pH	unitless	7.3	Assumption.
Suspended sediment deposition velocity	m/day	2	USEPA 1997b.
Total suspended sediment concentration	kg[sediment]/m^3[water column]	0.05	USEPA 2005.
Water temperature	degrees K	298	USEPA 2005.

[a] Set using the volume element properties named "top" and "bottom."

Exhibit A-10. Sediment Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value Used	Reference
Depth[a]	m	0.05	McKone et al. 2001 (Table 3).
Fraction sand	unitless	0.25	Assumption.
Organic carbon fraction	unitless	0.02	McKone et al. 2001 (Table 3).
Porosity of the sediment zone	volume[total pore space]/volume[sediment compartment]	0.6	USEPA 2005.
Solid material density in sediment	kg[sediment]/m^3[sediment]	2,600	McKone et al. 2001 (Table 3).
pH	unitless	7.3	Assumption.
Sediment resuspension velocity	m/day	6.69E-05	Calculated from water balance model.

[a] Set using the volume element properties named "top" and "bottom."

Exhibit A-11. Aquatic Animals Food Chain, Density, and Mass for the TRIM.FaTE Screening Scenario

Aquatic Biota (Consuming Organism)	Fraction Diet								Biomass (kg/m^2)	Body Weight (kg)	Reference
	Algae	Zooplankton	Benthic Invertebrate	Water Column Herbivore	Benthic Omnivore	Water Column Omnivore	Benthic Carnivore	Water Column Carnivore			
Benthic Invertebrate	0%	0%	0%	0%	0%	0%	0%	0%	0.020	2.55E-04	Assumption.
Water Column Herbivore	0%	100%	0%	0%	0%	0%	0%	0%	0.002	0.025	Assumption.
Benthic Omnivore	0%	0%	100%	0%	0%	0%	0%	0%	0.002	2.50E-01	Assumption.
Water Column Omnivore	0%	0%	0%	100%	0%	0%	0%	0%	0.001	0.25	Assumption.
Benthic Carnivore	0%	0%	50%	0%	50%	0%	0%	0%	0.001	2.0	Assumption.
Water Column Carnivore	0%	0%	0%	0%	0%	100%	0%	0%	0.0002	2.0	Assumption.
Zooplankton	100%	0%	0%	0%	0%	0%	0%	0%	0.0064	5.70E-08	Assumption.

Exhibit A-12. Cadmium Chemical-Specific Parameters for the TRIM.FaTE Screening Scenario

Parameter Name[a]	Units	Value	Reference
CAS number[b]	unitless	7440-43-9	-
Diffusion coefficient in pure air	m^2[air]/day	0.71	USEPA 1999 (Table A-2-35).
Diffusion coefficient in pure water	m^2[water]/day	8.16E-05	USEPA 1999 (Table A-2-35).
Henry's Law constant	Pa-m^3/mol	1.00E-37	USEPA 1999 (Table A-2-35; assumed to be zero).
Melting point	degrees K	594	ATSDR 1999.
Molecular weight	g/mol	112.41	ATSDR 1999.
Octanol-air partition coefficient (K_{oa})	m^3[air]/m^3[octanol]	-	-
Octanol-carbon partition coefficient (K_{oc})		-	-
Octanol-water partition coefficient (K_{ow})	L[water]/kg[octanol]	-	-

[a] All parameters in this table are TRIM.FaTE chemical properties.

[b] This CAS numbers applies to elemental Cd; however, the cations of cadmium are being modeled.

Exhibit A-13. Mercury Chemical-Specific Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value			Reference
		Hg(0)[b]	Hg(2)[b]	MHg[b]	
CAS number	unitless	7439-97-6	14302-87-5	22967-92-6	-
Diffusion coefficient in pure air	m^2[air]/day	0.478	0.478	0.456	USEPA 1997b.
Diffusion coefficient in pure water	m^2[water]/day	5.54E-05	5.54E-05	5.28E-05	USEPA 1997b.
Henry's Law constant	Pa-m^3/mol	719	7.19E-05	0.0477	USEPA 1997b.
Melting point	degrees K	234	5.50E+02	443	CARB 1994.
Molecular weight	g/mol	201	201	216	USEPA 1997b.
Octanol-water partition coefficient (K_{ow})	L[water]/kg[octanol]	4.15	3.33	1.7	Mason et al. 1996.
Vapor washout ratio	m^3[air]/m^3[rain]	1,200	1.6E+06	0	USEPA 1997b, based on Petersen et al. 1995.

[a] All parameters in this table are TRIM.FaTE chemical properties.

[b] On this and all following tables, Hg(0) = elemental mercury, Hg(2) = divalent mercury, and MHg = methyl mercury.

Exhibit A-14. PAH Chemical-Specific Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value							
		2Methyl	**712DMB**	**Acenaphthene**	**Acenaphthylene**	**BaA**	**BaP**	**BbF**	**BghiP**
CAS number	unitless	91-57-6	57-97-6	83-32-9	208-96-8	56-55-3	50-32-8	205-99-2	191-24-2
Diffusion coefficient in pure air	m^2/day	0.451	0.691	0.009	0.388	0.441	0.372	0.009	0.190
Diffusion coefficient in pure water	m^2/day	6.70E-05	6.91E-05	8.64E-05	6.03E-05	7.78E-05	7.78E-05	8.64E-05	4.54E-05
Henry's Law constant	Pa-m^3/mol	50.56	0.20	18.50	12.70	1.22	0.07	0.05	0.03
Melting point	degrees K	307.75	396.65	366.15	365.65	433	452	441	550.15
Molecular weight	g/mol	142.20	256.35	154.21	152.20	228.29	252.32	252.32	276.34
Octanol-water partition coefficient (K$_{ow}$)	L[water]/L[octanol]	7.24E+03	6.31E+05	8.32E+03	1.00E+04	6.17E+05	9.33E+05	6.03E+05	4.27E+06

Parameter Name	Units	Value							
		BkF	**Chr**	**DahA**	**Fluoranthene**	**Fluorene**	**IcdP**		
CAS number	unitless	207-08-9	218-01-9	53-70-3	206-44-0	86-73-7	193-39-5		
Diffusion coefficient in pure air	m^2/day	0.009	0.009	0.009	0.009	0.009	0.009		
Diffusion coefficient in pure water	m^2/day	8.64E-05	8.64E-05	8.64E-05	8.64E-05	8.64E-05	8.64E-05		
Henry's Law constant	Pa-m^3/mol	0.04	0.53	0.0076	1.96	9.81	0.03		
Melting point	degrees K	490	531	539	383.15	383.15	437		
Molecular weight	g/mol	252.32	228.29	278.33	202.26	166.20	276.34		
Octanol-water partition coefficient (K$_{ow}$)	L[water]/L[octanol]	8.71E+05	5.37E+05	3.16E+06	1.45E+05	1.51E+04	5.25E+06		

Exhibit A-14. PAH Chemical-Specific Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Reference
CAS number	unitless	-
Diffusion coefficient in pure air	m^2/day	USEPA 2005. Exceptions include USEPA 1997a (7,12-Dimethylbenz(a)anthracene), and USEPA 2007 (2-Methylnaphthalene, Acenaphthylene, and Benzo(g,h,i)perylene)
Diffusion coefficient in pure water	m^2/day	USEPA 2005. Exceptions include USEPA 1997a (7,12-Dimethylbenz(a)anthracene), and USEPA 2007 (2-Methylnaphthalene, Acenaphthylene, and Benzo(g,h,i)perylene)
Henry's Law constant	Pa-m^3/mol	USEPA 2005. Exceptions include USEPA 2003 (2-Methylnaphthalene) HSDB 2001a (7,12-Dimethylbenz(a)anthracene), HSDB 2001b (Acenaphthylene), and HSDB 2001c (Benzo(g,h,i)perylene)
Melting point	degrees K	Budavari 1996. Exceptions include USEPA 2003 (2-Methylnaphthalene), HSDB 2001a (7,12-Dimethylbenz(a)anthracene), HSDB 2001b (Acenaphthylene), HSDB 2001c (Benzo(g,h,i)perylene), and USEPA 2005 (Acenaphthene, Fluoranthene, and Fluorene)
Molecular weight	g/mol	Budavari 1996. Exceptions include USEPA 2003 (2-Methylnaphthalene), HSDB 2001a (7,12-Dimethylbenz(a)anthracene), HSDB 2001b (Acenaphthylene), HSDB 2001c (Benzo(g,h,i)perylene), and USEPA 2005 (Acenaphthene, Fluoranthene, and Fluorene)
Octanol-water partition coefficient (K_{ow})	L[water]/L[octanol]	Hansch et al. 1995. Exceptions include Passivirta et al. 1999 (Acenaphthylene, Benzo(k)fluoranthene, and Indeno(1,2,3-cd)pyrene), and Sangster 1993 (Benzo(b)fluoranthene)

Exhibit A-15. Dioxin Chemical-Specific Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value						
		1,2,3,4,6,7,8,9-OCDD	**1,2,3,4,6,7,8,9-OCDF**	**1,2,3,4,6,7,8-HpCDD**	**1,2,3,4,6,7,8-HpCDF**	**1,2,3,4,7,8,9-HpCDF**	**1,2,3,4,7,8-HxCDD**	**1,2,3,4,7,8-HxCDF**
CAS number	unitless	3268-87-9	39001-02-0	35822-46-9	67562-39-4	55673-89-7	39227-28-6	70648-26-9
Diffusion coefficient in pure air	m^2/day	0.751	0.168	0.782	0.176	0.176	0.816	0.183
Diffusion coefficient in pure water	m^2/day	6.91E-05	6.91E-05	6.91E-05	6.91E-05	6.91E-05	6.91E-05	6.91E-05
Henry's Law constant	Pa-m^3/mol	0.684	0.19	1.22	1.43	1.42	1.08	1.45
Melting point	degrees K	603.0	259.0	538.0	236.5	222.0	546.0	499.0
Molecular weight	g/mol	460	443.76	425.2	409.31	409.31	391	374.87
Octanol-water partition coefficient (K$_{ow}$)	L[water]/L[octanol]	1.58E+08	1.00E+08	1.00E+08	2.51E+07	7.94E+06	6.31E+07	1.00E+07
Parameter Name	**Units**	**Value**						
		1,2,3,6,7,8-HxCDD	**1,2,3,6,7,8-HxCDF**	**1,2,3,7,8,9-HxCDD**	**1,2,3,7,8,9-HxCDF**	**1,2,3,7,8-PeCDD**	**1,2,3,7,8-PeCDF**	**2,3,4,6,7,8-HxCDF**
CAS number	unitless	57653-85-7	57117-44-9	19408-74-3	72918-21-9	40321-76-4	57117-41-6	60851-34-5
Diffusion coefficient in pure air	m^2/day	0.816	0.183	0.816	0.183	0.854	0.192	0.183
Diffusion coefficient in pure water	m^2/day	6.91E-05	6.91E-05	6.91E-05	6.91E-05	6.91E-05	6.91E-05	6.91E-05
Henry's Law constant	Pa-m^3/mol	1.11	0.741	1.11	1.11	0.263	0.507	1.11
Melting point	degrees K	558.0	506.0	517.0	509.0	513.0	499.0	512.5
Molecular weight	g/mol	390.84	374.87	390.84	374.87	356.4	340.42	374.87
Octanol-water partition coefficient (K$_{ow}$)	L[water]/L[octanol]	1.62E+08	8.24E+07	1.62E+08	3.80E+07	1.86E+07	6.17E+06	8.31E+07

Exhibit A-15. Dioxin Chemical-Specific Parameters for the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value			Reference
		2,3,4,7,8-PeCDF	2,3,7,8-TCDD	2,3,7,8-TCDF	
CAS number	unitless	57117-31-4	1746-01-6	51207-31-9	-
Diffusion coefficient in pure air	m^2/day	0.192	0.899	0.203	US EPA 2005
Diffusion coefficient in pure water	m^2/day	6.91E-05	4.84E-05	5.19E-05	US EPA 2005
Henry's Law constant	Pa-m^3/mol	0.505	3.33	1.46	US EPA 2005
Melting point	degrees K	469.3	578.0	500.0	Mackay et al. 2000. Exceptions include USEPA 2000a (1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDF, and 1,2,3,7,8-PeCDD), ATSDR 1998 (1,2,3,6,7,8-HxCDF, 1,2,3,7,8-PeCDF, and 2,3,4,6,7,8-HxCDF), and NLM 2002 (1,2,3,7,8,9-HxCDD)
Molecular weight	g/mol	340.42	322	306	Mackay et al. 2000. Exceptions include ATSDR 1998 (1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 1,2,3,7,8-PeCDD, 1,2,3,7,8-PeCDF, and 2,3,4,6,7,8-HxCDF) and NLM 2002 (1,2,3,6,7,8-HxCDD and 1,2,3,7,8,9-HxCDD)
Octanol-water partition coefficient (K_{ow})	L[water]/L[octanol]	3.16E+06	6.31E+06	1.26E+06	Mackay et al. 1992 as cited in USEPA 2000b. Exceptions include Mackay et al. 2000 (1,2,3,4,7,8,9-HpCDF), USEPA 2000a (1,2,3,6,7,8-HxCDD, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDD, 1,2,3,7,8,9-HxCDF, and 2,3,4,6,7,8-HxCDF), and Sijm et al. 1989 as cited in USEPA 2000b (1,2,3,7,8-PeCDD)

Exhibit A-16. Cadmium Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value	Reference
Air Compartment Type			
Particle dry deposition velocity	m/day	260	Calculated from Muhlbaier and Tissue 1980.
Washout ratio	m^3[air]/m^3[rain]	200,000	MacKay et al. 1986.
Surface Soil Compartment Type			
Use input characteristic depth (Boolean)	0 = no, Else = yes	0	Assumption.
Root Zone Soil Compartment Type			
Use input characteristic depth (Boolean)	0 = no, Else = yes	0	Assumption.
Vadose Zone Soil Compartment Type			
Use input characteristic depth (Boolean)	0 = no, Else = yes	0	Assumption.
Surface Water Compartment Type			
Ratio of concentration in water to concentration in algae to concentration dissolved in water	L[water]/g[algae wet wt]	1.87	McGeer et al. 2003.

Exhibit A-17. Mercury Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value			Reference
		Hg(0)	Hg(2)	MHg	
Air Compartment Type					
Particle dry deposition velocity	m/day	500	500	500	CalTOX value cited in McKone et al. 2001.
Demethylation rate	1/day	N/A	N/A	0	Assumption.
Methylation rate	1/day	0	0	0	Assumption.
Oxidation rate	1/day	0.00385	0	0	Low end of half-life range (6 months to 2 years) in USEPA 1997b.
Reduction rate	1/day	0	0	0	Assumption.
Washout ratio	m^3[air]/m^3[rain]	200,000	200,000	200,000	Assumption.
Surface Soil Compartment Type					
Use input characteristic depth (Boolean)	0 = no, Else = yes	0	0	0	Assumption.
Soil-water partition coefficient	L[water]/kg[soil wet wt]	1,000	58,000	7,000	USEPA 1997b.
Vapor dry deposition velocity	m/day	50	2500	0	Hg(0) - from Lindberg et al. 1992; Hg(2) - estimate by USEPA using the Industrial Source Complex (ISC) Model - [See Vol. III, App. A of the Mercury Study Report (USEPA 1997b)].
Demethylation rate	1/day	N/A	N/A	0.06	Range reported in Porvari and Verta 1995 is 3E-2 to 6E-2 /day; value is average maximum potential demethylation rate constant under anaerobic conditions.
Methylation rate	1/day	0	0.001	0	Range reported in Porvari and Verta 1995 is 2E-4 to 1E-3 /day; value is average maximum potential methylation rate constant under anaerobic conditions.
Oxidation rate	1/day	0	0	0	Value assumed in USEPA 1997b.
Reduction rate	1/day	0	1.25E-05	0	Value used for untilled surface soil (2cm), 10% moisture content, in USEPA 1997b; general range is (0.0013/day)*moisture content to (0.0001/day)*moisture content for forested region (Lindberg 1996; Carpi and Lindberg 1997).

Exhibit A-17. Mercury Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	**Units**	**Value**			**Reference**
		Hg(0)	**Hg(2)**	**MHg**	
Root Zone Soil Compartment Type					
Use input characteristic depth (Boolean)	0 = no, Else = yes	0	0	0	Assumption.
Soil-water partition coefficient	L[water]/kg[soil wet wt]	1,000	58,000	7,000	USEPA 1997b.
Demethylation rate	1/day	N/A	N/A	0.06	Range reported in Porvari and Verta 1995 is 3E-2 to 6E-2 /day; value is average maximum potential demethylation rate constant under anaerobic conditions.
Methylation rate	1/day	0	0.001	0	Range reported in Porvari and Verta 1995 is 2E-4 to 1E-3 /day; value is average maximum potential methylation rate constant under anaerobic conditions.
Oxidation rate	1/day	0	0	0	Value assumed in USEPA 1997b.
Reduction rate	1/day	0	3.25E-06	0	Value used for tilled surface soil (20cm), 10% moisture content, in USEPA 1997b (Lindberg 1996; Carpi and Lindberg 1997).
Vadose Zone Soil Compartment Type					
Use input characteristic depth (Boolean)	0 = no, Else = yes	0	0	0	Assumption.
Soil-water partition coefficient	L[water]/kg[soil wet wt]	1,000	58,000	7,000	USEPA 1997b.
Demethylation rate	1/day	N/A	N/A	0.06	Range reported in Porvari and Verta 1995 is 3E-2 to 6E-2 /day; value is average maximum potential demethylation rate constant under anaerobic conditions.
Methylation rate	1/day	0	0.001	0	Range reported in Porvari and Verta 1995 is 2E-4 to 1E-3 /day; value is average maximum potential methylation rate constant under anaerobic conditions.
Oxidation rate	1/day	0	0	0	Value assumed in USEPA 1997b.
Reduction rate	1/day	0	3.25E-06	0	Value used for tilled surface soil (20cm), 10% moisture content, in USEPA 1997b (Lindberg 1996; Carpi and Lindberg 1997).

Exhibit A-17. Mercury Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value			Reference
		Hg(0)	Hg(2)	MHg	
Groundwater Compartment Type					
Soil-water partition coefficient	L[water]/kg[soil wet wt]	1,000	58,000	7,000	USEPA 1997b.
Demethylation rate	1/day	N/A	N/A	0.06	Range reported in Porvari and Verta 1995 is 3E-2 to 6E-2 /day; value is average maximum potential demethylation rate constant under anaerobic conditions.
Methylation rate	1/day	0	0.001	0	Range reported in Porvari and Verta 1995 is 2E-4 to 1E-3 /day; value is average maximum potential methylation rate constant under anaerobic conditions.
Oxidation rate	1/day	1.00E-08	0	0	Small default nonzero value (0 assumed in USEPA 1997b).
Reduction rate	1/day	0	3.25E-06	0	Value used for tilled surface soil (20cm), 10% moisture content, in USEPA 1997b (Lindberg 1996; Carpi and Lindberg 1997).
Surface Water Compartment Type					
Algal surface area-specific uptake rate constant	nmol/[µm2-day-nmol]	0	2.04E-10	3.60E-10	Assumes radius = 2.5mm, Mason et al. 1995b, Mason et al. 1996; Hg(0) assumed same as Hg(2).
D_{ow} ("overall K_{ow}")	L[water]/kg[octanol]	0	-a	-b	Mason et al. 1996.
Solids-water partition coefficient	L[water]/kg[solids wet wt]	1,000	100,000	100,000	USEPA 1997b.
Vapor dry deposition velocity	m/day	N/A	2500		USEPA 1997b (Vol. III, App. A).
Demethylation rate	1/day	N/A	N/A	0.013	Average range of 1E-3 to 2.5E-2/day from Gilmour and Henry 1991.
Methylation rate	1/day	0	0.001	0	Value used in EPA 1997; range is 1E-4 to 3E-4/day (Gilmour and Henry 1991).
Oxidation rate	1/day	0	0	0	Assumption.
Reduction rate	1/day	0	0.0075	0	Value used in USEPA 1997b; reported values range from less than 5E-3/day for depths greater than 17m, up to 3.5/day (Xiao et al. 1995; Vandal et al. 1995; Mason et al. 1995a; Amyot et al. 1997).

Exhibit A-17. Mercury Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value			Reference
		Hg(0)	Hg(2)	MHg	
Sediment Compartment Type					
Solids-water partition coefficient	L[water]/kg[solids wet wt]	3,000	50,000	3,000	USEPA 1997b.
Demethylation rate	1/day	N/A	N/A	0.0501	Average range of 2E-4 to 1E-1/day from Gilmour and Henry 1991.
Methylation rate	1/day	0	1.00E-04	0	Value used in EPA 1997b; range is 1E-5 to 1E-3/day, Gilmour and Henry 1991.
Oxidation rate	1/day	0	0	0	Assumption.
Reduction rate	1/day	0	1.00E-06	0	Inferred value based on presence of Hg(0) in sediment porewater (USEPA 1997b; Vandal et al. 1995).

[a] TRIM.FaTE Formula Property, which varies from 0.025 to 1.625 depending on pH and chloride concentration.

[b] TRIM.FaTE Formula Property, which varies from 0.075 to 1.7 depending on pH and chloride concentration.

Exhibit A-18. PAH Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value								
		2Methyl	712DMB	Acenaph-thene	Acenaph-thylene	BaA	BaP	BbF	BghiP	BkF
Air Compartment Type										
Particle dry deposition velocity	m/day	500	500	500	500	500	500	500	500	500
Half-life	day	0.154	0.092	0.3	0.208	0.125	0.046	0.596	0.215	0.458
Washout ratio		200000	200000	200000	200000	200000	200000	200000	200000	200000
Surface Soil Compartment Type										
User input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	0	0	0	0
Half-life	day	18	24	56	66.5	680	530	610	415	2140
Root Zone Soil Compartment Type										
User input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	0	0	0	0
Half-life	day	18	24	56	66.5	680	530	610	415	2140
Vadose Zone Soil Compartment Type										
User input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	0	0	0	0
Half-life	day	36	48	112	133	1360	1060	1220	830	4280
Groundwater Compartment Type										
Half-life	day	36	48	112	133	1360	1060	1220	830	4280
Surface Water Compartment Type										
Ratio Of Conc In Algae To Conc Dissolved In Water	(g[chem]/kg[algae]) / (g[chem]/L[water])	2.6	333.4	3	3.7	325	510	317	1539	473
Half-life	day	78	216	25	184	0.375	0.138	90	1670	62.4
Sediment Compartment Type										
Half-life	day	2290	2290	2290	2290	2290	2290	2290	2290	2290

Exhibit A-18. PAH Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value					Reference
		Chr	DahA	Fluoranthene	Fluorene	IcdP	
Air Compartment Type							
Particle dry deposition velocity	m/day	500	500	500	500	500	McKone et al. 2001.
Half-life	day	0.334	0.178	0.46	0.46	0.262	Howard et al. 1991 / upper bound measured or estimated value. Exceptions include ATSDR 2005 (2-Methylnaphthalene), USEPA 1998 (7,12-Dimethylbenz(a)anthracene, Benzo(g,h,i)perylene, and Fluoranthene) / average of range, HSDB 2001d (Acenaphthene), HSDB 2001b (Acenaphthylene), and Spero et al. 2000 (Fluorene).
Washout ratio		200000	200000	200000	200000	200000	Mackay et al. 1986.
Surface Soil Compartment Type							
User input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	Assumption.
Half-life	day	1000	940	275	33	730	MacKay et al. 2000 / average of range. Exceptions include ATSDR 2005 (2-Methylnaphthalene), USEPA 1998 (7,12-Dimethylbenz(a)anthracene, Benzo(g,h,i)perylene, and Fluoranthene) / average of range, HSDB 2001d (Acenaphthene), HSDB 2001b (Acenaphthylene), and HSDB 2001e (Fluorene).
Root Zone Soil Compartment Type							
User input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	Assumption.
Half-life	day	1000	940	275	33	730	Howard et al. 1991 / upper bound measured or estimated value. Exceptions include ATSDR 2005 (2-Methylnaphthalene), USEPA 1998 (7,12-Dimethylbenz(a)anthracene, Benzo(g,h,i)perylene, and Fluoranthene) / average of range, HSDB 2001d (Acenaphthene), HSDB 2001b (Acenaphthylene), and HSDB 2001e (Fluorene).
Vadose Zone Soil Compartment Type							
User input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	Assumption.

Exhibit A-18. PAH Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value					Reference
		Chr	DahA	Fluoranthene	Fluor-ene	IcdP	
Vadose Zone Soil Compartment Type, continued							
Half-life	day	2000	1880	550	66	1460	Howard et al. 1991 / upper bound measured or estimated value. Exceptions include ATSDR 2005 (2-Methylnaphthalene), USEPA 1998 (7,12-Dimethylbenz(a)anthracene, Benzo(g,h,i)perylene, and Fluoranthene) / twice average of range, HSDB 2001d (Acenaphthene) / multiplied by 2, HSDB 2001b (Acenaphthylene) / multiplied by 2, and HSDB 2001e (Fluorene) / multiplied by 2.
Groundwater Compartment Type							
Half-life	day	2000	1880	550	66	1460	Howard et al. 1991 / upper bound measured or estimated value. Exceptions include ATSDR 2005 (2-Methylnaphthalene), USEPA 1998 (7,12-Dimethylbenz(a)anthracene, Benzo(g,h,i)perylene, and Fluoranthene) / twice average of range, HSDB 2001d (Acenaphthene) / multiplied by 2, HSDB 2001b (Acenaphthylene) / multiplied by 2, and HSDB 2001e (Fluorene) / multiplied by 2.
Surface Water Compartment Type							
RatioOfConcInAlgaeToConcDissolvedInWater	(g[chem]/kg[algae])/(g[chem]/L[water])	280	1388	67.4	5.8	1653	K_{ow} from Del Vento and Dachs 2002.
Half-life	day	1.626	97.8	160	8.5	750	Howard et al. 1991 / upper bound measured or estimated value. Exceptions include HSDB 2005 (2-Methylnaphthalene), HSDB 2001a (7-12 Dimethylbenz(a)anthracene), HSDB 2001d (Acenaphthene), HSDB 2001b (Acenaphthylene), and HSDB 2001c (Benzo(g,h,i)perylene), Montgomery 2000 (Fluoranthene), and Boyle 1985 (Fluorene).
Sediment Compartment Type							
Half-life	day	2290	2290	2290	2290	2290	Mackay et al. 1992 / PAH values are the mean half-life of the log class that Mackay et al. assigned for sediment, except for BbF and IcdP, which were not in Table 2.3 of Mackay et. al.

Exhibit A-19. Dioxin Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value					
		1,2,3,4,6,7,8,9 -OCDD	1,2,3,4,6,7,8,9 -OCDF	1,2,3,4,6,7,8- HpCDD	1,2,3,4,6,7,8- HpCDF	1,2,3,4,7,8,9- HpCDF	1,2,3,4,7,8- HxCDD
Air Compartment Type							
Deposition Velocity	m/day	500	500	500	500	500	500
Half-life	day	162	321	64	137	122	42
Washout Ratio	m^3[air]/m^3[rain]	91000	22000	64000	32000	32000	9000
Surface Soil Compartment Type							
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	0
Halflife	day	3650	3650	3650	3650	3650	3650
Root Zone Soil Compartment Type							
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth	0 = No, Else = Yes	0	0	0	0	0	0
Half-life	day	3650	3650	3650	3650	3650	3650
Vadose Zone Soil Compartment Type							
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	0
Half-life	day	1008	1008	1008	1008	1008	1008
Groundwater Compartment Type							
Half-life	day	1008	1008	1008	1008	1008	1008
Surface Water Compartment Type							
Ratio Of Conc In Algae To Conc Dissolved In Water	(g[chem]/g[algae])/ (g[chem]/L[water])	5.31	4.54	4.54	2.83	1.9	3.88
Half-life	day	0.67	0.58	47	0.58	0.58	6.3
Sediment Compartment Type							
Half-life	day	1095	1095	1095	1095	1095	1095

Exhibit A-19. Dioxin Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value					
		1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDD	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDD	1,2,3,7,8,9-HxCDF	1,2,3,7,8-PeCDD
Air Compartment Type							
Deposition velocity	m/day	500	500	500	500	500	500
Half-life	day	78	28	55	28	51	18
Washout ratio	m^3[air]/m^3[rain]	10000	9000	10000	9000	10000	18000
Surface Soil Compartment Type							
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	0
Half-life	day	3650	3650	3650	3650	3650	3650
Root Zone Soil Compartment Type							
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth	0 = No, Else = Yes	0	0	0	0	0	0
Half-life	day	3650	3650	3650	3650	3650	3650
Vadose Zone Soil Compartment Type							
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0	0
Half-life	day	1008	1008	1008	1008	1008	1008
Groundwater Compartment Type							
Half-life	day	1008	1008	1008	1008	1008	1008
Surface Water Compartment Type							
Ratio Of Conc In Algae To Conc Dissolved In Water	(g[chem]/g[algae])/ (g[chem]/L[water])	2.06	5.36	4.25	5.36	3.26	1.55
Half-life	day	0.58	6.3	0.58	6.3	0.58	2.7
Sediment Compartment Type							
Half-life	day	1095	1095	1095	1095	1095	1095

Exhibit A-19. Dioxin Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value				
		1,2,3,7,8-PeCDF	2,3,4,6,7,8-HxCDF	2,3,4,7,8-PeCDF	2,3,7,8-TCDD	2,3,7,8-TCDF
Air Compartment Type						
Deposition velocity	m/day	500	500	500	500	500
Half-life	day	31	59	33	12	19
Washout ratio	m^3[air]/m^3[rain]	13000	10000	14000	18000	19000
Surface Soil Compartment Type						
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0
Half-life	day	3650	3650	3650	3650	3650
Root Zone Soil Compartment Type						
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth	0 = No, Else = Yes	0	0	0	0	0
Half-life	day	3650	3650	3650	3650	3650
Vadose Zone Soil Compartment Type						
Input characteristic depth	m	0.08	0.08	0.08	0.08	0.08
Use input characteristic depth (Boolean)	0 = No, Else = Yes	0	0	0	0	0
Half-life	day	1008	1008	1008	1008	1008
Groundwater Compartment Type						
Half-life	day	1008	1008	1008	1008	1008
Surface Water Compartment Type						
Ratio Of Conc In Algae To Conc Dissolved In Water	(g[chem]/g[algae])/ (g[chem]/L[water])	1.75	4.26	1.39	1.76	0.71
Half-life	day	0.19	0.58	0.19	2.7	0.18
Sediment Compartment Type						
Half-life	day	1095	1095	1095	1095	1095

Exhibit A-19. Dioxin Chemical-Specific Parameters for Abiotic Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Reference
Air Compartment Type	
Deposition velocity	McKone et al. 2001.
Half-life	Atkinson 1996 as cited in USEPA 2000b; vapor phase reaction with hydroxyl radical.
Washout ratio	Vulykh et al. 2001.
Surface Soil Compartment Type	
Input characteristic depth	Not used (model set to calculate value).
Use input characteristic depth (Boolean)	Assumption.
Half-life	Mackay et al. 2000; the degradation rate was cited by multiple authors, value is for 2,3,7,8-TCDD.
Root Zone Soil Compartment Type	
Input characteristic depth	Not used (model set to calculate value).
Use input characteristic depth	Assumption.
Half-life	Mackay et al. 2000; the degradation rate was cited by multiple authors, value is for 2,3,7,8-TCDD.
Vadose Zone Soil Compartment Type	
Input characteristic depth	Not used (model set to calculate value).
Use input characteristic depth (Boolean)	Assumption.
Half-life	Average value of the range presented in Mackay et al. 2000; based on estimated unacclimated aerobic biodegradation half-life, value is for 2,3,7,8-TCDD.
Groundwater Compartment Type	
Half-life	Average value of the range presented in Mackay et al. 2000; based on estimated unacclimated aerobic biodegradation half-life, value is for 2,3,7,8-TCDD.
Surface Water Compartment Type	
Ratio Of Conc In Algae To Conc Dissolved In Water	Estimated from K_{ow} value using model from DelVento and Dachs 2002
Half-life	Kim and O'Keefe 1998, as cited in USEPA 2000b.
Sediment Compartment Type	
Half-life	Estimation based on Adriaens and Grbic-Galic 1992,1993 and Adriaens et al. 1995 as cited in USEPA 2000b.

Exhibit A-20. Cadmium Chemical-Specific Parameters for Plant Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value	Reference
Leaf Compartment Type			
Transfer factor to leaf particle	1/day	0.002	Assumption.
Particle on Leaf Compartment Type			
Transfer factor to leaf	1/day	0.200	Assumption.
Root Compartment Type - Grasses and Herbs[a]			
Root to Root Soil Partition-Alpha of Steady State	unitless	0.95	Henning et al. 2001.
Root to Root Soil Partition-Partitioning Coefficient	m^3[bulk root soil]/m^3[root]	0.23	Nriagu 1980; based on average value calculated from various agricultural plant species.
Root to Root Soil Partition-Time to Reach Alpha	day	28	Henning et al. 2001.
Stem Compartment Type - Grasses and Herbs[a]			
Transpiration stream concentration factor (TSCF)	m^3[soil pore water]/m^3[xylem fluid]	0.45	Tsiros et al. 1999.

[a] Roots and stems are not modeled for deciduous or coniferous forest in the current version of TRIM.FaTE.

Exhibit A-21. Mercury Chemical-Specific Parameters for Plant Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value			Reference
		Hg(0)	Hg(2)	MHg	
Leaf Compartment Type					
Transfer factor to leaf particle	1/day	0.002	0.002	0.002	Assumed based on 1% of transfer factor from leaf particle to leaf.
Demethylation rate	1/day	N/A	N/A	0.03	Calculated from Bache et al. 1973.
Methylation rate	1/day	0	0	0	Assumed from Gay 1975, Bache et al. 1973.
Oxidation rate	1/day	1.0E+06	0	0	Assumed to be nearly instantaneous
Reduction rate	1/day	0	0	0	Assumption.
Particle on Leaf Compartment Type					
Transfer factor to leaf	1/day	0.2	0.2	0.2	Assumption.
Demethylation rate	1/day	N/A	N/A	0	Assumption.
Methylation rate	1/day	0	0	0	Assumption.
Oxidation rate	1/day	0	0	0	Assumption.
Reduction rate	1/day	0	0	0	Assumption.
Root Compartment Type - Grasses and Herbs[a]					
Alpha for root-root zone bulk soil	unitless	0.95	0.95	0.95	Selected value.
Root/root-zone-soil-water partition coefficient	m^3[bulk root soil]/ m^3[root]	0	0.18	1.2	Hg^{2-} geometric mean Leonard et al. 1998, John 1972, Hogg et al. 1978; MHg-assumed, based on Hogg et al. 1978.
t-alpha for root-root zone bulk soil	day	21	21	21	Assumption.
Demethylation rate	1/day	N/A	N/A	0	Assumption.
Methylation rate	1/day	0	0	0	Assumption.
Oxidation rate	1/day	0	0	0	Assumption.
Reduction rate	1/day	0	0	0	Assumption.
Stem Compartment Type - Grasses and Herbs[a]					
Transpiration stream concentration factor (TSCF)	m^3[soil pore water]/m^3[xylem fluid]	0	0.5	0.2	Calculation from Norway spruce, Scots pine, Bishop et al. 1998.
Demethylation rate	1/day	N/A	N/A	0.03	Calculated from Bache et al. 1973.
Methylation rate	1/day	0	0	0	Assumption.
Oxidation rate	1/day	0	0	0	Assumption.
Reduction rate	1/day	0	0	0	Assumption.

[a] Roots and stems are not modeled for deciduous or coniferous forest in the current version of TRIM.FaTE.

Exhibit A-22. PAH Chemical-Specific Parameters for Plant Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value								
		2Methyl	712DMB	Acenaph-thene	Acenaph-thylene	BaA	BaP	BbF	BghiP	BkF
Leaf Compartment Type										
Transfer factor to leaf particle	1/day	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04
Half-life	day	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Particle on Leaf Compartment Type										
Transfer factor to leaf	1/day	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04
Half-life	day	2.31	2.31	2.31	2.31	1.84	2.31	3.56	2.31	17.80
Root Compartment Type - Grasses and Herbs[a]										
Half-life	day	34.60	34.60	34.60	34.60	34.60	34.60	34.60	34.60	34.60
Root soil-water interaction - alpha	unitless	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Stem Compartment Type - Grasses and Herbs[a]										
Half-life	day	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50

[a] Roots and stems are not modeled for deciduous or coniferous forest in the current version of TRIM.FaTE.

Exhibit A-23. PAH Chemical-Specific Parameters for Plant Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value					Reference
		Chr	DahA	Fluoran-thene	Fluorene	IcdP	
Leaf Compartment Type							
Transfer factor to leaf particle	1/day	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	Assumption.
Half-life	day	3.50	3.50	3.50	3.50	3.50	Edwards 1988 (calculated from metabolic rate constant).
Particle on Leaf Compartment Type							
Transfer factor to leaf	1/day	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	Assumption.
Half-life	day	4.12	17.80	2.31	2.31	17.80	Calculated as 2 times the measured photolysis half-life from Mackay et al. 1992. Exceptions include values that have been set equal to Benzo(a)pyrene (2-Methylnaphthalene; 7,12-Dimethylbenz(a)anthracene; Acenaphthene; Acenaphthylene; Benzo(ghi)perylene; Fluoranthene; and Fluorene).
Root Compartment Type - Grasses and Herbs[a]							
Half-life	day	34.60	34.60	34.60	34.60	34.60	Edwards 1988 (calculated from metabolic rate constant).
Root soil water interaction - alpha	unitless	0.95	0.95	0.95	0.95	0.95	Assumption.
Stem Compartment Type - Grasses and Herbs[a]							
Half-life	day	3.50	3.50	3.50	3.50	3.50	Edwards 1988 (calculated from metabolic rate constant).

[a] Roots and stems are not modeled for deciduous or coniferous forest in the current version of TRIM.FaTE.

Exhibit A-23. Dioxin Chemical-Specific Parameters for Plant Compartments in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value	Reference
		All Dioxins	
Leaf Compartment Type			
Transfer factor to leaf particle	1/day	0.003	Calculated as 1 percent of transfer factor to leaf; highly uncertain.
Half-life	day	70	Arjmand and Sandermann 1985, as cited in Komoba et al. 1995; soybean root cell culture metabolism test data for DDE.
Particle on Leaf Compartment Type			
Transfer factor to leaf	1/day	0.3	Assumption based on USEPA 2000b (an estimate for mercury) and Trapp 1995; highly uncertain.
Half-life	day	4.4	McCrady and Maggard 1993; photodegradation sorbed to grass foliage in sunlight; assumed 10% sunlight per day.
Root Compartment Type - Grasses and Herbs[a]			
Half-life	day	70	Arjmand and Sandermann 1985, as cited in Komoba et al. 1995; soybean root cell culture metabolism test data for DDE.
Root soil-water interaction - alpha	unitless	0.95	Assumption.
Stem Compartment Type - Grasses and Herbs[a]			
Half-life	day	70	Arjmand and Sandermann 1985, as cited in Komoba et al. 1995; soybean root cell culture metabolism test data for DDE.

[a] Roots and stems are not modeled for deciduous or coniferous forest in the current version of TRIM.FaTE.

Exhibit A-24. Cadmium Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value	Reference
Zooplankton Compartment Type			
Absorption rate constant	L[water]/kg[fish wet wt]-day	1500	Goulet 2007.
Assimilation efficiency from algae	unitless	0.5	Goulet 2007.
Elimination rate constant	1/day	0.03	Goulet 2007.
Benthic Invertebrate Compartment Type			
Sediment partitioning - alpha of equilibrium	unitless	0.95	Assumption.
Sediment partitioning - partition coefficient	kg[bulk sed/kg[invertebrate wet wt]	0.27	Assumption.
Sediment partitioning - time to reach alpha of equilibrium	day	21	Hare et al. 2001.
Benthic Omnivore Compartment Type			
Assimilation efficiency from food	unitless	0.1	Assumption based on Yan and Wang 2002.
Absorption rate constant	unitless	1.23	Calculated based on body weight from regression in Hendriks and Heikens 2001.
Elimination rate constant	unitless	1.73E-02	Assumption.
Benthic Carnivore Compartment Type			
Assimilation efficiency from food	unitless	0.1	Assumption based on Yan and Wang 2002.
Absorption rate constant	unitless	0.66	Calculated based on body weight from regression in Hendriks and Heikens 2001.
Elimination rate constant	unitless	1.68E-03	Assumption.
Water-column Herbivore Compartment Type			
Assimilation efficiency from food	unitless	0.1	Assumed value based on Yan and Wang 2002.
Assimilation efficiency from plants	unitless	0.1	Assumed value based on Yan and Wang 2002.
Absorption rate constant	unitless	2.46	Calculated based on body weight from regression in Hendriks and Heikens 2001.
Elimination rate constant	unitless	1.73E-02	Assumption.

Exhibit A-24. Cadmium Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value	Reference
Water-column Omnivore Compartment Type			
Assimilation efficiency from food	unitless	0.1	Assumption based on Yan and Wang 2002.
Assimilation efficiency from plants	unitless	0.1	Assumption based on Yan and Wang 2002.
Absorption rate constant	unitless	1.23	Calculated based on body weight from regression in Hendriks and Heikens 2001.
Elimination rate constant	unitless	1.73E-02	Assumption.
Water-column Carnivore Compartment Type			
Assimilation efficiency from food	unitless	0.1	Assumption based on Yan and Wang 2002.
Absorption rate constant	unitless	0.66	Calculated based on body weight from regression in Hendriks and Heikens 2001.
Elimination rate constant	unitless	1.73E-02	Assumption

Exhibit A-25. Mercury Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value			Reference
		Hg(0)	Hg(2)	MHg	
Zooplankton Compartment Type					
Assimilation Efficiency From Algae	unitless	0.2	0.015	0.5	Environment Canada 2002.
Half-life	day	1.0E+09	1.0E+09	1.0E+09	Assumption.
How Much Faster Hg Elimination Is Than For MHg	unitless	3	3	1	Assumption.
Methylation rate	1/day	0	0	0	Assumption.
Oxidation rate	1/day	0	1.0E+06	0	Assumption.
Reduction rate	1/day	0	0	0	Assumption.
Benthic Invertebrate Compartment Type					
Alpha of equilibrium for sediment partitioning	unitless	0.95	0.95	0.95	Selected value (i.e., proportion of equilibrium achieved by time "t").
Benthic invertebrate-bulk sediment partition coefficient	kg[bulk sediment]/kg[invertebrate wet wt]	0.0824	0.0824	5.04	Hg(0) - assumed based on Hg(2) value; Hg(2) and MHg - Saouter et al. 1991.
t-alpha for equilibrium for sediment partitioning	day	14	14	14	Experiment duration from Saouter et al. 1991.
All Fish Compartments Types[a]					
Elimination adjustment factor	unitless	3	3	1	Trudel and Rasmussen 1997.
Assimilation efficiency from food	unitless	0.06	0.06	0.5	Williams et al. 2010.
Demethylation rate	1/day	N/A	N/A	0	Assumption.
Methylation rate	1/day	0	0	0	Assumption.
Oxidation rate	1/day	1.0E+06	0	0	Assumption.
Reduction rate	1/day	0	0	0	Assumption.
Water-column Herbivore Compartment Type					
Assimilation efficiency from plankton	unitless	0.06	0.06	0.5	Williams et al. 2010.

[a] Screening scenario includes: Benthic Omnivore, Benthic Carnivore, Water-column Herbivore, Water-column Omnivore, and Water-column Carnivore.

Exhibit A-26. PAH Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value								
		2Methyl	712DMB	Acenaph-thene	Acenaph-thylene	BaA	BaP	BbF	BghiP	BkF
Zooplankton Compartment Type										
Absorption rate constant	L[water]/kg[fish wet wt]-day	790	42650.94	42231	42302.18	42650.81	42652.78	42650.68	42655.77	42652.5
Assimilation efficiency from algae	unitless	0.5	0.25	0.5	0.5	0.46	0.25	0.25	0.25	0.25
Elimination rate constant	1/day	169.68	2.03	148.07	123.44	2.073	1.3864	2.12	0.33	1.48
Half-life	day	0.007788	17	0.00239	0.00239	1.284	16.5	17	17	17
Benthic Invertebrate Compartment Type										
Clearance constant	unitless	100.6	100.6	100.6	100.6	100.6	100.6	100.6	100.6	100.6
V_d (ratio of concentration in benthic invertebrates to concentration in water)	ml/g	7235	7235	7235	7235	7235	7235	7235	7235	7235
Half-life	day	0.722	17	0.722	0.722	1.284	16.5	17	17	17
All Fish Compartment Types[a]										
Gamma fish	unitless	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Assimilation efficiency from food	unitless	0.5	0.15	0.5	0.32	0.15	0.15	0.15	0.15	0.15
Half-life	day	0.2	2	0.2	0.2	0.408	1.925	2	2	2

[a] Screening scenario includes: Benthic Omnivore, Benthic Carnivore, Water-column Herbivore, Water-column Omnivore, and Water-column Carnivore.

Exhibit A-26. PAH Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value					Reference
		Chr	DahA	Fluoran-thene	Fluorene	IcdP	
Zooplankton Compartment Type							
Absorption rate constant	L[water]/kg[fish wet wt]-day	42649.95	42655.48	142000	15000	42655.93	K_{ow} from Arnot et al. 2004. Exception is Berrojalbiz et al. 2009 (2-Methylnaphthalene, Fluoranthene, and Fluorene).
Assimilation efficiency from algae	unitless	0.46	0.25	0.49	0.5	0.25	K_{ow} from Arnot et al. 2004. Exception is maximum value from Wang and Wang 2006 (7,12-Dimethylbenz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Dibenz(a,h)anthracene, and Indeno(1,2,3-cd)pyrene).
Elimination rate constant	1/day	2.3746	0.4331	8.678	81.87	0.269	K_{ow} from Arnot et al. 2004.
Half-life	day	0.495	17	0.00239	0.0002476	17	McElroy 1990. Exceptions include Berrojalbiz et al. 2009 (2-Methylnaphthalene, Fluoranthene, and Fluorene) and Moermond et al. 2007 (Benz(a)anthracene and Benzo(a)pyrene).
Benthic Invertebrate Compartment Type							
Clearance constant	unitless	100.6	100.6	100.6	100.6	100.6	Stehly et al. 1990.
V_d (ratio of concentration in benthic invertebrates to concentration in water)	ml/g	7235	7235	7235	7235	7235	Stehly et al. 1990.
Half-life	day	0.495	17	0.722	0.722	17	Moermond et al. 2007.

Exhibit A-26. PAH Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	**Units**	**Value**					**Reference**
		Chr	**DahA**	**Fluoran-thene**	**Fluorene**	**IcdP**	
All Fish Compartment Types[a]							
Gamma fish	unitless	0.2	0.2	0.2	0.2	0.2	Thomann 1989.
Assimilation efficiency from food	unitless	0.15	0.15	0.14	0.14	0.15	Lemair et al. 1992. Exceptions include Barber 2008 (2-Methylnaphthalene and Acenaphthene) and Niimi and Palazzo 1986 (Acenaphthylene, Fluoranthene, and Fluorene).
Half-life	day	0.533	2	0.165	0.2	2	Moermond et al. 2007.

[a] Screening scenario includes: Benthic Omnivore, Benthic Carnivore, Water-column Herbivore, Water-column Omnivore, and Water-column Carnivore.

Exhibit A-27. Dioxin Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value								
		1,2,3,4,6,7,8,9-OCDD	1,2,3,4,6,7,8,9-OCDF	1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,3,4,7,8-HxCDD	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDD	1,2,3,6,7,8-HxCDF
Zooplankton Compartment										
Absorption rate constant	L[water]/kg[fish wet wt]-day	8640	8640	8640	8640	8640	8640	8640	8640	8640
Assimilation efficiency from algae	unitless	0.08	0.05	0.21	0.09	0.2	0.31	0.31	0.31	0.31
Elimination rate constant	1/day	0.0102	0.016	0.016	0.0616	0.1829	0.0252	0.1474	0.0099	0.0194
Half-life	day	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06
Benthic Invertebrate Compartment										
Clearance constant	unitless	0	0	0	0	0	0	0	0	0
Sediment partitioning partition coefficient	kg/kg	0.0013	0.0017	0.0055	0.0012	0.042	0.033	0.0081	0.013	0.02
Sediment partitioning alpha of equilibrium	unitless	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Sediment partitioning time to reach alpha of equilibrium	days	120	42	120	42	42	120	42	120	42
V_d (ratio of concentration in benthic invertebrates to concentration in water)	ml/g	0	0	0	0	0	0	0	0	0
Half-life	day	5776.2	5776.2	5776.2	5776.2	5776.2	5776.2	5776.2	5776.2	5776.2
All Fish Compartments[a]										
Assimilation efficiency from food	unitless	0.08	0.05	0.21[b]	0.09	0.2	0.31[c]	0.31	0.31	0.31
Chemical uptake rate via gill	L[water]/kg[fish wet wt]-day	11	6	56	25	50	102	200	300	200
Half-life	day	70	70	70	70	70	70	70	70	70

Exhibit A-27. Dioxin Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Value							
		1,2,3,7,8,9-HxCDD	1,2,3,7,8,9-HxCDF	1,2,3,7,8-PeCDD	1,2,3,7,8-PeCDF	2,3,4,6,7,8-HxCDF	2,3,4,7,8-PeCDF	2,3,7,8-TCDD	2,3,7,8-TCDF
Zooplankton Compartment									
Absorption Rate Constant	L[water]/kg[fish wet wt]-day	8640	8640	8640	8640	8640	8640	8640	8640
Assimilation Efficiency from Algae	unitless	0.31	0.31	0.42	0.42	0.31	0.42	0.41	0.51
Elimination Rate Constant	1/day	0.0099	0.0413	0.0819	0.2316	0.0192	0.4331	0.2268	1.0375
Half-life	day	7E+06	7E+06	7E+06	7E+06	7E+08	7E+08	7E+06	7E+08
Benthic Invertebrate Compartment									
Clearance Constant	unitless	0	0	0	0	0	0	0	0
Sediment Partitioning Partition Coefficient	kg/kg	0.015	0.067	0.098	0.024	0.072	0.17	0.205	0.056
Sediment Partitioning Alpha of Equilibrium	unitless	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Sediment Partitioning Time to Reach Alpha of Equilibrium	days	120	42	120	42	42	42	120	42
V_d (ratio of concentration in benthic invertebrates to concentration in water)	ml/g	0	0	0	0	0	0	0	0
Half-life	day	5776.2	5776.2	5776.2	5776.2	5776.2	5776.2	5776.2	5776.2
All Fish Compartments[a]									
Assimilation efficiency from food	unitless	0.31	0.31	0.42	0.42	0.31	0.42	0.41	0.51
Chemical uptake rate via gill	L[water]/kg[fish wet wt]-day	300	200	700	300	200	400	600	400
Half-life	day	70	70	70	70	70	70	70	70

Exhibit A-27. Dioxin Chemical-Specific Parameters for Aquatic Species in the TRIM.FaTE Screening Scenario

Parameter Name	Units	Reference
Zooplankton Compartment		
Absorption rate constant	L[water]/kg[fish wet wt]-day	Zhang et al. 2011; used copepod k_u value.
Assimilation efficiency from algae	unitless	Morrison et al. 1999. Exceptions include Niimi and Oliver 1986 (1,2,3,4,6,7,8,9-OCDD, 1,2,3,4,6,7,8,9-OCDF), Berntssen et al. 2007 (1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDF), and 1,2,3,4,7,8,9-HpCDF set conservatively as approximate linear interpolation between values for 1,2,3,4,7,8-HxCDD and 1,2,3,4,6,7,8-HpCDD / 1,2,3,4,6,7,8-HpCDF (i.e., 0.3 to 0.1–0.2).
Elimination rate constant	1/day	Arnot and Gobas 2004; used K_{ow} value.
Half-life	day	Morrison et al. 1999; used metabolic rates for invertebrates.
Benthic Invertebrate Compartment		
Clearance constant	unitless	Assumption.
Sediment partitioning partition coefficient	kg/kg	Rubinstein et al. 1990; used TCDD data for sandworm.
Sediment partitioning alpha of equilibrium	unitless	Rubinstein et al. 1990.
Sediment Partitioning Time to Reach Alpha of Equilibrium	days	Rubinstein et al. 1990.
V_d (ratio of concentration in benthic invertebrates to concentration in water)	ml/g	Assumption.
Half-life	day	Rubinstein et al. 1990; used TCDD data for sandworm.
All Fish Compartmentsa		
Assimilation Efficiency from Food	unitless	Morrison et al. 1999. Exceptions include Niimi and Oliver 1996 (1,2,3,4,6,7,8,9-OCDD, 1,2,3,4,6,7,8,9-OCDF), Van den Berg et al. 1994 (1,2,3,4,6,7,8-HpCDD), Berntssen et al. 2007 (1,2,3,4,6,7,8-HpCDF), and 1,2,3,4,7,8,9-HpCDF set conservatively as approximate linear interpolation between values for 1,2,3,4,7,8-HxCDD and 1,2,3,4,6,7,8-HpCDD / 1,2,3,4,6,7,8-HpCDF (i.e., 0.3 to 0.1–0.2).
Chemical Uptake Rate Via Gill	L[water]/kg[fish wet wt]-day	Muir et al. 1985. Exception is Opperhuizen et al. 1986 (1,2,3,7,8,9-HxCDF, 1,2,3,7,8-PeCDD, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 2,3,7,8-TCDD, 2,3,7,8-TCDF).
Half-life	day	Berntssen et al. 2007.

[a] Screening scenario includes: Benthic Omnivore, Benthic Carnivore, Water-column Herbivore, Water-column Omnivore, and Water-column Carnivore.

[b] 0.21 used for benthic omnivore, water column omnivore, and water column herbivore; 0.13 used for benthic carnivore and water column carnivore.

[c] 0.31 used for benthic omnivore, water column omnivore, benthic carnivore, and water column carnivore; 0.37 used for water column herbivore.

References

Adriaens, P., Q. Fu, and D. Grbic-Galic. 1995. Bioavailability and transformation of highly chlorinated dibenzo-p-dioxins and dibenzofurans in anaerobic soils and sediments. *Environmental Science and Technology* 29(9): 2252-2260.

Adriaens, P., and D. Grbic-Galic. 1993. Reductive dechlorination of PCDD/F by anaerobic cultures and sediments. *Organohalogen Compounds* 12: 107-110.

Adriaens, P., and D. Grbic-Galic. 1992. Effect of cocontaminants and concentration on the anaerobic biotransformation of PCDD/F in methanogenic river sediments. *Organohalogen Compounds* 8: 209-212.

ATSDR (Agency for Toxic Substances and Disease Registry). 2005. Toxicological profile for naphthalene,1-methylnaphthalene, and 2-methylnaphthalene. Available at: http://www.atsdr.cdc.gov/ToxProfiles/TP.asp?id=240&tid=43.

ATSDR. 1999. Toxicological profile for cadmium. Available at http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=48&tid=15.

ATSDR. 1998. Toxicological profile for chlorodibenzo-p-dioxins (CDDs). Available at: http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=938&tid=194.

Ambrose, R.A., Jr., T.A. Wool, and J.L. Martin. 1995. The water quality analysis simulation program, WASP5, Part A: Model documentation. Athens, GA: U.S. EPA National Exposure Research Laboratory, Ecosystems Division.

APHA (American Public Health Association). 1995. Standard methods for the examination of water and waste water. Washington, DC.

Amyot, M., D. Lean, and G. Mierle. 1997. Photochemical formation of volatile mercury in high arctic lakes. *Environmental Toxicology and Chemistry* 16(10):2054-2063.

Arjmand, M., and H. Sandermann. 1985. Metabolism of DDT and related compounds in cell suspension cultures of soybean (*Glycine max* L.) and wheat (*Tritucum aestivum* L.) *Pesticide Biochemistry and Physiology* 23:389.

Arnot, J., and F.A. Gobas. 2004. A food web bioaccumulation model for organic chemicals in aquatic ecosystems. *Environmental Toxicology and Chemistry* 23(10):2343-2355.

Atkinson, R. 1996. Atmospheric chemistry of PCBs, PCDDs and PCDFs. *Issues in Environmental Science and Technology* 6: 53-72.

Bache, C.A., W.J. Gutenmann, L.E. St. John, Jr., R.D. Sweet, H.H. Hatfield, and D.J. Lisk. 1973. Mercury and methylmercury content of agricultural crops grown on soils treated with various mercury compounds. *Journal of Agricultural and Food Chemistry* 21:607-613.

Baes, C.F., III, R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. A review and analysis of parameters for assessing transport of environmentally released radionuclides through agriculture. ORNL-5786. Oak Ridge National Laboratory, Oak Ridge, TN.

Barber, M.C. 2008. Dietary uptake models used for modeling the bioaccumulation of organic contaminants in fish. *Environmental Toxicology and Chemistry* 27(4):755-777.

Berntssen, M.H.G., T.A. Giskegjerde, G. Rosenlund, B.E. Torstensen, and A.K. Lundebye. 2007. Predicting world health organization toxic equivalency factor dioxin and dioxin-like polychlorinated biphenyl levels in farmed Atlantic salmon (*Salmo salar*) based on known levels in feed. *Environmental Toxicology and Chemistry* 26(1):13-23. doi: 10.1897/06-122r.1.

Berrojalbiz, N., S. Lacorte, A. Calbet, E. Saiz, C. Barata, and J. Dachs. 2009. Accumulation and cycling of polycyclic aromatic hydrocarbons in zooplankton. *Environmental Science and Technology* 43(7):2295-2301. doi: 10.1021/es8018226.

Bidleman, T.F. 1988. Atmospheric processes. *Environmental Science and Technology* 22:361-367.

Bishop, K.H.; Lee, Y.H.; Munthe, J.; Dambrine, E. 1998. Xylem sap as a pathway for total mercury and methylmercury transport from soils to tree canopy in the boreal forest. *Biogeochemistry* 40: 101-113.

Boyle, T. 1985. Validation and predictability of laboratory methods for assessing the fate and effects of contaminants in aquatic ecosystems. Baltimore, MD: ASTM International.

Budavari, S. [ed.]. 1996. The Merck Index - An encyclopedia of chemicals, drugs, and biologicals. Whitehouse Station, NJ: Merck and Co., Inc., p. 178.

CARB (California Air Resources Board). 1994. Development of intermedia transfer factors for pollutants, Volume II: Metals and non-volatile organic compounds. PB95-260691. California: Air Resources Board. March.

Cal EPA (California Environmental Protection Agency). 1993. CalTOX, A multimedia total-exposure model for hazardous-waste sites, Part II: The dynamic multimedia transport and transformation. Model Prepared for: The Office of Scientific Affairs. Department of Toxic Substances Control. Sacramento, California. December. Draft Final.

Carpi, A., and S.E. Lindberg. 1997. Sunlight-mediated emission of elemental mercury from soil amended with municipal sewage sludge. *Environmental Science and Technology* 31(7):2085-2091.

Coe, J.M., and S.E. Lindberg. 1987. The morphology and size distribution of atmospheric particles deposited on foliage and inert surfaces. *Journal of the Air Pollution Control Association* 37:237-243.

Crank, J., N.R. McFarlane, J.C. Newby, G.D. Paterson, and J.B. Pedley. 1981. Diffusion processes in environmental systems. In: Paterson et al. 1991. London: Macmillan Press, Ltd.

Del Vento, S., and J. Dachs. 2002. Prediction of uptake dynamics of persistent organic pollutants by bacteria and phytoplankton. *Environmental Toxicology and Chemistry* 21(10):2099-2107.

Edwards, N.T. 1988. Assimilation and metabolism of polycyclic aromatic hydrocarbons by vegetation – an approach to this controversial issue and suggestions for future research. In: (M. Cooke and A.J. Dennis, eds.) *Polynuclear Aromatic Hydrocarbons: A Decade of Progress*. Battelle Press, Columbus, OH; pp. 211-229.

Environment Canada. 2002. Ecosystem Health Science-Based Solutions: Canadian Tissue Residue Guidelines for the protection of Wildlife Consumers of Aquatic Biota: Methylmercury. Report No. 1-4.

Gay, D.D. 1975. Biotransformation and chemical form of mercury in plants. International Conference on Heavy Metals in the Environment, pp. 87-95. Vol. II, Part 1. October.

Gilmour, C.C., and E.A. Henry. 1991. Mercury methylation in aquatic systems affected by acid deposition. *Environmental Pollution* 71:131-169.

Goulet, R.R., S. Krack, P.J. Doyle, L. Hare, B. Vigneault, and J.C. McGeer. 2007. Dynamic multipathway modeling of Cd bioaccumulation in *Daphnia magna* using waterbourne and dietborne exposures. *Aquatic Toxicology.* 81: 117-125.

Hansch, C., A. Leo, and D. Hoekman. 1995. Exploring QSAR - Hydrophobic, electronic, and steric constants. Washington, DC: American Chemical Society 154.

Hare, L; Tessier, A; and Warren, L. 2001. Cadmium accumulation by invertebrates living at the sediment–water interface. *Environmental Toxicology and Chemistry* 20: 880-889.

Harner, T., and Bidleman, T.F. 1998. Octanol-air partition coefficient for describing particle/gas partitioning of aromatic compounds in urban air. *Environmental Science and Technology* 32:1494-1502.

HSDB (Hazardous Substances Data Bank). 2005. Bethesda, MD: National Library of Medicine, U.S. [Last Revision Date 10/27/2005]. 2-Methylnaphthalene; Hazardous Substances Databank Number: 5274. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+5274.

HSDB. 2001a. Bethesda, MD: National Library of Medicine, U.S. [Last Revision Date 08/09/2001]. 7,12-Dimethylbenz(a)anthracene; Hazardous Substances Databank Number: 2938. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+2938.

HSDB. 2001b. Bethesda, MD: National Library of Medicine, U.S. [Last Revision Date 08/09/2001]. Acenaphthylene; Hazardous Substances Databank Number: 2661. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+2661.

HSDB. 2001c. Bethesda, MD: National Library of Medicine, U.S. [Last Revision Date 08/09/2001]. Benzo(ghi)perylene; Hazardous Substances Databank Number: 6177. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+6177.

HSDB. 2001e. Bethesda, MD: National Library of Medicine, U.S. [Last Revision Date 08/09/2001]. Fluorene; Hazardous Substances Databank Number: 2165. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+2165.

HSDB. 2001d. Bethesda, MD: National Library of Medicine, U.S. [Last Revision Date 08/09/2001]. Acenaphthene; Hazardous Substances Databank Number: 2659. Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+2659.

Hendriks, AJ; and Heikens, A. 2001. The power of size. 2. Rate constants and equilibrium ratios for accumulation of inorganic substances related to species weight. *Environmental Toxicology and Chemistry* 20: 1421-1437.

Henning, B.J., H.G. Snyman, and T.A.S. Aveling. 2001. Plant-soil interactions of sludge-borne heavy metals and the effect on maize (Zea mays L.) seedling growth. *Water SA* 27(1):71-78.

Hogg, T.J., J.R. Bettany, and J.W.B. Stewart. 1978. The uptake of 203Hg-labeled mercury compounds by bromegrass from irrigated undisturbed soil columns. *Journal of Environmental Quality* 7:445-450.

Holzworth, G.C. 1972. Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. Prepared for EPA Office of Air Programs. Research Triangle Park, NC.

Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko. 1991. Handbook of environmental degradation rates. Chelsea, Michigan: Lewis Publishers

Hudson, R., S.A. Gherini, C.J. Watras, and D. Porcella. 1994. Modeling the biogeochemical cycle of mercury in lakes: The Mercury Cycling Model (MCM) and its application to the MTL Study Lakes. In: C.J. Watras and J.W. Huckabee, eds. Mercury pollution integration and synthesis. Lewis Publishers. pp. 473-523.

ICF(ICF International). 2005. Memorandum: TRIM.FaTE screening scenario: Aquatic food web analysis; submitted to Deirdre Murphy and Terri Hollingsworth, U.S. EPA, from Margaret McVey and Rebecca Kauffman, ICF Consulting. October 18.

Jackson, R.B., J. Canadell, J.R. Ehleringer, H.A. Mooney, O.E. Sala, and E.D. Schulze. 1996. A global analysis of root distributions for terrestrial biomes. *Oecologia* 108:389-411.

John, M.K. 1972. Mercury uptake from soil by various plant species. *Bulletin of Environmental Contamination and Toxicology* 8:77-80.

Kaushal, S.S., P.M. Groffman, G.E. Likens, K.T. Belt, W.P. Stack, V.R. Kelly, L.E. Band, and G.T. Fisher, 2005. Increased Salinization of Fresh Water in the Northeastern United States. *Proceedings of the National Academy of Sciences* 102:13517-13520.

Kim, M., and P. O’Keefe. 1998. The role of natural organic compounds in photosensitized degradation of polychlorinated dibenzo-p-dioxins and dibenzofurans. *Organohalogen Compounds* 36: 377-380.

Komoba, D., C. Langebartels, and H. Sandermann. 1995. Metabolic processes for organic chemicals in plants. In: Plant contamination modeling and simulation of organic chemical processes. Trapp, S., and Mc Farlane, J.C., eds., CRC Press, Boca Raton, FL. Pages 69-103.

Leith, H. 1975. Primary productivity in the biosphere. In: H. Leith and R.W. Whitaker. Ecological Studies, Volume 14. Springer-Verlag.

Lemair, P., A. Mathieu, S. Carriere, J.F. Narbonne, M. Lafaurie, and J. Giudicelli. 1992. Hepatic biotransformation enzymes in aquaculture European sea bass (*Dicentrarchus labrax*): kinetic parameters and induction with benzo(a)pyrene. *Comparative Biochemistry and Physiology* 103(B): 847-853.

Leonard, T.L., G.E. Taylor, Jr., M.S. Gustin, and G.C.J. Fernandez. 1998. Mercury and plants in contaminated soils: 1. Uptake, partitioning, and emission to the atmosphere. *Environmental Toxicology and Chemistry* 17:2063-2071.

Lindberg, S.E., T.P. Meyers, G.E. Taylor, R.R. Turner, and W.H. Schroeder 1992. Atmosphere-Surface Exchange of Mercury to a Forest: Results of Modelling and Gradient Approaches. *Journal of Geophysical Research* 97(D2):2519-2528.

Lindberg, S.E. 1996. Forests and the global biogeochemical cycle of mercury: The importance of understanding air/vegetation exchange processes. In: W. Baeyans et al., eds. Global and regional mercury cycles: Sources, fluxes, and mass balances. pp. 359-380.

Mackay, D., W.Y. Shiu, and K.C. Ma. 2000. Physical-chemical properties and environmental fate handbook. Boca Raton, FL: CRC Press LLC.

Mackay, D., W.Y. Shiu, and K.C. Ma. 1992. Illustrated handbook of physical-chemical properties and environmental fate for organic chemicals: polynuclear aromatic hydrocarbons, polychlorinated dioxins, and dibenzofurans. Chelsea, MI: Lewis Publishers.

Mackay, D., S. Patterson, and W.H. Schroeder. 1986. Model describing the rates of transfer processes of organic chemicals between atmosphere and water. *Environmental Science and Technology* 20(8): 810-816.

Mason, R.P., J.R. Reinfelder, and F.M.M. Morel. 1996. Uptake, toxicity, and trophic transfer of mercury in a coastal diatom. *Environmental Science and Technology* 30(6):1835-1845.

Mason, R.P., F.M.M. Morel, and H.F. Hemond. 1995a. The role of microorganisms in elemental mercury formation in natural waters. *Water, Air, and Soil Pollution* 80:775-787.

Mason, R.P., J.R. Reinfelder, and F.M.M. Morel. 1995b. Bioaccumulation of mercury and methylmercury. *Water Air and Soil Pollution* 80(1-4):915-921.

McCrady, J.K., and S.P. Maggard. 1993. Update and photodegradation of 2,3,7,8-tetrachloro-p-dioxin sorbed to grass foliage. *Environmental Science and Technology* 27: 343-350.

McElroy, A. E. 1990. Polycyclic aromatic hydrocarbon metabolism in the polychaete *Nereis virens*. *Aquatic Toxicology* 18(1):35-50.

McGeer, J.C., K.V. Brix, J.M. Skeaff, D.K. DeForest, S.I. Brigham, W.J. Adams, and A. Green. 2003. Inverse relationship between bioconcentration factor and exposure concentration for metals: implications for hazard assessment of metals in the aquatic environment. *Environmental Toxicology and Chemistry* (22)5:1017–1037.

McKone, T.E., A. Bodnar, and E. Hertwich. 2001. Development and evaluation of state-specific landscape data sets for multimedia source-to-dose models. University of California at Berkeley. Supported by the U.S. Environmental Protection Agency (Sustainable Technology Division, National Risk Management Research Laboratory) and Environmental Defense Fund. July. LBNL-43722.

Millard, E.S., D.D. Myles, O.E. Johannsson, and K.M. Ralph. 1996. Phytoplankton photosynthesis at two index stations in Lake Ontario 1987-1992: assessment of the long-term response to phosphorus control. *Canadian Journal of Fisheries and Aquatic Sciences* 53: 1092-1111.

Moermond, C. T. A., T.P. Traas, I. Roessink, K. Veltmam, A.J. Hendriks, and A.A. Koelmans. 2007. Modeling decreased food chain accumulation of PAHs due to strong sorption to carbonaceous materials and metabolic transformation. *Environmental Science and Technology* 41(17):6185-6191. doi: 10.1021/es0702364.

Montgomery, J. 2000. Groundwater chemicals desk reference. Boca Raton, FL: CRC Press LLC, p. 1701. Morrison, H.A., D.M. Whittle, C.D. Metcalfe, and A.J. Niimi. 1999. Application of a food web bioaccumulation model for the prediction of polychlorinated biphenyl, dioxin, and furan congener concentrations in Lake Ontario aquatic biota. *Canadian Journal of Fisheries and Aquatic Sciences* 56(8):1389-1400.

Morrison, H., Whittle, D., et al. 1999. Application of a food web bioaccumulation model for the prediction of polychlorinated biphenyl, dioxin, and furan congener concentrations in Lake Ontario aquatic biota. Can. J. Fish. Aquat. Sci. 56: 1389–1400 (1999).

Muhlbaier, J., and G.T. Tissue. 1980. Cadmium ion the southern basin of Lake Michigan. *Water, Air and Soil Pollution* (15):45-49.

Muir, D.C., W.K. Marshall, and G.R. Webster. 1985. Bioconcentration of PCDDs by fish: Effects of molecular structure and water chemistry. *Chemosphere* 14(6/7):829-833.

Muller, H. and Prohl, G. 1993. ECOSYS-87: A dynamic model for assessing radiological consequences of nuclear accidents. Health Physics 64(3):232-252.

NLM (National Library of Medicine). 2002. Hazardous Substance Data Bank (HSDB). Available at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB.

Niimi, A., and B. Oliver. 1986. Biological half-lives of chlorinated dibenzo-p-dioxins and dibenzofurans in rainbow trout (*Salmo gairdeneri*). *Environmental Toxicology* 5:49-53.

Niimi, A.J,. and V. Palazzo. 1986. Biological half-lives of eight polycyclic aromatic hydrocarbons (PAHs) in rainbow trout (*Salmo gairdneri*). *Water Research* 20(4):503-507.

Nriagu, J.O. 1980. Cadmium in the environment. Part I: Ecological cycling. New York: John Wiley & Sons. Chapter 15: Uptake and effects of cadmium in higher plants. pp. 608-609.

Opperhuizen, A., W.J. Wagenaar, F.W.M. van der Wielen, M. van den Berg, K. Olie, and F.A.P.C. Gobas.1986. Uptake and elimination of PCDD/PCDF congeners by fish after aqueous exposure to a fly-ash extract from a municipal incinerator. *Chemosphere* 15(9–12):2049-2053. doi: 10.1016/0045-6535(86)90511-4.

Passivirta, J., Sinkkonen, S., Mikkelson, P., Rantio, T., Wania, F. (1999) Estimation of vapor pressures, solubilities and Henry's law constants of selected persistent organic pollutants as functions of temperature. Chemosphere 39, 811–832.

Paterson, S., D. Mackay, and A. Gladman. 1991. A fugacity model of chemical uptake by plants from soil and air. *Chemosphere* 23:539-565.

Petersen, G., A. Iverfeldt, and J. Munthe. 1995. Atmospheric mercury species over Central and Northern Europe. Model calculations and comparison with observations from the Nordic Air and Precipitation Network for 1987 and 1988. *Atmospheric Environment* 29:47-68.

Porvari, P., and M. Verta. 1995. Methylmercury production in flooded soils: A laboratory study. *Water, Air, and Soil Pollution* 80:765-773.

Riederer, M. 1995. Partitioning and transport of organic chemicals between the atmospheric environment and leaves. In: Trapp, S. and J. C. McFarlane, eds. Plant contamination: Modeling and simulation of organic chemical processes. Boca Raton, FL: Lewis Publishers. pp. 153-190.

Rubinstein, N.I., R.J. Pruell, B.K. Taplin, J.A. LiVolsi, and C.B. Norwood. 1990. Bioavailability of 2,3,7,8-TCDD, 2,3,7,8-TCDF and PCBs to marine benthos from Passaic river sediments. *Chemosphere* 20:1097-1102.

Sangster, J. (1993) LOGKOW, A Databank of Evaluated Octanol-Water Partition Coefficients. 1st Edition, Montreal, Quebec, Canada.

Saouter, E., F. Ribeyre, A. Boudou, and R. Maurybrachet. 1991. *Hexagenia rigida* (Ephemeroptera) as a biological model in aquatic ecotoxicology - Experimental studies on mercury transfers from sediment. *Environmental Pollution* 69:51-67.

Sijm, D.T.H.M., H. Wever, P.J. de Vries, and A. Opperhuizen. 1989. Octan-1-ol/water partition coefficients of polychlorinated dibenzo-p-dioxins and dibenzofurans: experimental values determined with a stirring method. *Chemosphere* 19(1-6):263-266.

Simonich, S.L., and R.A. Hites. 1994. Importance of vegetation in removing polycyclic aromatic hydrocarbons from the atmosphere. *Nature* 370:49-51.

Spero, J., B. DeVito, and L. Theodore. [eds.]. 2000. Regulatory chemicals handbook. New York, NY: CRC Press, p. 1072.

Stehly, G.R., P.F. Landrum, M.G. Henry, and C. Klemm. 1990. Toxicokinetics of PAHs in *Hexagenia Environmental Toxicology and Chemistry* 9:167-174.

Thibodeaux, L.J. 1996. Environmental chemodynamics: Movement of chemicals in air, water, and soil. New York, NY: John Wiley and Sons, Inc.

Thomann, R.V. 1989. Bioaccumulation model of organic-chemical distribution in aquatic food-chains. *Environmental Science and Technology* 23(6):699-707.

Trapp, S. 1995. Model for uptake of xenobiotics into plants. In: Trapp, S. and J. C. McFarlane, eds. Plant contamination: Modeling and simulation of organic chemical processes. Boca Raton, FL: Lewis Publishers. pp. 107-151.

Trudel, M., and J.B. Rasmussen. 1997. Modeling the elimination of mercury by fish. *Environmental Science and Technology* 31:1716-1722.

Tsiros, I.X.; R.B. Ambrose, and A. Chronopoulou-Sereli. 1999. Air-vegetation partitioning of toxic chemicals in environmental simulation modeling. Global NEST: *The International Journal* 1(3):177-184.

USEPA (U.S. Environmental Protection Agency). 2007. Draft risk assessment for the Siemens Water Technologies Corp. carbon reactivation facility Parker, Arizona. Appendix F. Chemical-physical parameters for compounds not in USEPA's HHRAP. Available at: http://www.epa.gov/region9/waste/siemens/pdf/RiskAssessment/siemens-riskassessAppxF.pdf.

USEPA. 2005. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Companion Database. Available at: http://www3.epa.gov/epawaste/hazard/tsd/td/combust/riskvol.htm#volume2.

USEPA 2003. Toxicological Review of 2-Methylnaphthalene. Available online at: http://cfpub.epa.gov/ncea/iris/iris_documents/documents/toxreviews/1006tr.pdf.

USEPA. 2000a. Estimation Program Interface (EPI) suite. Office of Pollution Prevention and Toxics (OPPT). Available at: http://www2.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface

USEPA. 2000b. Draft exposure and human health reassessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin TCDD) and related compounds, Volume 3: Properties, environmental levels, and background exposures, Chapter 2: Physical and chemical properties and fate and Appendix A. EPA/600/P-00/001Bc. Available at: http://www.epa.gov/ncea/pdfs/dioxin/part1/volume3/chap-2.pdf.

USEPA. 1999. Screening level ecological risk assessment protocol for hazardous waste combustion facilities. Peer Review Draft, November. Available at: http://www3.epa.gov/epawaste/hazard/tsd/td/combust/ecorisk.htm.

USEPA. 1998. Chemical fate half-lives for Toxics Release Inventory (TRI) chemicals. July. SRC TR 98-008.

USEPA. 1997a. Supplemental background document; Nongroundwater pathway risk assessment; Petroleum process waste listing determination. Appendix B. Compound specific input values. Available at: http://www.epa.gov/osw/hazard/wastetypes/wasteid/petroref/appendb.pdf.

USEPA. 1997b. U.S. Environmental Protection Agency. Mercury study report to congress. Volume III: Fate and transport of mercury in the environment. Office of Air Quality Planning and Standards and Office of Research and Development.

Van den Berg, M., J. De Jongh, H. Poiger, and J.R. Olson. 1994. The toxicokinetics and metabolism of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) and their relevance for toxicity. *CRC Critical Reviews in Toxicology* 24(1):1-74.

Vandal, G.M., W.F. Fitzgerald, K.R. Rolfhus, and C.H.Lamborg. 1995. Modeling the elemental mercury cycle in Pallette Lake, Wisconsin, USA. *Water, Air, and Soil Pollution* 80:789-798.

Vulykh, N., and V. Shatalov. 2001. Investigation of Dioxin/Furan Composition in Emissions and in Environmental Media: Selection of Congeners for Modeling. Technical Note 6/2001. Meteorological Synthesizing Center - East.

Wang, X., and W.X. Wang. 2006. Bioaccumulation and transfer of benzo (a) pyrene in a simplified marine food chain. *Marine Ecology Progress Series* 312:101-111.

Williams, J.J., J. Dutton, C.Y. Chen, and N.S. Fisher. 2010. Metal (As, Cd, Hg, and CH_3Hg) bioaccumulation from water and food by the benthic amphipod *Leptocherius plumulosus*. *Environmental Toxicology and Chemistry* 29(8):1755-1761.

Wilmer, C., and M. Fricker. 1996. Stomata. Second ed. New York, NY: Chapman and Hall. p. 121.

WI DNR (Wisconsin Department of Natural Resources) 2007. A Guide to Understanding the Hydrologic Condition of Wisconsin's Lake Superior Watersheds. Wisconsin Department of Natural Resources (DNR).

Xiao, Z.F., D. Stromberg, and O. Lindqvist. 1995. Influence of humic substances on photolysis of divalent mercury in aqueous solution. *Water, Air, and Soil Pollution* 80:789-798.

Yan, X; and Wang, WX. 2002. Exposure and potential food chain transfer factor of Cd, Se and Zn in marine fish *Lutjanus argentimaculatus*. *Marine Ecology Progress Series* 238: 173-186.

Zhang, Q., L. Yang, and W.X. Wang. 2011. Bioaccumulation and trophic transfer of dioxins in marine copepods and fish. *Environmental Pollution* 159(12):3390-3397.

Attachment B. Description of Multimedia Ingestion Risk Calculator (MIRC) Used for RTR Exposure and Risk Estimates

CONTENTS, ATTACHMENT B

Exhibits, Attachment B

Equations, Attachment B

1. Introduction

1.1. Purpose and Overview

This document provides a detailed description of the *Multimedia Ingestion Risk Calculator* (MIRC), a modeling tool and database designed to assist in estimating risks via multiple ingestion pathways, particularly for food products grown or raised at home or on a farm.[27] MIRC was designed to estimate risks to humans from ingestion of produce or animal products, fish, and water in the vicinity of a source of chemical emissions to air. The user can evaluate either generalized (e.g., health protective default) or more site-specific scenarios using the same tool. MIRC includes a database of exposure parameter values, offering the user the option of selecting mean, median, and upper percentile values for many parameters, data permitting. Generally health protective default values were assigned to each parameter in the tool and the default configuration is used for initial risk screening efforts by EPA's Office of Air Quality Planning and Standards' (OAQPS) for Risk and Technology Review (RTR) multimedia risk assessments. MIRC also allows the user to define the farm food chain (FFC) parameter values and receptor characteristics to better represent a site-specific scenario.

With user-input concentrations for one or more chemicals in air and soil and air-to-surface deposition rates, MIRC calculates the chemical's concentrations in home- or farm-grown produce and animal food products using FFC algorithms adapted from EPA's *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (hereafter referred to as HHRAP; EPA 2005a). MIRC uses these calculated concentrations, along with user-input chemical concentrations for fish and drinking water, to estimate chemical intake rates, as average daily doses (ADDs), for adults, children, and nursing infants. Users can obtain chemical input concentrations and deposition rates from measurements at an actual site or from a transport and fate model, such as TRIM.FaTE, as is done for RTR risk assessment.

For a specified set of chemical concentrations and MIRC parameter options, MIRC calculates ADDs separately for adults, four age groups of children, and infants to reflect differences in food ingestion rates and diet at different lifestages. MIRC estimates age-specific hazard quotients (HQs) as the ratio of age-specific ADDs to the reference dose (RfD) for a chemical. The most appropriate HQ for a chemical depends on its toxic mode of action and the duration of exposure required to produce an effect. MIRC also estimates average lifetime ADDs and compares those to cancer slope factors (CSFs) to estimate cancer risks. A breast milk ingestion pathway is available to estimate exposure and risks to nursing infants.

MIRC was developed to be a flexible, transparent application. The tool includes chemical transfer and ingestion exposure algorithms and a database of parameter values, many with several options, used by these equations. The MIRC database includes values for the relevant physiochemical properties and toxicity reference values for more than 500 chemicals, including approximately 60 inorganics taken primarily from a database developed for HHRAP (EPA 2005a). Although designed for OAQPS' RTR assessments for sources of hazardous air pollutants (HAPs), the tool is flexible in its design and can be used to assess risks in many other contexts where soil and air concentrations are predicted or measured.

1.2. Scope of MIRC

For persistent and bioaccumulative (PB) chemicals, risks from direct inhalation of the chemical can be much less than risks from ingestion of the chemical in water, fish, and food products

---

[27] Fully functional versions of MIRC have been developed in both Access™-based and Excel™-based formats; however, MIRC currently is not publicly available.

grown in an area of chemical deposition. Vegetables and fruits in such areas can become contaminated directly by deposition of the airborne chemical to foliage, fruits, and vegetables or indirectly by root uptake of the chemical deposited to soils. Livestock can be exposed to the PB chemicals via ingestion of contaminated forage and incidental ingestion of contaminated soils.

For PB chemicals, evaluation of the inhalation pathway for air pollutants may reveal only a portion of the risk to individuals in such populations. Households that consume high quantities of self-caught fish or locally grown produce and animal products may be particularly susceptible to ingestion of chemicals transferred from air in the vicinity of an air emissions source. For PB chemicals in particular, therefore, EPA developed methods of estimating risk from indirect exposure pathways associated with the deposition of airborne chemicals to gardens and farms, as described in HHRAP (EPA 2005a).

1.3. Use in EPA's Air Toxics Program

For PB-HAPs, indirect exposure pathways, such as ingestion, might contribute more to total risk than the inhalation pathway. EPA therefore developed several computer software tools to assist in evaluating exposure and risk from non-inhalation pathways. EPA developed the Total Risk Integrated Methodology (TRIM) Environmental Fate, Transport, and Ecological Exposure (TRIM.FaTE) computer program to simulate the release, transport, and fate of HAPs from a specific source throughout the area in which local (non-source) chemical deposition is likely to be a concern. TRIM.FaTE models the transport of individual chemicals from the source through air by advection (wind) of particle- and vapor-phase chemical and deposition of the chemical from air to terrestrial and aquatic ecosystems by wet and dry deposition. Movement of the chemical through a watershed via erosion and runoff, uptake by plants, and other abiotic and biotic transfer processes also are simulated. For the chemical that reaches surface waters, TRIM.FaTE models uptake and bioaccumulation to trophic level (TL) 3 and 4 fish (i.e., pan fish and game fish, respectively).

MIRC was developed to process TRIM.FaTE results, in particular, air deposition rates and the concentrations of a chemical, after a specified duration of emissions, in several spatially explicit environmental compartments, including air, surface and root-zone soils, surface and ground waters, and fish. MIRC uses those results to calculate exposure to the chemical through ingestion of locally grown foods, including various types of fruits and vegetables, poultry, swine, and dairy (and beef) cattle. MIRC also calculates the associated risks for individuals who consume those foods. MIRC was designed to use specific TRIM.FaTE results to estimate FFC concentrations, ingestion exposures, and human health risks for OAQPS' RTR assessments. It uses the same approach that OAQPS intends to implement directly in its TRIM system via three modules beyond TRIM.FaTE: TRIM Farm Food Chain, TRIM.Expo$_{\text{Ingestion}}$, and TRIM.Risk.[28]

1.4. MIRC Highlights

Although designed to assist EPA OAQPS in its RTR assessments, MIRC is a stand-alone software application that can be used in other contexts. A user can supply either measured or estimated chemical concentrations for soil, air, water, and fish, and also can provide air deposition rates likely for the location(s) of interest based on local meteorology. The user can accept the default values for many exposure parameters and screen for small possibilities of risk, or the user can select other options or overwrite parameter values to tailor the estimates to a specific scenario or location.

---

[28] General information about the TRIM system is available at http://www2.epa.gov/fera/total-risk-integrated-methodology-trim-general.

MIRC complies with EPA's latest guidelines for exposure and risk assessment, including HHRAP; the Agency's 2005 *Guidelines for Carcinogen Risk Assessment* (Cancer Guidelines), *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (Supplemental Guidance), and *Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants* (EPA 2005b,c,d); and its 2008 *Child-Specific Exposure Factors Handbook* (EPA 2008a). In particular, MIRC provides several important capabilities:

- When provided air and soil concentrations, the MIRC software package allows rapid calculation of screening-level exposures and risks associated with household consumption of locally grown/raised foods.
- MIRC can calculate exposures and risks associated with incidental ingestion of surface soils, fish consumption, and drinking water.
- The tool calculates ADDs (i.e., chemical intake rates) for six "built-in" age groups to allow use of age-group-specific body weights, ingestion rates, food preferences, and susceptibility to toxic effects.
- Its database of chemical information covers plant- and animal-specific transfer factors and other inputs that determine concentrations in farm food stuffs.
- Value options for receptor characteristics in the database include the mean and 50th, 90th, 95th, and 99th percentile values where data permit.
- For carcinogens with a mutagenic mode of action, MIRC estimates a lifetime ADD using the three lifestages and potency adjustment factors recommended in EPA's 2005 Cancer Guidelines and Supplemental Guidance.
- The data for exposure parameters in the tool have been updated to include the latest recommended values for children issued September 30, 2008, in the Agency's Child-Specific Exposure Factors Handbook (CSEFH) (EPA 2008a).

1.5. Organization of This Attachment

Sections 2 through 5 of this attachment describe the exposure and risk models implemented in MIRC. Section 2 provides an overview of the FFC exposure scenario and indicates options available to a user to tailor the scenario to specific applications. Section 3 describes the exposure algorithms used in MIRC, including how ADDs are calculated. Section 4 presents the toxicity reference values included in MIRC to calculate risks. Section 5 describes the risk characterization algorithms in MIRC. Section 6 of this document describes data input options for the model. Section 7 describes the default parameterization of MIRC for application to health protective risk screening assessments, and Section 8 provides the references.

Note that the default parameterization described in Section 7 was used to estimate Tier 1 screening threshold emission rates of PB-HAPs from RTR facilities. These emissions levels are assumed to pose negligible risk to subsistence communities in the vicinity of a facility emitting the PB-HAPs to air. Users of MIRC can modify the default values for many of the parameters to better represent a specific exposure scenario.

2. MIRC Overview

The *Multimedia Ingestion Risk Calculator* (MIRC) software package is designed to allow rapid calculation of screening-level exposures and risks associated with subsistence and recreational farmer/fisher populations in the vicinity of a source of chemical emissions to air. The tool allows a user to assess human exposures via ingestion pathways, including drinking water consumption, incidental soil ingestion, fish ingestion, and ingestion of ten types of farm food chain (FFC) products: exposed fruits, protected fruits, exposed vegetables, protected vegetables, root vegetables, beef, total dairy, pork, poultry, and eggs. The tool also includes a breast milk ingestion and risk module for nursing infants. For fruits and vegetables, the terms “exposed” and “protected” refer to whether the edible portion of the plant is exposed to the atmosphere.

The remainder of this overview consists of three sections. The first (Section 2.1 of this attachment) provides an overview of the MIRC software package. The second and third sections summarize the ingestion exposure pathways included in the tool and the “built-in” receptor age categories, respectively (Sections 2.2 and 2.3 of this attachment).

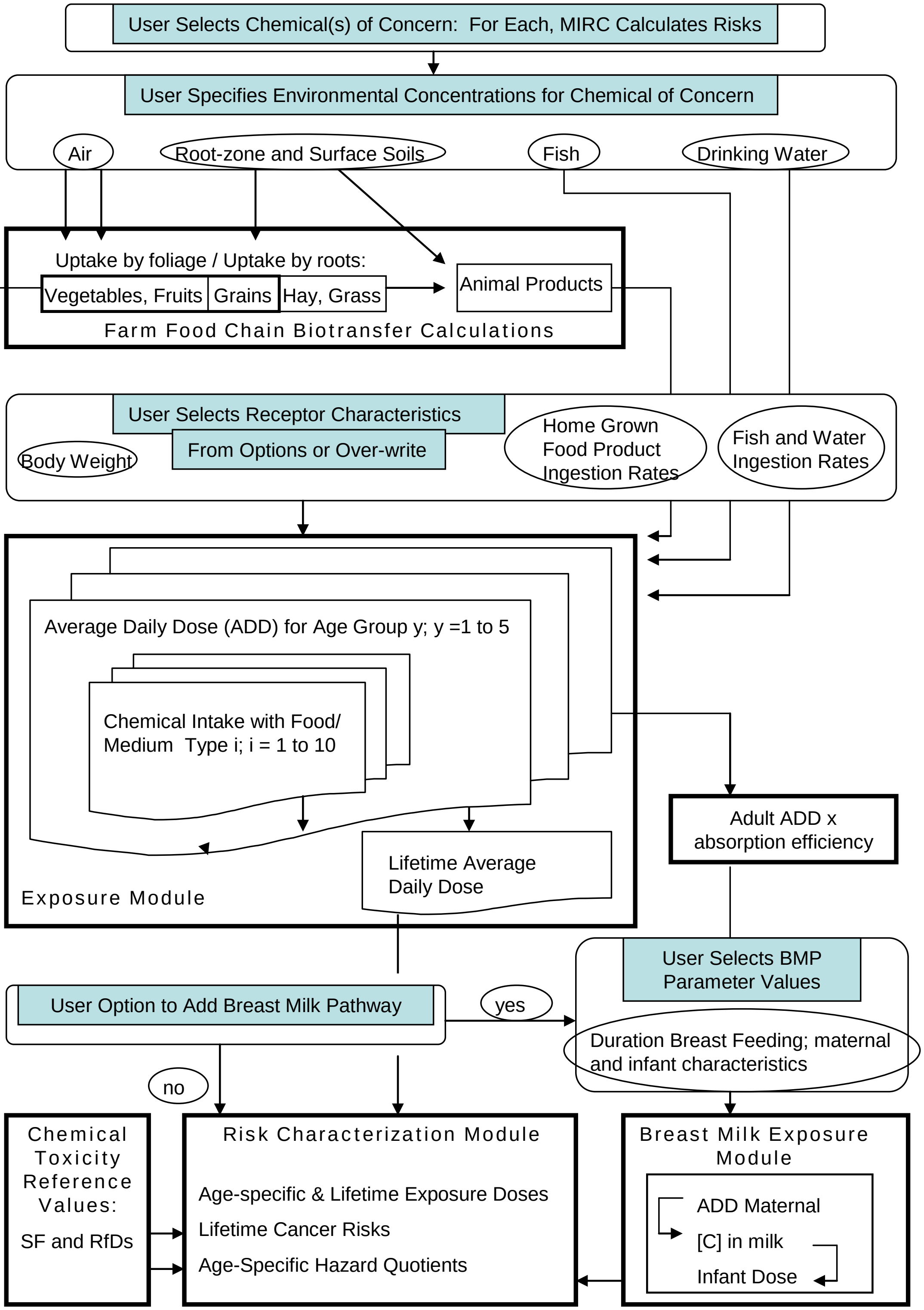
2.1. Software

The MIRC application includes the following components:

- A graphical user interface through which the user locates and accesses various input and output tables.
- Input tables in which the user can enter environmental concentrations of a chemical estimated for air, soil, drinking water, and fish tissue.
- Internal chemical transfer and exposure algorithms and database of options for FFC algorithm parameter value, chemical-specific inputs, and exposure factors.
- Tabulated outputs of calculated chemical concentrations in the various farm food products (e.g., fruits, vegetables, beef, eggs) and ADDs for those foods and for water and fish ingestion for each receptor category.
- Output tables with estimated cancer risks and non-cancer hazard estimates associated with total ingestion exposure to each chemical for each receptor category.

Exhibit B-1 provides a flowchart displaying the types of required and optional inputs and the general flow of calculations carried out by the tool.

Exhibit B-1. Overview of MIRC Software Application for Performing Farm-Food-Chain Ingestion Exposure and Risk Calculations



A form within the graphical user interface enables the user to construct specific scenarios by choosing ingestion sources, receptor ages, and other input choices (e.g., diet composition, body weight percentiles). This feature facilitates the assessment of various exposure scenarios. To begin an assessment, the user must supply values for the following chemical-specific parameters for the scenario being evaluated:

- Air concentration of total chemical,
- Fraction chemical in air in vapor-phase,
- Wet and dry deposition rates for particle-phase chemical,
- Drinking water concentration,
- Chemical concentration in surface soils (two locations; can be tilled and untilled),
- Chemical concentration in root-zone soils (two locations; can be tilled and untilled), and
- Chemical concentrations in upper trophic-level fish.

Users can input measured values or values estimated by TRIM.FaTE or other models for these parameters.

The MIRC application uses the input data and a variety of empirical transfer factor values (included in its database) to estimate chemical concentrations in nine categories of FFC food types (see Section 2.2 of this attachment). The FFC algorithms and transfer factor values included in MIRC are based on those presented in Chapter 5 of EPA's HHRAP (EPA 2005a).

For outputs, MIRC is designed to calculate individual cancer risk and non-cancer hazard quotients for one chemical at a time. It is up to the risk assessor to determine if cancer risks or hazard quotients may be additive across two or more chemicals (i.e., if they cause toxic effects in the same target organ by the same mode of action, such as multiple polycyclic aromatic hydrocarbons (PAHs) that are carcinogenic by a mutagenic mode of action).

The tool assumes that an individual is exposed via all of the pathways specified (e.g., fruits and vegetables, animal products, soil, etc.). The tool therefore is useful in estimating risk to the maximally exposed individuals in a risk assessment. To evaluate other receptor populations, the user must specify the each exposure scenario separately.

2.2. Exposure Pathways

MIRC estimates the concentrations of chemicals in FFC food categories grown in an area of airborne chemical deposition using algorithms and parameter values provided in HHRAP (EPA 2005a). FFC foods are evaluated in ten categories: exposed fruit, protected fruit, exposed vegetables, protected vegetables, root vegetables, beef, total dairy, pork, poultry, and eggs. Exhibit B-2 summarizes the pathways by which chemicals are transferred to these food media. Note that for a general Tier 1 screening-level assessment, all of the pathways can be modeled, as is the case for EPA's *Risk and Technology Review* (RTR) calculation of screening threshold emission rates for persistent and bioaccumulative hazardous air pollutants (PB-HAPs) (EPA 2008b).

Exhibit B-2. Transfer Pathways for Modeled Farm Food Chain (FFC) Media

Farm Food Media	Chemical Transfer Pathways
Exposed fruit and vegetables	• Direct deposition from air of particle-bound chemical • Air-to-plant transfer of vapor phase chemical • Root uptake from soil
Protected fruit and vegetables (including root vegetables)	• Root uptake from soil
Beef and total dairy (including milk)	• Ingestion of forage, silage, and grain[a] • Soil ingestion
Pork	• Ingestion of silage and grain[a] • Soil ingestion
Poultry and eggs	• Ingestion of grain[a] • Soil ingestion

[a] Chemical concentrations in forage, silage, and grain are estimated via intermediate calculations analogous to those used for aboveground produce.

Produce types included in the FFC can accumulate a chemical directly from air and/or soil. For exposed produce, chemical mass is assumed to be transferred to plants from the air in two ways. First, particle-bound chemical can deposit directly on the plant surface. Second, the uptake of vapor-phase chemicals by plants through their foliage can occur. For both exposed and protected produce, the concentration in the plant derived from exposure to the chemical in soil is estimated using an empirical bioconcentration factor (BCF) that relates the concentration in the plant to the concentration present in the soil. For belowground root vegetables, a root concentration factor is applied. The algorithms used to estimate produce concentrations are presented in Section 3.1.1 of this attachment.

Chemical concentrations in animal products are estimated based on the amount of chemical consumed through the diet, including incidental ingestion of soil while grazing. The diet options for farm animals in MIRC include forage (plants grown on-site for animal grazing, such as grass), silage (wet forage grasses, fresh-cut hay, or other fresh plant material that has been stored and fermented), and feed grain products grown on the farm (e.g., corn, soybeans). All three animal feed products are assumed to accumulate chemical via root uptake from the soil. Forage and silage also can accumulate chemical via direct deposition of particle-bound chemical and vapor transfer.

The algorithms in MIRC are based on the assumptions that beef and dairy cattle consume all three feed products, while pigs consume only silage and grain and chickens consume only grain. The incidental ingestion of the chemical in soils during grazing or consumption of foods placed on the ground is estimated using empirical soil ingestion values. For secondary animal products (dairy products and eggs), chemical concentrations are estimated by applying a biotransfer factor to the estimated concentration in the "source" animal (cows and chickens, respectively). The algorithms used to estimate animal product concentrations are described in Section 3.1.2 of this attachment.

2.3. Receptor Groups

As noted in EPA risk assessment guidelines (EPA 2005b,c,d, 2008a), exposures of children are expected to differ from exposures of adults due to differences in body weights, ingestion rates, dietary preferences, and other factors. It is important, therefore, to evaluate the contribution of exposures during childhood to total lifetime risk using appropriate exposure factor values.

EPA's HHRAP (Chapter 4, EPA 2005a) recommends assessing exposures for children and adults separately, but considers all non-infant children in one category. Specifically, HHRAP recommends eight categories of receptor: farmer, child farmer, resident, child resident, fisher, child fisher, acute receptor, and nursing infant. Over time, different EPA programs have used different child age groupings to evaluate body weights, ingestion rates, and other parameter values needed to estimate chemical exposures and risks to children.

To improve the match between age groups used to estimate values across exposure parameters, in 2005, EPA recommended a standard set of child age categories for exposure and risk assessments (EPA 2005b). EPA recommended four age groups for infants: birth to < 1 month; 1 to < 3 months; 3 to < 6 months; and 6 to < 12 months. For young children, EPA recommended an additional four age groups: 1 to < 2 years; 2 to < 3 years; 3 to < 6 years; and 6 to < 11 years. Two age groupings were recommended for teenagers and young adults: 11 to < 16 years; and 16 to < 21 years. These age groupings correspond to different developmental stages and reflect different food ingestion rates per unit body weight, with the highest ingestion rates occurring for the youngest, most rapidly growing, age groups.

For purposes of RTR assessment using MIRC, the selection of age categories is limited by the categories for which most of the FFC food ingestion rates have been calculated. In Chapter 13 of both its *Exposure Factors Handbook* (EFH; EPA 2011a) and its *Child-Specific Exposure Factors Handbook* (CSEFH; EPA 2008a), EPA summarized home-grown/raised food ingestion rates for four children's age groups: 1 to < 3 years; 3 to < 6 years; 6 to < 12 years; and 12 to < 20 years. Intake rates were not calculated for children younger than 1 year because infants are unlikely to consume those foods. They are more likely to be nursing or to be fed formula and other commercial baby-food products.

Although the age groupings used to estimate FFC ingestion rates do not match precisely the groupings that EPA recommended in 2005 for Agency exposure assessments (EPA 2005b), they are the only age-groupings for which such data are available. The U.S. Department of Agriculture's (USDA's) 1987-1988 *Nationwide Food Consumption Survey* (USDA 1992, 1993, 1994a) remains the most recent survey of ingestion rates for home-grown foods, and EPA's analysis of those data, published in its 2011 EFH, remains the most recently published major analysis of those data. Because ingestion of home-grown produce and animal products are the primary exposure pathways for which MIRC was developed, those are the age groupings used for all child parameter values used to estimate exposure and risk in MIRC.

Thus, in MIRC, values for each exposure parameter were estimated for adults (20 to 70 years) and five children's age groups:

- infants under 1 year (i.e., 0 to < 1 year);
- children ages 1 through 2 years (i.e., 1 to < 3 years);
- children ages 3 through 5 years (i.e., 3 to < 6 years);
- children ages 6 through 11 years (i.e., 6 to < 12 years); and
- children ages 12 through 19 years (i.e., 12 to < 20 years).

See Sections 5.1 and 5.2 for descriptions of the risk characterization algorithms used to calculate cancer and non-cancer effects, respectively, for the above age groupings. Exposure and risks to infants under 1 year of age are estimated only for the breast-milk-ingestion pathway.

For assessment of cancer risks from early-life exposure, EPA recognizes that infants and children may be more sensitive to a carcinogenic chemical than adults, with cancers appearing earlier in life or with lower doses experienced during childhood (EPA 2005c, d). Thus, the "potency" of a carcinogen might be higher for infants and children than for adults. To date, however, data by which to evaluate the relative sensitivity of children and adults to the same daily dose of a carcinogen remain limited. Based on analyses of radioactive and other carcinogenic chemicals, EPA recommends evaluating two lifestages for children separately from adults for chemicals that cause cancer by a mutagenic mode of action (MOA): from birth to < 2 years and from 2 to < 16 years (EPA 2005c,d). EPA also suggests that, as data become available regarding carcinogens with a mutagenic MOA, further refinements of these age groupings may be considered.

For assessing risks from exposures to carcinogenic chemicals that act via a mutagenic MOA, the two early lifestages recommended by EPA (EPA 2005c,d) also are included in MIRC:

- children under the age of 2 years (i.e., 0 to < 2 years); and
- children from 2 through 15 years (i.e., 2 to < 16 years).

Different age groupings are needed for the assessment of risks from carcinogenic chemicals with a mutagenic MOA and other carcinogens with other or unknown MOAs. Currently in MIRC, the only PB-HAPs with a mutagenic mode of carcinogenesis are the carcinogenic PAHs. See Section 5.1 for a description of the age-dependent adjustment factors (ADAFs) that are used to calculate cancer risks for chemicals with a mutagenic MOA.

3. Exposure Algorithms

The exposure algorithms in MIRC are described below in four sections. Section 3.1 of this attachment presents the algorithms used to estimate chemical concentrations in FFC foods from chemical concentrations in soil and air. Pathway-specific algorithms used to estimate chemical intakes by adults and non-infant children are described in Section 3.2, and total chemical intake calculations are described in Section 3.3. Finally, the sets of algorithms used to estimate chemical intake via consumption of breast milk by nursing infants are described in Section 3.4. As noted previously, the exposure algorithms used in MIRC are based on those presented in HHRAP (EPA 2005b). Any differences between MIRC and HHRAP are explained in this section.

3.1. Farm Food Chain Algorithms

The algorithms and parameters used to estimate chemical concentrations in produce and animal products are described in Sections 3.1.1 and 3.1.2 of this attachment, respectively. Discussions of the parameter value options and the values selected as defaults in MIRC for RTR risk assessment are provided in Section 6.2. The use of TRIM.FaTE to model chemical fate and transport in the environment prior to FFC calculations drives the most significant difference between the FFC algorithms included in HHRAP and the equations used for RTR. The approach in HHRAP uses estimated ambient air concentrations and deposition rates from dispersion model simulations that use unit emission rates. Chemical-specific emission rates (adjusted for vapor and particle-bound fractions) are then incorporated into some of the HHRAP FFC algorithms to calculate concentrations in FFC media. Soil concentrations are calculated using a similar approach in HHRAP. For assessment of multipathway exposures for RTR, TRIM.FaTE is used to estimate air concentrations, air-to-surface deposition rates, and soil concentrations, and these outputs are used in the FFC algorithms.

3.1.1. Estimating Chemical Concentrations in Produce

Produce (vegetables and fruits) can become contaminated directly by deposition of airborne chemicals to foliage and fruits or indirectly by uptake of chemicals deposited to the soil. Given these two contamination processes, produce is divided into two main groups: aboveground and belowground produce. Aboveground produce is divided into fruits and vegetables. These groups are further subdivided into “exposed” and “protected” depending on whether the edible portion of the plant is exposed to the atmosphere or is protected by a husk, hull, or other outer covering.

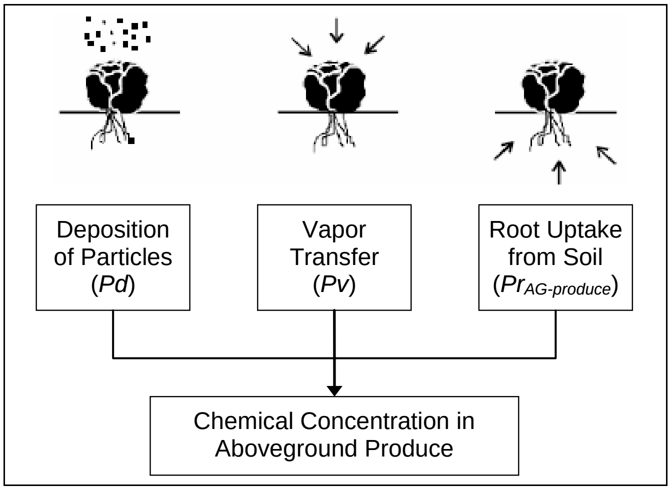
Exhibit B-3 lists the pathways by which chemicals are transferred to the FFC produce categories. Note that for a general screening-level assessment, all of the pathways can be modeled, as was done for EPA’s calculation of Tier 1 screening threshold emission rates for PB-HAPs in its RTR assessments (EPA 2008b), and as described in the Technical Support Document. Sections 3.1.1.1 and 3.1.1.2 below describe the transfer pathways and algorithms for aboveground and belowground produce, respectively.

Exhibit B-3. Chemical Transfer Pathways for Produce

Farm Food Media		Chemical Transfer Pathways
Aboveground Produce	Exposed fruits and vegetables	Direct deposition from air of particle-bound chemical Air-to-plant transfer of vapor phase chemical Root uptake from soil
	Protected fruits and vegetables	Root uptake from soil
Belowground Produce	Root vegetables	Root uptake from soil

3.1.1.1. Aboveground Produce

Exhibit B-4. Estimating Chemical Concentration in Aboveground Produce



For aboveground *exposed* produce, chemical mass is assumed to be transferred to plants from the air in three ways, as illustrated in Exhibit B-4. First, particle-bound chemical can deposit directly on the plant surface via deposition (Pd). The amount of chemical accumulated is estimated based on the areal fraction of chemical deposition intercepted by the plant surface, minus a loss factor that is intended to account for removal of deposited chemical by wind and rain and changes in concentration due to growth dilution. Second, for chemical present in air in the vapor phase, the concentration of chemical accumulated by the plant’s foliage is estimated using an empirical air-to-plant biotransfer factor (Pv). Third, the chemical concentration in the plant due to root uptake from the soil ($Pr_{AG\text{-}produce}$) is estimated using an empirical bioconcentration factor ($Br_{AG\text{-}produce}$) that relates the chemical concentration in the plant to the average chemical concentration in the soil at the root-zone depth in the produce-growing area ($Cs_{root\text{-}zone\_produce}$).

The edible portions of aboveground *protected* produce are not subject to contamination via particle deposition (*Pd*) or vapor transfer *(Pv*). Therefore, root uptake of chemicals is the primary mechanism through which aboveground protected produce becomes contaminated. As shown below, the chemical concentration in the aboveground plant due to root uptake from soil ($Pr_{AG\text{-}produce\text{-}DW}$) is estimated using an empirical bioconcentration factor ($Br_{AG\text{-}produce\text{-}DW}$) that relates the chemical concentration in the plant to the average chemical concentration in the soil at the root-zone depth in the produce-growing area ($Cs_{root\text{-}zone\_produce}$). These equations all assume measurements on a dry-weight (DW) basis.

Equation B-1. Chemical Concentration in Aboveground Produce

$$C_{AG-produce-DW(i)} = \mathrm{P}r_{AG-produce-DW(i)} + Pd_{(i)} + Pv_{(i)}$$

where:

$C_{AG\text{-}produce\text{-}DW(i)}$ = Concentration of chemical in edible portion of aboveground produce type i, exposed or protected, on a dry-weight (DW) basis (mg/kg produce DW)

$Pd_{(i)}$ = Chemical concentration in edible portion of aboveground produce type i due to deposition of particles (mg/kg produce DW); for protected aboveground produce, Pd equals zero

$Pr_{AG\text{-}produce\text{-}DW(i)}$ = Chemical concentration in edible portion of aboveground produce type i, exposed or protected, due to root uptake from soil at the root-zone depth of the produce growing area (mg/kg produce DW)

$Pv_{(i)}$ = Chemical concentration in edible portion of aboveground produce type i due to air-to-plant transfer (µg/g [or mg/kg] produce DW); for protected aboveground produce, Pv equals zero

Equation B-2. Chemical Concentration in Aboveground Produce Due to Root Uptake

$$\mathrm{P}r_{AG-produce-DW(i)} = Cs_{\text{root-zone\_produce}} \times Br_{AG-produce-DW(i)}$$

where:

$Pr_{AG\text{-}produce\text{-}DW(i)}$ = Concentration of chemical in edible portion of aboveground produce type *i*, *exposed* or *protected*, due to root uptake from soil at root-zone depth in the produce-growing area, on a dry-weight (DW) basis (mg/kg produce DW)

$Cs_{root\text{-}zone\_produce}$ = Average chemical concentration in soil at root-zone depth in produce-growing area (mg/kg soil DW)

$Br_{AG\text{-}produce\text{-}DW(i)}$ = Chemical-specific plant/soil chemical bioconcentration factor for edible portion of aboveground produce type *i*, *exposed* or *protected* (g soil DW / g produce DW)

Equation B-3. Chemical Concentration in Aboveground Produce Due to Deposition of Particle-phase Chemical

$$Pd_{(i)} = \frac{1{,}000 \times (Drdp + (Fw \times Drwp)) \times Rp_{(i)} \times (1 - e^{(-kp(i)*Tp(i))})}{Yp_{(i)} \times kp_{(i)}}$$

where:

$Pd_{(i)}$	=	Chemical concentration in aboveground produce type *i* on a dry-weight (DW) basis due to particle deposition (mg/kg produce DW); set equal to zero for *protected* aboveground produce
$Drdp$	=	Average annual dry deposition of particle-phase chemical (g/m^2-yr)
Fw	=	Fraction of wet deposition that adheres to plant surfaces; 0.2 for anions, 0.6 for cations and most organics (unitless)
$Drwp$	=	Average annual wet deposition of particle-phase chemical (g/m^2-yr)
$Rp_{(i)}$	=	Interception fraction of the edible portion of plant type *i* (unitless)
$kp_{(i)}$	=	Plant surface loss coefficient for plant type *i* (yr^{-1})
$Tp_{(i)}$	=	Length of exposure to deposition in the field per harvest of the edible portion of plant type *i* (yr)
$Yp_{(i)}$	=	Yield or standing crop biomass of the edible portion of plant type i (kg produce DW/m^2)

Note that Equation B-3 differs from Equation 5-14 in HHRAP, from which it is derived. In HHRAP, Equation 5-14 includes the term *Q* x (*1 – Fv*) to indicate the emissions rate, in g/sec, of chemical from the source and the proportion of the chemical that remains in, or partitions to, the particle-phase in the air. Also in HHRAP, the dry and wet particle phase deposition rates, *Dydp* and *Dywp,* respectively, are normalized to the emission rate and are expressed in units of sec/m^2-yr.

With MIRC, the user inputs both the dry and wet particle-phase deposition rates, *Drdp* and *Drwp*, respectively, in units of g/m^2-yr for a specific location relative to an emissions source. Those deposition rates might be values measured near that location or estimated using a fate and transport model, such as TRIM.FaTE, in conjunction with local meteorological information and emissions rate data. The chemical emissions term used in HHRAP, *Q*, therefore, is not used in MIRC's Equation B-3. In addition, in MIRC, *Drdp* and *Drwp*, the average annual dry- and wet-particle-phase deposition rates, respectively, are in units of g/m^2-yr. Users of TRIM.FaTE should note that the dry- and wet-particle-deposition rates output from TRIM.FaTE are in units of g/m^2-day; therefore, users must adjust the TRIM.FaTE output values to units of g/m^2-yr (i.e., multiply by 365 days/yr) before inputting values for *Drdp* and *Drwp* into MIRC.

Equation B-4. Chemical Concentration in Aboveground Produce Due to Air-to-Plant Transfer of Vapor-phase Chemical

$$Pv_{(i)} = \frac{Ca \times Fv \times Bv_{AG(i)} \times VG_{AG(i)}}{\rho_a}$$

where:

$Pv_{(i)}$ = Concentration of chemical in edible portion of aboveground produce type *i* from air-to-plant transfer of vapor-phase chemical on a dry-weight (DW) basis (µg/g produce DW); set equal to zero for *protected* aboveground produce

Ca = Average annual *total* chemical concentration in air (g/m^3)

Fv = Fraction of airborne chemical in vapor phase (unitless)

$Bv_{AG(i)}$ = Air-to-plant biotransfer factor for aboveground produce type *i* for vapor-phase chemical in air ([mg/g produce DW] / [mg/g air], i.e., g air/ g produce DW)

$VG_{AG(i)}$ = Empirical correction factor for aboveground *exposed* produce type *i* to address possible overestimate of the diffusive transfer of chemical from the outside to the inside of bulky produce, such as fruit (unitless)

ρ_a = Density of air (g/m^3)

Note that Equation B-4 differs from Equation 5-18 in HHRAP, from which it is derived. In HHRAP, Equation 5-18 includes the term *Q* x *Fv* to indicate the emissions rate, in g/sec, of chemical from the source and the fraction of the chemical in vapor phase in the air. HHRAP also includes the parameter *Cyv*, or the unitized yearly average air concentration of vapor-phase chemical in units of µg-sec/g-m^3. For MIRC, the user inputs the average annual total air concentration of the chemical, *Ca*, for a specific location relative to the source in units of g/m^3; MIRC includes a chemical-specific default value for *Fv* for chemicals included in its database. The air concentration might be a value measured near that location or a value estimated by a fate and transport model such as TRIM.FaTE. Users of TRIM.FaTE should note that the average annual concentration of the total chemical in air (i.e., total of both vapor and particulate phases), *Ca*, output from TRIM.FaTE is in units µg/m^3; therefore, the user must adjust the value to units of g/m^3 (i.e., divide by 1,000 µg/g) before entering it in MIRC.

The calculations of chemical concentration in aboveground produce, ($C_{AG\text{-}produce\text{-}DW}$), shown above, are on a dry-weight (DW) basis. The family FFC food ingestion rates, on the other hand, are on a fresh- or wet-weight (WW) basis. MIRC therefore calculates the concentration in aboveground produce on a wet-weight basis, $C_{AG\text{-}produce\text{-}WW}$, using Equation B-5 and the moisture content (*MAF*) of the FFC food category.

Equation B-5. Conversion of Aboveground Produce Chemical Concentration from Dry- to Wet-Weight Basis

$$C_{AG-produce-WW(i)} = C_{AG-produce-DW(i)} \times \left(\frac{(100 - MAF_{(i)})}{100} \right)$$

where:

$C_{AG\text{-}produce\text{-}WW(i)}$ = Chemical concentration in edible portion of aboveground produce type i on a wet-weight (WW) basis (mg/kg produce WW)

$C_{AG\text{-}produce\text{-}DW(i)}$ = Chemical concentration in edible portion of aboveground produce type i on a dry-weight (DW) basis (mg/kg produce DW)

$MAF_{(i)}$ = Moisture adjustment factor for aboveground produce type i to convert the chemical concentration estimated for dry-weight produce to the corresponding chemical concentration for full-weight fresh produce (percent water)

3.1.1.2. Belowground Produce

The equations by which chemical concentrations are estimated in belowground produce are different for nonionic organic chemicals than for inorganic chemicals and ionic organic chemicals.

3.1.1.2.1. Nonionic Organic Chemicals

For belowground produce, the nonionic organic chemical concentration in the tuber or root vegetable is derived from exposure to the chemical in soil and is estimated using an empirical root concentration factor (*RCF*) and the average chemical concentration in the soil at the root-zone depth in the produce-growing area ($Cs_{root\text{-}zone\_produce}$), as shown in Equation B-6. The RCF relates the chemical concentration in the plant on a wet-weight basis to the average chemical concentration in the root-zone soil ($Cs_{root\text{-}zone\_produce}$) on a dry-weight basis. Belowground produce (i.e., tubers or root vegetables) are protected from the deposition and vapor transfer by being covered by soil. Therefore, root uptake of chemicals is the primary mechanism through which belowground produce becomes contaminated.

Equation B-6. Chemical Concentration in Belowground Produce: Nonionic Organic Chemicals

$$\mathrm{C}_{\mathrm{BG\text{-}produce\text{-}WW}} = \frac{Cs_{root-zone\_produce} \times RCF \times VG_{rootveg}}{Kds \times UCF}$$

where:

$C_{BG\text{-}produce\text{-}WW}$	=	Concentration of chemical in belowground (BG) produce (i.e., tuber or root vegetable) on a wet-weight (WW) basis (mg chemical/kg produce WW)*
$Cs_{root\text{-}zone\_produce}$	=	Average chemical concentration in soil at root-zone depth in produce-growing area, on a dry-weight (DW) basis (mg chemical/kg soil DW)
RCF	=	Chemical-specific root concentration factor for tubers and root produce (L soil pore water/kg root WW)*
$VG_{rootveg}$	=	Empirical correction factor for belowground produce (i.e., tuber or root vegetable) to account for possible overestimate of the diffusive transfer of chemicals from the outside to the inside of bulky tubers or roots (based on carrots and potatoes) (unitless) *
Kds	=	Chemical-specific soil/water partition coefficient (L soil pore water/kg soil DW)
UCF	=	Units conversion factor of 1 kg/L

*Note that there is only one type of BG produce; hence there are no plant-type-specific subscripts.

The RCF, as developed by Briggs *et al*. (1982), is the ratio of the chemical concentration in the edible root on a wet-weight basis to its concentration in the soil pore water. RCFs are based on experiments with growth solutions (hydroponic) instead of soils; therefore, it is necessary to divide the soil concentration by the chemical-specific soil/water partition coefficient (*Kds*). There is no conversion of chemical concentrations in belowground produce from DW to WW because the values are already on a WW basis.

For nonionic organic chemicals, it is possible to predict RCF values and Kds values (for a specified soil organic carbon content) from an estimate of the chemical's K_{ow} from empirically derived regression models. Those models are shown in HHRAP Appendix A-2, Equations A-2-14 and A-2-15 (RCF) and in Equations A-29 and A-2-10 (Kds). The RCF and Kds values so calculated for many of the chemicals in HHRAP are included in the MIRC database (including the values for PAHs and dioxins).

3.1.1.2.2. Inorganic and Ionic Organic Chemicals

For inorganic chemicals and ionized organic chemicals, it is not possible to predict RCF or Kds values from K_{ow}. For inorganic chemicals, chemical specific empirical values for the root/soil bioconcentration factor must be used. The root/soil bioconcentration factor, now specified as $Br_{BG\text{-}produce\text{-}DW}$, must be obtained from the literature for each inorganic chemical on a DW basis. For inorganic chemicals, therefore, Equation B-7 is used instead of Equation B-6.

Equation B-7. Chemical Concentration in Belowground Produce: Inorganic Chemicals

$$C_{BG\text{-}produce\text{-}DW} = \frac{Cs_{root-zone\_produce} \times Br_{BG-produce-DW} \times VG_{rootveg}}{1}$$

where:

$C_{BG\text{-}produce\text{-}DW}$ = Concentration of chemical in edible portion of aboveground produce, due to root uptake from soil at root-zone depth in the produce-growing area, on a dry-weight (DW) basis (mg/kg produce DW)

$Cs_{root\text{-}zone\_produce}$ = Average chemical concentration in soil at root-zone depth in produce-growing area (mg/kg soil DW)

$Br_{BG\text{-}produce\text{-}DW}$ = Chemical-specific root/soil chemical bioconcentration factor for edible portion of belowground produce (g soil DW / g produce DW)

$VG_{rootveg}$ = Empirical correction factor for belowground produce (as in Equation B-6) (unitless)

As for the aboveground produce, the DW estimate of concentration of chemical in the root vegetables must be transformed to a WW estimate, as shown in Equation B-8.

Equation B-8. Conversion of Belowground Produce Chemical Concentration from Dry- to Wet-Weight Basis

$$C_{BG-produce-WW} = C_{BG-produce-DW} \times \left(\frac{(100 - MAF_{BG})}{100} \right)$$

where:

$C_{BG\text{-}produce\text{-}WW}$ = Chemical concentration in edible portion of belowground produce on a weight-weight (WW) basis (mg/kg produce WW)

$C_{BG\text{-}produce\text{-}DW}$ = Concentration of chemical in edible portion of aboveground produce, due to root uptake from soil at root-zone depth in the produce-growing area, on a dry-weight (DW) basis (mg/kg produce DW)

$MAF_{(BG)}$ = Moisture adjustment factor (as in Equation B-5, but single value for below ground produce) (percent water)

3.1.2. Estimating Chemical Concentrations in Animal Products

Chemical concentrations in animal products are estimated based on the amount of chemical consumed by each animal group *m* through each plant feed type *i* ($Plant_{Ch\text{-}Intake(i,m)}$) and incidental ingestion of soil for ground-foraging animals ($Soil_{Ch\text{-}Intake(m)}$). Exhibit B-5 summarizes the pathways by which chemicals are transferred to these home- or farm-raised animal food products. Note that for a general screening-level assessment, all of the pathways can be modeled, as is done for EPA's RTR calculation of screening threshold emission rates for PB-HAPs (EPA 2008b).

The feed options for farm animals in MIRC include forage (plants grown on-site for animal grazing, such as grass), silage (wet forage grasses, fresh-cut hay, or other fresh plant material that has been stored and fermented), and grain products grown on the farm. As seen in Exhibit B-5, the algorithms in MIRC for chemical intake with plant feeds ($Plant_{Ch\text{-}Intake(i,m)}$) are based on the assumptions that beef and dairy cattle consume all three plant feed products, while pigs consume only silage and grain, and chickens consume only grain.

Exhibit B-5. Chemical Transfer Pathways for Animal Products

Farm Food Media		Chemical Transfer Pathways
Animal Products	Beef and total dairy (including milk)	• Ingestion of forage, silage, and grain[a] • Incidental soil ingestion
	Pork	• Ingestion of silage and grain[a] • Incidental soil ingestion
	Poultry and eggs	• Ingestion of grain[a] • Incidental soil ingestion

[a] Chemical concentrations in plant feed (i.e., forage, silage, and grain) are estimated via intermediate calculations (see Equation B-13, Equation B-14, Equation B-3, and Equation B-4).

Forage and silage are exposed to the air and can accumulate chemicals via direct deposition of particle-bound chemical and transfer of vapor-phase chemical, while all animal feed grains are assumed to be protected from the air by a husk or pod (e.g., corn, soybeans). All three animal feed products are assumed to accumulate chemical via root uptake.

Chemical concentrations are estimated for animal feeds using algorithms analogous to those for aboveground farm produce described above. MIRC uses Equation B-9 to calculate the concentration of chemical in beef, pork, or total dairy and Equation B-10 to calculate the concentration of chemical in poultry or eggs. The chemical concentration in mammalian farm animals (i.e., beef and pigs) is adjusted using a metabolism factor (*MF*) that accounts for endogenous degradation of the chemical (see Equation B-9). *MF* is set to 1.0 for chemicals that are not metabolized and for chemicals for which the metabolic degradation rate is unknown. Although other vertebrates, including birds, are likely to have similar metabolic pathways for most chemicals, the health protective assumption is that birds do not metabolize any chemicals; therefore, the *MF* is omitted from Equation B-10 for poultry and eggs.

Equation B-9. Chemical Concentration in Beef, Pork, or Total Dairy

$$C_{mammal(m)} = Ba_{(m)} \times MF \times \left(Soil_{Ch-Intake(m)} + \sum_{i=1}^{n} Plant_{Ch-Intake(i,m)} \right)$$

where:

$C_{mammal(m)}$ = Concentration of chemical in mammalian animal product *m*, where *m* = beef, pork, or total dairy (mg chemical/kg animal product WW)

$Ba_{(m)}$ = Chemical-specific biotransfer factor for chemical in diet to chemical in animal food product *m*, where *m* = beef, pork, or total dairy ([mg chemical/kg animal product WW] / [mg chemical intake/day] or day/kg WW)

MF = Chemical-specific mammalian metabolism factor that accounts for endogenous degradation of the chemical (unitless)

$Soil_{Ch\text{-}Intake(m)}$ = Incidental ingestion of chemical in surface soils by livestock type *m* during grazing or consumption of foods placed on the ground (mg/day); see Equation B-11 below

$Plant_{Ch\text{-}Intake(i,m)}$ = For livestock (animal product) type *m*, ingestion of chemical from plant feed type *i* (mg chemical/kg livestock WW); see Equation B-12 below

(If *m* =beef or total dairy, then *n* = 3 and *i* = forage, silage, and grain; *m* = pork, then *n* = 2 and *i* = silage and grain; *m* = poultry, then *n* = 1 and *I* = grain.)

Equation B-10. Chemical Concentration in Poultry or Eggs

$$C_{poultry(m)} = Ba_{(m)} \times \left(Soil_{Ch-Intake(m)} + Plant_{Ch-Intake(i,m)}\right)$$

where:

$C_{poultry(m)}$ = Concentration of chemical in food product *m*, where *m* = poultry or eggs (mg chemical/kg animal product WW)

$Ba_{(m)}$ = Chemical-specific biotransfer factor for food product *m*, where *m* = poultry or eggs (day/kg animal product WW)

$Soil_{Ch\text{-}Intake(m)}$ = Incidental ingestion of chemical in surface soils by consumption of food on the ground (mg chemical/day) where *m* = poultry; see Equation B-11

$Plant_{Ch\text{-}Intake(i,m)}$ = For poultry (and eggs), animal *m*, ingestion of the chemical in plant feed type *i* (mg chemical/day), which for poultry is limited to grain; see Equation B-12

In MIRC, the incidental ingestion of the chemical in soils by livestock during grazing or consumption of feed placed on the ground ($Soil_{Ch\text{-}Intake(m)}$) is estimated using empirical soil ingestion rates (*Qs*) and a soil bioavailability factor for livestock (*Bs*), as shown in Equation B-11. At this time, the default value for *Bs* in MIRC for all chemicals is 1.0 (i.e., the chemical in soil is assumed to be 100 percent bioavailable to the animal). This assumption may be reasonably accurate for the soil surface to which airborne chemical is deposited. MIRC allows the user to enter a surface soil concentration for areas where livestock forage, $Cs_{S\text{-}livestock}$, that is distinct from the surface soil concentration input for areas where produce may be grown and where humans might incidentally ingest soils (see Section 6.1 of this attachment).

Equation B-11. Incidental Ingestion of Chemical in Soil by Livestock

$$Soil_{Ch-Intake(m)} = Qs \times Cs_{s-livestock} \times Bs$$

where:

$Soil_{Ch\text{-}Intake(m)}$ = Incidental ingestion of the chemical in surface soils by livestock type *m* during grazing or consumption of foods placed on the ground (mg chemical/day)

$Qs_{(m)}$ = Quantity of soil eaten by animal type *m* each day (kg soil DW/day)

$Cs_{s\text{-}livestock}$ = Chemical concentration in surface soil in contaminated area where livestock feed (mg chemical/kg soil DW)

Bs = Soil bioavailability factor for livestock (unitless) (assumed to be the same for birds and mammals)

Animal ingestion of the chemical in feed is calculated for each type of livestock based on their assumed diets. For *m* = beef and dairy cattle, chemical intake is estimated for all three feed types: *i* = forage, silage, and grain. For pork, chemical intake is estimated only for silage and grain. The chemical intake for poultry is based on grain consumption only. The intake of chemical with each feed type, *i*, $Plant_{Ch\text{-}Intake(i,m)}$, is calculated separately according to Equation B-12. Note that the animal feed ingestion rates are on a dry-weight (DW) basis; hence, no DW to wet weight (WW) conversion is needed.

Equation B-12. Ingestion of Chemical in Feed by Livestock

$$Plant_{Ch-Intake(i,m)} = F_{(i,m)} \times Qp_{(i,m)} \times C_{feed(i)}$$

where:

$Plant_{\,Ch\text{-}Intake(i,m)}$ = Ingestion of chemical in plant feed type *i* (mg chemical/day), where *i* = forage, silage, or grain, for livestock type *m*

$F_{(i,m)}$ = Fraction of plant feed type *i* obtained from contaminated area used to grow animal feed, where *I* = forage, silage, or grain (unitless) for livestock type *m*

$Qp_{(i,m)}$ = Quantity of plant feed type *i* consumed per animal per day (kg plant feed DW/day), where *i* = forage, silage, or grain, for livestock type *m*

$C_{feed(i)}$ = Concentration of chemical in ingested plant feed type *i* (mg chemical/kg plant feed DW), where *i* = forage, silage, or grain

The concentrations of chemical in the three different types of plant feeds for livestock are calculated according to Equation B-13. The equation is the same as that for aboveground produce in Equation B-1, with the exception that the concentrations are for plants used as animal feeds (not produce consumed by humans) and all types of plant feed (i.e., forage, silage, and grain) are aboveground.

Equation B-13. Chemical Concentration in Livestock Feed (All Aboveground)

$$C_{feed(i)} = Pr_{feed(i)} + Pd_{(i)} + Pv_{(i)}$$

where:

$C_{feed(i)}$ = Concentration of chemical in plant feed type *i* on a dry-weight (DW) basis (mg chemical/kg plant feed DW), where *i* = forage, silage, or grain

$Pr_{feed(i)}$ = Concentration of chemical in plant feed type *i* due to root uptake from soil (mg/kg DW), where *i* = forage, silage, or grain; see Equation B-14 below

$Pd_{(i)}$ = Concentration of chemical in plant feed type *i* due to wet and dry deposition of particle-phase chemical (mg/kg DW), where *i* = forage, silage, or grain; when *i* = grain, the *Pd* term equals zero

$Pv_{(i)}$ = Concentration of chemical in plant feed type *i* due to air-to-plant transfer of vapor-phase chemical (µg/g [or mg/kg] DW) where *i* = forage, silage, or grain; when *i* = grain, the *Pd* term equals zero

MIRC calculates the chemical concentration in animal feed due to root uptake from the soil using Equation B-14. The equation is the same as Equation B-2, except that a *Br* value appropriate to grasses is used and MIRC allows for different soil concentrations in the area used to grow animal feed than in the area used to grow produce for human consumption (see Section 6.1 of this attachment, user inputs). Note that for feed type *i* = grains, the *Pd* and *Pv* terms do not apply (are set to zero), because the feed products (i.e., corn kernels, soy beans) are protected from the air (i.e., by husks, pods).

Equation B-14. Chemical Concentration in Livestock Feed Due to Root Uptake

$$\mathrm{P}r_{feed(i)} = Cs_{root-zone\_feed(i)} \times Br_{feed(i)}$$

where:

$Pr_{feed(i)}$ = Concentration of chemical in plant feed type *i* due to root uptake from soil on a dry-weight (DW) basis (mg chemical/kg plant feed DW), where *i* = forage, silage, or grain

$Cs_{root\text{-}zone\_feed(i)}$ = Average chemical concentration in soil at root-zone depth in area used to grow plant feed type *i* (mg chemical/kg soil DW), where *i* = forage, silage, or grain

$Br_{feed(i)}$ = Chemical-specific plant-soil bioconcentration factor for plant feed type *i* (kg soil DW/kg plant feed DW), where *i* = forage, silage, or grain

The algorithms used to calculate $Pd_{(i)}$ and $Pv_{(i)}$ when plant feed type *i* = forage and silage are identical to those used to calculate $Pd_{(i)}$ and $Pv_{(i)}$ for aboveground exposed produce (i.e., Equation B-3 and Equation B-4, respectively).

There are no conversions of DW feed to WW feed, because all feed ingestion rates for livestock are based on DW feed.

3.2. Chemical Intake Calculations for Adults and Non-Infant Children

MIRC calculates human chemical intake rates from the ingestion of home-grown foods as average daily doses (ADDs) normalized to body weight for each age group, chemical, and food type separately. ADDs, calculated using Equation B-15, are expressed in milligrams of chemical per kilogram of receptor body weight per day (mg/kg-day).

Equation B-15. Average Daily Dose for Specified Age Group and Food Type

$$ADD_{(y,i)} = \left(\frac{C_{(i)} \times IR_{(y,i)} \times FC_{(i)} \times ED_{(y)}}{BW_{(y)} \times AT_{(y)}} \right) \left(\frac{EF_{(y)}}{365\ \text{days}} \right)$$

where:

$ADD_{(y,i)}$ = Average daily dose for age group y from food type or ingestion medium i (mg chemical/kg body weight-day)

$C_{(i)}$ = Concentration of chemical in food type i harvested from the contaminated area (mg chemical/kg food or mg food/L water)

$IR_{(y,i)}$ = Ingestion rate for age group y of food type i (kg/day or L/day)

$FC_{(i)}$ = Fraction of food type i that was harvested from contaminated area (unitless)

$ED_{(y)}$ = Exposure duration for age group y (years)

$BW_{(y)}$ = Body weight for age group y (kg)

$AT_{(y)}$ = Averaging time for calculation of daily dose (years) for age group y, set equal to ED in MIRC

$EF_{(y)}$ = Annual exposure frequency for age group y (days)

Equation B-15 takes into account the chemical concentration in each food type *i* (or in water), the quantity of food brought into the home for consumption, the loss of some of the mass of the foods due to preparation and cooking, how much of the food is consumed per year, the amount of the food obtained from contaminated areas, and the consumer's body weight (EPA 2011a, 2003a). In MIRC, ADDs are calculated separately for each chemical, home-grown food type, and consumer age group.

ADD values, expressed as intakes, not absorbed doses, are appropriate for comparison with RfDs and for use with cancer slope factors (CSFs) to estimate risk, as discussed in Section 5 of this attachment. An exception is for the breast-milk exposure pathway, where calculating the dose available to and absorbed by the nursing infant is related to the dose absorbed by the mother as discussed in Section 3.4 of this attachment.

MIRC evaluates only one exposure scenario at a time. For screening-level assessments, all components of this equation are assumed to remain constant for consumers in a given age group over time (e.g., seasonal and annual variations in diet are not explicitly taken into account). To calculate an $ADD_{(y,i)}$ from the contaminated area for food group *i* over an entire lifetime of exposure, age-group-specific ingestion rates and body weights are used for the age groups described in Section 2.3 of this attachment. In MIRC, the averaging time used to calculate the daily dose for an age group (AT_y) is equal to the exposure duration for that group (ED_y); therefore these variables drop out of Equation B-15.

For each chemical included in a screening scenario, total average daily exposure for age group *y* ($ADD_{(y)}$) is estimated as the sum of chemical intake from all ingestion pathways combined: Note that the last exposure pathway is limited to infants.

- Incidental soil ingestion;
- Ingestion of fish;
- Ingestion of homegrown fruits (exposed and protected);
- Ingestion of homegrown vegetables (exposed, protected, and root);
- Ingestion of animal products from home-raised animals:
  - Milk and other dairy products from cows,

  - Beef products,
  - Pork products, and
  - Poultry and eggs;
- Ingestion of drinking water from specified source; and
- Ingestion of breast milk by infants.

The algorithms for the first six exposure pathways listed above are described in Sections 3.2.1 through 3.2.6 of this attachment. The algorithms for the breast-milk ingestion pathway are described in Section 3.4.

3.2.1. Chemical Intake from Soil Ingestion

Equation B-16 shows the equation used to estimate chemical intake through incidental ingestion of soil.

Equation B-16. Chemical Intake from Soil Ingestion

$$ADD_{Soil\,(y)} = \left(\frac{C_{Soil} \times IR_{Soil(y)} \times FC_{Soil} \times 0.001\ \frac{mg}{\mu g}}{BW_{(y)}} \right) \left(\frac{EF}{365 \text{ days}} \right)$$

where:

$ADD_{Soil(y)}$ = Average daily chemical intake from incidental ingestion of soil or ingestion by child in age group *y* (mg chemical/kg body weight-day)

C_{Soil} = Concentration of chemical in soil from contaminated area on a dry-weight (DW) basis (µg/g soil DW)

$IR_{Soil(y)}$ = Soil ingestion rate for age group *y* (g DW/day)

FC_{Soil} = Fraction of soil ingested that is from contaminated area (unitless)

$BW_{(y)}$ = Body weight for age group *y* (kg)

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤ 365 days)

Note: MIRC saves soil ingestion rates in units of mg/day (not g/day); therefore, there is an additional 0.001 g/mg conversion unit in the actual MIRC algorithm than shown here.

3.2.2. Chemical Intake from Fish Ingestion

Ingestion of locally caught fish is included as a possible exposure pathway in MIRC (Equation B-17). Two types of fish are included in the exposure algorithm: trophic level 3.5 (abbreviated as TL3) fish, equivalent to benthic carnivores such as catfish and trophic level 4 (TL4) fish in the water column, equivalent to game fish such as lake trout and walleye. The chemical concentration in fish in Equation B-17 is estimated as the consumption-weighted chemical concentration using Equation B-18.

Equation B-17. Chemical Intake from Fish Ingestion

$$ADD_{Fish(y)} = (1 - L1_{Fish}) \times (1 - L2_{Fish}) \times \frac{\left(C_{Fish} \times IR_{Fish(y)} \times 0.001\frac{\text{kg}}{\text{g}} \times FC_{Fish}\right)}{BW_{(y)}} \times \left(\frac{EF}{365\ \text{days}}\right)$$

Equation B-18. Consumption-weighted Chemical Concentration in Fish

$$\mathrm{C_{Fish}} = (\mathrm{C_{FishTL3}} \times \mathrm{F_{TL3}}) + (\mathrm{C_{FishTL4}} \times \mathrm{F_{TL4}})$$

where:

$ADD_{Fish(y)}$ = Average daily chemical intake from ingestion of local fish for age group *y* (mg/kg-day)

$L1_{Fish}$* = Weight of fish brought into home that is discarded during preparation (e.g., head, bones, liver, other viscera, belly fat, skin with fat) (unitless)

$L2_{Fish}$* = Loss of weight during cooking, such as evaporation and loss of fluids into pan (unitless)

$C_{FishTL3}$ = Chemical concentration in whole fish for trophic level 3.5 (TL3) fish on a wet-weight (WW) basis (mg/kg WW)

$C_{FishTL4}$ = Chemical concentration in whole fish for trophic level 4 (TL4) fish on a wet-weight (WW) basis (mg/kg WW)

F_{TL3} = Fraction of fish intake that is from TL3 (unitless)

F_{TL4} = Fraction of fish intake that is from TL4 (unitless)

C_{Fish} = Consumption-weighted mean chemical concentration in total fish (i.e., as specified by Equation B-18) (mg/kg WW)

FC_{Fish} = Fraction of local fish consumed derived from contaminated area (unitless)

$BW_{(y)}$ = Body weight for age *y* (kg)

$IR_{Fish(y)}$* = Local fish ingestion rate for age *y* (g WW/day)

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤ 365 days)

*Parameter values must be internally consistent. In contrast to the tables included in MIRC for ingestion rate options for homegrown food products, which are based on the products as brought into the home from the field (see Section 6.3.3 of this attachment), the tables of fish ingestion rate options included in MIRC are on an “as consumed” basis (i.e., after preparation and cooking losses), and L1 and L2 therefore are set equal to zero. If the user wishes to enter local fish ingestion rates on an “as harvested” basis, the user also should enter L1 and L2 values as specified in Section 6.4.3 of this attachment.

When whole fish are prepared for cooking, it is usual for the viscera, head, and fins to be removed, particularly for larger fish. Many persons also remove (or do not eat) the skin, bones, and belly fat. EPA has, therefore, estimated the proportion of the weight of whole fish that tends to be lost during preparation and cooking across a variety of fish species (EFH; EPA 2011a) and included those losses in its HHRAP algorithms for chemical intake from fish ($L1_{Fish}$ and $L2_{Fish}$ in Equation B-17).

3.2.3. Chemical Intake from Fruit Ingestion

Average daily doses of a chemical from homegrown exposed fruits are calculated separately for exposed and protected fruits (Equation B-19 and Equation B-20, respectively).

Equation B-19. Chemical Intake from Consumption of Exposed Fruits

$$ADD_{ExpFruit(y)} = (1 - L1_{ExpFruit}) \times (1 - L2_{ExpFruit}) \times \left(C_{ExpFruit} \times IR_{ExpFruit(y)} \times 0.001 \frac{\text{kg}}{\text{g}} \times FC_{ExpFruit} \right) \times \left(\frac{EF}{365 \text{ days}} \right)$$

Equation B-20. Chemical Intake from Consumption of Protected Fruits

$$ADD_{ProFruit(y)} = (1 - L1_{ProFruit}) \times \left(C_{ProFruit} \times IR_{ProFruit(y)} \times 0.001 \frac{\text{kg}}{\text{g}} \times FC_{ProFruit} \right) \times \left(\frac{EF}{365 \text{ days}} \right)$$

where:

$ADD_{ExpFruit(y)}$ $ADD_{ProFruit(y)}$	=	Average daily chemical intake from ingestion of exposed fruit or protected fruit (depending on subscript) (mg chemical/kg body weight-day)
$L1_{ExpFruit}$	=	Mean reduction in fruit weight resulting from removal of skin or peel, core or pit, stems or caps, seeds and defects, and from draining liquids from canned or frozen forms (unitless)
$L1_{ProFruit}$	=	Mean reduction in fruit weight that results from paring or other preparation techniques for protected fruits (unitless)
$L2_{ExpFruit}$	=	Mean reduction in fruit weight that results from draining liquids from cooked forms of the fruit (unitless)
$C_{ExpFruit}$ $C_{ProFruit}$	=	Chemical concentration in whole exposed fruits or whole protected fruits (depending on subscript) on a wet-weight (WW) basis (mg chemical/kg exposed fruit WW)
EF	=	Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤ 365 days)
$FC_{ExpFruit}$ $FC_{ProFruit}$	=	Fraction of exposed fruits or protected fruits (depending on subscript) obtained from contaminated area (unitless)
$IR_{ExpFruit(y)}$ $IR_{ProFruit(y)}$	=	Ingestion rate of home-grown exposed fruits or protected fruits (depending on subscript) for age *y* (g WW/kg body weight-day)

Fruit ingestion rates in the survey were based on weights of unprepared fruits (e.g., one apple; one pear) or the weight of a can of fruit (e.g., 8 oz. can). The weight of the fruit ingested is less than the initial weight owing to common preparation actions ($L1_{ExpFruit}$ and $L1_{ProFruit}$; e.g., coring apples and pears; peeling apples; pitting cherries). Cooking of exposed fruit (e.g., berries, apples, peaches) often results in further weight loss that results from liquids lost during cooking and drained from the cooking vessel ($L2_{ExpFruit}$). EPA has assumed that cooking of protected fruit results in no loss of weight for the fruit.

3.2.4. Chemical Intake from Vegetable Ingestion

MIRC includes three separate algorithms for homegrown vegetables adapted from EPA's HHRAP Modeling System (EPA 2005a): one for exposed vegetables such as asparagus, broccoli, lettuce, and tomatoes (although they are actually a fruit); one for protected vegetables such as corn, cabbage, soybeans, and peas; and one for root vegetables such as carrots, beets, and potatoes (see Equation B-21, Equation B-22, and Equation B-23, respectively).

Equation B-21. Chemical Intake from Exposed Vegetables

$$ADD_{ExpVeg(y)} = \left(1 - L1_{ExpVeg}\right) \times \left(C_{ExpVeg} \times IR_{ExpVeg(y)} \times 0.001\frac{\text{kg}}{\text{g}} \times FC_{ExpVeg}\right) \times \left(\frac{EF}{365\text{ days}}\right)$$

Equation B-22. Chemical Intake from Protected Vegetables

$$ADD_{ProVeg(y)} = \left(1 - L1_{ProVeg}\right) \times \left(C_{ProVeg} \times IR_{ProVeg(y)} \times 0.001\frac{\text{kg}}{\text{g}} \times FC_{ProVeg}\right) \times \left(\frac{EF}{365\text{ days}}\right)$$

Equation B-23. Chemical Intake from Root Vegetables

$$ADD_{RootVeg(y)} = \left(1 - L1_{RootVeg}\right) \times \left(1 - L2_{RootVeg}\right) \times \left(C_{RootVeg} \times IR_{RootVeg(y)} \times 0.001\frac{\text{kg}}{\text{g}} \times FC_{RootVeg}\right) \times \left(\frac{EF}{365\text{ days}}\right)$$

where:

$ADD_{ExpVeg(y)}$, $ADD_{ProVeg(y)}$, $ADD_{RootVeg(y)}$ = Average chemical intake from ingestion of exposed vegetables, protected vegetables, or root vegetables (depending on subscript) for age group *y* (mg chemical/kg body weight-day)

$L1_{ExpVeg}$ = Mean net preparation and cooking weight loss for exposed vegetables (unitless); includes removing stalks, paring skins, discarding damaged leaves

$L1_{ProVeg}$ = Mean net cooking weight loss for protected vegetables (unitless); includes removing husks, discarding pods of beans and peas, removal of outer leaves

$L1_{RootVeg}$ = Mean net cooking weight loss for root vegetables (unitless); includes losses from removal of tops and paring skins

$L2_{RootVeg}$ = Mean net post cooking weight loss for root vegetables from draining cooking liquids and removal of skin after cooking (unitless)

C_{ExpVeg}, C_{ProVeg}, $C_{RootVeg}$ = Chemical concentration in exposed vegetables, protected vegetables, or root vegetables (depending on subscript) on a wet-weight (WW) basis (mg chemical/kg vegetable WW)

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤365 days)

FC_{ExpVeg}, FC_{ProVeg}, $FC_{RootVeg}$ = Fraction of exposed vegetables, protected vegetables, or root vegetables (depending on subscript) obtained from contaminated area (unitless)

$IR_{ExpVeg(y)}$, $IR_{ProVeg(y)}$, $IR_{RootVeg(y)}$ = Ingestion rate of exposed vegetables, protected vegetables, or root vegetables (depending on subscript) for age group *y* (g vegetable WW/kg body weight-day)

3.2.5. Chemical Intake from Animal Product Ingestion

Calculations of chemical intake from the consumption of farm animals and related food products are provided below in Equation B-24 through Equation 2-28 for homegrown beef, dairy (milk), pork, poultry, and eggs, respectively.

Equation B-24. Chemical Intake from Ingestion of Beef

$$ADD_{Beef(y)} = (1 - L1_{Beef}) \times (1 - L2_{Beef}) \times \left(C_{Beef} \times IR_{Beef(y)} \times 0.001 \frac{\text{kg}}{\text{g}} \times FC_{Beef} \right) \times \left(\frac{EF}{365\ \text{days}} \right)$$

where:

$ADD_{Beef(y)}$ = Average daily chemical intake from ingestion of beef for age group y (mg/kg-day)

$L1_{Beef}$ = Mean net cooking loss for beef (unitless)

$L2_{Beef}$ = Mean net post cooking loss for beef (unitless)

C_{Beef} = Concentration of contaminant in beef (mg/kg WW))

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤ 365 days)

$IR_{Beef(y)}$ = Ingestion rate of contaminated beef for age group y (g WW/kg-day)

$FCBeef$ = Fraction of beef consumed raised on contaminated area or fed contaminated silage and grains (unitless)

Equation B-25. Chemical Intake from Dairy Ingestion

$$ADD_{Dairy(y)} = \left(C_{Dairy} \times IR_{Dairy(y)} \times 0.001 \frac{\text{kg}}{\text{g}} \times FC_{Dairy} \right) \times \left(\frac{EF}{365\ \text{days}} \right)$$

where:

$ADD_{Dairy(y)}$ = Average daily chemical intake from ingestion of total dairy for age group *y* (mg/kg-day)

C_{Dairy} = Average concentration of contaminant in total dairy (mg/kg WW)

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤ 365 days)

$IR_{Dairy(y)}$ = Ingestion rate of contaminated total dairy for age group *y* (g WW/kg-day)

FC_{Dairy} = Fraction of total dairy products from contaminated area (unitless)

Equation B-26. Chemical Intake from Pork Ingestion

$$ADD_{Pork(y)} = (1 - L1_{Pork}) \times (1 - L2_{Pork}) \times \left(C_{Pork} \times IR_{Pork(y)} \times 0.001 \frac{\text{kg}}{\text{g}} \times FC_{Pork} \right) \times \left(\frac{EF}{365\ \text{days}} \right)$$

where:

$ADD_{Pork(y)}$ = Average daily chemical intake from ingestion of pork for age group y (mg/kg-day)

$L1_{Pork}$ = Mean net cooking loss for pork (unitless); includes dripping and volatile losses during cooking; averaged over various cuts and preparation methods

$L2_{Pork}$ = Mean net post cooking loss for pork (unitless); includes losses from cutting, shrinkage, excess fat, bones, scraps, and juices; averaged over various cuts and preparation methods

C_{Pork} = Concentration of contaminant in pork (mg/kg WW)

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤365 days)

$IR_{Pork(y)}$ = Ingestion rate of contaminated pork for age y (g WW/kg-day)

FC_{Pork} = Fraction of pork obtained from contaminated area (unitless)

Equation B-27. Chemical Intake from Poultry Ingestion

$$ADD_{Poultry(y)} = (1 - L1_{Poultry}) \times (1 - L2_{Poultry}) \times \left(C_{Poultry} \times IR_{Poultry(y)} \times 0.001 \frac{\text{kg}}{\text{g}} \times FC_{Poultry} \right) \times \left(\frac{EF}{365\text{ days}} \right)$$

where:

$ADDPoultry(y)$ = Average daily dose (chemical intake) from ingestion of poultry (mg/kg-day)

$L1Poultry$ = Mean net cooking loss for poultry (unitless)

$L2Poultry$ = Mean net post cooking loss for poultry (unitless)

$CPoultry$ = Concentration of chemical in poultry (mg/kg WW)

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤365 days)

$IRPoultry(y)$ = Ingestion rate of poultry for age group y (g WW/kg-day)

$FC_{Poultry}$ = Fraction of poultry from contaminated area or fed contaminated grains (unitless)

The reduction in the weight of beef, pork, and poultry during and after cooking may correlate with an increase or decrease in the concentration of the chemical in the food as consumed depending on the chemical and depending on the cooking method.

Equation B-28. Chemical Intake from Egg Ingestion

$$ADD_{Egg(y)} = \left(C_{Egg} \times IR_{Egg(y)} \times 0.001 \frac{\text{kg}}{\text{g}} \times FC_{Egg} \right) \times \left(\frac{EF}{365\text{ days}} \right)$$

where:

$ADD_{Egg(y)}$ = Average daily chemical intake from ingestion of eggs for age group y (mg/kg-day)

C_{Egg} = Concentration of contaminant in eggs (mg/kg WW)

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤ 365 days)

$IR_{Egg(y)}$ = Ingestion rate of contaminated eggs for age group *y* (g WW/kg-day)

FC_{Egg} = Fraction of eggs obtained from contaminated area (unitless)

3.2.6. Chemical Intake from Drinking Water Ingestion

If the user chooses to evaluate chemical ingestion via drinking water, the user specifies a chemical concentration in g/L (equivalent to mg/mL) based on their particular scenario. The chemical concentration could represent water from groundwater wells, community water, nearby surface waters, or other source. For this exposure pathway, ingestion rates are in units of milliliters of water per day (mL/day) (see Equation B-29).

Equation B-29. Chemical Intake from Drinking Water Ingestion

$$ADD_{DW(y)} = \left(\frac{C_{DW} \times IR_{DW(y)} \times FC_{DW}}{BW_{(y)}} \right) \times \left(\frac{EF}{365\ \text{days}} \right)$$

where:

$ADD_{DW(y)}$ = Average daily chemical intake from ingestion of drinking water from local residential water source for age group *y* (mg/kg-day)

C_{DW} = Concentration of contaminant in drinking water (g/L)

$IR_{DW(y)}$ = Drinking water ingestion rate for age group *y* (mL/day)

FC_{DW} = Fraction of drinking water obtained from contaminated area (unitless)

$BW_{(y)}$ = Body weight of age group *y* (kg)

EF = Exposure frequency; number of days per year of exposure for family(ies) as specified for scenario (≤365 days)

3.3. Total Chemical Intake

To estimate the total ADD, or intake of a chemical from all of the exposure media that a single individual in each age group is expected to contact (e.g., soil, local fish, five types of home-grown produce, and five types of home-raised animals or animal products), the media-specific chemical intakes are summed for each age group. Total average daily exposure for a particular age group *y* ($ADD_{(y)}$) is estimated as the sum of chemical intake from all ingestion pathways combined, as illustrated in Equation B-30 through Equation B-35 below.

Equations B-30 to B-35. Total Average Daily Dose of a Chemical for Different Age Groups

Equation B-30. $ADD_{(<1)} = ADD_{breastmilk}$

Equation B-31. $ADD_{(1-2)} = \sum_{i=1}^{n} ADD_{(1-2,i)}$

Equation B-32. $ADD_{(3-5)} = \sum_{i=1}^{n} ADD_{(3-5,i)}$

Equation B-33. $ADD_{(6-11)} = \sum_{i=1}^{n} ADD_{(6-11,i)}$

Equation B-34. $ADD_{(12-19)} = \sum_{i=1}^{n} ADD_{(12-19,i)}$

Equation B-35. $ADD_{(adult)} = \sum_{i=1}^{n} ADD_{(adult,i)}$

where i represents the i^{th} food type or ingestion medium and n equals the total number of food types or ingestion media, and *ADD* parameters are defined below:

$ADD_{(<1)}$ = Total average daily dose of chemical for infants less than one year from ingestion of breast milk (mg/kg-day)

$ADD_{(1-2)}$ = Total average daily dose of chemical from all ingestion sources for children ages 1 through 2 years (mg/kg-day)

$ADD_{(3-5)}$ = Total average daily dose for children ages 3 through 5 years (mg/kg-day)

$ADD_{(6-11)}$ = Total average daily dose for children ages 6 through 11 years (mg/kg-day)

$ADD_{(12-19)}$ = Total average daily dose for children ages 12 through 19 years (mg/kg-day)

$ADD_{(adult)}$ = Total average daily dose for adult age 20 up to 70 years (mg/kg-day)

The lifetime average daily dose (*LADD*) is calculated as the time-weight average of the *ADD* values for each age group (Equation B-36).

Equation B-36. Lifetime Average Daily Dose (LADD)

$$LADD = ADD_{(<1)}\left(\frac{1}{70}\right) + ADD_{(1\text{-}2)}\left(\frac{2}{70}\right) + ADD_{(3\text{-}5)}\left(\frac{3}{70}\right) + ADD_{(6\text{-}11)}\left(\frac{6}{70}\right) + ADD_{(12\text{-}19)}\left(\frac{8}{70}\right) + ADD_{(adult)}\left(\frac{50}{70}\right)$$

The time-weighting factors simply equal the duration of exposure for the specified age category in years divided by the total lifespan, assumed to be 70 years.

3.4. Chemical Intake Calculations for Nursing Infants

The scientific literature indicates that infants can be exposed to some chemicals via their mothers' breast milk. The magnitude of the exposure can be estimated from information on the mother's exposure, data on the partitioning of the chemical into various compartments of the mother's body and into breast milk, and information on the infant's consumption of milk and absorption of the chemical. To add this exposure pathway to the MIRC application, we adapted exposure algorithms and default assumptions from EPA's *Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions* (EPA 1998), hereafter referred to as MPE, as explained below.

Note that this pathway generally is of most concern for *lipophilic* bioaccumulative chemicals (e.g., dioxins) that can cause developmental effects. The period of concern for the more *hydrophilic* chemicals that cause developmental effects generally is earlier, that is, from conception to birth. Hydrophilic chemicals generally exchange well between the maternal and fetal blood supplies at the placenta.

3.4.1. Infant Average Daily Absorbed Dose

The average daily dose of chemical *absorbed* by the infant (DAI_{inf}) is estimated in MIRC with Equation B-37. This basic exposure equation relies on the concentration of the chemical in the breast milk, the infant's breast-milk ingestion rate (IR_{milk}), the absorption efficiency of the chemical by the oral route of exposure (AE_{inf}), the bodyweight of the infant (BW_{inf}), and the duration of breast feeding (*ED*). Equation B-37 is EPA's (EPA 1998) modification of an average daily dose for the infant model first published by Smith (1987) and includes variables for both the concentration of the chemical in the breast milk fat ($C_{milkfat}$) and the concentration of the chemical in the aqueous phase of breast milk ($C_{aqueous}$). The remainder of the DAI_{inf}-associated equations assume that most chemicals of concern will partition *either* to the lipid phase *or* to the aqueous phase of breast milk, although some chemicals may partition significantly to both phases of milk. Thus, the remaining equations in MIRC assume that either $C_{milkfat}$ or $C_{aqueous}$ is equal to zero and hence drops out of the equation.

For the parameters in Equation B-37 (and the equations that follow) that are not calculated from another equation, an EPA default value and options for other values available in MIRC for the infant breast-milk-exposure pathway are described in Section 6.4 of this attachment. The user also can overwrite those parameter values with a different value from the literature as appropriate.

Equation B-37. Average Daily Dose of Chemical to the Nursing Infant

$$DAI_{inf} = \frac{\left[\left(C_{milkfat} \times f_{mbm}\right) + \left(C_{aqueous} \times \left(1 - f_{mbm}\right)\right)\right] \times IR_{milk} \times AE_{inf} \times ED}{BW_{inf} \times AT}$$

where:

DAI_{inf} = Average daily dose of chemical absorbed by infant (mg chemical/kg body weight-day)

$C_{milkfat}$ = Concentration of chemical in lipid phase of maternal milk (mg chemical/kg milk lipid; calculated using Equation B-38)

f_{mbm} = Fraction of fat in breast milk (unitless)

$C_{aqueous}$ = Concentration of chemical in aqueous phase of maternal milk (mg chemical/kg aqueous phase milk; calculated using Equation B-42)

IR_{milk} = Infant milk ingestion rate over the duration of nursing (kg milk/day)

AE_{inf} = Absorption efficiency of the chemical by the oral route of exposure (i.e., chemical-specific fraction of ingested chemical that is absorbed by the infant) (unitless)

ED = Exposure duration, i.e., duration of breast feeding (days)

BW_{inf} = Body weight of infant averaged over the duration of nursing (kg)

AT = Averaging time associated with exposure of interest; equal to ED (days)

As mentioned above, Equation B-37 includes terms for the chemical in both the lipid- and non-lipid phases of milk. The remaining equations, however, assume that a chemical of concern will partition to the lipid or aqueous phase of breast milk, but not to both. Different models are used to estimate $C_{milkfat}$ (described in Section 3.4.2 of this attachment) and $C_{aqueous}$ (described in Section 3.4.3 of this attachment).

3.4.2. Chemical Concentration in Breast Milk Fat

When developing the Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions (MPE) (EPA 1998), EPA reviewed three first-order kinetics models for estimating chemical concentration in breast milk fat. The model selected for use in MIRC is the model selected in MPE. The other two models were not considered in MPE because one used a biotransfer factor (BTF) approach considered more of a screening model than a predictive tool (Travis *et al.* 1988) and the other assumed that the contaminant concentration in the maternal fat compartment is at steady state and that the concentration in breast milk fat is the same as in maternal body fat (Smith 1987). The model in MIRC is a changing-concentration model that EPA adapted from a model by Sullivan *et al*. (1991). The model, shown in Equation B-38, estimates the average chemical concentration in the breast milk over the entire period of breast feeding by reference to a maximum theoretical steady-state concentration. Studies of lipophilic chemicals such as dioxins suggest that concentrations in the maternal milk are highest during the first few weeks of breast feeding and then decrease over time (ATSDR 1998). Equation B-38 accounts for the changing concentration in breast milk fat, but estimates one average value to represent the concentration over the entire duration of breast feeding. The model is dependent on the maternal body burden of the chemical and assumes that the chemical concentration in breast milk fat is the same as the concentration in general maternal body fat. According to reviewers of the model, this assumption warrants further investigation because milk fat appears to be synthesized in the mammary glands and may have lower chemical concentrations than general body fat stores (EPA 2001a).

Equation B-38. Chemical Concentration in Breast Milk Fat

$$C_{milkfat} = \frac{DAI_{mat} \times f_f}{k_{elim} \times f_{fm}} \times \left[\frac{k_{elim}}{k_{fat\_elac}} + \frac{1}{k_{fat\_elac} \times t_{bf}} \left(1 - e^{-k_{elim} t_{pn}} - \frac{k_{elim}}{k_{fat\_elac}} \right) \left(1 - e^{-k_{fat\_elac} t_{bf}} \right) \right]$$

where:

$C_{milkfat}$ = Concentration of chemical in lipid phase of maternal milk (mg chemical/kg lipid)

DAI_{mat} = Daily absorbed maternal chemical dose (mg chemical/kg maternal body weight-day; calculated using Equation B-39)

f_f = Fraction of total maternal body burden of chemical that is stored in maternal fat (mg chemical in body fat / mg total chemical in whole body; value from literature or EPA default - see Section 6.5 of this attachment)

k_{elim} = Chemical-specific total elimination rate constant for elimination of the chemical by non-lactating women (per day; e.g., via urine, bile to feces, exhalation; value from literature or calculated using Equation B-40)

f_{fm} = Fraction of maternal body weight that is fat stores (unitless)

k_{fat_elac} = Chemical-specific rate constant for total elimination of chemical in the lipid phase of milk during nursing (per day; value from literature or calculated using Equation B-41)

t_{bf} = Duration of breast feeding (days)

t_{pn} = Duration of mother's exposure prior to parturition and initiation of breast feeding (days)

Equation B-38 relies on the daily maternal absorbed intake (DAI_{mat}) to determine the concentration of the chemical in the breast milk fat. DAI_{mat} is multiplied by the fraction of the chemical that is stored in maternal fat (f_f) to determine the amount (i.e., mass) of chemical in the fat. This product, divided by the chemical-specific elimination rate constant (k_{elim}) for non-lactating adult women and the fraction of the mother's weight that is fat (f_{fm}), represents the maximum theoretical steady-state concentration of the chemical in an adult woman. If used alone to estimate the chemical concentration in breast milk fat, the equation as explained thus far is likely to overestimate the chemical concentration in milk fat because it does not account for losses due to breast feeding. Alone, this term ($DAI_{mat}\, f_f \,/\, k_{elim}\, f_{fm}$) also assumes that the biological half-life of the chemical in the mother's breast milk fat is small relative to the duration of the mother's exposure. However, for chemicals with half-lives that are longer than the exposure duration, which are the chemicals of concern in the applications of MIRC to date, an additional term is needed to determine the average concentration in the milk fat over the duration of her exposure.

To account for breast feeding losses and longer chemical half-lives in the mother than the exposure duration, an additional term is included in Equation B-38. This term includes a fraction dependent on two rate constants, k_{elim} and the elimination constant for a lipophilic chemical in lactating women via the lipid phase of breast milk (k_{fat_elac}), the duration of the mother's chemical exposure prior to nursing (t_{pn}), and the duration of breast feeding (t_{bf}). The whole body concentration ($DAI_{mat}\, f_f \,/\, k_{elim}\, f_{fm}$), the maximum theoretical steady-state concentration, is multiplied by the rate of elimination averaged over the duration of the mother's exposure, including her exposure prior to and during lactation. To review the derivation of Equation B-38, see Appendix B of MPE (EPA 1998).

To estimate an average daily dose *absorbed* by an infant's mother, or DAI_{mat}, the average daily dose (*ADD*) (in mg/kg-day) for the chemical from all sources that MIRC calculates for adults ($ADD_{(adult)}$, described in Section 3.3 of this attachment, Equation B-35), is multiplied by an absorption efficiency (AE_{mat}) or fraction of the chemical absorbed by the oral route of exposure, as shown in Equation B-39. The value for AE_{mat} can be estimated from absorption efficiencies for adults in general. Available data for some chemicals, in particular some inorganic compounds, indicate AE values for ingestion exposures of substantially less than 100 percent. For a few of these chemicals, data also indicate lower AEs for the chemical when ingested in food or in soil than when ingested in water (e.g., cadmium). For a screening level assessment, however, it is reasonable to either assume 100 percent for the AE_{mat} or to use the higher AE_{mat} of the food and water AE_{mat} values if available; hence, a single AE_{mat} parameter is included in Equation B-39.

Equation B-39. Daily Maternal Absorbed Intake

$$DAI_{mat} = ADD_{(adult)} \times AE_{mat}$$

where:

DAI_{mat} = Daily maternal dose of chemical absorbed from medium *i* (mg/kg-day)

$ADD_{(adult)}$ = Average daily dose to the mother (mg/kg-day) (calculated by MIRC – see Section 3.3 of this attachment, Equation B-35)

AE_{mat} = Absorption efficiency of the chemical by the oral exposure route (i.e., chemical-specific fraction of ingested chemical that is absorbed) by the mother (unitless) (value from literature or EPA default – see Section 6.4 of this attachment)

Equation B-35, used to calculate $ADD_{(adult)}$, is based on many medium-specific ingestion rates that are normalized to body weight. The adult body weights to which the homegrown food ingestion rates are normalized are the body weights of the consumers in the original USDA survey (see Section 6.3.3 of this attachment), which included both males and females. An assumption in the breast-milk exposure pathway is that those ingestion rates also are applicable to nursing mothers. The original data for ingestion rates for soil, drinking water, and fish are on a per person basis for males and females combined. MIRC divides those chemical intakes by an adult body weight for males and females combined as specified by the user (e.g., 71.4 kg mean value) to estimate the ADD normalized to body weight from those sources. If the user finds that those exposure media contribute the majority of the chemical intake for the risk scenario under consideration, the user may use alternative ingestion rates for those media and alternative body weights for nursing women, as described in Section 6.5 of this attachment.

Elimination rates for chemicals often are reported as the half-life of the chemical in the body following a known dose of chemical. Many chemicals exhibit a two-phase elimination process, the first being more rapid than the second. For screening risks for persistent and bioaccumulative chemicals, the half-life of the slower phase of elimination, presumably from non-blood compartments of the body, is the more important of the two. Assuming first-order kinetics, Equation B-40 is used to convert a measured half-life for elimination of a chemical for adults or non-lactating women to an elimination rate constant (EPA 1998). The equation can be used to estimate any kind of chemical loss rate constant from a measured chemical half-life.

Equation B-40. Biological Elimination Rate Constant for Chemicals for Non-lactating Women

$$k_{elim} = \frac{\ln 2}{h}$$

where:

k_{elim} = Chemical-specific elimination rate constant for elimination of the chemical for non-lactating women (per day; e.g., via urine, bile to feces, exhalation)

$ln2$ = Natural log of 2 (unitless constant)

h = Chemical-specific biological half-life of chemical for non-lactating women (days)

For chemicals transferred from the body of lactating women to breast milk, the rate of chemical elimination is augmented by the rate of chemical loss via the milk through breast feeding. The total elimination rate for lactating women sometimes is measured directly and reported in the literature. Where direct measurements are not available, and for chemicals that partition predominantly to the lipid-phase of milk, EPA has used Equation B-41 to estimate the total chemical elimination rate for lactating women, k_{fat_elac} (EPA 1998).

Equation B-41. Biological Elimination Constant for Lipophilic Chemicals for Lactating Women

$$k_{fat\_elac} = k_{elim} + \frac{IR_{milk} \times f_f \times f_{mbm}}{f_{fm} \times BW_{mat}}$$

where:

k_{fat_elac} = Rate constant for total elimination of chemical during nursing (per day); accounts for both elimination by adults in general and the additional chemical elimination via the lipid phase of milk in nursing women

k_{elim} = Elimination rate constant for chemical from adults, including non-lactating women (per day; e.g., via urine, bile to feces, exhalation; chemical-specific; value from literature or calculated from half-life using Equation B-40)

IR_{milk} = Infant milk ingestion rate over the duration of nursing (kg/d)

f_f = Fraction of total maternal body burden of chemical that is stored in maternal fat (mg chemical in body fat / mg chemical total in body; value from literature or EPA default)

f_{mbm} = Fraction of fat in breast milk (unitless)

f_{fm} = Fraction of maternal body weight that is fat stores (unitless)

BW_{mat} = Maternal body weight over the entire duration of the mother's exposure to the chemical including during pregnancy and lactation (kg)

Equation B-41 is based on a model from Smith (1987) and accounts for the additional elimination pathway for lipophilic chemicals via the breast milk fat. The term K_{fat_elac} is estimated by adding an estimate of the first-order elimination constant for breast feeding losses to k_{elim}, which is the chemical-specific total elimination rate constant for non-lactating women. The breast feeding losses are estimated from the infant's intake rate of breast milk (IR_{milk}), the fraction of the total maternal body burden of the chemical that is stored in maternal body fat (f_f), the fraction of the mother's breast milk that consists of fat (lipids) (f_{mbm}), the mother's body weight (BW_{mat}), and the fraction of the mother's weight that is body fat (f_{fm}). In Equation B-41, the value for the mother's body weight should be specific to women of child-bearing age, as opposed to a body weight value for both males and females that is used to estimate an adult average daily dose and the mother's absorbed daily intake in Equation B-39. Body weight values for the mother are described in Section 6.5 of this attachment. Smith's (1987) model assumes that the chemical partitions to the lipid-phase of breast milk to the same degree that it partitions into the mother's body fat. For highly lipophilic compounds, losses from breast feeding can be larger than losses by all other pathways (EPA 1998).

3.4.3. Chemical Concentration in Aqueous Phase of Breast Milk

When developing MPE (EPA 1998), EPA also considered models to estimate chemical concentrations in the aqueous phase of breast milk ($C_{aqueous}$). EPA adapted Smith's (1987) steady state concentration model for estimating $C_{milkfat}$ and developed the $C_{aqueous}$ model shown in Equation B-42 (EPA 1998). Chemicals that would partition to the aqueous phase of human milk include water-soluble chemicals, such as salts of metals, and other hydrophilic chemicals that may be in equilibrium with bound forms of the chemical in different tissues. The $C_{aqueous}$ equation assumes that the chemical concentration in the aqueous phase of milk is directly proportional to the chemical concentration in the mother's blood plasma. The portion of chemical sequestered in red blood cells (e.g., bound to RBC proteins) is assumed to be unavailable for direct transfer to breast milk.

Equation B-42. Chemical Concentration in Aqueous Phase of Breast Milk

$$C_{aqueous} = \frac{DAI_{mat} \times f_{pl} \times Pc_{bm}}{k_{aq\_elac} \times f_{pm}}$$

where:

$C_{aqueous}$ = Concentration of chemical in aqueous phase of maternal milk (mg/kg)

DAI_{mat} = Daily absorbed maternal chemical dose (mg/kg-day; calculated by Equation B-39)

f_{pl} = Fraction of chemical in the body (based on absorbed intake) that is in the blood plasma compartment (unitless; value from literature or calculated by Equation B-43)

Pc_{bm} = Partition coefficient for chemical between the plasma and breast milk in the aqueous phase (unitless); assumed to equal 1.0

k_{aq_elac} = Chemical-specific rate constant for total elimination of chemical in the aqueous phase of milk during nursing (per day; value from literature or calculated in Equation B-44)

f_{pm} = Fraction of maternal weight that is blood plasma (unitless)

Equation B-42 is a steady-state concentration model that, like the Equation B-38 for $C_{milkfat}$, is dependent on the maternal absorbed daily intake (DAI_{mat}). In Equation B-42, DAI_{mat} is multiplied by the fraction of the absorbed chemical that is circulating in the blood plasma compartment (f_{pl}) and a partitioning coefficient for the chemical between plasma and the aqueous phase of breast milk (Pc_{bm}). For highly water-soluble chemicals that are not transported via special carrier molecules, the chemical is assumed to diffuse passively from the mother's blood serum to the aqueous phase of her milk, in which case Pc_{bm} would equal 1.0. The denominator includes the biological elimination constant for the chemical in the aqueous phase of breast milk in lactating women (k_{aq_elac}) and the fraction of the mother's weight that is plasma (f_{pl}). Because the model assumes steady-state, it does not account for chemical species with long half-lives in the body or for body burden losses due to lactation. These factors are important for highly lipophilic chemicals and for non-lipophilic chemicals such as methyl mercury, lead, and cadmium that partition into body compartments such as red blood cells and bone. While these latter chemicals or forms of these chemicals are water-soluble when free, they have relatively long half-lives because they are in equilibrium with the chemical bound to macromolecules in some tissue compartments. Lead is of particular concern because it can be released from the bone into the blood during lactation, and thus into the breast milk (EPA 2001a). Due to this limitation, the model may over- or underestimate exposure to the infant.

Because Equation B-42 is based on the relationship between the chemical concentrations in the aqueous phase of breast milk and the blood plasma, a value for the fraction of the chemical in the mother's blood plasma (f_{pl}) is required. Ideally, an empirical value for f_{pl} should be used. If empirical values are not available, f_{pl} can be estimated from Equation B-43, provided that an empirical value can be found for the fraction of the chemical in the body that is in the mother's whole blood compartment (f_{bl}; EPA 1998).

Equation B-43. Fraction of Total Chemical in Body in the Blood Plasma Compartment

$$f_{pl} = \frac{f_{bl} \times f_{bp}}{f_{bp} + Pc_{RBC}\left(1 - f_{bp}\right)}$$

where:

f_{pl} = Fraction of chemical in body (based on absorbed intake) that is in the blood plasma compartment (unitless); chemical-specific

f_{bl} = Fraction of chemical in body (based on absorbed intake) in the whole blood compartment (unitless); chemical-specific

f_{bp} = Fraction of whole blood that is plasma (unitless)

$PcRBC$ = Partition coefficient for chemical between red blood cells and plasma (unitless); chemical-specific

If the fraction of the total chemical in the body that is in the whole blood compartment (f_{bl}) is known for a given chemical, then the fraction of that chemical that is in blood plasma depends only on the partition coefficient for the chemical between the red blood cells and the plasma (Pc_{RBC}) and the fraction of whole blood that is plasma (f_{bp}).

Another parameter for which a value is needed to solve Equation B-42 is the total chemical elimination rate for lactating women for hydrophilic chemicals, k_{aq_elac}. As for k_{fat_elac} for lipophilic chemicals, k_{aq_elac} for hydrophilic chemicals would be equal to k_{elim} plus the loss rate for the chemical in the aqueous phase of breast-milk during lactation. In the case of hydrophilic chemicals, EPA has yet to propose a term for the additional elimination of a chemical in the aqueous phase of milk from breast feeding. Given basic physiological mechanisms, we assume that chemical loss rates via urine are likely to be significantly higher than loss rates from nursing, however. This is because the counter-current anatomy of kidney tubules allows substantial concentration of chemicals in the tubules for elimination in urine compared with the concentration in circulating blood and because of active secretion of some chemicals into urine. Therefore, the best estimation of elimination of hydrophilic chemicals by lactating women is simply k_{elim}, the elimination of the chemical from a non-lactating woman, as shown in Equation B-40. The extent to which k_{elim} is an underestimate of k_{aq_elac} for a given chemical will determine the extent of health protective bias in k_{aq_elac}.

Equation B-44. Biological Elimination Rate Constant for Hydrophilic Chemicals

$$k_{aq\_elac} = k_{elim}$$

where:

k_{aq_elac} = Chemical-specific rate constant for total elimination of chemical by lactating women for hydrophilic chemicals (per day)

k_{elim} = Chemical-specific rate constant for total elimination of chemical by non-lactating women (per day; e.g., via urine, bile to feces, exhalation; value from literature or calculated from half-life using Equation B-40)

3.4.4. Alternative Model for Infant Intake of Methyl Mercury

In this version of MIRC, we were unable to fully parameterize the aqueous model for mercury. In particular, no empirical value could be found for the steady-state fraction of total hydrophilic chemical body burden in the mother that is in the blood plasma (f_{pl}, see Exhibit B-29). This parameter could be estimated using Equation B-43 if a suitable chemical-specific fraction of chemical in the body that is in the whole blood (f_{bl}) could be found. However, the value found for f_{bl} is based on a single-dose study and is not considered reliable for use in chronic exposure calculations.

We therefore conducted a literature search to identify existing physiologically based toxicokinetic (PBTK) models of lactational transfer of methylmercury (MeHg) in humans. Most PBTK models that we identified focused on gestational transfer of mercury between mother and fetus, including a PBTK dynamic compartmental model for gestational transfer of MeHg in humans developed by Gearhart *et al*. (1995, 1996), and reparameterized by Clewell *et al*. (1999).

We did find, however, that Byczkowski and Lipscomb (2001) had added a lactational transfer module to the Clewell *et al*. (1999) model. Byczkowski and Lipscomb compared their model's predictions to epidemiological data from mother-nursing-infant pairs obtained following an accidental high-dose poisoning in Iraq (Amin-Zaki *et al*. 1976) and from 34 mother-nursing-infant pairs examined in a low-dose, chronic exposure environment (Fujita and Takabatake 1977). Using data from the Iraq incident, Byczkowski and Lipscomb (2001) found good agreement between their model's predictions and the clinical data relating MeHg concentrations in breast milk to MeHg concentrations in infant's blood with time following the poisoning. To compare their model's predictions to data from chronic exposure to low doses of MeHg, Byczkowski and Lipscomb (2001) simulated MeHg intake for 500 days prior to conception, continued through gestation, and 6.5 months (200 days) of lactation. Their model's predictions were consistent with Fujita and Takabatake's (1977) study, although use of hair/blood partition coefficients based on the results of the 1977 study precluded use of this comparison as model validation. Both the model predictions and the mean values from the 1977 data indicated that the concentration of MeHg in the blood of nursing infants was close to the MeHg concentration in their mothers' blood (approximately 0.025 to 0.027 mg/L, Figure 4 of report). At those blood concentrations, the PBTK model estimated the average maternal intake of MeHg to be 0.68 ± 0.33 (SD) µg/kg-day and the average infant intake of MeHg to be 0.80 ± 0.38 µg/kg-day. Therefore, for purposes of MIRC, the DAI_{inf} of MeHg is estimated to be the same as the maternal intake per unit body weight (Equation B-42).

Equation B-45. Calculation of Infant Average Daily Absorbed Dose of Methyl Mercury

$$DAI_{inf\_MeHg} = DAI_{mat\_MeHg}$$

where:

DAI_{inf_MeHg} = Average daily dose of MeHg absorbed by infant from breast milk (mg/kg-day)

DAI_{mat_MeHg} = Average daily dose of methyl mercury absorbed by the mother, predominantly from fish (mg/kg-day)

4. Dose-Response Values Used for Assessment

Chemical dose-response values included in MIRC include carcinogenic potency slope factors for ingestion and non-cancer oral reference doses (RfDs) for chronic exposures. The dose-response values currently used in MIRC for RTR assessments are shown in Exhibit B-6 For some chemicals, OAQPS has identified dose-response values for use in RTR (EPA 2007a), and these dose-response values are used in MIRC for RTR assessments. In general, OAQPS chose these values based on the following hierarchy of sources: EPA's Integrated Risk Information System (IRIS); the Centers for Disease Control's Agency for Toxic Substances and Disease Registry (ATSDR); and the California Environmental Protection Agency's (CalEPA's) Office of Environmental Health Hazard Assessment (OEHHA) Toxicity Criteria Database. For PB-HAP chemicals that are currently evaluated in MIRC but do not currently have dose-response values identified by OAQPS for RTR, alternative methods for deriving values were used (see Sections 4.2 and 4.4 of this attachment).

Exhibit B-6. Oral Dose-response Values Used to Calculate RTR Screening Threshold Emission Rates for PB-HAP Chemicals[a]

Chemical	CAS No.	Cancer Slope Factor		Reference Dose	
		Value (mg/kg-day)$^{-1}$	Source	Value (mg/kg-day)	Source
Inorganics					
Cadmium compounds in food[b]	7440439	not available		1.0E-03	IRIS
Mercury (elemental)	7439976	not available		not available	
Mercuric chloride	7487947	not available		3.0E-04	IRIS
Methyl mercury (MeHg)	22967926	not available		1.0E-04	IRIS
Dioxins					
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822469	1.50E+03	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562394	1.50E+03	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673897	1.50E+03	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227286	1.50E+04	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,4,7,8-Hexachlorodibenzofuran	70648269	1.50E+04	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653857	1.50E+04	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,6,7,8-Hexachlorodibenzofuran	57117449	1.50E+04	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408743	6.20E+03	IRIS	not available	
1,2,3,7,8,9-Hexachlorodibenzofuran	72918219	1.50E+04	Derived from WHO 2005 TEFs[c]	not available	
2,3,4,6,7,8-Hexachlorodibenzofuran	60851345	1.50E+04	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268879	4.50E+01	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001020	4.50E+01	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321764	1.50E+05	Derived from WHO 2005 TEFs[c]	not available	
1,2,3,7,8-Pentachlorodibenzofuran	57117416	4.50E+03	Derived from WHO 2005 TEFs[c]	not available	
2,3,4,7,8-Pentachlorodibenzofuran	57117314	4.50E+04	Derived from WHO 2005 TEFs[c]	not available	
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746016	1.50E+05	EPA ORD	7E-10	IRIS
2,3,7,8-Tetrachlorodibenzofuran	51207319	1.50E+04	Derived from WHO 2005 TEFs[c]	not available	

Exhibit B-6. Oral Dose-response Values Used to Calculate RTR Screening Threshold Emission Rates for PB-HAP Chemicals[a]

Chemical	CAS No.	Cancer Slope Factor		Reference Dose	
		Value (mg/kg-day)$^{-1}$	Source	Value (mg/kg-day)	Source
Polycyclic Organic Matter					
1-Methylnaphthalene	90120	5.0E-01	EPA 1999, POM Group 72002[d]	7.0E-02	ATSDR
2-Acetylaminofluorene	53963	1.0E+01	EPA 1999, POM Group 75002[d]	not available	
2-Chloronaphthalene	91587	5.0E-01	EPA 1999, POM Group 72002[d]	8.0E-02	IRIS
2-Methylnaphthalene	91576	5.0E-01	EPA 1999, POM Group 72002[d]	5.0E-02	ATSDR
3-Methylcholanthrene	56495	2.2E+1	CalEPA	not available	
7,12-Dimethylbenz(a)anthracene	57976	2.5E+02	CalEPA	not available	
Acenaphthene	83329	5.0E-01	EPA 1999, POM Group 72002[d]	6.0E-02	IRIS
Acenaphthylene	208968	5.0E-01	EPA 1999, POM Group 72002[d]	not available	
Anthracene	120127	0[e]	IRIS	3.0E-01	IRIS
Benz(a)anthracene	56553	1.2E+00	CalEPA	not available	
Benzo(a)pyrene	50328	7.3E+00	IRIS	not available	
Benzo(b)fluoranthene	205992	1.2E+00	CalEPA	not available	
Benzo(e)pyrene	192972	5.0E-01	EPA 1999, POM Group 72002[d]	not available	
Benzo(g,h,i)perylene	191242	5.0E-01	EPA 1999, POM Group 72002[d]	not available	
Benzo(k)fluoranthene	207089	1.2E+00	CalEPA	not available	
Carbazole	86748	2.0E-02	HEAST	not available	
Chrysene	218019	1.2E-01	CalEPA	not available	
Dibenzo(a,h)anthracene	53703	4.1E+00	CalEPA	not available	
Dibenzo(a,i)pyrene	189559	1.2E+02	CalEPA	not available	
Dibenzo(a,j)acridine	224420	1.2E+00	CalEPA	not available	
Fluoranthene	206440	5.0E-01	EPA 1999, POM Group 72002[d]	4.0E-02	IRIS
Fluorene	86737	5.0E-01	EPA 1999, POM Group 72002[d]	4.0E-02	IRIS
Indeno(1,2,3-c,d)pyrene	193395	1.2E+00	CalEPA	not available	
PAH, total	234	5.0E-01	EPA 1999, POM Group 71002[d]	not available	
Perylene	198550	5.0E-01	EPA 1999, POM Group 72002[d]	not available	
Phenanthrene	85018	0[e]	IRIS	not available	
Polycyclic Organic Matter	246	5.0E-01	EPA 1999, POM Group 71002[d]	not available	

Exhibit B-6. Oral Dose-response Values Used to Calculate RTR Screening Threshold Emission Rates for PB-HAP Chemicals[a]

Chemical	CAS No.	Cancer Slope Factor		Reference Dose	
		Value $(mg/kg\text{-}day)^{-1}$	Source	Value (mg/kg-day)	Source
Pyrene	129000	0[e]	IRIS	3.0E-02	IRIS
Retene	483658	5.0E-01	EPA 1999, POM Group 72002[d]	not available	

ATSDR = Agency for Toxic Substances and Disease Registry, IRIS = Integrated Risk Information System, EPA OAQPS = EPA's Office of Air Quality Planning and Standards, CalEPA = California EPA, EPA ORD = EPA's Office of Research and Development, HEAST = EPA Health Effects Assessment Tables, TEF = toxic equivalency factor

[a] Values as of June 2012; these values may be updated as newer ones become available.

[b] There are RfDs for both water ingestion and food ingestion for cadmium – the RfD for food is used.

[c] Dose-response values for these dioxin congeners are not available from EPA sources. CSFs for these congeners were derived as discussed in Section 4.2 of this attachment.

[d] The method to assign oral cancer slope factors to polycyclic organic matter (POM) without CSFs available from other EPA sources is the same as that used in the 1999 National Air Toxics Assessment (EPA 1999). A complete description of the methodology is available at: http://archive.epa.gov/nata2002/web/pdf/pom_approach.pdff and is summarized in Section 4.4 of this attachment.

[e] Weight of evidence evaluations indicated that the available data were adequate to determine that this chemical was not carcinogenic (EPA 2010a),

4.1. Cadmium

EPA has developed two chronic RfDs for cadmium (Cd), one for food and one for water, based on data in IRIS indicating a lower absorption efficiency of cadmium from food than from water. The default RfD set in MIRC is the higher RfD for Cd compounds in food (as described in Section A.2.3, the drinking water exposure pathway is not modeled in the screening scenario because the likelihood that humans would use a lake as a drinking water source is assumed to be low). Users of MIRC who assess exposures via drinking water would need to use the RfD for Cd compounds in water (i.e., 5.0E-04 mg/kg-day).

4.2. Dioxins (2,3,7,8-TCDD)

For chemicals for which the critical health effect is developmental, either *in utero* and/or during the first months or years of life, the exposure duration and timing of exposure for comparison with the RfD (or comparable values) require special consideration. The most sensitive health endpoints for both mercury and 2,3,7,8-TCDD are neurological effects during development that have long-lasting effects on learning and social behaviors. To ensure a protective risk characterization for these chemicals, it is important to use the shortest exposure duration appropriate, at the appropriate life stage, for comparison with the toxicity reference values. This approach avoids "dilution" of an estimated average ADD that would result from averaging the lower daily chemical intake rates normalized to body weight for older children and adults with the potentially higher daily intake rates of infants over a longer exposure averaging period.

The convention for assessing risk from mixtures of dioxins is by application of toxic equivalency factors (TEFs) to dioxin concentrations, which are then expressed as toxic equivalents (TEQs). Of the dioxin congeners, 2,3,7,8-TCDD is the most widely studied and considered to be one of the most toxic congeners. It is therefore assigned a TEF of 1, with the other dioxin congener TEQ concentrations scaled relative to 2,3,7,8-TCDD concentrations on the basis of toxicity. For risk assessment of dioxins for RTR (with one exception), the World Health Organization (WHO) 2005 TEFs presented in Exhibit B-7 were used to derive the CSFs (shown in Exhibit B-6) for dioxin congeners without available EPA dose response values. The one exception is 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin, whose TEF was based on data from IRIS.

Exhibit B-7. WHO 2005 Toxic Equivalency Factors (TEFs) for Dioxin Congeners

Dioxin Congener	CAS No.	WHO 2005 Toxic Equivalency Factor[a]
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822469	0.01
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562394	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673897	0.01
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227286	0.1
1,2,3,4,7,8-Hexachlorodibenzofuran	70648269	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653857	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	57117449	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin[b]	19408743	0.04
1,2,3,7,8,9-Hexachlorodibenzofuran	72918219	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	60851345	0.1
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268879	3E-04
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001020	3E-04
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321764	1
1,2,3,7,8-Pentachlorodibenzofuran	57117416	0.03
2,3,4,7,8-Pentachlorodibenzofuran	57117314	0.3
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746016	1
2,3,7,8-Tetrachlorodibenzofuran	51207319	0.1

[a] Source: van den Berg et al. 2006, with the one exception in the next footnote.

[b] For 1,2,3,7,8,9-HexCDD, OAQPS identified an oral cancer slope factor from IRIS. For the purposes of these multipathway assessments, EPA uses the TEF derived from this IRIS oral CSF (6200 1/mg/kg/d, equaling a TEF of 0.041) rather than the WHO 2005 TEF of 0.1.

4.3. Mercury

The RfD applies to the pregnant mother as well as young children. EPA has not specified the minimum exposure duration at the RfD level of exposure that is appropriate to use in characterizing risk; we assume 10 years for women of childbearing age and 1 year for infants. We note that human exposures to MeHg are primarily through the consumption of fish and shellfish (EPA 2001b). EPA found that, on average, approximately 76 percent of the exposure to MeHg for women of childbearing age could be attributed to ingestion of mercury in freshwater and estuarine fish and shellfish, with the remaining 24 percent derived from marine fish and shellfish. Other sources accounted for less than 0.06 percent of total exposures (EPA 2001b).

4.4. Polycyclic Organic Matter

Dose-response values for some of the POM species that are included in the screening assessment were not identified by OAQPS; for these POM species, an alternative methodology for identifying CSFs was needed. Previously, for risk assessment of inhalation exposures to polycyclic organic matter (POM) for EPA's National-Scale Air Toxics Assessments (NATA) and for RTR, OAQPS developed an approach for characterizing risks associated with the individual POM species and POM groups reported in the National Emissions Inventory (NEI). Individual POMs were assigned to one of eight POM groups according to cancer potencies derived by EPA for IRIS and by CalEPA, and based on assumptions regarding relative carcinogenicity. OAQPS then estimated an inhalation CSF for each POM group. The same approach was used to derive oral CSFs for POMs without available CSFs. Each POM group (with all its member

POM species reported in NEI, not just the species currently evaluated in this assessment) and the corresponding CSFs using this methodology are presented in Exhibit B-8. These group CSFs are used only when OAQPS has not, for the purposes of RTR, identified a CSF specific to the individual chemical.

Exhibit B-8. Oral Dose-response Values for Polycyclic Organic Matter (POM) Groups[a]

Individual POM or POM Group	CAS No.	Cancer Slope Factor[b] (mg/kg-day)$^{-1}$
POM Group 71002		
Benz(a)anthracene/chrysene (7-PAH)	103	0.5
Total PAH	234	
Polycyclic organic matter	246	
16-PAH	40	
16-PAH–7-PAH	75040	
POM Group 72002		
Anthracene	120127	0.5
Pyrene	129000	
Benzo(g,h,i) perylene	191242	
Benzo(e)pyrene	192972	
Benzo(c)phenanthrene	195197	
Perylene	198550	
Benzo(g,h,i)fluoranthene	203123	
Benzo(a)fluoranthene	203338	
Fluoranthene	206440	
Acenaphthylene	208968	
1-Methylpyrene	2381217	
12-Methylbenz(a)anthracene	2422794	
Methylbenzopyrenes	247	
Methylchrysene	248	
Methylanthracene	26914181	
Benzofluoranthenes	56832736	
9-Methylbenz(a)anthracene	779022	
1-Methylphenanthrene	832699	
Acenaphthene	83329	
Phenanthrene	85018	
Fluorene	86737	
2-Methylnaphthalene	91576	
2-Chloronaphthalene	91587	
POM Group 73002		
7,12-Dimethylbenz(a)anthracene	57976	1000
POM Group 74002		
Dibenzo(a,i)pyrene	189559	100
Dibenzo(a,h)pyrene	189640	

Exhibit B-8. Oral Dose-response Values for Polycyclic Organic Matter (POM) Groups[a]

Individual POM or POM Group	CAS No.	Cancer Slope Factor[b] (mg/kg-day)$^{-1}$
POM Group 75002		
3-Methylcholanthrene	56495	10
Dibenzo(a,e)pyrene	192654	
5-Methylchrysene	3697243	
Benzo(a)pyrene	**50328**	
Dibenzo(a,h)anthracene	53703	
POM Group 76002		
Benzo(b+k)fluoranthene	102	1
Indeno(1,2,3-c,d)pyrene	193395	
Benzo(j)fluoranthene	205823	
Benzo(b)fluoranthene	205992	
Benzo(k)fluoranthene	207089	
Dibenzo(a,j)acridine	224420	
Benz(a)anthracene	56553	
POM Group 77002		
Chrysene	218019	0.1
POM Group 78002		
7-PAH	75	0.5

[a] These group CSFs are used only when OAQPS has not, for the purposes of RTR, identified a CSF specific to the individual chemical.

[b] The method to assign oral cancer slope factors to POM groups was the same as that used in the 1999 National Air Toxics Assessment (EPA 1999). A complete description of the methodology is available at: http://archive.epa.gov/nata2002/web/pdf/pom_approach.pdf.

5. Risk Estimation

For persistent and bioaccumulative hazardous air pollutants (PB-HAPs), risks from inhalation of a chemical directly from air generally will be negligible compared with risks from ingestion of the chemical from foodstuffs grown in an area subject to air deposition of the chemical. Risk characterization for carcinogens with a linear mode of action at low doses is described in Section 5.1 of this attachment. Risk characterization for chemicals likely to exhibit a threshold for response (e.g., non-cancer hazards) is described in Section 5.2.

5.1. Cancer Risks

The estimated risk of developing cancer from exposure to a chemical from a specified source is characterized as the excess lifetime cancer risk (ELCR). The ELCR represents the incremental probability of an individual developing cancer over a lifetime as a result of lifetime exposure to the chemical. For a known or suspected carcinogen with a low-dose linear mode of action, the estimated ELCR is calculated as the product of the lifetime average daily dose (LADD) and the cancer slope factor (CSF):

Equation B-46. Calculation of Excess Lifetime Cancer Risk

$$ELCR = LADD \times CSF$$

where:

$ELCR$ = Estimated excess lifetime cancer risk from a chemical summed across all exposure pathways and media (unitless)

$LADD$ = Lifetime average total daily dose from all exposure pathways and media (mg/kg-day)

CSF = Oral carcinogenic potency slope factor for chemical (per mg/kg-day)

As described in Section 3.3 of this attachment, the *LADD* (in mg/kg-day) for a chemical is calculated to reflect age-related differences in exposure rates that are experienced by a hypothetical individual throughout his or her lifetime of exposure. The total chemical intake is normalized to a lifetime, which for the purposes of this assessment is assumed to be 70 years.

EPA considers the possibility that children might be more sensitive than adults to toxic chemicals, including chemical carcinogens (EPA 2005b,c). Where data allow, EPA recommends development of lifestage-specific cancer potency CSFs. To date, EPA has developed a separate slope factor for early lifestage exposure for only one chemical (i.e., 1,1,1-trichloroethane; EPA 2007b), and current data availability for most chemicals preclude this approach. EPA has, therefore, examined options for default adjustments of the CSF to protect children. To date, the only mode of action (MOA) for carcinogenesis for which EPA has adequate data to develop a reasonable quantitative default approach is mutagenesis (EPA 2005b,c). For carcinogens with a mutagenic MOA for cancer, EPA concluded that the carcinogenic potency of a chemical may be approximately tenfold greater for the first 2 years of life (i.e., birth up to second birthday) and threefold greater for the next 14 years of life (i.e., ages 2 through 15) than for adults (EPA 2005c). These conclusions are represented by age-dependent adjustment factors (ADAFs) of 10, 3, and 1 for the first two lifestages and for adults, respectively.

These three lifestages do not match the age categories for the home-grown food ingestion rates, the age categories in MIRC. As a consequence, ADAFs for the age groups in MIRC are adapted as time-weighted average values as follows:

$$ADAF_{(<1)} = 10$$

$$ADAF_{(1\text{-}2)} = \frac{(10 \times 1\,\text{yr}) + (3 \times 1\,\text{yr})}{2} = 6.5$$

$$ADAF_{(3\text{-}5)} = 3$$

$$ADAF_{(6\text{-}11)} = 3$$

$$ADAF_{(12\text{-}19)} = \frac{(3 \times 4\ \text{yrs}) + (1 \times 4\ \text{yrs})}{8} = 2$$

$$ADAF_{(adult)} = 1$$

To estimate total lifetime risk from a lifetime of exposure to such a chemical, EPA recommends estimating the cancer risk for each of the three lifestages separately and then adding the risks for *i* = 1 to 6 age groups.

Equations B-47 to B-53. Lifetime Cancer Risk: Chemicals with a Mutagenic MOA for Cancer

Equation B-47. $Risk_{(<1)} = ADD_{(0–<1)} \times 10 \times CSF \times (1\ yr/70\ yr)$

Equation B-48. $Risk_{(1–2)} = ADD_{(1–2)} \times 6.5 \times CSF \times (2\ yr/70\ yr)$

Equation B-49. $Risk_{(3–5)} = ADD_{(3–5)} \times 3 \times CSF \times (3\ yr/70\ yr)$

Equation B-50. $Risk_{(6–11)} = ADD_{(6–11)} \times 3 \times CSF \times (6\ yr/70\ yr)$

Equation B-51. $Risk_{(12–19)} = ADD_{(12–19)} \times 2 \times CSF \times (8\ yr/70\ yr)$

Equation B-52. $Risk_{(adult)} = ADD_{(adult)} \times 1 \times CSF \times (50\ yr/70\ yr)$

Equation B-53. $\mathbf{ELCR} = \sum_{i=1}^{n} Risk_{(i)}$

In other words, Equation B-53 indicates that the total excess lifetime cancer risk (ELCR) equals the sum of the age-group-specific risks estimated by Equation B-47 through Equation B-52, where:

$Risk_{(<1)}$ = Risk from chemical ingestion in first year of life
$Risk_{(1-2)}$ = Risk from chemical ingestion from first birthday through age 2 years
$Risk_{(3-5)}$ = Risk from chemical ingestion from age 3 through 5 years of age
$Risk_{(6-11)}$ = Risk from chemical ingestion from age 6 through 11 years of age
$Risk_{(12-19)}$ = Risk from chemical ingestion from age 12 through 19 years of age
$Risk_{(adult)}$ = Risk from chemical ingestion from age 20 to 70 years age
$ADD_{(<1)}$ = Average daily dose for infants under one year of age (mg/kg-day)
$ADD_{(1-2)}$ = Average daily dose from first birthday through age 2 years of age (mg/kg-day)
$ADD_{(3-5)}$ = Average daily dose from age 3 through 5 years of age (mg/kg-day)
$ADD_{(6-11)}$ = Average daily dose from age 6 through 11 years of age (mg/kg-day)
$ADD_{(12-19)}$ = Average daily dose from age 12 through 19 years of age (mg/kg-day)
$ADD_{(adult)}$ = Average daily dose for adults age 20 to 70 years of age (mg/kg-day)
CSF = Oral carcinogenic potency slope factor for chemical (per mg/kg-day)
$Risk_{(i)}$ = Risk from chemical ingestion for the i^{th} age group
$ELCR$ = Total extra lifetime cancer risk (incremental or extra risk)
n = Number of age groups (i.e., 6)

5.2. Non-cancer Hazard Quotients

Non-cancer risks are presented as hazard quotients (HQs), that is, the ratio of the estimated daily intake (i.e., ADD) to the reference dose (e.g., chronic RfD). If the HQ for a chemical is equal to or less than 1, EPA believes that there is no appreciable risk that non-cancer health effects will occur. If the HQ is greater than 1 then there is at least some possibility for an adverse health effect. The larger the HQ value, the more likely it is that an adverse health effect may occur.

5.2.1. Hazard Quotients for Chemicals with a Chronic RfD

For chemicals with a chronic RfD, MIRC calculates an HQ for each age group separately using Equation B-54 to indicate the potential for adverse health effects associated with chronic exposure via ingestion pathways. The HQ is the ratio of a long-term, daily average exposure normalized to the receptor's body weight (i.e., ADD) to the RfD for that chemical. HQs are threshold effects and are not additive across age groups.

Equation B-54. Hazard Quotient for Chemicals with a Chronic RfD

$$HQ = \frac{ADD}{RfD}$$

where:

HQ = Hazard quotient for chemical (unitless)

ADD = Average daily ingested dose of chemical (mg/kg-day) from all food types and ingested media for the age group

RfD = Chronic oral reference dose for chemical (mg/kg-day)

5.2.2. Hazard Quotients for Chemicals with RfD Based on Developmental Effects

For chemicals for which the toxicity reference value is an RfD based on developmental effects, a shorter exposure duration (ED) and averaging time (AT) may be required. For this type of chemical (e.g., methylmercury, 2,3,7,8-TCDD), the appropriate ED/AT and sensitive lifestage for exposure may need to be estimated from the information provided in the critical developmental study(ies) from which the RfD was derived (e.g., in consultation with the RfD documentation in EPA’s IRIS or in a toxicological profile developed for the chemical). For screening-level risk assessments, however, a health protective approach is to compare the highest ADD from among the child age categories provided in MIRC to the RfD, as is done for all PB-HAPs. This approach ensures that the highest exposure from among the various age groups evaluated is taken into consideration, regardless of which age group might be most relevant to the health effect of interest (i.e., the age group on which the RfD is based).

5.2.3. Hazard Index for Chemicals with RfDs

When conducting screening-level assessments for multiple chemicals, it can be informative to calculate a hazard index (HI) for toxicologically similar chemicals (EPA 2000). The HI is the sum of HQs across chemicals (not age groups) as shown in Equation B-55. As with the HQ, if the HI value is less than 1, adverse health effects are not expected for that suite of chemicals. If the screening level HI exceeds 1, however, the risk assessor may in some instances, evaluate the assumptions of the screening-level assessment to determine if more realistic local values are available for parameters that drive risk. In addition, the risk assessor may need to examine the mode of action (MOA) and target organ(s) for the chemicals with the highest HQs to develop an appropriate approach to assessing their potential joint action.

Equation B-55. Hazard Index Calculation

$$HI = HQ_1 + HQ_2 \ldots \; HQ_n$$

where:

HI = Hazard index (unitless)
HQ_1 = Hazard Quotient for chemical 1 (unitless)
HQ_2 = Hazard Quotient for chemical 2 (unitless)
HQ_n = Hazard Quotient for chemical n (unitless)

The HI approach can be appropriate for chemicals with the same MOA and same target organ; however, MOA often is difficult to determine. An HI usually is “developed for each exposure route of interest, and for a single toxic effect or for toxicity to a single target organ” (EPA 2000; p 79). If a receptor is exposed to multiple chemicals that affect different target organs or that operate by different MOAs, and if more than one HQ is close to 1, the risk assessor in some circumstances, may consider whether chemical interactions play a role in chemical toxicity (EPA 2000). Exposures to more than one chemical can result in a greater or lesser toxic response than might be predicted on the basis of one or the other chemical acting alone (toxicologically independent) or acting in concert (toxicologically similar chemicals). Users are referred to EPA’s *Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures* for approaches to assessing the potential for adverse health effects from exposure to multiple chemicals (EPA 2000).

Note that users of MIRC are responsible for determining how to interpret HQs for multiple chemicals.

6. Model Input Options

This section describes the input options currently included in MIRC. Required user inputs for environmental media concentrations and air deposition rates, such as those predicted by (output of) TRIM.FaTE, are described in Section 6.1 of this attachment. Values for farm-food-chain (FFC) parameters for specific types of produce and animal products are discussed in Section 6.2. Options for parameterizing receptor characteristics are described in Section 6.3, including age-group-specific values for body weight, water ingestion, and food ingestion by food type. Options for other exposure parameter values in MIRC, such as exposure frequency and loss of chemical during food preparation and cooking, are provided in Section 6.4.

Where values for chemical-specific parameters are presented, values are presented only for PB-HAP chemicals currently evaluated using the TRIM-based RTR screening scenario. The database included with MIRC contains chemical-specific parameter values for a large number of chemicals (more than 500), because all of the chemical-specific input data compiled by EPA for use in HHRAP were uploaded into MIRC. However, only chemicals that are PB-HAPs evaluated for RTR are discussed in this document (see Sections 1.1.1 and 2.2.2), and the HHRAP inputs provided for other chemicals have not been reviewed or verified. The data presented in this chapter were reviewed and used to develop the set of modeling defaults used to calculate screening threshold emission rates for RTR. Note that the default values used to estimate RTR screening thresholds, and the justification for selecting a specific value from the data sets described in this chapter, are discussed in Chapter 7.

6.1. Environmental Concentrations

As noted in Section 2 of this attachment, MIRC is intended to estimate exposures and risks to self-sufficient farming and fishing families from ingestion of FFC media in an area of airborne chemical deposition. The tool analyzes one exposure scenario at a time (e.g., adult farmer exposed to dioxin from ingestion of beef); therefore, it is best used to evaluate a maximally exposed individual (MEI) or family when MIRC is used to screen for possible risks.

The following values specific to the air pollutant of concern are required inputs to MIRC:

- a single air concentration (in g/m^3);
- the fraction of chemical in the air that is in the vapor phase;
- air-to-surface deposition rates for both vapor- and particle-phase chemical in the air (in g/m^2-yr);
- two fish tissue concentrations, one each for forage and game fish (i.e., fish in TL 3 and TL 4) (in mg/kg wet weight);
- concentrations in drinking water (in g/L); and
- four chemical concentrations in soil (in µg/g dry weight), one each for:
  - surface soil in produce growing area,
  - surface soil where livestock feed,
  - root-zone soil in produce growing area, and
  - root-zone soil in livestock feed growing area.

The MIRC software is configured to estimate ingestion exposures via drinking water for a specified chemical concentration in the drinking water source (e.g., groundwater well). However, no exposure via drinking water is assumed to occur when calculating the Tier 1 screening thresholds. As discussed in Section 2.2.3, the drinking water exposure pathway is not modeled for the scenario developed for the Tier 1 assessment because the likelihood that humans would use a lake as a drinking water source is assumed to be low.

The user must provide the inputs listed above; no default values are included for these parameters in MIRC. Media concentrations output by TRIM.FaTE can be entered into the tool manually from model output files or can be imported directly from the TRIM.FaTE output files. For RTR evaluations, a tool to facilitate this process was developed using a Microsoft® Excel™ routine written in Visual Basic.

6.2. Farm-Food-Chain Parameter Values

Using the chemical information specified in Section 6.1 above as inputs, MIRC calculates chemical concentrations in foods that are commonly grown or raised on family farms: exposed and protected fruits; exposed and protected vegetables; root vegetables; beef; total dairy products; pork; and poultry and eggs.

6.2.1. List of Farm-Food-Chain (FFC) Parameters

MIRC estimates chemical concentrations in the produce identified above using algorithms from HHRAP (EPA 2005a) as described in Section 3.2 of this attachment. Parameter values required for these HHRAP algorithms, including chemical-specific media transfer factors (e.g., soil-to-plant transfer coefficients) and plant- and animal-specific properties (e.g., plant interception fraction, quantity of forage consumed by cattle), are included in tables in MIRC. As described in Section 7 of this attachment, the HHRAP-recommended parameter values are the default values in MIRC; however, these and other inputs in MIRC can be revised as needed. Exhibit B-9 describes the parameters that are included in the algorithms used to estimate chemical concentrations in the farm food categories. The parameter names and symbols are referenced in this section for plants/produce and animal products.

Exhibit B-9. MIRC Parameters Used to Estimate Chemical Concentrations in Farm Foods

Parameter	Description	Units
Plants/Produce		
$Br_{AG\text{-}produce\text{-}DW(i)}$	Chemical-specific plant/soil chemical bioconcentration factor for edible portion of aboveground produce type i, exposed or protected	Unitless (g soil DW / g produce DW)
$Bv_{AG(i)}$	Chemical-specific air-to-plant biotransfer factor for aboveground produce type i for vapor-phase chemical in air	Unitless ([mg chemical / g DW plant] / [mg chemical / g air])
Fw	Fraction of wet deposition that adheres to plant surfaces; 0.2 for anions, 0.6 for cations and most organics	Unitless
Kds	Chemical-specific soil/water partition coefficient	L soil pore water / kg soil DW
$kp_{(i)}$	Plant-specific surface loss coefficient for aboveground exposed produce and animal forage and silage	yr^{-1}
$MAF_{(i)}$	Moisture adjustment factor for aboveground produce type *i* to convert the chemical concentration estimated for dry-weight produce to the corresponding chemical concentration for full-weight fresh produce	Percent water
RCF	Chemical-specific root concentration factor for tubers and root produce on a wet-weight (WW) basis	L soil pore water/ kg root WW
$Rp_{(i)}$	Plant-specific interception fraction for the edible portion of aboveground exposed produce or animal forage and silage	Unitless
$Tp_{(i)}$	Length of plant exposure to deposition per harvest of the edible portion of aboveground exposed produce or animal forage and silage	Year
$VG_{AG(i)}$	Empirical correction factor for aboveground exposed produce type i to address possible overestimate of the diffusive transfer of chemical from the outside to the inside of bulky produce, such as fruit	Unitless
$VG_{rootveg}$	Empirical correction factor for belowground produce (i.e., tuber or root vegetable) to account for possible overestimate of the diffusive transfer of chemicals from the outside to the inside of bulky tubers or roots (based on carrots and potatoes)	Unitless
$Yp_{(i)}$	Plant-specific yield or standing crop biomass of the edible portion of produce or animal feed	kg produce DW/m^2
Animal Products		
Bs	Soil bioavailability factor for livestock	Unitless
MF	Chemical-specific mammalian metabolism factor that accounts for endogenous degradation of the chemical	Unitless

Exhibit B-9. MIRC Parameters Used to Estimate Chemical Concentrations in Farm Foods

Parameter	Description	Units
$Ba_{(beef)}$	Chemical-specific biotransfer factor for chemical in diet of cow to chemical in beef on a fresh-wet (FW; equivalent to WW) basis	mg chemical/kg FW tissue/mg chemical/day or day/kg FW tissue
$Ba_{(dairy)}$	Biotransfer factor in dairy	day/kg FW tissue
$Ba_{(pork)}$	Biotransfer factor in pork	day/kg FW tissue
$Ba_{(poultry)}$	Biotransfer factor in poultry	day/kg FW tissue
$Ba_{(eggs)}$	Biotransfer factor in eggs	day/kg FW tissue
$Qs_{(m)}$	Quantity of soil eaten by animal type m each day	kg/day
$Qp_{(i,m)}$	Quantity of plant feed type i consumed per animal type m each day	kg/day

Source: EPA Source: EPA 2005a
DW = dry weight; FW = fresh weight; WW = wet weight

6.2.2. Produce Parameter Values

Exhibit B-10 and Exhibit B-11 provide the chemical-specific input values that are the current defaults for produce FFC food types in MIRC. Exhibit B-12 presents additional non-chemical-specific input values for parameters used in the algorithms that calculate chemical concentrations in produce. Unless otherwise noted, the default parameter values were obtained from HHRAP. Options for other parameter values are not included in MIRC at this time; however, the user can overwrite values if appropriate. Refer to HHRAP (EPA 2005a, Chapter 5 and associated appendices) for detailed descriptions of these parameters and documentation of input values.

Exhibit B-10. Chemical-Specific Inputs for Produce Parameters for Chemicals Included in MIRC

Chemical	Fraction of Wet Deposition (*Fw*) (unitless)[a]	Root Concentration Factor (*RCF*) (belowground) (L/kg)[b]	Soil-Water Partition Coefficient (*Kds*) (L/kg)[c]	Chemical Air-to-Plant Biotransfer Factor ($Bv_{AG(i)}$) (unitless)[d]
Inorganics				
Cadmium compounds	0.6	NA	7.5E+01	NA[e]
Mercury (elemental)	0.6	NA	1.0E+03	0[f]
Mercuric chloride	0.6	NA	5.8E+04	1.8E+03
Methyl mercury	0.6	NA	7.0E+03	0[f]
PAHs				
2-Methylnaphthalene	0.6	2.2E+02	5.0E+01	1.4E+00
7,12-Dimethylbenz(a)anthracene	0.6	6.8E+03	4.0E+03	4.2E+04
Acenaphthene	0.6	2.4E+02	3.9E+01	4.6E+00
Acenaphthylene	0.6	2.8E+02	6.8E+01	8.1E+00
Benz(a)anthracene	0.6	6.7E+03	2.9E+03	6.8E+03
Benzo(a)pyrene	0.6	9.2E+03	7.8E+03	1.7E+05

Exhibit B-10. Chemical-Specific Inputs for Produce Parameters for Chemicals Included in MIRC

Chemical	Fraction of Wet Deposition (*Fw*) (unitless)[a]	Root Concentration Factor (*RCF*) (belowground) (L/kg)[b]	Soil-Water Partition Coefficient (*Kds*) (L/kg)[c]	Chemical Air-to-Plant Biotransfer Factor ($Bv_{AG(i)}$) (unitless)[d]
Benzo(b)fluoranthene	0.6	6.6E+03	3.8E+03	1.7E+05
Benzo(g,h,i)perylene	0.6	3.0E+04	2.6E+04	2.3E+06
Benzo(k)fluoranthene	0.6	8.7E+03	5.5E+03	2.8E+05
Chrysene	0.6	6.0E+03	3.4E+03	1.4E+04
Dibenz(a,h)anthracene	0.6	2.3E+04	1.4E+04	6.2E+06
Fluoranthene	0.6	2.2E+03	3.9E+02	9.0E+02
Fluorene	0.6	3.8E+02	6.2E+01	1.6E+01
Indeno(1,2,3-cd)pyrene	0.6	3.5E+04	3.2E+04	2.8E+06
Dioxins				
OctaCDD, 1,2,3,4,6,7,8,9-	0.6	4.8E+05	7.8E+05	2.4E+06
OctaCDF, 1,2,3,4,6,7,8,9-	0.6	3.4E+05	4.9E+05	2.3E+06
HeptaCDD, 1,2,3,4,6,7,8-	0.6	3.4E+05	4.9E+05	9.1E+05
HeptaCDF, 1,2,3,4,6,7,8-	0.6	1.2E+05	1.2E+05	8.3E+05
HeptaCDF, 1,2,3,4,7,8,9-	0.6	4.8E+04	3.9E+04	8.3E+05
HexaCDD, 1,2,3,4,7,8-	0.6	2.4E+05	3.1E+05	5.2E+05
HexaCDF, 1,2,3,4,7,8-	0.6	5.7E+04	4.9E+04	1.6E+05
HexaCDD, 1,2,3,6,7,8-	0.6	4.9E+05	8.0E+05	5.2E+05
HexaCDF, 1,2,3,6,7,8-	0.6	2.9E+05	4.1E+05	1.6E+05
HexaCDD, 1,2,3,7,8,9 -	0.6	4.9E+05	8.0E+05	5.2E+05
HexaCDF, 1,2,3,7,8,9-	0.6	1.6E+05	1.9E+05	1.6E+05
HexaCDF, 2,3,4,6,7,8-	0.6	2.9E+05	4.1E+05	1.6E+05
PentaCDD, 1,2,3,7,8-	0.6	9.2E+04	9.2E+04	2.4E+05
PentaCDF, 1,2,3,7,8-	0.6	3.9E+04	3.0E+04	9.8E+04
PentaCDF, 2,3,4,7,8-	0.6	2.3E+04	1.6E+04	9.8E+04

Exhibit B-10. Chemical-Specific Inputs for Produce Parameters for Chemicals Included in MIRC

Chemical	Fraction of Wet Deposition (*Fw*) (unitless)[a]	Root Concentration Factor (*RCF*) (belowground) (L/kg)[b]	Soil-Water Partition Coefficient (*Kds*) (L/kg)[c]	Chemical Air-to-Plant Biotransfer Factor ($Bv_{AG(i)}$) (unitless)[d]
TetraCDD, 2,3,7,8-	0.6	4.0E+04	3.1E+04	6.6E+04
TetraCDF, 2,3,7,8-	0.6	1.2E+04	6.2E+03	4.6E+04

Source: EPA 2005a. NA = not applicable.

[a] 6E-01 is the value for cations and most organic chemicals. As described in HHRAP (EPA 2005a), Appendix B (available at http://www3.epa.gov/epawaste/hazard/tsd/td/combust/risk.htm), EPA estimated this value (EPA 1994a, 1995a) from a study by Hoffman et al. (1992) in which soluble gamma-emitting radionuclides and insoluble particles tagged with gamma-emitting radionuclides were deposited onto pasture grass via simulated rain. Note that the values developed experimentally for pasture grass may not accurately represent all aboveground produce-specific values. Also note that values based on the behavior of insoluble particles tagged with radionuclides may not accurately represent the behavior of organic compounds under site-specific conditions.

[b] For nonionic organic chemicals, as described in HHRAP (EPA 2005a), Appendix A (available at http://www3.epa.gov/epawaste/hazard/tsd/td/combust/risk.htm), RCF is used to calculate the below-ground transfer of contaminants from soil to a root vegetable on a wet-weight basis as shown in Equation B-6. EPA estimated chemical-specific values for RCF from empirical regression equations developed by Briggs et al. (1982) based on their experiments measuring uptake of compounds into barley roots from growth solution. Briggs' regression equations allow calculation of RCF values from log Kow. For metals and mercuric compounds, empirical values for soil to root vegetable transfer on a dry-weight basis are available in the literature, thus the RCF was not needed.

[c] As discussed in HHRAP (EPA 2005a), Appendix A, Kds describes the partitioning of a compound between soil pore-water and soil particles and strongly influences the release and movement of a compound into the subsurface soils and underlying aquifer. Kds values for mercuric compounds were obtained from EPA (1997b). Kds for cadmium compounds were obtained from EPA 1996. For all PAHs and dioxins, Kds was calculated by multiplying Koc times the screening scenario's fraction organic carbon content (0.008). Empirical information for Koc was available for acenaphthene, benz(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, fluoranthene, and fluorene in USEAP 1996. For all other organic compounds, the Koc was calculated using the correlation equations presented in USEAP 2005a.

[d] As discussed in HHRAP (EPA 2005a), Appendix A, the value for mercuric chloride was obtained from EPA 1997b. BvAG(i) values for PAHs were calculated using the correlation equation derived for azalea leaves as cited in Bacci et al. (1992), then reducing this value by a factor of 100, as suggested by Lorber (1995), who concluded that the Bacci factor reduced by a factor of 100 was similar to his own observations in various studies. The values for dioxins were obtained from Lorber and Pinsky (2000).

[e] It is assumed that metals, with the exception of vapor-phase elemental mercury, do not transfer significantly from air into leaves.

[f] Speciation and fate and transport of mercury from emissions suggest that BvAG(i) values for elemental and methyl mercury are likely to be zero (EPA 2005a).

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
Inorganics				
Cadmium compounds	Exp. Fruit	1.3E-01	-	1.0E+00
	Exp. Veg.	1.3E-01	-	1.0E+00
	Forage	3.6E-01	-	1.0E+00
	Grain	6.2E-02	-	-
	Prot. Fruit	1.3E-01	-	-
	Prot. Veg.	1.3E-01	-	-
	Root	6.4E-02	1.0E+00	-
	Silage	3.6E-01	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
Mercury (elemental)	Exp. Fruit	-	-	1.0E+00
	Exp. Veg.	-	-	1.0E+00
	Forage	-	-	1.0E+00
	Grain	-	-	-
	Prot. Fruit	-	-	-
	Prot. Veg.	-	-	-
	Root	-	1.0E+00	-
	Silage	-	-	5.0E-01
Mercuric chloride	Exp. Fruit	1.5E-02	-	1.0E+00
	Exp. Veg.	1.5E-02	-	1.0E+00
	Forage	0.0E+00	-	1.0E+00
	Grain	9.3E-03	-	-
	Prot. Fruit	1.5E-02	-	-
	Prot. Veg.	1.5E-02	-	-
	Root	3.6E-02	1.0E+00	-
	Silage	0.0E+00	-	5.0E-01
Methyl mercury	Exp. Fruit	2.9E-02	-	1.0E-02
	Exp. Veg.	2.9E-02	-	1.0E-02
	Forage	0.0E+00	-	1.0E+00
	Grain	1.9E-02	-	-
	Prot. Fruit	2.9E-02	-	-
	Prot. Veg.	2.9E-02	-	-
	Root	9.9E-02	1.0E-02	-
	Silage	0.0E+00	-	5.0E-01
PAHs				
2-Methylnaphthalene	Exp. Fruit	2.3E-01	-	1.0E+00
	Exp. Veg.	2.3E-01	-	1.0E+00
	Forage	2.3E-01	-	1.0E+00
	Grain	2.3E-01	-	-
	Prot. Fruit	2.3E-01	-	-
	Prot. Veg.	2.3E-01	-	-
	Root	4.4E+00	1.0E+00	-
	Silage	2.3E-01	-	5.0E-01
7,12-Dimethylbenz(a)anthracene	Exp. Fruit	1.7E-02	-	1.0E-02
	Exp. Veg.	1.7E-02	-	1.0E-02
	Forage	1.7E-02	-	1.0E+00
	Grain	1.7E-02	-	-
	Prot. Fruit	1.7E-02	-	-
	Prot. Veg.	1.7E-02	-	-
	Root	1.7E+00	1.0E-02	-
	Silage	1.7E-02	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
Acenaphthene	Exp. Fruit	2.1E-01	-	1.0E+00
	Exp. Veg.	2.1E-01	-	1.0E+00
	Forage	2.1E-01	-	1.0E+00
	Grain	2.1E-01	-	-
	Prot. Fruit	2.1E-01	-	-
	Prot. Veg.	2.1E-01	-	-
	Root	6.2E+00	1.0E+00	-
	Silage	2.1E-01	-	5.0E-01
Acenaphthylene	Exp. Fruit	1.9E-01	-	1.0E-02
	Exp. Veg.	1.9E-01	-	1.0E-02
	Forage	1.9E-01	-	1.0E+00
	Grain	1.9E-01	-	-
	Prot. Fruit	1.9E-01	-	-
	Prot. Veg.	1.9E-01	-	-
	Root	4.1E+00	1.0E-02	-
	Silage	1.9E-01	-	5.0E-01
Benz(a)anthracene	Exp. Fruit	1.7E-02	-	1.0E-02
	Exp. Veg.	1.7E-02	-	1.0E-02
	Forage	1.7E-02	-	1.0E+00
	Grain	1.7E-02	-	-
	Prot. Fruit	1.7E-02	-	-
	Prot. Veg.	1.7E-02	-	-
	Root	2.3E+00	1.0E-02	-
	Silage	1.7E-02	-	5.0E-01
Benzo(a)pyrene	Exp. Fruit	1.4E-02	-	1.0E-02
	Exp. Veg.	1.4E-02	-	1.0E-02
	Forage	1.4E-02	-	1.0E+00
	Grain	1.4E-02	-	-
	Prot. Fruit	1.4E-02	-	-
	Prot. Veg.	1.4E-02	-	-
	Root	1.2E+00	1.0E-02	-
	Silage	1.4E-02	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
Benzo(b)fluoranthene	Exp. Fruit	1.8E-02	-	1.0E-02
	Exp. Veg.	1.8E-02	-	1.0E-02
	Forage	1.8E-02	-	1.0E+00
	Grain	1.8E-02	-	-
	Prot. Fruit	1.8E-02	-	-
	Prot. Veg.	1.8E-02	-	-
	Root	1.7E+00	1.0E-02	-
	Silage	1.8E-02	-	5.0E-01
Benzo(g,h,i)perylene	Exp. Fruit	5.7E-03	-	1.0E-02
	Exp. Veg.	5.7E-03	-	1.0E-02
	Forage	5.7E-03	-	1.0E+00
	Grain	5.7E-03	-	-
	Prot. Fruit	5.7E-03	-	-
	Prot. Veg.	5.7E-03	-	-
	Root	1.1E+00	1.0E-02	-
	Silage	5.7E-03	-	5.0E-01
Benzo(k)fluoranthene	Exp. Fruit	1.4E-02	-	1.0E-02
	Exp. Veg.	1.4E-02	-	1.0E-02
	Forage	1.4E-02	-	1.0E+00
	Grain	1.4E-02	-	-
	Prot. Fruit	1.4E-02	-	-
	Prot. Veg.	1.4E-02	-	-
	Root	1.6E+00	1.0E-02	-
	Silage	1.4E-02	-	5.0E-01
Chrysene	Exp. Fruit	1.9E-02	-	1.0E-02
	Exp. Veg.	1.9E-02	-	1.0E-02
	Forage	1.9E-02	-	1.0E+00
	Grain	1.9E-02	-	-
	Prot. Fruit	1.9E-02	-	-
	Prot. Veg.	1.9E-02	-	-
	Root	1.7E+00	1.0E-02	-
	Silage	1.9E-02	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
Dibenz(a,h)anthracene	Exp. Fruit	6.8E-03	-	1.0E-02
	Exp. Veg.	6.8E-03	-	1.0E-02
	Forage	6.8E-03	-	1.0E+00
	Grain	6.8E-03	-	-
	Prot. Fruit	6.8E-03	-	-
	Prot. Veg.	6.8E-03	-	-
	Root	1.6E+00	1.0E-02	-
	Silage	6.8E-03	-	5.0E-01
Fluoranthene	Exp. Fruit	4.0E-02	-	1.0E-02
	Exp. Veg.	4.0E-02	-	1.0E-02
	Forage	4.0E-02	-	1.0E+00
	Grain	4.0E-02	-	-
	Prot. Fruit	4.0E-02	-	-
	Prot. Veg.	4.0E-02	-	-
	Root	5.6E+00	1.0E-02	-
	Silage	4.0E-02	-	5.0E-01
Fluorene	Exp. Fruit	1.5E-01	-	1.0E-02
	Exp. Veg.	1.5E-01	-	1.0E-02
	Forage	1.5E-01	-	1.0E+00
	Grain	1.5E-01	-	-
	Prot. Fruit	1.5E-01	-	-
	Prot. Veg.	1.5E-01	-	-
	Root	6.2E+00	1.0E-02	-
	Silage	1.5E-01	-	5.0E-01
Indeno(1,2,3-cd)pyrene	Exp. Fruit	5.1E-03	-	1.0E-02
	Exp. Veg.	5.1E-03	-	1.0E-02
	Forage	5.1E-03	-	1.0E+00
	Grain	5.1E-03	-	-
	Prot. Fruit	5.1E-03	-	-
	Prot. Veg.	5.1E-03	-	-
	Root	1.1E+00	1.0E-02	-
	Silage	5.1E-03	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
Dioxins				
OctaCDD, 1,2,3,4,6,7,8,9-	Exp. Fruit	7.1E-04	-	1.0E-02
	Exp. Veg.	7.1E-04	-	1.0E-02
	Forage	7.1E-04	-	1.0E+00
	Grain	7.1E-04	-	-
	Prot. Fruit	7.1E-04	-	-
	Prot. Veg.	7.1E-04	-	-
	Root	6.1E-01	1.0E-02	-
	Silage	7.1E-04	-	5.0E-01
OctaCDF, 1,2,3,4,6,7,8,9-	Exp. Fruit	9.2E-04	-	1.0E-02
	Exp. Veg.	9.2E-04	-	1.0E-02
	Forage	9.2E-04	-	1.0E+00
	Grain	9.2E-04	-	-
	Prot. Fruit	9.2E-04	-	-
	Prot. Veg.	9.2E-04	-	-
	Root	6.8E-01	1.0E-02	-
	Silage	9.2E-04	-	5.0E-01
HeptaCDD, 1,2,3,4,6,7,8-	Exp. Fruit	9.2E-04	-	1.0E-02
	Exp. Veg.	9.2E-04	-	1.0E-02
	Forage	9.2E-04	-	1.0E+00
	Grain	9.2E-04	-	-
	Prot. Fruit	9.2E-04	-	-
	Prot. Veg.	9.2E-04	-	-
	Root	6.8E-01	1.0E-02	-
	Silage	9.2E-04	-	5.0E-01
HeptaCDF, 1,2,3,4,6,7,8-	Exp. Fruit	2.0E-03	-	1.0E-02
	Exp. Veg.	2.0E-03	-	1.0E-02
	Forage	2.0E-03	-	1.0E+00
	Grain	2.0E-03	-	-
	Prot. Fruit	2.0E-03	-	-
	Prot. Veg.	2.0E-03	-	-
	Root	9.4E-01	1.0E-02	-
	Silage	2.0E-03	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
HeptaCDF, 1,2,3,4,7,8,9-	Exp. Fruit	4.0E-03	-	1.0E-02
	Exp. Veg.	4.0E-03	-	1.0E-02
	Forage	4.0E-03	-	1.0E+00
	Grain	4.0E-03	-	-
	Prot. Fruit	4.0E-03	-	-
	Prot. Veg.	4.0E-03	-	-
	Root	1.2E+00	1.0E-02	-
	Silage	4.0E-03	-	5.0E-01
HexaCDD, 1,2,3,4,7,8-	Exp. Fruit	1.2E-03	-	1.0E-02
	Exp. Veg.	1.2E-03	-	1.0E-02
	Forage	1.2E-03	-	1.0E+00
	Grain	1.2E-03	-	-
	Prot. Fruit	1.2E-03	-	-
	Prot. Veg.	1.2E-03	-	-
	Root	7.6E-01	1.0E-02	-
	Silage	1.2E-03	-	5.0E-01
HexaCDF, 1,2,3,4,7,8-	Exp. Fruit	3.5E-03	-	1.0E-02
	Exp. Veg.	3.5E-03	-	1.0E-02
	Forage	3.5E-03	-	1.0E+00
	Grain	3.5E-03	-	-
	Prot. Fruit	3.5E-03	-	-
	Prot. Veg.	3.5E-03	-	-
	Root	1.2E+00	1.0E-02	-
	Silage	3.5E-03	-	5.0E-01
HexaCDD, 1,2,3,6,7,8-	Exp. Fruit	7.0E-04	-	1.0E-02
	Exp. Veg.	7.0E-04	-	1.0E-02
	Forage	7.0E-04	-	1.0E+00
	Grain	7.0E-04	-	-
	Prot. Fruit	7.0E-04	-	-
	Prot. Veg.	7.0E-04	-	-
	Root	6.1E-01	1.0E-02	-
	Silage	7.0E-04	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
HexaCDF, 1,2,3,6,7,8-	Exp. Fruit	1.0E-03	-	1.0E-02
	Exp. Veg.	1.0E-03	-	1.0E-02
	Forage	1.0E-03	-	1.0E+00
	Grain	1.0E-03	-	-
	Prot. Fruit	1.0E-03	-	-
	Prot. Veg.	1.0E-03	-	-
	Root	7.1E-01	1.0E-02	-
	Silage	1.0E-03	-	5.0E-01
HexaCDD, 1,2,3,7,8,9-	Exp. Fruit	7.0E-04	-	1.0E-02
	Exp. Veg.	7.0E-04	-	1.0E-02
	Forage	7.0E-04	-	1.0E+00
	Grain	7.0E-04	-	-
	Prot. Fruit	7.0E-04	-	-
	Prot. Veg.	7.0E-04	-	-
	Root	6.1E-01	1.0E-02	-
	Silage	7.0E-04	-	5.0E-01
HexaCDF, 1,2,3,7,8,9-	Exp. Fruit	1.6E-03	-	1.0E-02
	Exp. Veg.	1.6E-03	-	1.0E-02
	Forage	1.6E-03	-	1.0E+00
	Grain	1.6E-03	-	-
	Prot. Fruit	1.6E-03	-	-
	Prot. Veg.	1.6E-03	-	-
	Root	8.5E-01	1.0E-02	-
	Silage	1.6E-03	-	5.0E-01
HexaCDF, 2,3,4,6,7,8-	Exp. Fruit	1.0E-03	-	1.0E-02
	Exp. Veg.	1.0E-03	-	1.0E-02
	Forage	1.0E-03	-	1.0E+00
	Grain	1.0E-03	-	-
	Prot. Fruit	1.0E-03	-	-
	Prot. Veg.	1.0E-03	-	-
	Root	7.1E-01	1.0E-02	-
	Silage	1.0E-03	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
PentaCDD, 1,2,3,7,8-	Exp. Fruit	2.4E-03	-	1.0E-02
	Exp. Veg.	2.4E-03	-	1.0E-02
	Forage	2.4E-03	-	1.0E+00
	Grain	2.4E-03	-	-
	Prot. Fruit	2.4E-03	-	-
	Prot. Veg.	2.4E-03	-	-
	Root	1.0E+00	1.0E-02	-
	Silage	2.4E-03	-	5.0E-01
PentaCDF, 1,2,3,7,8-	Exp. Fruit	4.6E-03	-	1.0E-02
	Exp. Veg.	4.6E-03	-	1.0E-02
	Forage	4.6E-03	-	1.0E+00
	Grain	4.6E-03	-	-
	Prot. Fruit	4.6E-03	-	-
	Prot. Veg.	4.6E-03	-	-
	Root	1.3E+00	1.0E-02	-
	Silage	4.6E-03	-	5.0E-01
PentaCDF, 2,3,4,7,8-	Exp. Fruit	6.8E-03	-	1.0E-02
	Exp. Veg.	6.8E-03	-	1.0E-02
	Forage	6.8E-03	-	1.0E+00
	Grain	6.8E-03	-	-
	Prot. Fruit	6.8E-03	-	-
	Prot. Veg.	6.8E-03	-	-
	Root	1.5E+00	1.0E-02	-
	Silage	6.8E-03	-	5.0E-01
TetraCDD, 2,3,7,8-	Exp. Fruit	4.5E-03	-	1.0E-02
	Exp. Veg.	4.5E-03	-	1.0E-02
	Forage	4.5E-03	-	1.0E+00
	Grain	4.5E-03	-	-
	Prot. Fruit	4.5E-03	-	-
	Prot. Veg.	4.5E-03	-	-
	Root	1.3E+00	1.0E-02	-
	Silage	4.5E-03	-	5.0E-01

Exhibit B-11. Chemical-Specific Inputs by Plant Type for Chemicals in MIRC

Compound Name	Plant Part	Plant-Soil Bio-Concentration Factor ($Br_{AG\text{-}produce\text{-}DW(i)}$) (unitless)[a]	Empirical Correction Factor- Belowground Produce ($VG_{rootveg}$) (unitless)[b]	Empirical Correction Factor- Aboveground Produce ($VG_{AG(i)}$) (unitless)[c]
TetraCDF, 2,3,7,8-	Exp. Fruit	1.2E-02	-	1.0E-02
	Exp. Veg.	1.2E-02	-	1.0E-02
	Forage	1.2E-02	-	1.0E+00
	Grain	1.2E-02	-	-
	Prot. Fruit	1.2E-02	-	-
	Prot. Veg.	1.2E-02	-	-
	Root	1.9E+00	1.0E-02	-
	Silage	1.2E-02	-	5.0E-01

[a] As discussed in HHRAP (EPA 2005a), the $Br_{AG\text{-}produce\text{-}DW(i)}$ for aboveground produce and forage accounts for the uptake from soil and the subsequent transport of contaminants through the roots to the aboveground plant parts. For organics, correlation equations to calculate values for *Br* on a dry weight basis were obtained from Travis and Arms (1988). For cadmium, *Br* values were derived from uptake slope factors provided in EPA 1992. Uptake slope is the ratio of contaminant concentration in dry weight plant tissue to the mass of contaminant applied per hectare soil. *Br* aboveground values for mercuric chloride and methyl mercury were calculated using methodology and data from Baes, et al. (1984). *Br* forage values for mercuric chloride and methyl mercury (on a dry weight basis) were obtained from EPA 1997b. The HHRAP methodology assumes that elemental mercury doesn't deposit onto soils. Therefore, it's assumed that there is no plant uptake through the soil.

[b] As discussed in HHRAP (EPA 2005a), Appendix B, $VG_{rootveg}$ represents an empirical correction factor that reduces produce concentration. Because of the protective outer skin, size, and shape of bulky produce, transfer of lipophilic chemicals (i.e., log K_{ow} greater than 4) to the center of the produce is not likely. In addition, typical preparation techniques, such as washing, peeling, and cooking, further reduce the concentration of the chemical in the vegetable as consumed by removing the high concentration of chemical on and in the outer skin, leaving the flesh with a lower concentration than would be the case if the entire vegetable were pureed without washing. For belowground produce, HHRAP (EPA 2005a) recommends using a $VG_{rootveg}$ value of 0.01 for PB-HAP with a log K_{ow} greater than 4 and a value of 1.0 for PB-HAP with a log K_{ow} less than 4 based on information provided in EPA 1994b. In developing these values, EPA (1994b) assumed that the density of the skin and the whole vegetable are equal (potentially overestimating the concentration of PB-HAP in belowground produce due to root uptake).

[c] As discussed in HHRAP (EPA 2005a), Appendix B, VG_{ag} represents an empirical correction factor that reduces aboveground produce concentration and was developed to estimate the transfer of PB-HAP into leafy vegetation versus bulkier aboveground produce (e.g., apples). Because of the protective outer skin, size, and shape of bulky produce, transfer of lipophilic PB-HAP (log K_{ow} greater than 4) to the center of the produce is not likely. In addition, typical preparation techniques, such as washing, peeling, and cooking, further reduce residues. For aboveground produce, HHRAP (EPA 2005a) recommends using a VG_{ag} value of 0.01 for PB-HAP with a log K_{ow} greater than 4 and a value of 1.0 for PB-HAP with a log K_{ow} less than 4 based on information provided in EPA 1994b. In developing these values, EPA (1994b) assumed the following: (1) translocation of compounds deposited on the surface of aboveground vegetation to inner parts of aboveground produce would be insignificant (potentially underestimating the concentration of PB-HAP in aboveground produce due to air-to-plant transfer); (2) the density of the skin and the whole vegetable are equal (potentially overestimating the concentration of PB-HAP in aboveground produce due to air-to-plant transfer); and (3) the thickness of vegetable skin and broadleaf tree skin are equal (effects on the concentration of PB-HAP in aboveground produce due to air-to-plant transfer unknown).

For forage, HHRAP recommends a VG_{ag} value of 1.0, also based on information provided in EPA 1994b.

A VG_{ag} value for silage is not provided in EPA 1994b; the VGag value for silage of 0.5 was obtained from NC DEHNR (1997); however, NC DEHNR does not present a specific rationale for this recommendation. Depending on the composition of the site-specific silage, this value may under- or overestimate the actual value.

Exhibit B-12. Non-Chemical-Specific Produce Inputs

Plant Part	Interception Fraction ($Rp_{(i)}$) (unitless)[a]	Plant Surface Loss Coefficient ($kp_{(i)}$) (1/year)[b]	Length of Plant Exposure to Deposition ($Tp_{(i)}$) (year)[c]	Yield or Standing Crop Biomass ($Yp_{(i)}$) (kg/m^2)[d]	Plant Tissue-Specific Moisture Adjustment Factor ($MAF_{(i)}$) (percent)[e]
Exposed Vegetable	0.982	18	0.16	5.66	92
Protected Fruit	NA	NA	NA	NA	90
Protected Vegetable	NA	NA	NA	NA	80
Forage (animal feed)	0.5	18	0.12	0.24	92
Exposed Fruit	0.053	18	0.16	0.25	85
Root Vegetables	NA	NA	NA	NA	87
Silage (animal feed)	0.46	18	0.16	0.8	92
Grain (animal feed)	NA	NA	NA	NA	90

Source: EPA 2005a. NA = not applicable.

[a] Baes *et al*. (1984) used an empirical relationship developed by Chamberlain (1970) to identify a correlation between initial Rp values and pasture grass productivity (standing crop biomass [*Yp*]) to calculate *Rp* values for exposed vegetables, exposed fruits, forage, and silage. Two key uncertainties are associated with using these values for *Rp*: (1) Chamberlain's (1970) empirical relationship developed for pasture grass may not accurately represent aboveground produce. (2) The empirical constants developed by Baes *et al*. (1984) for use in the empirical relationship developed by Chamberlain (1970) may not accurately represent the site-specific mixes of aboveground produce consumed by humans or the site-specific mixes of forage or silage consumed by livestock.

[b] The term *kp* is a measure of the amount of chemical that is lost to natural physical processes (e.g., wind, water) over time. The HHRAP-recommended value of 18 yr^{-1} (also recommended by EPA 1994a and 1998) represents the midpoint of a range of values reported by Miller and Hoffman (1983). There are two key uncertainties associated with using these values for *kp*: (1) The recommended equation for calculating *kp* includes a health protective bias in that it does not consider chemical degradation processes. (2) Given the reported range of *kp* values from 7.44 to 90.36 yr^{-1}, plant concentrations could range from about 1.8 times higher to about 5 times lower than the plant concentrations estimated in FFC media using the midpoint *kp* value of 18.

[c] HHRAP (EPA 2005a) recommends using a *Tp* value of 0.16 years for aboveground produce and cattle silage. This is consistent with earlier reports by EPA (1994a, 1998) and NC DEHNR (1997), which recommended treating *Tp* as a constant based on the average period between successive hay harvests. Belcher and Travis (1989) estimated this period at 60 days. *Tp* is calculated as 60 days ÷ 365 days/year = 0.16 years. For forage, the average of the average period between successive hay harvests (60 days) and the average period between successive grazing (30 days) is used (that is, 45 days), and *Tp* is calculated as (60 days + 30 days)/ 2 ÷ 365 days/yr = 0.12 yr. Two key uncertainties are associated with use of these values for *Tp*: (1) The average period between successive hay harvests (60 days) may not reflect the length of the growing season or the length between successive harvests for site-specific aboveground produce crops. The concentration of chemical in aboveground produce due to direct (wet and dry) deposition (*Pd*) will be underestimated if the site-specific value of *Tp* is less than 60 days, or overestimated if the site-specific value of *Tp* is more than 60 days.

[d] *Yp* values for aboveground produce and forage were calculated using an equation presented in Baes *et al*. (1984) and Shor *et al*. (1982): $Yp = Y_{hi} / A_{hi}$, where Y_{hi} = Harvest yield of i^{th} crop (kg DW) and A_{hi} = Area planted to i^{th} crop (m2), and using values for Y_h and A_h from USDA (1994b and 1994c). A production-weighted U.S. average *Yp* of 0.8 kg DW/m2 for silage was obtained from Shor *et al*. 1982.

[e] *MAF* represents the plant tissue-specific moisture adjustment factor to convert dry-weight concentrations into wet-weight concentrations (which are lower owing to the dilution by water compared with dry-weight concentrations). Values obtained from Chapter 10 of EPA's 2003 SAB Review materials for 3MRA Modeling System, Volume II, “Farm Food Chain and Terrestrial Food Web Data” (EPA 2003a), which references EPA 1997c. Note that the value for grain used as animal feed is based on corn and soybeans, not seed grains such as barley, oats, or wheat.

6.2.3. Animal Product Parameter Values

MIRC also requires chemical-specific inputs for many of the animal product algorithms. The relevant values are shown in Exhibit B-13 for the chemicals included in MIRC to date. The HHRAP algorithms require additional inputs for the animal products calculations that are not specific to PB-HAPs, but are specific to the animal and animal product type. The soil and plant ingestion rates recommended in HHRAP for beef cattle, dairy cattle, swine, and chicken are provided in Exhibit B-14.

Exhibit B-13. Animal Product Chemical-specific Inputs for Chemicals Included in MIRC

Compound Name	Soil Bio-Availability Factor (*Bs*) (unitless)	Biotransfer Factors (Ba_m) (day/kg FW tissue)[a] and Metabolism Factors (MF) (unitless)[b]						
		Mammal				Non-mammal		
		Beef (Ba_{beef})	Dairy (Ba_{dairy})	Pork (Ba_{pork})	*MF*	Eggs (Ba_{eggs})	Poultry ($Ba_{poultry}$)	*MF*
Inorganics								
Cadmium compounds	1	1.2E-04	6.5E-06	1.9E-04	1	2.5E-03	1.1E-01	NA
Mercury (elemental)	1	0	0	0	1	0	0	NA
Mercuric chloride	1	1.1E-04	1.4E-06	3.4E-05	1	2.4E-02	2.4E-02	NA
Methyl mercury	1	1.2E-03	1.7E-05	5.1E-06	1	3.6E-03	3.6E-03	NA
PAHs								
2-Methylnaphthalene	1	2.4E-02	5.0E-03	2.9E-02	0.01	1.0E-02	1.7E-02	NA
7,12-Dimethylbenz(a)anthracene	1	3.9E-02	8.3E-03	4.8E-02	0.01	1.7E-02	2.9E-02	NA
Acenaphthene	1	2.5E-02	5.2E-03	3.0E-02	0.01	1.0E-02	1.8E-02	NA
Acenaphthylene	1	2.6E-02	5.5E-03	3.1E-02	0.01	1.1E-02	1.9E-02	NA
Benz(a)anthracene	1	3.9E-02	8.3E-03	4.8E-02	0.01	1.7E-02	2.9E-02	NA
Benzo(a)pyrene	1	3.8E-02	8.0E-03	4.6E-02	0.01	1.6E-02	2.8E-02	NA
Benzo(b)fluoranthene	1	3.9E-02	8.3E-03	4.8E-02	0.01	1.7E-02	2.9E-02	NA
Benzo(g,h,i)perylene	1	2.9E-02	6.1E-03	3.5E-02	0.01	1.2E-02	2.1E-02	NA
Benzo(k)fluoranthene	1	3.8E-02	8.0E-03	4.6E-02	0.01	1.6E-02	2.8E-02	NA
Chrysene	1	4.0E-02	8.4E-03	4.8E-02	0.01	1.7E-02	2.9E-02	NA
Dibenz(a,h)anthracene	1	3.1E-02	6.5E-03	3.8E-02	0.01	1.3E-02	2.3E-02	NA
Fluoranthene	1	4.0E-02	8.5E-03	4.9E-02	0.01	1.7E-02	3.0E-02	NA
Fluorene	1	2.9E-02	6.1E-03	3.5E-02	0.01	1.2E-02	2.1E-02	NA
Indeno(1,2,3-cd)pyrene	1	2.7E-02	5.8E-03	3.3E-02	0.01	1.2E-02	2.0E-02	NA
Dioxins								
OctaCDD, 1,2,3,4,6,7,8,9-	1	6.9E-03	1.4E-03	8.3E-03	1	2.9E-03	5.1E-03	NA
OctaCDF, 1,2,3,4,6,7,8,9-	1	8.8E-03	1.8E-03	1.1E-02	1	3.7E-03	6.5E-03	NA
HeptaCDD, 1,2,3,4,6,7,8-	1	8.8E-03	1.8E-03	1.1E-02	1	3.7E-03	6.5E-03	NA

Exhibit B-13. Animal Product Chemical-specific Inputs for Chemicals Included in MIRC

Compound Name	Soil Bio-Availability Factor (*Bs*) (unitless)	Biotransfer Factors (Ba_m) (day/kg FW tissue)[a] and Metabolism Factors (MF) (unitless)[b]						
		Mammal				Non-mammal		
		Beef (Ba_{beef})	Dairy (Ba_{dairy})	Pork (Ba_{pork})	*MF*	Eggs (Ba_{eggs})	Poultry ($Ba_{poultry}$)	*MF*
HeptaCDF, 1,2,3,4,6,7,8-	1	1.6E-02	3.5E-03	2.0E-02	1	6.9E-03	1.2E-02	NA
HeptaCDF, 1,2,3,4,7,8,9-	1	2.4E-02	5.1E-03	3.0E-02	1	1.0E-02	1.8E-02	NA
HexaCDD, 1,2,3,4,7,8-	1	1.1E-02	2.3E-03	1.3E-02	1	4.6E-03	8.1E-03	NA
HexaCDF, 1,2,3,4,7,8-	1	2.3E-02	4.8E-03	2.8E-02	1	9.6E-03	1.7E-02	NA
HexaCDD, 1,2,3,6,7,8-	1	6.8E-03	1.4E-03	8.2E-03	1	2.9E-03	5.0E-03	NA
HexaCDF, 1,2,3,6,7,8-	1	9.7E-03	2.0E-03	1.2E-02	1	4.1E-03	7.1E-03	NA
HexaCDD, 1,2,3,7,8,9 -	1	6.8E-03	1.4E-03	8.2E-03	1	2.9E-03	5.0E-03	NA
HexaCDF, 1,2,3,7,8,9-	1	1.4E-02	2.9E-03	1.7E-02	1	5.8E-03	1.0E-02	NA
HexaCDF, 2,3,4,6,7,8-	1	9.6E-03	2.0E-03	1.2E-02	1	4.1E-03	7.1E-03	NA
PentaCDD, 1,2,3,7,8-	1	1.8E-02	3.9E-03	2.2E-02	1	7.8E-03	1.4E-02	NA
PentaCDF, 1,2,3,7,8-	1	2.6E-02	5.5E-03	3.2E-02	1	1.1E-02	1.9E-02	NA
PentaCDF, 2,3,4,7,8-	1	3.1E-02	6.5E-03	3.8E-02	1	1.3E-02	2.3E-02	NA
TetraCDD, 2,3,7,8-	1	2.6E-02	5.5E-03	3.2E-02	1	1.1E-02	1.9E-02	NA
TetraCDF, 2,3,7,8-	1	3.6E-02	7.7E-03	4.4E-02	1	1.5E-02	2.7E-02	NA

Source: EPA 2005a, unless otherwise indicated. NA = not applicable.

[a] As discussed in HHRAP (EPA 2005a), Appendix A, biotransfer factors for mercury compounds were obtained from EPA 1997b. Considering speciation, fate, and transport of mercury from emission sources, elemental mercury is assumed to be vapor-phase and hence is assumed not to deposit to soil or transfer into aboveground plant parts. As a consequence, there is no transfer of elemental mercury into animal tissues. Biotransfer factors for cadmium compounds were obtained from EPA 1995b. Biotransfer factors for dioxins and PAHs were calculated from chemical octanol-water partitioning coefficients (K_{ow} values) using the correlation equation from RTI (2005) and assuming the following fat contents: milk - 4%; beef - 19%; pork - 23%; poultry -14%; and eggs - 8%.

[b] As discussed in HHRAP (EPA 2005a), EPA (1995c) recommends using a metabolism factor (MF) to account for metabolism of PAHs by mammals to offset the amount of bioaccumulation suggested by biotransfer factors. EPA has recommended an MF of 0.01 for bis(2-ethylhexyl)phthalate (BEHP) and 1.0 for all other chemicals (EPA 1995d). For MIRC, an MF of 0.01 is also used to calculate concentrations of PAHs in food products from mammalian species based on the work of Hofelt et al. (2001). This factor takes into account the P450-mediated metabolism of PAHs in mammals; applying this factor in our approach reduced the concentrations of chemicals in beef, pork, and dairy by two orders of magnitude.

Exhibit B-14. Soil and Plant Ingestion Rates for Animals

Animal	Soil Ingestion Rate – $Qs_{(m)}$ (kg/day)[a]	Plant Part Consumed by Animal	Plant Ingestion Rate – $Qp_{(l,m)}$ (kg/day)
Beef cattle[b]	0.5	Silage	2.5
		Forage	8.8
		Grain	0.47
Dairy cattle[c]	0.4	Silage	4.1
		Forage	13.2
		Grain	3.0
Swine[d]	0.37	Silage	1.4
		Grain	3.3
Chicken (eggs)[e]	0.022	Grain	0.2

Source: EPA 2005a HHRAP (Chapter 5).

[a] Beef cattle: NC DEHNR (1997) and EPA (1994b) recommended a soil ingestion rate for subsistence beef cattle of 0.5 kg/day based on Fries (1994) and NAS (1987). As discussed in HHRAP, Fries (1994) reported soil ingestion to be 4 percent of the total dry matter intake. NAS (1987) cited an average beef cattle weight of 590 kg, and a daily dry matter intake rate (non-lactating cows) of 2 percent of body weight. This results in a daily dry matter intake rate of 11.8 kg DW/day and a daily soil ingestion rate of about 0.5 kg/day.

Dairy cattle: NC DEHNR (1997) and EPA (1994b) recommended a soil ingestion rate for dairy cattle of 0.4 kg/day based on Fries (1994) and NAS (1987). As discussed in HHRAP, Fries (1994) reported soil ingestion to be 2 percent of the total dry matter intake. NAS (1987) cited an average beef cattle weight of 630 kg and a daily dry matter intake rate (non-lactating cows) of 3.2 percent of body weight. This resulted in a daily dry matter intake rate of 20 kg/day DW, and a daily soil ingestion rate of approximately 0.4 kg/day. Uncertainties associated with Qs include the lack of current empirical data to support soil ingestion rates for dairy cattle and the assumption of uniform contamination of soil ingested by cattle.

Swine: NC DEHNR (1997) recommended a soil ingestion rate for swine of 0.37, estimated by assuming a soil intake that is 8% of the plant ingestion rate of 4.3 kg DW/day. Uncertainties include the lack of current empirical data to support soil ingestion rates and the assumption of uniform contamination of the soil ingested by swine.

Chicken: HHRAP (EPA 2005a) assumes that chickens consume 10 percent of their total diet (which is approximately 0.2 kg/day grain) as soil, a percentage that is consistent with the study from Stephens *et al*. (1995). Uncertainties include the lack of current empirical data to support soil ingestion rates for chicken and the assumption of uniform contamination of soil ingested by chicken.

[b] The beef cattle ingestion rates of forage, silage, and grain are based on the total daily intake rate of about 12 kg DW/day (based on NAS [1987] reporting a daily dry matter intake that is 2 percent of an average beef cattle body weight of 590 kg) and are supported by NC DEHNR (1997), EPA (1994b and 1990), and Boone *et al*. (1981). The principal uncertainty associated with these *Qp* values is the variability between forage, silage, and grain ingestion rates for cattle.

[c] The dairy cattle ingestion rates of forage, silage, and grain are based on the total daily intake rate of about 20 kg DW/day (NAS 1987; EPA 1992) as recommended by NC DEHNR (1997). Uncertainties include the proportion of each food type in the diet, which varies from location to location. Assuming uniform contamination of plant materials consumed by cattle also introduces uncertainty.

[d] Swine are not grazing animals and are assumed not to eat forage (EPA 1998). EPA (1994b and 1998) and NC DEHNR (1997) recommended including only silage and grains in the diet of swine. EPA (1995c) recommended an ingestion rate of 4.7 kg DW/day for a swine, referencing NAS (1987). Assuming a diet of 70 percent grain and 30 percent silage (EPA 1990), HHRAP estimated ingestion rates of 3.3 kg DW/day (grain) and 1.4 kg DW/day (silage). Uncertainties associated with *Qp* include variability of the proportion of grain and silage in the diet, which varies from location to location.

[e] Chickens consume grain provided by the farmer. The daily quantity of grain feed consumed by chicken is assumed to be 0.2 kg/day (Ensminger (1980), Fries (1982), and NAS (1987). Uncertainties associated with this variable include the variability of actual grain ingestion rates from site to site. In addition, assuming uniform contamination of plant materials consumed by chicken introduces some uncertainty.

6.3. Adult and Non-Infant Exposure Parameter Values

The exposure parameters included in MIRC and their default and other value options are summarized in the following subsections. The default values were selected to result in a highly health protective screening scenario. Parameter value options were primarily obtained or estimated from EPA's *Exposure Factors Handbook* (EFH; EPA 2011a) and *Child-Specific Exposure Factors Handbook* (CSEFH; EPA 2008a). Where values were reported for age groupings other than those used in MIRC (see Section 2.3 above for MIRC age groups), time-weighted average values were estimated for the MIRC age groups from the available data.

In MIRC, ingestion rates for home-produced farm food items are included for exposed fruit, protected fruit, exposed vegetables, protected vegetables, root vegetables, beef, total dairy, pork, poultry, and eggs. Those ingestion rates are already normalized to body weight (i.e., $g_{wet\ weight}$/kg-day) (EPA 2011a). The body weight parameter values presented in Exhibit B-15, therefore, are not applied in the chemical intake (ADD) equations for these food types.

In MIRC, ingestion rates also are included for drinking water (mL/day), soil (mg/day), and fish (g/day). These ingestion rates, however, are on a per person basis (i.e., not normalized for body weight). The body weight parameter values presented in Exhibit B-15, therefore, are applied in the chemical intake (ADD) equations for these media.

6.3.1. Body Weights

Body weight (BW) options included in MIRC include mean, 5th, 10th, 50th, 90th, and 95th percentile values for adults and the five children's age groups: <1 year; 1–2 years; 3–5 years; 6–11 years; and 12–19 years. For its default screening assessment, EPA uses the mean BW for each age group. The BWs currently in the MIRC database are listed in Exhibit B-15.

In general, BW values for the five children's age groups were calculated from the summary data provided in Table 8-3 of EPA's 2008 CSEFH. For purposes of comparison, alternative BW values for children ages 12 through 19 years also were estimated using data from Portier *et al*. (2007). These values are listed in the last row of Exhibit B-15, but are not included in MIRC. The means calculated using the two methods for children ages 12 through 19 years were essentially identical at 64 kg. The other percentile values for this age group using the two methods differed by approximately 10 percent or less.

Exhibit B-15. Mean and Percentile Body Weight Estimates for Adults and Children

Lifestage (years)	Duration (years)	Body Weight (kg)					
		Mean	5th	10th	50th	90th	95th
Adult[a] (20-70)	50	80.0[a]	52.9	56	69.3	89.7	97.6
Child < 1[b]	1	7.83	6.03	6.38	7.76	9.24	9.66
Child 1-2[c]	2	12.6	9.9	10.4	12.5	14.9	15.6
Child 3-5[d]	3	18.6	13.5	14.4	17.8	23.6	26.2
Child 6-11[e]	6	36.0	22.1	24.0	33.5	51.2	58.6
Child 12-19[f]	8	64.2	39.5	45	64.2	83.5	89
[Child 12-19[g]	*8*	*64.3*	*41.1*	*44.6*	*60.9*	*88.5*	*98.4]*

[a] BW represents the recommended body weight from EPAs 2011 EFH. Although the 18 to 74 year age category in EPA's EFH does not match exactly the age 20 to 70 year categorization of adults in MIRC, the magnitude of error in the mean and percentile body weights is likely to be very small (i.e., less than 1%).

[b] Each BW represents a time-weighted average of body weights for age groups birth to <1 month, 1 to <3 months, 3 to <6 months, and 6 to <12 months from Table 8-3 of the 2008 CSEFH. Original sample sizes for each of these age groups can also be found in Table 8-3.

[c] Each BW represents a time-weighted average of body weights for age groups 1 to <2 years and 2 to <3 years from Table 8-3 of the 2008 CSEFH. Original sample sizes for each of these age groups can also be found in Table 8-3.

[d] BWs obtained directly from Table 8-3 of the 2008 CSEFH (age group 3 to <6 years).

[e] Each BW represents a time-weighted average of body weights for age groups 6 to <11 years and 11 to <16 years from Table 8-3 of the 2008 CSEFH. Original sample sizes for each of these age groups can also be found in Table 8-3.

[f] Mean BW estimated using Table 8-22 of the 2008 CSEFH, which is based on NHANES IV data as presented in Portier et al. (2007). This estimate was calculated as the average of the 8 single-year age groups from 12 to 13 years through 19 to 20 years. Values for the other percentiles were estimated using Portier et al., 2007.

[g] Each BW represents a time-weighted average of body weights for age groups 11 to <16 years and 16 to <21 years from Table 8-3 of the 2008 CSEFH. Estimated values include 11-year-olds and individuals through age 20, which contributes to uncertainty in the estimates for 12 to 19 years. Those values are provided for comparison purposes only and are not included in MIRC.

6.3.2. Water Ingestion Rates

MIRC also includes the option of calculating chemical ingestion via drinking water obtained from surface-water sources or from wells (i.e., from groundwater) in the contaminated area. Users have the option in MIRC to set drinking water ingestion rates to zero or to revise the drinking water ingestion rates in MIRC to better reflect site-specific water uses. The 2008 CSEFH recommends values for drinking water ingestion rates for children based on a study reported by Kahn and Stralka (2008). Table 3-4 of the CSEFH provides *per capita* estimates of community water ingestion rates by age categories. Community water ingestion includes both direct and indirect ingestion of water from the tap. *Direct ingestion* is defined as direct consumption of water as a beverage, while *indirect ingestion* includes water added during food or beverage preparation. The source of these data is the 1994-1996 and 1998 U.S. Department of Agriculture's (USDA's) *Continuing Survey of Food Intakes by Individuals* (CSFII) (USDA 2000). Exhibit B-16 includes the drinking water ingestion rates for children that are included in MIRC.

Mean and percentile adult drinking water ingestion rates were obtained from EPA (2004b), which presents estimated *per capita* water ingestion rates for various age categories based on data collected by the USDA's 1994–1996 and 1998 CSFII (USDA 2000). Adult ingestion rates, presented in Exhibit B-16, represent community water ingestion, both direct and indirect as defined above, for males and females combined, ages 20 years and older.

Exhibit B-16. Estimated Daily Per Capita Mean and Percentile Water Ingestion Rates for Children and Adults[a]

Lifestage (years)	Ingestion Rates, Community Water (mL/day)				
	Mean	50th	90th	95th	99th
Child <1[b]	504	482	969	1113	1440
Child 1-2[c]	332	255	687	903	1318
Child 3-5[d]	382	316	778	999	1592
Child 6-11[e]	532	417	1149	1499	2274
Child 12-19[f]	698	473	1641	2163	3467
Adult[g]	1219	981	2534	3087	4567

Sources: EPA 2004, 2008a

*The sample size does not meet minimum reporting requirements as described in EPA 2008a. For some of these MIRC age groupings, the values are based on the time-weighted average value for 2 or more age ranges from CSEFH Table 3-4. One or more age ranges within the group may not meet the minimum reporting requirements, but not necessarily all of them fall within this category.

[a] Source is Kahn and Stralka 2008, also presented in the CSEFH (EPA 2008a).

[b] Each IR represents a time-weighted average of ingestion rates for age groups birth to <1 month, 1 to <3 months, 3 to <6 months, and 6 to <12 months from Table 3-4 of the 2008 CSEFH.

[c] Each IR represents a time-weighted average of ingestion rates for age groups 1 to <2 years and 2 to <3 years from Table 3-4 of the 2008 CSEFH.

[d] Each IR represents the ingestion rate for age group 3 to <6 years from Table 3-4 of the 2008 CSEFH.

[e] Each IR represents the ingestion rate for age group 6 to <11 years from Table 3-4 of the 2008 CSEFH. This value represents a health protective (i.e., slightly low) estimate of IR for ages 6 through 11 years since 11-year olds are not included in this CSEFH age group.

[f] Each IR represents a time-weighted average of ingestion rates for age groups 11 to <16 years, 16 to <18, and 18 to <21 years from Table 3-4 of the 2008 CSEFH. Note that estimated values include 11-year-olds and individuals through age 20, which contributes to uncertainty in the estimates for 12 to 19 years.

[g] Adult drinking water ingestion rates were obtained from EPA (2004b), Appendix E, Part I, Table A1 for community water, both sexes (ages 20+), direct plus indirect water ingestion.

6.3.3. Local Food Ingestion Rates

MIRC includes mean, median, 90th, 95th, and 99th percentile food-specific ingestion rates (IRs) for consumers-only of farm food chain (FFC) media for adults and children. The mean and percentile values are from EPA's analysis of data from the USDA's 1987 to 1988 *Nationwide Food Consumption Survey* (NFCS) (USDA 1993), as presented in Chapter 13 of the Agency's *Exposure Factors Handbook* (i.e., Intake Rates for Various Home Produced Food Items) (EPA 2011a). Consumers-only means that individuals who did not report eating a specified type of food during the three-day period covered by the food ingestion part of the survey were not included in the analysis of ingestion rates for that food type. The questionnaire included the options for a household to self-identify in one or more of five categories: as a household that gardens, raises animals, hunts, fishes, or farms. As of September 2008, that survey was the most recent NFCS available (EPA 2008a, CSEFH), and we are not aware of any that might be more recent.[29]

For the adult age group in MIRC, data were compiled on food-specific IRs separately for two types of households as indicated in the "Response to Questionnaire" (EPA 2011a, Chapter 13): (1) households that farm (F) and (2) households that garden or raise animals (HG for homegrown). This division reflects EPA's data analysis. EPA tabulated IRs for fruits and vegetables separately for households that farm and households that garden. Similarly, EPA tabulated IRs for animals and animal products for households that farm and for households that raise animals. Thus, the first type of household, F, represents farmers who may both grow crops and raise animals and who are likely to consume more homegrown/raised foods than the second type of household. The second type of household, HG, represents the non-farming households that may consume lower amounts of home-grown or raised foods (i.e., HG encompasses both households that garden and households that raise animals).

The food-specific ingestion rates are based on the amount of each food type that households that farm (F) or households that garden and raise animals (HG) produced and brought into their homes for consumption and the number of persons consuming the food. EPA averaged the actual consumption rate for home-grown foods over the 1-week survey period.

The default food-specific ingestion rates in MIRC for adults are those for farming households (F) in Exhibit B-17. The user can specify use of the non-farming household (HG) ingestion rates if they are more appropriate for the user's exposure scenario.

Exhibit B-17. Summary of Age-Group Specific Food Ingestion Rates for Farm Food Items

Product	Child (age in yr)					Adult (20–70 yrs)
	<1	1–2	3–5	6–11	12–19	
Mean ingestion rates (g/kg-day)						
Beef[a]	N/A	4.14	4.00	3.77	1.72	1.93
Dairy[b]	N/A	91.6	50.9	27.4	13.6	2.96
Eggs[a]	N/A	2.46	1.42	0.86	0.588	0.606
Exposed Fruit[a]	N/A	6.14	2.60	2.52	1.33	1.19
Exposed Vegetable[a]	N/A	3.48	1.74	1.39	1.07	1.38
Pork[a]	N/A	2.23	2.15	1.50	1.28	1.10
Poultry[a]	N/A	3.57	3.35	2.14	1.50	1.37

---

[29] Note that EPA's 2008 CSEFH does not distinguish between exposed and protected fruits and vegetables when recommending food ingestion rates based on the same data set for the same age categories. EPA's 1997 analysis for its EFH therefore remains the most appropriate data source for use in MIRC.

Exhibit B-17. Summary of Age-Group Specific Food Ingestion Rates for Farm Food Items

Product	Child (age in yr)					Adult (20–70 yrs)
	<1	1–2	3–5	6–11	12–19	
Protected Fruit[a]	N/A	16.6	12.4	8.50	2.96	5.19
Protected Vegetable[a]	N/A	2.46	1.30	1.10	0.78	0.862
Root Vegetable[a]	N/A	2.52	1.28	1.32	0.94	1.03
Water (mL/day)[c]	N/A	332	382	532	698	1218
Median ingestion rates (g/kg-day)						
Beef[a]	N/A	2.51	2.49	2.11	1.51	1.55
Dairy[b]	N/A	125	66.0	34.4	15.5	2.58
Eggs[a]	N/A	1.51	0.83	0.561	0.435	0.474
Exposed Fruit[a]	N/A	1.82	1.11	0.61	0.62	0.593
Exposed Vegetable[a]	N/A	1.89	1.16	0.64	0.66	0.812
Pork[a]	N/A	1.80	1.49	1.04	0.89	0.802
Poultry[a]	N/A	3.01	2.90	1.48	1.30	0.922
Protected Fruit[a]	N/A	7.59	5.94	3.63	1.23	2.08
Protected Vegetable[a]	N/A	1.94	1.04	0.79	0.58	0.564
Root Vegetable[a]	N/A	0.46	0.52	0.57	0.56	0.59
Water (mL/day)[c]	N/A	255	316	417	473	981
90th percentile ingestion rates (g/kg-day)[d]						
Beef[a]	N/A	9.49	8.83	11.4	3.53	4.41
Dairy[b]	N/A	185	92.5	57.4	30.9	6.16
Eggs[a]	N/A	4.90	3.06	1.90	1.30	1.31
Exposed Fruit[a]	N/A	12.7	5.41	6.98	3.41	2.37
Exposed Vegetable[a]	N/A	10.7	3.47	3.22	2.35	3.09
Pork[a]	N/A	4.90	4.83	3.72	3.69	2.23
Poultry[a]	N/A	7.17	6.52	4.51	3.13	2.69
Protected Fruit[a]	N/A	44.8	32.0	23.3	7.44	15.1
Protected Vegetable[a]	N/A	3.88	2.51	2.14	1.85	1.81
Root Vegetable[a]	N/A	7.25	4.26	3.83	2.26	2.49
Water (mL/day)[c]	N/A	687	778	1149	1640	2534
95th percentile ingestion rates (g/kg-day)						
Beef[a]	N/A	12.9	12.5	12.5	3.57	5.83
Dairy[b]	N/A	167	89.9	56.0	32.3	7.80
Eggs[a]	N/A	5.38	3.62	2.37	1.43	1.59
Exposed Fruit[a]	N/A	14.6	6.07	11.7	4.78	3.38
Exposed Vegetable[a]	N/A	11.9	6.29	5.47	3.78	4.46
Pork[a]	N/A	6.52	6.12	4.73	6.39	2.60
Poultry[a]	N/A	8.10	7.06	5.07	3.51	3.93
Protected Fruit[a]	N/A	48.3	35.1	26.9	11.4	19.2
Protected Vegetable[a]	N/A	9.42	5.10	3.12	2.20	2.83
Root Vegetable[a]	N/A	10.4	4.73	5.59	3.32	3.37

Exhibit B-17. Summary of Age-Group Specific Food Ingestion Rates for Farm Food Items

Product	Child (age in yr)					Adult (20–70 yrs)
	<1	1–2	3–5	6–11	12–19	
Water (mL/day)[c]	N/A	903	999	1499	2163	3087
99^{th} percentile ingestion rates (g/kg-day)						
Beef[a]	N/A	20.9	19.8	13.3	4.28	6.84
Dairy[b]	N/A	180	87.2	54.8	34.7	9.20
Eggs[a]	N/A	16.2	11.2	8.19	4.77	1.83
Exposed Fruit[a]	N/A	25.2	32.5	15.7	5.9	13.0
Exposed Vegetable[a]	N/A	12.1	7.36	13.3	5.67	8.42
Pork[a]	N/A	8.71	9.74	6.61	4.29	3.87
Poultry[a]	N/A	9.63	10.24	6.12	4.60	4.93
Protected Fruit[a]	N/A	109	71.2	58.2	19.1	34.4
Protected Vegetable[a]	N/A	9.42	5.31	5.40	2.69	5.56
Root Vegetable[a]	N/A	10.4	4.73	7.47	5.13	7.57
Water (mL/day)[c]	N/A	1318	1592	2274	3467	4567

[a] Primary source for values was the 1987–1988 NFCS survey; compiled results are presented in Chapter 13 of 2011 Exposure Factors Handbook (EPA, 2011a). When data were unavailable for a particular age group, intake rate for all age groups was used multiplied by the age-specific ratio of intake based on national population intake rates from CSFII.

[b] Primary source for values was 1987–1988 NFCS survey, compiled results presented in Chapter 13 of 2011 Exposure Factors Handbook (EPA, 2011a). When data were unavailable for a particular age group, intake rate for all age groups was used multiplied by the age-specific ratio of intake based on national population intake rates from an NHANES 2003–2006 analysis in Chapter 11 of the Exposure Factors Handbook.

[c] Primary source for children less than 3 years of age was a Kahn and Stralka (2008) analysis of CSFII data, and from EPA's analysis of NHANES 2003–2006 data for children and adults greater than three. All data tables that were used and justifications for data sources are presented in Chapter 3 of the 2011 Exposure Factors' Handbook.

[d] Default ingestion rate percentile used in MIRC for Tier 1 assessments and chemical threshold calculations.

For children, EPA estimated food-specific IRs for four age categories (EPA 2011a): 1–2 years, 3–5 years, 6–11 years, and 12–19 years. Sample sizes were insufficient to distinguish IRs for children in different types of households; hence, for children, a single IR value represents both F and HG households for a given food type and age category (Exhibit B-17). For some food types and age categories, there were insufficient data for EPA to provide consumer-only intake rates (i.e., data set for the subpopulation consisted of fewer than 20 observations). The HHRAP methodology, Section 6.2.2.2, recommends a method by which to calculate the "missing" age-specific consumer-only ingestion rates, as explained below. Food-specific intake rates (IRs) for those child age groups and food items not included in Chapter 13 of the 2011 EFH, that is $IR_{age\_group\_x}$, were derived using the following information:

- Mean or percentile-specific consumer-only intake of the farm food item, as brought into the home, for the total NFCS survey population (from EFH Chapter 13) – IRCO_total;
- Mean or percentile-specific per capita intake of the food type from all sources, as consumed, for the specific child age group, from Chapter 3 of the CSFII Analysis of Food Intake Distributions (EPA 2003c) – IRPC, age_group_x; and
- Mean or percentile-specific per capita intake of the farm food item for the total CSFII survey population (from Chapter 3 of EPA 2003c) – IRPC_total.

The ratio of $IR_{PC,\ age\_group\_x}$ to $\mathrm{IR}_{\mathrm{PC\_total}}$ from the CSFII data shows the consumption rate of a particular food type by a specific age group relative to the consumption rate for that food type for the population as a whole. The ratio of $IR_{CO,\ age\_group\_x}$ to IR_{CO_total}, that is the consumption rate of a particular food type by a specific age group (consumers only) relative to the consumption rate for that food type for the NFCS survey population as a whole (consumers only), should be approximately the same. Given the assumption that the two ratios are equal, Equation B-56 was used to calculate the "missing" age-specific consumer-only *IRs*:

Equation B-56. Calculation of Age-Group-Specific and Food-Specific Ingestion Rates

$$IR_{CO,\ age\_group\_x} = \frac{IR_{CO\_total} \times IR_{PC,\ age\_group\_x}}{IR_{PC\_total}}$$

where:

$IR_{CO,\ age\_group\_x}$ = Mean or percentile-specific *consumer-only* intake of the food type from all sources, as consumed, for the specific child age group X

IR_{CO_total} = Mean or percentile-specific *consumer-only* intake of the farm food item, as brought into the home, for the <u>total</u> NFCS survey population

$IR_{PC,\ age\_group\_x}$ = Mean or percentile-specific *per capita* intake of the food type from all sources, as consumed, for the specific child age group X from the CSFII

IR_{PC_total} = Mean or percentile-specific *per capita* intake of the farm food item for the <u>total</u> CSFII survey population

In this discussion, *per capita* (as opposed to *consumer-only*) indicates the intake rates are based on the entire population rather than the subset of the population that ingests the particular food category (i.e., consumers). Here, the use of *per capita* ingestion rates is recommended by the HHRAP methodology because no consumer-only percentile-specific intakes are provided for the different age groups.

The above calculation implicitly assumes that the distribution of the consumption rate for a food type for a specific age group (consumers only) has the same shape as the distribution of the consumption rate for a food type for a specific age group in the general population (*per capita*). Otherwise, the separate calculation of each percentile might yield intake estimates that decrease as the percentile increases. This calculation artifact could occur if the shapes of the two distributions differ in the upper percentiles (or "tails") of the distributions.

In the instances where the above calculations were used to fill data gaps in the above exhibit, only the dairy child-specific age group intake estimates are not strictly increasing with increasing percentile. The distributions likely track better (and thus the above assumption of equal ratios is more reasonable) for lower percentiles, with deviations occurring due to outlier ingestion rates based on only a few respondents in the tails of the distributions. The MIRC defaults use the 90th percentile ingestion estimates, which are likely more reliable than the 95th or 99th percentile estimates in this particular calculation.

6.3.4. Local Fish Ingestion Rates

6.3.4.1. Screening Scenario

The USDA's 1987 to 1988 Nationwide Food Consumption Survey (NFCS) (USDA 1993, 1994a), as presented in Chapter 13 of the Agency's Exposure Factors Handbook (i.e., Intake Rates for

Various Home Produced Food Items) (EPA 2011a), includes family-caught fish ingestion rates by age category. There are several disadvantages, however, to using that data source to estimate fish ingestion rates. First, due to inadequate sample sizes, EPA did not report fish ingestion rates for children less than 6 years of age. Second, the NFCS data were collected more than two decades ago. Third, the reported fish ingestion rates are for ages 6 to 11 and 12 to 19 and are based on 29 and 21 individuals in each age category, respectively (EPA 2011a, Table 13-20). Finally, the ingestion rates from NFCS data are based on total weight of fish as brought into the home, and do not include losses from preparation of the fish (i.e., removal of inedible parts and, possibly, the skin). Estimates of preparation losses for fish intended to apply to the NFCS fish ingestion rate data are very uncertain and are based on a wide variety of freshwater, estuarine, and marine fish, and squid (EPA 2011a, Table 13-69). Additionally, when considering the multipathway screening methodology, it is important that potential health effects to those individuals who are most likely to have the greatest PB-HAP exposure are not underestimated and, therefore, ingestion rates that are reflective of subsistence fisher ingestion rates are desired. Therefore, a more recent survey was sought that included larger sample sizes, data for children younger than six years, ingestion rates for the parts of fish actually consumed, and ingestion rates reflective of subsistence fisher ingestion rates.

Taking all of these issues into consideration, the default adult fish ingestion rate selected for use in MIRC is 373 g/day, which is the estimated 99th percentile of fish ingestion rates for woman fishers as reported by Burger (2002). This rate is based upon ingestion of “wild-caught” fish, which includes freshwater, estuarine, and marine species, while our screening scenarios focus only on freshwater fish from lakes. This is notable because a number of studies indicate that fish ingestion rates are limited by species and habitat (i.e., lake, river, estuary, and ocean) and that the majority of the fish consumed in the United States are from river, marine and estuarine habitats versus lakes. Thus, although the fish ingestion rate for this group of subsistence fishers is not the highest fish ingestion rate available for use by EPA, we do believe it strikes the appropriate balance between being health protective and having screening scenarios so conservative that they are of limited use in the decision making process. This high-end fish ingestion rate is appropriate in the context of the conservative screening scenario used in the RTR process. This methodology is particularly applicable for national rulemakings given that it is very likely that subsistence woman fishers of child bearing age are located throughout the United States. Finally, we note that using a high-end subsistence fish ingestion rate is consistent with section 112 of the CAA, which focuses on risks associated with maximally exposed individuals.

Because Burger (2002) did not estimate fish ingestion rates for children, another data source was needed to develop ingestion rates for the child age categories that are used in MIRC. The child ingestion rates need to be consistent with the Burger adult ingestion rate, reflective of subsistence fisher ingestion rates, and based on adequate sample sizes. To satisfy these requirements, data on child ingestion rates from EPA’s *Estimated Per Capita Fish Consumption in the United States* (EPA 2002) were selected for use. Specifically, the estimated 99th percentile of *as-prepared*, *consumer-only* ingestion rates for finfish and shellfish were selected (see Section 4.2.1.1 Table 5 of EPA 2002).The original data were collected as part of the 1994–96 and 1998 USDA Continuing Survey of Intakes by Individuals (CSFII; USDA 2000). Values reflect “as prepared” ingestion rates for which cooking and preparation losses (*L1* and *L2*) did not need to be considered. “Total” fish as reported in this source represents consumption of finfish plus shellfish.

Because the child age categories used in MIRC differ from the CSFII age categories presented in EPA 2002, the CSFII data were adjusted for use in MIRC. The CSFII data did not provide ingestion rates for the 1–2 year age category. To estimate ingestion rates for this age group, EPA used the ingestion rate for the 3–5 year age category scaled downward by the ratio of the mean body weight of the 1–2 year age group to the mean body weight of the 3–5 year age group. Because MIRC uses a 3–5 year age category, no adjustment was needed for CSFII data from that age category. For the 6–11 and 12–19 age categories, time-weighted average ingestion rates were calculated based on the CSFII ingestion rates. Exhibit B-18 provides the fish ingestion rates used in the screening assessment.

Exhibit B-18. Fish Ingestion Rates Used in Screening Assessment

	Ingestion Rates (g/day)					
	Infants <1 yr	**Child 1–2 yrs**	**Child 3–5 yrs**	**Child 6–11 yrs**	**Child 12–19 yrs**	**Adult 20–70 yrs**
	NA	107.7[a]	159.0[b]	268.2[c]	331.0[c]	373[d]

[a] A fish ingestion rate for ages 1-2 years was not available. The value represents the consumer-only fish ingestion rate for ages 3 to 5 from EPA (2002) (Section 4.2.1.1 Table 5 [freshwater/estuarine habitat]), scaled down by the ratio of the mean Child 1-2 body weight to the mean Child 3-5 body weight.

[b] This value represents the consumer-only fish ingestion rate for ages 3 to 5 from EPA (2002), Section 4.2.1.1 Table 5 (freshwater/estuarine habitat) rounded to the nearest full number.

[c] These values represent time-weighted average consumer-only fish ingestion rates based on ingestion rates from EPA (2002), Section 4.2.1.1 Table 5 (freshwater/estuarine habitat).

[d] This value represents the 99th percentile ingestion rate of wild caught fish for women as reported by Burger (2002).

6.3.4.2. Other Values Available in MIRC

EPA's (2002) analysis of freshwater and estuarine fish consumption from the USDA's Continuing Survey of Food Intake by Individuals (CSFII) for 1994-96 and 1998 was chosen to provide fish ingestion rate options by age category in MIRC. Although the fish consumption rates reported in the CSFII include all sources, commercial and self-caught, for purposes of screening level risk assessments, it was assumed that all freshwater and estuarine fish consumed are self-caught. The inclusion of commercially obtained and estuarine fish will overestimate locally caught freshwater fish ingestion rates for most populations in the United States; however, it also might underestimate locally caught fish ingestion rates for some populations (e.g., Native Americans, Asian and Pacific Island communities, rural African American communities). Because consumption of locally caught fish varies substantially from region to region in the United States and from one population or ethnic group to the next, users of MIRC are encouraged to use more locally relevant data whenever available.

For children, MIRC also includes values for the mean and the 90th, 95th, and 99th percentile fish *per-capita* ingestion rates (freshwater and estuarine fish only) based on EPA's analysis of 1994-96 and 1998 CSFII data (EPA 2002, 2008a). Those rates include individuals who eat fish and those who do not eat fish. As shown in EPA's 2008 CSEFH, Table 10-7, the 90th percentile *per capita* ingestion rates estimated from the two-day CSFII recall period are zero for some child age groups. Although not presented in CSEFH Table 10-7, median ingestion rates for all child age groups would be zero (considering the "consumer only" sample sizes [CSEFH Table 10-9] relative to the "*per-capita*" sample sizes in Table 10-7).

The high percentile fish ingestion rates that are zero result from the short duration of the CSFII recall period (two days) compared with the averaging time of interest (a year) and the relatively infrequent consumption of fish (e.g., on the order of once a week to once a month or less) compared with the near daily ingestion of other types of food products (e.g., dairy, produce, meat). Use of zero for fish ingestion rates, however, is not useful in MIRC. As a result, an alternative method was used to estimate fish ingestion rates for children and adults that could provide reasonable, non-zero values for all age groups and percentiles.

The alternative, age-group-specific fish ingestion rates were derived using values for each age group, *y*:

- Mean or other appropriate percentile consumer-only fish ingestion rates for age group *y*, IRCO,*y*, from EPA's Estimated Per Capita Fish Consumption in the United States (EPA 2002), Section 5.2.1.1, Table 5, for freshwater/estuarine habitat.[30]
- Fraction of the population consuming freshwater/estuarine fish, FPC,*y*, calculated as consumer-only sample size / U.S. population sample for age group *y*. The data to calculate those fractions are available in the 2008 CSEFH and EPA 2002.

Equation B-57 was used to calculate the alternative, *per capita* fish ingestion rates by age group ($IR_{PC,y}$):

Equation B-57. Calculation of Alternative Age-Group-Specific Fish Ingestion Rates

$$\mathrm{IR}_{\mathrm{PC,y}} = \mathrm{IR}_{\mathrm{CO,y}} \times \mathrm{F}_{\mathrm{PC,y}}$$

where:

$IR_{PC,y}$ = *Per capita* fish ingestion rate for age group *y* (g/day)

$IR_{CO,y}$ = *Consumer-only* fish ingestion rates for age group *y* (g/day) (EPA 2002, Section 5.2.1.1, Table 5, for freshwater/estuarine habitat)

$F_{PC,y}$ = Fraction of the population consuming freshwater/estuarine fish, calculated as consumer-only sample size / total U.S. population sample size for age group *y* (unitless) (2008 CSEFH, EPA 2002)

In the above, *per capita* (as opposed to *consumer-only*) indicates the intake rates are based on the entire population rather than the subset of the population that ingests the particular food category. Here, *per capita* ingestions are recommended by the HHRAP methodology because no consumer-only percentile-specific intakes are provided for the different age groups.

The mean and percentile consumer-only fish ingestion rates for children and adults and the fraction of the population consuming freshwater/estuarine fish used in calculating long-term *per capita* fish ingestion rates by age group are presented in Exhibit B-19 and Exhibit B-20. The mean and percentile *per capita* fish ingestion rates estimated using this methodology are summarized in Exhibit B-21 and are available in MIRC. The fish ingestion rates provided in Exhibit B-21 and included in MIRC are intended to represent the harvest and consumption of fish in surface waters in a hypothetical depositional area. For site-specific application of this tool, users should consider using more localized survey data to estimate more appropriate fish ingestion rates. The fishing season varies substantially across the United States by latitude, and fish consumption patterns also vary by type of water body (e.g., ponds, lakes, rivers, streams, estuaries, coastal marine), cultural heritage, and general geographic area. Therefore, use of more localized information is encouraged. Note that as indicated in Exhibit 16 and Exhibit 18, in developing the screening threshold emission rates, health protective fish ingestion rates for child and adult fish consumers that more closely represent exposures of a high-end recreational fisher were used.

---

[30] Most of these data also are provided in Table 10-9 of the CSEFH; the median values, however, are not presented in the CSEFH, and values for the mean and all other percentiles are slightly different due to rounding.

As noted in Section 6.4.3 of this attachment, if the user overwrites the fish IRs shown in Exhibit B-21 with fresh-weight as caught values (e.g., values obtained from a local creel survey), the user is advised to set non-zero values for the preparation and cooking loss factors L1 and L2 in Equation B-15. Suggested values are presented in Section 6.4.3.

Exhibit B-19. Daily Mean and Percentile *Consumer-Only* Fish Ingestion Rates for Children and Adults ($IR_{CO,y}$)[a]

Lifestage (years)	Ingestion Rates, All Fish (g/day)				
	Mean	50th	90th	95th	99th
Child <1	NA	NA	NA	NA	NA
Child 1-2[b]	27.31	15.61	64.46	87.60	138.76*
Child 3-5[c]	40.31	23.04	95.16	129.31	204.84*
Child 6-11[d]	61.49	28.46	156.86*	247.69*	385.64*
Child 12-19[e]	79.07	43.18	181.40*	211.15*	423.38*
Adult[f]	81.08	47.39	199.62*	278.91	505.65*

Sources: EPA 2002, 2008a

NA = not applicable; it is assumed that children < 1 year of age do not consume fish.

*Indicates that the sample size does not meet minimum reporting requirements as described in EPA 2002. Owing to the small sample sizes, these upper percentiles values are highly uncertain.

[a] *Per capita* fish ingestion (FI) rates for children by age group are available from Chapter 10 of the CSEFH (EPA 2008a); however, all 50th and some 90th percentile ingestion rates are zero. *Per capita* FI rates were therefore estimated as described in Equation B-57 to provide reasonable, non-zero values for all age groups and percentiles.

[b] A fish IR for ages 1-2 years was not available. The value represents the consumer-only fish ingestion rate for ages 3 to 5 from EPA (2002) (Section 5.2.1.1 Table 5 [freshwater/estuarine habitat]), scaled down by the ratio of the mean Child 1-2 body weight to the mean Child 3-5 body weight.

[c] These values represent the consumer-only fish ingestion rate for ages 3 to 5 from EPA (2002), Section 5.2.1.1 Table 5 (freshwater/estuarine habitat). Sample size = 442.

[d] These values represent the consumer-only fish ingestion rate for ages 6 to 10 from EPA (2002), Section 5.2.1.1 Table 5 (freshwater/estuarine habitat). Sample size = 147.

[e] These values represent the time-weighted average *per capita* fish ingestion rate for ages 11 to 15 and 16 to 17 years from EPA (2002), Section 5.1.1.1 Table 5 (freshwater/estuarine habitat); the value may underestimate ingestion rate for ages 12 to 19 years. Sample size = 135.

[f] These values represent the consumer-only fish ingestion rate for individuals 18 years and older from EPA (2002), Section 5.2.1.1 Table 4 (freshwater/estuarine habitat). Sample size = 1,633.

Exhibit B-20. Fraction of Population Consuming Freshwater/Estuarine Fish on a Single Day ($F_{PC,y}$)

Lifestage (years)	Fraction Consuming Fish
Child 3-5	0.0503[a]
Child 6-11	0.0440[b]
Child 12-19	0.0493[c]
Adult	0.08509[d]

Sources: EPA 2002, 2008a

[a] This value was calculated using the ages 3 to 5 sample size for consumers only divided by the sample size for the U.S. population divided by 2 to represent the proportion consuming fish on a single day (the consumers-only group includes individuals who consumed fish on at least one of two survey days) to match the one-day ingestion rate.

[b] As in footnote a, the value was calculated using the ages 6 to 10 sample size for consumers only divided by the sample size for U.S. population divided by 2.

[c] The value was calculated by summing the ages 11 to 15 and 16 to 17 sample sizes for consumers only and dividing by both by the sum of the sample sizes for U.S. population and by a factor of 2.

[d] The value was calculated using the ages 18 and older sample size for consumers only divided by the sample size for U.S. population from Section 5.1.1.1 Table 4. The result was divided by 2 to represent a one-day sampling period in order to match the one-day ingestion rate.

Exhibit B-21. Calculated Long-term Mean and Percentile *per capita* Fish Ingestion Rates for Children and Adults ($IR_{PC,y}$)

Lifestage (years)	Ingestion Rates, All Fish (g/day)				
	Mean	50th	90th	95th	99th
Child <1	NA	NA	NA	NA	NA
Child 1-2[a]	1.37	0.79	3.24	4.41	6.98
Child 3-5[b]	2.03	1.16	4.79	6.51	10.3
Child 6-11[c]	2.71	1.25	6.90	10.9	17.0
Child 12-19[d]	3.90	2.13	8.95	10.4	20.9
Adult[e]	6.90	4.03	16.99	23.73	43.02

Sources: EPA 2002, 2008a

NA = not applicable; it is assumed that children < 1 year of age do not consume fish.

[a] Values were calculated as (consumer-only IR for Child 1-2) x (fraction of population consuming fish for Child 3-5).

[b] Values were calculated as (consumer-only IR for Child 3-5) x (fraction of population consuming fish for Child 3-5).

[c] Values were calculated as (consumer-only IR for Child 6-11) x (fraction of population consuming fish for Child 6-11).

[d] Values were calculated as (consumer-only IR estimated for Child 12-19) x (fraction of population estimated to consume fish for Child 12-19).

[e] Values were calculated as (consumer-only IR for Adults) x (fraction of population consuming fish for Adults).

MIRC also includes values for the mean and the 90th percentile fish ingestion rates for recreational fishers, black and female recreational fishers, and fishers of Hispanic, Laotian, and Vietnamese descent which are shown in Exhibit B-22. These latter three populations are culturally or economically disposed to higher rates of fish ingestion than the general population. Recreational fisher values are from the EFH (EPA, 2011a). Black and female recreational fishers ingestion rates are presented in Burger (2002). The fish ingestion rates for Hispanic, Laotian, and Vietnamese populations were derived from a study by Shilling *et al*. (2010) of contaminated fish consumption in California's Central Valley Delta. Shilling *et al*. (2010) reported mean and 95th percentile ingestion rates for each subpopulation. In part due to the low sample size in the Shilling study (n of 30 to 45), 95th percentile values were believed to be unrealistically high. The 90th percentile ingestion rate estimates presented in Exhibit B-22 for Hispanic, Laotian, and Vietnamese fishers were derived by EPA using information from Shilling *et al*. (2010; EPA, 2010).

Exhibit B-22. Calculated Mean and 90th Percentile Per capita Fish Ingestion Rates for Populations of Recreational Fishers ($IR_{PC,y}$)

Subpopulation							
Percentile	Units	Recreational Fisher[a]	Female Recreational Fisher[b]	Black Recreational Fisher[b]	Hispanic Recreational Fisher[c]	Laotian Recreational Fisher[c]	Vietnamese Recreational Fisher[c]
Ingestion of Fish							
Mean	g/day	8	39.1	171	25.8	47.2	27.1
90th	g/day	11	123	446	98	144.8	99.1

[a] 1997 Exposure Factors Handbook (USEPA, 1997a)
[b] Burger (2002) weights are "as consumed" for locally caught fish.
[c] Shilling, F., A. White, L. Lippert, and M. Lubell. 2010. Contaminated fish consumption in California's Central Valley Delta. Environmental Research 110:334-344.

Applications to date of MIRC have used whole fish concentrations estimated by TRIM.FaTE. The proportion of lipid in TL3 and TL4 fish in TRIM.FaTE is assumed to be 5.7 percent (by weight) for the whole fish, based on information provided by Thomann (1989). The lipid content of the part(s) of the fish normally consumed is likely to be less than 5.7 percent. For example, EPA estimated a consumption-weighted mean lipid value for fillets of fish from TL3 to be 2.6 percent and from TL4 to be 3.0 percent (Table 6-9 in EPA 2003b). If a user of MIRC wishes to account for reduced chemical concentration in fillet compared with whole fish for lipophilic chemicals, the user can specify a "preparation" loss of chemical (see Section 6.4 of this attachment).

For lipophilic chemicals (e.g., log K_{ow} greater than 4), which partition primarily into the fatty tissues of fish, much of the higher concentration tissues might be stripped from the fish during preparation (e.g., belly fat, viscera which includes fat in liver, etc., fat under skin). The degree to which the concentration of chemical in a fillet is less than the average total concentration in the whole fish is chemical specific. Assuming the chemical concentration in the fillet is the same as in the whole fish may result in a health protective bias for highly lipophilic chemicals. For persons who prefer to consume fillets with the skin on and do not discard belly fat, assuming the same concentration of chemical in the fish consumed as in the whole fish also is protective.

6.3.5. Soil Ingestion Rates

Adult gardeners and farmers may incidentally ingest soils from gardening activities, and gardening and farming families might ingest soil particles that adhere to exposed fruits and exposed and belowground vegetables. Soils that are re-suspended in the air by wind can resettle on exposed fruits and vegetables. Children may incidentally ingest soils in those ways, but in addition, children playing outdoors may ingest soils directly or by hand-to-mouth activities during play. MIRC includes soil ingestion rate options by age group for these types of exposures. MIRC does not include options for children who may exhibit pica, or the recurrent ingestion of unusually high amounts of soil (i.e., on the order of 1,000 - 5,000 mg/day or more) (EPA 2008a).

Data on soil ingestion rates are sparse; the soil ingestion rates listed in Exhibit B-23 and included in MIRC are based on very limited data, as is evident from the values listed. The studies evaluated by EPA for children generally focused on children between the ages of 1 and 3 to 6 years and were not specific to families that garden or farm. The default ingestion rates in MIRC are the 90th percentile values, as for other ingestion rate parameters.

Exhibit B-23. Daily Mean and Percentile Soil Ingestion Rates for Children and Adults

Age Group (years)	Soil Ingestion Rate (mg/day)				
	Mean[a]	50th [a]	90th	95th	99th
Child < 1	NA				
Child 1-2	50	50	200[b]	200[b]	200[b]
Child 3-5	50	50	200[b]	200[b]	200[b]
Child 6-11	50	50	201[c]	331[d]	331[d]
Child 12-19	50	50	201[c]	331[d]	331[d]
Adult 20-70	20	20	201[c]	331[d]	331[d]

Sources: EPA 2008a, EPA 2011a

[a] For mean and 50th percentile soil ingestion rates for children, value represents a “central tendency” estimate from EPA’s 2008 CSEFH, Table 5-1. For adults, value is the recommended mean value for adults from EPA’s 2011 EFH, Chapter 5, Table 5-1.

[b] Values are the recommended “upper percentile” value for children from EPA’s 2011 EFH, Chapter 4, Table 4-23. The 2008 CSEFH and 2011 EFH included a high-end value associated with pica only, but this value has not been used.

[c] Values are 90th percentile adult ingestion rates calculated in Stanek et al. 1997; used to represent older children and adults.

[d] Values are 95th percentile adult ingestion rates calculated in Stanek et al. 1997; used to represent older children and adults.

6.3.6. Total Food Ingestion Rates

Although not included in MIRC for deterministic screening-level exposure and risk assessments, total food ingestion rates would be included in any probabilistic module developed for MIRC. The total food ingestion rates presented in Exhibit B-24 will be used to normalize or to truncate the sum of food-specific ingestion rates to reasonable values. This procedure is particularly important when chemical intake from multiple upper-percentile food ingestion rates for different types of food are added together. Individuals representing the upper percentile ingestion rate for one food category might not be the same individuals who reported high percentile ingestion rates for one or any of the other food categories.

Exhibit B-24. Daily Mean and Percentile *Per Capita* Total Food Intake for Children and Adults

Lifestage (years)	Percent of Group Consuming Food	Mean	50th	90th	95th	99th
Total Food Intake (g/day, as consumed)						
Child < 1[a]	67.0% - 99.7% [h]	322	270	599	779	1152
Child 1-2[b]	100%	1,032	996	1537	1703	2143
Child 3-5[c]	100%	1,066	1,020	1,548	1,746	2,168
Child 6-11[d]	100%	1,118	1,052	1,642	1,825	2,218
Child 12-19[e]	100%	1,197	1,093	1,872	2,231	2,975
Adult[f]	100%	1,100	1,034	1,738	2,002	2,736
Total Food Intake (g/kg-day, as consumed)						
Child < 1[a]	67.0% - 99.7% [h]	39	34	72	95	147
Child 1-2[b]	100%	82	79	125	144	177
Child 3-5[c]	100%	61	57	91	102	132
Child 6-11[d]	100%	40	38	61	70	88
Child 12-19[e]	100%	21	19	34	40	51
Adult[g]	100%	14.8	13.9	23.7	27.6	35.5

Sources: EPA 2005e, 2008a

[a] These values represent a time-weighted average for age groups birth to <1 month (N=88), 1 to <3 months (N=245), 3 to <6 months (N=411), and 6 to <12 months (N=678) from Table 14-3 of the 2008 CSEFH.

These values represent a time-weighted average for age groups 1 to <2 years (N=1,002) and 2 to <3 years (N=994) from Table 14-3 of the 2008 CSEFH.

[c] These values were obtained from Table 14-3 of the 2008 CSEFH (age group 3 to <6 years, N=4,112).

[d] These values were obtained from Table 14-3 of the 2008 CSEFH (age group 6 to <11 years, N=1,553). These values represents a health protective (i.e., slightly low) estimate for ages 6 through 11 years since 11-year olds are not included in this CSEFH age group.

[e] These values represent a time-weighted average for age groups 11 to <16 years (N=975) and 16 to <21 (N=743) years from Table 14-3 of the 2008 CSEFH. Note that estimated values include 11-year-olds and individuals through age 20, which contributes to uncertainty in the estimates.

[f] These values represent a time-weighted average for age groups 20 to 39 years (N=2,950) and 40 to 69 years (N=4,818) from Table 5B of the 2005 EPA analysis of CSFII.

[g] These values represent a time-weighted average for age groups 20 to 39 years (N=2,950) and 40 to 69 years (N=4,818) from Table 5A of the 2005 EPA analysis of CSFII.

[h] Percents consuming foods from Table 14-3 of the 2008 CSEFH include: 67.0% (birth to <1 month); 74.7% (1 to <3 months); 93.7% (3 to <6 months); and 99.7% (6 to <12 months). Infants under the age of 1 that consume breast milk are classified as "non-consumers" of food.

6.4. Other Exposure Factor Values

The other exposure parameters included in the MIRC algorithms are exposure frequency (Section 6.4.1), fraction of the food type obtained from the contaminated area (Section 6.4.2), and reduction in the weight of the food types during preparation and cooking (Section 6.4.3). For the breast milk ingestion pathway, additional exposure parameters are included in the FFC algorithms (Section 6.5).

6.4.1. Exposure Frequency

The exposure frequency (EF) represents the number of days per year that an individual consumes home-produced food items that are contaminated with the chemical being evaluated. In MIRC, the default value for EF is 365 days/year for all exposure sources and all potential receptors. This assumption is consistent with the food ingestion rates used in MIRC (i.e., daily intake rates equivalent to annual totals divided by 365 days) and does not imply that residents necessarily consume home-produced food products every day of the year.

If the user wishes to evaluate daily intake rates based on shorter averaging times, the user can overwrite both the food-specific ingestion rates and the EF for each home-grown food product. Users of MIRC might want to specify a lower EF values for various food types where residents obtain some of their diet from commercial sources and where consumption of home grown produce is seasonal.

6.4.2. Fraction Contaminated

The fraction contaminated (FC) represents the fraction of each food product consumed that is contaminated by the chemical at a level consistent with environmental concentrations in the area of concern (e.g., area with maximum deposition rates). Obviously, the most health protective assumption is that all food products consumed (i.e., 100 percent) are from the location represented by the chemical concentrations input into MIRC.

For non-infant children and the adult age cohorts, MIRC includes the default FC of 1, assuming that 100 percent of the food product consumed is produced by households that farm, garden, or raise animals. The user can vary this default FC value for individual food products to tailor the assessment to a particular exposure scenario.

6.4.3. Preparation and Cooking Losses

Food preparation and cooking losses are included in the FFC exposure calculations to account for the amount of a food product as brought into the home that is not ingested due to loss during preparation, cooking, or post-cooking. These losses need to be accounted for in the ADD equations because the food ingestion rates calculated from the USDA 1987 to 1988 NFCS are based on the weight of home grown produce and animal products brought from the field into the house prior to any type of preparation. Not all of the produce or products were eventually ingested. In general, some parts of the produce and products are discarded during preparation while other parts might not be consumed even after cooking (e.g., bones). Thus, the actual food ingested is generally less than the amount brought into the home.

Three distinct types of preparation and cooking losses are included in the ingestion exposure algorithms in MIRC: (1) loss of parts of the food type from paring (i.e., removing the skin from vegetables and fruits) or other types of preparation (e.g., removing pits, coring, deboning), (2) additional loss of weight for the food type during cooking (e.g., evaporation of water), and (3) post-cooking losses (e.g., non-consumption of bones, draining cooking liquid [e.g., spinach]). MIRC includes mean values for these three types of preparation and cooking losses for exposed fruit, protected fruit, exposed vegetables, protected vegetables, root vegetables, beef, pork, poultry, and fish. Different types of losses apply to different types of foods. Therefore, the losses can be represented by only two parameters, *L1* and *L2*, the definitions of which vary according to the food type as explained in the endnotes in Exhibit B-25. All preparation and cooking loss parameter values were estimated as specified in the exhibit's endnotes from data presented in Chapter 13 of the EPA's 1997 and 2011 EFH (EPA 1997a and 2011a).

Exhibit B-25. Fraction Weight Losses from Preparation of Various Foods

Product	Mean Cooking, Paring, or Preparation Loss (Cooking Loss Type 1 [L1]) (unitless)[a]	Mean Net Post Cooking (Cooking Loss Type 2 [L2]) (unitless)[b]
Exposed Fruit[c]	0.244	0.305
Exposed Vegetable	0.162[d]	NA
Protected Fruit	0.29[e]	NA
Protected Vegetable	0.088[f]	NA
Root Vegetable[g]	0.075	0.22
Beef	0.27	0.24
Pork	0.28	0.36
Poultry	0.32	0.295[h]
Fish[i]	0.0	0.0

Source: EPA 1997a and 2011a

NA = Not Available

[a] For *fruits*, includes losses from draining cooked forms. For *vegetables*, includes losses due to paring, trimming, flowering the stalk, thawing, draining, scraping, shelling, slicing, husking, chopping, and dicing and gains from the addition of water, fat, or other ingredients. For *meats*, includes dripping and volatile losses during cooking.

[b] For *fruits*, includes losses from removal of skin or peel, core or pit, stems or caps, seeds and defects; may also include losses from removal of drained liquids from canned or frozen forms. For *vegetables*, includes losses from draining or removal of skin. For *meats*, includes losses from cutting, shrinkage, excess fat, bones, scraps, and juices.

[c] These values represent averages of means for all fruits with available data (except oranges) (Table 13-6).

[d] This value represents an average of means for all exposed vegetables with available data (Table 13-7). Exposed vegetables include asparagus, broccoli, cabbage, cucumber, lettuce, okra, peppers, snap beans, and tomatoes.

[e] This value was set equal to the value for oranges (Table 13-6).

[f] This value represents an average of means for all protected vegetables with available data (Table 13-7). Protected vegetables include pumpkin, corn, peas, and lima beans.

[g] These values represent averages of means for all root vegetables with available data (Table 13-7). Root vegetables include beets, carrots, onions, and potatoes.

[h] This value represents an average of means for chicken and turkey (Table 13-5).

[i] If the user changes fish ingestion rates to match a survey of the whole weight of fish brought into the home from the field (divided by the consumers of the fish), an appropriate value for L1 would be 0.31 and an appropriate L2 would be 0.11 (EPA 2011a).

There are substantial uncertainties associated with the L1 and L2 parameters, including the wide variation in values across produce types that were averaged together to recommend a central tendency value for each. For example, the L2 factor does not distinguish between weight loss during cooking by water evaporation, which might leave the chemical in the food (chemical not lost), and pouring the cooking liquid down the drain (chemical lost) or using the liquid to create a sauce (chemical not lost). In addition, the concentration of chemical might be highest in the skin, which often is discarded, and lower in the consumed portion of many bulky fruits and vegetables. Finally, the data EPA used to evaluate L1 included negative losses (i.e., weight gains) due to hydration of dried vegetables (e.g., peas and lima beans), which increases the range of L1 values across different vegetables.

Note that the default L1 and L2 values for fish are set to zero. That is because the data source for the fish ingestion rates is not the USDA's 1987 to 1988 NFCS (USDA 1993, 1994a) as reported in EPA's EFH, which reported food as brought into the home, as is the case for the other food categories. Instead, the fish IR data included in MIRC are based on parts actually consumed, and so no loss processes for preparation are needed.

If the user manually changes fish ingestion rates to match a local survey of the whole weight of fish brought into the home from the field (divided by number of persons consuming the fish), the user should also set the L1 and L2 parameter to non-zero values.

6.4.4. Food Preparation/Cooking Adjustment Factor (FPCAF) for Fish

In addition to estimating the weight of the food that is lost to preparation and cooking, there also can be changes in the chemical concentrations due to cooking. Because the fish consumption rates are "as consumed" and the fish concentration is based on uncooked fish, adjustments should be made to reflect the chemical concentrations in fish after cooking. In order to account for this phenomenon, an FPCAF can be applied to the uncooked fish concentration to estimate a concentration in cooked fish. The following sections discuss FPCAFs for each of the 4 PB-HAPs.

6.4.4.1. Mercury

In the U.S. EPA Revised Technical Support Document: National-Scale Assessment of Mercury Risk to Populations with High Consumption of Self-caught Freshwater Fish (EPA 2011b), a food preparation/cooking adjustment factor (FPCAF) of 1.5 was used to adjust methyl-mercury (MeHg) concentrations in consumed fish (i.e., a 50% increase in MeHg concentration due to cooking). Cooking fish typically increases MeHg levels per unit fish (as consumed) because MeHg concentrates in the muscle, while preparation involves removal primarily of non-muscle elements of the fish. The value is based on a study by Morgan et al. (1997).

6.4.4.2. Cadmium

Similar to mercury, cadmium will bind to muscle and will be retained during the cooking process. As such, the same FPCAF of 1.5 that is used for mercury is assumed for cadmium.

6.4.4.3. Dioxin

Dioxins are lipophilic and have been demonstrated to be lost during cooking. Based on a literature review, an FPCAF of 0.7 to is applied to account for these losses during the cooking process. A brief summary of supporting literature follows.

- Schecter et al. (1998) found that the mass of PCDD and PCDF in fresh catfish fillet (skin on) decreased by about 50 percent per serving portion during cooking. Given the simultaneous losses of moisture/fats during broiling of the catfish, the PCDDs and PCDFs concentrations decreased by 33 percent (i.e., multiply uncooked concentration in fresh fish by a factor of 0.66 = 0.70 to one significant digit).
- Reinert et al. (1972) reported higher losses of another highly lipophilic chemical, DDT, from cooking fish fillets of bloaters, yellow perch, lake trout, and coho salmon. Concentrations of DDT in fish fillet portions for lake trout and coho salmon, top predators, were reduced by 64 to 72 percent by frying or broiling, primarily through preferential loss of fat (and lipophilic DDT) during cooking. The investigators did not report skin on or off; however, they used steak cuts instead of flat fillets, which provide a smaller ratio of skin to muscle than is the case for fillets that constitute one side of the fish.
- Zabik and Zabik (1995) quantified the reduction in TCDD concentration of cooked, with the skin off, fillets compared with uncooked fillet with skin for fish harvested from the Great Lakes. Concentrations in the cooked fish with the skin off were reduced relative to the raw fillet with the skin on by approximately 44 percent for walleye, 80 percent for white bass, and 61 percent for lake trout. Comparing losses of TCDD for fillets cooked with the skin on versus fillets that were both skinned and cooked, Zabik and Zabik (1995) found reductions in TCDD concentrations of approximately 43 percent for Chinook Salmon cooked with the skin on and 57 percent for chinook salmon cooked with

> the skin off. They found a 37 percent reduction of TCDD concentration for carp fillets cooked with the skin on and 54 percent reduction if the skin was removed.

The three studies listed above indicate that the 0.7 factor is not likely to overestimate loss of PCDD/PCDFs from fish during cooking (pan frying, broiling, grilling). Reductions in TCDD concentrations could be much higher with skin removal and trimming of fat.

6.4.4.4. PAHs

While it is reasonable to assume that there might be losses of lipophilic PAHs during the cooking process, there is insufficient information to distinguish what the net loss (or gain) during cooking might be because cooking can create PAHs from proteins in the tissue. The literature acknowledges these competing forces, but does not provide information to disentangle the gain and loss mechanisms. As such, a neutral approach was taken, which is to assume an adjustment factor of 1.0 (i.e., no adjustment) for PAHs.

6.5. Breast-Milk Infant Exposure Pathway Parameter Values

Values used for parameters in the breast-milk exposure pathway algorithms (see Section 3.4 of this attachment) can be scenario-specific, receptor-specific, and/or chemical-specific and might be empirically derived or estimated by an appropriate model. For parameters that are scenario-specific or for which empirical values are required, the default values provided in MIRC are listed. For parameters for which MIRC calculates values, the appropriate equation is listed. Scenario- and receptor-specific parameters are discussed in Section 6.5.1 and chemical-specific parameters are discussed in Section 6.5.2.

6.5.1. Receptor-specific Parameters

Receptor-specific values are needed for parameters that describe the characteristics or activities of the exposed individual. In this context, there are two relevant receptors: the mother and the infant. Exhibit B-26 lists the parameters and their default values. The text that follows describes the input value or value options for each exposure parameter required by MIRC to calculate the infant absorbed chemical intake rate, or DAI_{inf}. For parameter values that can be estimated when empirical values are not available, see the equation description in Section 3.4 of this attachment.

Exhibit B-26. Scenario- and Receptor-Specific Input Parameter Values Used to Estimate Infant Exposures via Breast Milk

Parameter	Description	Default Value
AT	Averaging time for infant's exposure via breast milk, i.e., duration of nursing (days)	=ED
BW_{inf}	Body weight of infant (kg) averaged over duration of nursing exposure	7.8
BW_{mat}	Body weight of mother (kg) averaged over duration of mother's exposure	66
DAI_{mat}	Daily absorbed intake of chemical by mother (mg/kg-day)	Equation B-36
ED	Exposure duration for infant, i.e., duration of breast feeding (days)	=AT
AT/ED	Averaging time divided by exposure duration	1.0
f_{bp}	Fraction of mother's whole blood that is plasma (unitless)	0.65
f_{fm}	Fraction of mother's body weight that is fat (unitless)	0.30
f_{mbm}	Fraction of fat in mother's breast milk (unitless)	0.04
f_{pm}	Fraction of mother's body weight that is plasma (unitless)	0.046
IR_{milk}	Mean infant milk ingestion rate over duration of nursing (kg/day)	0.709
t_{bf}	Duration of breast feeding (days)	365
t_{pn}	Duration of maternal chemical exposure prior to nursing (days)	3285

Averaging time (*AT*) and exposure duration (*ED*). AT refers to the time over which the infant's exposure to the chemical of concern is averaged. *ED* refers to the duration of the infant's exposure. For the exposure scenario considered for this age group, both *AT* and *ED* equal the duration of the nursing period, and they therefore cancel each other out in the infant average daily dose equation.

Infant body weight (BW_{inf}). The user selects a value for BW_{inf}, the time-weighted average body weight of the infant over the entire duration of breast feeding, based on the age at which the infant stops breast feeding. For example, if the infant breast feeds for one year, the user should select the body weight for an infant that is averaged from birth to the first birthday. Similarly, if an infant breast feeds for 6 months, the user should select the body weight for an infant that is averaged from birth to six months. Because the default breast feeding duration (t_{bf}) is one year (i.e., 365 days), the default infant body weight is 7.8 kg, which is the time-weighted average for the mean infant body weight between birth and the first birthday from EPA's 2008 *Child Specific Exposure Factors Handbook* (CSEFH; EPA 2008a). Exhibit B-27 presents additional values for the infant body weight parameter that the user can select instead of the MIRC default.

Exhibit B-27. Average Body Weight for Infants

Statistic	0 to < 6 months (kg)	0 to < 12 months (kg)	0 to < 18 months (kg)	0 to < 24 months (kg)
Mean	6.5	7.8[a]	9.0	9.6
5th percentile	5.0	6.0	7.0	7.5
10th percentile	5.3	6.4	7.4	7.8
15th percentile	5.5	6.7	7.7	8.2
25th percentile	5.8	7.0	8.1	8.7
50th percentile	6.4	7.8	8.9	9.5
75th percentile	7.1	8.6	9.9	10.5
85th percentile	7.4	9.0	10.3	11.0

Exhibit B-27. Average Body Weight for Infants

Statistic	0 to < 6 months (kg)	0 to < 12 months (kg)	0 to < 18 months (kg)	0 to < 24 months (kg)
Mean	6.5	7.8[a]	9.0	9.6
90th percentile	7.7	9.2	10.6	11.3
95th percentile	8.0	9.7	11.1	11.8

Source: EPA (2008a); each value is the time-weighted average from the data summaries presented in the CSEFH, Table 8-3.
[a] MIRC default

Maternal body weight (BW_{mat}). This parameter represents the body weight of the mother averaged over the entire duration of the mother's exposure to the chemical of concern. The maternal body weight is needed to calculate the biological elimination constant for the lipophilic chemical in lactating women (k_{fat_elac}). MIRC assumes that the mother will be pregnant for 9 months (i.e., 0.75 year) and will be lactating for 1 year. The MIRC default maternal body weight also assumes that the mother has been exposed for 10 years total. For 8.25 years, she is not pregnant or lactating, for 0.75 year she is pregnant, and for 1 year she is lactating. The MIRC default BW_{mat} of 66 kg is based on CSFII data compiled by EPA for non-lactating and non-pregnant women between the ages of 15 and 44 (i.e., women of child-bearing age), lactating women, and pregnant women (EPA 2004). Exhibit B-28 presents additional values for the maternal body weight parameter which the user may choose to use instead of the MIRC default. The BW_{mat} value is *not* the value that MIRC uses to estimate the mother's absorbed daily intake (DAI_{mat}). The daily ingestion rates for home-grown/raised food products in MIRC are for men and women combined, with the rates normalized to body weight. The ingestion rates for soil, water, and fish included in MIRC are not normalized to body weight but are based on both men and women. For those ingestion rates, MIRC uses an average body weight value for males and females to estimate the average daily dose (intake) of the chemical in mg/kg-day. These values are subject to the assumption that the body-weight normalized ingestion rates and resulting ADD values are applicable to nursing mothers.

Exhibit B-28. Time-weighted Average Body Weight for Mothers

Statistic	Weight (kg)
Mean	66.0[a]
5th	47.1
10th	50.2
25th	54.3
50th	62.0
75th	72.0
90th	85.7
95th	97.0

Source: EPA 2004
[a] MIRC default value

Exposure duration (*ED*). See discussion of *AT* and *ED* above.

Fraction of mother's whole blood that is plasma (f_{bp}). Steinbeck (1954) reported that plasma volume accounts for approximately 60 percent of the total blood volume in non-lactating human females (EPA 1998). Harrison (1967) and Ueland (1976) reported plasma volumes between 63 to 70 percent in postpartum women (EPA 1998). The default value in MIRC of 65 percent (0.65) is the value recommended by EPA in its *Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions* (MPE, EPA 1998).

Fraction of mother's body weight that is fat (f_{fm}). A limitation of using a steady-state, instead of a dynamic partitioning, model for lactational transfer of chemicals is that several key parameters change over the course of exposure. For example, Equation B-38, used to estimate the concentration of a lipophilic chemical in breast milk fat, assumes that the mother's body fat will remain constant over the entire duration of breast feeding (t_{bf}), which is unlikely to be true (EPA 2001a). Another limitation of the single analytic model is that chemical transfer rates from blood to milk are unlikely to be the same as the rate of mobilization of the chemical from fat stores to the blood (EPA 2001a). Studies cited in ATSDR's toxicological profile for chlorinated dibenzo-p-dioxins show a correlation between percent body fat and the elimination rate of dioxins, with longer half-lives for dioxins in individuals with a higher proportion of fat in their bodies (ATSDR 1998). In the context of a screening model, however, EPA recommends a default value for the fraction of a mother's body comprised of fat of 0.3 based on data and discussions presented by Smith (1987) and Sullivan *et al*. (1991) (EPA 1998). A fraction of 0.3 indicates that 30 percent of the mother's body weight is fat, which is a health protective value (EPA 2001a). To establish a health protective screening scenario, the MIRC default value for f_{fm} is 0.30**.**

Fraction of fat in mother's breast milk (f_{mbm}). The $C_{milkfat}$ model (Equation B-38) assumes that a constant fraction of breast milk is fat, even though there is evidence that indicates variation in the fat content of breast milk throughout lactation (Sim and McNeil 1992). Different studies suggest a fat content of breast milk in humans of between 1 and 5 percent (Jensen 1987, Schecter *et al*. 1994, Hong *et al*. 1994, McLachlan 1993, Bates *et al*. 1994, NAS 1991, Butte *et al*. 1984, Maxwell and Burmaster 1993, EPA 2011a, Smith 1987, Sullivan *et al*. 1991). The MIRC default value for f_{mbm} of 0.04 (i.e., 4 percent) is the value EPA recommended for MPE (EPA 1998).

Fraction of maternal weight that is plasma (f_{pm}). Altmann and Dittmer (1964) estimated that plasma volume for adult women ranged from 37 to 60 mL/kg of body weight and averaged about 45 mL/kg. Ueland (1976) observed that the average plasma volume of women 6 weeks postpartum was 45 mL/kg of body weight. Using a value of 1.026 for the specific gravity of plasma from Conley (1974), EPA estimated a value of 0.046 for the fraction of maternal weight that is plasma (EPA 1998). The MIRC default for f_{pm} therefore is 0.046.

Infant breast milk ingestion rate (IR_{milk}). Milk ingestion rates vary with several factors, including the age and size of the infant and use of other foods such as formula. Based on its review of a several studies, EPA recommended time-weighted average and upper percentile milk ingestion rates for infants that nurse for six and for twelve months (EPA 2011a, Table 15-3). To estimate an "average" value, EPA first estimated study-sample-size weighted average values for 1 through 12 months of age and then developed time-weighted average milk ingestion rates from those (EPA 2011a). EPA estimated an upper percentile (upper bound) value as the mean plus two standard deviations. MIRC converts the ingestion rates measured volumetrically (mL/day) to mass-based estimates (kg/day) assuming the density of human milk to be 1.03 g/mL (reported by NAS 1991 and recommended by EPA 2011a). The resulting values are shown in the first two rows of Exhibit B-29. The MIRC screening-level default of 980 mL/day is an upper-bound estimate based on a one-year nursing period.

Exhibit B-29 also includes the recommended values for four non-overlapping age categories from the CSEFH (EPA 2008a, Table 15-1). The values demonstrate that although infants grow substantially from birth to one year of age, the "upper bound" estimates of their milk ingestion rates are very close to 1 liter per day at all stages of development in the first year.

Exhibit B-29. Infant Breast Milk Intake Rates

Age Category	Average (mL/d)	Average (kg/d)	"Upper Bound" (mL/d)	"Upper Bound" (kg/d)	Reference
1 to 6 months	742	0.764	1,033	1.064	EPA 2011a[†]
0 to < 12 months	688	0.709	980[a]	1.01[a]	EPA 2011a[†]
0 to < 1 month	510	0.525	950	0.979	EPA 2008a[††]
1 to < 3 months	690	0.711	980	1.01	EPA 2008a[†]
3 to < 6 months	770	0.793	1,000	1.03	EPA 2008a[†]
6 to < 12 months	620	0.639	1,000	1.03	EPA 2008a[†]

[a]MIRC default; [†] Based on review of multiple studies; [††] Based on a single study

Duration of breast feeding (t_{bf}). This parameter is equal to the infant's exposure duration (*ED*) and the infant's averaging time (*AT*). In its MPE Methodology, EPA asserts a health protective value for the duration of breast feeding of 1 year (i.e., 365 days) and a central tendency estimate of 6 months (180 days) (EPA 1998). Reviewers of MPE noted that 365 days may be overly health protective, given that only 20 percent of infants are breast fed for 6 months, at which point alternative foods are introduced, at least in addition to breast milk (EPA 2001a). Nonetheless, to establish a health protective screening scenario, the MIRC default for t_{bf} is 365 days.

Duration of the mother's exposure to the chemical of concern prior to nursing (t_{pn}). The model shown as Equation B-38 includes this parameter to reduce the over-estimate of chemical concentration in milk fat that occurs if the model is applied to a chemical with a long biological half-life (e.g., many years). The factor is needed for applications of the model to scenarios with a brief exposure duration (e.g., beginning a few months prior to the start of nursing) relative to the chemical half-life. As the duration of an exposure scenario increases to meet and exceed the chemical half-life, however, the overestimate that occurs without this parameter is reduced. For example, assume a chemical biological half-life of 8 years and a nursing period of 1 year. If exposure of the mother starts at the beginning of nursing, using Equation B-38 without the t_{pn} term results in an over-estimate of the concentration of the chemical in breast milk by a factor of 28.1 compared with the prediction using Equation B-38 with the t_{pn} term (EPA 1998, Table 9-6). However, at longer pre-natal exposures of the mother, the magnitude of the over-estimate is reduced: for a 10-year exposure, the magnitude of the overestimate without the t_{pn} term is 2.28, and for a 30-year exposure, the overestimate is reduced to 1.39.

For purposes of the screening-level assessment, we assume an exposure duration equal to the MIRC default half-life for dioxins, or 10 years. Only 3,285 days of that period are pre-natal (i.e., 3650 minus 365 days, assuming 1 year lactation period). Although longer exposure periods are possible for the screening scenario, there is sufficient uncertainty in the model to merit accepting a health protective bias for this parameter value.

6.5.2. Chemical-Specific Parameter Values

The chemical-specific parameters in the breast-milk pathway in MIRC are listed in Exhibit B-30. Note that the parameters for which values are needed are different for the lipophilic chemicals (i.e., dioxins), for which lactational transfer is assumed to occur via milk fat, and inorganic chemicals, for which the transfer is assumed to occur via the aqueous phase of breast milk (i.e., mercury). All dioxin congeners were assumed to manifest identical values as TCDD in regard to breast milk-related parameters.

Exhibit B-30. Chemical-specific Input Parameter Values for Breast Milk Exposure Pathway

Parameter and Description		2,3,7,8-TCDD	MeHg
AE_{inf}	Infant absorption efficiency of the chemical by the oral route of exposure (i.e., fraction of ingested chemical that is absorbed by the infant; unitless)	1.0 (default)	1.0 (default)
AE_{mat}	Maternal absorption efficiency of the chemical by the oral route of exposure (i.e., fraction of ingested chemical that is absorbed by the mother; unitless)	1.0 (default)	1.0 (default)
f_{bl}	Fraction of steady-state total body burden of hydrophilic chemical in mother that is in the mother's whole blood compartment (unitless)	NA	0.059 (Kershaw *et al*. 1980)[a]
f_f	Fraction of steady-state lipophilic chemical body burden in mother that is stored in body fat (unitless)	≥0.90 (ATSDR 1992)	NA
$f_{\mathbf{pl}}$	Fraction of steady-state total hydrophilic chemical body burden in mother that is in the blood plasma compartment (unitless)	NA	Not yet identified[b]
h	Biological half-life for chemical in non-lactating women (days)	3650 (EPA 1994c)	50 (Sherlock *et al*. 1984)
k_{aq_elac}	Rate constant for total elimination of hydrophilic chemicals by lactating women (per day)	NA	$= k_{elim}$
k_{elim}	Rate constant for elimination of chemical for non-lactating women (per day; related to chemical half-life)	1.9E-04[b]	1.4E-02 [c]
k_{fat_elac}	Rate constant for total elimination of lipophilic chemicals by lactating women (per day)	Est. using Equation B-41	NA
Pc_{bm}	Partition coefficient for hydrophilic chemical between maternal *blood plasma* and aqueous phase of breast milk (g milk/g plasma; model assumption)	NA	1.0 (model assumption)
Pc_{RBC}	Partition coefficient for hydrophilic or protein-bound chemical between *red blood cells* (RBC) and *plasma* in maternal blood (mL whole blood/mL RBC)	NA	40 (Hollins *et al*. 1975)

NA = not applicable. ND = not yet determined from literature.

[a] This value is based on a single-dose study and may not be appropriate for a chronic exposure model.

[b] An empirical value for this variable is currently missing for application of model.

[c] This value was calculated from biological half-life (*h*) using Equation B-40.

Absorption efficiency of the chemical by the oral route of exposure for the infant (AE_{inf}). The models included in MIRC assume that the AE_{inf} from the lipid phase of breast milk is equal to the AE_{inf} from the aqueous phase of the milk. Reviewers of the model stated that this assumption may not be valid and that ideally, the equation DAI_{inf} would include variables for the AE_{inf} from the breast milk fat and the AE_{inf} from the aqueous phase of breast milk (EPA 2001a). However, since the MIRC assumption is that chemicals will partition to either the lipid or aqueous phase of milk, it is not necessary at this time to have multiple AE_{inf} values for a given chemical. If data on the AE from the mother or an adult but not for the infant are available, data for the adult may be used for AE_{inf}. Reviewers also recommended that chemical-specific values come from studies that account for absorption of the chemical from milk, because absorption from other matrices (e.g., solid foods) may not be relevant (EPA 2001a). If chemical-specific data are not available for adults or infants, a health protective default value for AE_{inf} for a screening level assessment is 1.0, which assumes 100 percent absorption (EPA 1998).

The default value for AE_{inf} in MIRC for both MeHg and dioxin is 1.0. For ingested lipophilic chemicals, it is reasonable to assume that absorption will be high (EPA 2004c). ATSDR (1998) reported that dioxins are well absorbed by the oral route of exposure, with one human experiment indicating more than 86 percent absorption. It is EPA policy to assume 100 percent absorption for chemicals with reported *AEs* of 50 percent or higher (EPA 2004c). MeHg also is well absorbed, with measured values as high as 95 percent, and so a value of 100 percent is used in MIRC (EPA 2001b).

Absorption efficiency of the chemical by the oral route of exposure for the mother (AE_{mat}). The default value for both dioxins and MeHg is 1.0, as described in the previous paragraph.

Fraction of total maternal chemical body burden that is in the whole blood (f_{bl}). The default value for MeHg in MIRC, 0.059, is from Kershaw *et al*. (1980), which reported kinetics of blood deposition and clearance of MeHg in humans. Individuals consumed one meal of fish that contained between 18 and 22 µg Hg/kg body weight. The fraction of the dose deposited in the blood volume after mercury was fully distributed in tissues was 5.9 percent or 0.059. This study used a single-dose and thus may not be appropriate for a chronic exposure analysis.

Fraction of total maternal chemical body burden that is in body fat (f_f). Based on ATSDR's *Toxicological Profile for Selected PCBs* (ATSDR 1992) and Sullivan *et al*. (1991), EPA concluded that the "fraction of ingested contaminant stored in fat may be >90%" for lipophilic chemicals such as PCBs and dioxins (EPA 1998). This statement was interpreted to mean that 90 percent of the maternal body burden of chemical at "steady state" is located in body fat for dioxins at steady state.

Fraction of total maternal chemical body burden that is in blood plasma (f_{pl}). For hydrophilic chemicals, this parameter represents the steady-state fraction of the total chemical in the body that is circulating in the blood plasma. Values for f_{pl} may be available for some chemicals in the scientific literature. No value for this parameter for methyl mercury has been identified from the literature at this time. A value can be calculated using Equation B-43. However, this equation requires a reliable value for f_{bl}, and the value found for mercury may not be appropriate for a chronic exposure analysis (see above).

Chemical half-life in non-lactating women (h). In general, highly lipophilic chemicals tend to have relatively long biological half-lives. EPA estimates that the half-life for dioxins is between 7 and 10 years (EPA 1994a). ATSDR estimates that the half-life for 2,3,7,8-TCDD in particular may be as long as 12 years (ATSDR 1998). To establish a health protective screening scenario, the MIRC default half-life for dioxins is set to 10 years or 3650 days.

The half-life for methylmercury is on the order of weeks, not years. Greenwood *et al*. (1978) measured blood clearance rates for MeHg in lactating Iraqi women exposed accidentally to MeHg via bread prepared from wheat treated with a fungicide that contained MeHg. The data indicated a mean half-life for MeHg of approximately 42 days. Sherlock *et al*. (1984) reported an average measured half-life for MeHg of 50 days with a range of 42-70 days. The MIRC default for MeHg is set to the longer average half-life of 50 days.

Chemical elimination rate constant for lactating women – aqueous (k_{aq_elac}). The parameter k_{aq_elac} is equal to k_{elim} plus the loss rate for the chemical in the aqueous phase of breast-milk during lactation. EPA has yet to propose a term for the additional elimination of a chemical in the aqueous phase of milk from breast feeding. In the absence of empirical values, a reasonable assumption for water soluble chemicals is that k_{aq_elac} is equal to k_{elim} as discussed for Equation B-43. The extent to which k_{elim} is an underestimate of k_{aq_elac} for a given chemical will determine the extent of health protective bias in k_{aq_elac}.

Chemical elimination rate constant for non-lactating women (k_{elim}). Although values for this parameter often are reported directly in the literature, MIRC estimates k_{elim} from chemical half-life assuming first-order kinetics as shown in Equation B-40. For example, for a biological half-life of 3,650 days for dioxins, k_{elim} is estimated to be 1.9E-04 per day. Assuming a biological half-life of 50 days for MeHg, the value for k_{elim} is estimated to be 0.014 per day.

Rate constant for total elimination of lipophilic chemicals by lactating women (k_{fat_elac}). Although values for this parameter might be found in the scientific literature for some chemicals, in MIRC, k_{fat_elac} for dioxins is calculated from Equation B-41. When the parameters in that equation are set to the default values in MIRC for dioxins, MIRC estimates a value of 0.0015 per day for k_{fat_elac}.

Partition coefficient for chemical between maternal blood plasma and aqueous phase of breast milk (Pc_{bm}). The aqueous model, presented in Equation B-42, assumes that the concentrations in the plasma and aqueous phase of breast milk are directly proportional (EPA 1998). Therefore, the default value for this parameter for MeHg in MIRC is 1.0.

Partition coefficient for chemical between red blood cells and plasma in maternal blood (Pc_{RBC}). Chemical-specific values for this parameter should be located in the scientific literature. If chemical-specific values are unavailable and it is assumed that there is equal distribution of the chemical in the plasma and red blood cells, EPA suggests a default value of 1.0 (EPA 1998). For MeHg, MIRC includes a value of 40 based on Hollins *et al*. (1975) study of cats exposed to MeHg, which reported a ratio of radio-labeled mercury in red blood cells to plasma of 97.7 to 2.3 (i.e., ratio of 42.5).

7. Summary of MIRC Default Exposure Parameter Settings

The default settings included in MIRC are intended to be characteristic of a health protective (but plausible) exposure scenario that results in a negligible or extremely low chance of underestimating risk. These default parameter values were used to derive the screening threshold emission rates used for screening emissions of PB-HAPs from sources included in RTR risk assessments. These values are the default, or initial setting, for parameter values in MIRC as described in Section 6 of this attachment. This section summarizes the default parameter values used to calculate screening thresholds.

This chapter is organized to present the chemical- and scenario-specific inputs to MIRC by data type. The screening-level analysis uses 90th percentile ingestion rates for soil, breast milk, and farm food items and 99th percentile ingestion rates for fish (presented in Section 7.1) and population-specific characteristic assumptions (presented in Section 7.2), that are generally health protective in nature. Screening thresholds were derived for five RTR chemical species: benzo(a)pyrene, cadmium, mercuric chloride, methyl mercury, and 2,3,7,8-TCDD; Section 7.3 presents chemical-specific parameter inputs for these five chemicals. Finally, Section 7.4 presents default parameter values for the nursing infant exposure scenario, which applied only to dioxin and methyl mercury as discussed in Section 3.4.

7.1. Default Ingestion Rates

The screening-level (or default) values for ingestion rates for soil, breast milk, and for each farm food item are equal to the 90th percentile of the distribution of national data for that ingestion medium. In general, these values were obtained from the 2011 Exposure Factors Handbook or the 2008 Child-Specific Exposure Factors Handbook (see Exhibit B-31). Fish ingestion rates are also available from these sources; however, as described in Section 6.3.4, these sources were not used to obtain fish ingestion rates.

7.1.1. Fish Ingestion Rates

The adult fish ingestion rate was obtained from Burger (2002), a study that examined daily consumption of wild-caught fish for high-end recreationalists (white, black and female) in South Carolina. For female high-end consumers of wild-caught fish, Burger identified average and higher-percentile consumption rates as follows: 39.1 g/day (mean), 123 g/day (90th percentile), 172 g/day (95th percentile), and 373 g/day (99th percentile). As shown in Exhibit B-31 and discussed in Section 6.3.4, for adults, the rate of fish ingestion assumed in the screening scenario is 373 g/day, which corresponds to the 99th percentile value estimated by Burger for adult females. This value was selected to be representative of subsistence fishers.

For the child age groups, as discussed in Section 6.3.4, the baseline fish ingestion rates for the screening scenario are based on “as prepared” total freshwater/estuarine fish ingestion rates at the 99th percentile of the distribution for the *consumer-only* population (i.e., inclusive only of people who consume fish, rather than per-capita rates, which include both consumers and non-consumers), as estimated in EPA (2002), Section 4.2.1.1. Some adjustments were necessary because the age groups evaluated for RTR (which correspond to the age groups for which farm food ingestion rates are available) do not all directly correspond to the age groups in the EPA (2002) report. As described in Section 6.3.4, these adjustments convert the available age-specific data on fish ingestion rates to the age-specific values needed for MIRC.

For the screening-level fish ingestion exposure scenario, the consumer evaluated is an individual who regularly consumes a large amount of fish that he or she has caught locally over the course of a 70-year lifetime. Modeled exposures are intended to encompass those of a subsistence fisher whose diet comprises a substantial proportion of fish. The scenario is not, however, intended to represent the maximum possible exposure an individual subsistence fisher might experience.

Although the fish ingestion rates presented here are representative of the 99th percentile of the evaluated data set, the use of these inputs (compared with 90th percentile values used for other food types) is not considered to be inconsistent. This is due to the idiosyncrasies of the survey data on fish consumption, the fact that the data sets for homegrown foods and fish are not parallel, and the consideration of rates appropriate for subsistence fishers, as described above.

As discussed above, EPA believes that use of these fish ingestion rates strikes the appropriate balance between being health protective and having screening scenarios so conservative that they are of limited use in the decision making process. This high-end fish ingestion rate is appropriate in the context of the conservative screening scenario used in the RTR process and is applicable for national rulemakings given that it is very likely that subsistence woman fishers of child bearing age are located throughout the United States. Using a high-end subsistence fish ingestion rate also is consistent with section 112 of the CAA, which focuses on risks associated with maximally exposed individuals.

7.1.2. Farm Food Chain Ingestion

The default settings assume that all food types are obtained from the area of chemical deposition specified by the user (i.e., fraction of food from contaminated area = 1.0).

For estimates of screening threshold emission rates for PB-HAPS, environmental concentrations and air deposition rates were estimated using TRIM.FaTE for the area of maximal deposition in the vicinity of a hypothetical facility, and thus represent risks estimated for a maximally exposed individual/farm/family.

Exhibit B-31 also includes a sum of the 90th percentile ingestion rates for homegrown food categories and 99th percentile fish ingestion to show the implied total food ingestion rate associated with setting multiple food-type-specific ingestion rates at upper percentiles. Because these upper percentile values for each farm food category are likely to reflect different individuals, it is likely that addition of multiple upper percentile intake values will exceed the total food ingestion rates expected for the general population. This sum is shown on the third row from the bottom (Total Food: Homegrown Only).

The second row from the bottom presents the 90th percentile of the distribution of *individual total food ingestion rates* from the USDA's 1994-96 and 1998 *Continuing Survey of Food Intakes by Individuals* (CSFII) (USDA 2000) data sets, as analyzed by EPA (EPA 2005e). The total ingestion rate for the farming households (third row from bottom) takes into account the cooking losses typical of each food category to provide a better comparison with the 90th percentile individual total food ingestion rates from CSFII (which are based on consumption of prepared foods). The final row of Exhibit B-31 shows the likely magnitude of the overestimates by age category by presenting the ratio of the two preceding rows. The values in this row demonstrate the potential for overestimating intake by using upper percentile values for all food groups. This bias may be considered when evaluating the results estimated by MIRC.

Exhibit B-31. Farm Food Category Ingestion Rates for Health Protective Screening Scenario for Farming Households

Product	Screening-Level Consumer Ingestion Rate						Units
	Infants <1 yr	Child 1–2 yrs	Child 3–5 yrs	Child 6–11 yrs	Child 12–19 yrs	Adult 20–70 yrs	
Farm Food Item							
Beef[a]	NA	9.49	8.83	11.4	3.53	4.41	g/kg-day
Dairy[b]	NA	185	92.5	57.4	30.9	6.16	g/kg-day
Eggs[a]	NA	4.90	3.06	1.90	1.30	1.31	g/kg-day
Exposed Fruit[a]	NA	12.7	5.41	6.98	3.41	2.37	g/kg-day
Exposed Vegetable[a]	NA	10.7	3.47	3.22	2.35	3.09	g/kg-day
Pork[a]	NA	4.90	4.83	3.72	3.69	2.23	g/kg-day
Poultry[a]	NA	7.17	6.52	4.51	3.13	2.69	g/kg-day
Protected Fruit[a]	NA	44.8	32.0	23.3	7.44	15.1	g/kg-day
Protected Vegetable[a]	NA	3.88	2.51	2.14	1.85	1.81	g/kg-day
Root Vegetable[a]	NA	7.25	4.26	3.83	2.26	2.49	g/kg-day
Other							
Breast milk[c]	1.01	NA	NA	NA	NA	NA	kg/day
Soil (dry)	NA	200[d]	200[d]	201[e]	201[e]	201[e]	mg/day
Fish (per individual)[f]	NA	107.7[g]	159.0[g]	268.2[h]	331.0[h]	373	g/day

Exhibit B-31. Farm Food Category Ingestion Rates for Health Protective Screening Scenario for Farming Households

Product	Screening-Level Consumer Ingestion Rate						Units
	Infants <1 yr	Child 1–2 yrs	Child 3–5 yrs	Child 6–11 yrs	Child 12–19 yrs	Adult 20–70 yrs	
Total Food Ingestion Rates for Comparison Only (not in MIRC; excludes soil and water)							
Total Food: Homegrown only[i]	NA	259	142	99	51	35.5	g/kg-day
Total Food: All Sources[j]	NA	125	91	61	34	23.7	g/kg-day
Overestimate (ratio of Homegrown/Total)	NA	2.1	1.6	1.6	1.5	1.3	(unitless)

Sources: EPA 2011a, EPA 2008a, unless otherwise noted.

NA = not applicable

[a] Primary source for values was the 1987–1988 NFCS survey; compiled results are presented in Chapter 13 of the 2011 Exposure Factors Handbook (EPA, 2011a). When data were unavailable for a particular age group, the intake rate for all age groups was multiplied by the age-specific ratio of intake based on national population intake rates from CSFII.

[b] Primary source for values was 1987–1988 NFCS survey, compiled results are presented in Chapter 13 of the 2011 Exposure Factors Handbook (EPA, 2011a). When data were unavailable for a particular age group, the intake rate for all age groups was multiplied by the age-specific ratio of intake based on national population intake rates from an NHANES 2003–2006 analysis in Chapter 11 of the Exposure Factors Handbook.

[c] Infants are assumed to consume only breast milk for one year.

[d] These values are the recommended “upper percentile” value for children from EPA’s 2011 EFH, Chapter 4, Table 4-23. The 2008 CSEFH and 2011 EFH included a high-end value associated with pica only, but this value has not been used.

[e] These values are 90th percentile adult ingestion rates calculated in Stanek et al. 1997, and they are used to represent older children and adults.

[f] The ingestion rate for adults was obtained from Burger (2002) and is the 99th percentile value for adult females considered high-end recreationists; this value is believed to be representative of subsistence fishers. The 99th percentile values for children were derived based on EPA’s Estimated Per Capita Fish Consumption in the United States (2002)—Section 4.2.1.1 Table 5 (for child age categories) adjusted and scaled. Values reflect “as prepared” ingestion rates.

[g] The fish ingestion rate for children aged 3–5 years was obtained directly from Section 4.2.1.1, Table 5 in the EPA (2002) report (value presented is rounded); for these children, the RTR age-group range matches the EPA (2002) age category. Fish ingestion rates for children less than 3 years old, however, were not provided. Therefore, for children aged 1–2 years, the fish ingestion rate was calculated using the ingestion rate for children aged 3–5 years scaled downward by the ratio of the mean body weight of children aged 1–2 years to the mean body weight of children aged 3–5-years.

[h] Time-weighted average ingestion rates were calculated using the EPA (2002) fish ingestion estimates in order to adjust for the differences between the age group ranges used for the RTR screening and those presented in the 2002 EPA report.

[i] Sum of post-cooking food ingestion rates. This estimate is calculated by multiplying the food ingestion rates on previous rows (excluding soil and water) by (1-L_1)x(1-L_2), where L_1 and L_2 are the loss rates from Exhibit B-25. The rows are then summed to get the total post-cooking ingestion rate.

[j] 90th percentile total food intake rates from EPA 2008a and 2005e based on CSFII data 1994-96 and 1998; see Section 6.3.6 of this document.

7.2. Default Screening-Level Population-Specific Parameter Values

The screening-level values for body weights (BWs) for the RTR screening threshold analysis, which serve as the default values in MIRC, are mean values and are presented in Exhibit B-32. As stated in Section 6 of this attachment, EPA recommends using the mean BW for each age group when using upper percentile values for medium ingestion rates. Use of the mean body weights introduces no bias toward over- or underestimating risk.

Exhibit B-32. Mean Body Weight Estimates for Adults and Children[a]

Lifestage (years)	Duration (years)	Mean Body Weight (kg)
Adult[b] (20-70)	50	80.0
Child < 1[c]	1	7.83
Child 1-2[c]	2	12.6
Child 3-5[d]	3	18.6

Exhibit B-32. Mean Body Weight Estimates for Adults and Children[a]

Lifestage (years)	Duration (years)	Mean Body Weight (kg)
Child 6-11[e]	6	36.0
Child 12-19[f]	8	64.2

[a] Sources: EPA 1997, 2008a

[b] EPA-recommended value (EPA 2011a).

[d] These values were obtained directly from Table 8-3 of the 2008 CSEFH.

[e] Each BW represents a time-weighted average of BWs for age groups 6 to <11 years and 11 to <16 years from Table 8-3 of the 2008 CSEFH. Original sample sizes for each of these age groups can also be found in Table 8-3.

[f] These values were calculated as time-weighted average BW for age groups 11 to <16 years and 16 to <21 years from Table 8-3 of the 2008 CSEFH. The direction of the possible bias is unknown. The values match the estimate based on Table 8-22 of the NHANES IV data as presented by Portier et al. (2007).

7.3. Default Chemical-Specific Parameter Values for Screening Analysis

Exhibit B-33 presents chemical-specific parameter values for input to MIRC for the screening-level analysis. Values for bioavailability when ingested in soil (*Bs*), mammalian metabolism factors (*MF*), correction factors for belowground produce ($VG_{rootveg}$), wet deposition fractions (*Fw*), air to plant transfer factors (Bv_{AG}), root concentration factors (*RCF*), and soil-water partition coefficient (*Kds*) are presented in Exhibit B-33.

Exhibit B-33. Chemical-Specific Parameter Values for Input to MIRC[a]

Parameter	Description	Benzo(a)-pyrene	Cadmium	Mercuric chloride	Methyl mercury	2,3,7,8-TCDD	Units
Bs	Soil bioavailability factor for livestock	1	1	1	1	1	unitless
MF	Mammalian metabolism factor	0.01	1	1	1	1	unitless
VGrootveg	Empirical correction factor for belowground produce, i.e., tuber or root vegetable, to account for possible overestimate of the transfer of chemicals from the outside to the inside of bulky tubers or roots (based on carrots and potatoes)	0.01	1	1	0.01	0.01	unitless
Fw	Fraction of wet deposition that adheres to plant surfaces; 0.2 for anions, 0.6 for cations and most organics	0.6	0.6	0.6	0.6	0.6	unitless

Exhibit B-33. Chemical-Specific Parameter Values for Input to MIRC[a]

Parameter	Description	Benzo(a)-pyrene	Cadmium	Mercuric chloride	Methyl mercury	2,3,7,8-TCDD	Units
BvAG	Air-to-plant biotransfer factor for aboveground produce for vapor-phase chemical in air	174,523	0	1,800	0	65,500	[mg/g produce DW]/[mg/g air]
RCF	Chemical-specific root concentration factor for tubers and root produce	9,180	0	0	0	40,002	L soil pore water/kg root WW
Kds	Chemical-specific soil/water partition coefficient	7,750	75	58,000	7,000	31,126	L soil pore water/kg soil DW

[a] Values presented in this exhibit are also presented in previous exhibits; however exact values used in the assessment are presented here, rather than values restricted by significant figures. In addition, only values for those chemicals that are specifically used in the screening assessment are provided here.

Only single estimates were developed for each of these parameters for HHRAP (EPA 2005a), and the potential direction and magnitude of bias toward over- or underestimating risks were not investigated in this assessment. The inputs that are both chemical-specific and plant-type-specific, as presented in Exhibit B-11, are *not* repeated here. Again, only single estimates were developed for these parameters and the potential direction and magnitude of bias toward over- or underestimating risks were not investigated. Finally, Exhibit B-34 presents biotransfer factors for each of the chemicals and animal types for which screening threshold emissions were calculated.

Exhibit B-34. Chemical and Animal-Type Specific Biotransfer Factor (Ba) Values for Input to MIRC

([mg chemical/kg WW tissue or dairy] / [mg chemical intake/day] = day/kg WW tissue or dairy)

Chemical	Beef	Dairy	Pork	Eggs	Poultry
Benzo(a)pyrene	3.8E-02	8.0E-03	4.6E-02	1.6E-02	2.8E-02
Cadmium	1.2E-04	6.5E-06	1.9E-04	2.5E-03	1.1E-01
Mercuric chloride	1.1E-04	1.4E-06	3.4E-05	2.4E-02	2.4E-02
Methyl mercury	1.2E-03	1.7E-05	5.1E-06	3.6E-03	3.6E-03
2,3,7,8-TCDD	3.6E-02	7.7E-03	4.4E-02	1.5E-02	2.7E-02

7.4. Screening-Level Parameter Values for Nursing Infant Exposure

MIRC is configured to evaluate risk to nursing infants exposed to dioxins and to methylmercury (MeHg) in their mother’s milk for a family farming and catching fish in the area of maximal air deposition of chemical. Input values were summarized in Section 6.5 of this attachment.

7.4.1. Dioxins

For dioxins, chemical intake via breast milk by nursing infants was estimated using the model presented in EPA’s *Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions* (MPE, EPA 1998). The assumption that lactational transfer of dioxins to the infant occurs via the lipid-phase of milk appears reasonable. The following screening-level assumptions used in that model should bias the results toward health-protective estimates of risks.

- Duration of nursing is a full year and no other foods or liquids are consumed by the infant; a more "typical" value would be six months.
- Absorption efficiency of dioxin in food or milk by mother and infant are 100 percent; this assumption might overestimate absorption but probably by no more than 15 percent (see Section 6.5.2).
- The fat content of human milk is assumed to be 4 percent, a value toward the high end of the reported range of values (1 to 5 percent).
- The maternal chemical intake is estimated using upper percentile ingestion rates for the different homegrown foods (see discussion for Exhibit B-31); this assumption might overestimate total ingestion of homegrown foods by a factor of more than 2 (see Exhibit B-31).
- If the fraction of the maternal body burden of dioxin that is in the body fat compartment is greater than 90 percent, as suggested by ATSDR (1998), then actual exposures of the infant may be less than estimated.

There also are parameter values and model assumptions for the lipid-phase breast-milk pathway for which possible bias is unknown.

- The accuracy of the model is unknown; it has not been verified or validated with empirical data.
- Using a half-life of 10 years for dioxins may over- or under-estimate risks.

Finally, there is one assumption that might possibly introduce some bias toward underestimating risks. The model results are sensitive to the biological half-life of the chemical in the mother relative to the length of her exposure prior to the lactation period. Using an exposure duration for the mother equal to the assumed half-life for dioxins, 10 years, may underestimate the duration of exposure of the mother.

7.4.2. Methyl Mercury

For MeHg, empirical data from a single human study (Fujita and Takabatake 1977) was used in conjunction with a physiologically based pharmacokinetic (PBPK) model of lactational transfer of MeHg developed and partially validated by Byczkowski and Lipscomb (2001) to support a very simple predictive model. Both the human data and the PBPK model indicated that for relatively low MeHg exposures, the concentration of MeHg in the nursing infant's blood is similar to its concentration in the mother's blood. The PBPK model suggested in addition that the average daily dose of MeHg absorbed from milk by the nursing infant (DAI_{inf}) is indistinguishable from the dose of MeHg absorbed by its mother from her food (DAI_{mat}). The data are limited, and the model includes various assumptions; however, there is no known directional bias in the estimates.

8. References

Altman, P.L., and D.S. Dittmer, Eds. 1964. Biology Data Book. Volume 1. Bethesda, MD. 263-264 (As cited in EPA 1998).

Amin-Zaki, L., S. Elhassani, M.A. Majeed, T.W. Clarkson, R.A. Doherty, M.R. Greenwood, and T. Giovanoli-Jakubczak. 1976. Perinatal methylmercury poisoning in Iraq. Am. J. Diseases in Children 130: 1070-1076 (As cited in Byczkowski and Lipscomb 2001).

ATSDR (Agency for Toxic Substances and Disease Registry). 1992. Toxicological profile for selected PCBs (Arochlor- 1260, 1254, 1248, 1242, 1232, 1221, and 1016). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service (As cited in EPA 1998).

ATSDR. 1998. Toxicological profile for chlorinated dibenzo-p-dioxins. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Bacci E., M. Cerejeira, C. Gaggi, G. Chemello, D. Calamari, and M. Vighi. 1992. Chlorinated dioxins: Volatilization from soils and bioconcentration in plant leaves. *Bull. Environ. Contam. Toxicol.* 48: 401-408.

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. Review and analysis of parameters and assessing transport of environmentally released radionuclides through agriculture. ORNL-5786. Oak Ridge National Laboratory. Oak Ridge, Tennessee. September.

Bates, M.N., D.S. Hannah, S.J. Buckland, J.A. Taucher, and T. van Mannen. 1994. Chlorinated organic contaminants in breast milk of New Zealand women*. Environmental Health Perspectives* 102(Supplement 1): 211-217.

Belcher, G.D., and C.C. Travis. 1989. Modeling support for the RURA and municipal waste combustion projects: Final report on sensitivity and uncertainty analysis for the terrestrial food chain model. Interagency Agreement No. 1824-A020-A1, Office of Risk Analysis, Health and Safety Research Division, Oak Ridge National Laboratory. Oak Ridge, Tennessee. October.

Boone, F.W., Y.C. Ng, and J.M. Palm. 1981. Terrestrial pathways of radionuclide particulates. *Health Physics* 41:735-747.

Briggs, G.G., R.H. Bromilow, and A.A. Evans. 1982. Relationships between lipophilicity and root uptake and translocation of non-ionized chemicals by barley. *Pesticide Science* 13: 495-504 (As cited in EPA 2005a, Appendix A-2).

Burger J. 2002. Daily consumption of wild fish and game: Exposures of high end recreationalists. *International Journal of Environmental Health Research* 12:343-354.

Butte, N.F., C. Garza, E.O. Smith, and B.L. Nichols. 1984. Human milk intake and growth in exclusively breast-fed infants. *The Journal of Pediatrics* 104(2):187-195.

Byczkowski, J.Z., and J.C. Lipscomb. 2001. Physiologically based pharmacokinetic modeling of the lactational transfer of methylmercury. *Risk Analysis* 21(5): 869-882.

Chamberlain, A.C. 1970. Interception and retention of radioactive aerosols by vegetation. *Atmospheric Environment* 4: 57-78.

Clewell, H.J, J.M. Gearhart, R.P. Gentry, T.R Covington, C.B. VanLandingham, C.B. Crump, and A.M. Shipp. 1999. Evaluation of the uncertainty in an oral reference dose for methylmercury due to interindividual variability in pharmacokinetics. *Risk Analysis* 19: 547-558 (As cited in Byczkowski and Lipscomb 2001).

Conley, C.L. 1974. The blood. Medical Physiology 13(2). V.B. Moutcasle, Ed. 1997. The C.V. Mosby Company, St. Louis, MO. 1027-1046 (As cited in EPA 1998).

Ensminger, M.E. 1980. Poultry Science. Interstate Printers and Publishers, Inc. Danville, Illinois.

Fries, G. F. 1982. Potential polychlorinated biphenyl residues in animal products from application of contaminated sewage sludge to land. *J. Environ. Qual.* 11:14.

Fries, G.F. 1994. Personal communication between G.F. Fries, U.S. Department of Agriculture, and Glenn Rice and Jennifer Windholtz, U.S. Environmental Protection Agency, Office of Research and Development. Agricultural Research Service. March.

Fujita, M., and E. Takabatake. 1977. Mercury levels in human maternal and neonatal blood, hair and milk. *Bull. Environ. Contam. Toxicol.* 18(2): 205-209.

Gearhart, J.M., H.J. Clewell III, K.S. Crump, A.M. Shipp, and A. Silvers. 1995. Pharmacokinetic dose estimates of mercury in children and dose-response curves of performance tests in a large epidemiological study. *Water, Air, Soil Pollut.* 80: 49-58 (As cited in Byczkowski and Lipscomb 2001).

Gearhart, J., T. Covington, and H. Clewell III. 1996. Application of a physiologically based pharmacokinetic model for MeHg in a dose reconstruction of the Iraqi accidental exposures. Paper presented at the Fourth International Conference on Mercury as a Global Pollutant, Congress Centre, Hamburg, Germany; August (As cited in Byczkowski and Lipscomb 2001).

Greenwood, M.R., T.W. Clarkson, R.A. Doherty, A.H. Gates, L. Amin-Zaki, S. Elhassani, and M.A. Majeed. 1978. Blood clearance half-times in lactating and nonlactating members of a population exposed to mercury. *Environ. Res.* 16: 48-54.

Harrison, K.A. 1967. Blood volume changes in severe anemia in pregnancy. *Lancet* 1(7480):20-25.

Hofelt, C.S., M. Honeycutt, J.T. McCoy, and L.C. Haws. 2001. Development of a metabolism factor for polycyclic aromatic hydrocarbons for use in multipathway risk assessments of hazardous waste combustion facilities. *Reg. Toxicol. Pharmacol*. 33:60-65.

Hoffman, F.O., K.M. Thiessen, M.L. Frank, and B.G. Blaylock. 1992. Quantification of the interception and initial retention of radioactive contaminants deposited on pasture grass by simulated rain. *Atmospheric Environ.* 26a(18): 3313-3321.

Hollins, J.G., R.F. Willes, F.R. Bryce, S.M. Charbonneau, and I.C. Munro. 1975. The whole body retention and tissue distribution of Hg methylmercury in adult cats. *Toxicol. App. Pharmacol.* 33: 438-449.

Hong, C.S., J. Xiao, A.C. Casey, B. Bush, E.F. Fitzgerald, and S.A. Hwang. 1994. Mono-ortho and non-ortho-substituted polychlorinated biphenyls in human milk from Mohawk and control women: Effects of maternal factors and previous lactation. *Arch. Environ. Contam. Toxicol.* 27(3): 431-437.

Jensen, A.A. 1987. Polychlorinated biphenyls (PCBs), polychlorodibenzo-p-dioxins (PCDDs) and polychlorodibenzofurans (PCDFs) in human milk, blood and adipose tissue. *Sci. Total Environ.* 64(3): 259-293.

Kahn, H., and K. Stralka. 2008. Estimated daily average *per capita* water ingestion by child and adult age categories based on USDA's 1994-96 and 1998 continuing survey of food intakes individuals. *J. Expo. Anal. Environ. Epidemiol.* 1-9.

Kershaw, T.G., T.W. Clarkson , and P.H. Dhahir . 1980. The relationship between blood levels and dose of methylmercury in man. *Arch. Environ. Health* 35(1): 28-36.

Lorber, M. 1995. Development of an air-to-plant vapor phase transfer for dioxins and furans. Presented at the 15th International Symposium on Chlorinated Dioxins and Related Compounds. August 21-25, 1995 in Edmonton, Canada. Abstract in *Organohalogen Compounds* 24:179-186.

Lorber, M., and P. Pinsky. 2000. An evaluation of three empirical air-to-leaf models for polychlorinated dibenzo-p-dioxins and dibenzofurans. *Chemosphere* 41(6):931-41.

Maxwell, N.I., and D.E. Burmaster. 1993. A simulation model to estimate a distribution of lipid intake from breast milk during the first year of life. *Journal of Exposure Analysis and Environmental Epidemiology* 3(4): 383-406.

McLachlan, M.S. 1993. Digestive tract absorption of polychlorinated dibenzo-p-dioxins, dibenzofurans and biphenyls in a nursing infant. *Toxicology and Applied Pharmacology* 123(1): 68-72.

Miller, C.W., and F.O. Hoffman. 1983. An examination of the environmental half-time for radionuclides deposited on vegetation. *Health Physics* 45(3): 731-744.

Morgan, J.N., M.R. Berry, and R.L. Graves. 1997. Effects of Commonly Used Cooking Practices on Total Mercury Concentration in Fish and Their Impact on Exposure Assessments. *Journal of Exposure Analysis and Environmental Epidemiology* 7(1):119-133.

NAS (National Academy of Sciences). 1987. Predicting Feed intake of Food-Producing Animals. National Research Council, Committee on Animal Nutrition, Washington, D.C.

NAS. 1991. Nutrition During Lactation. National Academies Press. Washington, DC.

NC DEHNR (North Carolina Department of Health, Environment, and Natural Resources). 1997. North Carolina Protocol for Performing Indirect Exposure Risk Assessments for Hazardous Waste Combustion Units. January.

Portier K., J. Tolson, and S. Roberts. 2007. Body weight distributions for risk assessment. *Risk Anal.* 27(1): 11-26.

Reinert, RE; Stewart, D; Seagran, HL. 1972. Effects of dressing and cooking on DDT concentrations in certain fish from Lake Michigan. Journal of Fisheries Research Board of Canada. 29(5): 525-529.

RTI. 2005. Methodology for predicting cattle biotransfer factors. Prepared for U.S. Environmental Protection Agency (EPA) Office of Solid Waste. EPA Contract No. 68-W-03-042. September. Available at: http://www3.epa.gov/epawaste/hazard/tsd/td/combust/finalmact/ssra/btfreportfull05.pdf.

Schecter, A., P. Fürst, C. Fürst, O. Päpke, M. Ball, J. Ryan, H. Cau, L. Dai, H. Quynh, H.Q. Cuong, N. Phuong, P. Phiet, A. Beim, J. Constable, J. Startin, M. Samedy, and Y. Seng. 1994. Chlorinated dioxins and dibenzofurans in human tissue from general populations: A selective review. *Environmental Health Perspectives* 102(Supplement 1): 159-171.

Sherlock, J., D. Hislop, G. Newton, G. Topping, and K. Whittle. 1984. Elevation of mercury in human blood from controlled ingestion of methylmercury in fish. *Human Toxicology* 3: 117-131 (As cited in USFDA 2009).

Shilling, F., White, A. Lippert, L, and M. Lubell. 2010. Contaminated fish consumption in California's Central Valley Delta. *Environmental Research* 110: 334-344.

Shor, R.W., C.F. Baes, and R.D. Sharp. 1982. Agricultural production in the United States by county: A compilation of information from the 1974 census of agriculture for use in terrestrial food-chain transport and assessment models. Oak Ridge National Laboratory Publication. ORNL-5786

Sim, M.R. and J.J. McNeil. 1992. Monitoring chemical exposure using breast milk: A methodological review. *American Journal of Epidemiology* 136(1): 1-11.

Smith, A.H. 1987. Infant exposure assessment for breast milk dioxins and furans derived from waste incineration emissions. *Risk Analysis* 7:347-353.

Stanek, E.J., E.J. Calabrese, R. Barnes, P. Pekow. 1997. Soil ingestion in adults – results of a second pilot study. *Toxicol. Environ. Safety* 36:249-257.

Steinbeck, A.W. 1954. Plasma and blood volumes of normal Australian females. Australian *Journal of Experimental Biology and Medical Science* 32(1): 95-9.

Stephens, R.D., M. Petreas, and G.H. Hayward. 1995. Biotransfer and bioaccumulation of dioxins and furans from soil: Chickens as a model for foraging animals. *Science Total Environment* 175: 253-273. July 20.

Sullivan, M.J., S.R. Custance, and C.F. Miller. 1991. Infant exposure to dioxin in mother's milk resulting from maternal ingestion of contaminated fish. *Chemosphere* 23(8-10): 1387-1396.

Thomann, R.V. 1989. Bioaccumulation model of organic-chemical distribution in aquatic food-chains. *Environ. Sci. Technol*. 23(6): 699-707.

Travis, C.C., and A.D. Arms. 1988. Bioconcentration of organics in beef, milk, and vegetation. *Environ. Sci. Technol.* 22:271-274.

Travis, C.C., H.A. Hattemer-Frey and A.A. Arms. 1988. Relationship between dietary intake of organic chemicals and their concentrations in human adipose tissue and breast milk. Arch. Environ. Contam. Toxicol. 17:473-478.

Ueland, K. 1976. Maternal cardiovascular dynamics. VII. Maternal cardiovascular dynamics. Intrapartum blood volume changes. *Am. J. Obstetrics Gynecol*. 126(6): 671-677.

USDA (U.S. Department of Agriculture). 1992. Changes in Food Consumption and Expenditures in American Households during the 1980's. USDA, Washington, D.C. Statistical Bulletin o. 849. (As cited in EPA 1997)

USDA. 1993. Food and Nutrient Intakes by Individuals in the United States, 1 Day, 1987-88. Nationwide Food Consumption Survey 1987-88, NFCS Report No. 87-I-1. (As cited in EPA 1997)

USDA. 1994a. Food Consumption and Dietary Levels of Households in the United States, 1987-88. Agricultural Research Service, Report No. 87-H-1. (As cited in EPA 1997)

USDA. 1994b. Vegetables 1993 Summary. National Agricultural Statistics Service, Agricultural Statistics Board. Washington, D.C. Vg 1-2 (94). Jan.

USDA. 1994c. Noncitrus Fruits and Nuts 1993 Summary. National Agricultural Statistics Service, Agricultural Statistics Board, Washington, D.C. Fr Nt 1-3 (94).

USDA. 2000. 1994–96, 1998 Continuing Survey of Food Intakes by Individuals (CSFII). CD-ROM. Agricultural Research Service, Beltsville Human Nutrition Research Center, Beltsville, MD. Available from the National Technical Information Service, Springfield, VA, Accession Number PB-2000500027. (As cited in EPA 2008a, Chapter 14)

EPA (US. Environmental Protection Agency). 1990. Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions. Environmental Criteria and Assessment Office. ORD.EPA-600-90-003. January.

EPA. 1992. Technical Support Document for the Land Application of Sewage Sludge: Volumes I and II. EPA 822/R-93-001a. Office of Water. Washington, D.C.

EPA. 1994a. Revised Draft Guidance for Performing Screening Level Risk Analysis at Combustion Facilities Burning Hazardous Wastes. Attachment C, Draft Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities. Office of Emergency and Remedial Response. Office of Solid Waste. December 14.

EPA. 1994b. Estimating Exposure to Dioxin-Like Compounds. Volume II: Properties, Sources, Occurrence, and Background Exposures. External Review Draft. Office of Research and Development. Washington, DC. EPA/600/6-88/005Cc. June.

EPA. 1994c. Estimating Exposure to Dioxin-Like Compounds. External Review Draft. Office of Research and Development, Washington, D.C. EPA/600/6-88/005Cb. June. Available at: http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=438673.

EPA. 1995a. Review Draft Development of Human Health-Based and Ecologically-Based Exit Criteria for the Hazardous Waste Identification Project. Volumes I and II. Office of Solid Waste. March 3.

EPA. 1995b. Memorandum Regarding Further Studies for Modeling the Indirect Exposure Impacts from Combustor Emissions. From Mathew Lorber, Exposure Assessment Group, and Glenn Rice, Indirect Exposure Team, Environmental Criteria and Assessment Office. Washington, D.C. January 20.

EPA. 1995c. Further Issues for Modeling the Indirect Exposure Impacts from Combustor Emissions. Office of Research and Development. Washington, D.C. January 20.

EPA. 1995d. Waste Technologies Industries Screening Human Health Risk Assessment (SHHRA): Evaluation of Potential Risk from Exposure to Routine Operating Emissions. Volume V. External Review Draft. U.S. EPA Region 5, Chicago, Illinois.

EPA. 1996. Soil Screening Guidance: User's Guide. Office of Solid Waste and Emergency Response, Washington D.C. EPA/540/R-96/018, April 1996.

EPA. 1997a. Exposure Factors Handbook. Volumes I, II, and III. Office of Research and Development, Washington, D.C. EPA-600-P-95-002Fa,b,c. August. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12464.

EPA. 1997b. Mercury Study Report to Congress. Volume III: Fate and Transport of Mercury in the Environment. Office of Air Quality Planning and Standards and Office of Research and Development. EPA-452/R-97-005. December.

EPA. 1997c. Parameter Guidance Document. National Center for Environmental Assessment, NCEA-0238.

EPA. 1998. Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions. National Center for Environmental Assessment, Cincinnati, OH. EPA-600-R-98-137. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=55525.

EPA. 1999. 1999 National-Scale Air Toxics Assessment Results; Approach for Modeling POM. Available at: http://archive.epa.gov/nata2002/web/pdf/pom_approach.pdf.

EPA. 2001a. Peer Review of EPA's Hazardous Waste Identification Rule Risk Assessment Model: Breast milk exposure model for the HWIR 3MRA Model. Prepared by Eastern Research Group for EPA Office of Solid Wastes. 68-W5-0057.

EPA. 2001b. Water Quality Criterion for the Protection of Human Health: Methylmercury. Office of Water, Office of Science and Technology. Washington D.C. EPA-823-R-01-001. January. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/health/upload/2009_01_15_criteria_methylmercury_mercury-criterion.pdf.

EPA. 2002. Estimated *Per capita* Fish Consumption in the United States. Office of Water, Office of Science and Technology, Washington, D.C. EPA-821- C- 02-003. August. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/health/upload/consumption_report.pdf.

EPA. 2003a. Chapter 10 In: Multimedia, Multipathway, and Multireceptor Risk Assessment (3MRA) Modeling System, Volume II: Site-based, Regional, and National Data. SAB Review Draft. EP-530/D-03-001b. Office of Research and Development, Athens, GA, and Research Triangle Park, NC, and Office of Solid Waste, Washington, D.C. July. Available at: http://www.epa.gov/osw/hazard/wastetypes/wasteid/hwirwste/risk03.htm.

EPA. 2003b. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000): Technical Support Document. Volume 2: Development of National Bioaccumulation Factors. Office of Water, Office of Science and Technology, Washington, D.C. EPA-822-R-03-030. December. Available at: http://water.epa.gov/scitech/swguidance/standards/criteria/health/methodology/.

EPA. 2003c. CSFII Analysis of Food Intake Distributions. Office of Research and Development, National Center for Environmental Assessment, Washington, D.C. EPA-600-R-03-29. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=56610.

EPA. 2004. Estimated *Per capita* Water Ingestion and Body Weight in the United States – An Update. Office of Water, Office of Science and Technology, Washington, D.C. EPA-822-R-00-001. October. Available at: http://water.epa.gov/action/advisories/drinking/upload/2005_05_06_criteria_drinking_percapita_2004.pdf.

EPA. 2004c. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. Office of Superfund Remediation and Technology Innovation, Washington, D.C. EPA/540/R/99/005; OSWER 9285.7-02EP; NTIS PB99-963312. July.

EPA. 2005a. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Office of Solid Waste and Emergency Response, Washington, DC. EPA-530-R-05-006. September. Available at: http://www.epa.gov/osw/hazard/tsd/td/combust/risk.htm.

EPA. 2005b. Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants. Risk Assessment Forum. Washington, DC. November. EPA/630/P-03/003F. Available at: http://www2.epa.gov/sites/production/files/2013-09/documents/agegroups.pdf.

EPA. 2005c. Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum, Washington, DC. EPA/630/P-03/001F. March. Available from: http://www2.epa.gov/sites/production/files/2013-09/documents/cancer_guidelines_final_3-25-05.pdf.

EPA. 2005d. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum: Washington, D.C. EPA-630/R-03-003F. March. Available at: http://www.epa.gov/ttn/atw/childrens_supplement_final.pdf.

EPA. 2005e. Analysis of Total Food Intake and Composition of Individual's Diet Based on the U.S. Department of Agriculture's 1994-96, 1998 Continuing Survey of Food Intakes By Individuals (CSFII) (Final). Office of Research and Development, National Center for Environmental Assessment, Washington, D.C. EPA/600/R-05/062F. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=132173.

EPA. 2007a. Prioritized Chronic Dose-Response Values for Screening Risk Assessments (Table 1). Office of Air Quality Planning and Standards; June 12, 2007. Available at: http://www.epa.gov/ttn/atw/toxsource/summary.html.

EPA. 2007b. Toxicological Review of 1,1,1-Trichloroethane (CAS No. 71-55-6) In Support of Summary Information on the Integrated Risk Information System (IRIS). Office of Research and Development, Washington, DC. EPA/635/R-03/006. August. Available at: http://www.epa.gov/iris.

EPA. 2008a. Child-Specific Exposure Factors Handbook. Office of Research and Development, Washington, D.C. EPA/600/R-06/096F. September. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243 .

EPA. 2008b. Draft Report on EPA OAQPS Risk and Technology Review Methodologies: For Review by the EPA Science Advisory Board; Case Studies – MACT I Petroleum Refining Sources, Portland Cement Manufacturing. Office of Air Quality Planning and Standards, Office of Air and Radiation, Research Triangle Park, NC. July 14, 2008.

EPA. 2010. U.S. EPA. Development of a Relative Potency Factor (RPF) Approach for Polycyclic Aromatic Hydrocarbon (PAH) Mixtures (External Review Draft). Washington, DC, EPA/635/R-08/012A February. Available at: http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=194584

EPA. 2011a. Exposure Factors Handbook: 2011 Edition. Office of Research and Development, Washington, D.C. EPA/600/R-090/052F. September. Available at: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252.

EPA. 2011b. Revised Technical Support Document: National-Scale Assessment of Mercury Risk to Populations with High Consumption of Self-caught Freshwater Fish; In Support of the Appropriate and Necessary Finding for Coal- and Oil-Fired Electric Generating Units. Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA-452/R-11-009. December.

Van den Berg, M., L.S. Birnbaum, M. Denison, M. De vito, W. Farlans, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L.. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. tuomisto, M. Tysklind, N. Walker, and R.E. Peterson. 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. *Toxicol Sci.* 93(2): 223-41.

Zabik, ME; Zabik, MJ. 1995. Tetra-chlorodibenzo-p-dioxin residue reduction by cooking/processing of fish fillets harvested from the Great Lakes. Bulletin of Environmental Contamination and Toxicology. 55:264-269.

[This page intentionally left blank.]

Attachment C. Dermal Risk Screening

[This page intentionally left blank.]

CONTENTS, ATTACHMENT C

[This page intentionally left blank.]

Exhibits, Attachment C

[This page intentionally left blank.]

Non-inhalation exposure to PB-HAPs can occur by way of the dermal pathway through contact with PB-HAP-contaminated soil and water. However, dermal absorption of chemicals that are originally airborne is generally a relatively minor pathway of exposure compared to other exposure pathways (EPA 2006, Cal/EPA 2000). This section demonstrates that for the conservative tiered screening scenario developed for RTR multipathway evaluation, the dermal exposure route is not a significant risk pathway when compared to the ingestion pathway. In general, the RTR multipathway assessment followed the protocol for evaluating a reasonable maximum exposure as described in EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Model, Part E, Supplemental Guidance for Dermal Risk Assessment* (EPA 2004).

1. Hazard Identification and Dose Response Assessment

To assess the potential contribution of dermal exposure to non-inhalation exposure, we evaluated the potential for cancer and chronic non-cancer effects for the four PB-HAPs currently assessed in the multipathway screening evaluation for RTR: cadmium, divalent mercury, 2,3,7,8-TCDD, and benzo(a)pyrene. EPA has not developed carcinogenic potency slope factors (CSFs) and non-cancer reference doses (RfDs) specifically for evaluating potential human health concerns associated with dermal exposure to PB-HAPs. Instead, dermal toxicity values can be derived from oral toxicity values via route-to-route extrapolation by adjusting for gastrointestinal (GI) absorption. EPA recommends making this adjustment only when GI absorption of the chemical is significantly less than 100% (i.e., less than 50 percent). Otherwise, a default value of complete (100 percent) oral absorption is assumed, and no adjustment is made (EPA 2004).

The absorbed cancer slope factor (CSF_{ABS}) is based on the oral cancer slope factor (CSF_O) and the fraction of the contaminant absorbed in the gastrointestinal track (ABS_{GI}), as follows:

$$CSF_{ABS} = \frac{CSF_o}{ABS_{GI}}$$

where:

CSF_{ABS} = Absorbed slope factor $(\text{mg/kg-day})^{-1}$

CSF_o = Oral slope factor $(\text{mg/kg-day})^{-1}$

ABS_{GI} = Fraction of chemical absorbed in gastrointestinal tract (unitless)

The absorbed reference dose (RfD_{ABS}) is based on the oral reference dose (RFD_O) and the fraction of the contaminant absorbed in the gastrointestinal tract (ABS_{GI}), as shown below.

$$RfD_{ABS} = RfD_o \times ABS_{GI}$$

where:

RfD_{ABS} = Absorbed reference dose (mg/kg-day)

RfD_o = Oral reference dose (mg/kg-day)

ABS_{GI} = Fraction of chemical absorbed in gastrointestinal tract (unitless)

The GI absorptions for 2,3,7,8-TCDD and all polycyclic aromatic hydrocarbons (PAHs) (which includes benzo[a]pyrene) were estimated to be greater than 50 percent. Therefore, as shown in Exhibit C-1, no adjustments to the available oral CSFs were required. For cadmium and divalent mercury, adjustments were made based on absorption data provided in RAGS Part E, Exhibit 4-1. The RfDs for dermal exposure to cadmium and divalent mercury are also shown in Exhibit C-1.

Exhibit C-1. Cancer Slope Factors and Reference Doses Based on Absorbed Dose

PB-HAP	Fraction of Contaminant Absorbed in GI Tract (ABS_{GI}) (unitless)	Absorbed Cancer Slope Factor (CSF_{ABS})[a] (mg/kg-day)$^{-1}$	Absorbed Reference Dose (RfD_{ABS})[a] (mg/kg-day)
Cadmium Compounds	0.05	NA	2.5E-05
Divalent Mercury	0.07	NA	2.1E-05
2,3,7,8-TCDD	No adjustment required [b]	1.5E+05	1.0E-09
Benzo[a]pyrene	No adjustment required [b]	1.0E+01	NA

NA = Not applicable

[a] Oral dose response values are presented in Appendix 2. Only the resulting adjusted dose response values are presented in this table.

[b] According to RAGS Part E, Exhibit 4-1, GI absorption is expected to be greater than 50%.

2. Dermal Exposure Estimation

Dermal exposures and risks resulting from absorption of the chemical through the skin from contact with contaminated water and soil were evaluated for the RTR screening scenario. Individuals were assumed to be exposed on a fraction of their bodies (i.e., their head, forearms, hands, lower legs, and feet) to contaminated soil from the TRIM.FaTE surface soil parcel with the highest concentration (N1) on a daily basis. For the water evaluation, individuals were assumed to be exposed to contaminated surface water with the same PB-HAP concentration as the TRIM.FaTE screening scenario lake over their entire bodies on a daily basis.

2.1. Equations for Estimating Dermal Exposure

The general equation used to estimate dermal absorbed dose (DAD) for water or soil is shown below, and is expressed in milligrams of PB-HAP per kilogram of receptor body weight per day (mg/kg-day). DADs are calculated separately for the water and soil pathways and then added together for each age group.

$$DAD = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT}$$

where:

DA_{event} = Absorbed dose per event; chemical-specific; equation for DA_{event} also differs depending on water or soil contact (mg/cm^2-event)

EV = Event frequency (events/day)

ED = Exposure duration (years)

EF = Exposure frequency (days/year)

SA = Skin surface area available for contact (cm^2)

BW = Body weight (kg)

AT = Averaging time; for non-cancer effects, equals ED x 365 days/year; for cancer effects, equals 70 years x 365 days/year (days)

DA_{event} is estimated to be the total dose absorbed through the skin at the end of exposure and the equation for calculation is different for organic and inorganic chemicals in water and for soil. The equations for calculating these chemical-specific DA_{event} values for water contact are provided in RAGS Part E, Chapter 3 (see Equations 3.2 – 3.4). For soil, the equation for calculating these chemical-specific DA_{event} values is provided in RAGS Part E, Chapter 3 (see Equation 3.12).

$$\textit{Water – Organic Chemicals:}\quad DA_{event} = C_w \times 2 \times FA \times K_p \sqrt{\frac{6 \times \tau_{event} \times t_{event}}{\pi}}$$

$$\textit{Water – Inorganic Chemicals:}\quad DA_{event} = C_w \times K_p \times t_{event}$$

$$\textit{Soil – All Chemicals:}\quad DA_{event} = C_s \times AF \times ABS \times CF$$

where:

DA_{event} = Absorbed dose per event (mg/cm^2-event)

C_w C_s = Chemical concentration in water (mg/cm^3) or soil (mg/kg)

K_p = Chemical-specific dermal permeability coefficient of compound in water (cm/hr)

FA = Chemical-specific fraction absorbed; accounts for loss due to the regular shedding of skin cells of some chemical originally dissolved into skin (unitless)

τ_{event} = Chemical-specific lag time per event (hr/event)

t_{event} = Receptor-specific event duration (hr/event)

AF = Receptor- and activity-specific adherence factor of soil to skin (mg/cm^2-event)

ABS = Chemical-specific dermal absorption fraction (unitless)

CF = Conversion factor (10^{-6} kg/mg)

2.2. Exposure Factors and Assumptions

The exposure parameters included in this assessment and their default and other value options are summarized in this subsection. Default values were selected to result in a highly conservative estimate of exposure (i.e., exposures are likely overestimated). Parameter values were primarily obtained or estimated from RAGS Part E (EPA 2004) and the Child-Specific Exposure Factors Handbook (CSEFH, EPA 2008). Receptor-and scenario-specific exposure assumptions are discussed first, and a discussion of chemical-specific parameters values follows. Estimated water and soil exposure concentrations are presented at the end of this subsection.

2.3. Receptor-Specific Parameters

Dermal exposures and risks were estimated for the same age groups used in the ingestion exposure assessment: adults (ages 20 to 70 years) and five child age groups: <1 year; 1 to 2 years; 3 to 5 years; 6 to 11 years; and 12 to 19 years. The body weight values used in the ingestion exposure assessment were used in the dermal exposure assessment.

Body surface areas (SAs) for water and soil exposures for adults were calculated using Appendix C, Exhibit C-1, of RAGS Part E. For children, SAs for water and soil exposures for the five children's age groups were estimated using Tables 7-1 and 7-2 of the CSEFH, respectively. For SA (water), individuals were assumed to shower or bathe in the water with 100 percent of their body exposed. For SA (soil), it was assumed that individuals were exposed on a fraction of their total body, specifically their head, forearms, hands, lower legs, and feet. Based on information provided in RAGS Part E, the SA for forearms was calculated using the SA for arms and assuming a forearm-to-arm ratio of 0.45, and the SA for lower legs was estimated using the SA for legs and assuming a lower leg-to-leg ratio of 0.4.

Values for body SA by age group are summarized in Exhibit C-2.

Exhibit C-2. Receptor-Specific Body Surface Area Assumed to be Exposed to Chemicals

Age Group[a] (years)	Surface Area for Water Exposure (cm^2)	Surface Area for Soil Exposure (cm^2)
Adult 20-70	18,150[g]	6,878[h]
Child <1[b]	3,992	1,772
Child 1-2[c]	5,700	2,405
Child 3-5[d]	7,600	3,354
Child 6-11[e]	10,800	4,501
Child 12-19[f]	17,150	6,906

[a] Sources for the child groups included Table 7-1 (total body surface area for SA-Water), and Table 7-2 (fraction of total body surface area for SA-Soil) of the 2008 CSEFH.

[b] Represents a time-weighted average for age groups birth to <1 month, 1 to <3 months, 3 to <6 months, and 6 to <12 months.

[c] Represents a time-weighted average for age groups 1 to <2 years and 2 to <3 years.

[d] Values for age group 3 to <6 years in the 2008 CSEFH.

[e] Values for age group 6 to <11 years in the 2008 CSEFH. Represents a conservative (i.e., slightly low) estimate for ages 6 through 11 years since 11-year olds are not included in this CSEFH age group.

[f] Represents a time-weighted average for age groups 11 to <16 years and 16 to <21 years. Note that estimated values include 11-year-olds and individuals through age 20, which contributes to uncertainty in the estimates for 12 to 19 years.

[g] Represents the average total surface area of adults from Table C-1 of RAGS Part E.

[h] Represents the average surface area of adults for head, forearms, hands, lower legs, and feet from Table C-1 of RAGS Part E.

2.4. Scenario-Specific Parameters

Exhibit C-3 summarizes the exposure values related to frequency and duration of contact. In general, these are the recommended defaults for calculating a reasonable maximum exposure (RME) for a residential scenario as proposed by EPA in RAGS Part E, Chapter 3.

Exhibit C-3. Scenario-Specific Exposure Values for Water and Soil Contact

Exposure Parameter	Receptor	Value	Source
Water Contact			
Event Duration (t_{event}) (hr/event)	Child	1	Reasonable maximum exposure scenario for showering/bathing from RAGS Part E, Exhibit 3-2
	Adult	0.58	
Soil Contact			
Soil Adherence Factor (AF) (mg/cm^2)	Child	0.2	For children, value is geometric mean value for children playing (wet soil) and for adults, value is geometric mean value for an adult farmer from RAGS Part E, Exhibit 3-3
	Adult	0.1	
Both Media			
Event Frequency (EV) (events/day)	All	1	Reasonable maximum exposure scenario from RAGS Part E, Exhibits 3-2 and 3-5.
Exposure Frequency (EF) (days/year)	All	350	
Exposure Duration (ED) (years)	Child <1	1	Represents the number of years included in the age group; also used in ingestion exposure calculations.
	Child 1-2	2	
	Child 3-5	3	
	Child 6-11	6	
	Child 12-19	8	
	Adult 20-70	50	
Averaging Time (AT) (days)	For cancer assessment, an AT equal to a lifetime (70 years) × 365 days/year is used. Same value used in ingestion exposure calculations. For non-cancer assessment, an AT equal to the exposure duration (ED) × 365 days/year is used, so AT will vary by receptor group. Same value used in ingestion exposure calculations.		

2.5. Chemical-Specific Parameters

The chemical-specific parameters required to quantitatively evaluate dermal pathway exposures are listed in Exhibit C-4. For the water concentration in the dermal analysis, the modeled TRIM.FaTE chemical concentration in the screening scenario pond at the screening threshold emission rate was used. For the soil concentration, the modeled TRIM.FaTE chemical concentration in surface soil in parcel N1 (untilled soil, closest to facility) of the screening scenario at threshold emission rate was used. This same soil concentration was also used in ingestion exposure calculations for soil ingestion.

Dermal absorption of chemicals in water is based on the use of a dermal permeability coefficient (K_p), which measures the rate that a chemical penetrates the skin. Dermal absorption of soil-bound chemicals is based on the use of a dermal absorption fraction (ABS), which is a measure of how much of a chemical the skin absorbs through contact with soil.

Exhibit C-4. Chemical-Specific Dermal Exposure Values for Water and Soil Contact

PB-HAP	Cadmium	Divalent Mercury	2,3,7,8-TCDD	Benzo[a] pyrene	Source
Chemical concentration in Water (Cw) (mg/cm^3)	2.4E-08	1.9E-09	2.6E-18	2.1E-13	TRIM.FaTE modeled concentration in screening scenario pond
Chemical concentration in Soil (Cs) (mg/kg)	6.9E-02	6.3E-02	2.2E-10	1.4E-04	TRIM.FaTE modeled concentration in surface soil in parcel N1 in screening scenario
Permeability coefficient in water (Kp) (cm/hour)	0.001	0.001	0.81	0.7	Values from RAGS Part E, Exhibits B-3 (organics) and B-4 (inorganics)
Fraction absorbed water (FA) (unitless)	NA	NA	0.5	1.00	Values from RAGS Part E, Exhibits B-3; only used for organic chemicals
Lag time per event (event) (hr/event)	NA	NA	6.82	2.69	Values from RAGS Part E, Exhibits B-3; only used for organic chemicals
Dermal absorption fraction (ABS) from soil (unitless)	0.001	0.045[a]	0.03	0.13	Values from RAGS Part E, Exhibit 3-4, unless otherwise noted

[a] Value obtained from Bioavailability in Environmental Risk Assessment (Hrudey et al. 1996).

3. Screening-Level Cancer Risks and Non-Cancer Hazard Quotients

Toxicity values were used in conjunction with exposure information to evaluate the potential for cancer risks and non-cancer health hazards. Risk estimation methods are presented below.

3.1. Dermal Cancer Risk

Cancer risk for the dermal route was calculated as the product of the age-specific *DAD*s and the absorbed CSF for each chemical, as follows:

$$\textit{Dermal Cancer Risk} = DAD \times CSF_{ABS}$$

where:

DAD = Dermal Absorbed Dose (mg/kg-day)

CSF_{ABS} = Absorbed cancer slope factor $(mg/kg\text{-}day)^{-1}$

Lifetime dermal cancer risks were calculated for 2,3,7,8-TCDD and benzo[a]pyrene. The total risk accounts for dermal exposures that an individual might receive from these PB-HAPs in water plus soil over his or her lifetime (70 years).

3.2. Dermal Hazard Quotient

Dermal hazard quotient (HQ) was estimated as the ratio of age-specific *DAD*s to the absorbed RfD for each chemical, as shown below:

$$Dermal\ HQ = DAD / RfD_{ABS}$$

where:

DAD = Dermal Absorbed Dose (mg/kg-day)

RfD_{ABS} = Absorbed reference dose (mg/kg-day)

The aggregate HQ accounts for exposures that an individual in a receptor group may receive from the PB-HAP in water and soil over the exposure duration. Non-cancer hazard is not additive *across* the age groups evaluated here.

4. Dermal Screening Results

Exhibit C-5 presents a summary of estimated dermal non-cancer hazards by age group. A summary of estimated lifetime dermal cancer risks is provided in Exhibit C-6. The highest HQ value was 0.006 (representing divalent mercury exposure for children less than 1 year of age) or less. This is approximately 170 times less than the potential ingestion hazard quotients associated with the screening scenario (i.e. emissions of divalent mercury in the screening scenario resulted in an ingestion hazard quotient of 1). The highest estimated individual lifetime cancer risk associated with potential dermal exposures was 4.1E-09 for benzo[a]pyrene; this value is approximately 240 times smaller than the ingestion risk (i.e., 1E-06) estimated for the same screening threshold emission rate.

Exhibit C-5. Summary of Dermal Non-Cancer Hazards

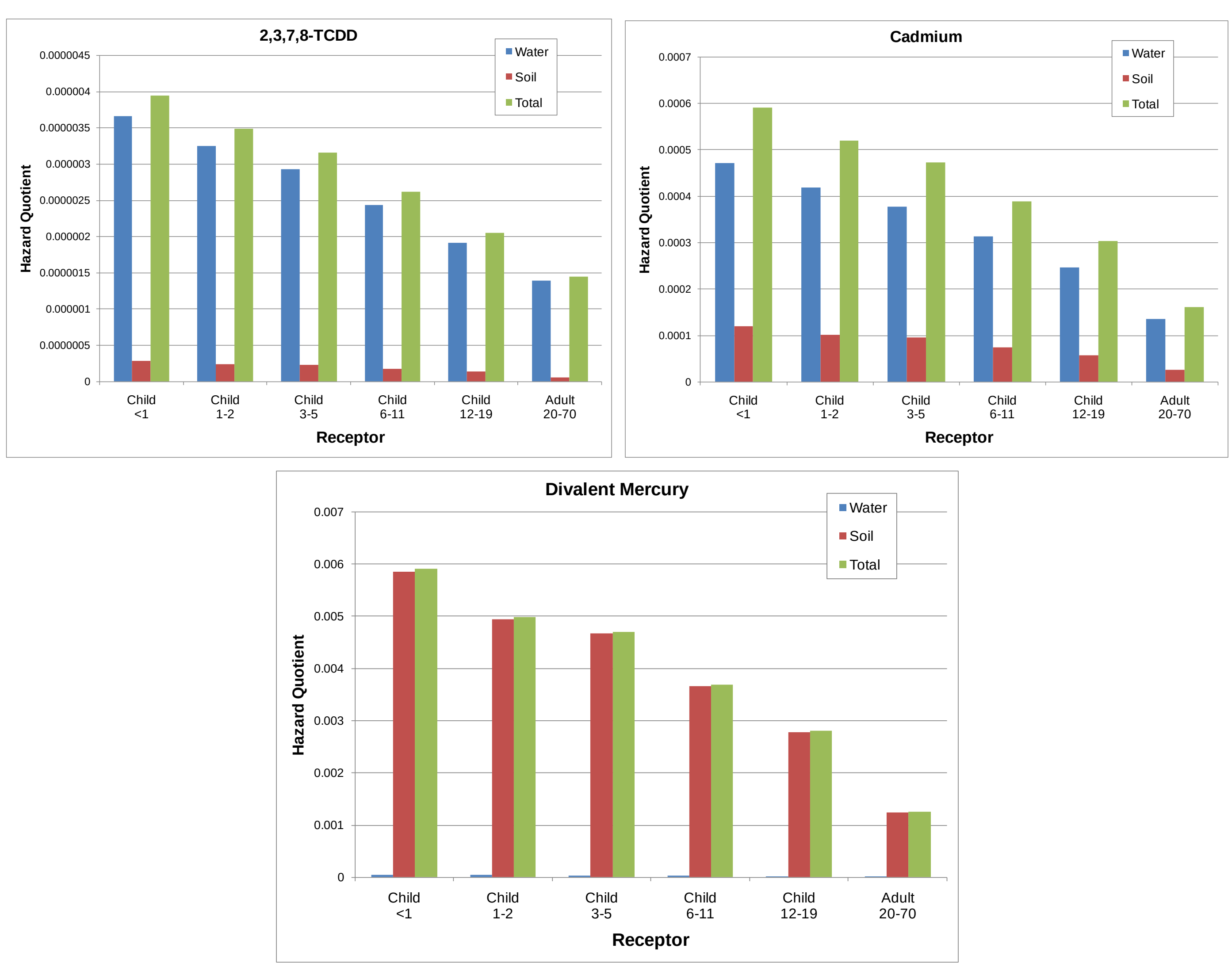


Exhibit C-6. Summary of Dermal Cancer Risks

PB-HAP	Dermal Lifetime Cancer Risk	Magnitude of Difference[a]
2,3,7,8-TCDD		
Water	2.64E-10	>3,700
Soil	1.49E-11	>67,300
Total	2.79E-10	>3,500
Benzo[a]pyrene		
Water	1.50E-09	>600
Soil	2.63E-09	>300
Total	4.12E-09	>200

[a] Represents the magnitude of difference between the estimated dermal risk and the potential ingestion risk associated with the screening scenario.

Based on these results and taking into consideration the extremely conservative nature of the dermal exposure calculations, it was assumed that it is not necessary to incorporate dermal exposures in calculating multipathway screening threshold levels. Specifically, the daily exposure durations of 0.58 hour for adults and 1 hour for children used to calculate dermal exposure from water are highly conservative and assume that the individual is bathing in surface water taken directly from a contaminated lake or is swimming in the lake for 350 days of the year. The exposure frequency of 350 days and corresponding skin surface area available for contact with contaminated soils (i.e., head, hands, arms, legs, and feet) likely also grossly overestimates dermal exposure to soil.

5. References

Cal/EPA (California Environmental Protection Agency) Office of Environmental Health Hazard Assessment (OEHHA). 2000. Air Toxics Hot Spots Program Risk Assessment Guidelines; Part IV, Exposure Assessment and Stochastic Analysis Technical Support Document. Section 6, Dermal Exposure Assessment. September. Available at: http://www.oehha.ca.gov/air/hot_spots/pdf/chap6.pdf.

Hrudey, S.E., W. Chen, and C.G. Roussex, 1996. Bioavailability in environmental risk assessment. CRC Press, Inc, Lewis publishers.

EPA (Environmental Protection Agency). 2004. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R99/005. Available at: http://www2.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e.

EPA. 2006. Risk and Technology Review (RTR) Assessment Plan. Office of Air and Radiation. November 20. Available at: http://www.epa.gov/sab/panels/consul_risk_and_tech_assessment_plan.htm.

EPA. 2008. Child-Specific Exposure Factors Handbook. Office of Research and Development, Washington, D.C. EPA/600/R-06/096F. September. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243.

Attachment D. Summary of TRIM.FaTE Parameters Considered for Inclusion in Tier 2 Assessment

[This page intentionally left blank.]

Exhibits, Attachment D

Exhibit D-1. TRIM.FaTE Parameters Considered for Inclusion in Tier 2 Assessment

Parameter	Mechanism of Potential Influence in TRIM	Assessment of Parameter Significance and Ease in Implementation	Uncertainty in Site-Specific Data for Facilities	Priority for Inclusion
Meteorological Parameters				
Wind direction (% of time wind blows toward the lake and farm)	In previous runs, direct deposition accounted for the bulk of chemical input onto farms and into lakes. Because wind direction is strongly correlated to direct deposition in a given location, media concentrations are potentially highly sensitive to this parameter. Also, because the percentage of time the prevailing wind blows in the direction of lakes and farms can vary considerably across locations, differences in this parameter might also result in significant changes in important environmental concentrations.	**Highly Significant**: Previous sensitivity analyses have confirmed this to be a very sensitive parameter in the Tier 1 Screening modeling set-up. Changing the fraction of time the wind blows toward the lake and farm by a factor of two corresponds to a change in the risk by a factor of two. **Low Effort to Implement:** This variable is relatively straightforward to vary in the Tier 2 screening scenarios.	**Low to Moderate:** The average fraction of time the wind blows in a given direction can be estimated for any surface meteorological station. Then, facilities can be linked to the closest surface meteorological station.	**High**
Wind speed	Wind speed can affect the location of the “peak” concentration and deposition patterns in a given model configuration, as well as the risk-distance profile.	**Highly Significant**: Previous sensitivity analyses have confirmed this to be a very sensitive parameter. However, wind speed does not vary widely across U.S. locations which could reduce its potential influence. **Low Effort to Implement:** This variable is relatively straightforward to vary in the Tier 2 screening scenarios.	**Low to Moderate:** The annually-averaged wind speed can be estimated for any surface meteorological station. Then, facilities can be linked to the closest surface meteorological station.	**High**

Exhibit D-1. TRIM.FaTE Parameters Considered for Inclusion in Tier 2 Assessment

Parameter	Mechanism of Potential Influence in TRIM	Assessment of Parameter Significance and Ease in Implementation	Uncertainty in Site-Specific Data for Facilities	Priority for Inclusion
Precipitation	Chemicals for which wet vapor or wet particle deposition processes are important are likely to be sensitive to the assumed level of precipitation.	**Highly Significant**: Previous sensitivity analyses have indicated a relatively high sensitivity of risk to precipitation for most PB-HAPs (PAHs, cadmium, and mercury). **Moderate Effort to Implement:** In implementing changes in precipitation in TRIM, care must be taken to also preserve the overall water balance in the model.	**Low to Moderate:** The annually-averaged precipitation rate can be estimated for the subset of surface meteorological stations that capture rainfall data. Then, facilities can be linked to the closest surface meteorological station with available data.	**High**

Exhibit D-1. TRIM.FaTE Parameters Considered for Inclusion in Tier 2 Assessment

Parameter	Mechanism of Potential Influence in TRIM	Assessment of Parameter Significance and Ease in Implementation	Uncertainty in Site-Specific Data for Facilities	Priority for Inclusion
Mixing height	Greater mixing heights increase the dispersion of pollutants in the atmosphere and consequently reduce deposition to the ground in the areas around the stack. This is likely to be a highly sensitive parameter if there is a sizeable variation in mixing heights between facilities.	**Highly Significant**: Previous sensitivity analyses have shown risk to be very sensitive to mixing height. **Low Effort to Implement:** This variable is relatively straightforward to vary in the Tier 2 screening scenarios.	**Moderate to High:** Mixing height estimates are available for upper air meteorological stations, and this set of stations is more limited than the set of surface meteorological stations. Each surface station can be linked to the closest upper air station to estimate the average mixing height. Then, facilities can be linked to the closest surface meteorological station. The relative uncertainty in mixing height for a given facility is high, given diurnal variations in mixing height and the smaller number of upper air stations.	**High**

Exhibit D-1. TRIM.FaTE Parameters Considered for Inclusion in Tier 2 Assessment

Parameter	Mechanism of Potential Influence in TRIM	Assessment of Parameter Significance and Ease in Implementation	Uncertainty in Site-Specific Data for Facilities	Priority for Inclusion
Configurational Parameters				
Distance of lake from stack	Deposition is known to decrease with distance from stack, although this relationship also depends on meteorological parameters such as wind speed and wind direction.	**Significance Difficult to Determine:** Limited results from previous TRIM model runs show an inconclusive relationship between risk and distance from stack, possibly as a result of limited statistical power. Some studies in the literature show a definite decreasing risk gradient with distance but others report too many confounding factors to isolate the precise relationship. **Moderate Effort to Implement:** This variable requires updates to the layout coordinates and requires more effort to vary in the Tier 2 screening scenarios than the meteorological parameters.	**Low:** The lakes within a given radius of each facility can be found using ArcGIS™.	**High**
Distance of farm from stack	Deposition is known to decrease with distance from stack, although this relationship also depends on meteorological parameters such as wind speed and wind direction.	**Significance Difficult to Determine:** Limited results from previous TRIM model runs show an inconclusive relationship between risk and distance from stack, possibly as a result of limited statistical power. Some studies in the literature show a definite decreasing risk gradient with distance but others report too many confounding factors to isolate the precise relationship. **Moderate Effort to Implement:** This variable requires updates to the layout coordinates and requires more effort to vary in the Tier 2 screening scenarios than the meteorological parameters.	**High:** Although the distance to the farm will likely affect risk, it is difficult to determine the precise land parcels near each facility that are actually used for farming now or in the future.	**Medium**

Exhibit D-1. TRIM.FaTE Parameters Considered for Inclusion in Tier 2 Assessment

Parameter	Mechanism of Potential Influence in TRIM	Assessment of Parameter Significance and Ease in Implementation	Uncertainty in Site-Specific Data for Facilities	Priority for Inclusion
Watershed: lake area ratio	A higher watershed:lake area ratio potentially increases the chemical input of water-soluble or particle-attached chemicals into the lake. But the associated higher flush rate will likely reduce this effect.	**Significance Difficult to Determine**: Changes in the watershed to lake ratio affect risk, but the interaction depends on other variables involved in the water balance. **Moderate Effort to Implement:** In implementing changes in the watershed:lake ratios in TRIM, care must be taken to also preserve the overall water balance in the model.	**High:** The portion of land serving as a watershed to a particular lake is difficult to determine.	**Medium**
Area and depth of lake	A higher lake area would capture more deposition but this effect might be counterbalanced by the ensuing larger volume of water, which reduces chemical concentration. Similarly, a deeper lake would also reduce concentrations, but this effect might be counterbalanced by the ensuing lower flush rates at a constant level of precipitation/runoff.	**Significance Difficult to Determine**: The impact of these parameters is inconclusive based on current studies using the TRIM model. **Moderate Effort to Implement:** The lake area variable requires updates to the layout coordinates and requires more effort to vary in the Tier 2 screening scenarios than the meteorological parameters. In implementing changes in these variables in TRIM, care must be taken to also preserve the overall water balance in the model.	**High:** While the area of lakes near a facility can be determined using GIS, the depth cannot.	**Medium**

Exhibit D-1. TRIM.FaTE Parameters Considered for Inclusion in Tier 2 Assessment

Parameter	Mechanism of Potential Influence in TRIM	Assessment of Parameter Significance and Ease in Implementation	Uncertainty in Site-Specific Data for Facilities	Priority for Inclusion
Physical Parameters				
Flush rate	A higher flush rate out of the lake would result in a higher rate of chemical output from the lake, assuming constant inflow and volume.	**Significance Difficult to Determine**: The impact of this parameter is inconclusive based on current studies using the TRIM model. **Moderate Effort to Implement:** In implementing changes in the flush rate in TRIM, care must be taken to also preserve the overall water balance in the model.	**High:** The flush rate of a lake cannot be determined easily for any lake found near a facility. In addition, erosion rates, watershed information, and lake depth needed to estimate the flushing rate are not readily available.	**Medium**
Runoff rate and fraction	A higher runoff rate (or fraction) would likely result in greater chemical input into the lake for some chemicals but also potentially a higher flush rate out of the lake.	**Significance Difficult to Determine**: The impact of this parameter is inconclusive based on current studies using the TRIM model. **Moderate Effort to Implement:** In implementing changes in the runoff rate and fraction in TRIM, care must be taken to also preserve the overall water balance in the model.	**High:** As with the flush rate, the runoff rate and fraction for any lake near a facility cannot be readily determined.	**Medium**
Erosion rate and fraction	A higher erosion rate would likely result in greater chemical input into the lake for particle-bound chemicals. It would also result in greater chemical transport onto farmlands, but this might be counterbalanced by equally greater erosion off farmland.	**Highly Significant**: Previous analyses have shown risk to be sensitive to this parameter for some chemicals. **Moderate Effort to Implement:** In implementing changes in the erosion rate and fraction in TRIM, care must be taken to also preserve the overall water balance in the model.	**High:** As with the flush rate, the erosion rate and fraction for any lake near a facility cannot be readily determined.	**Medium**

Exhibit D-1. TRIM.FaTE Parameters Considered for Inclusion in Tier 2 Assessment

Parameter	Mechanism of Potential Influence in TRIM	Assessment of Parameter Significance and Ease in Implementation	Uncertainty in Site-Specific Data for Facilities	Priority for Inclusion
Chemical Parameters				
Methylation/ demethylation rates (Hg)	For Hg, methylation and demethylation rates in lake sediment and surface water are potentially sensitive parameters affecting risk. A literature survey has indicated a relatively high range for rate constants describing these processes.	**Highly Significant**: Previous analyses run in TRIM have confirmed the high sensitivity of these parameters for Hg. **Low Effort to Implement:** This variable is relatively straightforward to vary in the Tier 2 screening scenarios.	**High:** The specific methylation / demethylation rates for mercury in the vicinity of a specific facility cannot be readily determined.	**Low**
Total phosphorus levels in the lake	The total phosphorus content of a lake is used as part of the TRIM.FaTE parameterization process to estimate the biomass content of different trophic levels. These biomass levels affect the biomagnification of chemicals up the food chain and potentially risk to human consumers of fish.	**Not Significant**: Previous analyses have shown limited sensitivity to total phosphorus levels. This is likely because the empirical equations predicting biomass in each trophic level depend in similar ways on the level of total phosphorus. So changes in total phosphorus do not significantly affect the ratio of biomass between the different trophic levels. **Low Effort to Implement:** This variable is relatively straightforward to vary in the Tier 2 screening scenarios.	**High:** The total phosphorus levels in lakes near a specific facility cannot be readily determined.	**Low**

[This page intentionally left blank.]

Attachment E. Analysis of Lake Size and Sustainable Fish Population

[This page intentionally left blank.]

CONTENTS, ATTACHMENT E

1. Introduction

Identifying the smallest size of a lake that might maintain self-sustaining populations of fish from trophic levels (TL) 3 and 4 and is sufficient to support at least one fisher at a specified fish ingestion rate requires consideration of many factors. Some factors depend on assumptions about the behavior of fishers who consume fish from a lake (see Section 2 below). Other factors depend upon the general biology of fish populations in North American ecoregions (see Section 3). Based on evaluation of these factors, a set of assumptions was developed to support the estimation of minimum lake sizes that are needed to sustain a particular total human ingestion rate in grams/day (see Section 4). Then, equations were developed (see Section 5) that were used to create Exhibit 26 (in Section 3.4 of the main body of the report), which was used to determine the threshold lake size of 25 acres.

2. Fisher Behavior

Several assumptions regarding fisher behavior are important for estimating a minimum lake size that is fishable. The first is a conservative assumption that fishers (and their family members) consume about 50:50 top carnivore fish from both the benthos and from the water column. Benthic carnivores (BC), such as catfish and chub that consume benthic invertebrates and small benthic fish, can grow to large sizes (e.g., 2 kg). Assuming a diet of 50 percent benthic invertebrates and 50 percent small benthic fish (e.g., young of the year that feed on algae or detritus), the BC fish category would represent trophic level (TL) 3.5. Pelagic piscivores—water column carnivores (WCC)—include species such as largemouth bass, lake trout, pickerel, and walleye. The WCC are modeled as TL 4, with 100 percent of their diet comprised of water column omnivores (WCO, e.g., pan fish such as bluegill and white perch), and the diet of the WCO is assumed to be 100 percent minnow-sized fish that feed on zooplankton and algae . The assumption of 50:50 WCC and BC consumption is conservative, because smaller, pan fish, are not included. Although fishers might prefer to catch and consume the pelagic (TL4) game fish species, their generally lower abundance compared with fish that also consume benthic invertebrates dictates that fishers will more often capture the benthic (TL3.5) carnivores. Some TL2 (herbivorous) fish such as carp attain “catchable” size, but they generally are not popular fish for consumption and are not considered here. .

A second assumption is that fishers and their family members consume only the fillet portion of a fish. According to Ebert et al. (1993), the edible fraction of fish as a proportion of total fresh body weight is 0.4 for salmon, 0.78 for smelt, and 0.3 for all other species. EPA recommends use of 0.30 for the consumable fraction of fish (USEPA, 1989). For this assessment, a 0.33 edible fraction for TL4 fish was assumed. That factor is roughly one-third, which we considered preferable to 0.30 to account for some proportion of salmon likely in the diet. This factor is used in the lake size analysis to estimate total fish biomass required to support specified human fish consumption rates.

A third assumption relates to ingestion rates of the fisher or fisher family. Fish ingestion rates used for the purpose of the Tier 2 assessment are the same as those in Tier 1 and are consistent with subsistence fisher ingestion rates (see Exhibit 18).

The final assumption is that the lake must support a sustainable fishery despite fish harvesting by humans; in other words, the lake shouldn’t be “fished out” by the harvest rate required to meet the subsistence fisher fish ingestion rate. The productivity of any particular fishery (local population of a species of fish) and the proportion of adult fish that can be harvested for human consumption are difficult values to estimate, and models to predict sustainable harvests of different fisheries are numerous and complex. Species-specific parameters of key to such models include fecundity with age and size; survivorship of eggs, fry, and juveniles to sexual maturity (recruitment); natural predation pressures; and temporal variation in food availability. For the purpose of this analysis, simplifying assumptions are required. In the analysis by Håkanson and Boulion (2004), which included a survey of 122 lakes, the authors noted that a typical loss from fishing by birds, mammals, and humans would be approximately 10 percent of the fish biomass in the prey fish compartment (TL3) and 10 percent of the biomass in the predator fish compartment (TL4). The authors also found that as overall lake productivity increased, the biomass of prey (TL3) fish increased more rapidly than the biomass of predator (TL4) fish. For our lake size analysis, we assumed that fishers can harvest 10 percent of the biomass of pelagic WCC fish without diminishing the fish population size.

3. Fish Biology

Fish life histories also are key to estimating the minimum surface area of a pond or lake that could support a sustainable fish population of WCC. The productivity and trophic structure of fish communities in ponds and lakes across the United States are varied. Thus, any set of assumptions is unlikely to all hold true at any given location. Nonetheless, three factors are important to any estimate of a minimum lake surface area for sustainable pelagic TL4 fishing: the general productivity of a lake (expressed as grams of fish wet weight per meter squared, g ww/m^2); the maximum likely proportion of the total fish biomass in a lake that is comprised of the top trophic level fish; and the minimum viable population (MVP) size required for the fish species to be self-sustaining in the short term (for at least a few decades).

3.1. Lake Productivity

The general productivity of a lake depends on many factors, including latitude, seasonal temperatures, and nutrients supporting the base of the food web. For lakes at approximately the same latitude in the same climate, nutrients play a key role in the total fish biomass that a lake might support. In a regression analysis of data on total phosphorus (TP) and fish biomass for 31 lakes across North America, Europe, and Russia, Nürnberg (1996) summarized the "limits" among three TP-defined lake trophic status categories with respect to total fish wet weight biomass per unit area:

Oligo-meso (TP = 10 µg/L) = 1.9 g ww/m^2
Meso-eutro (TP = 30 µg/L) = 3.7 g ww/m^2
Eutro-hypereutro (TP = 100 µg/L) = 8.5 g ww/m^2

Nürnberg (1996) also summarized total fish biomass limits from Bachmann et al. (1996) for the same lake trophic status categories based on a sample of 60 lakes in Florida:

Oligo-meso (TP = 10 µg/L) = 7.4 g ww/m^2
Meso-eutro (TP = 30 µg/L) = 10.6 g ww/m^2
Eutro-hypereutro (TP = 100 µg/L) = 15.6 g ww/m^2

As might be expected, for the same TP concentrations, standing fish biomass per unit area in the Florida lakes is two to three times higher than standing fish biomass for more northerly lakes with shorter growing seasons.

Hanson and Legget (1982) estimated the relationship between TP and standing stock of fish using a regression model based on samples from 21 lakes ranging in surface area from 0.1–25,000 hectares (~0.25–62,000 acres) and located between 0° and 56° N latitude and

121° E to 122° W longitude. Their linear regression relating TP to total fish standing biomass (B) had a correlation coefficient (r^2) of 0.84:

$$B = 0.792 + 0.072\,(TP)$$

where:

B = total fish biomass (kg/hectare)
TP = total phosphorous (µg/L)

The regression model of Hanson and Legget (1982) predicted total fish biomass densities in lakes of 3.0–9.5 g ww/m^2 for TP concentrations ranging from 10–50 µg/L for oligo-mesotrophic to mid-range eutrophic lakes. Another regression model from Hoyer and Canfield (1991) predicted fish biomass densities in streams of 2.6–6.6 g ww/m^2 over the same range of TP concentrations.

In general, for very small lakes, relatively low fish productivity is likely. For example, Demers et al. (2001) found fish standing biomass values of 2.73 and 3.81 g ww/m^2 in two lakes of 27 and 22 acres (11 and 9 hectares), respectively, in south-central Ontario. Brönmark and Weisner (1996) reported on aquatic communities from a sample of 44 small ponds in southern Sweden (most were less than 5 hectares ≈ 12 acres). They found no fish in 5 of the smaller ponds (mean surface area of 0.20 ± 0.097 acres)—which also exhibited lower TP concentrations than the larger ponds—and no piscivorous fish in another 11 of the 44 ponds (mean surface area of 0.46 ± 0.27 acres). For the 28 ponds with piscivorous (TL4) fish present, the mean pond surface area was 1.4 (±1.3 SD) acres.

Scientists have also examined the relationship between TP and total fish biomass in reservoirs. Yurk and Ney (1989) examined the relationship between TP and standing stock of fish in 22 reservoirs in southern Appalachia sampled in 1973. Their logarithmic regression relating TP to total fish standing biomass (B) used the following equation and had an r^2 of 0.75:

$$Log_{10}(B) = 1.07 + 1.14 \times Log_{10}(TP)$$

Use of the equations from Hanson and Legget (1982) and Yurk and Ney (1989) yielded similar predications of total fish biomass at low to intermediate TP concentrations. At low TP (e.g., 10 µg/L), predictions of total fish biomass were 3.0 g ww/m^2 (Yurk and Ney, 1989) and 1.6 g ww/m^2 (Hanson and Legget, 1982); at high TP (e.g., 100 µg/L), fish biomass predicted by the two models were 15.5 and 22.4 g ww/m^2, respectively.

Ideally, one would have data indicating TP levels in lakes in the vicinity of facilities for a Tier 2 assessment. Such data, however, are rarely readily available. For purposes of the screening assessment, therefore, we assume that fish productivity per unit area is independent of lake size over a wide range of lake sizes and that TP levels are unknown.

Leidy and Jenkins (1977) reported analyses of several large data sets to support modeling of fish productivity and carrying capacity in reservoirs across the United States for the National Reservoir Research Program. The analyses included studies of fish standing biomass by species in 61 reservoirs across the midwestern and eastern United States sampled at different times between 1952 and 1975. Only reservoirs of at least 500 acres (202 hectares) in size were included, with some exceeding 65,000 acres (in the Missouri drainage basin). Considering all 61 reservoirs, the mean biomass density of fish was 41.3 (± 30.4 SD) g ww/m^2. The minimum and maximum total fish biomass densities were 3.2 and 133.2 g ww/m^2, respectively, and the median value was 30.9 g ww/m^2. Reservoirs typically have large drainage basins, which in some areas can receive excess TP from large expanses of agricultural areas.

In summary, the fish productivity in lakes and reservoirs can vary by more than three orders of magnitude. The reservoirs surveyed by Leidy and Jenkins (1977) in general were much larger (and were often more shallow and nutrient rich) than the natural lakes surveyed by others discussed above. The mean standing fish biomass of approximately 41.3 g ww/m^2 from the reservoir survey is likely to be higher than a mean value for representative samples of natural lakes in the United States. For the purpose of estimating the minimum lake size that would support a sustainable WCC fishery, we rounded that value down to a single significant digit of 40 g ww/m^2 as the upper limit for total fish biomass in a lake. That standing biomass is higher than predicted by the regression models of Hanson and Legget (1982), Yurk and Ney (1989), and Nürnberg (1996) at a high total phosphorus of 100 µg/L (where phosphorous is the limiting nutrient). Less productive lakes would support fewer fish per unit area, and, therefore, would have to be larger to support a specified fish ingestion rate.

3.2. Proportion of Fish Biomass by Trophic Level

As indicated previously, for the Tier 2 assessment, the proportion of fish in a fisher's diet that consists of WCC (TL4) and BC (TL3.5) is assumed to be 50:50 by biomass (not numbers) for lakes that support the four trophic levels. In smaller lakes, TL4 fish are likely to be missing or rare, with TL3 fish in the water column (e.g., sunfish) being the highest trophic level supported by the primary productivity (algal/plant production) in some lakes. As a "rule of thumb" in ecology, 10 percent or less of the energy produced at one trophic level usually can be converted to biomass in the next trophic level (i.e., approximately 90 percent loss of energy) per trophic step. However, with different species having different energy assimilation efficiencies and with smaller species generally having higher turnover rates than larger species, the 10 percent energy rule does not necessarily translate into a standing biomass pyramid of similar proportions. In this section, the proportion of fish (based on biomass) that might be expected in the WCC and the BC fish compartments relative to total standing fish biomass are examined assuming that the lake is large enough to support WCC (pelagic TL4 fish).

Examination of several studies of fish biomass by trophic level indicated that top trophic level fish might comprise up to 20 percent of the standing fish biomass in many locations. Ploskey and Jenkins (1982) estimated that piscivorous fish, both those that are generally free-swimming or pelagic (e.g., pike, gar, walleye) and those that rest and forage primarily in the benthos (e.g., various species of catfish, suckers) comprise 22 percent of the total fish biomass in DeGray Lake, Arkansas (averaged across several years). Leidy and Jenkins (1977) estimated that 18 percent of the fish biomass across the 61 reservoirs they examined was piscivorous (minimum of 14 percent and maximum 24 percent). Demers et al. (2001) categorized 2 percent and 15 percent of the total fish biomass in two small lakes of 27 and 22 acres in size, respectively, as piscivorous/benthivorous fish (e.g., largemouth bass, creek chub); primary benthivores (e.g., catfish, suckers) dominated at >70 percent in both lakes.

One of the more recent food web models for freshwater lakes is that of Håkanson and Boulion (2004). They designed their model to predict productivity and standing crop of prey and predatory fishes in lakes of northern Europe. The authors acknowledged that fish feeding patterns are complicated by the fact that fish change their feeding preferences as they age. Some fish species consume zooplankton or benthic invertebrates in their first year, and switch to small fish and then to larger fish as they mature and grow in size.

Håkanson and Boulion (2004) created a “distribution coefficient” to indicate what proportion of the total fish biomass in a lake is prey versus predatory fish. Based on data from 122 lakes in Europe and North America, they concluded that 27 percent by biomass is a “normal” portion of predatory fish in a balanced system. They noted further, however, that for eutrophic lakes with TP levels >100 µg/L, the proportion of fish represented by piscivores declines to less than 20 percent. The piscivores included both benthic and pelagic species. We note that most benthic piscivores also consume benthic macroinvertebrates.

Based on the information above, the top trophic level fish are assumed to comprise 21 percent of the total fish biomass. With the bulk of productivity in lakes originating from detritus in the benthos, the total biomass of strictly pelagic game fish is expected to be less than that of benthic fish. Therefore, for purpose of this lake size analysis, the piscivorous/benthivorous fish were separated into two compartments, with 17.5 percent of the total fish biomass in a benthic carnivore (TL3.5 or BC) compartment and 3.5 percent of the total in a pelagic piscivore (WCC) compartment. Thus, the TL4 fish, when present, represent the limiting compartment for fish harvesting and consumption.

3.3. Minimum Viable Population Size

The final step in estimating the minimum lake size that can support sustainable fishing of its WCC fish species is to invoke the concept of minimum viable population (MVP) size. MVP is a concept used frequently in conservation biology for animals and is defined as the smallest population that will persist for a specified duration (e.g., 100 years) with a given probability (e.g., 95 percent). MVP for any given species and location depends on many attributes of the species biology (e.g., body size, reproductive rate, home range size, corridors between populations, variability in environmental characteristics that impact fecundity and survival). At lower numbers, the likelihood of population extinction increases due to environmental and demographic stochasticity (Menzie et al., 2008). As for fisheries biology, entire text books have been dedicated to applied population ecology with population simulations incorporating demographic and life-history characteristics, spatial separation of habitat patches and metapopulations, the probability of local catastrophes, genetic variation (e.g., drift), and other factors with predictions of time-to-extinction or probability of extinction within specified time periods (e.g., Soulé, 1987; Akçakaya et al., 1999). Consideration of such models in population-level ecological risk assessment has begun, but faces many challenges (Barnthouse et al., 2008). Moreover, that level of effort is beyond the resources available for screening-level assessments.

Much of the initial work on MVP investigated the genetic minima required for short-term survival, continuing adaptation to environmental change, and ultimately evolution. Inbreeding has been considered the primary threat to short-term survival and genetic drift the principal threat to losing the genetic variation required for adaptation (Shaffer, 1987). Several analyses (Senner, 1980; Franklin, 1980; Soulé, 1980; Frankel and Soulé, 1981; Lande and Barrowclough, 1987) have led to the conclusion that minimum effective population sizes on the order of 50 are required for short-term survival (e.g., several generations, decades), while effective population sizes on the order of 500 are necessary to provide adequate genetic variation for continuing adaptation over the long term (e.g., tens of generations, centuries for some animals) (Shaffer, 1981; 1987). Effective population size, N_e, is a measure of the rate of genetic drift (loss of genetic diversity or inbreeding), and its definition generally depends on the population in question (Rieman and Allendorft, 2001). N_e can be estimated mathematically based on stochastic behavior of gene frequencies in a diploid population. Simple models assume a fixed population size, constant fecundity, specified sex ratio, and no overlap between generations (see studies cited in NRC, 1986). For animals with 50:50 sex ratios, the effective population size is essentially the same as the actual breeding adult population size (Ewens et al., 1987). One of the most extensive population viability analyses in the United States has been conducted on the spotted owl (Boyce, 1993). Given the number and complexity of factors that influence MVP, however, including the definitions of time horizon (e.g., 100 years) and probability of survival (e.g., 95 percent), population biologists caution against using a "rule of thumb" for MVP across circumstances (Ewens et al., 1987).

Note that the MVP is appropriate for a single species of fish, not for generic categories of fish such as WCC or TL4. For this Tier 2 assessment, the MVP of 50 associated with short-term population survival was assumed for a TL4 fish species isolated in a lake. In reality, short-term extirpations from a lake can be countered by purposeful introductions from other lakes or during flooding events. Thus, an MVP of 500 was not considered necessary for game fish in lakes.

4. Summary of Assumptions for the Lake Size Analysis

The following assumptions were used in processing lake data for the Tier 2 assessment and in estimating the relationship between fish ingestion and sustainable harvest rates and lake size (see Section 3.4.1 of Attachment B).

1. Piscivorous fish (WCC and BC), when present, comprise approximately 21 percent of the standing biomass of fish (ignoring seasonal changes). The BC fish represent 17.5 percent of the standing fish biomass; WCCs account for 3.5 percent of the total fish biomass. Thus, WCC fish, when present, represent the limiting compartment for fish harvesting and consumption.
2. Humans can harvest 10 percent of the biomass of a fish compartment without threatening the population due to overharvesting.
3. The MVP size for a single WCC species is at least 50 adult fish for a local population to survive over the short term (more than a decade).
4. Only 33 percent of the fish is edible fillet muscle.

5. Equations Used to Determine Lake Fish Populations

The standing biomass of WCC (TL4) fish supported in Lake X can be calculated as the total standing biomass of fish (Total SB) multiplied by 0.035, based on the assumption that TL4 fish represent approximately 3.5 percent of the standing biomass in Lake X.

$$WCC\ SB = Total\ SB\ x\ Fraction\ WCC \qquad \textit{(Equation 1)}$$

where:

WCC SB = Standing biomass of WCC fish (g wet weight [ww]/m^2) in Lake X
Total SB = Total standing biomass of fish (g ww/m^2) in Lake X
Fraction WCC = Fraction of WCC fish in Lake X (i.e., 0.035)

Using WCC SB and the size of Lake X (Lake Size), the total number of WCC fish supported in Lake X can be calculated using Equation 2 below.

$$No.WCC = \frac{Lake\ Size\ x\ WCC\ SB\ x\ CF}{BW_a} \qquad \textit{(Equation 2)}$$

where:

No. WCC = Total number of WCC fish in Lake X

Lake Size = Size of Lake X (acres)

WCC SB = Standing biomass of WCC fish (g ww/m^2; from Equation 1)

CF = 4047 (unit conversion factor m^2/acre)

BW_a = Body weight of adult TL4 fish (2000 g; assumed)

The likely annual productivity of WCC fish (kg/year) in Lake X can be estimated using Equation 3.

$$Productivity\ WCC = \frac{Lake\ Size\ x\ WCC\ SB\ x\ CF1}{CF2} \qquad \textit{(Equation 3)}$$

where:

Productivity WCC= Likely annual productivity of WCC fish in Lake X (kg/year)

Lake Size = Size of the Lake X (acres)

WCC SB = Standing biomass of WCC fish (g ww/m^2; from Equation 1)

CF1 = 4047 (unit conversion factor 1, m^2/acre)

CF2 = 1000 (unit conversion factor 2, g/kg)

The maximum fish ingestion rate (g/day) for WCCs plus BCs associated with sustainable fishing can be predicted using Equation 4. It assumes that the fishers consume 50 percent WCC and 50 percent BC, represented by the factor of 2 in Equation 4.

$$Max\ Sustain\ IR\ (BC + WCC) = \frac{2\ x\ Productivity\ WCC\ x\ FF\ x\ HF\ x\ CF1}{CF2} \qquad \textit{(Equation 4)}$$

where:

Max Sustain IR (BC + WCC) = Predicted maximum sustainable ingestion rate for BC and WCCfish (g/day)

Productivity WCC = Likely annual productivity of WCC fish in Lake X (kg/year; from Equation 3)

FF = Fillet fraction; represents the assumed edible portion of fish (0.33; unitless)

HF = Annual harvest fraction (0.10; unitless)

CF1 = 1000 (unit conversion factor 1, g/kg)

CF2 = 365 (unit conversion factor 2, days/year)

6. References

Akçakaya, H.R., Burgman, M.A., and Ginzburg, L.R. 1999. Applied Population Ecology: Principles and Computer Exercises using RAMAS EcoLab. Sunderland, MA: Sinauer Associates, Inc. Publishers.

Bachmann, RW; Jones, BL; Fox, DD; Hoyer, M; Bull, LA; Canfield, DE. 1996. Relations between trophic state indicators and fish in Florida (USA) lakes. Canadian Journal of Fisheries and Aquatic Sciences. 53:842-855.

Barnthouse, L.W., Munns, W.R. Jr., and Sorensen, M.T. 2008. Population-Level Ecological Risk Assessment. Boca Raton, FL: CRC Taylor & Francis Group; Pnesacola, FL: Society of Environmental Toxicology and Chemistry (SETAC).

Boyce, M.S. 1993. Population viability analysis: adaptive management for threatened and endangered species. In: Wildlife Management Institute, Transactions of the 58th North American Wildlife and Natural Resources Conferences. Proceedings WWRC-93-19, pp. 520-527.

Brönmark, C. and S.E.B. Weisner. 1996. Decoupling of cascading trophic interactions in a freshwater benthic food chain. Oecologia 108: 534-541.

Demers, E., McQueen, D.J., Ramcharan, C.W., and A. Perez-Fuentetaja. 2001. Did piscivores regulate changes in fish community structure? Advanc. Limnol. 56: 49-80.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. N. Am. J. Fisheries Manage. 13: 737-745.

Ewens, W.J., Brockwell, P.J., Gani, J.M., and Resnick, S.I. 1987. Minimum viable population sizes in the presence of catastrophes. In: M.E. Soulé (ed.) Viable Populations for Conservation. United Kingdom, Cambridge: Cambridge University Press, pp. 59-68.

Frankel, O.H., and Soulé, M.E. 1981. Conservation and evolution. United Kingdom, Cambridge: Cambridge University Press.

Franklin, I.R. 1980. Evolutionary change in small populations. In: M.E. Soulé and B.A. Wilcox (eds.) Conservation Biology: An Evolutionary-Ecological Perspective. Sunderland, MA: Sinauer Associates; pp. 135-150. As cited by Shaffer, 1987.

Håkanson, L. and V.V. Boulion. 2004. Modeling production and biomasses of prey and predatory fish in lakes. Hydrobiologia 511: 125–150.

Hanson, J.M., and W.C. Leggett. 1982. Empirical prediction of fish biomass and yield. Can. J. Fish. Aquat. Sci. 39: 257-263.

Hoyer, M.V., and D.E. Canfield, Jr. 1991. A phosphorus-fish standing crop relationship for streams? Lake Reserv. Manage. 7: 25-32.

Lande, R., and Barrowclough, G.F. 1987. Effective population size, genetic variation, and their use in population management. In: M.E. Soulé (ed.) Viable Populations for Conservation. United Kingdom, Cambridge: Cambridge University Press, pp. 87-123.

Leidy, G.R., and Jenkins, R.M. 1977. The development of fishery compartments and population rate coefficients for use in reservoir ecosystem modeling. Contract Report Y-77-1 prepared by the National Reservoir Research Program, U.S. Fish and Wildlife Service, for the U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, USA.

Menzie, C., Bettinger, N., Fritz, A., Kapustka, L., Regan, H., Moller, V., and Noel, H. 2008. Population protection goals. In: Barnthouse, L.W., Munns, W.R. Jr., and Sorensen, M.T. 2008. Population-Level Ecological Risk Assessment. Boca Raton, FL: CRC Taylor & Francis Group; Pnesacola, FL: Society of Environmental Toxicology and Chemistry (SETAC), pp. 41-68.

NRC (National Research Council). 1986. Ecological Knowledge and Environmental Problem Solving. Committee on the Applications of Ecological Theory to Environmental Problems. Washington, DC: National Academies of Science Press.

Nürnberg, G.K. 1996. Trophic state of clear and colored, soft- and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Journal of Lake and Reservoir Management 12(4): 432-447.

Ploskey, G.R., and R.M. Jenkins. 1982. Biomass model of reservoir fish and fish-food interactions, with implications for management. North American Journal of Fisheries Management 2(2): 105-121.

Rieman, B.E., and Allendorf, F.W. 2001. Effective population size and genetic conservation criteria for bull trout. N. A. J. Fisheries Manage. 21:756-764.

Senner, J.W. 1980. Inbreeding depression and the survival of zoo populations. In: M.E. Soulé and B.A. Wilcox (eds.) Conservation Biology: An Evolutionary-Ecological Perspective. Sunderland, MA: Sinauer Associates; pp. 209-244. As cited by Shaffer, 1987.

Scaffer, M.L. 1981. Minimum population sizes for species conservation. Bioscience 31: 131-134.

Shaffer, M. 1987. Minimum viable populations: coping with uncertainty. In: M.E. Soulé (ed.) Viable Populations for Conservation. United Kingdom, Cambridge: Cambridge University Press, pp. 69-86.

Soulé, M.E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. In: M.E. Soulé and B.A. Wilcox (eds.) Conservation Biology: An Evolutionary-Ecological Perspective. Sunderland, MA: Sinauer Associates; pp. 151-170. As cited by Shaffer, 1987.

Soulé, M.E. (ed.) 1987. Viable Populations for Conservation. United Kingdom, Cambridge: Cambridge University Press.

USEPA (US Environmental Protection Agency). 1989. Assessing human health risks from chemically contaminated fish and shellfish: a guidance manual. EPA-503/8-89-002. Washington, DC.

Yurk, J.J., and J.J. Ney. 1989. Phosphorus-fish community biomass relationships in southern Appalachian reservoirs: can lakes be too clean for fish? Lake and Reservoir Management 5(2): 83-90.

[This page intentionally left blank.]

Appendix 7
Draft Protocol for Developing a TRIM.FaTE Model Scenario to Support a Site-Specific Risk Assessment in the RTR Program

Protocol for Developing a TRIM.FaTE Model Scenario to Support a Site-Specific Risk Assessment in the RTR Program

WORKING DRAFT

February 2014

Prepared For:

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711
Contract No. EP-W-12-010

Prepared By:

ICF International
2635 Meridian Parkway
Suite 200
Durham, NC 27713

[This page intentionally left blank.]

CONTENTS

TABLES

[This page intentionally left blank.]

1. Introduction

This document presents a protocol for developing TRIM.FaTE scenarios in support of site-specific risk assessments conducted within the RTR program using the TRIM.FaTE environmental fate and transport model.

This section describes the regulatory context, intended purpose of the protocol, the scope and limitations of the protocol, and some caveats to its use. It also presents a road-map to the content and structure of this document.

1.1 Regulatory Context and Approach to Risk Assessment for PB-HAPs

Section 112 of the Clean Air Act (CAA) directs the U.S. Environmental Protection Agency (EPA) to assess the risk remaining (i.e., residual risk) from emissions of persistent and bioaccumulative hazardous air pollutants (PB-HAPs) following the implementation of maximum achievable control technology (MACT) standards for emission sources. Such risk assessments for various emission source categories are a major component of EPA's Risk and Technology Review (RTR) program.

To evaluate ingestion exposures and human health risks for RTR on a source category basis, an iterative approach is currently employed. The approach enables EPA to confidently screen out PB-HAP emissions unlikely to pose health risks above levels of concern (i.e., a cancer risk exceeding 1-in-one million or a non-cancer hazard quotient exceeding 1[1]) and to focus additional resources on sources of greater concern within the category.

Two models are used to estimate ingestion exposure and ingestion risk in the RTR program:

- The Fate, Transport, and Ecological Exposure module of EPA's Total Risk Integrated Methodology (TRIM.FaTE) is used to model the fate and transport of pollutants released to the environment; and
- The Multimedia Ingestion Risk Calculator (MIRC) is used to estimate transfer and uptake into the food chain and exposure to receptors consuming contaminated food products and soil. A subset of media concentration estimates from TRIM.FaTE serve as inputs to MIRC, which also depends on other exposure and biotransfer-related input parameters.

The RTR approach is divided into three steps of increasing refinement:

1. Tier 1 of the approach identifies facility-level emissions of PB-HAPs within a source category and compares them to risk-based emission thresholds.

2. Tier 2 uses the actual location of the facility emitting PB-HAPs to refine a subset of the assumptions associated with the modeled Tier 1 environmental scenario while maintaining the Tier 1 ingestion exposure scenario assumptions; and

3. The final step, for facilities that cannot be ruled out based on the Tier 1 and Tier 2 screening process, is to conduct a more refined assessment, up to and sometimes including site-specific multipathway risk assessment. A site-specific risk assessment is intended to incorporate location- or facility-specific characteristics regarding the environment to which PB-HAPs are emitted, relevant exposure pathways, ingestion rates or other exposure factors, and other parameters. Site-specific risk assessments undertaken in the past as part of the RTR process have involved extensive literature searches for model parameters and required more time and resources to complete than the Tier 1 and Tier 2 screening analyses.

---

[1] EPA considers "cancer risks exceeding 1-in-one million" to refer to risks of at least 1.5-in-one million, and "non-cancer hazard quotients exceeding 1" to refer to hazard quotients of at least 1.5.

1.2 Purpose of this Protocol

The site-specific protocol presented in this document is intended to serve as a guiding framework to set up and parameterize scenarios in TRIM.FaTE that support accurate and cost-effective site-specific risk assessments as part of the RTR framework.

The purpose of the protocol is to develop a standard set of guidelines and recommendations for conducting site-specific assessments, providing a streamlined and replicable framework for configuring and parameterizing the TRIM.FaTE model. The protocol aims to balance modeling accuracy with cost-effectiveness in implementation, and to facilitate consistency and transparency across diverse assessments. This protocol is also intended to function as part of the technical documentation for future site-specific residual risk assessments by providing a clear and transparent description of the approach to parameterization and some of the relevant sources. Deviations from this protocol would need to be documented on a case-by-case basis. This document also provides guidance on ICF's FaTEmaster Scenario Builder tool and discusses how that tool can be used to support site-specific risk assessments using the TRIM.FaTE model.

1.3 Scope and Limitations

The site-specific protocol presented in this document focuses on the fundamental aspects of setting up a scenario in TRIM.FaTE from an RTR perspective. While the TRIM.FaTE User's Guide (U.S. EPA 2005) provides guidance on the mechanistic aspects of designing a simulation, the protocol focuses on identifying best practices that optimize model set-up efficiency while maintaining a high level of model precision in the RTR context.

These best practices have been developed with a focus on the impact of alternative model configuration and parameterization approaches on ingestion risk in the RTR process. Thus, if two alternative model configuration approaches are estimated to have similar impacts on risk estimates in the RTR process, the protocol will recommend the less effort-intensive approach where appropriate. For instance, the protocol identifies only a limited set of TRIM.FaTE model properties as requiring site-specific parameterization, while proposing land use-specific or nationally representative or health protective values for others based on the finding that relatively few model parameters substantially influence risk in the RTR context.

However, the protocol is not driven exclusively by considerations of cost-effectiveness. In some instances, the protocol aims to provide superior methods of model configuration based on model accuracy and scientific considerations that were previously not clearly articulated in available TRIM.FaTE guidance, and that have a focus on the RTR program.

This protocol is not intended to serve as a substitute for the TRIM.FaTE User's Guide (U.S. EPA 2005) or the TRIM.FaTE Technical Support Document (U.S. EPA 2002). It is not step-by-step guide to running the model. It is recommended that the protocol be read in conjunction with the User's Guide and the Technical Support Documentation to provide a holistic perspective on how the model should be used in site-specific RTR applications.

1.4 Caveats

The findings and recommendations presented in this document are subject to several caveats:

- Some of the conclusions presented in this protocol are based on a combination of available empirical evidence, theoretical considerations, and expert judgment. A "brute-force" empirical approach to test an extensive range of scenarios and parameters was not feasible.
- For some model parameters, ICF relied on sensitivity analyses performed on previous configurations of the model. It is possible that the results of previous sensitivity analyses differ slightly from the current Tier 1 model configuration.
- ICF did not test the sensitivity of model parameters in alternative model configurations; and

- ICF did not research and identify land use-specific parameter values for soil properties values as part of this protocol, although it recommends their use.

Despite these limitations, the current recommendations are expected to meet the objectives of providing a cost-effective and accurate approach to site-specific risk assessment in the RTR program. However, users are encouraged to extend site-specific model design and parameterization beyond the levels proposed here as circumstances permit.

1.5 Protocol Road Map

This protocol contains the following types of information:

- best practices for TRIM.FaTE model configuration for use in site-specific RTR applications;
- documentation of the rationale for best practice recommendations;
- nationally representative or health protective model parameter values for site-specific applications of TRIM.FaTE; and
- a guide to the FaTEmaster Scenario Builder tool to create input files for TRIM.FaTE.

These distinct elements are woven together in the following structure:

- Section 2 sets the context with a summary of TRIM.FaTE input files and their content;
- Section 3 discusses the model's meteorological data requirements, potential data sources, approaches to address missing data, data processing requirements, and the issue of plume rise;
- Section 4 presents recommendations and rationale for best practices for designing air and surface parcels in TRIM.FaTE;
- Section 5 presents recommendations and rationale for best practices for defining surface hydrology and erosion parameters required by TRIM.FaTE;
- Section 6 identifies parameters recommended for site-specific parameterization;
- Section 7 identifies parameters recommended for land-use specific parameterization;
- Section 8 identifies parameters recommended for national default parameterization;
- Section 9 presents a guide to using ICF's FaTEmaster Scenario Builder tool in site-specific RTR applications; and
- Section 10 discusses potential future improvements and enhancements to the protocol.

2. A Brief Introduction to TRIM.FaTE Input Requirements

TRIM.FaTE is a spatially and temporally explicit multimedia environmental fate and transport model that estimates the concentrations of emitted chemicals in biotic and abiotic environmental media. The model uses a compartmental box model approach to track the movement of chemicals in environmental media. The model is based on representing environmental media as compartments, moving chemical mass between interacting compartments consistent with a set of governing mathematical algorithms that describe environmental physical and chemical processes, and assuming instantaneous mixing within each compartment.

2.1 TRIM.FaTE Input Files and Contents

TRIM.FaTE requires a variety of inputs from users to define the modeled environment and to quantify the various environmental mass transfer processes. These inputs are provided to the model in the form of the following files:

- A "volume elements" file defines the spatial layout of the modeled domain in terms of three-dimensional abiotic compartments. Each volume element provides a frame of reference for one or more biotic compartments within it.
- A "compartments" file places biotic and abiotic compartments (modeling unit containing chemical mass) within the volume elements.
- A library file contains all the model algorithms, properties, and emission source information. Examples of the kinds of properties that are defined in the library file include:
    - scenario characteristics (e.g., start/stop time, modeling time parameters, output options);
    - source characteristics (e.g., chemicals emitted, location, emission rate);
    - chemical-specific properties, including physical-chemical (e.g., molecular weight, K_{ow}) and abiotic chemical-specific (e.g., degradation half-life);
    - non-chemical-specific characteristics of biota (e.g., body weight, food intake rate);
    - site-specific ecological setting data and characteristics of biota (e.g., type of species present, population and density information, food web relationships); and
    - abiotic environmental setting data such as abiotic media characteristics (e.g., air/water content of soil, pH of surface water, suspended sediment density), runoff/erosion fractions for adjacent surface soil compartments, and water flow between connected surface water compartments.
- A properties file typically contains: (i) simulation- and site-specific property values that are used to overwrite default library values, and (ii) the location of time-varying input files for parameters such as meteorological and vegetation parameters.

These input files must be developed using syntax that is consistent with TRIM.FaTE requirements. ICF's FaTEmaster Scenario Builder tool, discussed further in Section 9, provides a spreadsheet-based interface that facilitates the automated generation of syntactically accurate TRIM.FaTE input files from user-specified inputs. Further detail on the required syntax of the input files, and the process of setting up and running the model using these input files, is available in the TRIM.FaTE User's Guide (U.S. EPA, 2005).

Much of the challenge in a site-specific TRIM.FaTE application lies in designing a spatial layout that is consistent with the nature of the governing algorithms and that reflects the environmental dynamics of the modeled domain, researching and estimating numerous environmental properties that serve as inputs into the model, finding and preparing appropriate meteorological and climate-related data, and setting up the input files. The following sections will discuss the optimal methods of performing these tasks from the perspective of a site-specific RTR application.

2.2 Recommended Sequence of Activities for TRIM.FaTE Set Up

The following sections of this document focus on various aspects of TRIM.FaTE set up as discrete elements in the model configuration process. There are, however, interconnections between the research required to guide various components of the set up process. Although there are no firm rules governing the order in which the model's input files must be developed, this protocol recommends a sequence of activities as a means to enhance efficiency and accuracy in the model configuration process:

1. Perform qualitative spatial analyses of topography, hydrography (boundaries of watersheds, flow lines), and land cover around the site. This will aid in identifying meteorology data, identifying modeled lakes and farms or potential farmland, and shaping the model domain;

2. Identify meteorological data based on RTR considerations (e.g., what meteorology did the RTR inhalation risk assessment use for the site?), data availability, data quality, and the representativeness of the data and instrument siting with respect to the modeled facility. Further,

create the meteorological file and use the meteorological data and emission source parameters to estimate plume rise where necessary;

3. Identify lakes to model based on lake size and a preliminary assessment of risk potential and data availability;

4. Identify farms or potential farmland to model based on a preliminary assessment of risk potential and data availability;

5. Create spatial layout;

6. Estimate and define surface hydrology and erosion dynamics within the layout;

7. Gather data on site-specific properties per the protocol;

8. Enter input property data into FaTEmaster Scenario Builder tool;

9. Generate TRIM.FaTE input files; and

10. Run TRIM.FaTE.

3. Meteorological Data Development

3.1 The Role of Meteorological Data in TRIM.FaTE

The algorithms that simulate the advection of chemicals between the air compartments and the simultaneous deposition of chemicals to the underlying surface compartments depend on numerous meteorological parameters such as wind speed, wind direction, mixing height, and rainfall rate, amongst others. Sensitivity analyses have indicated that meteorological parameters are among the most risk influential parameters in the TRIM.FaTE model (U.S. EPA 2009). Previous evaluations have also suggested that the effects of these parameters are important in TRIM.FaTE, favoring the use of time-varying meteorological data at the temporal resolution at which the measurements are reported, rather than data averaged over longer time periods.

For these reasons, it is recommended that all meteorological parameters be site-specific. This accounts for the potential interactive effects between meteorological parameters. The meteorology data should also be hourly, where possible—averaging to coarser time steps can obscure real trends in the data.

This section discusses best practices in incorporating site-specific meteorological parameters in TRIM.FaTE applications.

3.2 Summary of Meteorological Parameterization in TRIM.FaTE

The following steps, discussed in greater detail in subsequent sections, serve as a general guide to generating TRIM.FaTE meteorology input data in RTR site-specific applications:

1. Determine the meteorology time step to be used (e.g., hourly, *n* hours per day, daily, etc.). Surface meteorology data available from federal agencies is typically hourly. Longer time steps reduce model run time but can obscure real and significant trends in the data. Hourly values are recommended;

2. If it is appropriate to use the same meteorology data used in RTR inhalation risk assessments, obtain those data. Otherwise, identify the source(s) of meteorology data that meet the following criteria:

The data contain all the meteorology fields required by TRIM.FaTE. Note that upper-air radiosonde data do not contain mixing height values. Mixing height values must be calculated, typically using a combination of surface and upper-air data (see Bullet 3 below);.

a. The data have no more than 10 percent missing data for any of the meteorology fields required by TRIM.FaTE; and

b. The data are as representative as possible of the area being modeled.

3. If necessary, use a meteorological preprocessor or other method of estimating mixing heights at the desired time step (upper-air data is typically measured twice daily with a radiosonde and does not include mixing heights);

4. Replace all missing data with values that are as reasonable as possible;

5. If desired (although not recommended), aggregate the meteorology data to larger time steps. Then, replicate the data as needed to create a meteorology input file that covers the entire period of modeling; and

6. The combination of emission source characteristics (e.g., exit gas temperatures and velocities) and meteorological characteristics (e.g., stability, ambient temperature) might lead to significant emission plume rise during some time steps. In these cases, the user may use the emission source characteristics and meteorology data to estimate plume rise values.

3.3 Required Meteorological Parameters and Data Time Steps

TRIM.FaTE meteorology data must include the fields in Table 3-1. Mixing heights are not part of observed surface meteorology data. Mixing heights can be manually estimated using a vertical profile plot of upper-air data from radiosondes, though the typical method of calculating mixing heights relies on using surface and upper-air observed data in a meteorological processor such as AERMOD's meteorological processor (AERMET) or the U.S. EPA mixing height program. These meteorological processors, sources of surface and upper-air data, and sources of pre-calculated mixing heights are discussed in Section 3.4.

Surface meteorology data are typically available in hourly time steps, with some wind data available at smaller time steps. Upper-air data from radiosondes are typically available twice per day. These data time steps (hourly for surface data, twice-daily for upper-air data) are typically required by meteorological processors to estimate hourly mixing height values. The TRIM.FaTE meteorology data file does not require hourly time steps, although hourly data are typically used in site-specific assessments. Larger time steps will shorten model run time. The aggregation of data into larger time steps (although not recommended) should take place *after* mixing height values are determined.

Table 3-1. Meteorological Parameters Required for Meteorology Input File for TRIM.FaTE

Parameter	Format	Units	Further Description and Notes
Date	M/D/YYYY	NA	NA
Hour	Numeric	NA	NA
Time Zone	e.g., "EST"	NA	NA
Horizontal Wind Speed	Numeric	m/s	NA

Parameter	Format	Units	Further Description and Notes
Wind Direction	Numeric degrees	degrees clockwise from north; blowing from	e.g., from north is 360 degrees; from east is 90 degrees; from south is 180 degrees; and so on. 0 degrees is reserved for calm winds (e.g., wind speed = 0 m/s)
Air Temperature	Numeric	K	NA
Mixing Height	Numeric	m	Not an observed parameter. Must be calculated, typically using a meteorology processor with surface and upper-air data inputs.
Rain Rate	Numeric	m/day	NA
Cumulative Rain	Numeric	m	Total precipitation in a precipitation event. A multi-hour event will have equal cumulative rainfall values for each hour.
Is Day	Boolean (i.e., 1 or 0)	NA	Daytime (value of 1; after sunrise) or nighttime (value of 0; after sunset). Calculated using U.S. EPA's SR-SS.exe program, available with TRIM.FaTE.

3.4 Selecting Appropriate Surface and Upper-air Data

RTR inhalation risk assessments match a facility with the Automated Surface Observing Station that is closest to the facility and that has relatively complete data for one recent year (that year is currently 2011). That surface station is coupled with its closest, regularly reporting upper-air station. Unless meteorology data were measured at the facility itself, it is usually appropriate to use those same meteorology stations for RTR ingestion risk assessments, subject to EPA discretion and the availability of good quality data for multiple recent years.

Surface and upper-air radiosonde data can be obtained from the National Climatic Data Center (NCDC), regional climate centers, and third party vendors. Some sources of hourly surface meteorological data across the United States are shown in Table 3-2. These data sources are shown with generally the more current and more spatially dense data (i.e., the large and freely available Integrated Surface Hourly data) listed first. Some state agencies also maintain their own station networks and might be good sources of meteorology data.

Twice-daily upper-air radiosonde data from stations operated by federal agencies can be obtained for free from the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) in Forecast Systems Laboratory (FSL) format for over 100 U.S. stations and for 1994 through present, where available (ESRL 2011). ESRL also has archived FSL-formatted upper-air data going back to 1946, available for purchase on disc. Mixing heights are not part of observational data. Hourly mixing heights can be manually estimated or they can be calculated using a combination of surface and upper-air data. Typically, these hourly mixing height calculations are performed in a meteorology data preprocessor such as AERMET (U.S. EPA 2012a). AERMET accepts some of the surface meteorology data formats presented in Table 3-2 and FSL-formatted upper-air data. Pre-calculated, twice-daily mixing height data also are available from U.S. EPA for over 70 U.S. stations for 1984 through 1991 (U.S. EPA 2010a) and can be used in the computer version of the meteorological processor for the Regulatory Air Model (PCRAMMET; U.S. EPA 2012c).

The user should select appropriate data based on proximity of the station to the modeling site and on the station site's representativeness of the modeling site (e.g., elevation, land use, and wind flow). Evaluating the representativeness of the site and data is subjective. The surface and upper-air stations closest to the modeling site often will be the best choices. Because the upper-air station network is much sparser than the surface network, proximity might be a less restrictive criterion in choosing upper-air stations compared to choosing surface stations. Instead, it might be more important to choose an upper-air site that experiences boundary layer characteristics that are similar to those of the modeling site. For example, if the modeling site is well inland, it might not be appropriate to use an upper-air station on the coast.

The availability and quality of the data must also be considered. It is typically recommended that no more than 10 percent of the data be missing, and the data values should be within expected bounds. The user should also note that some meteorological data are archived in UTC, or Zulu time, which is functionally the same as Greenwich Mean Time and equivalent to Eastern Standard Time plus five hours. The data should be converted to local standard time for use in TRIM.FaTE, and standard time must be used throughout the year (most archived meteorology data are in standard time).

One year of data might be sufficient, as long as the data on average are representative of recent climatological averages at the site. NCDC 30-year climate normals are recommended for comparison (NCDC 2011). When data from a single year are found to be significantly different from typical conditions, the user can use several consecutive years that, together on average, are closer to typical conditions.

3.5 Replacing Missing Data

TRIM.FaTE requires that there be no missing data in its meteorology fields. U.S. EPA's recommended guidance for replacing missing meteorology data (U.S. EPA 1992) has a series of objective data replacement steps as a first pass, but those steps might not fill in all missing data. The guidance suggests some subjective procedures for filling in remaining missing data; however, these are manual steps and do not cover all possible cases of missing data (e.g., if more than a few contiguous hours of data are missing). A meteorologist or experienced air quality modeler should perform these subjective data fill procedures. The user should expect that the quality of substituted values will be worse for longer contiguous periods of missing data versus only a few contiguous hours of missing data. However, as long as the amount of data originally missing is no more than 10 percent, and as long as the substituted values are not out of normal bounds, then substituted data will have only a small impact on modeling results—especially for TRIM.FaTE assessments where the desired outputs are final accumulated media concentrations after several decades of modeling.

ICF developed a tool (AERMET2TRIM), based in Microsoft Access, that fills in missing data in all meteorology fields needed by TRIM.FaTE. The procedures are based on those provided in U.S. EPA (1992). AERMET2TRIM requires first that AERMET be run on the surface and upper-air data in order to estimate hourly mixing heights. AERMET2TRIM then reformats the data into the format required by TRIM.FaTE.

Table 3-2. Potential Sources of Hourly Surface Meteorological Data (not all-inclusive)

Name	Notes on Measured Data	Years Available	Spatial Coverage	Source	Other Notes
Integrated Surface Hourly (ISH) Data	NA	Over 100 years to today, where available	Thousands of stations worldwide	NCDC (2008)	Available in two formats -- abbreviated and full. AERMET requires the full format. The availability and structure of the formats have changed through the years and through the different available data storage media. Free via online download.
Quality Controlled Local Climatological Data (QCLCD)	NA	2005 to today	Approx. 1,600 U.S. stations	NCDC (2013)	Free via online download.
U.S. EPA AERMOD-formatted data for the Human Exposure Model (HEM-3)	Not strictly observational data – processed observational data through AERMOD's preprocessors to produce AERMOD-ready format.	2011 only	Over 800 U.S. stations	U.S. EPA (2013)	Free from EPA.
Solar and Meteorological Surface Observation Network (SAMSON)	NA	1961 through 1990, where available	Approx. 237 U.S. stations	NCDC (2012)	File formats changed after approx. 2007. Available for purchase on disc.
U.S. EPA Support Center for Regulatory Atmospheric Modeling (SCRAM)	No precipitation data (request DSI-3240 format precipitation data from NCDC)	1984 through 1992, where available	Approx. 250 U.S. stations	U.S. EPA (2010b)	DSI-1440 format. Free via online download.

3.6 Aggregate and Duplicate

If desired (though not recommended), the user should aggregate the data to conform to the modeling time step being used. Values of wind speed, air temperature, mixing height, and rain rates should be averaged. For wind direction, the hourly values of wind speed and wind direction should be used to calculate the vector components of the wind (i.e., u and v values), those vector components should be averaged, and the averaged vectors should be used to calculate the average wind direction. Calculate new cumulative rain values after averaging the rain rates. Use professional judgment to determine appropriate values for the “Is Day” parameter.

Previous site-specific assessments conducted using TRIM.FaTE typically have used 50-year modeling periods. The meteorology data in TRIM.FaTE format should be duplicated as necessary to produce a 50-year data period (or other appropriate time period that matches the facility lifetime/emissions period selected during the initial assessment planning stage). For example, if the meteorology data represent years 2008 through 2011, the user should copy-and-paste that four-year period to create 50 years of data (e.g., 2000 through 2049). The user should make sure that the year values are changed appropriately, and that leap years contain data for February 29. If the user’s original meteorology data do not contain a leap day, simply duplicate data from February 28 and label as February 29.

3.7 Plume Rise

Emission plumes in nature usually have a vertical component to their dispersion pattern (i.e., plume rise). Multiple forces can affect vertical dispersion, including the temperature of the plume compared to the ambient air temperature, the wind speed at the release point, the ambient vertical temperature gradient, atmospheric stability, the diameter of the release point, and the temperature and velocity of the emissions as they exit the release point.

TRIM.FaTE does not calculate plume rise. Instead, emitted chemicals are advected horizontally through fully mixed air compartments whose dimensions are defined by the user. This advection occurs in one of two air volume compartments—the mixing layer compartment (where people, plants, animals, soil, and water are exposed to the chemicals) or the upper-air compartment above the mixing layer (where the chemicals are removed from ground-level exposure; i.e., a sink). Because an emission source’s release height is static, the mixing height for a given modeling time step determines which air layer the chemicals are emitted into in that time step.

AERMET2TRIM has a function that estimates hourly plume rise given the physical parameters of an emission source (i.e., latitude-longitude coordinates, release point height and diameter, and exit gas temperature and velocity), the horizontal distance from the source at which to estimate the plume rise (i.e., the radius of the modeled source parcel), and the meteorology data being used for the TRIM.FaTE analysis. Because AERMET output data do not contain cloud ceiling heights, the AERMET2TRIM plume rise calculations require a supplementary file containing those data (such ceiling data are available in ISH and SAMSON data, for example). These plume rise estimations are based on methods summarized by Seinfeld and Pandis (1998). The output from this function is a text file with hourly values for effective release height, which is the actual release height plus the hourly plume rise value. If desired, the user can then aggregate the data to the time step being modeled.

Including hourly effective release heights will increase model runtime. In previous TRIM.FaTE site-specific assessments, a 5% rule has been used to judge whether or not to use hourly heights; that is, if the effective release height was above the mixing height less than 5% of the time, hourly heights were not used (i.e., the static, physical stack height was used). The user also has the option to estimate an average effective release height for the entire modeling period, and simply use that average height as the release height for all modeling times.

4. Air and Surface Parcel Design

4.1 The Role of Spatial Layouts in TRIM.FaTE

One of the primary inputs required by the TRIM.FaTE model is the specification of a spatial layout using Cartesian coordinates to define the vertices of surface and air parcels and volume elements. This information is input into the model via the “volume elements” input file. To construct the volume elements input file, users are required to divide the modeled domain into two-dimensional air parcels and surface parcels. Air and surface parcels need not line up in all cases. Each parcel is also associated with a height, which may vary in time. The parcel coordinates and height are combined to define three-dimensional abiotic volume elements that contain biotic and abiotic compartments used to model the movement of chemical mass in TRIM.FaTE.

In a site-specific assessment, the spatial layout should capture the features of interest (e.g., farms or lakes) at the surface level and also specify how the overlying air domain is to be divided to produce accurate and informative estimates. Although the TRIM.FaTE User’s Guide (U.S. EPA 2005) provides useful mechanistic guidelines and rules of thumb on the design of air and surface parcels, those recommendations are not specific to the RTR context and are not based on an ingestion risk perspective. The following guidelines, as noted in the introduction to this document, are intended to support site-specific risk assessments in the RTR program and should be considered in addition to the instructions and recommendations provided in the User’s Guide and Technical Support Document (U.S. EPA 2002).

4.2 Theoretical Considerations Influencing Parcel Design

Discussed below are the theoretical considerations related to the TRIM.FaTE model that were used to inform the air and surface parcel design recommendations presented later in this section.

4.2.1 Cross-Wind Dispersion

TRIM.FaTE models the movement of chemical mass based on first-order differential equations. Consequently, the model does not account for dispersive processes in air that carry mass in a cross-wind direction. Air parcel design must be conscious of, and attempt to compensate for, this limitation of the TRIM.FaTE model. For instance, using a square grid for air parcels may result in “pipeline flow” with the bulk of the emitted chemical concentrated in a compartment directly downwind. The concentration estimates based on such a design would not align well with empirical evidence or with theoretical Gaussian plume models that are based on the second-order advection dispersion equation.

Although a compartmental model with instantaneous mixing (such as TRIM.FaTE) could never produce identical spatial results to a Gaussian plume model, air parcel design in TRIM.FaTE must attempt to ensure that an appropriate amount of lateral dispersion is permitted to occur. The Pasquill-Gifford estimates of cross-wind dispersion are commonly applied as parameters in air dispersion models for alternative atmospheric conditions (U.S. EPA 1995). These cross-wind dispersion estimates are in the form of graphs which plot cross-wind dispersion as a function of downwind distance. The Turner equations are mathematical representations of these plots. A plot of the Turner equations, which numerically approximate the Pasquill-Gifford estimates of cross-wind dispersion, suggests that 99% of the emitted mass in neutral atmospheric conditions is likely to be contained within a cone subtending an angle of 20 degrees from the source, assuming a constant wind direction through the centerline. This provides a guideline about the ideal breadth of air parcels, especially those downwind of features of interest.

4.2.2 Numerical Diffusion

All compartmental models potentially experience the issue of “numerical diffusion,” which refers, in the context of an air dispersion model, to the propagation of mass further downwind at a given point in time than is physically possible given the wind speed. Maintaining a fixed relationship between the size of the time step used in the simulation, the length of compartments, and the wind speed helps prevent issues of numerical diffusion. Users interested in strict time accuracy are advised to ensure that compartment lengths are shorter than the wind speed multiplied by the model time-step. For RTR purposes, however, average annual values in the 50th year are of primary interest, and strict restraints on parcel length for a given time-step are considered less important but still good practice to implement.

4.2.3 Shape of the Deposition Profile with Distance from Source

The TRIM.FaTE model produces a deposition profile that has the largest values in the source compartment and decreases with increasing distance in a pattern similar to an exponential curve. Theoretical and empirical evidence suggests, however, that the maximum deposition rate would not be experienced at the point of emission, but further downwind. At a wind speed of 5 m/s, the point of maximum deposition for fine particulates and gases was estimated to be between 1 and 5 km (Overcamp 1976). Users of the TRIM.FaTE model should therefore be conscious of potential overestimation of deposition in surface parcels adjacent to the source and a potential for bias in the deposition profile.

4.3 Empirical Evidence Relating to TRIM.FaTE Parcel Design

A limited number of TRIM.FaTE scenarios were modeled to provide empirical data about the impact on risks (in the RTR context) from air and surface parcel layout design. Most of these scenarios were based on simple variations of the Tier 1 screening scenario layout. The main findings are summarized here:

- Extending an air parcel beyond the outer boundary of the underlying surface parcel (i.e., having an air parcel “overhang” the surface parcel beneath it) reduces deposition over the surface parcel compared to air parcels that are co-terminus with surface parcels (i.e., having the air parcel directly overlay the surface parcel);
- The number of air parcels that precede the air parcel overlying the surface feature of interest (i.e., the number of air parcels between the source parcel and an air parcel of interest) does not materially impact deposition over that surface parcel;
- Soil concentrations in the surface compartment adjacent to the source are considerably higher than if the same surface compartment is set back by a short distance of approximately 400m (i.e., a 400-m buffer parcel between the source and the parcel of interest). This is consistent with TRIM.FaTE’s exponential deposition gradient; and
- Increasing the length and/or breadth of a surface compartment might substantially reduce surface soil concentrations

More detailed results from these scenarios are documented in Appendix A.

4.4 Recommended Best Practices for Air and Surface Parcel Design

The following recommendations for air and surface parcel design are intended to maintain a high degree of modeling accuracy while reducing design effort and potentially optimizing computer run time. While these guidelines are intended to facilitate optimal parcel design, every scenario is unique and might require site-specific adjustments beyond the suggested approach provide here. Any adjustments or improvements to the proposed approach should aim to be consistent with the governing principles and empirical evidence discussed earlier in Section 4.

Step 1: Identify Features of Interest

Several steps are recommended for identifying features of interest:

- Use geospatial data (e.g., aerial imagery, data on watersheds and water bodies, and remotely-sensed land cover and crop growth) to identify features of potential interest from the RTR perspective, such as farms and lakes;

  - Geospatial data can include Google Earth (Google 2013), the National Hydrography Dataset (USGS 2013), the National Land Cover Database (MRLC 2013), and the Cropland Data Layer (USDA 2013).
- Consider only lakes that are at least as large as 25 acres (approx. 10 hectares)[2] and that research suggests are fishable; and
- Use the following guidance to finalize the selection of lakes and farms for modeling:
  - Limit farms to those within roughly 5 km of the source;
  - Do not select multiple farms in the same direction from the source;
  - Do not select farms adjacent to the source parcel. Choose a buffer distance of at least 400 m;
  - Prefer farms and lakes closer to the emission source versus those farther away;
  - Prefer lakes for which preliminary research suggests good availability of modeling data (e.g., flush rates, depth, pH, total phosphorus levels, suspended sediment concentration);
  - Prefer lakes and farms that are frequently downwind from the emission source, if they exist, based on the meteorology data selected for modeling; and
  - Prefer the lake(s) selected in the Tier 2 screening analysis.

Step 2: Breadth of Air Parcels (Air Parcel Radials)

Several steps are recommended for defining the breath of air parcels:

1. Emissions center point: Identify the center point of what will later become the emission source parcel. It should roughly be the centroid of all the actual emission sources of concern at the facility;

2. Draw 20-degree radials: Manually or using geospatial software, overlay radials that intersect at the source center point, are 20 degrees apart. These radials roughly create triangles and represent preliminary breadth boundaries of air parcels;

3. Adjust the radial grid: Rotate the radial grid so that the maximum number of surface features of interest (e.g., farms and lakes) falls within single triangles;

4. Smaller features of interest: For features that fall within a single triangle, use the boundaries of the triangle to define the breadth dimension of the air parcel overlying the surface feature;

5. Larger features of interest: For features that fall within multiple triangles, merge and adjust the multiple triangles into a single triangle that fully contains the feature. For instance, if a lake subtends an angle of 50 degrees with respect to the source, three 20 degree triangles should be merged and adjusted to form a 50 degree triangle to define the breadth of the overlying air parcel. This process will distort the shape of the surrounding triangles (i.e., they will be greater than the suggested 20 degrees), but that is acceptable; and

6. Areas not overlying features of interest: For air parcels not overlying any features of interest, less resolution is required. Merge three 20 degree triangles to create a 60 degree triangle to define the breadth dimension of the overlying air parcel.

---

[2] Based on available data, for RTR multipathway emission screening analyses, EPA defines potentially fishable lakes as those larger than 100 acres, without exceeding 100,000 acres. Even a 100-acre lake is unlikely to be large enough to sustain harvesting the number of piscivorous fish required for the current screening ingestion rate (i.e., 373 g ww fillet/day). This is discussed in Section B.3.1 of Attachment B in Appendix 4 to the Risk Report. However, EPA includes smaller lakes (as small as 25 acres) in site-specific RTR multipathway analyses to be health protective and to ensure that small lakes that might be more highly contaminated than estimated by the screening analyses are not eliminated.

Step 3: Define the Outer Boundaries of the Domain

Draw the outer boundaries of the domain approximately 5 km beyond the farthest feature of interest (in relation to the emission source), using the remaining parcel radials as the design template. This 5-km buffer is flexible depending on the characteristics of the nearby watersheds and how they might impact the runoff and erosion of chemical into the features of interest. Truncate the outer boundary of the domain in areas without features of interest, provided that these areas contribute much less significantly than other areas toward chemical runoff or erosion towards the features of interest.

Step 4: Complete Air and Surface Parcels for Features of Interest

Within the triangle overlying the feature (defined in Step 2), encase the feature within a trapezoid (⏢) by drawing straight lines at an angle to the sides of the triangle to define the inside boundary (the side closest to the source) and outside boundary of the feature. The trapezoid should be perpendicular to an imaginary radial originating at the emission source center point; put another way, these new lines should be parallel to each other and perpendicular to an imaginary radial bisecting the triangle, thus creating a trapezoid.

Where possible, the surface parcel representing the feature of interest should coincide with the air parcel trapezoid described above. This might require slightly distorting the dimensions of the surface feature of interest, but that is a permissible approach when the shape of the feature of interest is not very different from the overlying air parcel trapezoid.

For irregular surface features (i.e., those whose shapes are very different from the overlying air parcel trapezoid), create additional surface parcels as required to fill the space between the actual boundaries of the feature of interest and the boundaries of the overlying air parcel trapezoid. The additional surface parcels adjacent to the features of interest should be constructed subject to the consistency of land cover, terrain patterns, and/or hydrography. A single adjacent parcel should never surround another parcel entirely. Instead, two adjacent parcels should bound the irregularly shaped feature on either side.

Step 5: Draw Air and Surface Parcels for the Emission Source

The air and surface parcels for the emission source should line up. The source parcel should be centered on the center point identified in Step 2 above and should accurately reflect where chemicals of concern are actually being emitted at the facility (i.e., it should fully contain all of the actual emission sources of concern). It should be a polygon where each side connects the sides of each air parcel triangle, and each side is perpendicular to an imaginary radial bisecting the triangle. For example, if the air parcel triangles each subtend exactly 60 degrees, and if the real emission sources span a 500-m distance, then the source parcel would be a perfect hexagon that is centered on the emission source center point and has a diameter of 500 m.

Step 6: Complete Air and Surface Parcels Upwind of the Features of Interest

Within the two radials that bound a feature of interest, create a single air parcel between the feature and the source parcel (i.e., upwind of the feature of interest). Like the air parcel above the feature itself, this upwind air parcel will be a trapezoid bounded by two lines that define the inside and outside boundaries (parallel to the inside and outside lines of the feature, relative to the emission source) and by the radials.

There should be a corresponding surface parcel that lines up with the upwind air parcel. If the upwind region contains several different regimes of land cover, terrain, and/or hydrography that are large relative to the region, then divide the surface parcel into separate parcels for each of those different, major regimes. For example, for an upwind surface parcel oriented north-south, if the northern half contains urban land cover and the southern half is a deciduous forest, then it might be reasonable to divide the parcel into a northern parcel (with no vegetation) and a southern parcel (with deciduous forest). On the other hand, if the region is a scattered mix of forested and pasture/hay land cover, it would not be reasonable or efficient to create many very small parcels for each small area of forest or pasture/hay.

Step 7: Air and Surface Parcels Downwind of the Features of Interest

Create an air parcel downwind of the feature of interest (i.e., on the side of the feature opposite the emission source) with a length dimension no larger than 5 km. The relative small size of this downwind parcel increases the accuracy of chemical transfer via runoff and erosion.

There should be a corresponding surface parcel that lines up with the downwind air parcel. If the downwind region contains several different regimes of land cover, terrain, and/or hydrography that are large relative to the region, then divide the surface parcel into separate parcels for each of those different, major regimes.

Step 8: Complete Air and Surface Parcels Crosswind of the Features of Interest

Several considerations are recommended for defining air parcels crosswind of features of interest (i.e., parcels to the “left” and “right” of the feature, relative to the emission source):

- The outside boundary of an air parcel immediately crosswind of a feature of interest should not extend beyond the outside boundary of the feature itself (i.e., the outside boundaries of the feature parcel and the crosswind parcel, relative to the emission source, should connect). This is to increase the accuracy of chemical transfer via runoff and erosion;
- The breadth dimensions of a crosswind air parcel should be defined by the radial grid. That is, the “left” and “right” sides of the crosswind parcels (relative to the emission source) should be defined by the radial grid developed in Step 2 above;
- The inside boundary is the source parcel, unless there is already a parcel drawn between the source and the crosswind parcel (i.e., a parcel related to a different feature of interest); and
- There should be a corresponding surface parcel that lines up with the crosswind air parcel. If the crosswind region contains several different regimes of land cover, terrain, and/or hydrography that are large relative to the region, divide the surface parcel into separate parcels for each of those different, major regimes.

Step 9: All Other Air and Surface Parcels

All other air and surface parcels should be fitted within the boundaries defined by: (i) the air parcel radials (Step 2); (ii) the boundaries of the features of interest and their upwind, downwind, and crosswind neighbors (Steps 6-8); and (iii) the outer boundaries of the domain (Step 3). These other air and surface parcels are subject to continuity of land cover, terrain, and/or hydrography, as discussed in the above steps.

5. Surface Hydrology and Erosion Property Definitions

5.1 Surface Parcel Chemical Transfer Dynamics in TRIM.FaTE

The TRIM.FaTE model incorporates the ability to account for chemical transfers between adjacent surface parcels via runoff and erosion. The algorithms that model surface runoff and erosion in TRIM.FaTE simulate the advective chemical transfer dynamics between surface parcels without requiring spatial elevation information or land-cover details as inputs. Instead, the algorithms depend on inputs explicitly specifying the destination of erosion and runoff from a specific parcel. In other words, for each surface parcel, users must specify the proportion of the erosion and runoff originating in that parcel that reaches specific adjacent parcels. These inputs are known as link properties in TRIM.FaTE and are typically specified in the TRIM.FaTE “properties” file discussed in Section 2. Users must also separately specify the average runoff and erosion rate for each surface parcel. These inputs are combined internally with estimates of the chemical concentration in surface soil and soil water to estimate mass transfers that occur in conjunction with erosion and runoff processes.

The inter-parcel runoff and erosion parameter inputs in TRIM.FaTE are inherently site-specific because there is no logical default value for the percentage of runoff and erosion from one parcel that reaches an adjacent parcel. Simulations indicate that ingestion risk in the RTR process is sensitive to the choice of these values (refer to Appendix A). This section discusses options for parameterizing these inputs in site-specific TRIM.FaTE applications for RTR.

For users not having access to (or expertise in using) geographical information systems (GIS) software with features to quantitatively analyze surface hydrology and erosion, the recommended method of estimating parcel-to-parcel runoff/erosion fractions is summarized in Section 5.2. If sophisticated GIS software with features to analyze surface hydrology and erosion based on elevation is to be used, the recommended method is summarized in Section 5.3.

5.2 Estimating Runoff and Erosion Fractions without Sophisticated GIS Software

Without a license for sophisticated GIS software, the user can still obtain free GIS viewing tools that allow the user to display multiple layers of geospatial data and that have limited interaction with the data, including querying the data and measuring distances. With such viewing software, the method for estimating runoff/erosion fractions provided in Module 11 of the TRIM.FaTE User's Guide (U.S. EPA 2005) is appropriate. This method is summarized briefly here, with some additional tips not provided in the User's Guide.

Step 1: Assemble Hydrological and Elevation Data

The user should obtain geospatial data indicating boundaries of hydrological units relevant to the modeling domain. These hydrological data are available from the U.S. Geological Survey (USGS) National Hydrography Dataset (NHD; USGS 2013). These hydrography data should already have been obtained and used to inform the design of the modeling parcels. The NHD offers several levels of hydrological units, typically from regions (the most spatially coarse) to subwatersheds (typically the highest spatial resolution). Considering that the typical site-specific TRIM.FaTE modeling domain has a radius less than 50 km and is divided into several surface parcels, subbasins or watersheds will usually offer the most appropriate resolution for use in configuring parcels and estimating runoff/erosion fractions. The NHD also offers directional flow lines of streams, rivers, and other hydrographic features.

The user should also obtain elevation data for the modeling domain. High resolution data are available from the USGS National Elevation Dataset (NED; USGS 2006). These elevation data should already have been obtained and used to help construct the modeling parcels. The data with the highest spatial resolution are not necessary; 30-m resolution usually is appropriate.

Step 2: Relate Surface Modeling Parcels to Each Other and to Hydrological Units

The user should display the modeling surface parcels along with the appropriate hydrologic unit boundaries from the NHD. For each parcel ("sending parcel"), do the following:

- For each hydrologic unit that occupies at least part of the sending parcel, estimate (or calculate, if able) the ratio [surface area of the part of the hydrologic unit that is inside the sending parcel] to [surface area of the sending parcel];
- Identify each neighboring parcel ("receiving parcel"), including sinks where appropriate for the sides of the sending parcel that lie along the outer boundary of the modeling;
- For each hydrologic unit that occupies at least part of the sending parcel, estimate or calculate the length of each interface between the hydrologic unit and each receiving parcel (not discussed in the TRIM.FaTE User's Guide); and
- Estimate or calculate the fraction of the sending parcel's perimeter that interfaces with each receiving parcel (not discussed in the TRIM.FaTE User's Guide).

Step 3: Estimate Fraction of Runoff and Erosion

For each hydrologic unit that occupies at least part of a sending parcel, one should use NED elevation data and NHD flow lines to estimate the fraction of runoff that will flow from the hydrologic unit into each receiving parcel and, where appropriate, into sinks outside the modeling domain. A fraction might be 0 if the elevation and flow lines suggest that all water in the hydrologic unit flows away from a receiving parcel.

The User's Guide (U.S. EPA 2005) Section A.5 discusses runoff/erosion fractions. Although not discussed there, the NHD flow lines can help estimate the relative distribution of runoff from a sending parcel to its receiving parcels, or from a hydrologic unit in the sending parcel to a receiving parcel. One can examine the flow lines along each sending-receiving boundary to get a sense how much of the boundary has flows from the sending area to the receiving area. This information can be combined with information on how much of the sending area's perimeter interfaces with the receiving area in question, aiding the user in developing runoff/erosion fractions.

As discussed in the User's Guide Sections A.5 and A.6—separately for each hydrologic unit in a sending parcel, multiply [the fraction of sending parcel's area covered by the hydrologic unit] by [the runoff/erosion fraction from the hydrologic unit to the receiving parcel] for each of the sending parcel's receiving parcels. Then, for each of these receiving parcels, sum this product across the hydrologic units. This sum provides the final fraction of runoff/erosion from each sending parcel to each receiving parcel. For each sending parcel, the fractions will sum to 1 when sinks are included as appropriate.

Another option is to estimate the runoff and erosion fractions based on visual inspection. This approach does not explicitly relate the area of each hydrologic unit to each sending parcel. Therefore, it does not explicitly assume that water cannot cross the boundaries of hydrologic units. Like the methods described above, this option uses flow lines and the interfacial length between adjacent parcels. In this option, for each sending parcel, the user visually examines the NHD flow lines to see where (if at all) flow lines cross each interfacial boundary and *into* the receiving parcels. For each sending-receiving pair of parcels, the user should estimate (or measure, if possible) the length of the part of the interfacial boundary that has flow lines crossing into the receiving parcel. Then, divide that length by the total perimeter length of the sending parcel. This ratio provides the fraction of runoff/erosion from the sending parcel into the receiving parcel. Some professional judgment is required to subjectively adjust these fractions based on the relative magnitude of runoff across the various interfacial boundaries. These relative magnitudes can consider the overall terrain and flow patterns throughout the sending parcel (i.e., a flow into the receiving parcel with a relatively small fetch will likely carry less chemical into the receiving parcel than a flow with a relatively long fetch).

5.3 Estimating Runoff and Erosion Fractions with Sophisticated GIS Software

The method discussed in this section requires the use of ESRI® ArcGIS™ software. The software license must enable the "Spatial Analyst" extension. ICF is currently developing an ArcGIS™ model, coupled with a Microsoft® Excel™ post-processing tool, that largely automates the below procedures.

In ArcGIS, select the "Flow Direction" tool of the "Spatial Analyst" extension. Given a raster elevation dataset (such as the NED), this tool will determine the flow direction of each raster cell to the steepest downhill neighboring raster cell. The output of this tool will be a raster, where the value of each raster cell will indicate the flow direction.

Then, select the "Flow Accumulation" tool of the "Spatial Analyst" extension. The input to the "Flow Accumulation" tool is the output of the "Flow Direction" tool described above. Separately for each input raster cell, the "Flow Accumulation" tool will follow the flow direction into the appropriate neighboring cell, and continue following the flow direction of that cell into a third cell, and so on, "connecting the dots" of the flow vectors until an endpoint is reached. This creates flow lines across the raster. Then, the tool calculates the number of these flow lines that cross each raster cell. This is the "flow accumulation" number produced by this tool. The flow accumulation is unitless, as it does not represent an actual amount of water or chemical flowing from one place to another; the accumulation values should be viewed relative to each other.

For each sending parcel, the user would use the combination of flow direction and flow accumulation data from the above tools to calculate the total flow (unitless) from the sending parcel to each receiving parcel. The runoff/erosion fraction from the sending parcel into receiving parcel “A” would be the accumulated flow from the sending parcel to receiving parcel “A” divided by the total accumulated flow from the sending parcel to all its receiving parcels.

6. Compartment Properties Recommended for Site-Specific Parameterization

6.1 The Role of Properties in TRIM.FaTE

The TRIM.FaTE model is dependent on hundreds of user-specified properties that describe the biotic and abiotic environments being modeled. Properties in TRIM.FaTE can be broadly divided into the following types:

- non-chemical specific properties that define biotic compartments (e.g., biomass of game fish in a lake, the length of a leaf on a deciduous plant),
- non-chemical specific properties that define abiotic compartments (e.g., porosity of surface soil, the total suspended solids concentration in a lake),
- chemical-specific properties (including system-wide chemical properties such as the Henry’s Law constant, the octanol-water partition coefficient, and compartment-specific chemical properties such as reaction and degradation rate constants in various environmental media), and
- simulation-specific properties (e.g., model run-time, model time step).

All user-defined (e.g., non-formula) properties in a TRIM.FaTE scenario can be assigned simulation- or site-specific values. In theory, the more properties that are assigned site-specific values, the more accurately the simulation will represent chemical fate and transport at that location. Following this logic, the user should try to find site-specific values for as many properties as possible. However, although each model property is potentially important in defining a particular environmental fate and transport process, it is apparent based on theoretical considerations and empirical evidence (i.e., analysis of model results and model evaluations) that there is a subset of model properties that more significantly influences the environmental concentrations that drive the risks of importance in the exposure scenarios evaluated in RTR assessments. The fact that some parameters are more influential on results is true for complex models in general. This is the focus of sensitivity analyses.

In previous site-specific risk assessments using TRIM.FaTE, which were conducted for RTR and in other regulatory applications, a substantial portion of the level of effort required to perform the assessments was directed towards site-specific property parameterization. One of the specific objectives of this protocol is to take advantage of the results of sensitivity analyses and model evaluations conducted of TRIM.FaTE. Based on these results, we have identified those compartment properties that are a high priority for site-specific parameterization, those that can be adequately represented by regional or land-use-specific default values, and those for which nationally representative or health-protective values are adequate. This classification scheme is intended to reduce the level of effort required to adequately parameterize site-specific assessments while maintaining a high level of accuracy in risk estimates for RTR.

6.2 Approach to Prioritizing Properties for Site-Specific Parameterization

ICF relied on a combination of theoretical reasoning and empirical evidence to prioritize TRIM.FaTE properties for the purposes of this protocol. In this way, ICF was able to limit the need for “brute-force” empirical evaluations (e.g., comprehensive sensitivity analyses that systematically vary all or most of the user-defined inputs, such as those conducted prior to the 2009 SAB review (U.S. EPA 2009)) and additional resource-intensive literature searches. ICF's justification for determining that properties were ***not*** high priority was based on three lines of evidence:

1. ICF followed a **"process"-based approach** to rule out a large subset of TRIM.FaTE properties from the need for site-specific parameterization. This approach was founded on the idea that the TRIM.FaTE model produces greater than necessary resolution (in terms of the number of concentrations that are calculated for different environmental media types) when viewed from the RTR perspective. The individual human ingestion exposure scenarios evaluated for RTR rely most directly on results from TRIM.FaTE for surface soil compartments at the location of a farm and fish compartments in a lake of interest. All fate and transport processes—and the properties that exclusively define those processes—that do not strongly influence these concentrations can reasonably be ruled out from requiring site-specific parameterization. The implications of this approach will be discussed in greater detail below.

2. ICF also used practical considerations regarding **data availability** to rule out certain properties from site-specific parameterization. Over the course of numerous site-specific assessments and the parameterization of the screening scenarios, ICF has conducted literature searches on numerous TRIM.FaTE properties. ICF used the insight gained from these exercises to identify certain sets of parameters as being too data-scarce to parameterize on a site-specific basis at this time without expending a substantial amount of time and money (for possibly uncertain results).

3. **Physical constants and physicochemical properties** of the modeled PB-HAPs were also ruled out from site-specific parameterization based on their largely unchanging nature in the environment for the chemicals considered for RTR.

ICF evaluated the parameters not eliminated by the above considerations to determine which properties should be the focus of data collection efforts during site-specific TRIM.FaTE modeling for RTR. ICF conducted a limited number of evaluations and used the results of previous sensitivity analyses to decide which of these shortlisted parameters should be prioritized for site-specific parameterization, for land-use-based parameterization, or for regional parameterization.

Other scenario properties such as emission period and the model's numerical integration time-step are typically not varied between site-specific assessments. These properties are not discussed further in this protocol, but are documented in Appendix B.

6.3 Elimination of Properties from Site-Specific Parameterization

6.3.1 Process-based Elimination of Parameters

The operative principle in the process-based elimination of parameters is that fate and transport processes that do not substantially influence concentrations of interest from an RTR perspective are less important to parameterize. ICF used theoretical considerations based on the evaluation of the underlying TRIM.FaTE algorithms, combined with empirical evidence from TRIM.FaTE simulations, to identify the less important fate and transport processes and eliminate the need to parameterize those processes on a site-specific basis. The specific processes identified as being of less importance in the RTR context and the underlying justification for ruling them out from site-specific consideration are listed below:

- Chemical transport via water percolation through the sub-surface soil layers (not including surface soil) does not affect farm soil or lake water concentrations. Theoretical considerations suggest that chemical, once transported into the lower soil layers, will not substantially make its way back to the surface compartments of interest;
- Chemical transport via sub-surface soil diffusive processes, although having the potential to transfer mass upwards, are not sizeable in comparison to advective transfer processes. An evaluation of relative mass flux in the Tier 1 screening scenario supports this assertion for all the chemicals evaluated; and

- Chemical transport to the lake via horizontal groundwater flow and recharge is negligibly small compared to other advective chemical inputs into the lake. The relative mass flux for this process compared to other advective transfer processes carrying chemical into the lake in the Tier 1 screening scenario supports this assertion for all chemicals evaluated.

Because the RTR user has no intrinsic interest in the concentrations prevailing in the lower soil layers, all of the above processes have been ruled out from consideration for site-specific parameterization. As a consequence, it is possible to rule out all sub-surface soil compartment properties from requiring site-specific parameterization.

6.3.2 Data Availability-based Elimination of Parameters

Chemical-Specific Aquatic Biota Properties: The aquatic biota compartments in TRIM.FaTE—currently including benthic invertebrates and five types of fish—are characterized by several potentially site-specific properties that control algorithms influencing the uptake, degradation, and elimination of chemicals in the aquatic organisms. These chemical-specific properties include the absorption rates of chemical into each type of fish from surface water, elimination rates from fish digestive systems, degradation rates within the fish, and other parameters. In the course of parameterizing TRIM.FaTE for the screening scenario and conducting extensive evaluations of parameter sensitivity, it has become apparent that only a limited number of studies are available for several of these properties for most combinations of chemicals and organisms.

Although these properties may potentially differ in alternative climates and conditions, it appears unlikely that additional literature searches and evaluations would yield better, more appropriate site-specific values than the current defaults. Until such time as more studies on these properties are available, practical considerations suggest that these chemical-specific aquatic biota properties be ruled out from site-specific parameterization.

Chemical-Specific Abiotic Compartment Properties: TRIM.FaTE algorithms model chemical reaction and degradation processes in several abiotic compartments (e.g., surface soil). These algorithms depend on chemical-specific parameters such as degradation rates (or half-lives), transformation rates, and other properties. Literature searches conducted during previous site-specific assessments in the RTR process and other regulatory applications using TRIM.FaTE have suggested that data are limited for these properties.

These chemical properties (with the exception of oxidation, reduction, and methylation and demethylation rates influencing mercury) therefore are currently ruled out from site-specific consideration. The mercury transformation properties have been shown to be highly risk-influential as well as variable across different ecosystem types and conditions, and these properties are reserved for site- or land-use-specific parameterization in the future, subject to greater data availability and the results of additional evaluations.

6.3.3 Combination of Data- and Sensitivity-based Elimination of Parameters

Terrestrial Vegetation: The terrestrial vegetation compartments in TRIM.FaTE—currently including grass, coniferous forest, deciduous forest, wetland grass, and wetland forest—are not directly part of the RTR risk assessment calculations (i.e., chemical concentrations in these compartments are not used as inputs to the MIRC ingestion exposure model). However, these compartments act as sinks for chemicals and also transfer chemicals from air to soil via litterfall. In this way, the choice of terrestrial vegetation influences surface soil concentrations and, ultimately, risk.

The terrestrial vegetation compartments depend on properties such as the lipid content of leaves, wet density of leaves, area indices of leaves, etc. Although it is possible that these properties differ on a site-specific basis—for instance, the characteristics of coniferous trees in Oregon are different from those of coniferous trees in North Carolina—these differences are not expected to have a substantial influence on risk. ICF's simulations indicate that the impact on risk of alternative vegetation scenarios is limited after accounting for differences in erosion regimes specific to land-use type (see Appendix A). It is expected that site-specific differences within a single vegetation type would be even lower.

Literature searches during previous site-specific assessments in the RTR process have indicated that highly intensive literature search would be required to parameterize the full range of terrestrial vegetation parameters required by the TRIM.FaTE algorithms. Based on the limited risk impact of terrestrial vegetation properties, and limited data availability at the site-specific level, these properties are currently ruled out from site-specific parameterization.

6.3.4 Elimination of Physical and Chemical Characteristics

Algorithms in the TRIM.FaTE model frequently depend on physical and chemical parameters, such as the Henry's Law constant and the octanol-water partition coefficient, to partition chemicals between phases within a compartment. These properties are, by their nature, relatively unchanging across most standard environmental conditions for the non-ionic organic compounds currently evaluated (i.e., dioxins and PAHs)[3]. These properties are thus ruled out from requiring site-specific parameterization for the time being.

6.4 Properties Recommended for Site-Specific Parameterization

Following the elimination process described above, ICF identified a set of parameters for further evaluation based theoretical considerations as well as higher sensitivity potential displayed in previous sensitivity analyses (e.g., U.S. EPA 2009). To estimate the risk influence of these parameters, ICF performed a limited set of additional sensitivity analyses. The evaluated parameters are listed below, grouped by compartment type:

- Air: dust load, fraction of organic matter.
- Surface Soil: unit soil loss, inter-compartment drainage and erosion fractions, soil particle density, soil air fraction, soil organic content, soil pH, soil water content.
- Surface Water and Sediment: suspended solids concentration, bed sediment density, suspended solids density, bed sediment porosity.
- Aquatic Biota: biomass of various aquatic biota compartments.
- Terrestrial Vegetation: "Allow exchange" and "litterfall" file inputs.

Unlike previous analyses, these sensitivity analyses were not based on fixed perturbations from the default values but instead used reasonable high and/or low bounds approximately corresponding to the range found in the environment. The impacts on risk were computed with respect to the Tier 1 screening scenario results at equivalent emission rates.

ICF extended the scope of the current analyses by also using the results of TRIM.FaTE sensitivity analyses conducted in previous regulatory applications and pertaining to air, surface soil, and surface water and sediment. Although these analyses were performed on a different version of the Tier 1 screening scenario set up, the results are considered informative.

The specific details of the analyses conducted as part of this protocol development are reported in Appendix A, while other supporting evidence has been drawn from previous reports (e.g., U.S. EPA 2009). Based on the results of these analyses, Table 6-1 contains TRIM.FaTE properties recommended for site-specific parameterization in the RTR process. These properties have been further classified as high, medium, and low priority to facilitate an appropriate allocation of available resources in the parameterization process.

---

[3] For mercury, some analogous properties, such as the partition coefficient for mercury in the aqueous phase, do vary according to pH; these relationships are incorporated into the model as formula properties.

Table 6-1. TRIM.FaTE Properties Recommended for Site-Specific Parameterization

Compartment	Property	Priority	Remark
Surface Water	Depth	High	Having depth as well as flush rate helps serve as a check on surface hydrology assumptions.
	Flush Rate	High	
	Suspended Solids Concentration	High	Attempt to find a column-averaged value.
	pH	Moderate	Important for metals.
	Algae Density	Moderate	May be estimated from total phosphorus concentrations in the absence of measured values.
	Organic Carbon Fraction	Moderate	Important for TCDD (U.S. EPA 2009). Data availability may be limited.
	Water Temperature	Moderate	Sensitive but unlikely to manifest wide range.
Aquatic Biota	Biomass	Moderate	May be estimated from total phosphorus concentrations in absence of measured values.
Surface Soil	pH	Moderate	Important for metals.
Terrestrial Biota	"Allow Exchange" and "Litterfall" data files	Low	These files govern how long leaves remain open for stomatal exchange during different times of the year and also when the leaves fall off the trees onto the surface soil. Although the impact of these properties has not been empirically tested, theoretical considerations suggest they will have a low impact when estimating average annual risks.

In addition to these values, meteorology parameters, surface hydrology and erosion-related parameters, and the spatial layout are fundamentally site-specific elements of a TRIM.FaTE simulation, as noted in the previous sections.

7. Properties Recommended for Land Use-Based Values

In addition to the properties identified in Section 6 as desirable for site-specific parameterization, we identified properties that also influence risk substantially but for which the impacts on risk are expected to be largely captured by land use-specific parameters. In other words, for these properties, accounting for variations that correspond to land use is expected to adequately account for any variation in these parameters (to the extent that they influence risk). Additional variation in parameter values resulting from site-specific variations within a particular land use category is not expected to be significant. For example, differences in surface soil erosion (as expressed by the unit soil loss rate property in TRIM.FaTE) are expected to be larger between the average deciduous forest and the average parcel of tilled soil than between different types of deciduous forest or between different types of tilled soil. The use of land use-specific values for such properties is expected, therefore, to adequately capture their impact on risk estimates in the RTR process.

The rationale for identifying properties as land use-based in this protocol is a combination of risk sensitivity analysis (Appendix A and U.S. EPA 2009), professional judgment about the range exhibited in the environment, and expected data availability at the site-specific level. For land use-specific properties, users performing a site-specific assessment should identify the land use type of each surface parcel in the FaTEmaster Scenario Builder tool. The tool would then automatically assign the appropriate land use-specific property values. It should be noted, however, that the tool is not currently parameterized with land-use specific property values.

Table 7-1 lists the TRIM.FaTE parameters that are recommended for land use-specific parameterization. These parameters are all related to the surface soil parcel and assume distinct values for each of the land use types modeled in TRIM.FaTE. These land use types currently include deciduous forest, coniferous forest, grass, agricultural soil, untilled soil, forested wetlands, and grassy wetlands. Other land use types may also be defined using the FaTEmaster Scenario Builder tool. Land use type is not an explicit input in TRIM.FaTE but is implicitly reflected in the TRIM.FaTE property values corresponding to each surface parcel.

Table 7-1. TRIM.FaTE Properties Recommended for Land use-Specific Parameterization

Property	Remark
Organic carbon fraction	Fraction of dry soil solids that is organic in origin.
Water content	The sum of the water and air content fractions of a soil determines its porosity.
Air content	
Particle density	Refers to the dry density of the average soil particle.
Rainfall/erosivity index	Universal Soil Loss Equation (USLE) properties used in FaTEmaster Scenario Builder Tool to compute each surface soil compartment’s average erosion rate.
Soil erodibility index	
Topographical (LS) factor	
Cover/management factor	
Supporting practices factor	
Fraction of precipitation that evapotranspires	Water balance-related property used in FaTEmaster Scenario Builder Tool to compute each surface soil compartment’s average runoff rate.
Fraction of precipitation subject to overland runoff	

8. Properties Recommended for National Values

Nationally-representative or health-protective values are recommended for all TRIM.FaTE properties that are not identified for site-specific or land use-based parameterization in Sections 6 and 7 above. These properties are expected either to (1) not substantially influence risk in the RTR process, (2) not have adequate data to support site-specific parameterization, or (3) be relatively constant in the environment, as discussed in greater detail in the approach described in Section 6. These properties have been previously characterized in the RTR Tier 1 and Tier 2 screening threshold derivation analyses by either nationally-representative values or health-protective values. The same values are recommended for these properties in site-specific analyses and are listed with references in Appendix B.

9. The FaTEmaster Scenario Builder

All user inputs can be provided to TRIM.FaTE via text-based or delimited data input files. The files must be defined in syntax specific to TRIM.FaTE; a full description of syntax requirements is provided in the TRIM.FaTE User's Guide (U.S. EPA 2005)

ICF's FaTEmaster Scenario Builder tool provides a Microsoft® Excel™-based environment that facilitates translation of user inputs into appropriately formatted TRIM.FaTE input files that can be used to set up and run site-specific scenarios. The FaTEmaster Scenario Builder tool does not, however, create the TRIM.FaTE Master Library file, which contains library properties and can be used to set property values that are not expected to vary between scenarios. The recommendations for the use of site-specific properties made earlier in this document are not envisaged to require changes to the TRIM.FaTE Master Library file. The FaTEmaster Scenario Builder tool is further documented in Appendix C.

10. Potential Future Improvements

This protocol represents a first attempt at documenting the current state of knowledge related to conducting site-specific environmental modeling in support of RTR multipathway risk assessments. The protocol could be enhanced in the future by documenting best practices and developing recommendations regarding the following issues (among others):

- Identification of land use-specific parameters for the identified soil properties based on literature review;
- Application of enhanced technical approaches, such as the use of a sensitivity score approach, to identify the most influential model properties;
- Potential development of regional parameters for a subset of model properties based on the results of further sensitivity analysis and data availability assessments;
- Greater use of graphics and figures to illustrate model set-up concepts;
- Enhanced technical editing to help the protocol be more self-explanatory and independent of other TRIM.FaTE support documents in its scope;
- Researching the potential for geographically variable biotransfer factors and other parameters in MIRC; and
- Further research and development of GIS-based approaches to surface hydrology and erosion property parameterization.

References

ESRL (Earth System Research Laboratory). 2011. NOAA/ESRL Radiosonde Database Access. Available online at: http://www.esrl.noaa.gov/raobs/. Accessed March 3, 2011.

Google. 2013. Google Earth. Available at http://www.google.com/earth/index.html. Accessed July 24, 2013.

Multi-resolution Land Characterization (MRLC) Consortium. 2013. National Land Cover Database. Available online at http://www.mrlc.gov/index.php. Web page last updated February 7, 2013.

NCDC (National Climatic Data Center). 2008. Integrated Surface Database. Available at: http://www.ncdc.noaa.gov/oa/climate/isd/index.php. Web page last updated August 20, 2008.

NCDC. 2011. NCDC 1981-2010 Climate Normal. Available at: http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html. Web page last updated January 5, 2011.

NCDC. 2012. NCDC CD-ROM and DVD Climate Products. Available at: http://ols.nndc.noaa.gov/plolstore/plsql/olstore.prodlist?category=C&subcatc=01&groupin=CDV.

NCDC. 2013. Quality Controlled Local Climatological Data (QCLCD). Available at: http://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/quality-controlled-local-climatological-data-qclcd.

Overcamp, TJ. 1976. A General Gaussian Diffusion-Deposition Model for Elevated Point Sources. Journal of Applied Meteorology 15:1167-1171.

Seinfeld, JH; Pandis, SN. 1998. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. Wiley-Interscience, New York, pp. 931–933.

U.S. Department of Agriculture (USDA). 2013. CropScape – Cropland Data Layer. Available online at http://nassgeodata.gmu.edu/CropScape/.

U.S. EPA (U.S. Environmental Protection Agency). 1992. Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models (Dennis Atkinson and Russell F. Lee). July 7, 1992. Available online at http://www.epa.gov/ttn/scram/surface/missdata.txt. Last accessed March 07, 2011.

U.S. EPA. 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models Volume II - Description of Model Algorithms. September 1995. (EPA-454/B-95-003b)

U.S. EPA. 2002. TRIM.FaTE Technical Support Document. U.S. EPA Office of Air Quality Planning and Standards. Available at: http://www.epa.gov/ttn/fera/trim_fate.html#current_user

U.S. EPA. 2005. TRIM.FaTE User’s Guide. Office of Air Quality Planning and Standards. September, 2005. Available at: http://www.epa.gov/ttn/fera/trim_fate.html#current_user.

U.S. EPA. 2009. Risk and Technology Review (RTR) Risk Assessment Methodologies: For Review by the EPA's Science Advisory Board. Attachment C-3 in Appendix C. (EPA-452/R-09-006)

U.S. EPA. 2010a. SCRAM (Support Center for Regulatory Atmospheric Modeling) Mixing Height Data. Available at: http://www.epa.gov/ttn/scram/mixingheightdata.htm. Web page last updated May 13, 2010.

U.S. EPA. 2010b. SCRAM Surface Meteorological Archived Data: 1984-1992. Available at: http://www.epa.gov/ttn/scram/surfacemetdata.htm. Web page last updated May 13, 2010.

U.S. EPA. 2012a. AERMET Meteorological Preprocessor. Available at: http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#aermet. Web page last updated December 18, 2012.

U.S. EPA. 2012b. Mixing Height Program. Available at: http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#mixing. Web page last updated December 18, 2012.

U.S. EPA. 2012c. PCRAMMET Meteorological Processor. Available at: http://www.epa.gov/ttn/scram/metobsdata_procaccprogs.htm#pcrammet. Web page last updated December 18, 2012.

U.S. EPA. 2013. HEM Download Page. Available at: http://www.epa.gov/ttn/fera/hem_download.html. Web page last updated June 19, 2013.

USGS (U.S. Geological Survey). 2006. National Elevation Dataset. Available at: http://ned.usgs.gov/. Web page last updated August, 2006.

USGS. 2013. National Hydrography Dataset. Available at http://nhd.usgs.gov/. Web page last updated July 19, 2013.

Appendix A. Documentation of Empirical Analyses Used to Prioritize TRIM.FaTE Properties

A.1. Introduction

ICF performed a series of empirical analyses to prioritize TRIM.FaTE model properties for site-specific parameterization. These analyses were based on changing the value of one or more model properties relative to the Tier 1 screening scenario and measuring the relative impact on risk. Unlike in a traditional sensitivity analysis, this analysis changed property values to approximate high and low-end values within the environmental range of the property of interest, instead of using a fixed perturbation. The measured impacts on risk, the expected range in the environment, and data availability were considered in prioritizing model properties for site-specific parameterization, as discussed in Sections 6 and 7.

Table A-1 summarizes the various empirical analyses that were conducted, the risk impact of the scenario modifications, and conclusions from the analyses.

Table A-1. Results and Conclusions from Empirical Analyses Used to Prioritize TRIM.FaTE Properties

Scenario Name	Scenario Description (with respect to Tier 1 Screening Scenario)	Normalized Risk Relative to Tier 1 Screening Scenario				Risk Impact of Scenario Modification	Conclusions
		TetraCDD, 2,3,7,8-	Benzo(A) pyrene	Cadmium	Methyl Mercury		
Tier 1 SS	Tier 1 Screening Scenario.	1.00	1.00	1.00	1.00	Designed to produce most conservative risk estimate.	All relative risks for modified scenarios are measured relative to the Tier 1 screening scenario.
WF1	Reduce watershed flows (erosion and runoff) to half screening scenario levels. Redirect remainder to sink. Maintain same flow directions as screening scenario.	0.56	0.69	0.21	0.38	Reducing the quantity of runoff and erosion reaching receiving compartments reduces chemical inputs into those compartments, including the lake, and reduces risk.	Surface hydrology and erosion flows (where and how much of the erosion and runoff from a compartment reaches) are potentially highly sensitive properties in the model (influencing risk by up to a factor of 10) and are recommended for site-specific parameterization.
WF2	Reduce watershed flows (erosion and runoff) to 1/10 screening scenario levels. Redirect remainder to sink. Maintain same flow directions as screening scenario.	0.34	0.68	0.11	0.25		
ER0	Switch off erosion.	0.39	1.02	1.10	0.43	Turning off erosion reduces chemical inputs into the lake and reduces chemical removal off the farm.	Although erosion is a relatively important process, its maximum impact on risk is less than a factor of 3, even when

Scenario Name	Scenario Description (with respect to Tier 1 Screening Scenario)	Normalized Risk Relative to Tier 1 Screening Scenario				Risk Impact of Scenario Modification	Conclusions
		TetraCDD, 2,3,7,8-	Benzo(A) pyrene	Cadmium	Methyl Mercury		
ER1	Double erosion rates.	1.09	0.99	0.86	0.86	Increasing erosion produces competing effects: while it increases chemical inputs into the lake, it also increases the burial rate of sediment and increases chemical removal from the farm.	accounting for variable runoff rates. A land-use specific parameterization approach is recommended for the average erosion rates of surface soil compartments.
ER-RUN1	Double erosion and runoff rates (same flush rate; higher lake depth).	0.94	0.96	0.74	0.89	Increasing the runoff rate increases the input of soluble chemicals into the lake and decreases the removal of those chemicals from the farm.	
ER-RUN2	Double erosion and runoff rates (higher flush rate; same lake depth).	1.09	0.99	0.74	0.85	Increased runoff rates can be accommodated by means of increased lake depths or increased flush rates.	
RUN1	Switch off runoff; maintain flush rate and depth.	0.99	1.00	0.70	0.96	Nullifying chemical transfer through runoff reduces chemical input into the lake and reduces chemical removal from the farm.	Runoff rates have a limited impact on risk. A land-use specific parameterization approach is recommended for average runoff rates from surface soil compartments.
RUN2	Implement cumulative runoff regime.	1.02	1.00	1.14	1.10	Assumes runoff from one compartment does not evaporate but contributes to runoff from the receiving compartment.	

Scenario Name	Scenario Description (with respect to Tier 1 Screening Scenario)	Normalized Risk Relative to Tier 1 Screening Scenario				Risk Impact of Scenario Modification	Conclusions
		TetraCDD, 2,3,7,8-	Benzo(A) pyrene	Cadmium	Methyl Mercury		
FR1	Double lake depth, half flush rate, same rainfall, and same runoff fraction.	0.71	0.96	1.00	1.15	Doubling depth reduces concentrations but halving the flush rate reduces chemical output from the lake.	Lake depth and flush rate have a modest impact on risk. However, knowledge of both these parameters can help guide the surface hydrology and erosion direction flows in the watershed which can more substantially influence risk. Site-specific parameterization is recommended for lake depth and flush rate.
FR2	Half lake depth, double flush rate, same rainfall, and same runoff fraction.	1.28	1.07	1.00	0.92	Halving depth increases concentrations but doubling the flush rate increases chemical output from the lake.	
FR3	Double depth, same flush rate, same rainfall, same runoff fraction (violate water balance in screening scenario).	0.69	0.96	0.58	1.02	Doubling depth reduces lake concentrations for most chemicals.	
FR4	Double flush rate, same depth, same rainfall, and same runoff fraction (violate water balance in screening scenario).	0.95	1.00	0.58	0.89	Doubling flush rate reduces lake concentrations.	
PERC1	Implement balanced percolation regime.	0.99	1.00	0.62	0.99	Assumes runoff from one compartment does not evaporate but percolates in the receiving compartment.	Percolation rate (the fraction of rainfall that is subject to percolation into the sub-surface) has a modest impact on risk. Land use-based parameterization is recommended for this property.

Scenario Name	Scenario Description (with respect to Tier 1 Screening Scenario)	Normalized Risk Relative to Tier 1 Screening Scenario				Risk Impact of Scenario Modification	Conclusions
		TetraCDD, 2,3,7,8-	Benzo(A) pyrene	Cadmium	Methyl Mercury		
R1	Reduce rainfall down to 1/3rd SS value; same lake depth; runoff rates and flush rate down to 1/3rd.	0.64	0.59	0.92	0.58	Reducing rainfall reduces chemical washout from air.	This run, when combined with earlier runs focusing on the impacts of flush rate, suggests that the chemical washout impact of rainfall has more influence on risk than the impact of rainfall levels on hydrological properties like flush rate. This reinforces the argument for site-specific meteorological parameters.
V_C	Set all surface compartments except farm to coniferous forests.	0.79	0.75	0.40	0.87	The choice of vegetation in surface soil compartments impacts risk by absorbing chemicals from air and soil and then redepositing them onto the surface soil via litterfall.	Land use-type has a limited impact on risk. Based on these results, terrestrial vegetation parameters are recommended for land-use specific parameterization. In interpreting these results, it is important to note that these runs have not been normalized for erosion rates. Therefore, the impacts on risk presented here are from a combination of impacts from differential erosion rates and vegetation types.
V_D	Set all surface compartments except farm to deciduous forests.	0.34	0.92	0.49	0.39		
V_G	Set all surface compartments except farm to grassland.	0.88	0.82	0.45	0.92		
V_U	Set all surface compartments except farm to untilled soil.	0.42	0.73	0.37	0.81		
V_WW	Set all surface compartments except farm to forested wetlands.	0.36	0.92	0.49	0.47		

Scenario Name	Scenario Description (with respect to Tier 1 Screening Scenario)	Normalized Risk Relative to Tier 1 Screening Scenario				Risk Impact of Scenario Modification	Conclusions
		TetraCDD, 2,3,7,8-	Benzo(A) pyrene	Cadmium	Methyl Mercury		
V_WG	Set all surface compartments except farm to grassy wetlands.	0.86	0.83	0.46	0.94		
BM1	Increase aquatic biomass uniformly by a factor of 10.	0.84	0.39	0.90	0.99	Increasing aquatic biomass reduces chemical concentration in biomass as the same amount of chemical is distributed in a higher amount of biomass.	Risk is sensitive to the aquatic biomass levels. These properties are therefore recommended for site-specific parameterization. In interpreting the results of these runs, it may be noted that all biomass levels were uniformly raised. In real applications, the biomass levels of the upper trophic levels may constitute a lower percentage of the total biomass as total biomass increases, suggesting slightly lower risk sensitivity than apparent here.
BM2	Increase aquatic biomass uniformly by a factor of 100.	0.35	0.32	0.29	0.79		
Air_DL1	Increase air dust load by a factor of 10.	2.34	2.31	0.50	0.98	Increasing the dust load in air increases	Although these runs indicate that air dust load

Scenario Name	Scenario Description (with respect to Tier 1 Screening Scenario)	Normalized Risk Relative to Tier 1 Screening Scenario				Risk Impact of Scenario Modification	Conclusions
		TetraCDD, 2,3,7,8-	Benzo(A) pyrene	Cadmium	Methyl Mercury		
Air_DL2	Increase air dust load by a factor of 100.	4.14	2.71	0.50	0.90	particulate deposition to the surface.	moderately influences risk, literature search indicated that the range manifested by this property is relatively small and the default value used is already in the high end of the observed range in the U.S. Therefore, this property is not recommended for site-specific parameterization.
Air_FOM1	Halve the fraction of organic matter in air solids.	0.87	0.66	0.50	1.00	The organic content of air solids can differentially influence chemical adherence to the solid phase.	Although these runs indicate that the fraction of organic matter in air solids moderately influences risk, literature search indicated that site-specific data may be difficult to obtain. This property is not recommended for site-specific parameterization.
Air_FOM2	Double the fraction of organic matter in air solids.	1.23	1.43	0.50	1.00		
Soil_Air	Double the soil air content.	1.21	1.29	0.50	1.14	Increasing the soil air fraction reduces soil solids, which distributes the same amount of chemical over a lower solids content, thereby increasing soil concentrations.	Although these runs indicate that air dust load moderately influences risk, literature search indicated that the range manifested by this property is relatively small and the default value used is already in the high end of the observed range in the U.S. Therefore, this property is not recommended for site-
Soil_FOC	Increase the soil organic fraction content by a factor of 10.	1.04	1.01	0.60	1.00	Increasing soil organic content increases chemical adherence to soil for some chemicals.	

Scenario Name	**Scenario Description (with respect to Tier 1 Screening Scenario)**	**Normalized Risk Relative to Tier 1 Screening Scenario**				**Risk Impact of Scenario Modification**	**Conclusions**
		TetraCDD, 2,3,7,8-	**Benzo(A) pyrene**	**Cadmium**	**Methyl Mercury**		
Soil_pH1	Set soil pH at 4.	1.00	1.00	0.39	1.00	Soil pH can influence chemical adherence to soil solids for some chemicals.	specific parameterization.
Soil_pH2	Set soil pH at 10.	1.00	1.00	0.66	1.00		
Soil_Rho	Set soil solids density at 1000 kg/m^3.	1.41	1.43	0.50	1.16	Decreasing soil particle density increases soil concentrations when normalized by soil weight.	
Soil_Water	Double the soil water content.	1.00	1.00	0.50	1.00	Increasing soil water content increases chemical removal by percolation for some chemicals.	
SusSed_TSS1	Increase lake suspended solids concentration by a factor of 2.	0.73	0.98	1.01	0.74	Increasing suspended solids in water causes more chemical to be deposited to sediment.	Suspended solids concentration in lakes has a moderate influence on risk. Due to the wide range potentially exhibited by this property, it has been recommended for site-specific parameterization.
SusSed_TSS2	Increase lake suspended solids concentration by a factor of 10.	0.33	0.98	0.46	0.38		
Sed_Bur	Halve sediment burial rate; same erosion rate (violate solids balance in screening scenario).	1.11	1.00	1.12	1.31	Decreasing the burial rate reduces the removal of chemicals from the sediment layer.	Sediment properties have a moderate impact on risk, given the limited range of values assumed by them in the environment.

Scenario Name	Scenario Description (with respect to Tier 1 Screening Scenario)	Normalized Risk Relative to Tier 1 Screening Scenario				Risk Impact of Scenario Modification	Conclusions
		TetraCDD, 2,3,7,8-	Benzo(A) pyrene	Cadmium	Methyl Mercury		
Sed_Rho	Decrease bed sediment particle density to 1000 kg/m^3.	1.36	1.00	0.63	2.74	The lower the sediment particle density, the lower the volumetric resuspension rate from sediment and the higher the volumetric burial rate.	
Sed_Por	Halve sediment bed porosity.	0.85	1.00	0.42	0.78	The lower the sediment porosity, the lower the volumetric resuspension rate from sediment and the lower the volumetric burial rate.	

[This page intentionally left blank.]

Appendix B. TRIM.FaTE National Property Values

B.1. Introduction

This protocol recommends the use of nationally representative or health protective values (referred to as national values) for TRIM.FaTE model properties that have not been identified for site-specific or land use-based parameterization.

These national values are readily accessible in the FaTEmaster Scenario Builder tool, with references. This tool is included with the protocol and is documented in Appendix C. The national values are also documented in Appendix 4 of the Risk Report (see its Attachment A, Addendum 1).

[This page intentionally left blank.]

Appendix C. The FaTEmaster Scenario Builder Tool

C.1. Introduction

A TRIM.FaTE scenario requires a variety of inputs from users to define the modeled environment and to parameterize the algorithms for physical, chemical, and biological processes that transfer and transform chemical mass between and within environmental media. These inputs are provided to the TRIM.FaTE model in the form of the following files:

- A “volume elements” file, which defines the spatial layout of the modeled domain in terms of three-dimensional abiotic compartments. Each volume element provides a frame of reference for one or more biotic compartments within it.
- A “compartments” file, which places biotic and abiotic compartments (modeling units containing chemical mass) within the volume elements.
- A Master Library file, which contains all the model algorithms, properties, and emission source information.
- A properties file, which typically contains (i) simulation- and scenario-specific properties that overwrite default values specified in the Master Library and (ii) the location of time-varying input files for parameters such as meteorological and vegetation parameters.

These input files must be constructed in syntax consistent with TRIM.FaTE requirements, as described in Module 3 of the TRIM.FaTE User’s Guide.

ICF’s FaTEmaster Scenario Builder tool provides an MS-Excel spreadsheet-based interface that facilitates the automated generation of syntactically accurate TRIM.FaTE input files derived from user-specified inputs. The tool does not output the TRIM.FaTE Master Library file.

This appendix describes how the FaTEmaster Scenario Builder tool can be used to construct input files for the TRIM.FaTE model for use in site-specific risk assessments in the RTR process. While this document discusses the principal steps required to operate the tool, it does not provide line-by-line guidance for each of the hundreds of inputs contained within it. The tool already incorporates comments and guidance for each input cell and is largely self-explanatory. This overview of the tool is intended to facilitate an enhanced understanding of the scope of the tool and its operational structure. This document is not intended to serve as a guide to running the TRIM.FaTE model itself.

C.1.1. Output Files from the FaTEmaster Scenario Builder Tool

The FaTEmaster Scenario Builder Tool produces five text output files, which serve in turn as input files to the TRIM.FaTE model. The filenames, contents, and purpose of the output files generated by the tool are described in Table C-1.

C.1.2. Summary Worksheets in the FaTEmaster Scenario Builder Tool

The FaTEmaster Scenario Builder Tool consists of 15 worksheets. The names, contents, and purpose of these worksheets are described in Table C-2, which has been color-coded in an identical manner to the worksheet “tabs” in the tool.

Table C-1. Output Files Generated by the FaTEmaster Scenario Builder Tool

File Name	Contents	Purpose
Sources.txt	Coordinates specifying the location of the emission sources and the chemical emission rates.	This file facilitates the creation of a unique scenario-specific TRIM.FaTE Sources Library. This file must be manually imported through the TRIM.FaTE graphical interface and saved as a library. This Sources Library must then be loaded to the site-specific TRIM.FaTE scenario together with the TRIM.FaTE Master Library.
Volume Elements.txt	Coordinates specifying the spatial dimensions of the volume elements and specification of the primary abiotic compartment within each volume element.	This file serves as a TRIM.FaTE input file to define the spatial layout of the modeled domain in terms of three-dimensional abiotic compartments, each of which can contain other biotic and abiotic compartments.
Compartments.txt	The names of biotic and non-primary abiotic compartments located within each primary abiotic compartment defined by the Volume Elements file.	This file serves as a TRIM.FaTE input file to situate user-specified biotic and abiotic compartments within each volume element. These compartments are the discrete units that contain chemical mass in TRIM.FaTE.
Properties.txt	Values defining site-specific properties relating to the scenario, biotic and abiotic compartments, and user-specified link properties.	This files serve as a TRIM.FaTE input file to define the values of various properties that define the scenario. It overwrites default values for these properties specified in the TRIM.FaTE Master Library file.
Other Properties.txt	Values defining properties that are not included amongst the standard sections of the tool for user-specification. This is a discretionary or optional file that may be useful when overwriting library properties that are not redefined by the standard elements of the tool.	This file serves as a TRIM.FaTE input file to define the values of any of the various properties that define the scenario. It overwrites default values for these properties specified in the TRIM.FaTE Master Library file.

Table C-2. Summary of Worksheets Generated by the FaTEmaster Scenario Builder Tool

Worksheet Name	Contents	Purpose
Tracking	• Command button • Documentation of version changes.	Contains “Export All” button that generates TRIM.FaTE input files based on values specified in other worksheets. Also serves as a documentation sheet for tool software developers only.
Parameters	• User-specified property values for several TRIM.FaTE model properties.	Provides a user-friendly interface for the definition of site-specific model properties. Adds the properties defined here to the Properties file.
Layout	• Coordinates of the vertices of the parcels that define the spatial layout. • Coordinates of the location of the emission sources. • Emission rates of each chemical species from each source.	Serves as a basis for the creation of the Volume Elements and the Sources output files.
Land	• User-specified parameter values for the USLE equation for different land use types.	Computes average erosion rates based on the USLE equation for surface soil compartments and adds those estimates to the Properties file. Also contains elements used to construct the Compartments file.
Soil	• User-specified property values for all soil layers differentiated by land use types.	Computes average runoff and percolation rates, and adds these estimates and other soil-related properties to the Properties file. Also contains elements used to construct the Compartments file.
Plants	• User-specified vegetation types and vegetation components for each land use category.	Places the appropriate vegetation composite compartments within soil compartments based on user-specified land use. This is used to construct the Compartments file.
Watersheds	• User-specified inter-compartment erosion and runoff directions and percentages.	Defines inter-compartmental link properties for runoff and erosion and adds them to the Properties file.
Lakes	• User-specified lake and sediment properties. • Equations to compute lake flush rates/depth and sediment resuspension velocity based on watershed flows.	Adds lake and sediment related properties, and computed lake and sediment hydrodynamic parameters, to the Properties file.
Fish	• User-specified aquatic food web and biomass levels.	Adds aquatic food web and biomass properties to the Properties file. These elements are also used to construct the Compartments file.

Worksheet Name	Contents	Purpose
Soil Data	• User-specified soil properties differentiated by land use type.	Serves as an input sheet for soil properties that is called by the "Soil" worksheet. May potentially be parameterized on a regional basis.
Sources	No user inputs are required on these worksheets. They are constructed from the inputs specified in the previous tabs and contain the content of the output files that will later be generated by the tool as text files.	
Volume		
Cmpts		
Props		
OtherProps	User may enter supplementary properties into this worksheet consistent with TRIM.FaTE syntax. This worksheet can be used to overwrite properties that are defined in the Master Library file or to define properties that are not previously defined either in the library file or other input files.	

C.1.3. Additional Salient Features of Worksheets in the FaTEmaster Scenario Builder Tool

This section provides a limited description of the features of the various worksheets within the FaTEmaster Scenario Builder, with a focus on the most salient operational aspects from the user perspective.

A general rule when working with the tool, also mentioned clearly at the top of each worksheet, is that only cells color-coded green may be modified by users. Blue and white color-coded cells are not to be modified by users.

(i) The *Tracking* Worksheet

- Users should click the "Export All" command button after they have made all the necessary input modifications to the other worksheets. This will be the final step in operating the tool.
- The remainder of the worksheet is intended for software developers only to document version changes in the tool.

(ii) The *Parameters* Worksheet

- Specify a "set up" file directory in cell D9.
  - Model output will be directed to this directory into a sub-folder named "Output".
  - This directory will also be the destination to which the tool will write its five output files.
  - This directory should contain the time-varying meteorological values file, leaf "allow exchange" file, and litterfall data file later referenced in the worksheet.
- In cell D48, enter the average annual precipitation based on the average from the time-varying site-specific meteorological file. This averaging must be performed manually offline.
- In cell D49, update the formula reference with the name of the applicable meteorological values file if they have changed.
- In cells D80, D92 and D103 update the formula with the names of the leaf allow exchange data files if they have changed.
- In cells D84, D96 and D107 update the formula with the names of the litterfall data files if they have changed.
- Note: Cells commented as "Reported Value" will be reported in the tables for documentation purposes but will not be used in TRIM.FaTE input files.

- Note: All other input cells may be updated as required. Cell comments have been provided for guidance.

(iii) The *Layout* Worksheet

- Based on the spatial layout for air and surface parcels developed in GIS or through manual mapping, enter the Cartesian coordinates of each vertex point in columns C and D. The center of the emissions source (or facility) parcel should be defined as the origin of the system.
- Specify offset coordinates in cells E9 and F9 to situate the layout spatially, consistent with the specified map projection system in cell D4. (This is similar to a latitude and longitude specification. It does not affect TRIM.FaTE results, however.)
- Specify the name of each parcel in the spatial layout and the vertex points that define the parcel in a clockwise or anticlockwise direction around the perimeter of the parcel in columns H and K.
- Specify the parcel category from the available options in column I.
- Specify the land use corresponding to each parcel in column J.
- Specify the source name, source parcel location, and source elevation in column U.
- Specify the chemical emission rates in column U.

(iv) The *Land* Worksheet

- In columns E through L, enter the USLE parameters that are used to compute average erosion rates for each land use type.
- Enter the vegetation type within each land use type.

(v) The *Soil* Worksheet

- This worksheet requires no user inputs. It draws inputs from other worksheets and calculates average runoff and percolation rates based on those values.

(vi) The *Plants* Worksheet

- Specify the vegetation components corresponding to each land use type.
- Note: If new types of vegetation components are being defined, their corresponding properties and algorithms should be defined in the Master Library or separately within property files.

(vii) The *Watersheds* Worksheet

- For each parcel, specify which of its adjoining parcels receive the runoff and erosion originating from that parcel and in what amounts (specified in percentages).
- Click on the “Refresh” button after updating the worksheet.

(viii) The *Lakes* Worksheet

- Specify lake and sediment properties in column K.
- Specify one of either lake depth or flush rate in cells K18 and K19.
- Note: The worksheet will compute the unspecified property (either lake depth or flush rate) using a water balance. The water balance assumes that runoff entering the lake is the sum of runoff entering the lake from adjacent soil compartments and cumulative runoff from the larger watershed.
- Note: The worksheet also computes sediment resuspension velocity and sediment burial rate using principles discussed in the TRIM.FaTE Technical Support Document (Section 4.2.2).

(ix) The *Fish* Worksheet

- Define the aquatic food web by specifying the diet fraction for each aquatic organism.
- Specify the total biomass of each organism type and the single body weight of each organism.

(x) The *Soil Data* Worksheet

- For each land-use type, specify properties for all soil layers.
- (Note: The tool has the capacity to accommodate region-specific definitions of soil parameters too but this functionality has not currently been parameterized.)

C.1.4. Generating Output Files from the FaTEmaster Scenario Builder Tool

After entering site-specific inputs into the various worksheets within the tool as required, the following steps should be used to complete the generation of output files:

- Navigate to the “Layout” tab, and click “Refresh”.
- Navigate to the “Watersheds” tab, and click “Refresh”.
- Navigate to the “Tracking” tab, and click “Export All”.

The five output files generated by the tool can then be used as input files to set up the site-specific TRIM.FaTE scenario. (It is reiterated that the tool does not generate the TRIM.FaTE Master Library file, the contents of which are largely invariable between applications.

Appendix 8

Dose-Response Values Used in the RTR Risk Assessments

Appendix 8. Dose-Response Values Used in the RTR Risk Assessments

Definition for Chronic Values

URE (unit risk estimate) = the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent over a lifetime at a concentration of 1 µg/m^3 in air.

RfC (reference concentration) = an estimate of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of harmful noncancer health effects during a lifetime.

Cancer Slope Factor = an upper-bound estimate of the increased cancer risk from a lifetime oral exposure to an agent.

RfD (reference dose) = an estimate of a continuous oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of harmful noncancer health effects during a lifetime.

Sources:
IRIS = EPA Integrated Risk Information System
ATSDR = US Agency for Toxic Substances Disease Registry
CAL = California EPA Office of Environmental Human Health Assessment
HEAST = EPA Health Effects Assessment Tables
EPA OAQPS = EPA Office of Air Quality Planning and Standards
EPA ORD = EPA Office of Research & Development

Definition of Acute Values

AEGL-1 (acute exposure guideline level 1) = the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2 (acute exposure guideline level 2) = the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

ERPG-1 (emergency response planning guideline 1) = the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient health effects or without perceiving a clearly defined objectionable odor.

ERPG-2 (emergency response planning guideline 2) = the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious adverse health effects or symptoms that could impair an individual's ability to take protective action.

REL (reference exposure level) = the concentration level at or below which no adverse health effects are anticipated for a specified exposure duration. RELs are based on the most sensitive, relevant, adverse health effect reported in the medical and toxicological literature and are designed to protect the most sensitive individuals in the population by the inclusion of margins of safety.

Sources:
National Advisory Committee on Acute Exposure Guideline Level for Hazardous Substances, reviewed and published by the National Research Council - AEGL
American Industrial Hygiene Association – ERPG
California EPA Office of Environmental Human Health Assessment - REL

Table 1. Chronic Cancer and Noncancer Inhalation and Oral Dose-Response Values and the Source of Those Values

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
1,1,1-Trichloroethane	71-55-6			5	IRIS		
1,1,2-Trichloroethane	79-00-5	0.000016	IRIS	0.4	CAL		
Hexachlorocyclohexans							
alpha-Hexachlorocyclohexane (a-HCH)	319-84-6	0.0018	IRIS	0.02	CAL		
beta-Hexachlorocyclohexane (b-HCH)	319-85-7	0.00053	IRIS	0.002	CAL		
Lindane (gamma-HCH)	58-89-9	0.00031	CAL	0.0003	CAL		
technical Hexachlorocyclohexane (HCH)	608-73-1	0.00051	IRIS				
1,2,4-Trichlorobenzene	120-82-1			0.2			
1,2-Dibromo-3-chloropropane	96-12-8	0.002	CAL	0.0002	IRIS		
1,2-Diphenylhydrazine	122-66-7	0.00022	IRIS				
1,2-Epoxybutane	106-88-7			0.02	IRIS		
1,3-Butadiene	106-99-0	0.00003	IRIS	0.002	IRIS		
1,3-Dichloropropene	542-75-6	0.000004	IRIS	0.02	IRIS		
1,3-Propane sultone	1120-71-4	0.00069	CAL				
p-Dichlorobenzene	106-46-7	0.000011	CAL	0.8	IRIS		
p-Dimethylaminoazobenzene	60-11-7	0.0013	CAL				
1,4-Dioxane	123-91-1	0.000005	IRIS	0.03	IRIS		
2,4,6-Trichlorophenol	88-06-2	0.0000031	IRIS				
2,4-Dinitrotoluene	121-14-2	0.000089	CAL	0.007	CAL		
2,4-Toluene diamine	95-80-7	0.0011	CAL				
2,4/2,6-Toluene diisocyanate mixture (TDI)	26471-62-5	0.000011	CAL	0.00007	IRIS		
2,4-Toluene diisocyanate	584-84-9	0.000011	CAL	0.00007	IRIS		
2-Chloroacetophenone	532-27-4			0.00003	IRIS		
2-Nitropropane	79-46-9	0.0000056	EPA OAQPS	0.02	IRIS		
3,3'-Dichlorobenzidine	91-94-1	0.00034	CAL				
4,4'-Methylene bis(2-chloroaniline)	101-14-4	0.00043	CAL				
4,4'-Methylenedianiline	101-77-9	0.00046	CAL	0.02	CAL		
Methylene diphenyl diisocyanate	101-68-8			0.0006	IRIS		
Acetaldehyde	75-07-0	0.0000022	IRIS	0.009	IRIS		
Acetamide	60-35-5	0.00002	CAL				
Acetonitrile	75-05-8			0.06	IRIS		
Acrolein	107-02-8			0.00002	IRIS		
Acrylamide	79-06-1	0.00016	IRIS	0.006	IRIS		
Acrylic acid	79-10-7			0.001	IRIS		
Acrylonitrile	107-13-1	0.000068	IRIS	0.002	IRIS		
Allyl chloride	107-05-1	0.000006	CAL	0.001	IRIS		
Aniline	62-53-3	0.0000016	CAL	0.001	IRIS		
Antimony Compounds							
Antimony compounds	7440-36-0			0.0002	IRIS		
Antimony oxide	1327-33-9			0.0002	IRIS		
Antimony pentafluoride	7783-70-2			0.0002	IRIS		
Antimony pentoxide	1314-60-9			0.0002	IRIS		
Antimony potassium tartrate	304-61-0			0.0002	IRIS		

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
Antimony tetroxide	1332-81-6			0.0002	IRIS		
Antimony trihydride	7803-52-3			0.0002	IRIS		
Antimony trioxide	1309-64-4			0.0002	IRIS		
Arsenic Compounds							
Arsenic acid	7778-39-4	0.0043	IRIS	0.000015	CAL		
Arsenic as lead arsenate	7784-40-9	0.0043	IRIS	0.000015	CAL		
Arsenic chloride	7784-34-1	0.0043	IRIS	0.000015	CAL		
Arsenic compounds	7440-38-2	0.0043	IRIS	0.000015	CAL	1.5	
Arsenic oxide	1327-53-3	0.0043	IRIS	0.000015	CAL		
Arsenic pentoxide	1303-28-2	0.0043	IRIS	0.000015	CAL		
Arsenic trioxide	1327-53-3	0.0043	IRIS	0.000015	CAL		
Arsine	7784-42-1			0.00005	IRIS		
Benzene	71-43-2	0.0000078[d]	IRIS	0.03	IRIS		
Benzidine	92-87-5	0.1072	IRIS	0.01	CAL		
Benzyl chloride	100-44-7	0.000049	CAL				
Beryllium Compounds							
Beryllium chloride	7787-47-5	0.0024	IRIS	0.00002	IRIS		
Beryllium compounds	7440-41-7	0.0024	IRIS	0.00002	IRIS		
Beryllium fluoride	7787-49-7	0.0024	IRIS	0.00002	IRIS		
Beryllium nitrate	13597-99-4	0.0024	IRIS	0.00002	IRIS		
Beryllium oxide	1304-56-9	0.0024	IRIS	0.00002	IRIS		
Bis(2-ethylhexyl)phthalate	117-81-7	0.0000024	CAL	0.01	CAL		
Bis(chloromethyl)ether	542-88-1	0.062	IRIS				
Bromoform	75-25-2	0.0000011	IRIS				
Cadmium Compounds							
Cadmium acetate	543-90-8	0.0018	IRIS	0.00001	ATSDR		
Cadmium compounds	7440-43-9	0.0018	IRIS	0.00001	ATSDR		0.001
Cadmium as cadmium cyanamide	20654-10-8	0.0018	IRIS	0.00001	ATSDR		
Cadmium nitrate	10325-94-7	0.0018	IRIS	0.00001	ATSDR		
Cadmium oxide	1306-19-0	0.0018	IRIS	0.00001	ATSDR		
Cadmium stearate	2223-93-0	0.0018	IRIS	0.00001	ATSDR		
Carbon disulfide	75-15-0			0.7	IRIS		
Carbon tetrachloride	56-23-5	0.000006	IRIS	0.1	IRIS		
Carbonyl sulfide	463-58-1			0.163[f]	EPA ORD		
Chlordane	57-74-9	0.0001	IRIS	0.0007	IRIS		
Chlorine	7782-50-5			0.00015	ATSDR		
Chlorobenzene	108-90-7			1	CAL		
Chlorobenzilate	510-15-6	0.000078	HEAST				
Chloroform	67-66-3			0.098	ATSDR		
Chloroprene	126-99-8	0.00048	IRIS	0.02	IRIS		
Chromium Compounds							
Ammonium chromate	7788-98-9	0.012	IRIS	0.0001	IRIS		
Ammonium dichromate	7789-09-5	0.012	IRIS	0.0001	IRIS		
Barium chromate	10294-40-3	0.012	IRIS	0.0001	IRIS		
Calcium chromate	13765-19-0	0.012	IRIS	0.0001	IRIS		
Chromic acid (VI)	7738-94-5	0.012	IRIS	0.0001	IRIS		
Chromic sulfuric acid	13530-68-2	0.012	IRIS	0.0001	IRIS		
Chromium (VI) as lead chromate	7758-97-6	0.012	IRIS	0.0001	IRIS		
Chromium (VI) as lead chromate oxide	18454-12-1	0.012	IRIS	0.0001	IRIS		
Chromium (VI) compounds	18540-29-9	0.012	IRIS	0.0001	IRIS		

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
Chromium (VI) trioxide, chromic acid mist	11115-74-5	0.012	IRIS	0.000008	IRIS		
Chromium compounds	7440-47-3	0.012	IRIS	0.0001	IRIS		
Chromium dioxide	12018-01-8	0.012	IRIS	0.0001	IRIS		
Potassium chromate	7789-00-6	0.012	IRIS	0.0001	IRIS		
Potassium dichromate	7778-50-9	0.012	IRIS	0.0001	IRIS		
Sodium chromate	7775-11-3	0.012	IRIS	0.0001	IRIS		
Sodium dichromate	10588-01-9	0.012	IRIS	0.0001	IRIS		
Strontium chromate	7789-06-2	0.012	IRIS	0.0001	IRIS		
Zinc chromate	13530-65-9	0.012	IRIS	0.0001	IRIS		
Zinc potassium chromate	11103-86-9	0.012	IRIS	0.0001	IRIS		
Cobalt Compounds							
Cobalt aluminate	1345-16-0			0.0001	ATSDR		
Cobalt bromide	7789-43-7			0.0001	ATSDR		
Cobalt carbonate	513-79-1			0.0001	ATSDR		
Cobalt carbonyl	10210-68-1			0.0001	ATSDR		
Cobalt chloride	7646-79-9			0.0001	ATSDR		
Cobalt compounds	7440-48-4			0.0001	ATSDR		
Cobalt hydrocarbonyl	16842-03-8			0.0001	ATSDR		
Cobalt naphtha	61789-51-3			0.0001	ATSDR		
Cobalt nitrate	Co Nitrate			0.0001	ATSDR		
Cobalt oxide	1307-96-6			0.0001	ATSDR		
Cobalt oxide (II,III)	1308-06-1			0.0001	ATSDR		
Hexanoic acid, 2-ethyl-, cobalt(2+) salt	136-52-7			0.0001	ATSDR		
Coke Oven Emissions							
Benzene soluble organics (BSO)	141	0.00099	IRIS				
Coke oven emissions	8007-45-2	0.00099	IRIS				
Methylene chloride soluble organics (MCSO)	142	0.00099	IRIS				
Cresols							
Cresols (mixed)	1319-77-3			0.6	CAL		
m-Cresol (3-methylphenol)	108-39-4			0.6	CAL		
o-Cresol	95-48-7			0.6	CAL		
p-Cresol (4-methy phenol)	106-44-5			0.6	CAL		
Cumene	98-82-8			0.4	IRIS		
Cyanide Compounds							
Acetone cyanohydrin	75-86-5			0.01	HEAST		
Barium cyanide	542-62-1			0.0008	IRIS		
Calcium cyanamide	156-62-7			0.0008	IRIS		
Calcium cyanide	592-01-8			0.0008	IRIS		
Copper cyanide	544-92-3			0.0008	IRIS		
Cyanazine	21725-46-2			0.0008	IRIS		
Cyanide as Cadmium Cyanamide	20654-10-8			0.0008	IRIS		
Cyanide compounds	57-12-5			0.0008	IRIS		
Cyanogen	460-19-5			0.0008	IRIS		
Cyanogen bromide	506-68-3			0.0008	IRIS		
Cyanogen chloride	506-77-4			0.0008	IRIS		
Cyanogen iodide	506-78-5			0.0008	IRIS		
Cyanophos	2636-26-2			0.0008	IRIS		
Cyanuric fluoride	675-14-9			0.0008	IRIS		
Ethylene cyanohydrin	109-78-4			0.0008	IRIS		
Hydrogen cyanide	74-90-8			0.0008	IRIS		

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
Isopropyl cyanide	78-82-0			0.0008	IRIS		
Potassium cyanide	151-50-8			0.0008	IRIS		
Potassium silver cyanide	506-61-6			0.0008	IRIS		
Potassium thiocyanate	333-20-0			0.0008	IRIS		
Silver cyanide	506-64-9			0.0008	IRIS		
Sodium cyanide	143-33-9			0.0008	IRIS		
Thiocyanate	Thiocyanate			0.0008	IRIS		
Thiocyanic acid, 2-(benzothiazolylthio) methyl est	21564-17-0			0.0008	IRIS		
Zinc cyanide	557-21-1			0.0008	IRIS		
Dichloroethyl ether	111-44-4	0.00033	IRIS				
Dichlorvos	62-73-7			0.0005	IRIS		
Diesel engine emissions	Diesel emis			0.005	IRIS		
Diethanolamine	111-42-2			0.003	CAL		
Dimethyl formamide	68-12-2			0.03	CAL		
Dioxins and Furans							
1,2,3,4,6,7,8,9-Octochlorodibenzo-p-dioxin	3268-87-9	0.0099	EPA ORD	0.00013	CAL	45	
1,2,3,4,6,7,8,9-Octochlorodibenzofuran	39001-02-0	0.0099	EPA ORD	0.00013	CAL	45	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.33	EPA ORD	0.000004	CAL	1500	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.33	EPA ORD	0.000004	CAL	1500	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.33	EPA ORD	0.000004	CAL	1500	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	39227-28-6	3.3	EPA ORD	0.0000004	CAL	15000	
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	3.3	EPA ORD	0.0000004	CAL	15000	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7	3.3	EPA ORD	0.0000004	CAL	15000	
1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9	3.3	EPA ORD	0.0000004	CAL	15000	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3	3.3	EPA ORD	0.0000004	CAL	6200	
1,2,3,7,8,9-Hexachlorodibenzofuran	72918-21-9	3.3	EPA ORD	0.0000004	CAL	15000	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4	33	EPA ORD	0.00000004	CAL	150000	
1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6	0.99	EPA ORD	0.0000013	CAL	4500	
2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5	3.3	EPA ORD	0.0000004	CAL	15000	
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	9.9	EPA ORD	0.00000013	CAL	45000	
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	33	EPA ORD	0.00000004	CAL	150000	
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	3.3	EPA ORD	0.0000004	CAL	15000	
Hexachlorodibenzo-p-dioxin	34465-46-8	3.3	EPA ORD	0.0000004	CAL		
Epichlorohydrin	106-89-8	0.0000012	IRIS	0.001	IRIS		
Ethyl benzene	100-41-4	0.0000025	CAL	1	IRIS		

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
Ethyl carbamate	51-79-6	0.000464	CAL				
Ethyl chloride	75-00-3			10	IRIS		
Ethylene dibromide	106-93-4	0.0006	IRIS	0.009	IRIS		
Ethylene dichloride	107-06-2	0.000026	IRIS	2.4	ATSDR		
Ethylene glycol	107-21-1			0.4	CAL		
Ethylene oxide	75-21-8	0.000088	CAL	0.03	CAL		
Ethylene thiourea	96-45-7	0.000013	CAL	0.003	CAL		
Ethylidene dichloride	75-34-3	0.0000016	CAL	0.5	HEAST		
Formaldehyde	50-00-0	0.000013	IRIS	0.0098	ATSDR		
Glycol ethers							
(Ethylenebis(oxyethylenenitrilo)) tetraacetic acid	67-42-5			0.02	IRIS		
1,2-Dimethoxyethane	110-71-4			0.02	IRIS		
1-Methoxy-2-propanol	107-98-2			0.02	IRIS		
2-(Hexyloxy)ethanol	112-25-4			0.02	IRIS		
2-Butoxyethyl acetate	112-07-2			0.02	IRIS		
2-Propoxyethyl acetate	20706-25-6			0.02	IRIS		
3-Methoxy-1-propanol	1589-49-7			0.02	IRIS		
Butyl carbitol acetate	124-17-4			0.02	IRIS		
Carbitol acetate	112-15-2			0.02	IRIS		
Di(ethylene glycol monobutyl ether) phthalate	16672-39-2			0.02	IRIS		
Diethylene glycol dibenzoate	120-55-8			0.02	IRIS		
Diethylene glycol diethyl ether	112-36-7			0.02	IRIS		
Diethylene glycol dimethyl ether	111-96-6			0.02	IRIS		
Diethylene glycol ethyl methyl ether	1002-67-1			0.02	IRIS		
Diethylene glycol monobutyl ether	112-34-5			0.02	HEAST		
Diethylene glycol monoethyl ether	111-90-0			0.02	IRIS		
Diethylene glycol monomethyl ether	111-77-3			0.02	IRIS		
Ethoxytriglycol	112-50-5			0.02	IRIS		
Ethylene glycol 2-ethylhexyl ether	1559-35-9			0.02	IRIS		
Ethylene glycol diethyl ether	629-14-1			0.02	IRIS		
Ethylene glycol ethyl ether	110-80-5			0.2	IRIS		
Ethylene glycol ethyl ether acetate	111-15-9			0.3	CAL		
Ethylene glycol methyl ether	109-86-4			0.02	IRIS		
Ethylene glycol methyl ether acetate	110-49-6			0.09	CAL		
Ethylene glycol mono-sec-butyl ether	7795-91-7			0.02	IRIS		
Ethylene glycol monovinyl ether	764-48-7			0.02	IRIS		
Glycol ethers	171			0.02	IRIS		
Methoxytriglycol	112-35-6			0.02	IRIS		
Methyl Cellosolve Acrylate	3121-61-7			0.02	IRIS		
N-Hexyl carbitol	112-59-4			0.02	IRIS		
Phenyl cellosolve	122-99-6			0.02	IRIS		
Propyl cellosolve	2807-30-9			0.02	IRIS		
Triethylene glycol dimethyl ether	112-49-2			0.02	IRIS		
Triglycol monobutyl ether	143-22-6			0.02	IRIS		

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
Heptachlor	76-44-8	0.0013	IRIS				
Hexachlorobenzene	118-74-1	0.00046	IRIS	0.003	CAL		
Hexachlorobutadiene	87-68-3	0.000022	IRIS	0.09	CAL		
Hexachlorocyclopentadiene	77-47-4			0.0002	IRIS		
Hexachloroethane	67-72-1			0.03	IRIS		
Hexamethylene-1,6-diisocyanate	822-06-0			0.00001	IRIS		
n-Hexane	110-54-3			0.7	IRIS		
Hydrazine	302-01-2	0.0049	IRIS	0.0002	CAL		
Hydrochloric acid	7647-01-0			0.02	IRIS		
Hydrofluoric acid	7664-39-3			0.014	CAL		
Isophorone	78-59-1			2	CAL		
Lead Compounds[e]							
Lead (II) oxide	1317-36-8			0.00015	EPA OAQPS		
Lead acetate	301-04-2			0.00015	EPA OAQPS		
Lead as lead arsenate	7784-40-9			0.00015	EPA OAQPS		
Lead as lead chromate	7758-97-6			0.00015	EPA OAQPS		
Lead as lead chromate oxide	18454-12-1			0.00015	EPA OAQPS		
Lead chloride	7758-95-4			0.00015	EPA OAQPS		
Lead compounds	7439-92-1			0.00015	EPA OAQPS		
Lead compounds (other than inorganic)	603			0.00015	EPA OAQPS		
Lead dioxide	1309-60-0			0.00015	EPA OAQPS		
Lead nitrate	10099-74-8			0.00015	EPA OAQPS		
Lead subacetate	1335-32-6			0.00015	EPA OAQPS		
Lead sulfate	7446-14-2			0.00015	EPA OAQPS		
Tetraethyl lead	78-00-2			0.00015	EPA OAQPS		
Tetramethyl lead	75-74-1			0.00015	EPA OAQPS		
Maleic anhydride	108-31-6			0.0007	CAL		
Manganese Compounds							
Manganese chloride	2145-07-6			0.0003	ATSDR		
Manganese compounds	7439-96-5			0.0003	ATSDR		
Manganese dioxide	1313-13-9			0.0003	ATSDR		
Manganese nitrate	10377-66-9			0.0003	ATSDR		
Manganese oxide	1317-35-7			0.0003	ATSDR		
Manganese sulfate	7785-87-7			0.0003	ATSDR		
Manganese tetroxide	1317-35-7			0.0003	ATSDR		
Manganese tricarbonyl (.eta.5-2,4-cyclopentadien-1-yl)-	12079-65-1			0.0003	ATSDR		
Manganese trioxide	1317-34-6			0.0003	ATSDR		
Mercury compounds							

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
Gaseous divalent mercury	201			0.0003	IRIS		0.0001
Mercuric acetate	1600-27-7			0.0003	IRIS		0.0001
Mercuric chloride	7487-94-7			0.0003	IRIS		0.0001
Mercuric nitrate	10045-64-0			0.0003	IRIS		0.0001
Mercuric oxide	21908-53-2			0.0003	IRIS		0.0001
Mercury (elemental)	7439-97-6			0.0003	IRIS		c
Mercury (organic)	22967-92-6			0.0003	IRIS		c
Mercury compounds	HGCMPDS			0.0003	IRIS		c*
Methoxyethylmercuric acetate	151-38-2			0.0003	IRIS		0.0001
Methyl mercury	22967-92-6			0.0003	IRIS		c
Methylmercuric dicyanamide	502-39-6			0.0003	IRIS		0.0001
Particulate divalent mercury	202			0.0003	IRIS		0.0001
Phenylmercuric acetate	62-38-4			0.0003	IRIS		0.0001
Methanol	67-56-1			20	IRIS		
Methyl bromide	74-83-9			0.005	IRIS		
Methyl chloride	74-87-3			0.09	IRIS		
Methyl isobutyl ketone	108-10-1			3	IRIS		
Methyl isocyanate	624-83-9			0.001	CAL		
Methyl methacrylate	80-62-6			0.7	IRIS		
Methyl tert-butyl ether	1634-04-4	0.00000026	CAL	3	IRIS		
Methylene chloride	75-09-2	0.000000016	IRIS	0.6	IRIS		
Naphthalene	91-20-3	0.000034	CAL	0.003	IRIS		
Nickel compounds							
Nickel (II) sulfate hexahydrate	10101-97-0	0.00048	EPA OAQPS	0.00009	ATSDR		
Nickel acetate	373-02-4	0.00048	EPA OAQPS	0.00009	ATSDR		
Nickel carbonyl	13463-39-3	0.00048	EPA OAQPS	0.00009	ATSDR		
Nickel chloride	7718-54-9	0.00048	EPA OAQPS	0.00009	ATSDR		
Nickel compounds	7440-02-0	0.00048	EPA OAQPS	0.00009	ATSDR		
Nickel nitrate	13138-45-9	0.00048	EPA OAQPS	0.00009	ATSDR		
Nickel oxide	1313-99-1	0.00048	EPA OAQPS	0.00002	CAL		
Nickel refinery dust	NI_DUST	0.00024	IRIS				
Nickel subsulfide	12035-72-2	0.00048	IRIS	0.00009	ATSDR		
Nickel sulfamate	13770-89-3	0.00048	EPA OAQPS	0.00009	ATSDR		
Nickel sulfate	7786-81-4	0.00048	EPA OAQPS	0.00009	ATSDR		
Nitrobenzene	98-95-3	0.00004	IRIS	0.009	IRIS		
Nitrosodimethylamine	62-75-9	0.022	IRIS				
N-Nitrosomorpholine	59-89-2	0.0019	CAL				
o-Toluidine	95-53-4	0.000051	CAL				
Pentachlorophenol	87-86-5	0.0000051	CAL	0.1	CAL		
Phenol	108-95-2			0.2	CAL		
Phosgene	75-44-5			0.0003	IRIS		
Phosphine	7803-51-2			0.0003	IRIS		
Phthalic anhydride	85-44-9			0.02	CAL		
Polychlorinated Biphenyls							

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
Aroclor 1016	12674-11-2	0.0001	IRIS				
Aroclor 1221	11104-28-2	0.0001	IRIS				
Aroclor 1242	53469-21-9	0.0001	IRIS				
Aroclor 1248	12672-29-6	0.0001	IRIS				
Aroclor 1254	11097-69-1	0.0001	IRIS				
Aroclor 1260	11096-82-5	0.0001	IRIS				
Polychlorinated biphenyls	1336-36-3	0.0001	IRIS				
2,4,4'-Trichlorobiphenyl (PCB-28)		0.0001	IRIS				
4,4'-Dichlorobiphenyl (PCB-15)		0.0001	IRIS				
Decachlorobiphenyl (PCB-209)		0.0001	IRIS				
Heptachlorobiphenyl		0.0001	IRIS				
Hexachlorobiphenyl		0.0001	IRIS				
Pentachlorobiphenyl		0.0001	IRIS				
Tetrachlorobiphenyl		0.0001	IRIS				
Polycyclic Organic Matter							
POM 71002		0.000088	CAL				
16-PAH	40	0.000088	CAL				
PAH, total	234	0.000088	CAL			0.5	
Polycyclic organic matter	246	0.000088	CAL			0.5	
POM 72002		0.000088	CAL				
1-Methylnaphthalene	90-12-0	0.000088	CAL			0.5	
1-Methylphenanthrene	832-69-9	0.000088	CAL				
1-Methylpyrene	2381-21-7	0.000088	CAL				
2-Methylnaphthalene	91-57-6	0.000088	CAL			0.5	
2-Naphthylamine	91-59-8	0.000088	CAL				
12-Methylbenz(a)anthracene	2422-79-9	0.000088	CAL				
beta-Chloronaphthalene	91-58-7	0.000088	CAL			0.5	
Acenaphthene	83-32-9	0.000088	CAL			0.5	
Acenaphthylene	208-96-8	0.000088	CAL			0.5	
Anthracene	120-12-7	b	IRIS				
Benzo(a)fluoranthene	203-33-8	0.000176	CAL			0.5	
Benzo(c)phenanthrene	195-19-7	0.000088	CAL			0.5	
Benzo(e)pyrene	192-97-2	0.000088	CAL			0.5	
Benzofluoranthenes	56832-73-6	0.000176	CAL			0.5	
Benzo(ghi)perylene	191-24-2	0.000088	CAL			0.5	
Coal tar	8007-45-2	0.000088	CAL				
Coronene	191-07-1	0.000088	CAL				
Extractable organic matter (EOM)	284	0.000088	CAL				
Fluoranthene	206-44-0	0.000088	CAL			0.5	
Fluorene	86-73-7	0.000088	CAL			0.5	
Indene	95-13-6	0.000088	CAL				
Methylanthracene	26914-18-1	0.000088	CAL				
Methylbenzopyrene	65357-69-9	0.000088	CAL				
Octabromodiphenyl ether	32536-52-0	0.000088	CAL				
Perylene	198-55-0	0.000088	CAL			0.5	
Phenanthrene	85-01-8	b	IRIS				
Pyrene	129-00-0	b	IRIS				
POM 73002		0.16	CAL				
7,12-Dimethylbenz[a]anthracene	57-97-6	0.1136	CAL			250	
POM 74002		0.016	CAL				
1,6-Dinitropyrene	42397-64-8	0.0176	CAL				
3-Methylcholanthrene	56-49-5	0.01008	CAL			22	
6-Nitrochrysene	7496-02-8	0.0176	CAL				

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE 1/(ug/m^3)**	**URE Source**	**RfC (mg/m^3)**	**RfC Source**	**Cancer Slope Factor (1/(mg/kg/d))**	**RfD (mg/kg/d)**
Dibenzo[a,h]pyrene	189-64-0	0.0176	CAL				
Dibenzo[a,i]pyrene	189-55-9	0.0176	CAL			120	
Dibenzo[a,l]pyrene	191-30-0	0.0176	CAL				
POM 75002		0.0016	CAL				
1,8-Dinitropyrene	42397-65-9	0.00176	CAL				
2-Acetylaminofluorene	53-96-3	0.00208	CAL			10	
5-Methylchrysene	3697-24-3	0.00176	CAL				
7H-Dibenzo[c,g]carbazole	194-59-2	0.00176	CAL				
Benzo[a]pyrene	50-32-8	0.00176	CAL			7.3	
Dibenzo[a,e]pyrene	192-65-4	0.00176	CAL				
Dibenzo[a,h]anthracene	53-70-3	0.00192	CAL			4.1	
Polycyclic aromatic hydrocarbon as B(a)P TEQ		0.00176	CAL				
POM 76002		0.00016	CAL				
1-Nitropyrene	5522-43-0	0.000176	CAL				
4-Nitropyrene	57835-92-4	0.000176	CAL				
5-Nitroacenaphthene	602-87-9	0.0000592	CAL				
Benz[a]anthracene	56-55-3	0.000176	CAL			1.2	
Benzo[b]fluoranthene	205-99-2	0.000176	CAL			1.2	
Benzo[b+k]fluoranthene	102	0.000176	CAL			1	
Benzo(g,h,i)fluoranthene	203-12-3	0.000176	CAL			1	
Benzo[j]fluoranthene	205-82-3	0.000176	CAL			1.2	
Benzo[k]fluoranthene	207-08-9	0.000176	CAL			1.2	
Dibenz[a,h]acridine	226-36-8	0.000176	CAL				
Dibenz[a,j]acridine	224-42-0	0.000176	CAL			1.2	
Indeno[1,2,3-c,d]pyrene	193-39-5	0.000176	CAL			1.2	
POM 77002		0.000016	CAL				
2-Aminoanthraquinone	117-79-3	0.00001504	CAL				
2-Nitrofluorene	607-57-8	0.0000176	CAL				
Carbazole	86-74-8	0.000016	CAL			0.02	
Chrysene	218-01-9	0.0000176	CAL			0.12	
POM 78002		0.00032	CAL				
7-PAH	75	0.00032	CAL				
Propionaldehyde	123-38-6			0.008	IRIS		
Propylene dichloride	78-87-5			0.004	IRIS		
Propylene oxide	75-56-9	0.0000037	IRIS	0.03	IRIS		
Radionuclides							
Uranium, insoluble	7440-61-1			0.0008	ATSDR		
Uranium (IV) dioxide	1344-57-6			0.0008	ATSDR		
Uranium compounds	7440-61-1			0.0008	ATSDR		
Uranium hexafluoride	7783-81-5			0.00004	ATSDR		
Uranium oxide	1344-59-8			0.0008	ATSDR		
Uranium, soluble	UranSol			0.00004	ATSDR		
Uranyl acetate dihydrate	541-09-3			0.00004	ATSDR		
Uranyl nitrate hexahydrate	13520-83-7			0.00004	ATSDR		
Selenium Compounds							
Hydrogen selenide	7783-07-5			0.00008	CAL		
Potassium selenate	7790-59-2			0.02	CAL		
Selenious acid	7783-00-8			0.02	CAL		
Selenium compounds	7782-49-2			0.02	CAL		
Selenium dioxide	7446-08-4			0.02	CAL		
Selenium disulfide	7488-56-4			0.02	CAL		
Selenium hexafluoride	7783-79-1			0.02	CAL		

		Inhalation				Oral (ingestion)[a]	
Pollutant	**CAS No.**	**URE** 1/(ug/m^3)	**URE Source**	**RfC** (mg/m^3)	**RfC Source**	**Cancer Slope Factor** (1/(mg/kg/d))	**RfD** (mg/kg/d)
Selenium oxide	12640-89-0			0.02	CAL		
Selenium oxychloride	7791-23-3			0.02	CAL		
Selenium sulfide	7446-34-6			0.02	CAL		
Selenourea	630-10-4			0.02	CAL		
Sodium selenate	13410-01-0			0.02	CAL		
Sodium selenite	10102-18-8			0.02	CAL		
Styrene	100-42-5			1	IRIS		
Styrene oxide	96-09-3			0.006	CAL		
Tetrachloroethene	127-18-4	0.00000026	IRIS	0.04	IRIS		
Titanium tetrachloride	7550-45-0			0.0001	ATSDR		
Toluene	108-88-3			5	IRIS		
Trichloroethylene	79-01-6	0.0000048	IRIS	0.002	IRIS		
Triethylamine	121-44-8			0.007	IRIS		
Vinyl acetate	108-05-4			0.2	IRIS		
Vinyl bromide	593-60-2	0.000032	HEAST	0.003	IRIS		
Vinyl chloride	75-01-4	0.0000088	IRIS	0.1	IRIS		
Vinylidene chloride	75-35-4			0.2	IRIS		
Xylenes							
m-Xylene	108-38-3			0.1	IRIS		
o-Xylene	95-47-6			0.1	IRIS		
p-Xylene	106-42-3			0.1	IRIS		
Xylenes (mixed)	1330-20-7			0.1	IRIS		

Notes:

[a] Benchmark values are provided only for those PB-HAPs for which multipathway risk is assessed (via TRIM). There may be other PB-HAPs in this table, even though no benchmark is presented.

[b] IRIS has determined this POM to be not carcinogenic.

[c] These forms of mercury do not represent divalent mercury, which is assessed in our multipathway risk screening. However, they may be included in our more refined multipathway assessments as they transform to various forms of mercury. *Emissions reported as “mercury compounds” is speciated into elemental, particulate divalent, and gaseous divalent as modeled accordingly in the multipathway screening assessment.

[d] The EPA IRIS assessment for benzene provides a range of plausible UREs. This assessment used the highest value in that range, 7.8E-06 µg/m3. The low end of the range is 2.2E-06 µg/m3.

[e] There is no reference concentration for lead. In considering noncancer hazards for lead in this assessment, we compared rolling three-month average exposure estimates to the National Ambient Air Quality Standard (NAAQS) for lead (0.15 µg/m3). The primary (health-based) standard is a maximum or not-to-be-exceeded, rolling three-month average, measured as total suspended particles (TSP). The secondary (welfare-based) standard is identical to the primary standard.

[f] A chronic screening level of 0.163 mg/m3 was developed for carbonyl sulfide by EPA ORD from a No Observed Adverse Effects Level of 200 ppm based on brain lesions and neurophysiological alterations in rodents.

Table 2. Acute Dose-Response Values

Pollutant	CAS No.	AEGL-1 (1-hr) (mg/m^3)	AEGL-2 (1-hr) (mg/m^3)	ERPG-1 (mg/m^3)	ERPG-2 (mg/m^3)	REL (1-hr) (mg/m^3)
1,1,1-Trichloroethane	71-55-6	1300	3300	1900	3800	68
1,1-Dimethylhydrazine	57-14-7		7.4			
1,2-Epoxybutane	106-88-7	210	410			
1,2-Propyleneimine	75-55-8		28			
1,3-Butadiene	106-99-0	1500	12000	22	440	
1,4-Dioxane	123-91-1	61	1200			3
2,4-Toluene diisocyanate	584-84-9	0.14	0.59	0.071	1.1	
Methylene diphenyl diisocyanate	101-68-8				5	
Acetaldehyde	75-07-0	81	490	18	360	0.47
Acetonitrile	75-05-8	22	540			
Acrolein	107-02-8	0.069	0.23	0.11	0.34	0.0025
Acrylic acid	79-10-7	4.4	140	2.9	150	6
Acrylonitrile	107-13-1	10	120	22	77	
Allyl chloride	107-05-1	8.8	170	9.4	130	
Aniline	62-53-3	30	46			
Antimony Compounds						
Antimony trihydride	7803-52-3		7.7			
Arsenic Compounds						
Arsenic acid	7778-39-4					0.0002
Arsenic as lead arsenate	7784-40-9					0.0002
Arsenic chloride	7784-34-1					0.0002
Arsenic compounds	7440-38-2					0.0002
Arsenic oxide	1327-53-3		3			0.0002
Arsenic pentoxide	1303-28-2					0.0002
Arsenic trioxide	1327-53-3					0.0002
Arsine	7784-42-1		0.54		1.6	0.0002
Benzene	71-43-2	170	2600	160	480	1.3[a]
Benzyl chloride	100-44-7			5.2	52	0.24
Beryllium Compounds						
Beryllium compounds	7440-41-7				0.025	
Biphenyl	92-52-4		61			
Bis(chloromethyl)ether	542-88-1		0.21		0.47	
Carbon disulfide	75-15-0	40	500	3.1	160	6.2
Carbon tetrachloride	56-23-5	280	1200	130	630	1.9
Carbonyl sulfide	463-58-1		140			
Chlorine	7782-50-5	1.5	5.8	2.9	8.7	0.21
Chloroacetic acid	79-11-8		26			
Chlorobenzene	108-90-7	46	690			
Chloroform	67-66-3		310		240	0.15
Chloromethyl methyl ether	107-30-2		1.6		3.3	
Cobalt Compounds						
Cobalt hydrocarbonyl	16842-03-8				0.9	
Cumene	98-82-8	250	1500			
Cyanide Compounds						
Acetone cyanohydrin	75-86-5	7	25			
Calcium cyanide	592-01-8	3.8	13			
Cyanogen	460-19-5	4.3	18			
Cyanogen chloride	506-77-4				1	
Hydrogen cyanide	74-90-8	2.2	7.8		11	0.34

Pollutant	**CAS No.**	**AEGL-1 (1-hr) (mg/m^3)**	**AEGL-2 (1-hr) (mg/m^3)**	**ERPG-1 (mg/m^3)**	**ERPG-2 (mg/m^3)**	**REL (1-hr) (mg/m^3)**
Isopropyl cyanide	78-82-0		51	28	140	
Dichlorvos	62-73-7	0.99	5.1			
Dimethyl formamide	68-12-2		270	6	300	
Dimethyl sulfate	77-78-1	0.12	0.62			
Epichlorohydrin	106-89-8	22	91	19	76	1.3
Ethyl acrylate	140-88-5	34	150	0.041	120	
Ethyl benzene	100-41-4	140	4800			
Ethylene dibromide	106-93-4	130	180			
Ethylene dichloride	107-06-2			200	810	
Ethylene imine (aziridine)	151-56-4		8.1			
Ethylene oxide	75-21-8		81		90	
Formaldehyde	50-00-0	1.1	17	1.2	12	0.055
Glycol ethers						
(Ethylenebis(oxyethylenenitrilo)) tetraacetic acid	67-42-5					0.093
1,2-Dimethoxyethane	110-71-4					0.093
1-Methoxy-2-propanol	107-98-2					0.093
2-(Hexyloxy)ethanol	112-25-4					0.093
2-Butoxyethyl acetate	112-07-2					0.093
2-Propoxyethyl acetate	20706-25-6					0.093
3-Methoxy-1-propanol	1589-49-7					0.093
Butyl carbitol acetate	124-17-4					0.093
Carbitol acetate	112-15-2					0.093
Di(ethylene glycol monobutyl ether) phthalate	16672-39-2					0.093
Diethylene glycol dibenzoate	120-55-8					0.093
Diethylene glycol diethyl ether	112-36-7					0.093
Diethylene glycol dimethyl ether	111-96-6					0.093
Diethylene glycol ethyl methyl ether	1002-67-1					0.093
Diethylene glycol monobutyl ether	112-34-5					0.093
Diethylene glycol monoethyl ether	111-90-0					0.093
Diethylene glycol monomethyl ether	111-77-3					0.093
Ethoxytriglycol	112-50-5					0.093
Ethylene glycol 2-ethylhexyl ether	1559-35-9					0.093
Ethylene glycol diethyl Ether	629-14-1					0.093
Ethylene glycol ethyl ether	110-80-5					0.37
Ethylene glycol ethyl ether acetate	111-15-9					0.14
Ethylene glycol methyl ether	109-86-4					0.093
Ethylene glycol methyl ether acetate	110-49-6					0.093
Ethylene glycol mono-sec-butyl ether	7795-91-7					0.093
Ethylene glycol monovinyl ether	764-48-7					0.093
Glycol ethers	171					0.093
Methoxytriglycol	112-35-6					0.093
Methyl Cellosolve Acrylate	3121-61-7					0.093
N-Hexyl carbitol	112-59-4					0.093
Phenyl cellosolve	122-99-6					0.093
Propyl cellosolve	2807-30-9					0.093
Triethylene glycol dimethyl ether	112-49-2					0.093
Triglycol monobutyl ether	143-22-6					0.093
Hexachlorobutadiene	87-68-3			11	32	
n-Hexane	110-54-3		10000			

Pollutant	CAS No.	AEGL-1 (1-hr) (mg/m^3)	AEGL-2 (1-hr) (mg/m^3)	ERPG-1 (mg/m^3)	ERPG-2 (mg/m^3)	REL (1-hr) (mg/m^3)
Hydrazine	302-01-2	0.13	17	0.65	6.5	
Hydrochloric acid	7647-01-0	2.7	33	4.5	30	2.1
Hydrofluoric acid	7664-39-3	0.82	20	1.6	16	0.24
Maleic anhydride	108-31-6			0.8	20	
Mercury compounds						
Mercury (elemental)	7439-97-6		1.7		2	0.0006
Methanol	67-56-1	690	2700	260	1300	28
Methyl bromide	74-83-9		820		190	3.9
Methyl chloride	74-87-3		1900	310	2100	
Methyl hydrazine	60-34-4		3.2			
Methyl iodide	74-88-4			150	290	
Methyl isocyanate	624-83-9		0.16	0.058	0.58	
Methyl methacrylate	80-62-6	70	490			
Methyl tert-butyl ether	1634-04-4	180	2100			
Methylene chloride	75-09-2	690	1900	1000	2600	14
Nickel compounds						
Nickel carbonyl	13463-39-3		0.25			
Parathion	56-38-2		1.5			
Phenol	108-95-2	58	89	38	190	5.8
Phosgene	75-44-5		1.2		2.0	0.004
Phosphine	7803-51-2		2.8		0.7	
Propionaldehyde	123-38-6	110	620			
Propylene oxide	75-56-9	170	690	120	590	3.1
Radionuclides						
Uranium (IV) dioxide	1344-57-6				10	
Uranium hexafluoride	7783-81-5	3.6	9.6	5	15	
Uranium oxide	1344-59-8				10	
Selenium Compounds						
Hydrogen selenide	7783-07-5		2.4		0.66	0.005
Styrene	100-42-5	85	550	210	1100	21
Tetrachloroethene	127-18-4	240	1600	680	1400	20
Titanium tetrachloride	7550-45-0	0.54	7.8	5	20	
Toluene	108-88-3	750	4500	190	1100	37
Trichloroethylene	79-01-6	700	2400	540	2700	
Triethylamine	121-44-8					2.8
Vinyl acetate	108-05-4	24	630	18	260	
Vinyl chloride	75-01-4	640	3100	1300	13000	180
Xylenes						
m-Xylene	108-38-3					22
o-Xylene	95-47-6					22
p-Xylene	106-42-3					22
Xylenes (mixed)	1330-20-7	560	4000			22

Notes:

[a] **The acute REL for benzene used in our risk assessment does not reflect the latest 1-hour value developed by California OEHHA. EPA is evaluating the derivation of the OEHHA value to determine whether it is appropriate for use in the RTR program.**

Appendix 9

Environmental Risk Screen

Table 1 – PB-HAP Benchmarks Included in the Environmental Risk Screen

Eco HAP	Assessment Endpoint	Benchmark Effects Level	Benchmark Value	Benchmark Source
Cadmium	Fish - Avian Piscivores	NOAEL (merganser)	0.7 (mg/kg BW/day)	d
Cadmium	Fish - Avian Piscivores	LOAEL (merganser)	1 (mg/kg BW/day)	d
Cadmium	Fish - Mammalian Piscivores	NOAEL (mink)	0.742 (mg/kg BW/day)	e
Cadmium	Fish - Mammalian Piscivores	LOAEL (mink)	7.42 (mg/kg BW/day)	e
Cadmium	Sediment Community	No-effect Level	0.6 (mg/kg dry wt)	b
Cadmium	Sediment Community	Threshold Level	1.2 (mg/kg dry wt)	a
Cadmium	Sediment Community	Probable-effect Level	3.5 (mg/kg dry wt)	b
Cadmium	Surface Soil - Dist. 1 - 312 m	Threshold - Mammalian Insectivores (shrew)	0.36 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 1 - 312 m	Threshold - Avian Ground Insectivores (woodcock)	0.77 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 1 - 312 m	Threshold Level - Plant Community	32 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 1 - 312 m	Threshold Level - Invertebrate Community	140 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 2 - 850 m	Threshold - Mammalian Insectivores (shrew)	0.36 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 2 - 850 m	Threshold - Avian Ground Insectivores (woodcock)	0.77 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 2 - 850 m	Threshold Level - Plant Community	32 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 2 - 850 m	Threshold Level - Invertebrate Community	140 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 3 - 1,500 m	Threshold - Mammalian Insectivores (shrew)	0.36 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 3 - 1,500 m	Threshold - Avian Ground Insectivores (woodcock)	0.77 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 3 - 1,500 m	Threshold Level - Plant Community	32 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 3 - 1,500 m	Threshold Level - Invertebrate Community	140 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 4 - 3,500 m	Threshold - Mammalian Insectivores (shrew)	0.36 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 4 - 3,500 m	Threshold - Avian Ground Insectivores (woodcock)	0.77 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 4 - 3,500 m	Threshold Level - Plant Community	32 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 4 - 3,500 m	Threshold Level - Invertebrate Community	140 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 5 - 7,500 m	Threshold - Mammalian Insectivores (shrew)	0.36 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 5 - 7,500 m	Threshold - Avian Ground Insectivores (woodcock)	0.77 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 5 - 7,500 m	Threshold Level - Plant Community	32 (mg/kg dry wt)	a
Cadmium	Surface Soil - Dist. 5 - 7,500 m	Threshold Level - Invertebrate Community	140 (mg/kg dry wt)	a

Eco HAP	Assessment Endpoint	Benchmark Effects Level	Benchmark Value	Benchmark Source
Cadmium	Water-column Community	Threshold Level	0.25 (ug/L)	c
Cadmium	Water-column Community	Frank-effect Level	2 (ug/L)	c
Dioxin	Fish - Avian Piscivores	NOAEL (merganser)	0.0000014 (mg/kg BW/day)	f
Dioxin	Fish - Avian Piscivores	LOAEL (merganser)	0.000014 (mg/kg BW/day)	f
Dioxin	Fish - Mammalian Piscivores	NOAEL (mink)	0.000000771 (mg/kg BW/day)	f
Dioxin	Fish - Mammalian Piscivores	LOAEL (mink)	0.00000771 (mg/kg BW/day)	f
Dioxin	Sediment Community	Threshold Level	0.00000116 (mg/kg dry wt)	g
Dioxin	Surface Soil - Dist. 1 - 312 m	Threshold - Mammalian Insectivores (shrew)	0.0000002 (mg/kg dry wt)	h
Dioxin	Surface Soil - Dist. 2 - 850 m	Threshold - Mammalian Insectivores (shrew)	0.0000002 (mg/kg dry wt)	h
Dioxin	Surface Soil - Dist. 3 - 1,500 m	Threshold - Mammalian Insectivores (shrew)	0.0000002 (mg/kg dry wt)	h
Dioxin	Surface Soil - Dist. 4 - 3,500 m	Threshold - Mammalian Insectivores (shrew)	0.0000002 (mg/kg dry wt)	h
Dioxin	Surface Soil - Dist. 5 - 7,500 m	Threshold - Mammalian Insectivores (shrew)	0.0000002 (mg/kg dry wt)	h
Dioxin	Water-column Community	Threshold Level	0.000012 (ug/L)	i
Dioxin	Water-column Community	Frank-effect Level	0.1 (ug/L)	i
Mercuric Chloride	Sediment Community	Threshold Level	0.15 (mg/kg dry wt)	a
Mercuric Chloride	Sediment Community	Probable-effect Level	0.7 (mg/kg dry wt)	j
Mercuric Chloride	Surface Soil - Dist. 1 - 312 m	Threshold Level - Plant Community	0.3 (mg/kg dry wt)	k
Mercuric Chloride	Surface Soil - Dist. 1 - 312 m	Threshold Level - Invertebrate Community	0.1 (mg/kg dry wt)	k
Mercuric Chloride	Surface Soil - Dist. 2 - 850 m	Threshold Level - Plant Community	0.3 (mg/kg dry wt)	k
Mercuric Chloride	Surface Soil - Dist. 2 - 850 m	Threshold Level - Invertebrate Community	0.1 (mg/kg dry wt)	k
Mercuric Chloride	Surface Soil - Dist. 3 - 1,500 m	Threshold Level - Plant Community	0.3 (mg/kg dry wt)	k
Mercuric Chloride	Surface Soil - Dist. 3 - 1,500 m	Threshold Level - Invertebrate Community	0.1 (mg/kg dry wt)	k
Mercuric Chloride	Surface Soil - Dist. 4 - 3,500 m	Threshold Level - Plant Community	0.3 (mg/kg dry wt)	k

Eco HAP	Assessment Endpoint	Benchmark Effects Level	Benchmark Value	Benchmark Source
Mercuric Chloride	Surface Soil - Dist. 4 - 3,500 m	Threshold Level - Invertebrate Community	0.1 (mg/kg dry wt)	k
Mercuric Chloride	Surface Soil - Dist. 5 - 7,500 m	Threshold Level - Plant Community	0.3 (mg/kg dry wt)	k
Mercuric Chloride	Surface Soil - Dist. 5 - 7,500 m	Threshold Level - Invertebrate Community	0.1 (mg/kg dry wt)	k
Mercuric Chloride	Water-column Community	Threshold Level	0.77 (ug/L)	c
Mercuric Chloride	Water-column Community	Frank-effect Level	1.4 (ug/L)	c
Mercury (methyl)	Fish - Avian Piscivores	NOAEL (merganser)	0.013 (mg/kg BW/day)	f
Mercury (methyl)	Fish - Avian Piscivores	LOAEL (merganser)	0.078 (mg/kg BW/day)	f
Mercury (methyl)	Fish - Mammalian Piscivores	NOAEL (mink)	0.0247 (mg/kg BW/day)	e
Mercury (methyl)	Fish - Mammalian Piscivores	LOAEL (mink)	0.123 (mg/kg BW/day)	e
Mercury (methyl)	Sediment Community	Threshold Level	0.2 (mg/kg dry wt)	l
Mercury (methyl)	Sediment Community	Probable-effect Level	1 (mg/kg dry wt)	l
Mercury (methyl)	Surface Soil - Dist. 1 - 312 m	Threshold Level - Invertebrate Community	0.67 (mg/kg dry wt)	I
Mercury (methyl)	Surface Soil - Dist. 2 - 850 m	Threshold Level - Invertebrate Community	0.67 (mg/kg dry wt)	i
Mercury (methyl)	Surface Soil - Dist. 3 - 1,500 m	Threshold Level - Invertebrate Community	0.67 (mg/kg dry wt)	i
Mercury (methyl)	Surface Soil - Dist. 4 - 3,500 m	Threshold Level - Invertebrate Community	0.67 (mg/kg dry wt)	i
Mercury (methyl)	Surface Soil - Dist. 5 - 7,500 m	Threshold Level - Invertebrate Community	0.67 (mg/kg dry wt)	i

Eco HAP	Assessment Endpoint	Benchmark Effects Level	Benchmark Value	Benchmark Source
Mercury (methyl)	Water-column Community	Threshold Level	0.0028 (ug/L)	c
Mercury (methyl)	Water-column Community	Frank-effect Level	0.099 (ug/L)	c
PAH	Fish - Mammalian Piscivores	NOAEL (mink)	0.417 (mg/kg BW/day)	e
PAH	Fish - Mammalian Piscivores	LOAEL (mink)	4.17 (mg/kg BW/day)	e
PAH	Sediment Community	No-effect Level	0.032 (mg/kg dry wt)	b
PAH	Sediment Community	Threshold Level	0.15 (mg/kg dry wt)	l, h
PAH	Sediment Community	Probable-effect Level	1.45 (mg/kg dry wt)	l
PAH	Surface Soil - Dist. 1 - 312 m	Threshold - Mammalian Insectivores (shrew)	1.52 (mg/kg dry wt)	h
PAH	Surface Soil - Dist. 2 - 850 m	Threshold - Mammalian Insectivores (shrew)	1.52 (mg/kg dry wt)	h
PAH	Surface Soil - Dist. 3 - 1,500 m	Threshold - Mammalian Insectivores (shrew)	1.52 (mg/kg dry wt)	h
PAH	Surface Soil - Dist. 4 - 3,500 m	Threshold - Mammalian Insectivores (shrew)	1.52 (mg/kg dry wt)	h
PAH	Surface Soil - Dist. 5 - 7,500 m	Threshold - Mammalian Insectivores (shrew)	1.52 (mg/kg dry wt)	h
PAH	Water-column Community	Threshold Level	0.014 (ug/L)	a, h, m
PAH	Water-column Community	Frank-effect Level	0.24 (ug/L)	a
Lead	Ambient Air	NAAQS Secondary Standard	0.15 ug/m^3	n

References:

a. U.S. EPA OSWER
b. Environment Canada
c. U.S. EPA OW
d. CA DTSC HERD (2009)
e. Sample, et. al, 1996
f. U.S. EPA 1995
g. U.S. EPA Region 3, 4, and 5.
h. U.S. EPA Region
i. U.S. EPA Region 4
j. Florida DEP, NOAA
k. ORNL and EPA R4, R6
l. MacDonald, et. al. 2000
m. U.S. EPA Region 6
n. NAAQS for Lead, Secondary Standard

Table 2 – Acid Gas Benchmarks Included in the Environmental Risk Screen

Acid Gas	Chronic 90-day Benchmark in µg/m3
Hydrochloric acid – LOEL	50[a]
Hydrofluoric acid – Plant Community LOEL	0.5
Hydrofluoric acid – Plant Community LOEL	0.4

a- Note that the human health RfC is 20 µg/m3, which is lower than the ecological benchmark.

Appendix 10 Detailed Risk Modeling Results

Appendix 10

Detailed Inhalation Risk Modeling Results

Table 1 - Facility Identification Information

Source Category	Facility FRS ID	Facility Name	Address	City	State
Pulp and Paper MACT 2	01001110011734935	Alabama River Cellulose, LLC	2373 Lena Landegger Hwy	Perdue Hill	AL
Pulp and Paper MACT 2	01023110017428773	Boise White Paper LLC	4585 Industrial Road	Jackson	AL
Pulp and Paper MACT 2	01025110000369280	Fort James-Pennington	7530 Hwy 114	Pennington	AL
Pulp and Paper MACT 2	01047110002438103	Georgia-Pacific Brewton LLC	32224 Hwy 31 S	Brewton	AL
Pulp and Paper MACT 2	01053110012508580	International Paper - Riverdale Mill	601 County Rd 78	Selma	AL
Pulp and Paper MACT 2	01071110000589435	International Paper Company	100 Jensen Rd	Prattville	AL
Pulp and Paper MACT 2	01091110000601965	International Paper Pine Hill	Hwy 10 E	Pine Hill	AL
Pulp and Paper MACT 2	01099110000589612	Resolute Forest Products - Coosa Pines Operatio	17589 Plant Rd	Coosa Pines	AL
Pulp and Paper MACT 2	01113110017400711	Rock-Tenn Mill Co LLC	28270 Us Hwy 80 W	Demopolis	AL
Pulp and Paper MACT 2	01121110000366121	WestRock - Stevenson Mill	1611 County Road 85	Stevenson	AL
Pulp and Paper MACT 2	01131110007233305	WestRock Company	Hwy 165 S	Cottonton	AL
Pulp and Paper MACT 2	12005110000518002	Clearwater Paper Corporation-Cypress Bend Mill	5082 Hwy. 4 N.	Arkansas City	AR
Pulp and Paper MACT 2	12033110000362447	Domtar A.W. LLC	285 Hwy 71 South	Ashdown	AR
Pulp and Paper MACT 2	12089110000588542	Evergreen Packaging Inc.	5201 Fairfield Road	Pine Bluff	AR
Pulp and Paper MACT 2	12089110000588551	Georgia-Pacific LLC Crossett Paper Mill	100 Mill Supply Rd.	Crossett	AR
Pulp and Paper MACT 2	12107110000588604	Green Bay Packaging - ARK KRAFT DIVISION	338 Highway 113	Morrilton	AR
Pulp and Paper MACT 2	12123110000362223	Mondi Bags USA, LLC	1701 Jefferson Pkwy	Pine Bluff	AR
Pulp and Paper MACT 2	13021110005666243	Foley Cellulose LLC, Foley Mill	One Buckeye Drive	Perry	FL
Pulp and Paper MACT 2	13051110000740958	Georgia-Pacific Consumer Operations LLC	215 County Road 216	Palatka	FL
Pulp and Paper MACT 2	13051110005670336	International Paper Company	375 Muscogee Road	Cantonment	FL
Pulp and Paper MACT 2	13099110012384589	Rayonier Performance Fibers LLC	10 Gum Street	Fernandina Beach	FL
Pulp and Paper MACT 2	13115110013763034	WestRock - Fernandina Beach Mill	N 8Th St	Fernandina Beach	FL
Pulp and Paper MACT 2	13127110000588365	WestRock Company - Panama City Mill	One Everitt Ave	Panama City	FL
Pulp and Paper MACT 2	13179110013498296	Georgia-Pacific Brunswick Operations	West 9Th Street	Brunswick	GA
Pulp and Paper MACT 2	13185110005666421	Georgia-Pacific Cedar Springs, LLC	12551 Hwy 273 West	Cedar Springs	GA
Pulp and Paper MACT 2	13193110007356002	Graphic Packaging Macon Mill	100 Graphic Packaging Int'l Way	Macon	GA
Pulp and Paper MACT 2	13245110000359718	International Paper - Augusta Mill	4278 Mike Padgett Highway	Augusta	GA
Pulp and Paper MACT 2	13305110007356422	International Paper Co - Savannah Complex	1201 W Lathrop Ave	Savannah	GA
Pulp and Paper MACT 2	22011110006020028	Interstate Paper LLC	2366 Interstate Paper Road	Riceboro	GA
Pulp and Paper MACT 2	22031110000450173	Packaging Corporation of America - Valdosta Mill	5495 Lake Park-Clyattville Rd	Clyattville	GA
Pulp and Paper MACT 2	22033110012384286	Rayonier Performance Fibers, LLC	4470 Savannah Highway	Jesup	GA
Pulp and Paper MACT 2	22049110000597514	TIN Inc. dba Temple-Inland	238 Mays Bridge Road	Rome	GA
Pulp and Paper MACT 2	22069110039166390	Weyerhaeuser NR Company	2449 Stagecoach Rd	Oglethorpe	GA
Pulp and Paper MACT 2	22073110017782568	Weyerhaeuser NR Port Wentworth	1 Bonnybridge Road	Port Wentworth	GA
Pulp and Paper MACT 2	22117110001274521	Clearwater Paper Corp - PPD & CPD, Idaho	803 Mill Road	Lewiston	ID
Pulp and Paper MACT 2	22125110043794374	Domtar Paper Company, LLC - Hawesville Opera	58 Wescor Rd	Hawesville	KY
Pulp and Paper MACT 2	37047110009719304	Wickliffe Paper Company	1724 Westvaco Rd	Wickliffe	KY
Pulp and Paper MACT 2	37049110000350478	Boise Packaging and Newsprint, LLC	4200 Hwy 190 W	Deridder	LA
Pulp and Paper MACT 2	37083110000586447	Georgia-Pacific Port Hudson Operations	1000 W Mount Pleasant Rd	Zachary	LA
Pulp and Paper MACT 2	37087110009846480	Graphic Packaging International, Inc. - Plant 31	1000 Jonesboro Rd	West Monroe	LA
Pulp and Paper MACT 2	37117110013794000	Hood Container of Louisiana LLC	2105 Hwy 964	St. Francisville	LA

Table 1 - Facility Identification Information

Source Category	Facility FRS ID	Facility Name	Address	City	State
Pulp and Paper MACT 2	45019110016966381	International Paper - Red River Mill	4537 Hwy 480	Campti	LA
Pulp and Paper MACT 2	45031110000587491	International Paper Co - Mansfield Mill	1202 Louisiana Hwy 509 Ne	Mansfield	LA
Pulp and Paper MACT 2	45041110019973493	Temple-Inland/Bogalusa Mill/Gaylord Container C	4Th St & Ave. U	Bogalusa	LA
Pulp and Paper MACT 2	45043110000353466	WestRock - Hodge Mill	100 Mill Street	Hodge	LA
Pulp and Paper MACT 2	45069110016989669	Luke Paper Company	300 Pratt Street	Luke	MD
Pulp and Paper MACT 2	45079110000351903	Catalyst Paper - Rumford Division	35 Hartford St	Rumford	ME
Pulp and Paper MACT 2	45091110000355035	Expera Old Town LLC	24 Portland St	Old Town	ME
Pulp and Paper MACT 2	51009110020680306	SAPPI - Somerset	1329 Waterville Rd	Skowhegan	ME
Pulp and Paper MACT 2	51019110000343922	Verso Paper - Androscoggin Mill	Po Box 20 Riley Rd	Jay	ME
Pulp and Paper MACT 2	51093110000560492	Woodland Pulp LLC	144 Main St	Baileyville	ME
Pulp and Paper MACT 2	51101110007317484	NewPage - Escanaba Paper Company	7100 County Rd. 426 PO Box 757	Escanaba	MI
Pulp and Paper MACT 2	51580110012505397	Packaging Corporation of America - Filer City Mill	2246 Udell St.	Filer City	MI
Pulp and Paper MACT 2	51670110012503781	Verso Quinnesec LLC	W-6791 Us Hwy 2 Quinnesec Mill	Quinnesec	MI
Pulp and Paper MACT 2	53011110000564586	Boise White Paper LLC - Intl Falls	400 2Nd St	International Falls	MN
Pulp and Paper MACT 2	53015110000490852	Sappi Cloquet LLC	2201Avenue B	Cloquet	MN
Pulp and Paper MACT 2	53015110000490898	Georgia Pacific Monticello LLC	604 N.A. Sandifer Hwy	Monticello	MS
Pulp and Paper MACT 2	53027110000490709	International Paper Co. - Vicksburg Mill	3737 Highway 3 North	Redwood	MS
Pulp and Paper MACT 2	53031110000490326	Leaf River Cellulose, LLC	157 Buck Creek Road	New Augusta	MS
Pulp and Paper MACT 2	53053110000490558	Weyerhaeuser NR Company, Columbus Cellulose Fibers	4335 Carson Road	Columbus	MS
Pulp and Paper MACT 2	53071110005312713	Blue Ridge Paper Products - Canton Mill	175 Main Street	Canton	NC
Pulp and Paper MACT 2	05003110000450921	Domtar Paper Company, LLC	Nc Highway 149 North	Plymouth	NC
Pulp and Paper MACT 2	05029110000597890	International Paper - Riegelwood Mill	865 John L Riegel Road	Riegelwood	NC
Pulp and Paper MACT 2	05041110012414985	Kapstone - Roanoke Rapids Mill	100 Gaston Road	Roanoke Rapids	NC
Pulp and Paper MACT 2	05069110000450752	Weyerhaeuser Company - Vanceboro Saw Mill	1785 Weyerhaeuser Road	Vanceboro	NC
Pulp and Paper MACT 2	05069110000450878	Finch Paper LLC	1 Glen St	Glens Falls	NY
Pulp and Paper MACT 2	05081110000756352	International Paper Ticonderoga Mill	568 Shore Airport Rd	Ticonderoga	NY
Pulp and Paper MACT 2	16069110009335905	P.H. Glatfelter Company - Chillicothe Facility	232 East 8Th Street	Chillicothe	OH
Pulp and Paper MACT 2	21007110000732173	WestRock - Coshocton Mill	500 North Fourth Street	Coshocton	OH
Pulp and Paper MACT 2	21091110000380926	International Paper Valliant Mill	1.5 Miles On Us 70 Sw Of Valliant	Valliant	OK
Pulp and Paper MACT 2	23007110000581415	Cascade Pacific Pulp	30480 American Dr	Halsey	OR
Pulp and Paper MACT 2	23017110000491940	Georgia-Pacific Consumer Products LP - Wauna	92326 Taylorville Road	Clatskanie	OR
Pulp and Paper MACT 2	23019110000581460	Georgia-Pacific Toledo, LLC	1400 Se Butler Bridge Rd	Toledo	OR
Pulp and Paper MACT 2	23025110017413468	International Paper Company	801 42Nd Street	Springfield	OR
Pulp and Paper MACT 2	23029110013359178	Appleton Papers Inc Spring Mill	100 Paper Mill Rd	Roaring Spring	PA
Pulp and Paper MACT 2	24001110007334072	Domtar Paper Company LLC - Johnsonburg Mill	100 W Center St	Johnsonburg	PA
Pulp and Paper MACT 2	26041110017408848	P. H. Glatfelter Co - Spring Grove Mill	228 S Main St	Spring Grove	PA
Pulp and Paper MACT 2	26043110017422467	Domtar Company:Marlboro Paper Mill	585 Willamette Rd	Bennettsville	SC
Pulp and Paper MACT 2	26101110000412045	International Paper - Eastover	4001 Mccords Ferry Road	Eastover	SC
Pulp and Paper MACT 2	27017110000426263	International Paper - Georgetown Mill	700 S Kaminski St	Georgetown	SC
Pulp and Paper MACT 2	27071110000427501	KapStone Charleston Kraft LLC	5600 Virginia Avenue	North Charleston	SC

Table 1 - Facility Identification Information

Source Category	Facility FRS ID	Facility Name	Address	City	State
Pulp and Paper MACT 2	28077110017416599	Resolute Forest Products - Catawba Operations	5300 Cureton Ferry Rd	Catawba	SC
Pulp and Paper MACT 2	28087110000590940	Sonoco:Hartsville	1 N Second St	Hartsville	SC
Pulp and Paper MACT 2	28111110002217379	WestRock - Florence Mill	7320 Paper Mill Rd	Florence	SC
Pulp and Paper MACT 2	28149110000605220	Bowater Newsprint & Directory - Calhoun Operations	5020 Highway 11, South	Calhoun	TN
Pulp and Paper MACT 2	36031110000325005	Domtar Paper Co LLC Kingsport Mill	100 Clinchfield Street	Kingsport	TN
Pulp and Paper MACT 2	36113110000324845	Packaging Corporation of America	Highway 57	Counce	TN
Pulp and Paper MACT 2	39031110000384735	International Paper TEXARKANA Mill	9978 Fm 3129	Queen City	TX
Pulp and Paper MACT 2	39141110000395117	Orange Mill	1750 Inland Road	Orange	TX
Pulp and Paper MACT 2	40089110000598639	Westvaco Texas LP	1913 Fm 105	Evadale	TX
Pulp and Paper MACT 2	41007110013844563	GP Big Island LLC	9363 Lee Jackson Hwy - Rte 501	Big Island	VA
Pulp and Paper MACT 2	41039110000488552	Greif Packaging LLC	861 Fibre Plant Rd	Amherst	VA
Pulp and Paper MACT 2	41041110014206117	International Paper - Franklin Mill	34040 Union Camp Dr.	Franklin	VA
Pulp and Paper MACT 2	41043110000488142	WestRock - Hopewell Mill	910 Industrial St	Hopewell	VA
Pulp and Paper MACT 2	42013110000332177	WestRock Company – Covington Mill	104 E Riverside St	Covington	VA
Pulp and Paper MACT 2	42047110000330400	WestRock Company - West Point Mill	1901 Main Street	West Point	VA
Pulp and Paper MACT 2	42133110017404664	Boise White Paper LLC	31831 W Hwy 12	Wallula	WA
Pulp and Paper MACT 2	47071110017418338	Georgia Pacific Consumer Products (Camas), LL	401 Ne Adams St	Camas	WA
Pulp and Paper MACT 2	47107110000605088	Gores Group, LLC	1701 First St	Cosmopolis	WA
Pulp and Paper MACT 2	47163110017711289	Longview Fibre Paper & Packaging Inc	300 Fibre Way	Longview	WA
Pulp and Paper MACT 2	48067110008148496	Port Townsend Paper Corp	100 Mill Rd	Port Townsend	WA
Pulp and Paper MACT 2	48241110000599594	WestRock - Tacoma Mill	801 Portland Ave	Tacoma	WA
Pulp and Paper MACT 2	48361110008146130	Weyerhaeuser Co	3401 Industrial Way	Longview	WA
Pulp and Paper MACT 2	55069110000422267	Domtar A.W. LLC	301 Point Basse Ave.	Nekoosa	WI
Pulp and Paper MACT 2	55073110000422043	Packaging Corporation of America-Tomahawk	N9090 County Road E	Tomahawk	WI
Pulp and Paper MACT 2	55087110000420973	Thilmany, LLC-Kaukauna Mill	600 Thilmany Rd	Kaukauna	WI
Pulp and Paper MACT 2	55141110000742796	Verso Corporation - Wisconsin Rapids Mill	950 4Th Ave N	Wisconsin Rapids	WI
Pulp and Paper MACT 2	55141110017413547	Wausau Paper Mills, LLC	100 Main St	Mosinee	WI

Table 2 – Maximum Predicted HEM-3 Chronic Risks

	Source Category Chronic Risk [1, 2]			Whole Facility Chronic Risk [1]			
Facility NEI ID	**Cancer MIR**	**Noncancer Max HI**	**Target Organ**	**Cancer MIR**	**Noncancer Max HI**	**Target Organ**	**% Source Contribution (Cancer MIR)**
24001110007334072	**3.63E-06**	1.33E-01	Respiratory	**4.37E-06**	1.58E-01	Respiratory	83%
01001110011734935	**2.72E-06**	1.22E-01	Respiratory	**2.73E-06**	1.21E-01	Respiratory	100%
42047110000330400	**1.99E-06**	2.88E-01	Respiratory	**3.04E-06**	2.32E-01	Respiratory	66%
53011110000564586	**1.73E-06**	1.04E-01	Respiratory	**2.68E-06**	1.84E-01	Respiratory	65%
22117110001274521	1.49E-06	4.67E-02	Respiratory	**3.36E-06**	1.18E-01	Respiratory	44%
45043110000353466	1.43E-06	1.05E-01	Respiratory	**3.24E-06**	2.06E-01	Respiratory	44%
42133110017404664	1.19E-06	1.02E-01	Respiratory	**2.33E-06**	1.47E-01	Respiratory	51%
41041110014206117	1.12E-06	7.11E-02	Respiratory	**2.99E-06**	1.22E-01	Respiratory	37%
28077110017416599	1.03E-06	4.31E-02	Respiratory	**1.70E-06**	6.20E-02	Respiratory	60%
37087110009846480	9.61E-07	3.05E-02	Respiratory	**1.55E-05**	5.05E-01	Respiratory	6%
53015110000490852	9.60E-07	5.31E-02	Respiratory	**1.50E-06**	7.03E-02	Respiratory	64%
41039110000488552	8.97E-07	3.15E-02	Respiratory	**1.92E-06**	7.24E-02	Respiratory	47%
51580110012505397	8.27E-07	5.96E-02	Respiratory	**2.75E-06**	1.03E-01	Respiratory	30%
12033110000362447	7.28E-07	4.15E-02	Respiratory	**1.86E-06**	1.05E-01	Respiratory	39%
39141110000395117	6.83E-07	5.28E-03	Respiratory	**4.14E-06**	6.78E-01	Respiratory	17%
22073110017782568	6.74E-07	3.42E-02	Respiratory	**9.03E-06**	2.99E-01	Respiratory	7%
37047110009719304	6.66E-07	2.80E-02	Respiratory	**2.98E-06**	1.71E-01	Respiratory	22%
47071110017418338	6.65E-07	4.98E-02	Respiratory	**3.54E-06**	4.41E-01	Respiratory	19%
51093110000560492	6.62E-07	8.14E-03	Respiratory	**1.53E-06**	7.50E-02	Respiratory	43%
01053110012508580	5.99E-07	2.96E-02	Respiratory	**1.51E-06**	6.92E-02	Respiratory	40%
01025110000369280	5.89E-07	2.52E-02	Respiratory	**2.21E-06**	1.06E-01	Respiratory	27%
28149110000605220	5.73E-07	3.02E-02	Respiratory	**2.33E-06**	9.00E-02	Respiratory	25%
48361110008146130	5.72E-07	7.03E-02	Respiratory	1.44E-06	9.06E-02	Respiratory	40%
55141110017413547	5.66E-07	2.44E-02	Respiratory	9.13E-07	1.20E-01	Respiratory	62%
51101110007317484	5.59E-07	3.50E-02	Respiratory	**3.07E-06**	1.33E-01	Respiratory	18%
23017110000491940	5.01E-07	5.46E-03	Respiratory	1.22E-06	7.20E-02	Respiratory	41%
13245110000359718	4.95E-07	2.80E-02	Respiratory	**1.59E-06**	9.41E-02	Respiratory	31%
23007110000581415	4.89E-07	3.40E-02	Respiratory	**2.62E-06**	2.28E-01	Respiratory	19%
12005110000518002	4.85E-07	2.36E-02	Respiratory	1.25E-06	5.04E-02	Respiratory	39%
01131110007233305	4.82E-07	3.24E-02	Respiratory	**4.88E-06**	2.37E-01	Respiratory	10%
05003110000450921	4.60E-07	3.44E-02	Respiratory	**2.53E-06**	1.44E-01	Respiratory	18%
53053110000490558	4.44E-07	6.12E-02	Respiratory	**3.69E-06**	1.41E-01	Respiratory	12%
21007110000732173	4.31E-07	3.03E-02	Respiratory	1.16E-06	6.02E-02	Respiratory	37%
13115110013763034	4.25E-07	2.94E-02	Respiratory	**4.02E-06**	1.34E-01	Respiratory	11%
47107110000605088	4.23E-07	8.62E-03	Respiratory	**2.88E-06**	8.77E-01	Neurological	15%
22049110000597514	3.93E-07	2.86E-02	Respiratory	1.36E-06	6.31E-02	Respiratory	29%
45091110000355035	3.78E-07	1.01E-02	Respiratory	1.49E-06	7.08E-02	Respiratory	25%
45019110016966381	3.68E-07	3.04E-02	Respiratory	1.05E-06	4.20E-02	Respiratory	35%
45079110000351903	3.60E-07	3.74E-02	Respiratory	6.50E-07	3.05E-01	Respiratory	55%

Table 2 – Maximum Predicted HEM-3 Chronic Risks

Facility NEI ID	Source Category Chronic Risk [1, 2]			Whole Facility Chronic Risk [1]			% Source Contribution (Cancer MIR)
	Cancer MIR	Noncancer Max HI	Target Organ	Cancer MIR	Noncancer Max HI	Target Organ	
41007110013844563	3.29E-07	1.53E-02	Respiratory	4.17E-07	1.91E-02	Respiratory	79%
13021110005666243	3.21E-07	2.86E-03	Respiratory	1.41E-06	1.61E-01	Respiratory	23%
12123110000362223	3.12E-07	3.73E-02	Respiratory	**8.06E-06**	3.28E-01	Respiratory	4%
53031110000490326	2.99E-07	1.08E-02	Respiratory	**8.80E-06**	5.28E-01	Respiratory	3%
12089110000588542	2.60E-07	6.38E-02	Respiratory	**1.58E-06**	1.19E-01	Respiratory	16%
27071110000427501	2.57E-07	2.65E-03	Respiratory	4.53E-07	1.95E-02	Respiratory	57%
13051110000740958	2.51E-07	1.49E-02	Respiratory	1.06E-06	4.21E-02	Respiratory	24%
23029110013359178	2.46E-07	1.42E-02	Respiratory	**1.17E-05**	5.48E-01	Respiratory	2%
05069110000450878	2.41E-07	1.13E-02	Respiratory	**1.88E-06**	1.63E-01	Respiratory	13%
13127110000588365	2.39E-07	2.25E-02	Respiratory	**3.78E-06**	1.53E-01	Respiratory	6%
48241110000599594	2.37E-07	2.34E-02	Respiratory	**2.67E-06**	8.71E-02	Respiratory	9%
01113110017400711	2.23E-07	1.17E-02	Respiratory	1.34E-06	5.48E-02	Respiratory	17%
23019110000581460	2.19E-07	3.87E-03	Respiratory	1.16E-06	4.27E-01	Respiratory	19%
05081110000756352	2.16E-07	1.63E-02	Respiratory	**1.95E-06**	7.93E-02	Respiratory	11%
22011110006020028	2.14E-07	1.19E-03	Respiratory	**2.26E-06**	3.34E-02	Respiratory	9%
16069110009335905	2.12E-07	2.28E-02	Respiratory	1.08E-06	5.15E-02	Respiratory	20%
05041110012414985	2.11E-07	3.60E-03	Developmental	3.96E-07	9.34E-02	Respiratory	53%
13305110007356422	1.94E-07	4.95E-02	Respiratory	**2.05E-06**	1.76E-01	Respiratory	9%
53071110005312713	1.89E-07	3.61E-02	Respiratory	5.90E-07	4.71E-02	Respiratory	32%
13099110012384589	1.88E-07	2.58E-03	Respiratory	**3.40E-06**	1.23E-01	Respiratory	6%
22125110043794374	1.87E-07	2.68E-03	Respiratory	8.20E-07	1.79E-02	Respiratory	23%
47163110017711289	1.83E-07	7.41E-03	Respiratory	1.22E-06	9.58E-01	Respiratory	15%
51019110000343922	1.79E-07	4.27E-03	Kidney	**6.99E-06**	3.77E-01	Respiratory	3%
26041110017408848	1.77E-07	8.02E-03	Neuorological	5.34E-07	5.48E-02	Respiratory	33%
37083110000586447	1.77E-07	4.18E-03	Kidney	**3.87E-06**	4.69E-02	Respiratory	5%
01071110000589435	1.76E-07	5.19E-03	Respiratory	**1.74E-06**	7.14E-02	Respiratory	10%
13179110013498296	1.68E-07	7.74E-03	Neuorological	3.42E-07	1.20E-02	Respiratory	49%
36031110000325005	1.63E-07	1.70E-02	Respiratory	7.08E-07	5.17E-02	Respiratory	23%
48067110008148496	1.61E-07	1.86E-02	Respiratory	6.67E-07	3.96E-02	Respiratory	24%
22031110000450173	1.47E-07	8.45E-03	Respiratory	9.73E-07	3.13E-02	Respiratory	15%
01047110002438103	1.46E-07	1.16E-02	Respiratory	1.13E-06	8.05E-02	Respiratory	13%
27017110000426263	1.43E-07	3.95E-03	Respiratory	5.17E-07	1.25E-02	Respiratory	28%
01023110017428773	1.40E-07	5.69E-03	Respiratory	**3.81E-06**	5.66E-02	Respiratory	4%
22033110012384286	1.39E-07	8.63E-03	Respiratory	1.03E-06	3.90E-02	Respiratory	13%
12107110000588604	1.35E-07	1.63E-03	Respiratory	**3.58E-06**	1.98E-01	Respiratory	4%
12089110000588551	1.32E-07	1.81E-02	Respiratory	7.77E-07	4.48E-02	Respiratory	17%
13185110005666421	1.24E-07	1.75E-02	Respiratory	1.16E-06	6.84E-01	Respiratory	11%
22069110039166390	1.24E-07	1.36E-02	Respiratory	1.13E-06	6.65E-02	Respiratory	11%
40089110000598639	1.17E-07	1.96E-02	Respiratory	**1.56E-06**	8.12E-02	Respiratory	7%

Table 2 – Maximum Predicted HEM-3 Chronic Risks

Facility NEI ID	Source Category Chronic Risk [1, 2]			Whole Facility Chronic Risk [1]			% Source Contribution (Cancer MIR)
	Cancer MIR	Noncancer Max HI	Target Organ	Cancer MIR	Noncancer Max HI	Target Organ	
05069110000450752	1.15E-07	5.37E-03	Respiratory	1.40E-06	3.00E-02	Respiratory	8%
39031110000384735	1.12E-07	4.47E-04	Immunological	1.18E-06	5.03E-02	Respiratory	9%
28111110002217379	1.10E-07	8.83E-03	Respiratory	1.20E-06	5.11E-02	Respiratory	9%
51009110020680306	1.08E-07	5.46E-04	Respiratory	7.71E-07	2.66E-02	Respiratory	14%
45041110019973493	9.67E-08	1.15E-02	Respiratory	2.16E-07	1.61E-02	Respiratory	45%
55087110000420973	9.40E-08	2.85E-03	Respiratory	4.53E-07	9.40E-02	Respiratory	21%
01099110000589612	9.10E-08	7.06E-03	Respiratory	4.48E-07	1.97E-02	Respiratory	20%
01121110000366121	9.03E-08	6.33E-03	Respiratory	**5.78E-06**	4.13E-02	Respiratory	2%
05029110000597890	9.03E-08	8.41E-04	Respiratory	**5.68E-06**	2.63E-01	Respiratory	2%
21091110000380926	8.80E-08	1.25E-02	Respiratory	**1.69E-06**	4.60E-02	Respiratory	5%
41043110000488142	8.60E-08	3.97E-03	Respiratory	1.87E-07	5.60E-02	Respiratory	46%
45069110016989669	8.26E-08	2.31E-02	Respiratory	1.38E-06	5.90E-02	Respiratory	6%
53015110000490898	7.16E-08	6.33E-03	Respiratory	1.27E-06	1.70E-01	Respiratory	6%
13051110005670336	6.94E-08	7.21E-03	Respiratory	**2.52E-06**	1.34E-01	Respiratory	3%
26043110017422467	6.81E-08	2.70E-03	Respiratory	2.79E-07	1.15E-02	Respiratory	24%
28087110000590940	6.77E-08	5.38E-04	Respiratory	1.35E-06	9.58E-02	Respiratory	5%
42013110000332177	5.56E-08	5.16E-03	Respiratory	1.03E-06	2.38E-01	Respiratory	5%
53027110000490709	4.88E-08	1.23E-03	Neuorological	5.76E-07	4.70E-01	Respiratory	8%
01091110000601965	4.46E-08	3.44E-03	Respiratory	5.09E-07	1.44E-02	Respiratory	9%
55073110000422043	4.18E-08	1.41E-02	Respiratory	5.07E-07	8.51E-02	Respiratory	8%
23025110017413468	2.71E-08	7.69E-04	Respiratory	1.41E-06	4.33E-02	Respiratory	2%
37049110000350478	2.52E-08	6.06E-03	Respiratory	9.42E-07	1.29E-01	Respiratory	3%
51670110012503781	1.86E-08	3.63E-03	Respiratory	5.09E-07	1.59E-01	Respiratory	4%
13193110007356002	1.67E-08	2.05E-04	Respiratory	9.35E-07	8.13E-03	Respiratory	2%
55141110000742796	1.43E-08	7.62E-03	Respiratory	1.39E-06	5.69E-02	Respiratory	1%
37117110013794000	1.37E-08	2.86E-03	Respiratory	**1.62E-06**	4.97E-02	Respiratory	1%
36113110000324845	1.18E-08	1.08E-03	Neuorological	5.95E-07	1.93E-01	Respiratory	2%
55069110000422267	6.69E-09	5.50E-05	Respiratory	2.31E-07	7.12E-03	Respiratory	3%
26101110000412045	4.68E-09	3.82E-05	Respiratory	**1.55E-06**	7.33E-02	Respiratory	0%
45031110000587491	3.79E-10	3.99E-06	Kidney	**4.29E-06**	2.11E-01	Respiratory	0%

1 BOLD indicates a cancer risk greater than 1 in a million or a noncancer risk greater than 1

2 Facility cancer and non-cancer risks represent MIR at census block locations using 2011 ICR Data.

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
12123110000362223	Acrolein	2.88E-01	1.04E-02	3.13E-03	6.55E-03	2.12E-03
42047110000330400	Acrolein	1.83E-01	6.65E-03	1.99E-03	4.17E-03	1.35E-03
01023110017428773	Acrolein	1.51E-01	5.48E-03	1.64E-03	3.43E-03	1.11E-03
53011110000564586	Acrolein	1.47E-01	5.34E-03	1.60E-03	3.35E-03	1.08E-03
45079110000351903	Acrolein	1.31E-01	4.74E-03	1.42E-03	2.97E-03	9.62E-04
24001110007334072	Acetaldehyde	1.27E-01	7.40E-04	1.22E-04	3.33E-03	1.66E-04
22125110043794374	Formaldehyde	1.25E-01	6.25E-03	4.04E-04	5.73E-03	5.73E-04
41007110013844563	Acrolein	1.10E-01	4.00E-03	1.20E-03	2.51E-03	8.12E-04
48067110008148496	Acrolein	8.73E-02	3.16E-03	9.49E-04	1.98E-03	6.42E-04
42047110000330400	Arsenic compounds	8.45E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48361110008146130	Acrolein	8.06E-02	2.92E-03	8.76E-04	1.83E-03	5.93E-04
23007110000581415	Acrolein	7.58E-02	2.75E-03	8.24E-04	1.72E-03	5.58E-04
01001110011734935	Acetaldehyde	7.24E-02	4.20E-04	6.95E-05	1.89E-03	9.46E-05
24001110007334072	Acrolein	7.10E-02	2.57E-03	7.71E-04	1.61E-03	5.22E-04
12089110000588542	Acrolein	5.22E-02	1.89E-03	5.67E-04	1.19E-03	3.83E-04
13305110007356422	Acrolein	5.08E-02	1.84E-03	5.52E-04	1.15E-03	3.74E-04
53071110005312713	Acrolein	4.93E-02	1.79E-03	5.36E-04	1.12E-03	3.63E-04
22117110001274521	Acetaldehyde	4.81E-02	2.79E-04	4.62E-05	1.26E-03	6.28E-05
53053110000490558	Acrolein	4.62E-02	1.67E-03	5.02E-04	1.05E-03	3.39E-04
53011110000564586	Formaldehyde	4.48E-02	2.24E-03	1.45E-04	2.05E-03	2.05E-04
45069110016989669	Acrolein	4.26E-02	1.54E-03	4.63E-04	9.67E-04	3.13E-04
28077110017416599	Acetaldehyde	4.25E-02	2.46E-04	4.07E-05	1.11E-03	5.54E-05
01023110017428773	Acetaldehyde	3.98E-02	2.31E-04	3.82E-05	1.04E-03	5.20E-05
01113110017400711	Arsenic compounds	3.88E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42047110000330400	Formaldehyde	3.78E-02	1.89E-03	1.22E-04	1.73E-03	1.73E-04
51580110012505397	Acrolein	3.54E-02	1.28E-03	3.85E-04	8.05E-04	2.61E-04
28149110000605220	Acrolein	3.38E-02	1.23E-03	3.68E-04	7.69E-04	2.49E-04
16069110009335905	Acrolein	3.34E-02	1.21E-03	3.63E-04	7.60E-04	2.46E-04
12033110000362447	Acrolein	3.30E-02	1.19E-03	3.58E-04	7.49E-04	2.42E-04
28149110000605220	Acetaldehyde	3.28E-02	1.90E-04	3.14E-05	8.56E-04	4.28E-05
13245110000359718	Acrolein	3.20E-02	1.16E-03	3.48E-04	7.27E-04	2.35E-04
01131110007233305	Acrolein	3.17E-02	1.15E-03	3.44E-04	7.19E-04	2.33E-04
05003110000450921	Acrolein	2.96E-02	1.07E-03	3.22E-04	6.73E-04	2.18E-04
01001110011734935	Acrolein	2.94E-02	1.07E-03	3.20E-04	6.69E-04	2.16E-04
41007110013844563	Acetaldehyde	2.84E-02	1.65E-04	2.73E-05	7.42E-04	3.71E-05
45043110000353466	Acrolein	2.83E-02	1.02E-03	3.07E-04	6.43E-04	2.08E-04
51101110007317484	Acrolein	2.66E-02	9.64E-04	2.89E-04	6.05E-04	1.96E-04
12123110000362223	Acetaldehyde	2.65E-02	1.54E-04	2.54E-05	6.93E-04	3.46E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
53015110000490852	Acrolein	2.52E-02	9.12E-04	2.74E-04	5.72E-04	1.85E-04
24001110007334072	Formaldehyde	2.49E-02	1.25E-03	8.06E-05	1.14E-03	1.14E-04
01053110012508580	Acrolein	2.45E-02	8.87E-04	2.66E-04	5.57E-04	1.80E-04
45079110000351903	Formaldehyde	2.40E-02	1.20E-03	7.75E-05	1.10E-03	1.10E-04
36031110000325005	Acrolein	2.27E-02	8.24E-04	2.47E-04	5.17E-04	1.67E-04
01047110002438103	Acrolein	2.21E-02	8.00E-04	2.40E-04	5.02E-04	1.62E-04
13115110013763034	Acrolein	2.17E-02	7.87E-04	2.36E-04	4.94E-04	1.60E-04
23017110000491940	Formaldehyde	2.11E-02	1.05E-03	6.82E-05	9.66E-04	9.66E-05
37047110009719304	Acetaldehyde	2.09E-02	1.21E-04	2.00E-05	5.45E-04	2.73E-05
05069110000450878	Acrolein	2.07E-02	7.52E-04	2.25E-04	4.71E-04	1.53E-04
13245110000359718	Acetaldehyde	2.07E-02	1.20E-04	1.98E-05	5.40E-04	2.70E-05
05069110000450878	Acetaldehyde	2.06E-02	1.20E-04	1.98E-05	5.39E-04	2.70E-05
42013110000332177	Hydrochloric acid	2.06E-02	1.61E-02	1.31E-03	9.63E-03	1.44E-03
51019110000343922	Arsenic compounds	2.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47071110017418338	Acrolein	2.03E-02	7.34E-04	2.20E-04	4.61E-04	1.49E-04
28077110017416599	Acrolein	1.98E-02	7.19E-04	2.16E-04	4.51E-04	1.46E-04
22125110043794374	Arsenic compounds	1.98E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01053110012508580	Acetaldehyde	1.97E-02	1.15E-04	1.89E-05	5.15E-04	2.58E-05
39141110000395117	Arsenic compounds	1.89E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42133110017404664	Acrolein	1.87E-02	6.79E-04	2.04E-04	4.26E-04	1.38E-04
41041110014206117	Acrolein	1.82E-02	6.61E-04	1.98E-04	4.14E-04	1.34E-04
21007110000732173	Acrolein	1.81E-02	6.56E-04	1.97E-04	4.12E-04	1.33E-04
01113110017400711	Acrolein	1.81E-02	6.56E-04	1.97E-04	4.12E-04	1.33E-04
51580110012505397	Acetaldehyde	1.78E-02	1.03E-04	1.70E-05	4.64E-04	2.32E-05
21007110000732173	Formaldehyde	1.72E-02	8.62E-04	5.57E-05	7.90E-04	7.90E-05
45041110019973493	Acrolein	1.71E-02	6.21E-04	1.86E-04	3.89E-04	1.26E-04
01099110000589612	Acrolein	1.71E-02	6.20E-04	1.86E-04	3.89E-04	1.26E-04
37047110009719304	Acrolein	1.66E-02	6.01E-04	1.80E-04	3.77E-04	1.22E-04
48067110008148496	Formaldehyde	1.65E-02	8.23E-04	5.33E-05	7.55E-04	7.55E-05
42013110000332177	Arsenic compounds	1.60E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12123110000362223	Formaldehyde	1.58E-02	7.92E-04	5.12E-05	7.26E-04	7.26E-05
05081110000756352	Acrolein	1.50E-02	5.44E-04	1.63E-04	3.41E-04	1.10E-04
16069110009335905	Formaldehyde	1.49E-02	7.43E-04	4.81E-05	6.81E-04	6.81E-05
42047110000330400	Hydrochloric acid	1.48E-02	1.15E-02	9.44E-04	6.92E-03	1.04E-03
22031110000450173	Acrolein	1.45E-02	5.25E-04	1.57E-04	3.29E-04	1.06E-04
22033110012384286	Acrolein	1.43E-02	5.20E-04	1.56E-04	3.26E-04	1.05E-04
45043110000353466	Acetaldehyde	1.42E-02	8.22E-05	1.36E-05	3.70E-04	1.85E-05
01023110017428773	Formaldehyde	1.40E-02	6.98E-04	4.52E-05	6.40E-04	6.40E-05
45043110000353466	Formaldehyde	1.39E-02	6.95E-04	4.50E-05	6.37E-04	6.37E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
01001110011734935	Formaldehyde	1.38E-02	6.88E-04	4.45E-05	6.31E-04	6.31E-05
12005110000518002	Acrolein	1.37E-02	4.97E-04	1.49E-04	3.12E-04	1.01E-04
24001110007334072	Methanol	1.33E-02	5.39E-04	1.38E-04	1.43E-03	2.86E-04
22049110000597514	Acrolein	1.31E-02	4.75E-04	1.43E-04	2.98E-04	9.64E-05
13179110013498296	Acrolein	1.30E-02	4.71E-04	1.41E-04	2.96E-04	9.56E-05
23007110000581415	Formaldehyde	1.30E-02	6.48E-04	4.19E-05	5.94E-04	5.94E-05
42013110000332177	Formaldehyde	1.25E-02	6.25E-04	4.04E-05	5.73E-04	5.73E-05
13127110000588365	Acrolein	1.24E-02	4.50E-04	1.35E-04	2.82E-04	9.12E-05
13021110005666243	Formaldehyde	1.24E-02	6.18E-04	4.00E-05	5.67E-04	5.67E-05
22073110017782568	Acrolein	1.22E-02	4.40E-04	1.32E-04	2.76E-04	8.94E-05
51580110012505397	Hydrochloric acid	1.20E-02	9.36E-03	7.66E-04	5.62E-03	8.42E-04
12005110000518002	Formaldehyde	1.18E-02	5.90E-04	3.82E-05	5.41E-04	5.41E-05
21007110000732173	Methanol	1.18E-02	4.77E-04	1.22E-04	1.27E-03	2.53E-04
53071110005312713	Formaldehyde	1.16E-02	5.80E-04	3.76E-05	5.32E-04	5.32E-05
53015110000490852	Arsenic compounds	1.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13115110013763034	Formaldehyde	1.16E-02	5.80E-04	3.75E-05	5.31E-04	5.31E-05
01121110000366121	Acrolein	1.14E-02	4.14E-04	1.24E-04	2.60E-04	8.41E-05
01025110000369280	Acrolein	1.14E-02	4.13E-04	1.24E-04	2.59E-04	8.39E-05
45019110016966381	Acrolein	1.13E-02	4.09E-04	1.23E-04	2.57E-04	8.31E-05
40089110000598639	Acrolein	1.12E-02	4.07E-04	1.22E-04	2.55E-04	8.25E-05
41007110013844563	Formaldehyde	1.09E-02	5.45E-04	3.52E-05	4.99E-04	4.99E-05
53011110000564586	Acetaldehyde	1.09E-02	6.31E-05	1.04E-05	2.84E-04	1.42E-05
28077110017416599	Formaldehyde	1.08E-02	5.39E-04	3.49E-05	4.94E-04	4.94E-05
23029110013359178	Acrolein	1.07E-02	3.86E-04	1.16E-04	2.42E-04	7.83E-05
53011110000564586	Arsenic compounds	1.04E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28149110000605220	Formaldehyde	1.04E-02	5.18E-04	3.35E-05	4.75E-04	4.75E-05
55141110017413547	Methanol	1.01E-02	4.09E-04	1.04E-04	1.08E-03	2.17E-04
12107110000588604	Formaldehyde	9.93E-03	4.96E-04	3.21E-05	4.55E-04	4.55E-05
13099110012384589	Formaldehyde	9.85E-03	4.92E-04	3.19E-05	4.51E-04	4.51E-05
28111110002217379	Acrolein	9.79E-03	3.55E-04	1.06E-04	2.23E-04	7.20E-05
13245110000359718	Formaldehyde	9.69E-03	4.84E-04	3.13E-05	4.44E-04	4.44E-05
27017110000426263	Formaldehyde	9.64E-03	4.82E-04	3.12E-05	4.42E-04	4.42E-05
37047110009719304	Formaldehyde	9.09E-03	4.55E-04	2.94E-05	4.17E-04	4.17E-05
21091110000380926	Acrolein	9.07E-03	3.29E-04	9.86E-05	2.06E-04	6.67E-05
48241110000599594	Acrolein	9.06E-03	3.28E-04	9.85E-05	2.06E-04	6.66E-05
53015110000490852	Formaldehyde	8.94E-03	4.47E-04	2.89E-05	4.10E-04	4.10E-05
13115110013763034	Hydrochloric acid	8.87E-03	6.90E-03	5.64E-04	4.14E-03	6.21E-04
55141110017413547	Acrolein	8.86E-03	3.21E-04	9.63E-05	2.01E-04	6.51E-05
22069110039166390	Acrolein	8.83E-03	3.20E-04	9.59E-05	2.01E-04	6.49E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
12089110000588551	Acrolein	8.80E-03	3.19E-04	9.57E-05	2.00E-04	6.47E-05
13185110005666421	Acrolein	8.74E-03	3.17E-04	9.50E-05	1.99E-04	6.42E-05
41039110000488552	Acrolein	8.64E-03	3.13E-04	9.39E-05	1.96E-04	6.35E-05
01091110000601965	Acrolein	8.58E-03	3.11E-04	9.33E-05	1.95E-04	6.31E-05
13305110007356422	Arsenic compounds	8.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45091110000355035	Formaldehyde	8.46E-03	4.23E-04	2.74E-05	3.88E-04	3.88E-05
45069110016989669	Formaldehyde	8.35E-03	4.17E-04	2.70E-05	3.83E-04	3.83E-05
01025110000369280	Acetaldehyde	8.27E-03	4.80E-05	7.93E-06	2.16E-04	1.08E-05
48361110008146130	Formaldehyde	8.18E-03	4.09E-04	2.65E-05	3.75E-04	3.75E-05
53071110005312713	Arsenic compounds	8.15E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41007110013844563	Methanol	8.08E-03	3.28E-04	8.38E-05	8.71E-04	1.74E-04
01053110012508580	Formaldehyde	8.08E-03	4.04E-04	2.61E-05	3.70E-04	3.70E-05
05069110000450878	Formaldehyde	7.84E-03	3.92E-04	2.54E-05	3.59E-04	3.59E-05
12033110000362447	Formaldehyde	7.83E-03	3.92E-04	2.53E-05	3.59E-04	3.59E-05
13305110007356422	Formaldehyde	7.82E-03	3.91E-04	2.53E-05	3.58E-04	3.58E-05
45019110016966381	Acetaldehyde	7.77E-03	4.51E-05	7.45E-06	2.03E-04	1.01E-05
22117110001274521	Methanol	7.65E-03	3.10E-04	7.93E-05	8.23E-04	1.65E-04
53053110000490558	Arsenic compounds	7.55E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47071110017418338	Formaldehyde	7.40E-03	3.70E-04	2.39E-05	3.39E-04	3.39E-05
13179110013498296	Formaldehyde	7.37E-03	3.68E-04	2.38E-05	3.38E-04	3.38E-05
21007110000732173	Acetaldehyde	7.28E-03	4.23E-05	6.99E-06	1.90E-04	9.51E-06
53053110000490558	Formaldehyde	7.26E-03	3.63E-04	2.35E-05	3.33E-04	3.33E-05
51580110012505397	Formaldehyde	7.25E-03	3.63E-04	2.35E-05	3.32E-04	3.32E-05
55141110017413547	Formaldehyde	7.23E-03	3.61E-04	2.34E-05	3.31E-04	3.31E-05
05069110000450752	Acetaldehyde	7.20E-03	4.18E-05	6.91E-06	1.88E-04	9.40E-06
22117110001274521	Formaldehyde	7.15E-03	3.58E-04	2.31E-05	3.28E-04	3.28E-05
01071110000589435	Acrolein	7.08E-03	2.57E-04	7.70E-05	1.61E-04	5.21E-05
53015110000490852	Acetaldehyde	7.07E-03	4.10E-05	6.78E-06	1.85E-04	9.23E-06
42133110017404664	Arsenic compounds	6.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05003110000450921	Formaldehyde	6.91E-03	3.46E-04	2.24E-05	3.17E-04	3.17E-05
01001110011734935	Methanol	6.83E-03	2.77E-04	7.08E-05	7.36E-04	1.47E-04
47107110000605088	Formaldehyde	6.83E-03	3.41E-04	2.21E-05	3.13E-04	3.13E-05
01113110017400711	Formaldehyde	6.42E-03	3.21E-04	2.08E-05	2.94E-04	2.94E-05
37049110000350478	Acrolein	6.34E-03	2.30E-04	6.89E-05	1.44E-04	4.66E-05
22117110001274521	Acrolein	6.33E-03	2.29E-04	6.88E-05	1.44E-04	4.66E-05
39031110000384735	Benzene	6.31E-03	4.83E-05	3.16E-06	5.13E-05	1.71E-05
45041110019973493	Formaldehyde	6.24E-03	3.12E-04	2.02E-05	2.86E-04	2.86E-05
55141110017413547	Acetaldehyde	5.89E-03	3.42E-05	5.65E-06	1.54E-04	7.69E-06
01131110007233305	Formaldehyde	5.84E-03	2.92E-04	1.89E-05	2.67E-04	2.67E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
51009110020680306	Formaldehyde	5.69E-03	2.84E-04	1.84E-05	2.61E-04	2.61E-05
22073110017782568	Formaldehyde	5.69E-03	2.84E-04	1.84E-05	2.61E-04	2.61E-05
01047110002438103	Formaldehyde	5.69E-03	2.84E-04	1.84E-05	2.61E-04	2.61E-05
01071110000589435	Formaldehyde	5.65E-03	2.83E-04	1.83E-05	2.59E-04	2.59E-05
41043110000488142	Formaldehyde	5.62E-03	2.81E-04	1.82E-05	2.58E-04	2.58E-05
48241110000599594	Formaldehyde	5.55E-03	2.78E-04	1.80E-05	2.54E-04	2.54E-05
55073110000422043	Acrolein	5.54E-03	2.01E-04	6.02E-05	1.26E-04	4.07E-05
28077110017416599	Methanol	5.53E-03	2.24E-04	5.73E-05	5.95E-04	1.19E-04
13051110000740958	Acrolein	5.50E-03	1.99E-04	5.98E-05	1.25E-04	4.04E-05
24001110007334072	Hydrochloric acid	5.43E-03	4.22E-03	3.45E-04	2.53E-03	3.80E-04
05041110012414985	Formaldehyde	5.37E-03	2.69E-04	1.74E-05	2.46E-04	2.46E-05
27071110000427501	Formaldehyde	5.35E-03	2.68E-04	1.73E-05	2.45E-04	2.45E-05
12089110000588542	Formaldehyde	5.31E-03	2.66E-04	1.72E-05	2.43E-04	2.43E-05
51093110000560492	Formaldehyde	5.28E-03	2.64E-04	1.71E-05	2.42E-04	2.42E-05
13051110000740958	Formaldehyde	5.24E-03	2.62E-04	1.70E-05	2.40E-04	2.40E-05
22031110000450173	Formaldehyde	5.11E-03	2.56E-04	1.65E-05	2.34E-04	2.34E-05
22049110000597514	Formaldehyde	5.10E-03	2.55E-04	1.65E-05	2.34E-04	2.34E-05
37087110009846480	Formaldehyde	5.09E-03	2.54E-04	1.65E-05	2.33E-04	2.33E-05
05069110000450752	Acrolein	5.03E-03	1.82E-04	5.47E-05	1.14E-04	3.70E-05
53011110000564586	Hydrochloric acid	5.03E-03	3.91E-03	3.20E-04	2.35E-03	3.52E-04
28087110000590940	Arsenic compounds	4.96E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53031110000490326	Formaldehyde	4.96E-03	2.48E-04	1.60E-05	2.27E-04	2.27E-05
53031110000490326	Acrolein	4.86E-03	1.76E-04	5.28E-05	1.10E-04	3.57E-05
51101110007317484	Formaldehyde	4.69E-03	2.35E-04	1.52E-05	2.15E-04	2.15E-05
23029110013359178	Formaldehyde	4.55E-03	2.27E-04	1.47E-05	2.08E-04	2.08E-05
53015110000490898	Formaldehyde	4.50E-03	2.25E-04	1.45E-05	2.06E-04	2.06E-05
12089110000588542	Acetaldehyde	4.49E-03	2.60E-05	4.30E-06	1.17E-04	5.86E-06
47071110017418338	Hydrochloric acid	4.46E-03	3.47E-03	2.84E-04	2.08E-03	3.12E-04
51019110000343922	Mercury (elemental)	4.45E-03	0.00E+00	1.57E-06	0.00E+00	1.33E-06
28087110000590940	Formaldehyde	4.44E-03	2.22E-04	1.44E-05	2.04E-04	2.04E-05
55087110000420973	Formaldehyde	4.44E-03	2.22E-04	1.44E-05	2.04E-04	2.04E-05
51580110012505397	Methanol	4.39E-03	1.78E-04	4.55E-05	4.73E-04	9.46E-05
23019110000581460	Formaldehyde	4.31E-03	2.15E-04	1.39E-05	1.97E-04	1.97E-05
24001110007334072	Chloroform	4.31E-03	0.00E+00	2.08E-06	0.00E+00	2.69E-06
39031110000384735	Acetaldehyde	4.21E-03	2.44E-05	4.04E-06	1.10E-04	5.50E-06
42133110017404664	Formaldehyde	4.20E-03	2.10E-04	1.36E-05	1.92E-04	1.92E-05
42047110000330400	Acetaldehyde	4.14E-03	2.40E-05	3.97E-06	1.08E-04	5.40E-06
23007110000581415	Arsenic compounds	4.14E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55141110000742796	Acrolein	4.09E-03	1.48E-04	4.45E-05	9.30E-05	3.01E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
12123110000362223	Methanol	4.06E-03	1.65E-04	4.21E-05	4.37E-04	8.75E-05
13127110000588365	Formaldehyde	4.03E-03	2.02E-04	1.30E-05	1.85E-04	1.85E-05
24001110007334072	Arsenic compounds	4.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05081110000756352	Formaldehyde	4.00E-03	2.00E-04	1.29E-05	1.83E-04	1.83E-05
01001110011734935	Hydrochloric acid	3.99E-03	3.10E-03	2.54E-04	1.86E-03	2.79E-04
45019110016966381	Formaldehyde	3.97E-03	1.99E-04	1.29E-05	1.82E-04	1.82E-05
40089110000598639	Formaldehyde	3.93E-03	1.96E-04	1.27E-05	1.80E-04	1.80E-05
51670110012503781	Acrolein	3.88E-03	1.40E-04	4.21E-05	8.81E-05	2.85E-05
26043110017422467	Formaldehyde	3.78E-03	1.89E-04	1.22E-05	1.73E-04	1.73E-05
36031110000325005	Formaldehyde	3.77E-03	1.88E-04	1.22E-05	1.73E-04	1.73E-05
05029110000597890	Formaldehyde	3.77E-03	1.88E-04	1.22E-05	1.73E-04	1.73E-05
26043110017422467	Acrolein	3.70E-03	1.34E-04	4.02E-05	8.41E-05	2.72E-05
42047110000330400	Methanol	3.69E-03	1.50E-04	3.83E-05	3.98E-04	7.95E-05
01025110000369280	Formaldehyde	3.65E-03	1.83E-04	1.18E-05	1.67E-04	1.67E-05
47107110000605088	Hydrochloric acid	3.65E-03	2.84E-03	2.32E-04	1.70E-03	2.55E-04
45091110000355035	Acrolein	3.58E-03	1.30E-04	3.89E-05	8.13E-05	2.63E-05
13185110005666421	Formaldehyde	3.54E-03	1.77E-04	1.14E-05	1.62E-04	1.62E-05
26041110017408848	Formaldehyde	3.52E-03	1.76E-04	1.14E-05	1.61E-04	1.61E-05
13099110012384589	Acetaldehyde	3.51E-03	2.04E-05	3.36E-06	9.16E-05	4.58E-06
41039110000488552	Formaldehyde	3.47E-03	1.74E-04	1.12E-05	1.59E-04	1.59E-05
48361110008146130	Acetaldehyde	3.41E-03	1.98E-05	3.27E-06	8.91E-05	4.45E-06
01121110000366121	Formaldehyde	3.40E-03	1.70E-04	1.10E-05	1.56E-04	1.56E-05
53011110000564586	Methanol	3.38E-03	1.37E-04	3.51E-05	3.64E-04	7.28E-05
05069110000450752	Formaldehyde	3.33E-03	1.66E-04	1.08E-05	1.53E-04	1.53E-05
13127110000588365	Hydrochloric acid	3.27E-03	2.54E-03	2.08E-04	1.53E-03	2.29E-04
21091110000380926	Formaldehyde	3.27E-03	1.63E-04	1.06E-05	1.50E-04	1.50E-05
13099110012384589	Acrolein	3.26E-03	1.18E-04	3.54E-05	7.41E-05	2.40E-05
37049110000350478	Formaldehyde	3.22E-03	1.61E-04	1.04E-05	1.47E-04	1.47E-05
23029110013359178	Arsenic compounds	3.14E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53071110005312713	Hydrochloric acid	3.14E-03	2.44E-03	2.00E-04	1.46E-03	2.19E-04
53015110000490898	Acrolein	3.11E-03	1.13E-04	3.39E-05	7.08E-05	2.29E-05
28149110000605220	Methanol	3.10E-03	1.26E-04	3.21E-05	3.33E-04	6.67E-05
01099110000589612	Formaldehyde	3.04E-03	1.52E-04	9.82E-06	1.39E-04	1.39E-05
41041110014206117	Formaldehyde	3.01E-03	1.50E-04	9.73E-06	1.38E-04	1.38E-05
01091110000601965	Formaldehyde	2.95E-03	1.48E-04	9.55E-06	1.35E-04	1.35E-05
23007110000581415	Acetaldehyde	2.86E-03	1.66E-05	2.74E-06	7.46E-05	3.73E-06
37087110009846480	Acrolein	2.84E-03	1.03E-04	3.09E-05	6.45E-05	2.09E-05
45079110000351903	Acetaldehyde	2.83E-03	1.64E-05	2.72E-06	7.39E-05	3.70E-06
45069110016989669	Hydrochloric acid	2.76E-03	2.14E-03	1.75E-04	1.29E-03	1.93E-04

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
37083110000586447	Formaldehyde	2.71E-03	1.35E-04	8.76E-06	1.24E-04	1.24E-05
53011110000564586	Mercury (elemental)	2.70E-03	0.00E+00	9.54E-07	0.00E+00	8.11E-07
05069110000450878	Methanol	2.68E-03	1.09E-04	2.78E-05	2.88E-04	5.77E-05
37117110013794000	Acrolein	2.66E-03	9.64E-05	2.89E-05	6.05E-05	1.96E-05
13051110005670336	Acrolein	2.62E-03	9.49E-05	2.85E-05	5.95E-05	1.93E-05
16069110009335905	Hydrochloric acid	2.59E-03	2.02E-03	1.65E-04	1.21E-03	1.82E-04
51580110012505397	Arsenic compounds	2.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01053110012508580	Methanol	2.55E-03	1.03E-04	2.64E-05	2.74E-04	5.49E-05
22069110039166390	Formaldehyde	2.50E-03	1.25E-04	8.08E-06	1.14E-04	1.14E-05
13179110013498296	Hydrochloric acid	2.45E-03	1.91E-03	1.56E-04	1.14E-03	1.72E-04
28111110002217379	Formaldehyde	2.43E-03	1.22E-04	7.87E-06	1.11E-04	1.11E-05
45079110000351903	Arsenic compounds	2.42E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53011110000564586	Benzene	2.37E-03	1.81E-05	1.18E-06	1.92E-05	6.42E-06
27017110000426263	Acrolein	2.35E-03	8.53E-05	2.56E-05	5.35E-05	1.73E-05
05069110000450752	Arsenic compounds	2.35E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51101110007317484	Acetaldehyde	2.33E-03	1.35E-05	2.23E-06	6.08E-05	3.04E-06
37047110009719304	Methanol	2.23E-03	9.04E-05	2.31E-05	2.40E-04	4.80E-05
13245110000359718	Methanol	2.19E-03	8.88E-05	2.27E-05	2.36E-04	4.71E-05
36031110000325005	Arsenic compounds	2.17E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22033110012384286	Formaldehyde	2.12E-03	1.06E-04	6.85E-06	9.71E-05	9.71E-06
13193110007356002	Formaldehyde	2.11E-03	1.05E-04	6.82E-06	9.66E-05	9.66E-06
45043110000353466	Hydrochloric acid	2.08E-03	1.62E-03	1.32E-04	9.71E-04	1.46E-04
23025110017413468	Formaldehyde	2.02E-03	1.01E-04	6.54E-06	9.26E-05	9.26E-06
05003110000450921	Acetaldehyde	2.02E-03	1.17E-05	1.94E-06	5.28E-05	2.64E-06
13305110007356422	Hydrochloric acid	2.01E-03	1.57E-03	1.28E-04	9.39E-04	1.41E-04
23007110000581415	Hydrochloric acid	1.99E-03	1.55E-03	1.27E-04	9.30E-04	1.39E-04
21007110000732173	Arsenic compounds	1.99E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13021110005666243	Arsenic compounds	1.92E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48067110008148496	Acetaldehyde	1.91E-03	1.11E-05	1.84E-06	5.00E-05	2.50E-06
22125110043794374	Acetaldehyde	1.89E-03	1.10E-05	1.82E-06	4.94E-05	2.47E-06
48361110008146130	Hydrochloric acid	1.88E-03	1.47E-03	1.20E-04	8.79E-04	1.32E-04
05069110000450752	Methanol	1.87E-03	7.57E-05	1.93E-05	2.01E-04	4.02E-05
16069110009335905	Arsenic compounds	1.86E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41041110014206117	Acetaldehyde	1.84E-03	1.07E-05	1.77E-06	4.81E-05	2.40E-06
13051110005670336	Formaldehyde	1.80E-03	8.98E-05	5.81E-06	8.23E-05	8.23E-06
28087110000590940	Methanol	1.79E-03	7.26E-05	1.86E-05	1.93E-04	3.85E-05
41007110013844563	Hydrochloric acid	1.70E-03	1.32E-03	1.08E-04	7.93E-04	1.19E-04
47163110017711289	Acrolein	1.70E-03	6.15E-05	1.84E-05	3.86E-05	1.25E-05
41041110014206117	Chlorine	1.68E-03	2.36E-04	6.10E-05	1.22E-04	4.07E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
12123110000362223	Arsenic compounds	1.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22125110043794374	Hydrochloric acid	1.68E-03	1.30E-03	1.07E-04	7.82E-04	1.17E-04
45043110000353466	Arsenic compounds	1.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51670110012503781	Formaldehyde	1.60E-03	7.99E-05	5.17E-06	7.32E-05	7.32E-06
48361110008146130	Arsenic compounds	1.59E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12005110000518002	Acetaldehyde	1.59E-03	9.21E-06	1.52E-06	4.14E-05	2.07E-06
23019110000581460	Arsenic compounds	1.59E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41043110000488142	Hydrochloric acid	1.57E-03	1.22E-03	1.00E-04	7.34E-04	1.10E-04
55073110000422043	Formaldehyde	1.57E-03	7.85E-05	5.08E-06	7.20E-05	7.20E-06
01025110000369280	Methanol	1.57E-03	6.36E-05	1.63E-05	1.69E-04	3.38E-05
55141110000742796	Formaldehyde	1.52E-03	7.58E-05	4.90E-06	6.95E-05	6.95E-06
41043110000488142	Acrolein	1.51E-03	5.46E-05	1.64E-05	3.43E-05	1.11E-05
48067110008148496	Arsenic compounds	1.50E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27017110000426263	Arsenic compounds	1.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13245110000359718	Arsenic compounds	1.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55069110000422267	Formaldehyde	1.46E-03	7.29E-05	4.71E-06	6.68E-05	6.68E-06
12033110000362447	Acetaldehyde	1.45E-03	8.43E-06	1.39E-06	3.79E-05	1.90E-06
01023110017428773	Hydrochloric acid	1.45E-03	1.13E-03	9.23E-05	6.77E-04	1.01E-04
51009110020680306	Benzene	1.44E-03	1.10E-05	7.22E-07	1.17E-05	3.91E-06
26041110017408848	Arsenic compounds	1.41E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42047110000330400	Mercury (elemental)	1.39E-03	0.00E+00	4.89E-07	0.00E+00	4.16E-07
01113110017400711	Acetaldehyde	1.36E-03	7.92E-06	1.31E-06	3.56E-05	1.78E-06
45043110000353466	Methanol	1.36E-03	5.53E-05	1.41E-05	1.47E-04	2.94E-05
51009110020680306	Acetaldehyde	1.33E-03	7.72E-06	1.28E-06	3.48E-05	1.74E-06
22117110001274521	Hydrochloric acid	1.33E-03	1.03E-03	8.43E-05	6.19E-04	9.28E-05
13115110013763034	Arsenic compounds	1.31E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27071110000427501	Hydrochloric acid	1.31E-03	1.02E-03	8.33E-05	6.11E-04	9.16E-05
37087110009846480	Acetaldehyde	1.31E-03	7.57E-06	1.25E-06	3.41E-05	1.70E-06
05041110012414985	Arsenic compounds	1.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27071110000427501	Arsenic compounds	1.28E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16069110009335905	Acetaldehyde	1.28E-03	7.42E-06	1.23E-06	3.34E-05	1.67E-06
37047110009719304	Arsenic compounds	1.22E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01053110012508580	Arsenic compounds	1.22E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12089110000588551	Acetaldehyde	1.21E-03	7.05E-06	1.16E-06	3.17E-05	1.59E-06
05069110000450878	Arsenic compounds	1.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23017110000491940	Acrolein	1.20E-03	4.35E-05	1.31E-05	2.73E-05	8.83E-06
13051110000740958	Hydrochloric acid	1.17E-03	9.11E-04	7.45E-05	5.47E-04	8.20E-05
01023110017428773	Methanol	1.15E-03	4.65E-05	1.19E-05	1.23E-04	2.47E-05
13115110013763034	Acetaldehyde	1.14E-03	6.64E-06	1.10E-06	2.99E-05	1.49E-06

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
51101110007317484	Arsenic compounds	1.13E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05003110000450921	Arsenic compounds	1.12E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01071110000589435	Hydrochloric acid	1.12E-03	8.72E-04	7.14E-05	5.23E-04	7.85E-05
39141110000395117	Hydrochloric acid	1.11E-03	8.66E-04	7.09E-05	5.20E-04	7.80E-05
12005110000518002	Arsenic compounds	1.11E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37047110009719304	Hydrochloric acid	1.11E-03	8.62E-04	7.05E-05	5.17E-04	7.76E-05
41041110014206117	Arsenic compounds	1.10E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22011110006020028	Formaldehyde	1.08E-03	5.40E-05	3.50E-06	4.95E-05	4.95E-06
13245110000359718	Hydrochloric acid	1.08E-03	8.40E-04	6.87E-05	5.04E-04	7.56E-05
05069110000450878	Hydrochloric acid	1.08E-03	8.37E-04	6.85E-05	5.02E-04	7.54E-05
13185110005666421	Hydrochloric acid	1.07E-03	8.31E-04	6.80E-05	4.99E-04	7.48E-05
22073110017782568	Acetaldehyde	1.06E-03	6.16E-06	1.02E-06	2.77E-05	1.39E-06
53053110000490558	Hydrochloric acid	1.06E-03	8.23E-04	6.74E-05	4.94E-04	7.41E-05
28077110017416599	Hydrochloric acid	1.04E-03	8.08E-04	6.61E-05	4.85E-04	7.27E-05
28077110017416599	Arsenic compounds	1.02E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22011110006020028	Arsenic compounds	1.02E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53071110005312713	Acetaldehyde	1.02E-03	5.90E-06	9.75E-07	2.65E-05	1.33E-06
45019110016966381	Methanol	1.01E-03	4.12E-05	1.05E-05	1.09E-04	2.19E-05
45041110019973493	Arsenic compounds	1.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48361110008146130	Methanol	1.01E-03	4.11E-05	1.05E-05	1.09E-04	2.18E-05
47071110017418338	Arsenic compounds	1.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01001110011734935	Arsenic compounds	9.84E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26101110000412045	Formaldehyde	9.80E-04	4.90E-05	3.17E-06	4.49E-05	4.49E-06
47071110017418338	Acetaldehyde	9.57E-04	5.55E-06	9.18E-07	2.50E-05	1.25E-06
12033110000362447	Arsenic compounds	9.29E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01099110000589612	Arsenic compounds	9.24E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13179110013498296	Acetaldehyde	9.15E-04	5.31E-06	8.78E-07	2.39E-05	1.20E-06
53015110000490852	Methanol	8.83E-04	3.58E-05	9.16E-06	9.51E-05	1.90E-05
01047110002438103	Arsenic compounds	8.80E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45041110019973493	Acetaldehyde	8.74E-04	5.07E-06	8.38E-07	2.28E-05	1.14E-06
13021110005666243	Acrolein	8.70E-04	3.15E-05	9.46E-06	1.98E-05	6.40E-06
22033110012384286	Acetaldehyde	8.67E-04	5.03E-06	8.31E-07	2.26E-05	1.13E-06
12005110000518002	Hydrochloric acid	8.49E-04	6.61E-04	5.40E-05	3.96E-04	5.94E-05
13179110013498296	Arsenic compounds	8.47E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47163110017711289	Formaldehyde	8.41E-04	4.21E-05	2.72E-06	3.86E-05	3.86E-06
05081110000756352	Arsenic compounds	8.39E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13305110007356422	Acetaldehyde	8.32E-04	4.83E-06	7.99E-07	2.17E-05	1.09E-06
13185110005666421	Arsenic compounds	8.32E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12123110000362223	Hydrochloric acid	8.18E-04	6.36E-04	5.20E-05	3.82E-04	5.72E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22033110012384286	Arsenic compounds	8.15E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51093110000560492	Arsenic compounds	8.06E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01113110017400711	Chloroform	7.91E-04	0.00E+00	3.83E-07	0.00E+00	4.94E-07
01131110007233305	Arsenic compounds	7.84E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22049110000597514	Arsenic compounds	7.70E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48067110008148496	Hydrochloric acid	7.65E-04	5.95E-04	4.87E-05	3.57E-04	5.36E-05
45041110019973493	Hydrochloric acid	7.65E-04	5.95E-04	4.87E-05	3.57E-04	5.36E-05
53053110000490558	Acetaldehyde	7.64E-04	4.43E-06	7.33E-07	2.00E-05	9.98E-07
12089110000588542	Arsenic compounds	7.64E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12123110000362223	Mercury (elemental)	7.59E-04	0.00E+00	2.68E-07	0.00E+00	2.28E-07
53011110000564586	Phenol	7.56E-04	7.56E-05	4.93E-05	1.15E-04	2.31E-05
12123110000362223	Phenol	7.53E-04	7.53E-05	4.91E-05	1.15E-04	2.30E-05
05041110012414985	Mercury (elemental)	7.52E-04	0.00E+00	2.65E-07	0.00E+00	2.26E-07
45091110000355035	Hydrochloric acid	7.51E-04	5.84E-04	4.78E-05	3.51E-04	5.26E-05
48241110000599594	Arsenic compounds	7.50E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24001110007334072	Hydrofluoric acid	7.26E-04	2.13E-04	8.71E-06	1.09E-04	1.09E-05
01025110000369280	Arsenic compounds	7.25E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01025110000369280	Hydrochloric acid	7.15E-04	5.56E-04	4.55E-05	3.34E-04	5.00E-05
51101110007317484	Hydrochloric acid	7.12E-04	5.54E-04	4.53E-05	3.32E-04	4.98E-05
53015110000490852	Hydrochloric acid	7.10E-04	5.52E-04	4.52E-05	3.31E-04	4.97E-05
22049110000597514	Hydrochloric acid	7.05E-04	5.48E-04	4.48E-05	3.29E-04	4.93E-05
24001110007334072	Carbon disulfide	7.02E-04	1.09E-04	8.71E-06	1.40E-03	2.72E-05
41007110013844563	Arsenic compounds	7.02E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
39141110000395117	Methanol	7.00E-04	2.84E-05	7.26E-06	7.54E-05	1.51E-05
22073110017782568	Arsenic compounds	6.95E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05041110012414985	Chloroform	6.94E-04	0.00E+00	3.36E-07	0.00E+00	4.34E-07
22033110012384286	Hydrochloric acid	6.90E-04	5.37E-04	4.39E-05	3.22E-04	4.83E-05
22049110000597514	Acetaldehyde	6.89E-04	4.00E-06	6.61E-07	1.80E-05	9.00E-07
01131110007233305	Acetaldehyde	6.86E-04	3.98E-06	6.58E-07	1.79E-05	8.95E-07
13127110000588365	Acetaldehyde	6.82E-04	3.96E-06	6.54E-07	1.78E-05	8.90E-07
12107110000588604	Arsenic compounds	6.77E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015110000490898	Hydrochloric acid	6.77E-04	5.27E-04	4.31E-05	3.16E-04	4.74E-05
53031110000490326	Arsenic compounds	6.72E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12089110000588542	Hydrochloric acid	6.71E-04	5.22E-04	4.27E-05	3.13E-04	4.70E-05
28149110000605220	Arsenic compounds	6.67E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12089110000588542	Methanol	6.60E-04	2.68E-05	6.85E-06	7.11E-05	1.42E-05
45079110000351903	Hydrochloric acid	6.58E-04	5.12E-04	4.19E-05	3.07E-04	4.61E-05
01121110000366121	Arsenic compounds	6.54E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51580110012505397	Hydrofluoric acid	6.44E-04	1.89E-04	7.73E-06	9.66E-05	9.66E-06

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22117110001274521	Arsenic compounds	6.43E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05081110000756352	Acetaldehyde	6.37E-04	3.70E-06	6.11E-07	1.66E-05	8.32E-07
22073110017782568	Hydrochloric acid	6.35E-04	4.94E-04	4.04E-05	2.96E-04	4.44E-05
42013110000332177	Mercury (elemental)	6.32E-04	0.00E+00	2.23E-07	0.00E+00	1.90E-07
42047110000330400	Phenol	6.32E-04	6.32E-05	4.12E-05	9.64E-05	1.93E-05
01099110000589612	Acetaldehyde	6.18E-04	3.59E-06	5.93E-07	1.61E-05	8.07E-07
28111110002217379	Arsenic compounds	6.16E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45069110016989669	Acetaldehyde	6.15E-04	3.57E-06	5.90E-07	1.61E-05	8.03E-07
01047110002438103	Acetaldehyde	6.12E-04	3.55E-06	5.87E-07	1.60E-05	7.99E-07
01053110012508580	Hydrochloric acid	6.05E-04	4.71E-04	3.85E-05	2.83E-04	4.24E-05
37083110000586447	Arsenic compounds	6.05E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45019110016966381	Hydrochloric acid	6.00E-04	4.67E-04	3.82E-05	2.80E-04	4.20E-05
48241110000599594	Acetaldehyde	5.98E-04	3.47E-06	5.74E-07	1.56E-05	7.81E-07
21091110000380926	Hydrochloric acid	5.86E-04	4.56E-04	3.73E-05	2.74E-04	4.10E-05
37087110009846480	Methanol	5.86E-04	2.38E-05	6.07E-06	6.31E-05	1.26E-05
05003110000450921	Hydrochloric acid	5.84E-04	4.55E-04	3.72E-05	2.73E-04	4.09E-05
22031110000450173	Arsenic compounds	5.73E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41041110014206117	Hydrochloric acid	5.71E-04	4.44E-04	3.64E-05	2.67E-04	4.00E-05
12107110000588604	Hydrochloric acid	5.59E-04	4.35E-04	3.56E-05	2.61E-04	3.91E-05
01047110002438103	Hydrochloric acid	5.56E-04	4.33E-04	3.54E-05	2.60E-04	3.89E-05
53011110000564586	Chloroform	5.55E-04	0.00E+00	2.69E-07	0.00E+00	3.47E-07
01099110000589612	Hydrochloric acid	5.53E-04	4.30E-04	3.52E-05	2.58E-04	3.87E-05
26041110017408848	Acetaldehyde	5.52E-04	3.20E-06	5.30E-07	1.44E-05	7.21E-07
37049110000350478	Hydrochloric acid	5.50E-04	4.27E-04	3.50E-05	2.56E-04	3.85E-05
28111110002217379	Acetaldehyde	5.49E-04	3.19E-06	5.27E-07	1.43E-05	7.17E-07
13099110012384589	Methanol	5.49E-04	2.23E-05	5.70E-06	5.92E-05	1.18E-05
55087110000420973	Acrolein	5.49E-04	1.99E-05	5.97E-06	1.25E-05	4.04E-06
22031110000450173	Hydrochloric acid	5.35E-04	4.16E-04	3.40E-05	2.50E-04	3.74E-05
12107110000588604	Acetaldehyde	5.34E-04	3.10E-06	5.12E-07	1.39E-05	6.97E-07
45079110000351903	Mercury (elemental)	5.27E-04	0.00E+00	1.86E-07	0.00E+00	1.58E-07
40089110000598639	Hydrochloric acid	5.26E-04	4.09E-04	3.34E-05	2.45E-04	3.68E-05
12107110000588604	Acrolein	5.17E-04	1.87E-05	5.62E-06	1.18E-05	3.80E-06
23017110000491940	Acetaldehyde	5.17E-04	3.00E-06	4.96E-07	1.35E-05	6.74E-07
36031110000325005	Acetaldehyde	5.10E-04	2.96E-06	4.89E-07	1.33E-05	6.66E-07
13051110000740958	Arsenic compounds	5.09E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45019110016966381	Arsenic compounds	5.09E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13099110012384589	Hydrochloric acid	5.07E-04	3.94E-04	3.23E-05	2.37E-04	3.55E-05
42047110000330400	Benzene	5.03E-04	3.85E-06	2.52E-07	4.09E-06	1.36E-06
01121110000366121	Acetaldehyde	5.03E-04	2.92E-06	4.83E-07	1.31E-05	6.57E-07

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
42047110000330400	Chloroform	5.00E-04	0.00E+00	2.42E-07	0.00E+00	3.13E-07
01071110000589435	Arsenic compounds	4.99E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01091110000601965	Arsenic compounds	4.91E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53031110000490326	Hydrochloric acid	4.90E-04	3.81E-04	3.12E-05	2.29E-04	3.43E-05
37049110000350478	Methanol	4.85E-04	1.97E-05	5.03E-06	5.23E-05	1.05E-05
22125110043794374	Methanol	4.85E-04	1.97E-05	5.03E-06	5.23E-05	1.05E-05
22031110000450173	Acetaldehyde	4.81E-04	2.79E-06	4.62E-07	1.26E-05	6.28E-07
26043110017422467	Acetaldehyde	4.78E-04	2.78E-06	4.59E-07	1.25E-05	6.25E-07
05029110000597890	Arsenic compounds	4.77E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01113110017400711	Hydrochloric acid	4.72E-04	3.67E-04	3.00E-05	2.20E-04	3.30E-05
01113110017400711	Mercury (elemental)	4.67E-04	0.00E+00	1.65E-07	0.00E+00	1.40E-07
05041110012414985	Acetaldehyde	4.67E-04	2.71E-06	4.48E-07	1.22E-05	6.10E-07
05069110000450752	Hydrochloric acid	4.61E-04	3.59E-04	2.93E-05	2.15E-04	3.23E-05
23029110013359178	Hydrochloric acid	4.59E-04	3.57E-04	2.92E-05	2.14E-04	3.21E-05
37087110009846480	Arsenic compounds	4.58E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28149110000605220	Hydrochloric acid	4.57E-04	3.56E-04	2.91E-05	2.13E-04	3.20E-05
12033110000362447	Hydrochloric acid	4.57E-04	3.55E-04	2.91E-05	2.13E-04	3.20E-05
42133110017404664	Acetaldehyde	4.56E-04	2.64E-06	4.37E-07	1.19E-05	5.95E-07
13021110005666243	Hydrochloric acid	4.54E-04	3.53E-04	2.89E-05	2.12E-04	3.18E-05
45079110000351903	Methanol	4.51E-04	1.83E-05	4.68E-06	4.86E-05	9.72E-06
23029110013359178	Acetaldehyde	4.40E-04	2.55E-06	4.22E-07	1.15E-05	5.74E-07
45043110000353466	Chloroform	4.12E-04	0.00E+00	2.00E-07	0.00E+00	2.58E-07
37049110000350478	Chlorine	4.11E-04	5.76E-05	1.49E-05	2.98E-05	9.92E-06
42133110017404664	Hydrochloric acid	4.09E-04	3.18E-04	2.60E-05	1.91E-04	2.86E-05
01121110000366121	Hydrochloric acid	3.98E-04	3.10E-04	2.53E-05	1.86E-04	2.79E-05
12005110000518002	Mercury (elemental)	3.98E-04	0.00E+00	1.40E-07	0.00E+00	1.19E-07
13051110000740958	Acetaldehyde	3.98E-04	2.31E-06	3.82E-07	1.04E-05	5.19E-07
55141110017413547	Hydrochloric acid	3.93E-04	3.05E-04	2.50E-05	1.83E-04	2.75E-05
12033110000362447	Methanol	3.93E-04	1.59E-05	4.07E-06	4.23E-05	8.45E-06
24001110007334072	Phenol	3.92E-04	3.92E-05	2.56E-05	5.98E-05	1.20E-05
41039110000488552	Arsenic compounds	3.91E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22125110043794374	Mercury (elemental)	3.89E-04	0.00E+00	1.37E-07	0.00E+00	1.17E-07
45069110016989669	Methanol	3.88E-04	1.57E-05	4.02E-06	4.18E-05	8.35E-06
13305110007356422	Methanol	3.87E-04	1.57E-05	4.01E-06	4.16E-05	8.33E-06
47163110017711289	Arsenic compounds	3.84E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23007110000581415	Mercury (elemental)	3.83E-04	0.00E+00	1.35E-07	0.00E+00	1.15E-07
01001110011734935	Carbon disulfide	3.82E-04	5.92E-05	4.74E-06	7.64E-04	1.48E-05
51009110020680306	Methanol	3.80E-04	1.54E-05	3.94E-06	4.09E-05	8.18E-06
01091110000601965	Hydrochloric acid	3.77E-04	2.93E-04	2.40E-05	1.76E-04	2.64E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
13051110005670336	Acetaldehyde	3.64E-04	2.11E-06	3.49E-07	9.51E-06	4.76E-07
01091110000601965	Acetaldehyde	3.64E-04	2.11E-06	3.49E-07	9.49E-06	4.75E-07
01047110002438103	Methanol	3.60E-04	1.46E-05	3.73E-06	3.87E-05	7.75E-06
41039110000488552	Methanol	3.57E-04	1.45E-05	3.70E-06	3.84E-05	7.69E-06
48067110008148496	Mercury (elemental)	3.56E-04	0.00E+00	1.26E-07	0.00E+00	1.07E-07
53071110005312713	Methanol	3.53E-04	1.43E-05	3.67E-06	3.81E-05	7.61E-06
21091110000380926	Acetaldehyde	3.53E-04	2.05E-06	3.39E-07	9.22E-06	4.61E-07
23025110017413468	Acrolein	3.52E-04	1.28E-05	3.83E-06	8.00E-06	2.59E-06
01071110000589435	Acetaldehyde	3.51E-04	2.03E-06	3.36E-07	9.16E-06	4.58E-07
01023110017428773	Arsenic compounds	3.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51101110007317484	Methanol	3.37E-04	1.37E-05	3.49E-06	3.63E-05	7.25E-06
41039110000488552	Acetaldehyde	3.32E-04	1.93E-06	3.18E-07	8.67E-06	4.33E-07
53031110000490326	Acetaldehyde	3.27E-04	1.90E-06	3.14E-07	8.55E-06	4.27E-07
27071110000427501	Acetaldehyde	3.26E-04	1.89E-06	3.13E-07	8.52E-06	4.26E-07
40089110000598639	Acetaldehyde	3.25E-04	1.88E-06	3.11E-07	8.48E-06	4.24E-07
41039110000488552	Hydrochloric acid	3.20E-04	2.49E-04	2.04E-05	1.49E-04	2.24E-05
22011110006020028	Acrolein	3.19E-04	1.15E-05	3.46E-06	7.24E-06	2.34E-06
23007110000581415	Methanol	3.18E-04	1.29E-05	3.30E-06	3.42E-05	6.84E-06
27017110000426263	Hydrochloric acid	3.14E-04	2.44E-04	2.00E-05	1.46E-04	2.20E-05
40089110000598639	Arsenic compounds	3.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53053110000490558	Methanol	3.06E-04	1.24E-05	3.17E-06	3.29E-05	6.58E-06
16069110009335905	Mercury (elemental)	3.05E-04	0.00E+00	1.08E-07	0.00E+00	9.16E-08
55073110000422043	Acetaldehyde	2.94E-04	1.70E-06	2.82E-07	7.67E-06	3.83E-07
36031110000325005	Methanol	2.90E-04	1.18E-05	3.00E-06	3.12E-05	6.24E-06
45091110000355035	Arsenic compounds	2.88E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21007110000732173	Carbon disulfide	2.87E-04	4.46E-05	3.56E-06	5.75E-04	1.11E-05
51093110000560492	Acrolein	2.86E-04	1.04E-05	3.11E-06	6.51E-06	2.10E-06
53011110000564586	1,2-Dimethoxyethane	2.81E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45043110000353466	Hydrofluoric acid	2.80E-04	8.20E-05	3.36E-06	4.20E-05	4.20E-06
53027110000490709	Formaldehyde	2.78E-04	1.39E-05	8.98E-07	1.27E-05	1.27E-06
12089110000588551	Arsenic compounds	2.77E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28111110002217379	Hydrochloric acid	2.77E-04	2.15E-04	1.76E-05	1.29E-04	1.94E-05
13127110000588365	Arsenic compounds	2.75E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22011110006020028	Hydrochloric acid	2.73E-04	2.12E-04	1.74E-05	1.27E-04	1.91E-05
47107110000605088	Acrolein	2.72E-04	9.86E-06	2.96E-06	6.18E-06	2.00E-06
37047110009719304	Chloroform	2.69E-04	0.00E+00	1.30E-07	0.00E+00	1.68E-07
53015110000490852	Mercury (elemental)	2.67E-04	0.00E+00	9.43E-08	0.00E+00	8.01E-08
55141110017413547	Arsenic compounds	2.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23025110017413468	Hydrochloric acid	2.60E-04	2.02E-04	1.65E-05	1.21E-04	1.82E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
55073110000422043	Hydrochloric acid	2.59E-04	2.01E-04	1.65E-05	1.21E-04	1.81E-05
13185110005666421	Acetaldehyde	2.56E-04	1.49E-06	2.46E-07	6.68E-06	3.34E-07
22117110001274521	Carbon disulfide	2.54E-04	3.94E-05	3.15E-06	5.08E-04	9.85E-06
41041110014206117	Methanol	2.54E-04	1.03E-05	2.63E-06	2.73E-05	5.46E-06
16069110009335905	Phenol	2.49E-04	2.49E-05	1.62E-05	3.80E-05	7.60E-06
13021110005666243	Acetaldehyde	2.48E-04	1.44E-06	2.38E-07	6.47E-06	3.24E-07
51670110012503781	Arsenic compounds	2.47E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13099110012384589	Phenol	2.46E-04	2.46E-05	1.60E-05	3.75E-05	7.49E-06
42133110017404664	Methanol	2.43E-04	9.88E-06	2.53E-06	2.62E-05	5.24E-06
13127110000588365	Methanol	2.43E-04	9.87E-06	2.52E-06	2.62E-05	5.24E-06
13115110013763034	Mercury (elemental)	2.42E-04	0.00E+00	8.55E-08	0.00E+00	7.27E-08
13245110000359718	Mercury (elemental)	2.42E-04	0.00E+00	8.53E-08	0.00E+00	7.25E-08
51670110012503781	Acetaldehyde	2.41E-04	1.40E-06	2.31E-07	6.28E-06	3.14E-07
55141110000742796	Hydrochloric acid	2.40E-04	1.87E-04	1.53E-05	1.12E-04	1.68E-05
05003110000450921	Methanol	2.37E-04	9.62E-06	2.46E-06	2.55E-05	5.10E-06
42013110000332177	Methanol	2.37E-04	9.60E-06	2.45E-06	2.55E-05	5.10E-06
37049110000350478	Acetaldehyde	2.35E-04	1.36E-06	2.25E-07	6.13E-06	3.06E-07
24001110007334072	Mercury (elemental)	2.35E-04	0.00E+00	8.28E-08	0.00E+00	7.04E-08
28077110017416599	Carbon disulfide	2.34E-04	3.62E-05	2.90E-06	4.67E-04	9.05E-06
12107110000588604	Di(ethylene glycol monobutyl ether) phthalat	2.32E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22069110039166390	Acetaldehyde	2.32E-04	1.35E-06	2.22E-07	6.06E-06	3.03E-07
37083110000586447	Chlorine	2.30E-04	3.23E-05	8.34E-06	1.67E-05	5.56E-06
22069110039166390	Hydrochloric acid	2.29E-04	1.78E-04	1.46E-05	1.07E-04	1.60E-05
28087110000590940	Acrolein	2.29E-04	8.30E-06	2.49E-06	5.21E-06	1.68E-06
23007110000581415	Phenol	2.26E-04	2.26E-05	1.47E-05	3.45E-05	6.91E-06
36113110000324845	Hydrochloric acid	2.24E-04	1.74E-04	1.43E-05	1.05E-04	1.57E-05
51093110000560492	Hydrochloric acid	2.22E-04	1.73E-04	1.42E-05	1.04E-04	1.56E-05
48067110008148496	Methanol	2.21E-04	8.98E-06	2.30E-06	2.38E-05	4.77E-06
05029110000597890	Hydrochloric acid	2.21E-04	1.72E-04	1.40E-05	1.03E-04	1.54E-05
13179110013498296	Mercury (elemental)	2.20E-04	0.00E+00	7.77E-08	0.00E+00	6.61E-08
23019110000581460	Acrolein	2.15E-04	7.81E-06	2.34E-06	4.90E-06	1.58E-06
53031110000490326	Methanol	2.15E-04	8.70E-06	2.22E-06	2.31E-05	4.62E-06
39031110000384735	Methanol	2.11E-04	8.55E-06	2.19E-06	2.27E-05	4.54E-06
45079110000351903	Phenol	2.07E-04	2.07E-05	1.35E-05	3.17E-05	6.33E-06
21007110000732173	Chloroform	2.06E-04	0.00E+00	9.95E-08	0.00E+00	1.29E-07
51093110000560492	Methanol	2.02E-04	8.18E-06	2.09E-06	2.17E-05	4.34E-06
45069110016989669	Arsenic compounds	2.01E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13051110005670336	Hydrochloric acid	2.00E-04	1.56E-04	1.28E-05	9.35E-05	1.40E-05
41007110013844563	Mercury (elemental)	1.99E-04	0.00E+00	7.03E-08	0.00E+00	5.97E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
01131110007233305	Methanol	1.99E-04	8.08E-06	2.06E-06	2.14E-05	4.29E-06
12005110000518002	Phenol	1.99E-04	1.99E-05	1.30E-05	3.03E-05	6.07E-06
05003110000450921	Mercury (elemental)	1.97E-04	0.00E+00	6.96E-08	0.00E+00	5.92E-08
13115110013763034	Phenol	1.94E-04	1.94E-05	1.26E-05	2.96E-05	5.92E-06
39141110000395117	Acetaldehyde	1.94E-04	1.12E-06	1.86E-07	5.05E-06	2.53E-07
01047110002438103	Mercury (elemental)	1.92E-04	0.00E+00	6.77E-08	0.00E+00	5.75E-08
21091110000380926	Arsenic compounds	1.90E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55087110000420973	Hydrochloric acid	1.89E-04	1.47E-04	1.20E-05	8.82E-05	1.32E-05
51019110000343922	Formaldehyde	1.87E-04	9.33E-06	6.04E-07	8.55E-06	8.55E-07
22073110017782568	Mercury (elemental)	1.86E-04	0.00E+00	6.55E-08	0.00E+00	5.57E-08
21007110000732173	Phenol	1.85E-04	1.85E-05	1.21E-05	2.83E-05	5.66E-06
12123110000362223	Methylene chloride	1.85E-04	3.76E-06	1.36E-06	2.59E-06	9.97E-07
01131110007233305	Hydrochloric acid	1.84E-04	1.43E-04	1.17E-05	8.59E-05	1.29E-05
13305110007356422	Mercury (elemental)	1.82E-04	0.00E+00	6.41E-08	0.00E+00	5.45E-08
37117110013794000	Formaldehyde	1.81E-04	9.07E-06	5.87E-07	8.31E-06	8.31E-07
22069110039166390	Arsenic compounds	1.80E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48361110008146130	Phenol	1.79E-04	1.79E-05	1.17E-05	2.73E-05	5.46E-06
27017110000426263	Acetaldehyde	1.78E-04	1.03E-06	1.71E-07	4.65E-06	2.33E-07
42133110017404664	Mercury (elemental)	1.72E-04	0.00E+00	6.07E-08	0.00E+00	5.16E-08
45043110000353466	Phenol	1.71E-04	1.71E-05	1.11E-05	2.61E-05	5.22E-06
01023110017428773	Di(ethylene glycol monobutyl ether) phthalat	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12005110000518002	Methanol	1.67E-04	6.79E-06	1.73E-06	1.80E-05	3.60E-06
37049110000350478	Carbon disulfide	1.67E-04	2.59E-05	2.07E-06	3.34E-04	6.48E-06
41043110000488142	Acetaldehyde	1.67E-04	9.69E-07	1.60E-07	4.36E-06	2.18E-07
12033110000362447	Mercury (elemental)	1.66E-04	0.00E+00	5.85E-08	0.00E+00	4.97E-08
12089110000588542	Phenol	1.65E-04	1.65E-05	1.08E-05	2.52E-05	5.04E-06
45043110000353466	Mercury (elemental)	1.63E-04	0.00E+00	5.74E-08	0.00E+00	4.88E-08
05069110000450878	Chlorine	1.62E-04	2.27E-05	5.88E-06	1.18E-05	3.92E-06
48361110008146130	Mercury (elemental)	1.59E-04	0.00E+00	5.62E-08	0.00E+00	4.78E-08
45091110000355035	Acetaldehyde	1.57E-04	9.09E-07	1.50E-07	4.09E-06	2.04E-07
53027110000490709	Mercury (elemental)	1.56E-04	0.00E+00	5.52E-08	0.00E+00	4.69E-08
37047110009719304	Mercury (elemental)	1.56E-04	0.00E+00	5.49E-08	0.00E+00	4.67E-08
01071110000589435	Mercury (elemental)	1.55E-04	0.00E+00	5.48E-08	0.00E+00	4.66E-08
47071110017418338	Mercury (elemental)	1.54E-04	0.00E+00	5.43E-08	0.00E+00	4.62E-08
41007110013844563	Phenol	1.52E-04	1.52E-05	9.93E-06	2.33E-05	4.65E-06
55141110000742796	Acetaldehyde	1.47E-04	8.55E-07	1.41E-07	3.85E-06	1.92E-07
45041110019973493	Mercury (elemental)	1.46E-04	0.00E+00	5.16E-08	0.00E+00	4.38E-08
53015110000490852	Phenol	1.46E-04	1.46E-05	9.49E-06	2.22E-05	4.45E-06
16069110009335905	1,2-Dimethoxyethane	1.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22049110000597514	Mercury (elemental)	1.45E-04	0.00E+00	5.13E-08	0.00E+00	4.36E-08
37083110000586447	Acetaldehyde	1.45E-04	8.42E-07	1.39E-07	3.79E-06	1.89E-07
01023110017428773	Mercury (elemental)	1.44E-04	0.00E+00	5.08E-08	0.00E+00	4.32E-08
05069110000450878	Hydrofluoric acid	1.43E-04	4.20E-05	1.72E-06	2.15E-05	2.15E-06
39141110000395117	Mercury (elemental)	1.43E-04	0.00E+00	5.03E-08	0.00E+00	4.28E-08
16069110009335905	Methanol	1.43E-04	5.79E-06	1.48E-06	1.54E-05	3.07E-06
13051110000740958	Mercury (elemental)	1.41E-04	0.00E+00	4.97E-08	0.00E+00	4.23E-08
01053110012508580	Mercury (elemental)	1.41E-04	0.00E+00	4.97E-08	0.00E+00	4.22E-08
01131110007233305	Mercury (elemental)	1.41E-04	0.00E+00	4.97E-08	0.00E+00	4.22E-08
48067110008148496	Phenol	1.38E-04	1.38E-05	9.02E-06	2.11E-05	4.22E-06
28077110017416599	Hydrofluoric acid	1.38E-04	4.04E-05	1.66E-06	2.07E-05	2.07E-06
05003110000450921	Phenol	1.37E-04	1.37E-05	8.91E-06	2.09E-05	4.17E-06
22073110017782568	Methanol	1.37E-04	5.54E-06	1.42E-06	1.47E-05	2.94E-06
27071110000427501	Benzene	1.36E-04	1.04E-06	6.82E-08	1.11E-06	3.69E-07
48361110008146130	Hydrofluoric acid	1.36E-04	3.97E-05	1.63E-06	2.03E-05	2.03E-06
53053110000490558	Mercury (elemental)	1.35E-04	0.00E+00	4.78E-08	0.00E+00	4.06E-08
22011110006020028	Mercury (elemental)	1.34E-04	0.00E+00	4.74E-08	0.00E+00	4.03E-08
51580110012505397	Phenol	1.33E-04	1.33E-05	8.67E-06	2.03E-05	4.06E-06
22117110001274521	Benzene	1.31E-04	1.00E-06	6.55E-08	1.06E-06	3.55E-07
01001110011734935	Mercury (elemental)	1.31E-04	0.00E+00	4.61E-08	0.00E+00	3.92E-08
22031110000450173	Mercury (elemental)	1.29E-04	0.00E+00	4.56E-08	0.00E+00	3.88E-08
28077110017416599	Phenol	1.29E-04	1.29E-05	8.41E-06	1.97E-05	3.94E-06
53071110005312713	Phenol	1.28E-04	1.28E-05	8.35E-06	1.96E-05	3.91E-06
01091110000601965	Mercury (elemental)	1.27E-04	0.00E+00	4.49E-08	0.00E+00	3.81E-08
40089110000598639	Mercury (elemental)	1.27E-04	0.00E+00	4.47E-08	0.00E+00	3.80E-08
01001110011734935	Chloroform	1.26E-04	0.00E+00	6.11E-08	0.00E+00	7.89E-08
47071110017418338	Phenol	1.25E-04	1.25E-05	8.17E-06	1.91E-05	3.83E-06
37047110009719304	Phenol	1.25E-04	1.25E-05	8.17E-06	1.91E-05	3.82E-06
13051110005670336	Methanol	1.25E-04	5.08E-06	1.30E-06	1.35E-05	2.69E-06
21007110000732173	Mercury (elemental)	1.25E-04	0.00E+00	4.40E-08	0.00E+00	3.74E-08
13179110013498296	Phenol	1.24E-04	1.24E-05	8.10E-06	1.90E-05	3.79E-06
12089110000588551	Methanol	1.24E-04	5.02E-06	1.28E-06	1.33E-05	2.67E-06
37117110013794000	Acetaldehyde	1.24E-04	7.17E-07	1.19E-07	3.23E-06	1.61E-07
23017110000491940	Methanol	1.22E-04	4.96E-06	1.27E-06	1.32E-05	2.63E-06
13245110000359718	Chloroform	1.20E-04	0.00E+00	5.81E-08	0.00E+00	7.50E-08
05069110000450878	Mercury (elemental)	1.19E-04	0.00E+00	4.19E-08	0.00E+00	3.56E-08
01001110011734935	Phenol	1.18E-04	1.18E-05	7.72E-06	1.81E-05	3.61E-06
01113110017400711	Methanol	1.17E-04	4.74E-06	1.21E-06	1.26E-05	2.51E-06
12005110000518002	Hydrofluoric acid	1.17E-04	3.41E-05	1.40E-06	1.75E-05	1.75E-06

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
48241110000599594	Hydrochloric acid	1.16E-04	8.99E-05	7.36E-06	5.40E-05	8.09E-06
01053110012508580	Phenol	1.14E-04	1.14E-05	7.46E-06	1.75E-05	3.49E-06
45091110000355035	Mercury (elemental)	1.14E-04	0.00E+00	4.04E-08	0.00E+00	3.43E-08
05069110000450878	Carbon disulfide	1.12E-04	1.73E-05	1.39E-06	2.24E-04	4.33E-06
47163110017711289	Acetaldehyde	1.12E-04	6.48E-07	1.07E-07	2.91E-06	1.46E-07
53071110005312713	Benzene	1.11E-04	8.50E-07	5.56E-08	9.03E-07	3.01E-07
53071110005312713	Mercury (elemental)	1.10E-04	0.00E+00	3.90E-08	0.00E+00	3.31E-08
13245110000359718	Carbon disulfide	1.10E-04	1.71E-05	1.37E-06	2.21E-04	4.27E-06
24001110007334072	Benzene	1.09E-04	8.37E-07	5.47E-08	8.89E-07	2.96E-07
37047110009719304	Carbon disulfide	1.09E-04	1.69E-05	1.36E-06	2.19E-04	4.24E-06
28149110000605220	Mercury (elemental)	1.09E-04	0.00E+00	3.85E-08	0.00E+00	3.27E-08
05069110000450878	Phenol	1.09E-04	1.09E-05	7.11E-06	1.67E-05	3.33E-06
01113110017400711	Phenol	1.09E-04	1.09E-05	7.10E-06	1.66E-05	3.33E-06
22033110012384286	Mercury (elemental)	1.08E-04	0.00E+00	3.83E-08	0.00E+00	3.25E-08
42133110017404664	Hydrofluoric acid	1.08E-04	3.17E-05	1.30E-06	1.63E-05	1.63E-06
28149110000605220	Chloroform	1.08E-04	0.00E+00	5.24E-08	0.00E+00	6.77E-08
21007110000732173	Benzene	1.08E-04	8.25E-07	5.40E-08	8.77E-07	2.92E-07
01053110012508580	Carbon disulfide	1.08E-04	1.67E-05	1.34E-06	2.15E-04	4.17E-06
13193110007356002	Acetaldehyde	1.07E-04	6.22E-07	1.03E-07	2.80E-06	1.40E-07
45041110019973493	Phenol	1.06E-04	1.06E-05	6.89E-06	1.61E-05	3.23E-06
12089110000588542	Mercury (elemental)	1.05E-04	0.00E+00	3.71E-08	0.00E+00	3.15E-08
12123110000362223	Carbon disulfide	1.05E-04	1.63E-05	1.30E-06	2.10E-04	4.07E-06
53031110000490326	Mercury (elemental)	1.05E-04	0.00E+00	3.69E-08	0.00E+00	3.14E-08
37083110000586447	Mercury (elemental)	1.04E-04	0.00E+00	3.65E-08	0.00E+00	3.11E-08
53015110000490898	Arsenic compounds	1.02E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37047110009719304	Hydrofluoric acid	1.02E-04	2.99E-05	1.23E-06	1.53E-05	1.53E-06
51101110007317484	Mercury (elemental)	1.01E-04	0.00E+00	3.56E-08	0.00E+00	3.02E-08
28149110000605220	Phenol	1.01E-04	1.01E-05	6.56E-06	1.54E-05	3.07E-06
45091110000355035	Methanol	1.00E-04	4.06E-06	1.04E-06	1.08E-05	2.16E-06
45079110000351903	Benzene	9.94E-05	7.60E-07	4.97E-08	8.08E-07	2.69E-07
22117110001274521	Mercury (elemental)	9.83E-05	0.00E+00	3.47E-08	0.00E+00	2.95E-08
23025110017413468	Arsenic compounds	9.82E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13305110007356422	Phenol	9.75E-05	9.75E-06	6.35E-06	1.49E-05	2.98E-06
53053110000490558	Phenol	9.73E-05	9.73E-06	6.34E-06	1.49E-05	2.97E-06
01001110011734935	Benzene	9.64E-05	7.37E-07	4.82E-08	7.83E-07	2.61E-07
26043110017422467	Mercury (elemental)	9.59E-05	0.00E+00	3.39E-08	0.00E+00	2.88E-08
21007110000732173	Hydrofluoric acid	9.57E-05	2.80E-05	1.15E-06	1.44E-05	1.44E-06
45069110016989669	Mercury (elemental)	9.53E-05	0.00E+00	3.36E-08	0.00E+00	2.86E-08
41007110013844563	1,2-Dimethoxyethane	9.49E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
01071110000589435	Phenol	9.47E-05	9.47E-06	6.17E-06	1.45E-05	2.89E-06
48241110000599594	Mercury (elemental)	9.46E-05	0.00E+00	3.34E-08	0.00E+00	2.84E-08
01121110000366121	Mercury (elemental)	9.35E-05	0.00E+00	3.30E-08	0.00E+00	2.81E-08
21007110000732173	Hydrochloric acid	9.32E-05	7.25E-05	5.93E-06	4.35E-05	6.53E-06
36113110000324845	Methanol	9.30E-05	3.77E-06	9.64E-07	1.00E-05	2.00E-06
13115110013763034	Methanol	9.29E-05	3.77E-06	9.63E-07	1.00E-05	2.00E-06
05081110000756352	Methanol	9.27E-05	3.76E-06	9.61E-07	9.98E-06	2.00E-06
05081110000756352	Mercury (elemental)	9.27E-05	0.00E+00	3.27E-08	0.00E+00	2.78E-08
37117110013794000	Methanol	9.24E-05	3.75E-06	9.58E-07	9.95E-06	1.99E-06
23007110000581415	Chloroform	9.16E-05	0.00E+00	4.43E-08	0.00E+00	5.72E-08
51580110012505397	Carbon disulfide	9.14E-05	1.42E-05	1.13E-06	1.83E-04	3.54E-06
45079110000351903	Chloroform	9.06E-05	0.00E+00	4.38E-08	0.00E+00	5.66E-08
47071110017418338	Methanol	8.98E-05	3.64E-06	9.31E-07	9.67E-06	1.93E-06
51093110000560492	Acetaldehyde	8.96E-05	5.20E-07	8.60E-08	2.34E-06	1.17E-07
53015110000490898	Methanol	8.92E-05	3.62E-06	9.25E-07	9.61E-06	1.92E-06
13021110005666243	Methanol	8.87E-05	3.60E-06	9.20E-07	9.55E-06	1.91E-06
47163110017711289	Hydrochloric acid	8.87E-05	6.90E-05	5.64E-06	4.14E-05	6.21E-06
51101110007317484	Phenol	8.86E-05	8.86E-06	5.77E-06	1.35E-05	2.70E-06
45069110016989669	Benzene	8.84E-05	6.76E-07	4.42E-08	7.19E-07	2.40E-07
55141110017413547	Hydrofluoric acid	8.81E-05	2.58E-05	1.06E-06	1.32E-05	1.32E-06
37049110000350478	Arsenic compounds	8.76E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51580110012505397	Benzene	8.76E-05	6.70E-07	4.38E-08	7.12E-07	2.37E-07
13245110000359718	Phenol	8.70E-05	8.70E-06	5.67E-06	1.33E-05	2.66E-06
41039110000488552	Mercury (elemental)	8.70E-05	0.00E+00	3.07E-08	0.00E+00	2.61E-08
01099110000589612	Mercury (elemental)	8.70E-05	0.00E+00	3.07E-08	0.00E+00	2.61E-08
22049110000597514	Phenol	8.63E-05	8.63E-06	5.62E-06	1.32E-05	2.63E-06
55069110000422267	Benzene	8.61E-05	6.58E-07	4.30E-08	6.99E-07	2.33E-07
13099110012384589	Arsenic compounds	8.45E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015110000490898	Mercury (elemental)	8.34E-05	0.00E+00	2.94E-08	0.00E+00	2.50E-08
13305110007356422	Chloroform	8.21E-05	0.00E+00	3.97E-08	0.00E+00	5.13E-08
37083110000586447	Hydrochloric acid	8.15E-05	6.34E-05	5.18E-06	3.80E-05	5.70E-06
01099110000589612	Methanol	8.02E-05	3.25E-06	8.31E-07	8.63E-06	1.73E-06
53053110000490558	Chloroform	7.94E-05	0.00E+00	3.84E-08	0.00E+00	4.96E-08
21007110000732173	Xylenes (mixed)	7.83E-05	3.07E-06	4.30E-07	0.00E+00	0.00E+00
23007110000581415	Benzene	7.79E-05	5.96E-07	3.89E-08	6.33E-07	2.11E-07
13127110000588365	Benzene	7.74E-05	5.92E-07	3.87E-08	6.29E-07	2.10E-07
53015110000490898	Acetaldehyde	7.70E-05	4.47E-07	7.38E-08	2.01E-06	1.01E-07
45041110019973493	Methanol	7.65E-05	3.10E-06	7.93E-07	8.24E-06	1.65E-06
37049110000350478	Mercury (elemental)	7.60E-05	0.00E+00	2.68E-08	0.00E+00	2.28E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22011110006020028	Acetaldehyde	7.52E-05	4.36E-07	7.21E-08	1.96E-06	9.81E-08
01001110011734935	Hydrofluoric acid	7.42E-05	2.17E-05	8.91E-07	1.11E-05	1.11E-06
47107110000605088	Acetaldehyde	7.41E-05	4.30E-07	7.11E-08	1.93E-06	9.67E-08
45043110000353466	Carbon disulfide	7.29E-05	1.13E-05	9.03E-07	1.46E-04	2.82E-06
53031110000490326	Phenol	7.22E-05	7.22E-06	4.71E-06	1.10E-05	2.21E-06
41043110000488142	Methanol	7.22E-05	2.93E-06	7.48E-07	7.77E-06	1.55E-06
51580110012505397	Mercury (elemental)	7.17E-05	0.00E+00	2.53E-08	0.00E+00	2.15E-08
05069110000450752	Benzene	7.08E-05	5.41E-07	3.54E-08	5.75E-07	1.92E-07
28077110017416599	Mercury (elemental)	7.08E-05	0.00E+00	2.50E-08	0.00E+00	2.12E-08
13185110005666421	Mercury (elemental)	6.94E-05	0.00E+00	2.45E-08	0.00E+00	2.08E-08
36031110000325005	Mercury (elemental)	6.86E-05	0.00E+00	2.42E-08	0.00E+00	2.06E-08
22033110012384286	Methanol	6.82E-05	2.77E-06	7.07E-07	7.35E-06	1.47E-06
48067110008148496	Benzene	6.81E-05	5.21E-07	3.41E-08	5.53E-07	1.84E-07
53015110000490898	Phenol	6.80E-05	6.80E-06	4.43E-06	1.04E-05	2.08E-06
05081110000756352	Phenol	6.78E-05	6.78E-06	4.42E-06	1.03E-05	2.07E-06
12005110000518002	Benzene	6.71E-05	5.13E-07	3.36E-08	5.46E-07	1.82E-07
28087110000590940	Mercury (elemental)	6.70E-05	0.00E+00	2.36E-08	0.00E+00	2.01E-08
53071110005312713	Chloroform	6.68E-05	0.00E+00	3.23E-08	0.00E+00	4.17E-08
13245110000359718	Hydrofluoric acid	6.65E-05	1.95E-05	7.98E-07	9.98E-06	9.98E-07
12005110000518002	1,2-Dimethoxyethane	6.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45091110000355035	Phenol	6.63E-05	6.63E-06	4.32E-06	1.01E-05	2.02E-06
47107110000605088	Methanol	6.56E-05	2.66E-06	6.80E-07	7.06E-06	1.41E-06
47163110017711289	Mercury (elemental)	6.47E-05	0.00E+00	2.29E-08	0.00E+00	1.94E-08
24001110007334072	Xylenes (mixed)	6.40E-05	2.51E-06	3.52E-07	0.00E+00	0.00E+00
13099110012384589	Chloroform	6.37E-05	0.00E+00	3.08E-08	0.00E+00	3.98E-08
51101110007317484	Hydrofluoric acid	6.33E-05	1.85E-05	7.60E-07	9.50E-06	9.50E-07
22117110001274521	Phenol	6.30E-05	6.30E-06	4.11E-06	9.62E-06	1.92E-06
01071110000589435	1,2-Dimethoxyethane	6.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22073110017782568	Phenol	6.29E-05	6.29E-06	4.10E-06	9.59E-06	1.92E-06
22069110039166390	Mercury (elemental)	6.28E-05	0.00E+00	2.22E-08	0.00E+00	1.89E-08
12107110000588604	Methanol	6.28E-05	2.55E-06	6.51E-07	6.76E-06	1.35E-06
28111110002217379	Mercury (elemental)	6.25E-05	0.00E+00	2.20E-08	0.00E+00	1.87E-08
45069110016989669	Phenol	6.19E-05	6.19E-06	4.03E-06	9.45E-06	1.89E-06
13021110005666243	Mercury (elemental)	6.13E-05	0.00E+00	2.16E-08	0.00E+00	1.84E-08
28149110000605220	Benzene	6.10E-05	4.67E-07	3.05E-08	4.96E-07	1.65E-07
12107110000588604	Mercury (elemental)	6.10E-05	0.00E+00	2.15E-08	0.00E+00	1.83E-08
22049110000597514	Methanol	6.08E-05	2.47E-06	6.30E-07	6.55E-06	1.31E-06
48067110008148496	Chloroform	6.07E-05	0.00E+00	2.94E-08	0.00E+00	3.79E-08
55087110000420973	Acetaldehyde	6.03E-05	3.50E-07	5.79E-08	1.58E-06	7.88E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
48361110008146130	Chloroform	6.03E-05	0.00E+00	2.92E-08	0.00E+00	3.77E-08
28149110000605220	Hydrofluoric acid	6.00E-05	1.76E-05	7.20E-07	8.99E-06	8.99E-07
21091110000380926	Phenol	6.00E-05	6.00E-06	3.91E-06	9.15E-06	1.83E-06
01025110000369280	Mercury (elemental)	5.97E-05	0.00E+00	2.11E-08	0.00E+00	1.79E-08
53015110000490852	Hydrofluoric acid	5.93E-05	1.74E-05	7.12E-07	8.90E-06	8.90E-07
53015110000490852	Benzene	5.92E-05	4.53E-07	2.96E-08	4.81E-07	1.60E-07
13185110005666421	Methanol	5.89E-05	2.39E-06	6.11E-07	6.34E-06	1.27E-06
55069110000422267	Acetaldehyde	5.86E-05	3.40E-07	5.62E-08	1.53E-06	7.65E-08
21091110000380926	Mercury (elemental)	5.80E-05	0.00E+00	2.05E-08	0.00E+00	1.74E-08
26041110017408848	Phenol	5.79E-05	5.79E-06	3.78E-06	8.84E-06	1.77E-06
01121110000366121	Phenol	5.78E-05	5.78E-06	3.77E-06	8.83E-06	1.77E-06
05041110012414985	Hydrochloric acid	5.78E-05	4.50E-05	3.68E-06	2.70E-05	4.05E-06
13179110013498296	Methanol	5.71E-05	2.32E-06	5.92E-07	6.15E-06	1.23E-06
53015110000490852	Chloroform	5.57E-05	0.00E+00	2.70E-08	0.00E+00	3.48E-08
01091110000601965	Phenol	5.40E-05	5.40E-06	3.52E-06	8.25E-06	1.65E-06
28087110000590940	Hydrochloric acid	5.36E-05	4.17E-05	3.41E-06	2.50E-05	3.75E-06
28077110017416599	Chloroform	5.35E-05	0.00E+00	2.59E-08	0.00E+00	3.35E-08
13127110000588365	Mercury (elemental)	5.33E-05	0.00E+00	1.88E-08	0.00E+00	1.60E-08
53011110000564586	Xylenes (mixed)	5.27E-05	2.07E-06	2.90E-07	0.00E+00	0.00E+00
37049110000350478	Phenol	5.27E-05	5.27E-06	3.43E-06	8.04E-06	1.61E-06
41041110014206117	Phenol	5.27E-05	5.27E-06	3.43E-06	8.04E-06	1.61E-06
28087110000590940	Acetaldehyde	5.26E-05	3.05E-07	5.05E-08	1.37E-06	6.87E-08
12033110000362447	Phenol	5.20E-05	5.20E-06	3.39E-06	7.94E-06	1.59E-06
13193110007356002	Methanol	5.20E-05	2.11E-06	5.39E-07	5.60E-06	1.12E-06
01053110012508580	Hydrofluoric acid	5.19E-05	1.52E-05	6.23E-07	7.78E-06	7.78E-07
26041110017408848	Methanol	5.16E-05	2.09E-06	5.35E-07	5.56E-06	1.11E-06
12005110000518002	Chloroform	5.15E-05	0.00E+00	2.49E-08	0.00E+00	3.22E-08
01113110017400711	1,2-Dimethoxyethane	5.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13305110007356422	Benzene	5.13E-05	3.93E-07	2.57E-08	4.17E-07	1.39E-07
01099110000589612	Phenol	5.13E-05	5.13E-06	3.35E-06	7.83E-06	1.57E-06
41041110014206117	Mercury (elemental)	5.10E-05	0.00E+00	1.80E-08	0.00E+00	1.53E-08
45043110000353466	Benzene	5.10E-05	3.90E-07	2.55E-08	4.14E-07	1.38E-07
13115110013763034	Benzene	5.07E-05	3.88E-07	2.54E-08	4.12E-07	1.37E-07
05041110012414985	Methanol	5.06E-05	2.06E-06	5.25E-07	5.45E-06	1.09E-06
01121110000366121	Methanol	5.03E-05	2.04E-06	5.22E-07	5.42E-06	1.08E-06
01131110007233305	Phenol	5.02E-05	5.02E-06	3.27E-06	7.66E-06	1.53E-06
23029110013359178	Phenol	5.01E-05	5.01E-06	3.27E-06	7.65E-06	1.53E-06
16069110009335905	Benzene	5.01E-05	3.83E-07	2.50E-08	4.07E-07	1.36E-07
05041110012414985	Carbon tetrachloride	4.98E-05	3.38E-07	7.88E-08	7.28E-07	1.50E-07

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
13179110013498296	Benzene	4.95E-05	3.79E-07	2.48E-08	4.02E-07	1.34E-07
23019110000581460	Acetaldehyde	4.91E-05	2.85E-07	4.71E-08	1.28E-06	6.41E-08
13245110000359718	Benzene	4.90E-05	3.75E-07	2.45E-08	3.98E-07	1.33E-07
37047110009719304	Benzene	4.90E-05	3.75E-07	2.45E-08	3.98E-07	1.33E-07
01025110000369280	Carbon disulfide	4.89E-05	7.57E-06	6.06E-07	9.77E-05	1.89E-06
53053110000490558	Benzene	4.83E-05	3.69E-07	2.41E-08	3.92E-07	1.31E-07
51093110000560492	Chlorine	4.81E-05	6.74E-06	1.74E-06	3.48E-06	1.16E-06
48241110000599594	Methanol	4.81E-05	1.95E-06	4.99E-07	5.18E-06	1.04E-06
13051110005670336	Mercury (elemental)	4.75E-05	0.00E+00	1.68E-08	0.00E+00	1.42E-08
55069110000422267	Hydrochloric acid	4.74E-05	3.69E-05	3.02E-06	2.21E-05	3.32E-06
13193110007356002	Phenol	4.72E-05	4.72E-06	3.08E-06	7.21E-06	1.44E-06
42133110017404664	Phenol	4.68E-05	4.68E-06	3.05E-06	7.14E-06	1.43E-06
37087110009846480	Phenol	4.68E-05	4.68E-06	3.05E-06	7.14E-06	1.43E-06
01091110000601965	Methanol	4.67E-05	1.90E-06	4.84E-07	5.03E-06	1.01E-06
55073110000422043	Mercury (elemental)	4.64E-05	0.00E+00	1.64E-08	0.00E+00	1.39E-08
55141110017413547	Chloroform	4.57E-05	0.00E+00	2.21E-08	0.00E+00	2.86E-08
13115110013763034	Chloroform	4.51E-05	0.00E+00	2.18E-08	0.00E+00	2.82E-08
55141110017413547	Benzene	4.49E-05	3.44E-07	2.25E-08	3.65E-07	1.22E-07
13193110007356002	Arsenic compounds	4.47E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26101110000412045	Benzene	4.46E-05	3.41E-07	2.23E-08	3.62E-07	1.21E-07
05003110000450921	Benzene	4.43E-05	3.39E-07	2.21E-08	3.60E-07	1.20E-07
48361110008146130	Benzene	4.34E-05	3.32E-07	2.17E-08	3.52E-07	1.17E-07
26041110017408848	Benzene	4.31E-05	3.30E-07	2.16E-08	3.50E-07	1.17E-07
53011110000564586	Methylene chloride	4.30E-05	8.73E-07	3.17E-07	6.02E-07	2.32E-07
26041110017408848	Mercury (elemental)	4.29E-05	0.00E+00	1.51E-08	0.00E+00	1.29E-08
27017110000426263	Methanol	4.26E-05	1.73E-06	4.42E-07	4.59E-06	9.17E-07
28111110002217379	Phenol	4.26E-05	4.26E-06	2.78E-06	6.50E-06	1.30E-06
51093110000560492	Hydrofluoric acid	4.24E-05	1.24E-05	5.08E-07	6.36E-06	6.36E-07
42047110000330400	Xylenes (mixed)	4.23E-05	1.66E-06	2.33E-07	0.00E+00	0.00E+00
37087110009846480	Hydrochloric acid	4.22E-05	3.29E-05	2.69E-06	1.97E-05	2.96E-06
22031110000450173	Methanol	4.22E-05	1.71E-06	4.38E-07	4.55E-06	9.09E-07
53011110000564586	Carbon disulfide	4.22E-05	6.54E-06	5.23E-07	8.44E-05	1.63E-06
05069110000450752	Carbon disulfide	4.19E-05	6.49E-06	5.19E-07	8.38E-05	1.62E-06
48067110008148496	1,2-Dimethoxyethane	4.18E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28149110000605220	Xylenes (mixed)	4.16E-05	1.63E-06	2.29E-07	0.00E+00	0.00E+00
51670110012503781	Mercury (elemental)	4.12E-05	0.00E+00	1.46E-08	0.00E+00	1.24E-08
16069110009335905	Chloroform	4.12E-05	0.00E+00	1.99E-08	0.00E+00	2.57E-08
01053110012508580	Chloroform	4.06E-05	0.00E+00	1.96E-08	0.00E+00	2.54E-08
13179110013498296	Chloroform	4.05E-05	0.00E+00	1.96E-08	0.00E+00	2.53E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
05003110000450921	Chloroform	4.03E-05	0.00E+00	1.95E-08	0.00E+00	2.52E-08
45019110016966381	Mercury (elemental)	4.00E-05	0.00E+00	1.41E-08	0.00E+00	1.20E-08
13051110000740958	Methanol	3.95E-05	1.60E-06	4.10E-07	4.25E-06	8.51E-07
42047110000330400	Carbon disulfide	3.95E-05	6.12E-06	4.90E-07	7.90E-05	1.53E-06
13185110005666421	Benzene	3.93E-05	3.00E-07	1.96E-08	3.19E-07	1.06E-07
51580110012505397	Chloroform	3.92E-05	0.00E+00	1.90E-08	0.00E+00	2.45E-08
36031110000325005	1,2-Dimethoxyethane	3.91E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12033110000362447	Chloroform	3.88E-05	0.00E+00	1.88E-08	0.00E+00	2.42E-08
55087110000420973	Arsenic compounds	3.86E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28111110002217379	Methanol	3.85E-05	1.56E-06	3.99E-07	4.14E-06	8.28E-07
51580110012505397	1,2-Dimethoxyethane	3.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41007110013844563	Benzene	3.80E-05	2.91E-07	1.90E-08	3.09E-07	1.03E-07
01053110012508580	Benzene	3.80E-05	2.90E-07	1.90E-08	3.08E-07	1.03E-07
28077110017416599	Benzene	3.78E-05	2.89E-07	1.89E-08	3.07E-07	1.02E-07
47071110017418338	Benzene	3.78E-05	2.89E-07	1.89E-08	3.07E-07	1.02E-07
53015110000490898	1,2-Dimethoxyethane	3.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45069110016989669	Chloroform	3.77E-05	0.00E+00	1.82E-08	0.00E+00	2.35E-08
26043110017422467	Methanol	3.76E-05	1.52E-06	3.90E-07	4.04E-06	8.09E-07
01071110000589435	Methanol	3.73E-05	1.51E-06	3.86E-07	4.01E-06	8.03E-07
45041110019973493	Benzene	3.72E-05	2.85E-07	1.86E-08	3.02E-07	1.01E-07
39031110000384735	Styrene	3.71E-05	9.16E-06	1.42E-06	3.71E-06	7.08E-07
22033110012384286	Phenol	3.69E-05	3.69E-06	2.40E-06	5.63E-06	1.13E-06
13245110000359718	1,2-Dimethoxyethane	3.67E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55141110017413547	Carbon disulfide	3.67E-05	5.69E-06	4.55E-07	7.34E-05	1.42E-06
23025110017413468	Acetaldehyde	3.67E-05	2.13E-07	3.52E-08	9.58E-07	4.79E-08
13127110000588365	Phenol	3.66E-05	3.66E-06	2.39E-06	5.59E-06	1.12E-06
26043110017422467	Phenol	3.65E-05	3.65E-06	2.38E-06	5.57E-06	1.11E-06
55073110000422043	Phenol	3.65E-05	3.65E-06	2.38E-06	5.56E-06	1.11E-06
39031110000384735	Toluene	3.64E-05	1.80E-06	2.99E-07	7.09E-06	1.22E-06
21007110000732173	Methylene chloride	3.64E-05	7.38E-07	2.68E-07	5.09E-07	1.96E-07
05069110000450878	Benzene	3.62E-05	2.77E-07	1.81E-08	2.94E-07	9.80E-08
36031110000325005	Phenol	3.60E-05	3.60E-06	2.35E-06	5.50E-06	1.10E-06
45079110000351903	1,2-Dimethoxyethane	3.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37083110000586447	Chloroform	3.57E-05	0.00E+00	1.73E-08	0.00E+00	2.23E-08
28111110002217379	Hydrofluoric acid	3.55E-05	1.04E-05	4.27E-07	5.33E-06	5.33E-07
01047110002438103	Phenol	3.50E-05	3.50E-06	2.28E-06	5.34E-06	1.07E-06
53015110000490852	1,2-Dimethoxyethane	3.47E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05081110000756352	Hydrochloric acid	3.45E-05	2.69E-05	2.20E-06	1.61E-05	2.42E-06
27017110000426263	Benzene	3.38E-05	2.59E-07	1.69E-08	2.75E-07	9.16E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
23029110013359178	Methanol	3.38E-05	1.37E-06	3.51E-07	3.64E-06	7.28E-07
21091110000380926	Methanol	3.36E-05	1.36E-06	3.48E-07	3.61E-06	7.23E-07
12123110000362223	1,2-Dimethoxyethane	3.35E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22073110017782568	Chloroform	3.34E-05	0.00E+00	1.62E-08	0.00E+00	2.09E-08
26043110017422467	Hydrochloric acid	3.32E-05	2.59E-05	2.12E-06	1.55E-05	2.33E-06
51019110000343922	Benzene	3.32E-05	2.54E-07	1.66E-08	2.69E-07	8.98E-08
23017110000491940	Hydrochloric acid	3.30E-05	2.56E-05	2.10E-06	1.54E-05	2.31E-06
12123110000362223	Benzene	3.27E-05	2.50E-07	1.63E-08	2.66E-07	8.86E-08
45091110000355035	Carbon disulfide	3.26E-05	5.06E-06	4.04E-07	6.52E-05	1.26E-06
05069110000450878	Chloroform	3.25E-05	0.00E+00	1.57E-08	0.00E+00	2.03E-08
37083110000586447	Methanol	3.24E-05	1.32E-06	3.36E-07	3.49E-06	6.99E-07
01047110002438103	1,2-Dimethoxyethane	3.22E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13051110000740958	1,2-Dimethoxyethane	3.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41043110000488142	Phenol	3.20E-05	3.20E-06	2.09E-06	4.89E-06	9.77E-07
45041110019973493	Chloroform	3.17E-05	0.00E+00	1.54E-08	0.00E+00	1.98E-08
45019110016966381	Phenol	3.13E-05	3.13E-06	2.04E-06	4.77E-06	9.55E-07
27071110000427501	Mercury (elemental)	3.08E-05	0.00E+00	1.09E-08	0.00E+00	9.25E-09
26101110000412045	Acetaldehyde	3.07E-05	1.78E-07	2.94E-08	8.01E-07	4.00E-08
55087110000420973	Methanol	3.06E-05	1.24E-06	3.17E-07	3.29E-06	6.59E-07
27071110000427501	Methanol	2.98E-05	1.21E-06	3.09E-07	3.21E-06	6.41E-07
37117110013794000	Mercury (elemental)	2.97E-05	0.00E+00	1.05E-08	0.00E+00	8.92E-09
22011110006020028	Benzene	2.97E-05	2.27E-07	1.48E-08	2.41E-07	8.04E-08
22031110000450173	1,2-Dimethoxyethane	2.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05029110000597890	Methanol	2.96E-05	1.20E-06	3.07E-07	3.19E-06	6.38E-07
41043110000488142	1,2-Dimethoxyethane	2.95E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40089110000598639	1,2-Dimethoxyethane	2.95E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22049110000597514	Benzene	2.93E-05	2.24E-07	1.47E-08	2.38E-07	7.94E-08
22117110001274521	Hydrofluoric acid	2.93E-05	8.57E-06	3.51E-07	4.39E-06	4.39E-07
51101110007317484	Chloroform	2.93E-05	0.00E+00	1.42E-08	0.00E+00	1.83E-08
12089110000588542	Methylene chloride	2.90E-05	5.88E-07	2.14E-07	4.06E-07	1.56E-07
23017110000491940	Carbon tetrachloride	2.89E-05	1.96E-07	4.58E-08	4.23E-07	8.73E-08
23019110000581460	Methanol	2.83E-05	1.15E-06	2.94E-07	3.05E-06	6.10E-07
01113110017400711	Benzene	2.81E-05	2.15E-07	1.40E-08	2.28E-07	7.60E-08
26041110017408848	Hydrochloric acid	2.79E-05	2.17E-05	1.78E-06	1.30E-05	1.95E-06
45043110000353466	Methylene chloride	2.73E-05	5.54E-07	2.01E-07	3.82E-07	1.47E-07
47107110000605088	Arsenic compounds	2.71E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45079110000351903	Carbon disulfide	2.71E-05	4.20E-06	3.36E-07	5.42E-05	1.05E-06
48241110000599594	Benzene	2.71E-05	2.07E-07	1.35E-08	2.20E-07	7.34E-08
51670110012503781	Phenol	2.70E-05	2.70E-06	1.76E-06	4.13E-06	8.25E-07

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22073110017782568	Benzene	2.70E-05	2.06E-07	1.35E-08	2.19E-07	7.30E-08
55141110000742796	Mercury (elemental)	2.68E-05	0.00E+00	9.48E-09	0.00E+00	8.05E-09
13245110000359718	Xylenes (mixed)	2.66E-05	1.04E-06	1.46E-07	0.00E+00	0.00E+00
36031110000325005	Chloroform	2.63E-05	0.00E+00	1.27E-08	0.00E+00	1.64E-08
01023110017428773	Toluene	2.62E-05	1.29E-06	2.15E-07	5.10E-06	8.81E-07
22049110000597514	Chloroform	2.61E-05	0.00E+00	1.26E-08	0.00E+00	1.63E-08
01023110017428773	Phenol	2.57E-05	2.57E-06	1.68E-06	3.92E-06	7.85E-07
55141110000742796	Phenol	2.55E-05	2.55E-06	1.66E-06	3.89E-06	7.78E-07
51101110007317484	Benzene	2.53E-05	1.93E-07	1.27E-08	2.06E-07	6.85E-08
12033110000362447	1,2-Dimethoxyethane	2.52E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36031110000325005	Hydrochloric acid	2.52E-05	1.96E-05	1.60E-06	1.17E-05	1.76E-06
26101110000412045	Hydrochloric acid	2.44E-05	1.90E-05	1.55E-06	1.14E-05	1.71E-06
01131110007233305	Benzene	2.41E-05	1.85E-07	1.21E-08	1.96E-07	6.54E-08
12089110000588542	Benzene	2.41E-05	1.84E-07	1.20E-08	1.96E-07	6.53E-08
26043110017422467	Arsenic compounds	2.41E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01025110000369280	Chloroform	2.41E-05	0.00E+00	1.17E-08	0.00E+00	1.51E-08
36031110000325005	Benzene	2.39E-05	1.83E-07	1.20E-08	1.94E-07	6.48E-08
41043110000488142	Mercury (elemental)	2.36E-05	0.00E+00	8.32E-09	0.00E+00	7.08E-09
13185110005666421	Phenol	2.35E-05	2.35E-06	1.53E-06	3.58E-06	7.17E-07
22011110006020028	Phenol	2.31E-05	2.31E-06	1.50E-06	3.52E-06	7.05E-07
36113110000324845	Formaldehyde	2.30E-05	1.15E-06	7.45E-08	1.05E-06	1.05E-07
01047110002438103	Benzene	2.30E-05	1.76E-07	1.15E-08	1.87E-07	6.23E-08
22031110000450173	Phenol	2.30E-05	2.30E-06	1.50E-06	3.50E-06	7.01E-07
23019110000581460	Mercury (elemental)	2.29E-05	0.00E+00	8.09E-09	0.00E+00	6.87E-09
37047110009719304	1,2-Dimethoxyethane	2.26E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41041110014206117	Chloroform	2.25E-05	0.00E+00	1.09E-08	0.00E+00	1.41E-08
12123110000362223	Chloroform	2.25E-05	0.00E+00	1.09E-08	0.00E+00	1.41E-08
22031110000450173	Chloroform	2.24E-05	0.00E+00	1.08E-08	0.00E+00	1.40E-08
01071110000589435	Benzene	2.22E-05	1.70E-07	1.11E-08	1.80E-07	6.01E-08
01131110007233305	Chloroform	2.19E-05	0.00E+00	1.06E-08	0.00E+00	1.37E-08
13127110000588365	Chloroform	2.18E-05	0.00E+00	1.06E-08	0.00E+00	1.36E-08
12033110000362447	Benzene	2.18E-05	1.67E-07	1.09E-08	1.77E-07	5.91E-08
28077110017416599	Xylenes (mixed)	2.17E-05	8.54E-07	1.20E-07	0.00E+00	0.00E+00
45091110000355035	Chlorine	2.17E-05	3.04E-06	7.85E-07	1.57E-06	5.23E-07
48241110000599594	Chloroform	2.16E-05	0.00E+00	1.05E-08	0.00E+00	1.35E-08
55141110017413547	Phenol	2.15E-05	2.15E-06	1.40E-06	3.29E-06	6.58E-07
01091110000601965	1,2-Dimethoxyethane	2.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45091110000355035	Carbon tetrachloride	2.11E-05	1.43E-07	3.34E-08	3.08E-07	6.36E-08
41007110013844563	Chloroform	2.08E-05	0.00E+00	1.01E-08	0.00E+00	1.30E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
26041110017408848	Chloroform	2.07E-05	0.00E+00	1.00E-08	0.00E+00	1.29E-08
37047110009719304	Methylene chloride	2.03E-05	4.12E-07	1.50E-07	2.84E-07	1.09E-07
28111110002217379	Chloroform	2.03E-05	0.00E+00	9.82E-09	0.00E+00	1.27E-08
12089110000588542	Chloroform	2.01E-05	0.00E+00	9.74E-09	0.00E+00	1.26E-08
13051110005670336	Phenol	1.96E-05	1.96E-06	1.28E-06	2.99E-06	5.97E-07
45043110000353466	Xylenes (mixed)	1.93E-05	7.60E-07	1.06E-07	0.00E+00	0.00E+00
53031110000490326	Benzene	1.93E-05	1.47E-07	9.64E-09	1.57E-07	5.22E-08
37083110000586447	Hydrofluoric acid	1.91E-05	5.60E-06	2.29E-07	2.87E-06	2.87E-07
01121110000366121	Benzene	1.91E-05	1.46E-07	9.55E-09	1.55E-07	5.17E-08
55073110000422043	Methanol	1.89E-05	7.66E-07	1.96E-07	2.03E-06	4.07E-07
41007110013844563	Toluene	1.88E-05	9.28E-07	1.55E-07	3.66E-06	6.33E-07
37083110000586447	Benzene	1.87E-05	1.43E-07	9.35E-09	1.52E-07	5.07E-08
23025110017413468	Methanol	1.85E-05	7.51E-07	1.92E-07	1.99E-06	3.99E-07
48067110008148496	Carbon disulfide	1.84E-05	2.85E-06	2.28E-07	3.68E-05	7.13E-07
01025110000369280	Phenol	1.84E-05	1.84E-06	1.20E-06	2.80E-06	5.60E-07
05041110012414985	Carbon disulfide	1.83E-05	2.84E-06	2.27E-07	3.66E-05	7.09E-07
42013110000332177	Methylene chloride	1.83E-05	3.71E-07	1.35E-07	2.56E-07	9.84E-08
12089110000588542	Carbon disulfide	1.81E-05	2.81E-06	2.24E-07	3.62E-05	7.01E-07
01023110017428773	Benzene	1.80E-05	1.37E-07	8.98E-09	1.46E-07	4.86E-08
40089110000598639	Methanol	1.79E-05	7.27E-07	1.86E-07	1.93E-06	3.86E-07
51580110012505397	Methyl bromide	1.79E-05	0.00E+00	8.50E-08	0.00E+00	3.67E-07
01001110011734935	Methylene chloride	1.78E-05	3.61E-07	1.31E-07	2.49E-07	9.59E-08
41039110000488552	1,2-Dimethoxyethane	1.78E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40089110000598639	Phenol	1.78E-05	1.78E-06	1.16E-06	2.72E-06	5.43E-07
01001110011734935	1,2-Dimethoxyethane	1.76E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05081110000756352	Chloroform	1.75E-05	0.00E+00	8.46E-09	0.00E+00	1.09E-08
22117110001274521	Xylenes (mixed)	1.74E-05	6.85E-07	9.59E-08	0.00E+00	0.00E+00
13051110000740958	Chloroform	1.74E-05	0.00E+00	8.43E-09	0.00E+00	1.09E-08
55141110000742796	Methanol	1.73E-05	7.03E-07	1.80E-07	1.86E-06	3.73E-07
05081110000756352	Benzene	1.73E-05	1.32E-07	8.65E-09	1.41E-07	4.68E-08
48361110008146130	Methylene chloride	1.70E-05	3.45E-07	1.25E-07	2.38E-07	9.15E-08
53011110000564586	Toluene	1.69E-05	8.36E-07	1.39E-07	3.30E-06	5.70E-07
39031110000384735	Xylenes (mixed)	1.68E-05	6.60E-07	9.24E-08	0.00E+00	0.00E+00
53015110000490898	Benzene	1.67E-05	1.28E-07	8.37E-09	1.36E-07	4.53E-08
41039110000488552	Chloroform	1.65E-05	0.00E+00	8.00E-09	0.00E+00	1.03E-08
01023110017428773	Methylene chloride	1.65E-05	3.35E-07	1.22E-07	2.31E-07	8.90E-08
05069110000450878	Xylenes (mixed)	1.65E-05	6.47E-07	9.05E-08	0.00E+00	0.00E+00
55087110000420973	Benzene	1.64E-05	1.26E-07	8.21E-09	1.33E-07	4.45E-08
22031110000450173	Benzene	1.63E-05	1.24E-07	8.13E-09	1.32E-07	4.41E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22033110012384286	Chloroform	1.62E-05	0.00E+00	7.83E-09	0.00E+00	1.01E-08
26043110017422467	Chloroform	1.60E-05	0.00E+00	7.72E-09	0.00E+00	9.98E-09
51670110012503781	Hydrochloric acid	1.59E-05	1.24E-05	1.01E-06	7.44E-06	1.12E-06
45019110016966381	Benzene	1.59E-05	1.22E-07	7.95E-09	1.29E-07	4.31E-08
24001110007334072	Toluene	1.57E-05	7.73E-07	1.29E-07	3.05E-06	5.27E-07
40089110000598639	Benzene	1.56E-05	1.20E-07	7.82E-09	1.27E-07	4.24E-08
01047110002438103	Chloroform	1.56E-05	0.00E+00	7.57E-09	0.00E+00	9.78E-09
12005110000518002	Carbon disulfide	1.55E-05	2.40E-06	1.92E-07	3.09E-05	6.00E-07
13099110012384589	Mercury (elemental)	1.54E-05	0.00E+00	5.44E-09	0.00E+00	4.63E-09
22117110001274521	Chloroform	1.54E-05	0.00E+00	7.44E-09	0.00E+00	9.61E-09
45091110000355035	Benzene	1.54E-05	1.17E-07	7.68E-09	1.25E-07	4.16E-08
23029110013359178	Chloroform	1.53E-05	0.00E+00	7.40E-09	0.00E+00	9.56E-09
23029110013359178	Benzene	1.52E-05	1.16E-07	7.61E-09	1.24E-07	4.12E-08
23025110017413468	Mercury (elemental)	1.52E-05	0.00E+00	5.36E-09	0.00E+00	4.56E-09
13051110000740958	Benzene	1.52E-05	1.16E-07	7.59E-09	1.23E-07	4.11E-08
12107110000588604	Benzene	1.52E-05	1.16E-07	7.58E-09	1.23E-07	4.10E-08
41043110000488142	Carbon disulfide	1.50E-05	2.33E-06	1.87E-07	3.01E-05	5.83E-07
12123110000362223	Toluene	1.50E-05	7.42E-07	1.24E-07	2.93E-06	5.06E-07
53011110000564586	Carbon tetrachloride	1.49E-05	1.01E-07	2.36E-08	2.18E-07	4.50E-08
51009110020680306	Styrene	1.49E-05	3.68E-06	5.69E-07	1.49E-06	2.84E-07
37049110000350478	Benzene	1.47E-05	1.12E-07	7.35E-09	1.19E-07	3.98E-08
28111110002217379	Benzene	1.46E-05	1.12E-07	7.32E-09	1.19E-07	3.96E-08
51101110007317484	1,2-Dimethoxyethane	1.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51101110007317484	Methylene chloride	1.45E-05	2.95E-07	1.07E-07	2.04E-07	7.83E-08
47107110000605088	Benzene	1.44E-05	1.10E-07	7.21E-09	1.17E-07	3.90E-08
51670110012503781	Methanol	1.44E-05	5.85E-07	1.49E-07	1.55E-06	3.10E-07
42133110017404664	Benzene	1.42E-05	1.09E-07	7.11E-09	1.16E-07	3.85E-08
13021110005666243	Benzene	1.42E-05	1.09E-07	7.10E-09	1.15E-07	3.85E-08
47163110017711289	Phenol	1.42E-05	1.42E-06	9.24E-07	2.16E-06	4.33E-07
45031110000587491	Formaldehyde	1.40E-05	6.99E-07	4.53E-08	6.41E-07	6.41E-08
22069110039166390	Phenol	1.40E-05	1.40E-06	9.11E-07	2.13E-06	4.27E-07
36113110000324845	Arsenic compounds	1.39E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41039110000488552	Phenol	1.37E-05	1.37E-06	8.93E-07	2.09E-06	4.18E-07
01091110000601965	Benzene	1.37E-05	1.05E-07	6.84E-09	1.11E-07	3.71E-08
55141110017413547	Carbon tetrachloride	1.36E-05	9.26E-08	2.16E-08	1.99E-07	4.12E-08
53011110000564586	Tetrachloroethene	1.36E-05	1.13E-06	1.70E-07	4.00E-07	1.94E-07
28077110017416599	Methylene chloride	1.35E-05	2.75E-07	9.98E-08	1.90E-07	7.29E-08
22069110039166390	Methanol	1.35E-05	5.48E-07	1.40E-07	1.45E-06	2.91E-07
22033110012384286	Benzene	1.35E-05	1.03E-07	6.74E-09	1.09E-07	3.65E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
41041110014206117	Benzene	1.34E-05	1.03E-07	6.72E-09	1.09E-07	3.64E-08
13099110012384589	Benzene	1.34E-05	1.03E-07	6.72E-09	1.09E-07	3.64E-08
05069110000450752	Mercury (elemental)	1.32E-05	0.00E+00	4.65E-09	0.00E+00	3.96E-09
05069110000450752	Phenol	1.32E-05	1.32E-06	8.58E-07	2.01E-06	4.02E-07
01023110017428773	Chloroform	1.31E-05	0.00E+00	6.34E-09	0.00E+00	8.19E-09
42047110000330400	Toluene	1.31E-05	6.45E-07	1.08E-07	2.55E-06	4.40E-07
01099110000589612	Benzene	1.31E-05	1.00E-07	6.54E-09	1.06E-07	3.54E-08
55087110000420973	Mercury (elemental)	1.31E-05	0.00E+00	4.61E-09	0.00E+00	3.92E-09
22125110043794374	Benzene	1.30E-05	9.95E-08	6.51E-09	1.06E-07	3.52E-08
22011110006020028	Methanol	1.29E-05	5.25E-07	1.34E-07	1.39E-06	2.79E-07
48361110008146130	Carbon disulfide	1.29E-05	2.00E-06	1.60E-07	2.59E-05	5.01E-07
12089110000588551	Carbon tetrachloride	1.29E-05	8.73E-08	2.04E-08	1.88E-07	3.88E-08
26043110017422467	Benzene	1.28E-05	9.82E-08	6.42E-09	1.04E-07	3.48E-08
55141110017413547	Mercury (elemental)	1.27E-05	0.00E+00	4.48E-09	0.00E+00	3.81E-09
22069110039166390	1,2-Dimethoxyethane	1.26E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51670110012503781	Benzene	1.25E-05	9.53E-08	6.23E-09	1.01E-07	3.38E-08
21091110000380926	Benzene	1.21E-05	9.28E-08	6.07E-09	9.86E-08	3.29E-08
01001110011734935	Xylenes (mixed)	1.21E-05	4.77E-07	6.68E-08	0.00E+00	0.00E+00
55073110000422043	Benzene	1.20E-05	9.16E-08	5.99E-09	9.74E-08	3.25E-08
41041110014206117	1,2-Dimethoxyethane	1.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53011110000564586	Styrene	1.19E-05	2.95E-06	4.55E-07	1.19E-06	2.28E-07
41007110013844563	Methylene chloride	1.19E-05	2.41E-07	8.75E-08	1.66E-07	6.39E-08
27017110000426263	Mercury (elemental)	1.18E-05	0.00E+00	4.15E-09	0.00E+00	3.53E-09
51670110012503781	Chloroform	1.17E-05	0.00E+00	5.67E-09	0.00E+00	7.32E-09
42133110017404664	Chloroform	1.15E-05	0.00E+00	5.58E-09	0.00E+00	7.21E-09
41043110000488142	Arsenic compounds	1.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41043110000488142	Carbon tetrachloride	1.11E-05	7.56E-08	1.76E-08	1.63E-07	3.36E-08
28149110000605220	Methylene chloride	1.11E-05	2.24E-07	8.15E-08	1.55E-07	5.95E-08
16069110009335905	Carbon disulfide	1.10E-05	1.70E-06	1.36E-07	2.20E-05	4.26E-07
37087110009846480	Carbon disulfide	1.10E-05	1.70E-06	1.36E-07	2.19E-05	4.24E-07
55073110000422043	Chloroform	1.09E-05	0.00E+00	5.29E-09	0.00E+00	6.83E-09
42047110000330400	Tetrachloroethene	1.08E-05	9.01E-07	1.35E-07	3.18E-07	1.55E-07
51580110012505397	Xylenes (mixed)	1.07E-05	4.22E-07	5.90E-08	0.00E+00	0.00E+00
22117110001274521	Methylene chloride	1.06E-05	2.15E-07	7.81E-08	1.48E-07	5.71E-08
13127110000588365	Carbon tetrachloride	1.05E-05	7.11E-08	1.66E-08	1.53E-07	3.16E-08
05029110000597890	Acetaldehyde	1.02E-05	5.92E-08	9.78E-09	2.66E-07	1.33E-08
22069110039166390	Benzene	1.01E-05	7.74E-08	5.06E-09	8.23E-08	2.74E-08
01091110000601965	Chloroform	1.01E-05	0.00E+00	4.89E-09	0.00E+00	6.31E-09
53027110000490709	Acetaldehyde	1.00E-05	5.80E-08	9.59E-09	2.61E-07	1.31E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
41039110000488552	Benzene	9.97E-06	7.62E-08	4.98E-09	8.10E-08	2.70E-08
01131110007233305	1,2-Dimethoxyethane	9.93E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01053110012508580	Methylene chloride	9.75E-06	1.98E-07	7.18E-08	1.36E-07	5.25E-08
21091110000380926	Chloroform	9.69E-06	0.00E+00	4.69E-09	0.00E+00	6.06E-09
13245110000359718	Methylene chloride	9.66E-06	1.96E-07	7.12E-08	1.35E-07	5.20E-08
01001110011734935	o-Xylene	9.57E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51101110007317484	Carbon disulfide	9.19E-06	1.42E-06	1.14E-07	1.84E-05	3.56E-07
23007110000581415	Carbon disulfide	9.14E-06	1.42E-06	1.13E-07	1.83E-05	3.54E-07
23017110000491940	Benzene	9.04E-06	6.92E-08	4.52E-09	7.35E-08	2.45E-08
28087110000590940	Benzene	8.97E-06	6.86E-08	4.49E-09	7.29E-08	2.43E-08
01023110017428773	Styrene	8.94E-06	2.21E-06	3.41E-07	8.94E-07	1.71E-07
40089110000598639	Chloroform	8.76E-06	0.00E+00	4.24E-09	0.00E+00	5.47E-09
45031110000587491	Arsenic compounds	8.73E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12123110000362223	Tetrachloroethene	8.72E-06	7.27E-07	1.09E-07	2.57E-07	1.25E-07
13051110000740958	Phenol	8.71E-06	8.71E-07	5.68E-07	1.33E-06	2.66E-07
13127110000588365	Toluene	8.71E-06	4.30E-07	7.16E-08	1.70E-06	2.93E-07
13115110013763034	Carbon disulfide	8.63E-06	1.34E-06	1.07E-07	1.73E-05	3.34E-07
45043110000353466	Methyl bromide	8.54E-06	0.00E+00	4.06E-08	0.00E+00	1.75E-07
51009110020680306	Toluene	8.45E-06	4.17E-07	6.95E-08	1.65E-06	2.84E-07
05003110000450921	Methylene chloride	8.24E-06	1.67E-07	6.07E-08	1.15E-07	4.44E-08
41041110014206117	Carbon disulfide	7.90E-06	1.22E-06	9.79E-08	1.58E-05	3.06E-07
28077110017416599	o-Xylene	7.88E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51093110000560492	Benzene	7.87E-06	6.02E-08	3.93E-09	6.39E-08	2.13E-08
42047110000330400	Methylene chloride	7.74E-06	1.57E-07	5.71E-08	1.08E-07	4.17E-08
22125110043794374	Styrene	7.68E-06	1.90E-06	2.93E-07	7.68E-07	1.47E-07
13127110000588365	Carbon disulfide	7.49E-06	1.16E-06	9.29E-08	1.50E-05	2.90E-07
01113110017400711	o-Xylene	7.46E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05069110000450878	Methylene chloride	7.45E-06	1.51E-07	5.49E-08	1.04E-07	4.01E-08
12033110000362447	Carbon disulfide	7.23E-06	1.12E-06	8.97E-08	1.45E-05	2.80E-07
41043110000488142	Benzene	7.11E-06	5.44E-08	3.55E-09	5.78E-08	1.93E-08
47107110000605088	Mercury (elemental)	7.07E-06	0.00E+00	2.50E-09	0.00E+00	2.12E-09
23019110000581460	Hydrochloric acid	7.03E-06	5.46E-06	4.47E-07	3.28E-06	4.92E-07
41007110013844563	Carbon disulfide	6.77E-06	1.05E-06	8.39E-08	1.35E-05	2.62E-07
37049110000350478	Hydrofluoric acid	6.76E-06	1.98E-06	8.12E-08	1.01E-06	1.01E-07
01001110011734935	Toluene	6.65E-06	3.28E-07	5.47E-08	1.30E-06	2.24E-07
53015110000490898	Chloroform	6.63E-06	0.00E+00	3.21E-09	0.00E+00	4.14E-09
01131110007233305	Carbon disulfide	6.56E-06	1.02E-06	8.14E-08	1.31E-05	2.54E-07
22069110039166390	Chloroform	6.53E-06	0.00E+00	3.16E-09	0.00E+00	4.08E-09
13305110007356422	Carbon disulfide	6.52E-06	1.01E-06	8.09E-08	1.30E-05	2.53E-07

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
47163110017711289	Methanol	6.39E-06	2.59E-07	6.63E-08	6.89E-07	1.38E-07
41007110013844563	Styrene	6.36E-06	1.57E-06	2.43E-07	6.36E-07	1.21E-07
13305110007356422	Xylenes (mixed)	6.35E-06	2.49E-07	3.49E-08	0.00E+00	0.00E+00
12123110000362223	Styrene	6.35E-06	1.57E-06	2.42E-07	6.35E-07	1.21E-07
36031110000325005	Carbon disulfide	6.33E-06	9.82E-07	7.86E-08	1.27E-05	2.45E-07
53053110000490558	Carbon disulfide	6.24E-06	9.67E-07	7.73E-08	1.25E-05	2.42E-07
45091110000355035	Chloroform	6.09E-06	0.00E+00	2.95E-09	0.00E+00	3.80E-09
53071110005312713	Xylenes (mixed)	6.09E-06	2.39E-07	3.35E-08	0.00E+00	0.00E+00
27017110000426263	Methylene chloride	6.04E-06	1.23E-07	4.45E-08	8.46E-08	3.25E-08
53071110005312713	o-Xylene	5.93E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47163110017711289	Benzene	5.90E-06	4.52E-08	2.95E-09	4.80E-08	1.60E-08
01047110002438103	Carbon disulfide	5.87E-06	9.11E-07	7.28E-08	1.17E-05	2.28E-07
23007110000581415	Tetrachloroethene	5.82E-06	4.85E-07	7.28E-08	1.71E-07	8.32E-08
53053110000490558	Xylenes (mixed)	5.82E-06	2.29E-07	3.20E-08	0.00E+00	0.00E+00
13021110005666243	Chloroform	5.71E-06	0.00E+00	2.76E-09	0.00E+00	3.57E-09
37047110009719304	Methyl bromide	5.58E-06	0.00E+00	2.65E-08	0.00E+00	1.14E-07
01113110017400711	Xylenes (mixed)	5.49E-06	2.16E-07	3.02E-08	0.00E+00	0.00E+00
23019110000581460	Benzene	5.47E-06	4.19E-08	2.74E-09	4.45E-08	1.48E-08
28077110017416599	Toluene	5.44E-06	2.68E-07	4.47E-08	1.06E-06	1.83E-07
47107110000605088	Chloroform	5.42E-06	0.00E+00	2.62E-09	0.00E+00	3.38E-09
55141110000742796	Benzene	5.38E-06	4.12E-08	2.69E-09	4.38E-08	1.46E-08
53015110000490852	Xylenes (mixed)	5.38E-06	2.11E-07	2.96E-08	0.00E+00	0.00E+00
24001110007334072	Methylene chloride	5.32E-06	1.08E-07	3.92E-08	7.45E-08	2.86E-08
37049110000350478	Chloroform	5.27E-06	0.00E+00	2.55E-09	0.00E+00	3.30E-09
47163110017711289	Chloroform	5.21E-06	0.00E+00	2.52E-09	0.00E+00	3.25E-09
55069110000422267	Arsenic compounds	5.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05069110000450878	Methyl bromide	5.17E-06	0.00E+00	2.46E-08	0.00E+00	1.06E-07
01025110000369280	Benzene	5.11E-06	3.91E-08	2.56E-09	4.15E-08	1.38E-08
37087110009846480	o-Xylene	5.08E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01053110012508580	Xylenes (mixed)	4.99E-06	1.96E-07	2.75E-08	0.00E+00	0.00E+00
47163110017711289	1,2-Dimethoxyethane	4.97E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01071110000589435	Chloroform	4.90E-06	0.00E+00	2.37E-09	0.00E+00	3.06E-09
01001110011734935	Styrene	4.87E-06	1.20E-06	1.86E-07	4.87E-07	9.30E-08
12107110000588604	Chloroform	4.72E-06	0.00E+00	2.28E-09	0.00E+00	2.95E-09
45079110000351903	Xylenes (mixed)	4.69E-06	1.84E-07	2.58E-08	0.00E+00	0.00E+00
01113110017400711	Carbon disulfide	4.68E-06	7.25E-07	5.80E-08	9.35E-06	1.81E-07
13185110005666421	Chloroform	4.66E-06	0.00E+00	2.25E-09	0.00E+00	2.91E-09
12089110000588551	Chloroform	4.57E-06	0.00E+00	2.21E-09	0.00E+00	2.86E-09
28077110017416599	Methyl bromide	4.55E-06	0.00E+00	2.16E-08	0.00E+00	9.33E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

		Maximum Hazard Quotient[1]				
Facility NEI ID	Pollutant	REL	AEGL1	AEGL2	ERPG1	ERPG2
13179110013498296	Carbon disulfide	4.53E-06	7.02E-07	5.61E-08	9.05E-06	1.75E-07
23007110000581415	Xylenes (mixed)	4.51E-06	1.77E-07	2.48E-08	0.00E+00	0.00E+00
27071110000427501	Tetrachloroethene	4.49E-06	3.74E-07	5.61E-08	1.32E-07	6.42E-08
05069110000450878	o-Xylene	4.43E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12123110000362223	Xylenes (mixed)	4.38E-06	1.72E-07	2.41E-08	0.00E+00	0.00E+00
01053110012508580	o-Xylene	4.35E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22031110000450173	Carbon disulfide	4.31E-06	6.69E-07	5.35E-08	8.63E-06	1.67E-07
01071110000589435	Carbon disulfide	4.29E-06	6.65E-07	5.32E-08	8.58E-06	1.66E-07
13021110005666243	Phenol	4.20E-06	4.20E-07	2.74E-07	6.41E-07	1.28E-07
53015110000490852	Tetrachloroethene	4.16E-06	3.47E-07	5.20E-08	1.22E-07	5.95E-08
13021110005666243	Carbon disulfide	4.14E-06	6.41E-07	5.13E-08	8.27E-06	1.60E-07
55141110000742796	Arsenic compounds	4.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45041110019973493	Carbon disulfide	4.11E-06	6.37E-07	5.10E-08	8.22E-06	1.59E-07
55141110000742796	Chloroform	4.11E-06	0.00E+00	1.99E-09	0.00E+00	2.57E-09
22125110043794374	Chloroform	4.09E-06	0.00E+00	1.98E-09	0.00E+00	2.56E-09
13127110000588365	Tetrachloroethene	4.01E-06	3.34E-07	5.01E-08	1.18E-07	5.72E-08
45019110016966381	Xylenes (mixed)	3.98E-06	1.56E-07	2.19E-08	0.00E+00	0.00E+00
23017110000491940	Chloroform	3.97E-06	0.00E+00	1.92E-09	0.00E+00	2.48E-09
37047110009719304	Xylenes (mixed)	3.97E-06	1.56E-07	2.18E-08	0.00E+00	0.00E+00
37087110009846480	Hydrofluoric acid	3.95E-06	1.16E-06	4.74E-08	5.92E-07	5.92E-08
21007110000732173	Styrene	3.89E-06	9.62E-07	1.49E-07	3.89E-07	7.43E-08
53071110005312713	Carbon disulfide	3.85E-06	5.97E-07	4.78E-08	7.71E-06	1.49E-07
22073110017782568	Xylenes (mixed)	3.83E-06	1.51E-07	2.11E-08	0.00E+00	0.00E+00
01025110000369280	Methylene chloride	3.80E-06	7.71E-08	2.80E-08	5.32E-08	2.05E-08
13051110000740958	Carbon disulfide	3.73E-06	5.78E-07	4.62E-08	7.45E-06	1.44E-07
45069110016989669	Xylenes (mixed)	3.69E-06	1.45E-07	2.03E-08	0.00E+00	0.00E+00
22049110000597514	Carbon disulfide	3.63E-06	5.62E-07	4.50E-08	7.26E-06	1.41E-07
42013110000332177	Carbon disulfide	3.61E-06	5.59E-07	4.48E-08	7.22E-06	1.40E-07
13115110013763034	Xylenes (mixed)	3.56E-06	1.40E-07	1.96E-08	0.00E+00	0.00E+00
48361110008146130	Tetrachloroethene	3.55E-06	2.96E-07	4.43E-08	1.04E-07	5.07E-08
40089110000598639	Carbon disulfide	3.52E-06	5.46E-07	4.37E-08	7.05E-06	1.37E-07
48361110008146130	Toluene	3.47E-06	1.71E-07	2.86E-08	6.77E-07	1.17E-07
48067110008148496	Xylenes (mixed)	3.47E-06	1.36E-07	1.91E-08	0.00E+00	0.00E+00
42133110017404664	Xylenes (mixed)	3.45E-06	1.36E-07	1.90E-08	0.00E+00	0.00E+00
13193110007356002	Hydrochloric acid	3.44E-06	2.68E-06	2.19E-07	1.61E-06	2.41E-07
05003110000450921	Tetrachloroethene	3.44E-06	2.87E-07	4.31E-08	1.01E-07	4.92E-08
24001110007334072	Tetrachloroethene	3.43E-06	2.86E-07	4.29E-08	1.01E-07	4.90E-08
05069110000450752	Styrene	3.41E-06	8.42E-07	1.30E-07	3.41E-07	6.51E-08
23007110000581415	Methylene chloride	3.40E-06	6.91E-08	2.51E-08	4.77E-08	1.83E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
27017110000426263	Xylenes (mixed)	3.39E-06	1.33E-07	1.87E-08	0.00E+00	0.00E+00
13115110013763034	Tetrachloroethene	3.39E-06	2.83E-07	4.24E-08	9.98E-08	4.85E-08
28149110000605220	Toluene	3.37E-06	1.66E-07	2.77E-08	6.56E-07	1.13E-07
13179110013498296	Tetrachloroethene	3.31E-06	2.76E-07	4.14E-08	9.74E-08	4.73E-08
21007110000732173	Carbon tetrachloride	3.30E-06	2.24E-08	5.22E-09	4.82E-08	9.94E-09
55069110000422267	Methanol	3.29E-06	1.34E-07	3.42E-08	3.55E-07	7.09E-08
12005110000518002	Methyl bromide	3.28E-06	0.00E+00	1.56E-08	0.00E+00	6.73E-08
42133110017404664	Carbon disulfide	3.27E-06	5.06E-07	4.05E-08	6.53E-06	1.27E-07
12005110000518002	Tetrachloroethene	3.20E-06	2.66E-07	4.00E-08	9.41E-08	4.57E-08
05003110000450921	Carbon disulfide	3.15E-06	4.88E-07	3.90E-08	6.30E-06	1.22E-07
22117110001274521	Styrene	3.08E-06	7.61E-07	1.18E-07	3.08E-07	5.88E-08
41043110000488142	Chloroform	3.08E-06	0.00E+00	1.49E-09	0.00E+00	1.92E-09
05069110000450878	Toluene	3.05E-06	1.50E-07	2.51E-08	5.94E-07	1.03E-07
24001110007334072	Styrene	3.05E-06	7.53E-07	1.16E-07	3.05E-07	5.82E-08
12123110000362223	Hydrofluoric acid	3.04E-06	8.91E-07	3.65E-08	4.57E-07	4.57E-08
51580110012505397	Methylene chloride	3.00E-06	6.09E-08	2.21E-08	4.20E-08	1.61E-08
37087110009846480	Mercury (elemental)	3.00E-06	0.00E+00	1.06E-09	0.00E+00	8.99E-10
12005110000518002	Methylene chloride	2.99E-06	6.07E-08	2.21E-08	4.19E-08	1.61E-08
37047110009719304	o-Xylene	2.98E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12005110000518002	Xylenes (mixed)	2.93E-06	1.15E-07	1.61E-08	0.00E+00	0.00E+00
05081110000756352	Carbon disulfide	2.89E-06	4.47E-07	3.58E-08	5.77E-06	1.12E-07
22073110017782568	Carbon disulfide	2.87E-06	4.45E-07	3.56E-08	5.75E-06	1.11E-07
26041110017408848	Xylenes (mixed)	2.87E-06	1.13E-07	1.58E-08	0.00E+00	0.00E+00
27017110000426263	Chloroform	2.86E-06	0.00E+00	1.38E-09	0.00E+00	1.78E-09
05069110000450752	Toluene	2.85E-06	1.41E-07	2.35E-08	5.56E-07	9.60E-08
41039110000488552	Carbon disulfide	2.84E-06	4.40E-07	3.52E-08	5.68E-06	1.10E-07
42047110000330400	Carbon tetrachloride	2.83E-06	1.92E-08	4.48E-09	4.13E-08	8.53E-09
36031110000325005	Hydrofluoric acid	2.82E-06	8.26E-07	3.38E-08	4.23E-07	4.23E-08
12089110000588551	Phenol	2.81E-06	2.81E-07	1.83E-07	4.29E-07	8.58E-08
48361110008146130	Xylenes (mixed)	2.75E-06	1.08E-07	1.51E-08	0.00E+00	0.00E+00
26043110017422467	Carbon disulfide	2.75E-06	4.26E-07	3.41E-08	5.50E-06	1.07E-07
48361110008146130	Methyl bromide	2.70E-06	0.00E+00	1.29E-08	0.00E+00	5.55E-08
05003110000450921	Xylenes (mixed)	2.69E-06	1.06E-07	1.48E-08	0.00E+00	0.00E+00
23029110013359178	Methylene chloride	2.68E-06	5.44E-08	1.97E-08	3.75E-08	1.44E-08
12089110000588542	Toluene	2.68E-06	1.32E-07	2.20E-08	5.21E-07	9.01E-08
51580110012505397	Toluene	2.66E-06	1.31E-07	2.18E-08	5.17E-07	8.94E-08
21007110000732173	Toluene	2.64E-06	1.30E-07	2.17E-08	5.14E-07	8.88E-08
51580110012505397	Carbon tetrachloride	2.63E-06	1.79E-08	4.17E-09	3.85E-08	7.94E-09
21091110000380926	Carbon disulfide	2.63E-06	4.08E-07	3.26E-08	5.26E-06	1.02E-07

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
37117110013794000	Phenol	2.62E-06	2.62E-07	1.71E-07	4.00E-07	7.99E-08
16069110009335905	Xylenes (mixed)	2.60E-06	1.02E-07	1.43E-08	0.00E+00	0.00E+00
13021110005666243	Methyl bromide	2.58E-06	0.00E+00	1.23E-08	0.00E+00	5.31E-08
16069110009335905	Tetrachloroethene	2.57E-06	2.15E-07	3.22E-08	7.57E-08	3.68E-08
51093110000560492	Chloroform	2.56E-06	0.00E+00	1.24E-09	0.00E+00	1.60E-09
05069110000450878	Carbon tetrachloride	2.55E-06	1.73E-08	4.05E-09	3.73E-08	7.71E-09
28087110000590940	Chloroform	2.55E-06	0.00E+00	1.24E-09	0.00E+00	1.60E-09
28149110000605220	Styrene	2.53E-06	6.25E-07	9.66E-08	2.53E-07	4.83E-08
16069110009335905	o-Xylene	2.53E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01091110000601965	Carbon disulfide	2.50E-06	3.87E-07	3.10E-08	5.00E-06	9.69E-08
45043110000353466	Styrene	2.49E-06	6.15E-07	9.50E-08	2.49E-07	4.75E-08
12089110000588551	Formaldehyde	2.49E-06	1.24E-07	8.04E-09	1.14E-07	1.14E-08
01121110000366121	Hydrofluoric acid	2.46E-06	7.20E-07	2.95E-08	3.69E-07	3.69E-08
22069110039166390	Carbon disulfide	2.44E-06	3.78E-07	3.02E-08	4.88E-06	9.45E-08
01001110011734935	Methyl bromide	2.44E-06	0.00E+00	1.16E-08	0.00E+00	5.00E-08
12089110000588542	Tetrachloroethene	2.41E-06	2.01E-07	3.01E-08	7.08E-08	3.44E-08
26041110017408848	Carbon disulfide	2.34E-06	3.62E-07	2.90E-08	4.67E-06	9.05E-08
37047110009719304	Toluene	2.34E-06	1.15E-07	1.92E-08	4.55E-07	7.86E-08
22125110043794374	Phenol	2.32E-06	2.32E-07	1.51E-07	3.54E-07	7.09E-08
01053110012508580	Tetrachloroethene	2.31E-06	1.93E-07	2.89E-08	6.81E-08	3.31E-08
22125110043794374	Carbon disulfide	2.28E-06	3.53E-07	2.82E-08	4.55E-06	8.82E-08
45041110019973493	Tetrachloroethene	2.27E-06	1.89E-07	2.84E-08	6.67E-08	3.24E-08
13179110013498296	Xylenes (mixed)	2.26E-06	8.89E-08	1.24E-08	0.00E+00	0.00E+00
37047110009719304	Styrene	2.24E-06	5.54E-07	8.57E-08	2.24E-07	4.28E-08
41007110013844563	Tetrachloroethene	2.24E-06	1.86E-07	2.80E-08	6.58E-08	3.20E-08
12089110000588551	Xylenes (mixed)	2.22E-06	8.73E-08	1.22E-08	0.00E+00	0.00E+00
53071110005312713	Toluene	2.19E-06	1.08E-07	1.80E-08	4.27E-07	7.38E-08
13245110000359718	Toluene	2.19E-06	1.08E-07	1.80E-08	4.27E-07	7.37E-08
45043110000353466	Toluene	2.18E-06	1.08E-07	1.79E-08	4.25E-07	7.34E-08
05069110000450878	Tetrachloroethene	2.16E-06	1.80E-07	2.70E-08	6.36E-08	3.09E-08
45091110000355035	Hydrofluoric acid	2.15E-06	6.28E-07	2.58E-08	3.22E-07	3.22E-08
22031110000450173	Xylenes (mixed)	2.15E-06	8.43E-08	1.18E-08	0.00E+00	0.00E+00
13245110000359718	Methyl bromide	2.14E-06	0.00E+00	1.02E-08	0.00E+00	4.40E-08
55073110000422043	Hydrofluoric acid	2.13E-06	6.22E-07	2.55E-08	3.19E-07	3.19E-08
53015110000490852	Methyl bromide	2.11E-06	0.00E+00	1.01E-08	0.00E+00	4.34E-08
37083110000586447	Carbon disulfide	2.10E-06	3.25E-07	2.60E-08	4.19E-06	8.13E-08
01023110017428773	Tetrachloroethene	2.09E-06	1.74E-07	2.62E-08	6.16E-08	2.99E-08
21007110000732173	Tetrachloroethene	2.08E-06	1.74E-07	2.60E-08	6.13E-08	2.98E-08
01023110017428773	Xylenes (mixed)	2.05E-06	8.04E-08	1.13E-08	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
47163110017711289	Carbon disulfide	2.04E-06	3.17E-07	2.53E-08	4.09E-06	7.92E-08
01121110000366121	Carbon disulfide	2.04E-06	3.16E-07	2.53E-08	4.08E-06	7.90E-08
27071110000427501	Xylenes (mixed)	2.04E-06	8.00E-08	1.12E-08	0.00E+00	0.00E+00
47071110017418338	Xylenes (mixed)	2.00E-06	7.87E-08	1.10E-08	0.00E+00	0.00E+00
53071110005312713	Methylene chloride	2.00E-06	4.05E-08	1.47E-08	2.80E-08	1.08E-08
42047110000330400	Styrene	1.98E-06	4.90E-07	7.57E-08	1.98E-07	3.79E-08
23007110000581415	Toluene	1.96E-06	9.65E-08	1.61E-08	3.81E-07	6.58E-08
13127110000588365	Xylenes (mixed)	1.95E-06	7.66E-08	1.07E-08	0.00E+00	0.00E+00
23017110000491940	Styrene	1.95E-06	4.81E-07	7.44E-08	1.95E-07	3.72E-08
01099110000589612	Carbon disulfide	1.92E-06	2.98E-07	2.38E-08	3.84E-06	7.44E-08
23019110000581460	Chloroform	1.92E-06	0.00E+00	9.29E-10	0.00E+00	1.20E-09
13305110007356422	Toluene	1.92E-06	9.47E-08	1.58E-08	3.74E-07	6.45E-08
22011110006020028	Carbon disulfide	1.92E-06	2.97E-07	2.38E-08	3.84E-06	7.43E-08
12033110000362447	o-Xylene	1.91E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22049110000597514	Tetrachloroethene	1.91E-06	1.59E-07	2.39E-08	5.63E-08	2.73E-08
45079110000351903	Toluene	1.91E-06	9.41E-08	1.57E-08	3.71E-07	6.41E-08
53015110000490852	Methylene chloride	1.90E-06	3.86E-08	1.40E-08	2.67E-08	1.03E-08
01053110012508580	Methyl bromide	1.90E-06	0.00E+00	9.04E-09	0.00E+00	3.90E-08
41007110013844563	Xylenes (mixed)	1.90E-06	7.45E-08	1.04E-08	0.00E+00	0.00E+00
45031110000587491	Mercury (elemental)	1.90E-06	0.00E+00	6.69E-10	0.00E+00	5.69E-10
53053110000490558	Toluene	1.89E-06	9.34E-08	1.56E-08	3.69E-07	6.37E-08
28149110000605220	Methyl bromide	1.89E-06	0.00E+00	8.99E-09	0.00E+00	3.88E-08
51019110000343922	Toluene	1.89E-06	9.31E-08	1.55E-08	3.67E-07	6.35E-08
37087110009846480	Methyl bromide	1.86E-06	0.00E+00	8.87E-09	0.00E+00	3.83E-08
13185110005666421	Carbon disulfide	1.86E-06	2.88E-07	2.30E-08	3.72E-06	7.20E-08
45041110019973493	Xylenes (mixed)	1.83E-06	7.19E-08	1.01E-08	0.00E+00	0.00E+00
51101110007317484	Methyl bromide	1.83E-06	0.00E+00	8.71E-09	0.00E+00	3.76E-08
13185110005666421	Xylenes (mixed)	1.82E-06	7.13E-08	9.98E-09	0.00E+00	0.00E+00
13245110000359718	Styrene	1.79E-06	4.43E-07	6.84E-08	1.79E-07	3.42E-08
55073110000422043	Xylenes (mixed)	1.76E-06	6.93E-08	9.70E-09	0.00E+00	0.00E+00
05069110000450752	Methyl bromide	1.76E-06	0.00E+00	8.37E-09	0.00E+00	3.61E-08
41041110014206117	Methylene chloride	1.73E-06	3.52E-08	1.28E-08	2.43E-08	9.34E-09
26041110017408848	Hydrofluoric acid	1.73E-06	5.06E-07	2.08E-08	2.59E-07	2.59E-08
51580110012505397	o-Xylene	1.73E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23017110000491940	Phenol	1.69E-06	1.69E-07	1.10E-07	2.58E-07	5.16E-08
23017110000491940	Carbon disulfide	1.69E-06	2.61E-07	2.09E-08	3.37E-06	6.53E-08
13185110005666421	o-Xylene	1.67E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37083110000586447	Methylene chloride	1.67E-06	3.38E-08	1.23E-08	2.33E-08	8.97E-09
53071110005312713	Tetrachloroethene	1.67E-06	1.39E-07	2.08E-08	4.90E-08	2.38E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
51580110012505397	Styrene	1.66E-06	4.09E-07	6.33E-08	1.66E-07	3.16E-08
01113110017400711	Tetrachloroethene	1.64E-06	1.37E-07	2.05E-08	4.82E-08	2.34E-08
51101110007317484	Tetrachloroethene	1.61E-06	1.34E-07	2.02E-08	4.75E-08	2.31E-08
28111110002217379	Carbon disulfide	1.61E-06	2.50E-07	2.00E-08	3.23E-06	6.25E-08
22073110017782568	Tetrachloroethene	1.58E-06	1.32E-07	1.97E-08	4.65E-08	2.26E-08
16069110009335905	Methylene chloride	1.57E-06	3.19E-08	1.16E-08	2.20E-08	8.45E-09
13127110000588365	Styrene	1.57E-06	3.88E-07	5.99E-08	1.57E-07	2.99E-08
51093110000560492	Phenol	1.56E-06	1.56E-07	1.02E-07	2.38E-07	4.76E-08
12107110000588604	Methyl bromide	1.55E-06	0.00E+00	7.37E-09	0.00E+00	3.18E-08
12089110000588542	Xylenes (mixed)	1.54E-06	6.05E-08	8.47E-09	0.00E+00	0.00E+00
37049110000350478	Methylene chloride	1.53E-06	3.10E-08	1.13E-08	2.14E-08	8.24E-09
13305110007356422	Tetrachloroethene	1.51E-06	1.26E-07	1.89E-08	4.44E-08	2.16E-08
26101110000412045	Methanol	1.50E-06	6.10E-08	1.56E-08	1.62E-07	3.24E-08
53053110000490558	Tetrachloroethene	1.50E-06	1.25E-07	1.88E-08	4.42E-08	2.15E-08
22049110000597514	Xylenes (mixed)	1.50E-06	5.90E-08	8.26E-09	0.00E+00	0.00E+00
12107110000588604	Carbon disulfide	1.47E-06	2.28E-07	1.83E-08	2.94E-06	5.70E-08
05003110000450921	Toluene	1.47E-06	7.26E-08	1.21E-08	2.87E-07	4.95E-08
45069110016989669	Methylene chloride	1.46E-06	2.97E-08	1.08E-08	2.05E-08	7.87E-09
05041110012414985	Phenol	1.45E-06	1.45E-07	9.44E-08	2.21E-07	4.42E-08
22033110012384286	Carbon disulfide	1.45E-06	2.24E-07	1.79E-08	2.89E-06	5.61E-08
12107110000588604	Phenol	1.44E-06	1.44E-07	9.41E-08	2.20E-07	4.41E-08
37117110013794000	Chloroform	1.44E-06	0.00E+00	6.95E-10	0.00E+00	8.97E-10
51101110007317484	Toluene	1.42E-06	6.98E-08	1.16E-08	2.76E-07	4.76E-08
27071110000427501	1,1,1-Trichloroethane	1.41E-06	7.39E-08	2.91E-08	5.05E-08	2.53E-08
45079110000351903	Methylene chloride	1.41E-06	2.86E-08	1.04E-08	1.97E-08	7.59E-09
55073110000422043	Carbon disulfide	1.41E-06	2.18E-07	1.74E-08	2.81E-06	5.45E-08
37087110009846480	Benzene	1.41E-06	1.08E-08	7.03E-10	1.14E-08	3.81E-09
12089110000588551	Styrene	1.40E-06	3.45E-07	5.34E-08	1.40E-07	2.67E-08
13099110012384589	Styrene	1.39E-06	3.43E-07	5.30E-08	1.39E-07	2.65E-08
13051110000740958	o-Xylene	1.37E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05003110000450921	o-Xylene	1.36E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13099110012384589	Methyl bromide	1.34E-06	0.00E+00	6.37E-09	0.00E+00	2.75E-08
12033110000362447	Toluene	1.33E-06	6.56E-08	1.09E-08	2.59E-07	4.48E-08
01121110000366121	Chloroform	1.32E-06	0.00E+00	6.39E-10	0.00E+00	8.25E-10
37087110009846480	Styrene	1.32E-06	3.25E-07	5.02E-08	1.32E-07	2.51E-08
45091110000355035	Styrene	1.31E-06	3.23E-07	5.00E-08	1.31E-07	2.50E-08
48067110008148496	Toluene	1.30E-06	6.41E-08	1.07E-08	2.53E-07	4.37E-08
53015110000490898	Methylene chloride	1.30E-06	2.63E-08	9.56E-09	1.82E-08	6.99E-09
01121110000366121	Tetrachloroethene	1.29E-06	1.07E-07	1.61E-08	3.79E-08	1.84E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
23007110000581415	Carbon tetrachloride	1.27E-06	8.59E-09	2.01E-09	1.85E-08	3.82E-09
53015110000490852	Toluene	1.26E-06	6.19E-08	1.03E-08	2.44E-07	4.22E-08
12005110000518002	Toluene	1.26E-06	6.19E-08	1.03E-08	2.44E-07	4.22E-08
45079110000351903	Styrene	1.25E-06	3.08E-07	4.76E-08	1.25E-07	2.38E-08
53071110005312713	Methyl bromide	1.25E-06	0.00E+00	5.93E-09	0.00E+00	2.56E-08
13099110012384589	Carbon disulfide	1.24E-06	1.92E-07	1.53E-08	2.47E-06	4.79E-08
28111110002217379	Methyl bromide	1.23E-06	0.00E+00	5.85E-09	0.00E+00	2.52E-08
01047110002438103	Xylenes (mixed)	1.19E-06	4.68E-08	6.55E-09	0.00E+00	0.00E+00
13115110013763034	Methylene chloride	1.19E-06	2.41E-08	8.75E-09	1.66E-08	6.40E-09
27017110000426263	Toluene	1.18E-06	5.82E-08	9.70E-09	2.30E-07	3.97E-08
22117110001274521	Methyl bromide	1.16E-06	0.00E+00	5.53E-09	0.00E+00	2.39E-08
45019110016966381	Toluene	1.15E-06	5.67E-08	9.45E-09	2.24E-07	3.87E-08
42133110017404664	Toluene	1.15E-06	5.66E-08	9.43E-09	2.23E-07	3.86E-08
01053110012508580	Toluene	1.14E-06	5.63E-08	9.39E-09	2.22E-07	3.84E-08
55141110000742796	Carbon disulfide	1.13E-06	1.75E-07	1.40E-08	2.26E-06	4.39E-08
28077110017416599	Tetrachloroethene	1.13E-06	9.43E-08	1.41E-08	3.33E-08	1.62E-08
12033110000362447	Xylenes (mixed)	1.12E-06	4.41E-08	6.17E-09	0.00E+00	0.00E+00
45031110000587491	Acetaldehyde	1.12E-06	6.48E-09	1.07E-09	2.92E-08	1.46E-09
41041110014206117	Xylenes (mixed)	1.11E-06	4.37E-08	6.12E-09	0.00E+00	0.00E+00
28077110017416599	Styrene	1.11E-06	2.74E-07	4.24E-08	1.11E-07	2.12E-08
47107110000605088	Styrene	1.11E-06	2.74E-07	4.23E-08	1.11E-07	2.12E-08
48361110008146130	Carbon tetrachloride	1.09E-06	7.38E-09	1.72E-09	1.59E-08	3.28E-09
12089110000588542	Styrene	1.08E-06	2.66E-07	4.11E-08	1.08E-07	2.06E-08
13127110000588365	Methylene chloride	1.06E-06	2.15E-08	7.81E-09	1.48E-08	5.71E-09
22033110012384286	Tetrachloroethene	1.06E-06	8.83E-08	1.32E-08	3.12E-08	1.51E-08
28111110002217379	Methylene chloride	1.05E-06	2.14E-08	7.76E-09	1.48E-08	5.67E-09
12005110000518002	o-Xylene	1.05E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22033110012384286	Methyl bromide	1.05E-06	0.00E+00	4.98E-09	0.00E+00	2.15E-08
45079110000351903	Hydrofluoric acid	1.05E-06	3.06E-07	1.25E-08	1.57E-07	1.57E-08
23029110013359178	Tetrachloroethene	1.03E-06	8.58E-08	1.29E-08	3.03E-08	1.47E-08
37117110013794000	Hydrochloric acid	1.02E-06	7.92E-07	6.48E-08	4.75E-07	7.13E-08
13115110013763034	Toluene	1.02E-06	5.02E-08	8.37E-09	1.98E-07	3.43E-08
13021110005666243	Tetrachloroethene	1.01E-06	8.42E-08	1.26E-08	2.97E-08	1.44E-08
13051110005670336	Carbon tetrachloride	1.01E-06	6.85E-09	1.60E-09	1.47E-08	3.04E-09
13021110005666243	Styrene	9.91E-07	2.45E-07	3.78E-08	9.91E-08	1.89E-08
45091110000355035	Methylene chloride	9.89E-07	2.01E-08	7.29E-09	1.39E-08	5.33E-09
48067110008148496	Methylene chloride	9.80E-07	1.99E-08	7.22E-09	1.37E-08	5.28E-09
05081110000756352	Tetrachloroethene	9.79E-07	8.16E-08	1.22E-08	2.88E-08	1.40E-08
45069110016989669	Toluene	9.73E-07	4.80E-08	8.00E-09	1.89E-07	3.27E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
28111110002217379	Tetrachloroethene	9.72E-07	8.10E-08	1.21E-08	2.86E-08	1.39E-08
13051110000740958	Xylenes (mixed)	9.47E-07	3.72E-08	5.21E-09	0.00E+00	0.00E+00
05081110000756352	Xylenes (mixed)	9.47E-07	3.72E-08	5.21E-09	0.00E+00	0.00E+00
12107110000588604	Styrene	9.44E-07	2.33E-07	3.60E-08	9.44E-08	1.80E-08
01121110000366121	Xylenes (mixed)	9.35E-07	3.67E-08	5.14E-09	0.00E+00	0.00E+00
16069110009335905	Methyl bromide	9.34E-07	0.00E+00	4.44E-09	0.00E+00	1.92E-08
51101110007317484	Xylenes (mixed)	9.34E-07	3.67E-08	5.13E-09	0.00E+00	0.00E+00
55141110017413547	Styrene	9.32E-07	2.30E-07	3.56E-08	9.32E-08	1.78E-08
01113110017400711	Methylene chloride	9.22E-07	1.87E-08	6.79E-09	1.29E-08	4.96E-09
47107110000605088	Methylene chloride	9.20E-07	1.87E-08	6.78E-09	1.29E-08	4.96E-09
13179110013498296	Toluene	9.17E-07	4.52E-08	7.54E-09	1.79E-07	3.08E-08
37083110000586447	1,1,1-Trichloroethane	9.07E-07	4.75E-08	1.87E-08	3.25E-08	1.62E-08
05081110000756352	o-Xylene	9.01E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37087110009846480	m-Xylene	8.99E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01071110000589435	Xylenes (mixed)	8.94E-07	3.51E-08	4.92E-09	0.00E+00	0.00E+00
51670110012503781	Carbon disulfide	8.92E-07	1.38E-07	1.11E-08	1.78E-06	3.46E-08
13021110005666243	Methylene chloride	8.88E-07	1.80E-08	6.55E-09	1.24E-08	4.78E-09
53053110000490558	o-Xylene	8.88E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05029110000597890	Mercury (elemental)	8.80E-07	0.00E+00	3.11E-10	0.00E+00	2.64E-10
45031110000587491	Benzene	8.80E-07	6.73E-09	4.40E-10	7.15E-09	2.38E-09
48067110008148496	Styrene	8.76E-07	2.16E-07	3.35E-08	8.76E-08	1.67E-08
01023110017428773	Carbon disulfide	8.74E-07	1.36E-07	1.08E-08	1.75E-06	3.39E-08
48361110008146130	Styrene	8.72E-07	2.15E-07	3.33E-08	8.72E-08	1.67E-08
16069110009335905	Toluene	8.65E-07	4.27E-08	7.11E-09	1.68E-07	2.91E-08
55069110000422267	Mercury (elemental)	8.65E-07	0.00E+00	3.05E-10	0.00E+00	2.59E-10
22125110043794374	Methylene chloride	8.65E-07	1.75E-08	6.37E-09	1.21E-08	4.66E-09
13305110007356422	Methylene chloride	8.62E-07	1.75E-08	6.35E-09	1.21E-08	4.64E-09
51580110012505397	Tetrachloroethene	8.60E-07	7.17E-08	1.07E-08	2.53E-08	1.23E-08
41043110000488142	Styrene	8.58E-07	2.12E-07	3.28E-08	8.58E-08	1.64E-08
22125110043794374	Tetrachloroethene	8.58E-07	7.15E-08	1.07E-08	2.52E-08	1.23E-08
36031110000325005	Toluene	8.49E-07	4.19E-08	6.98E-09	1.65E-07	2.85E-08
47107110000605088	Xylenes (mixed)	8.38E-07	3.29E-08	4.61E-09	0.00E+00	0.00E+00
13099110012384589	Toluene	8.34E-07	4.11E-08	6.86E-09	1.62E-07	2.81E-08
01113110017400711	Styrene	8.23E-07	2.03E-07	3.14E-08	8.23E-08	1.57E-08
45041110019973493	Methylene chloride	8.21E-07	1.66E-08	6.05E-09	1.15E-08	4.42E-09
36031110000325005	o-Xylene	8.21E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36031110000325005	Xylenes (mixed)	8.18E-07	3.21E-08	4.50E-09	0.00E+00	0.00E+00
53053110000490558	Methylene chloride	8.12E-07	1.65E-08	5.99E-09	1.14E-08	4.37E-09
37087110009846480	Toluene	7.97E-07	3.93E-08	6.55E-09	1.55E-07	2.68E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
01113110017400711	Toluene	7.92E-07	3.91E-08	6.51E-09	1.54E-07	2.66E-08
55073110000422043	Tetrachloroethene	7.91E-07	6.59E-08	9.89E-09	2.33E-08	1.13E-08
42133110017404664	Tetrachloroethene	7.82E-07	6.52E-08	9.78E-09	2.30E-08	1.12E-08
45091110000355035	Tetrachloroethene	7.73E-07	6.44E-08	9.66E-09	2.27E-08	1.10E-08
16069110009335905	Carbon tetrachloride	7.69E-07	5.22E-09	1.22E-09	1.12E-08	2.32E-09
27071110000427501	Styrene	7.67E-07	1.90E-07	2.93E-08	7.67E-08	1.46E-08
12107110000588604	Tetrachloroethene	7.60E-07	6.33E-08	9.49E-09	2.23E-08	1.09E-08
45041110019973493	Toluene	7.52E-07	3.71E-08	6.18E-09	1.46E-07	2.53E-08
26043110017422467	Xylenes (mixed)	7.46E-07	2.93E-08	4.11E-09	0.00E+00	0.00E+00
41007110013844563	o-Xylene	7.44E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28111110002217379	Xylenes (mixed)	7.39E-07	2.91E-08	4.07E-09	0.00E+00	0.00E+00
12107110000588604	Methylene chloride	7.38E-07	1.50E-08	5.44E-09	1.03E-08	3.98E-09
41039110000488552	o-Xylene	7.37E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22073110017782568	Methylene chloride	7.37E-07	1.50E-08	5.43E-09	1.03E-08	3.97E-09
22033110012384286	Xylenes (mixed)	7.35E-07	2.89E-08	4.04E-09	0.00E+00	0.00E+00
13179110013498296	Methylene chloride	7.30E-07	1.48E-08	5.38E-09	1.02E-08	3.93E-09
37117110013794000	Carbon disulfide	7.27E-07	1.13E-07	9.01E-09	1.45E-06	2.82E-08
45069110016989669	Tetrachloroethene	7.24E-07	6.03E-08	9.05E-09	2.13E-08	1.03E-08
45079110000351903	o-Xylene	7.23E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01099110000589612	Xylenes (mixed)	7.23E-07	2.84E-08	3.98E-09	0.00E+00	0.00E+00
47107110000605088	Tetrachloroethene	7.18E-07	5.98E-08	8.97E-09	2.11E-08	1.03E-08
47071110017418338	Toluene	7.15E-07	3.53E-08	5.88E-09	1.39E-07	2.40E-08
36031110000325005	Methylene chloride	7.14E-07	1.45E-08	5.26E-09	1.00E-08	3.85E-09
13099110012384589	Tetrachloroethene	7.09E-07	5.90E-08	8.86E-09	2.08E-08	1.01E-08
27017110000426263	Styrene	7.04E-07	1.74E-07	2.69E-08	7.04E-08	1.34E-08
01131110007233305	Hydrofluoric acid	6.90E-07	2.02E-07	8.28E-09	1.04E-07	1.04E-08
45069110016989669	Carbon tetrachloride	6.85E-07	4.65E-09	1.08E-09	1.00E-08	2.07E-09
28087110000590940	Methylene chloride	6.85E-07	1.39E-08	5.04E-09	9.58E-09	3.69E-09
01053110012508580	Styrene	6.84E-07	1.69E-07	2.61E-08	6.84E-08	1.31E-08
42133110017404664	Carbon tetrachloride	6.84E-07	4.64E-09	1.08E-09	1.00E-08	2.06E-09
27071110000427501	Phenol	6.78E-07	6.78E-08	4.42E-08	1.04E-07	2.07E-08
12107110000588604	Xylenes (mixed)	6.75E-07	2.65E-08	3.71E-09	0.00E+00	0.00E+00
05069110000450878	Styrene	6.72E-07	1.66E-07	2.57E-08	6.72E-08	1.28E-08
37049110000350478	Xylenes (mixed)	6.70E-07	2.63E-08	3.69E-09	0.00E+00	0.00E+00
13099110012384589	Methylene chloride	6.70E-07	1.36E-08	4.94E-09	9.38E-09	3.61E-09
12033110000362447	Styrene	6.69E-07	1.65E-07	2.55E-08	6.69E-08	1.28E-08
40089110000598639	o-Xylene	6.68E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40089110000598639	Xylenes (mixed)	6.66E-07	2.62E-08	3.66E-09	0.00E+00	0.00E+00
12089110000588551	Toluene	6.61E-07	3.26E-08	5.43E-09	1.29E-07	2.22E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
12089110000588551	Benzene	6.52E-07	4.99E-09	3.26E-10	5.30E-09	1.77E-09
12033110000362447	Methylene chloride	6.50E-07	1.32E-08	4.79E-09	9.10E-09	3.50E-09
05081110000756352	Methylene chloride	6.48E-07	1.31E-08	4.77E-09	9.07E-09	3.49E-09
12089110000588542	o-Xylene	6.47E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01047110002438103	o-Xylene	6.46E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21091110000380926	Tetrachloroethene	6.45E-07	5.38E-08	8.07E-09	1.90E-08	9.22E-09
53071110005312713	Styrene	6.42E-07	1.58E-07	2.45E-08	6.42E-08	1.22E-08
28077110017416599	Carbon tetrachloride	6.41E-07	4.35E-09	1.01E-09	9.37E-09	1.93E-09
41039110000488552	Xylenes (mixed)	6.41E-07	2.52E-08	3.52E-09	0.00E+00	0.00E+00
13193110007356002	Mercury (elemental)	6.37E-07	0.00E+00	2.25E-10	0.00E+00	1.91E-10
22049110000597514	Methylene chloride	6.33E-07	1.28E-08	4.66E-09	8.86E-09	3.41E-09
12005110000518002	Carbon tetrachloride	6.31E-07	4.28E-09	9.99E-10	9.23E-09	1.90E-09
45091110000355035	Methyl bromide	6.29E-07	0.00E+00	2.99E-09	0.00E+00	1.29E-08
28087110000590940	Styrene	6.24E-07	1.54E-07	2.38E-08	6.24E-08	1.19E-08
12123110000362223	Carbon tetrachloride	6.22E-07	4.22E-09	9.85E-10	9.09E-09	1.88E-09
13185110005666421	Methylene chloride	6.12E-07	1.24E-08	4.51E-09	8.57E-09	3.30E-09
41041110014206117	Methyl bromide	6.08E-07	0.00E+00	2.89E-09	0.00E+00	1.25E-08
13185110005666421	Toluene	5.97E-07	2.94E-08	4.91E-09	1.16E-07	2.01E-08
01091110000601965	Xylenes (mixed)	5.96E-07	2.34E-08	3.28E-09	0.00E+00	0.00E+00
48067110008148496	Carbon tetrachloride	5.94E-07	4.03E-09	9.41E-10	8.68E-09	1.79E-09
13115110013763034	Carbon tetrachloride	5.92E-07	4.02E-09	9.38E-10	8.65E-09	1.79E-09
22073110017782568	Styrene	5.88E-07	1.45E-07	2.24E-08	5.88E-08	1.12E-08
27071110000427501	Toluene	5.87E-07	2.90E-08	4.83E-09	1.14E-07	1.98E-08
41041110014206117	Carbon tetrachloride	5.87E-07	3.98E-09	9.29E-10	8.58E-09	1.77E-09
13051110000740958	Carbon tetrachloride	5.84E-07	3.96E-09	9.24E-10	8.53E-09	1.76E-09
51670110012503781	Xylenes (mixed)	5.83E-07	2.29E-08	3.21E-09	0.00E+00	0.00E+00
01131110007233305	o-Xylene	5.64E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01131110007233305	Xylenes (mixed)	5.64E-07	2.22E-08	3.10E-09	0.00E+00	0.00E+00
21091110000380926	Carbon tetrachloride	5.60E-07	3.80E-09	8.87E-10	8.19E-09	1.69E-09
51101110007317484	Styrene	5.60E-07	1.38E-07	2.14E-08	5.60E-08	1.07E-08
01091110000601965	Tetrachloroethene	5.59E-07	4.66E-08	6.99E-09	1.64E-08	7.99E-09
36031110000325005	Carbon tetrachloride	5.56E-07	3.77E-09	8.80E-10	8.12E-09	1.68E-09
01071110000589435	Methylene chloride	5.50E-07	1.12E-08	4.05E-09	7.70E-09	2.96E-09
28149110000605220	o-Xylene	5.48E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22049110000597514	Toluene	5.48E-07	2.70E-08	4.50E-09	1.07E-07	1.84E-08
13127110000588365	Methyl bromide	5.44E-07	0.00E+00	2.59E-09	0.00E+00	1.12E-08
21091110000380926	Xylenes (mixed)	5.42E-07	2.13E-08	2.98E-09	0.00E+00	0.00E+00
22073110017782568	Toluene	5.40E-07	2.66E-08	4.44E-09	1.05E-07	1.82E-08
22125110043794374	Xylenes (mixed)	5.38E-07	2.11E-08	2.96E-09	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
37049110000350478	Toluene	5.34E-07	2.63E-08	4.39E-09	1.04E-07	1.79E-08
51093110000560492	Tetrachloroethene	5.27E-07	4.39E-08	6.59E-09	1.55E-08	7.53E-09
13245110000359718	Carbon tetrachloride	5.23E-07	3.55E-09	8.28E-10	7.64E-09	1.58E-09
22069110039166390	Xylenes (mixed)	5.17E-07	2.03E-08	2.84E-09	0.00E+00	0.00E+00
51101110007317484	o-Xylene	5.16E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47107110000605088	Methyl bromide	5.12E-07	0.00E+00	2.44E-09	0.00E+00	1.05E-08
45079110000351903	Carbon tetrachloride	5.12E-07	3.48E-09	8.11E-10	7.49E-09	1.54E-09
22031110000450173	Carbon tetrachloride	5.08E-07	3.45E-09	8.04E-10	7.42E-09	1.53E-09
45069110016989669	Styrene	5.06E-07	1.25E-07	1.93E-08	5.06E-08	9.65E-09
23017110000491940	Tetrachloroethene	5.06E-07	4.21E-08	6.32E-09	1.49E-08	7.22E-09
01025110000369280	Xylenes (mixed)	5.04E-07	1.98E-08	2.77E-09	0.00E+00	0.00E+00
12033110000362447	Carbon tetrachloride	5.00E-07	3.39E-09	7.91E-10	7.30E-09	1.51E-09
22117110001274521	Toluene	4.99E-07	2.46E-08	4.10E-09	9.72E-08	1.68E-08
23007110000581415	Styrene	4.98E-07	1.23E-07	1.90E-08	4.98E-08	9.52E-09
13305110007356422	Styrene	4.90E-07	1.21E-07	1.87E-08	4.90E-08	9.35E-09
45091110000355035	o-Xylene	4.84E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22033110012384286	Methylene chloride	4.81E-07	9.76E-09	3.55E-09	6.74E-09	2.59E-09
13021110005666243	o-Xylene	4.75E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53015110000490852	Carbon tetrachloride	4.74E-07	3.22E-09	7.51E-10	6.93E-09	1.43E-09
13051110000740958	Methylene chloride	4.74E-07	9.61E-09	3.49E-09	6.63E-09	2.55E-09
23019110000581460	Styrene	4.72E-07	1.17E-07	1.80E-08	4.72E-08	9.01E-09
13051110000740958	Styrene	4.70E-07	1.16E-07	1.80E-08	4.70E-08	8.98E-09
05003110000450921	Styrene	4.67E-07	1.15E-07	1.78E-08	4.67E-08	8.92E-09
01047110002438103	Toluene	4.66E-07	2.30E-08	3.83E-09	9.08E-08	1.57E-08
01131110007233305	Toluene	4.64E-07	2.29E-08	3.81E-09	9.03E-08	1.56E-08
13051110005670336	Xylenes (mixed)	4.63E-07	1.82E-08	2.55E-09	0.00E+00	0.00E+00
01047110002438103	Carbon tetrachloride	4.57E-07	3.10E-09	7.24E-10	6.68E-09	1.38E-09
41043110000488142	Methylene chloride	4.57E-07	9.27E-09	3.37E-09	6.39E-09	2.46E-09
13099110012384589	o-Xylene	4.54E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12005110000518002	Styrene	4.49E-07	1.11E-07	1.71E-08	4.49E-08	8.57E-09
22031110000450173	Methylene chloride	4.48E-07	9.09E-09	3.30E-09	6.27E-09	2.41E-09
41041110014206117	Toluene	4.44E-07	2.19E-08	3.65E-09	8.65E-08	1.49E-08
51093110000560492	Styrene	4.44E-07	1.10E-07	1.70E-08	4.44E-08	8.48E-09
53015110000490852	Styrene	4.43E-07	1.09E-07	1.69E-08	4.43E-08	8.45E-09
37049110000350478	Tetrachloroethene	4.40E-07	3.67E-08	5.50E-09	1.29E-08	6.29E-09
01091110000601965	Carbon tetrachloride	4.34E-07	2.95E-09	6.87E-10	6.35E-09	1.31E-09
51093110000560492	Methylene chloride	4.34E-07	8.81E-09	3.20E-09	6.08E-09	2.34E-09
12033110000362447	Methyl bromide	4.33E-07	0.00E+00	2.06E-09	0.00E+00	8.89E-09
47163110017711289	Tetrachloroethene	4.33E-07	3.61E-08	5.41E-09	1.27E-08	6.18E-09

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
53053110000490558	Styrene	4.32E-07	1.07E-07	1.65E-08	4.32E-08	8.24E-09
41007110013844563	Carbon tetrachloride	4.32E-07	2.93E-09	6.83E-10	6.31E-09	1.30E-09
26041110017408848	Methylene chloride	4.29E-07	8.70E-09	3.16E-09	6.00E-09	2.31E-09
05081110000756352	Methyl bromide	4.28E-07	0.00E+00	2.03E-09	0.00E+00	8.78E-09
22031110000450173	Styrene	4.26E-07	1.05E-07	1.62E-08	4.26E-08	8.12E-09
37049110000350478	Carbon tetrachloride	4.24E-07	2.88E-09	6.72E-10	6.20E-09	1.28E-09
01091110000601965	Methylene chloride	4.22E-07	8.56E-09	3.11E-09	5.91E-09	2.27E-09
01047110002438103	Styrene	4.22E-07	1.04E-07	1.61E-08	4.22E-08	8.05E-09
37049110000350478	Styrene	4.21E-07	1.04E-07	1.61E-08	4.21E-08	8.04E-09
21091110000380926	Methylene chloride	4.21E-07	8.54E-09	3.10E-09	5.89E-09	2.27E-09
40089110000598639	Carbon tetrachloride	4.19E-07	2.84E-09	6.64E-10	6.13E-09	1.26E-09
01053110012508580	Carbon tetrachloride	4.15E-07	2.82E-09	6.57E-10	6.07E-09	1.25E-09
22011110006020028	Xylenes (mixed)	4.14E-07	1.63E-08	2.28E-09	0.00E+00	0.00E+00
01047110002438103	Methylene chloride	4.09E-07	8.31E-09	3.02E-09	5.73E-09	2.20E-09
01113110017400711	Carbon tetrachloride	4.08E-07	2.77E-09	6.46E-10	5.97E-09	1.23E-09
42133110017404664	Methylene chloride	4.06E-07	8.24E-09	2.99E-09	5.69E-09	2.19E-09
01113110017400711	Methyl bromide	4.06E-07	0.00E+00	1.93E-09	0.00E+00	8.34E-09
37083110000586447	Xylenes (mixed)	4.05E-07	1.59E-08	2.23E-09	0.00E+00	0.00E+00
37117110013794000	Arsenic compounds	4.04E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
01071110000589435	o-Xylene	3.91E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45043110000353466	Carbon tetrachloride	3.87E-07	2.63E-09	6.13E-10	5.66E-09	1.17E-09
28087110000590940	Xylenes (mixed)	3.80E-07	1.49E-08	2.09E-09	0.00E+00	0.00E+00
48241110000599594	Toluene	3.77E-07	1.86E-08	3.10E-09	7.35E-08	1.27E-08
13115110013763034	Methyl bromide	3.74E-07	0.00E+00	1.78E-09	0.00E+00	7.69E-09
28111110002217379	Toluene	3.72E-07	1.84E-08	3.06E-09	7.25E-08	1.25E-08
05081110000756352	Toluene	3.72E-07	1.84E-08	3.06E-09	7.25E-08	1.25E-08
55141110017413547	Toluene	3.72E-07	1.83E-08	3.05E-09	7.24E-08	1.25E-08
47107110000605088	Carbon disulfide	3.67E-07	5.69E-08	4.55E-09	7.34E-07	1.42E-08
36031110000325005	Styrene	3.64E-07	9.01E-08	1.39E-08	3.64E-08	6.96E-09
51101110007317484	Carbon tetrachloride	3.62E-07	2.46E-09	5.74E-10	5.29E-09	1.09E-09
13115110013763034	Styrene	3.61E-07	8.91E-08	1.38E-08	3.61E-08	6.89E-09
41043110000488142	Tetrachloroethene	3.56E-07	2.97E-08	4.45E-09	1.05E-08	5.09E-09
45041110019973493	Methyl bromide	3.51E-07	0.00E+00	1.67E-09	0.00E+00	7.20E-09
01131110007233305	Methylene chloride	3.42E-07	6.94E-09	2.52E-09	4.79E-09	1.84E-09
28087110000590940	Carbon disulfide	3.41E-07	5.29E-08	4.23E-09	6.83E-07	1.32E-08
47107110000605088	Phenol	3.39E-07	3.39E-08	2.21E-08	5.18E-08	1.04E-08
22033110012384286	Toluene	3.39E-07	1.67E-08	2.79E-09	6.60E-08	1.14E-08
05081110000756352	Carbon tetrachloride	3.36E-07	2.28E-09	5.32E-10	4.91E-09	1.01E-09
28087110000590940	Tetrachloroethene	3.35E-07	2.80E-08	4.19E-09	9.87E-09	4.79E-09

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
01071110000589435	Toluene	3.33E-07	1.64E-08	2.74E-09	6.49E-08	1.12E-08
41043110000488142	Xylenes (mixed)	3.29E-07	1.29E-08	1.81E-09	0.00E+00	0.00E+00
13305110007356422	Carbon tetrachloride	3.28E-07	2.23E-09	5.20E-10	4.80E-09	9.90E-10
41039110000488552	Carbon tetrachloride	3.26E-07	2.21E-09	5.16E-10	4.77E-09	9.83E-10
37047110009719304	Carbon tetrachloride	3.22E-07	2.18E-09	5.09E-10	4.70E-09	9.70E-10
05041110012414985	Styrene	3.21E-07	7.94E-08	1.23E-08	3.21E-08	6.14E-09
22031110000450173	Hydrofluoric acid	3.21E-07	9.40E-08	3.86E-09	4.82E-08	4.82E-09
22031110000450173	Toluene	3.19E-07	1.58E-08	2.63E-09	6.22E-08	1.07E-08
28087110000590940	Phenol	3.19E-07	3.19E-08	2.08E-08	4.87E-08	9.74E-09
27017110000426263	Tetrachloroethene	3.18E-07	2.65E-08	3.97E-09	9.35E-09	4.54E-09
23025110017413468	Methylene chloride	3.13E-07	6.35E-09	2.31E-09	4.38E-09	1.69E-09
12089110000588542	Methyl bromide	3.10E-07	0.00E+00	1.47E-09	0.00E+00	6.36E-09
01099110000589612	Methylene chloride	3.09E-07	6.26E-09	2.27E-09	4.32E-09	1.66E-09
55141110000742796	Xylenes (mixed)	3.09E-07	1.21E-08	1.70E-09	0.00E+00	0.00E+00
40089110000598639	Styrene	3.06E-07	7.56E-08	1.17E-08	3.06E-08	5.84E-09
53053110000490558	Carbon tetrachloride	3.06E-07	2.08E-09	4.84E-10	4.47E-09	9.23E-10
01131110007233305	Styrene	3.03E-07	7.49E-08	1.16E-08	3.03E-08	5.78E-09
12033110000362447	Tetrachloroethene	3.03E-07	2.52E-08	3.79E-09	8.91E-09	4.33E-09
12089110000588542	Carbon tetrachloride	3.03E-07	2.06E-09	4.80E-10	4.43E-09	9.13E-10
45041110019973493	Carbon tetrachloride	2.97E-07	2.01E-09	4.70E-10	4.34E-09	8.95E-10
40089110000598639	Methylene chloride	2.96E-07	6.01E-09	2.18E-09	4.15E-09	1.59E-09
41043110000488142	Methyl bromide	2.95E-07	0.00E+00	1.40E-09	0.00E+00	6.06E-09
23025110017413468	Styrene	2.95E-07	7.28E-08	1.12E-08	2.95E-08	5.62E-09
23019110000581460	Xylenes (mixed)	2.94E-07	1.16E-08	1.62E-09	0.00E+00	0.00E+00
05003110000450921	Methyl bromide	2.94E-07	0.00E+00	1.40E-09	0.00E+00	6.04E-09
53071110005312713	Carbon tetrachloride	2.93E-07	1.99E-09	4.65E-10	4.29E-09	8.85E-10
22049110000597514	Carbon tetrachloride	2.92E-07	1.98E-09	4.62E-10	4.27E-09	8.81E-10
22011110006020028	Chloroform	2.89E-07	0.00E+00	1.40E-10	0.00E+00	1.80E-10
01121110000366121	Methylene chloride	2.88E-07	5.83E-09	2.12E-09	4.03E-09	1.55E-09
13051110000740958	Toluene	2.86E-07	1.41E-08	2.35E-09	5.58E-08	9.63E-09
45019110016966381	Styrene	2.84E-07	7.03E-08	1.09E-08	2.84E-08	5.43E-09
41039110000488552	Methylene chloride	2.82E-07	5.72E-09	2.08E-09	3.95E-09	1.52E-09
01091110000601965	Toluene	2.81E-07	1.38E-08	2.31E-09	5.47E-08	9.44E-09
23019110000581460	Phenol	2.79E-07	2.79E-08	1.82E-08	4.26E-08	8.53E-09
47163110017711289	Xylenes (mixed)	2.73E-07	1.07E-08	1.50E-09	0.00E+00	0.00E+00
41039110000488552	Styrene	2.69E-07	6.64E-08	1.03E-08	2.69E-08	5.13E-09
22073110017782568	Methyl bromide	2.65E-07	0.00E+00	1.26E-09	0.00E+00	5.44E-09
23029110013359178	Toluene	2.65E-07	1.31E-08	2.18E-09	5.16E-08	8.91E-09
22073110017782568	Carbon tetrachloride	2.64E-07	1.79E-09	4.18E-10	3.86E-09	7.96E-10

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22033110012384286	Carbon tetrachloride	2.63E-07	1.78E-09	4.16E-10	3.84E-09	7.93E-10
53015110000490898	Tetrachloroethene	2.61E-07	2.18E-08	3.27E-09	7.68E-09	3.73E-09
40089110000598639	Toluene	2.61E-07	1.29E-08	2.14E-09	5.08E-08	8.77E-09
53015110000490898	Toluene	2.60E-07	1.28E-08	2.14E-09	5.07E-08	8.76E-09
01071110000589435	Methyl bromide	2.60E-07	0.00E+00	1.24E-09	0.00E+00	5.33E-09
45091110000355035	1,1,1-Trichloroethane	2.59E-07	1.36E-08	5.34E-09	9.28E-09	4.64E-09
01091110000601965	Methyl bromide	2.59E-07	0.00E+00	1.23E-09	0.00E+00	5.32E-09
26043110017422467	Carbon tetrachloride	2.59E-07	1.76E-09	4.10E-10	3.78E-09	7.81E-10
26101110000412045	Styrene	2.58E-07	6.38E-08	9.86E-09	2.58E-08	4.93E-09
01023110017428773	Methyl bromide	2.55E-07	0.00E+00	1.21E-09	0.00E+00	5.23E-09
28111110002217379	Carbon tetrachloride	2.55E-07	1.73E-09	4.03E-10	3.72E-09	7.68E-10
26101110000412045	Toluene	2.54E-07	1.25E-08	2.09E-09	4.95E-08	8.54E-09
22031110000450173	Methyl bromide	2.51E-07	0.00E+00	1.19E-09	0.00E+00	5.15E-09
01071110000589435	Carbon tetrachloride	2.50E-07	1.70E-09	3.96E-10	3.66E-09	7.55E-10
01001110011734935	Carbon tetrachloride	2.50E-07	1.70E-09	3.96E-10	3.65E-09	7.53E-10
26043110017422467	Toluene	2.50E-07	1.23E-08	2.05E-09	4.86E-08	8.40E-09
27071110000427501	o-Xylene	2.49E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
05003110000450921	Carbon tetrachloride	2.45E-07	1.66E-09	3.87E-10	3.57E-09	7.37E-10
53053110000490558	Methyl bromide	2.43E-07	0.00E+00	1.16E-09	0.00E+00	4.99E-09
45091110000355035	m-Xylene	2.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45091110000355035	p-Xylene	2.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51670110012503781	Toluene	2.41E-07	1.19E-08	1.98E-09	4.70E-08	8.12E-09
13179110013498296	Styrene	2.40E-07	5.94E-08	9.17E-09	2.40E-08	4.59E-09
45019110016966381	Tetrachloroethene	2.37E-07	1.98E-08	2.96E-09	6.97E-09	3.39E-09
41007110013844563	Methyl bromide	2.36E-07	0.00E+00	1.12E-09	0.00E+00	4.85E-09
21091110000380926	Methyl bromide	2.36E-07	0.00E+00	1.12E-09	0.00E+00	4.84E-09
41041110014206117	Styrene	2.29E-07	5.67E-08	8.76E-09	2.29E-08	4.38E-09
01091110000601965	Styrene	2.27E-07	5.62E-08	8.68E-09	2.27E-08	4.34E-09
41041110014206117	Tetrachloroethene	2.27E-07	1.89E-08	2.84E-09	6.68E-09	3.24E-09
37049110000350478	Methyl bromide	2.25E-07	0.00E+00	1.07E-09	0.00E+00	4.61E-09
05029110000597890	Styrene	2.24E-07	5.54E-08	8.57E-09	2.24E-08	4.28E-09
23025110017413468	Benzene	2.23E-07	1.70E-09	1.11E-10	1.81E-09	6.03E-10
13185110005666421	Carbon tetrachloride	2.21E-07	1.50E-09	3.50E-10	3.24E-09	6.68E-10
01025110000369280	Styrene	2.15E-07	5.31E-08	8.21E-09	2.15E-08	4.10E-09
42133110017404664	Methyl bromide	2.13E-07	0.00E+00	1.02E-09	0.00E+00	4.38E-09
45043110000353466	Tetrachloroethene	2.13E-07	1.77E-08	2.66E-09	6.25E-09	3.04E-09
41039110000488552	Toluene	2.12E-07	1.05E-08	1.75E-09	4.14E-08	7.14E-09
55141110000742796	Carbon tetrachloride	2.11E-07	1.43E-09	3.34E-10	3.09E-09	6.37E-10
13051110000740958	Methyl bromide	2.10E-07	0.00E+00	9.99E-10	0.00E+00	4.31E-09

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
45041110019973493	Styrene	2.08E-07	5.15E-08	7.96E-09	2.08E-08	3.98E-09
16069110009335905	Styrene	2.02E-07	5.00E-08	7.72E-09	2.02E-08	3.86E-09
53015110000490898	Xylenes (mixed)	2.00E-07	7.87E-09	1.10E-09	0.00E+00	0.00E+00
53015110000490898	Carbon tetrachloride	1.98E-07	1.34E-09	3.13E-10	2.89E-09	5.96E-10
42133110017404664	Styrene	1.94E-07	4.80E-08	7.42E-09	1.94E-08	3.71E-09
13185110005666421	Styrene	1.93E-07	4.78E-08	7.38E-09	1.93E-08	3.69E-09
13021110005666243	Toluene	1.93E-07	9.51E-09	1.58E-09	3.75E-08	6.48E-09
12089110000588551	Carbon disulfide	1.92E-07	2.98E-08	2.38E-09	3.84E-07	7.44E-09
55141110000742796	Tetrachloroethene	1.86E-07	1.55E-08	2.33E-09	5.48E-09	2.66E-09
55141110000742796	Methylene chloride	1.85E-07	3.75E-09	1.36E-09	2.59E-09	9.95E-10
22069110039166390	Carbon tetrachloride	1.79E-07	1.22E-09	2.84E-10	2.62E-09	5.41E-10
22069110039166390	Methylene chloride	1.77E-07	3.59E-09	1.30E-09	2.48E-09	9.53E-10
22069110039166390	Styrene	1.76E-07	4.36E-08	6.73E-09	1.76E-08	3.37E-09
22069110039166390	Toluene	1.76E-07	8.68E-09	1.45E-09	3.43E-08	5.92E-09
41039110000488552	Methyl bromide	1.76E-07	0.00E+00	8.35E-10	0.00E+00	3.61E-09
01071110000589435	Styrene	1.75E-07	4.33E-08	6.69E-09	1.75E-08	3.34E-09
13099110012384589	m-Xylene	1.74E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37117110013794000	Styrene	1.73E-07	4.28E-08	6.61E-09	1.73E-08	3.31E-09
47071110017418338	Styrene	1.64E-07	4.05E-08	6.26E-09	1.64E-08	3.13E-09
51670110012503781	Methylene chloride	1.64E-07	3.32E-09	1.21E-09	2.29E-09	8.81E-10
37083110000586447	Toluene	1.59E-07	7.86E-09	1.31E-09	3.10E-08	5.36E-09
22117110001274521	Carbon tetrachloride	1.59E-07	1.08E-09	2.52E-10	2.33E-09	4.80E-10
22011110006020028	Styrene	1.54E-07	3.81E-08	5.89E-09	1.54E-08	2.95E-09
01099110000589612	Toluene	1.54E-07	7.61E-09	1.27E-09	3.01E-08	5.19E-09
26041110017408848	Toluene	1.53E-07	7.53E-09	1.26E-09	2.97E-08	5.14E-09
13305110007356422	1,1,1-Trichloroethane	1.42E-07	7.45E-09	2.94E-09	5.10E-09	2.55E-09
45091110000355035	Toluene	1.42E-07	7.00E-09	1.17E-09	2.76E-08	4.77E-09
01131110007233305	Carbon tetrachloride	1.41E-07	9.59E-10	2.24E-10	2.06E-09	4.26E-10
13021110005666243	m-Xylene	1.40E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21091110000380926	Toluene	1.37E-07	6.78E-09	1.13E-09	2.68E-08	4.62E-09
28111110002217379	Styrene	1.34E-07	3.32E-08	5.13E-09	1.34E-08	2.57E-09
22011110006020028	Toluene	1.34E-07	6.60E-09	1.10E-09	2.60E-08	4.50E-09
13179110013498296	Carbon tetrachloride	1.30E-07	8.84E-10	2.06E-10	1.90E-09	3.93E-10
37117110013794000	Xylenes (mixed)	1.28E-07	5.03E-09	7.04E-10	0.00E+00	0.00E+00
22049110000597514	Styrene	1.24E-07	3.06E-08	4.73E-09	1.24E-08	2.37E-09
37117110013794000	Toluene	1.24E-07	6.10E-09	1.02E-09	2.41E-08	4.16E-09
22011110006020028	Tetrachloroethene	1.23E-07	1.03E-08	1.54E-09	3.63E-09	1.76E-09
22125110043794374	Toluene	1.23E-07	6.08E-09	1.01E-09	2.40E-08	4.14E-09
22011110006020028	Methylene chloride	1.23E-07	2.50E-09	9.07E-10	1.72E-09	6.63E-10

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
21007110000732173	1,1,1-Trichloroethane	1.20E-07	6.29E-09	2.48E-09	4.30E-09	2.15E-09
41043110000488142	1,1,1-Trichloroethane	1.20E-07	6.26E-09	2.47E-09	4.29E-09	2.14E-09
23029110013359178	Styrene	1.19E-07	2.94E-08	4.54E-09	1.19E-08	2.27E-09
55073110000422043	Toluene	1.16E-07	5.74E-09	9.56E-10	2.27E-08	3.91E-09
26101110000412045	Xylenes (mixed)	1.15E-07	4.50E-09	6.31E-10	0.00E+00	0.00E+00
47163110017711289	Toluene	1.12E-07	5.53E-09	9.21E-10	2.18E-08	3.77E-09
01121110000366121	Toluene	1.12E-07	5.50E-09	9.17E-10	2.17E-08	3.75E-09
37083110000586447	Carbon tetrachloride	1.12E-07	7.57E-10	1.77E-10	1.63E-09	3.36E-10
37083110000586447	Phenol	1.11E-07	1.11E-08	7.23E-09	1.69E-08	3.39E-09
13185110005666421	Tetrachloroethene	1.07E-07	8.89E-09	1.33E-09	3.14E-09	1.52E-09
48241110000599594	Styrene	1.02E-07	2.51E-08	3.88E-09	1.02E-08	1.94E-09
22031110000450173	Tetrachloroethene	9.90E-08	8.25E-09	1.24E-09	2.91E-09	1.41E-09
53011110000564586	1,1,1-Trichloroethane	9.86E-08	5.16E-09	2.03E-09	3.53E-09	1.76E-09
13051110000740958	Tetrachloroethene	9.26E-08	7.72E-09	1.16E-09	2.72E-09	1.32E-09
05081110000756352	Styrene	8.84E-08	2.18E-08	3.38E-09	8.84E-09	1.69E-09
47163110017711289	Methylene chloride	8.38E-08	1.70E-09	6.18E-10	1.17E-09	4.51E-10
55141110000742796	Toluene	8.27E-08	4.08E-09	6.80E-10	1.61E-08	2.78E-09
45031110000587491	Methanol	8.26E-08	3.35E-09	8.57E-10	8.90E-09	1.78E-09
26041110017408848	Styrene	8.19E-08	2.02E-08	3.13E-09	8.19E-09	1.56E-09
22117110001274521	Tetrachloroethene	7.98E-08	6.65E-09	9.98E-10	2.35E-09	1.14E-09
22033110012384286	Styrene	7.96E-08	1.97E-08	3.04E-09	7.96E-09	1.52E-09
53015110000490898	Methyl bromide	7.75E-08	0.00E+00	3.68E-10	0.00E+00	1.59E-09
37083110000586447	Styrene	7.56E-08	1.87E-08	2.89E-09	7.56E-09	1.44E-09
51093110000560492	Toluene	7.27E-08	3.59E-09	5.98E-10	1.42E-08	2.45E-09
47107110000605088	o-Xylene	6.96E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55141110017413547	Methylene chloride	6.85E-08	1.39E-09	5.05E-10	9.59E-10	3.69E-10
55141110017413547	Xylenes (mixed)	6.80E-08	2.67E-09	3.74E-10	0.00E+00	0.00E+00
41039110000488552	Tetrachloroethene	6.32E-08	5.27E-09	7.90E-10	1.86E-09	9.03E-10
55141110000742796	Styrene	6.05E-08	1.49E-08	2.31E-09	6.05E-09	1.15E-09
01121110000366121	Styrene	6.02E-08	1.49E-08	2.30E-09	6.02E-09	1.15E-09
45043110000353466	1,1,1-Trichloroethane	5.92E-08	3.10E-09	1.22E-09	2.12E-09	1.06E-09
21091110000380926	Styrene	5.87E-08	1.45E-08	2.24E-09	5.87E-09	1.12E-09
13245110000359718	Tetrachloroethene	5.75E-08	4.79E-09	7.18E-10	1.69E-09	8.21E-10
55073110000422043	Styrene	5.64E-08	1.39E-08	2.15E-09	5.64E-09	1.08E-09
23019110000581460	Toluene	5.33E-08	2.63E-09	4.38E-10	1.04E-08	1.79E-09
51670110012503781	Styrene	5.32E-08	1.31E-08	2.03E-09	5.32E-09	1.02E-09
26101110000412045	Mercury (elemental)	4.60E-08	0.00E+00	1.62E-11	0.00E+00	1.38E-11
01071110000589435	Tetrachloroethene	4.59E-08	3.83E-09	5.74E-10	1.35E-09	6.56E-10
27017110000426263	Carbon disulfide	3.79E-08	5.87E-09	4.69E-10	7.57E-08	1.47E-09

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
51670110012503781	Tetrachloroethene	3.72E-08	3.10E-09	4.65E-10	1.09E-09	5.31E-10
05069110000450878	1,1,1-Trichloroethane	3.69E-08	1.93E-09	7.60E-10	1.32E-09	6.60E-10
01047110002438103	Tetrachloroethene	3.19E-08	2.66E-09	3.99E-10	9.39E-10	4.56E-10
28077110017416599	1,1,1-Trichloroethane	3.06E-08	1.60E-09	6.31E-10	1.10E-09	5.48E-10
13051110000740958	Hydrofluoric acid	3.03E-08	8.87E-09	3.64E-10	4.55E-09	4.55E-10
13185110005666421	Methyl bromide	2.99E-08	0.00E+00	1.42E-10	0.00E+00	6.13E-10
53015110000490898	Styrene	2.94E-08	7.26E-09	1.12E-09	2.94E-09	5.61E-10
48067110008148496	Tetrachloroethene	2.92E-08	2.43E-09	3.65E-10	8.59E-10	4.17E-10
12107110000588604	Toluene	2.92E-08	1.44E-09	2.40E-10	5.68E-09	9.82E-10
37047110009719304	1,1,1-Trichloroethane	2.91E-08	1.52E-09	6.00E-10	1.04E-09	5.21E-10
47107110000605088	Toluene	2.91E-08	1.44E-09	2.39E-10	5.67E-09	9.80E-10
47163110017711289	Styrene	2.75E-08	6.79E-09	1.05E-09	2.75E-09	5.24E-10
36031110000325005	Tetrachloroethene	2.73E-08	2.28E-09	3.41E-10	8.03E-10	3.90E-10
01025110000369280	Toluene	2.70E-08	1.33E-09	2.22E-10	5.27E-09	9.10E-10
48361110008146130	1,1,1-Trichloroethane	2.63E-08	1.38E-09	5.42E-10	9.41E-10	4.71E-10
45079110000351903	Tetrachloroethene	2.52E-08	2.10E-09	3.15E-10	7.40E-10	3.60E-10
36113110000324845	Benzene	2.31E-08	1.76E-10	1.15E-11	1.87E-10	6.25E-11
16069110009335905	1,1,1-Trichloroethane	2.29E-08	1.20E-09	4.71E-10	8.18E-10	4.09E-10
12123110000362223	1,1,1-Trichloroethane	2.14E-08	1.12E-09	4.40E-10	7.64E-10	3.82E-10
12033110000362447	1,1,1-Trichloroethane	2.13E-08	1.11E-09	4.39E-10	7.62E-10	3.81E-10
40089110000598639	Tetrachloroethene	2.06E-08	1.72E-09	2.58E-10	6.07E-10	2.95E-10
47163110017711289	Carbon tetrachloride	1.98E-08	1.34E-10	3.13E-11	2.89E-10	5.96E-11
45069110016989669	1,1,1-Trichloroethane	1.88E-08	9.81E-10	3.86E-10	6.71E-10	3.36E-10
01001110011734935	1,1,1-Trichloroethane	1.81E-08	9.49E-10	3.74E-10	6.49E-10	3.25E-10
37047110009719304	Tetrachloroethene	1.75E-08	1.46E-09	2.19E-10	5.16E-10	2.51E-10
01053110012508580	1,1,1-Trichloroethane	1.74E-08	9.09E-10	3.58E-10	6.22E-10	3.11E-10
12005110000518002	1,1,1-Trichloroethane	1.64E-08	8.56E-10	3.37E-10	5.86E-10	2.93E-10
41043110000488142	Toluene	1.59E-08	7.86E-10	1.31E-10	3.10E-09	5.36E-10
13127110000588365	1,1,1-Trichloroethane	1.57E-08	8.20E-10	3.23E-10	5.61E-10	2.81E-10
28087110000590940	Toluene	1.40E-08	6.90E-10	1.15E-10	2.72E-09	4.71E-10
26041110017408848	1,1,1-Trichloroethane	1.38E-08	7.22E-10	2.84E-10	4.94E-10	2.47E-10
42133110017404664	1,1,1-Trichloroethane	1.33E-08	6.93E-10	2.73E-10	4.74E-10	2.37E-10
13245110000359718	1,1,1-Trichloroethane	1.30E-08	6.80E-10	2.68E-10	4.65E-10	2.33E-10
53071110005312713	1,1,1-Trichloroethane	1.30E-08	6.79E-10	2.68E-10	4.65E-10	2.32E-10
22031110000450173	1,1,1-Trichloroethane	1.28E-08	6.70E-10	2.64E-10	4.58E-10	2.29E-10
28149110000605220	1,1,1-Trichloroethane	1.23E-08	6.44E-10	2.54E-10	4.41E-10	2.20E-10
01001110011734935	Tetrachloroethene	1.23E-08	1.02E-09	1.54E-10	3.62E-10	1.76E-10
53053110000490558	1,1,1-Trichloroethane	1.18E-08	6.18E-10	2.43E-10	4.23E-10	2.11E-10
51101110007317484	1,1,1-Trichloroethane	1.18E-08	6.17E-10	2.43E-10	4.22E-10	2.11E-10

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

		Maximum Hazard Quotient[1]				
Facility NEI ID	Pollutant	REL	AEGL1	AEGL2	ERPG1	ERPG2
13051110000740958	1,1,1-Trichloroethane	1.11E-08	5.82E-10	2.29E-10	3.98E-10	1.99E-10
22117110001274521	1,1,1-Trichloroethane	1.09E-08	5.70E-10	2.24E-10	3.90E-10	1.95E-10
05081110000756352	1,1,1-Trichloroethane	1.05E-08	5.49E-10	2.16E-10	3.76E-10	1.88E-10
22033110012384286	1,1,1-Trichloroethane	1.04E-08	5.43E-10	2.14E-10	3.72E-10	1.86E-10
01113110017400711	1,1,1-Trichloroethane	9.99E-09	5.22E-10	2.06E-10	3.57E-10	1.79E-10
28111110002217379	1,1,1-Trichloroethane	9.78E-09	5.11E-10	2.01E-10	3.50E-10	1.75E-10
53015110000490852	1,1,1-Trichloroethane	9.39E-09	4.91E-10	1.93E-10	3.36E-10	1.68E-10
13115110013763034	1,1,1-Trichloroethane	9.29E-09	4.86E-10	1.92E-10	3.33E-10	1.66E-10
21091110000380926	1,1,1-Trichloroethane	9.22E-09	4.82E-10	1.90E-10	3.30E-10	1.65E-10
22069110039166390	Tetrachloroethene	8.81E-09	7.34E-10	1.10E-10	2.59E-10	1.26E-10
45041110019973493	1,1,1-Trichloroethane	8.61E-09	4.51E-10	1.78E-10	3.08E-10	1.54E-10
41039110000488552	1,1,1-Trichloroethane	8.59E-09	4.49E-10	1.77E-10	3.07E-10	1.54E-10
22049110000597514	1,1,1-Trichloroethane	8.25E-09	4.31E-10	1.70E-10	2.95E-10	1.48E-10
55069110000422267	Toluene	7.89E-09	3.89E-10	6.49E-11	1.54E-09	2.65E-10
12089110000588542	1,1,1-Trichloroethane	7.62E-09	3.99E-10	1.57E-10	2.73E-10	1.36E-10
55069110000422267	Styrene	7.42E-09	1.83E-09	2.83E-10	7.42E-10	1.42E-10
05003110000450921	1,1,1-Trichloroethane	7.25E-09	3.79E-10	1.49E-10	2.59E-10	1.30E-10
45031110000587491	Styrene	7.14E-09	1.76E-09	2.73E-10	7.14E-10	1.36E-10
45031110000587491	Toluene	7.09E-09	3.50E-10	5.83E-11	1.38E-09	2.39E-10
42047110000330400	1,1,1-Trichloroethane	7.01E-09	3.66E-10	1.44E-10	2.51E-10	1.25E-10
22073110017782568	1,1,1-Trichloroethane	6.98E-09	3.65E-10	1.44E-10	2.50E-10	1.25E-10
01131110007233305	Tetrachloroethene	6.94E-09	5.79E-10	8.68E-11	2.04E-10	9.92E-11
01091110000601965	1,1,1-Trichloroethane	6.35E-09	3.32E-10	1.31E-10	2.27E-10	1.14E-10
41007110013844563	1,1,1-Trichloroethane	5.84E-09	3.05E-10	1.20E-10	2.09E-10	1.04E-10
55141110000742796	1,1,1-Trichloroethane	5.05E-09	2.64E-10	1.04E-10	1.81E-10	9.03E-11
37049110000350478	1,1,1-Trichloroethane	4.51E-09	2.36E-10	9.29E-11	1.61E-10	8.07E-11
23025110017413468	Toluene	3.96E-09	1.95E-10	3.25E-11	7.70E-10	1.33E-10
55073110000422043	1,1,1-Trichloroethane	3.12E-09	1.63E-10	6.43E-11	1.12E-10	5.59E-11
55069110000422267	Xylenes (mixed)	3.10E-09	1.22E-10	1.70E-11	0.00E+00	0.00E+00
53011110000564586	Vinyl chloride	2.99E-09	8.41E-10	1.74E-10	4.14E-10	4.14E-11
47107110000605088	m-Xylene	2.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47107110000605088	p-Xylene	2.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42047110000330400	Vinyl chloride	2.12E-09	5.95E-10	1.23E-10	2.93E-10	2.93E-11
13185110005666421	1,1,1-Trichloroethane	1.94E-09	1.01E-10	3.99E-11	6.93E-11	3.47E-11
36113110000324845	Toluene	1.89E-09	9.32E-11	1.55E-11	3.68E-10	6.36E-11
16069110009335905	Vinyl chloride	1.55E-09	4.35E-10	8.99E-11	2.14E-10	2.14E-11
36031110000325005	1,1,1-Trichloroethane	1.50E-09	7.86E-11	3.10E-11	5.38E-11	2.69E-11
48067110008148496	1,1,1-Trichloroethane	1.47E-09	7.70E-11	3.03E-11	5.27E-11	2.63E-11
45079110000351903	1,1,1-Trichloroethane	1.31E-09	6.85E-11	2.70E-11	4.69E-11	2.34E-11

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
13115110013763034	Vinyl chloride	1.26E-09	3.55E-10	7.34E-11	1.75E-10	1.75E-11
23019110000581460	o-Xylene	1.19E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23007110000581415	Vinyl chloride	1.18E-09	3.32E-10	6.85E-11	1.63E-10	1.63E-11
13193110007356002	Toluene	1.13E-09	5.60E-11	9.33E-12	2.21E-10	3.82E-11
01047110002438103	1,1,1-Trichloroethane	1.13E-09	5.93E-11	2.33E-11	4.05E-11	2.03E-11
13193110007356002	Benzene	1.12E-09	8.53E-12	5.58E-13	9.06E-12	3.02E-12
13099110012384589	1,1,1-Trichloroethane	1.09E-09	5.68E-11	2.24E-11	3.88E-11	1.94E-11
48241110000599594	Tetrachloroethene	1.08E-09	9.03E-11	1.35E-11	3.19E-11	1.55E-11
40089110000598639	1,1,1-Trichloroethane	1.04E-09	5.45E-11	2.15E-11	3.73E-11	1.87E-11
41007110013844563	Vinyl chloride	1.01E-09	2.84E-10	5.87E-11	1.40E-10	1.40E-11
12089110000588551	1,1,1-Trichloroethane	1.01E-09	5.27E-11	2.08E-11	3.60E-11	1.80E-11
13021110005666243	1,1,1-Trichloroethane	9.22E-10	4.82E-11	1.90E-11	3.30E-11	1.65E-11
27017110000426263	1,1,1-Trichloroethane	7.96E-10	4.17E-11	1.64E-11	2.85E-11	1.43E-11
12107110000588604	1,1,1-Trichloroethane	7.50E-10	3.92E-11	1.55E-11	2.68E-11	1.34E-11
12005110000518002	Vinyl chloride	7.07E-10	1.99E-10	4.10E-11	9.79E-11	9.79E-12
01071110000589435	Vinyl chloride	6.70E-10	1.88E-10	3.89E-11	9.27E-11	9.27E-12
47107110000605088	1,1,1-Trichloroethane	6.68E-10	3.50E-11	1.38E-11	2.39E-11	1.20E-11
01023110017428773	1,1,1-Trichloroethane	6.63E-10	3.47E-11	1.37E-11	2.37E-11	1.19E-11
28087110000590940	1,1,1-Trichloroethane	6.09E-10	3.19E-11	1.26E-11	2.18E-11	1.09E-11
01113110017400711	Vinyl chloride	5.48E-10	1.54E-10	3.18E-11	7.58E-11	7.58E-12
45041110019973493	Vinyl chloride	4.57E-10	1.28E-10	2.65E-11	6.32E-11	6.33E-12
48067110008148496	Vinyl chloride	4.45E-10	1.25E-10	2.58E-11	6.16E-11	6.16E-12
22069110039166390	1,1,1-Trichloroethane	4.43E-10	2.32E-11	9.14E-12	1.59E-11	7.94E-12
13127110000588365	Di(ethylene glycol monobutyl ether) phthalat	4.25E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36031110000325005	Vinyl chloride	4.16E-10	1.17E-10	2.42E-11	5.76E-11	5.76E-12
22049110000597514	Vinyl chloride	4.13E-10	1.16E-10	2.40E-11	5.72E-11	5.72E-12
51580110012505397	Vinyl chloride	4.09E-10	1.15E-10	2.37E-11	5.66E-11	5.66E-12
12089110000588542	Vinyl chloride	3.99E-10	1.12E-10	2.32E-11	5.53E-11	5.53E-12
13245110000359718	Vinyl chloride	3.91E-10	1.10E-10	2.27E-11	5.42E-11	5.42E-12
51093110000560492	1,1,1-Trichloroethane	3.91E-10	2.04E-11	8.05E-12	1.40E-11	6.99E-12
45079110000351903	Vinyl chloride	3.83E-10	1.08E-10	2.23E-11	5.31E-11	5.31E-12
01131110007233305	1,1,1-Trichloroethane	3.77E-10	1.97E-11	7.78E-12	1.35E-11	6.75E-12
22073110017782568	Vinyl chloride	3.75E-10	1.06E-10	2.18E-11	5.20E-11	5.20E-12
12123110000362223	Vinyl chloride	3.57E-10	1.00E-10	2.07E-11	4.94E-11	4.94E-12
13179110013498296	Vinyl chloride	3.48E-10	9.79E-11	2.02E-11	4.82E-11	4.82E-12
21091110000380926	Vinyl chloride	3.47E-10	9.76E-11	2.02E-11	4.81E-11	4.81E-12
01047110002438103	Vinyl chloride	3.42E-10	9.63E-11	1.99E-11	4.74E-11	4.74E-12
05003110000450921	Vinyl chloride	3.41E-10	9.60E-11	1.98E-11	4.73E-11	4.73E-12
13051110000740958	Vinyl chloride	3.41E-10	9.59E-11	1.98E-11	4.72E-11	4.72E-12

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
01071110000589435	1,1,1-Trichloroethane	3.41E-10	1.78E-11	7.02E-12	1.22E-11	6.10E-12
05081110000756352	Vinyl chloride	3.29E-10	9.25E-11	1.91E-11	4.55E-11	4.55E-12
37049110000350478	Vinyl chloride	3.22E-10	9.06E-11	1.87E-11	4.46E-11	4.46E-12
22031110000450173	Vinyl chloride	3.15E-10	8.87E-11	1.83E-11	4.37E-11	4.37E-12
40089110000598639	Vinyl chloride	3.14E-10	8.82E-11	1.82E-11	4.34E-11	4.34E-12
42133110017404664	Vinyl chloride	2.76E-10	7.77E-11	1.60E-11	3.83E-11	3.83E-12
12033110000362447	Vinyl chloride	2.68E-10	7.54E-11	1.56E-11	3.71E-11	3.71E-12
37087110009846480	1,1,1-Trichloroethane	2.55E-10	1.33E-11	5.25E-12	9.12E-12	4.56E-12
37047110009719304	Vinyl chloride	2.41E-10	6.77E-11	1.40E-11	3.34E-11	3.34E-12
01091110000601965	Vinyl chloride	2.25E-10	6.33E-11	1.31E-11	3.12E-11	3.12E-12
53015110000490898	1,1,1-Trichloroethane	2.04E-10	1.07E-11	4.21E-12	7.31E-12	3.66E-12
41039110000488552	Vinyl chloride	1.90E-10	5.33E-11	1.10E-11	2.62E-11	2.62E-12
01001110011734935	Vinyl chloride	1.87E-10	5.26E-11	1.09E-11	2.59E-11	2.59E-12
13179110013498296	1,1,1-Trichloroethane	1.77E-10	9.25E-12	3.64E-12	6.33E-12	3.16E-12
51101110007317484	Vinyl chloride	1.56E-10	4.38E-11	9.04E-12	2.16E-11	2.16E-12
13185110005666421	Vinyl chloride	1.53E-10	4.29E-11	8.86E-12	2.11E-11	2.11E-12
53053110000490558	Vinyl chloride	1.49E-10	4.20E-11	8.66E-12	2.07E-11	2.07E-12
22069110039166390	Vinyl chloride	1.34E-10	3.77E-11	7.79E-12	1.86E-11	1.86E-12
22117110001274521	Vinyl chloride	1.32E-10	3.71E-11	7.67E-12	1.83E-11	1.83E-12
51670110012503781	Carbon tetrachloride	1.21E-10	8.19E-13	1.91E-13	1.76E-12	3.64E-13
01053110012508580	Vinyl chloride	1.20E-10	3.38E-11	6.98E-12	1.66E-11	1.66E-12
01131110007233305	Vinyl chloride	1.06E-10	2.97E-11	6.14E-12	1.46E-11	1.46E-12
23025110017413468	1,1,1-Trichloroethane	9.44E-11	4.94E-12	1.95E-12	3.38E-12	1.69E-12
40089110000598639	Methyl bromide	9.15E-11	0.00E+00	4.35E-13	0.00E+00	1.88E-12
37049110000350478	o-Xylene	8.62E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47163110017711289	Vinyl chloride	5.29E-11	1.49E-11	3.07E-12	7.33E-12	7.33E-13
13193110007356002	Xylenes (mixed)	3.35E-11	1.32E-12	1.84E-13	0.00E+00	0.00E+00
47163110017711289	1,1,1-Trichloroethane	2.69E-11	1.41E-12	5.55E-13	9.64E-13	4.82E-13
23025110017413468	Xylenes (mixed)	2.03E-11	7.98E-13	1.12E-13	0.00E+00	0.00E+00
36113110000324845	o-Xylene	1.81E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36113110000324845	1,1,1-Trichloroethane	1.27E-11	6.62E-13	2.61E-13	4.53E-13	2.27E-13
24001110007334072	Carbon tetrachloride	3.93E-12	2.70E-14	6.00E-15	5.70E-14	1.20E-14
51670110012503781	Vinyl chloride	1.42E-13	4.00E-14	8.00E-15	2.00E-14	2.00E-15
13127110000588365	o-Xylene	1.00E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00
39141110000395117	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-04
21007110000732173	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.46E-05
22125110043794374	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.05E-05
53011110000564586	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-05
42047110000330400	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-05

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

		Maximum Hazard Quotient[1]				
Facility NEI ID	Pollutant	REL	AEGL1	AEGL2	ERPG1	ERPG2
48241110000599594	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-05
27071110000427501	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-05
37083110000586447	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-05
01113110017400711	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05
51019110000343922	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.85E-06
13305110007356422	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.25E-06
23007110000581415	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.94E-06
13021110005666243	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.77E-06
45091110000355035	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-06
51580110012505397	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.03E-06
13127110000588365	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.03E-06
45079110000351903	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.84E-06
16069110009335905	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06
53015110000490852	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.06E-06
45041110019973493	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.97E-06
01131110007233305	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.84E-06
01071110000589435	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-06
37087110009846480	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-06
12123110000362223	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06
48067110008148496	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.37E-06
12005110000518002	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.14E-06
45043110000353466	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.12E-06
48361110008146130	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-06
13115110013763034	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-06
12089110000588542	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-06
53031110000490326	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-06
13245110000359718	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-06
37047110009719304	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-06
22033110012384286	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E-06
05003110000450921	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-06
51093110000560492	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-06
53053110000490558	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E-06
01023110017428773	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E-06
13179110013498296	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-06
01053110012508580	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-06
01047110002438103	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-06
41007110013844563	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06
51101110007317484	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-06
28087110000590940	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.47E-06

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
42133110017404664	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-06
01099110000589612	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-06
05081110000756352	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-06
45043110000353466	Methyl chloride	0.00E+00	0.00E+00	1.41E-06	8.66E-06	1.28E-06
12033110000362447	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-06
13185110005666421	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-06
05069110000450878	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-06
01001110011734935	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-06
22073110017782568	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-06
53071110005312713	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-06
41041110014206117	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-06
51670110012503781	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-06
01091110000601965	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.88E-07
22011110006020028	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.83E-07
28149110000605220	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.60E-07
21091110000380926	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.49E-07
01025110000369280	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.41E-07
42013110000332177	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.34E-07
13099110012384589	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.23E-07
01121110000366121	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.16E-07
36031110000325005	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.15E-07
28077110017416599	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.05E-07
13051110000740958	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.95E-07
22049110000597514	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.88E-07
37047110009719304	Methyl chloride	0.00E+00	0.00E+00	9.61E-07	5.89E-06	8.70E-07
40089110000598639	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.65E-07
22117110001274521	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.45E-07
41039110000488552	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.33E-07
41043110000488142	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.98E-07
47163110017711289	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.82E-07
12107110000588604	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.72E-07
22031110000450173	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.53E-07
55141110017413547	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.04E-07
28077110017416599	Methyl chloride	0.00E+00	0.00E+00	7.49E-07	4.59E-06	6.78E-07
05069110000450878	Methyl chloride	0.00E+00	0.00E+00	7.45E-07	4.57E-06	6.74E-07
53015110000490898	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.55E-07
47107110000605088	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.71E-07
12005110000518002	Methyl chloride	0.00E+00	0.00E+00	5.71E-07	3.50E-06	5.17E-07
21007110000732173	Methyl chloride	0.00E+00	0.00E+00	5.22E-07	3.20E-06	4.72E-07

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
01025110000369280	Methyl chloride	0.00E+00	0.00E+00	5.00E-07	3.07E-06	4.53E-07
28111110002217379	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.41E-07
55141110017413547	Methyl chloride	0.00E+00	0.00E+00	4.61E-07	2.83E-06	4.17E-07
24001110007334072	Methyl chloride	0.00E+00	0.00E+00	4.51E-07	2.77E-06	4.08E-07
01001110011734935	Methyl chloride	0.00E+00	0.00E+00	4.24E-07	2.60E-06	3.84E-07
51580110012505397	Methyl chloride	0.00E+00	0.00E+00	4.19E-07	2.57E-06	3.79E-07
13245110000359718	Methyl chloride	0.00E+00	0.00E+00	3.86E-07	2.36E-06	3.49E-07
37049110000350478	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-07
22069110039166390	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.16E-07
28149110000605220	Methyl chloride	0.00E+00	0.00E+00	3.31E-07	2.03E-06	3.00E-07
23019110000581460	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.84E-07
51101110007317484	Methyl chloride	0.00E+00	0.00E+00	3.09E-07	1.89E-06	2.79E-07
05069110000450752	Methyl chloride	0.00E+00	0.00E+00	3.06E-07	1.87E-06	2.76E-07
01053110012508580	Methyl chloride	0.00E+00	0.00E+00	3.00E-07	1.84E-06	2.71E-07
48361110008146130	Methyl chloride	0.00E+00	0.00E+00	2.91E-07	1.78E-06	2.63E-07
05029110000597890	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-07
51580110012505397	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	4.34E-07	2.24E-07
01023110017428773	Hexachlorobutadiene	0.00E+00	0.00E+00	0.00E+00	6.19E-07	2.13E-07
22117110001274521	Methyl chloride	0.00E+00	0.00E+00	1.96E-07	1.20E-06	1.77E-07
28111110002217379	Methyl chloride	0.00E+00	0.00E+00	1.92E-07	1.18E-06	1.74E-07
42047110000330400	Methyl chloride	0.00E+00	0.00E+00	1.70E-07	1.04E-06	1.54E-07
05069110000450752	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-07
12123110000362223	Methyl chloride	0.00E+00	0.00E+00	1.49E-07	9.14E-07	1.35E-07
55087110000420973	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-07
45079110000351903	Methyl chloride	0.00E+00	0.00E+00	1.21E-07	7.43E-07	1.10E-07
45043110000353466	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	2.05E-07	1.06E-07
37087110009846480	Methyl chloride	0.00E+00	0.00E+00	9.01E-08	5.52E-07	8.16E-08
53011110000564586	Trichloroethylene	0.00E+00	3.07E-07	8.95E-08	3.98E-07	7.96E-08
48361110008146130	Vinyl acetate	0.00E+00	8.58E-07	3.27E-08	1.14E-06	7.92E-08
24001110007334072	Trichloroethylene	0.00E+00	3.05E-07	8.90E-08	3.96E-07	7.91E-08
53011110000564586	1,3-Butadiene	0.00E+00	2.24E-08	2.80E-09	1.53E-06	7.63E-08
22125110043794374	Methyl chloride	0.00E+00	0.00E+00	8.23E-08	5.04E-07	7.44E-08
48067110008148496	Methyl chloride	0.00E+00	0.00E+00	8.09E-08	4.96E-07	7.32E-08
37047110009719304	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	1.36E-07	7.02E-08
53015110000490852	Vinyl acetate	0.00E+00	6.47E-07	2.46E-08	8.62E-07	5.97E-08
05069110000450878	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	1.13E-07	5.87E-08
42047110000330400	1,3-Butadiene	0.00E+00	1.69E-08	2.11E-09	1.15E-06	5.76E-08
13115110013763034	Methyl chloride	0.00E+00	0.00E+00	5.87E-08	3.60E-07	5.31E-08
28077110017416599	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	1.02E-07	5.28E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
53015110000490852	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	1.00E-07	5.20E-08
55141110017413547	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.09E-07	5.17E-08
13021110005666243	Methyl chloride	0.00E+00	0.00E+00	5.57E-08	3.41E-07	5.04E-08
05003110000450921	Methyl chloride	0.00E+00	0.00E+00	5.32E-08	3.26E-07	4.81E-08
13179110013498296	Methyl chloride	0.00E+00	0.00E+00	5.31E-08	3.26E-07	4.81E-08
16069110009335905	Methyl chloride	0.00E+00	0.00E+00	5.30E-08	3.25E-07	4.79E-08
16069110009335905	Vinyl acetate	0.00E+00	5.14E-07	1.96E-08	6.85E-07	4.74E-08
51580110012505397	Vinyl acetate	0.00E+00	5.09E-07	1.94E-08	6.78E-07	4.69E-08
12005110000518002	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	8.33E-08	4.31E-08
53011110000564586	Vinyl acetate	0.00E+00	4.28E-07	1.63E-08	5.71E-07	3.95E-08
12123110000362223	Vinyl acetate	0.00E+00	4.24E-07	1.62E-08	5.66E-07	3.92E-08
45041110019973493	Methyl chloride	0.00E+00	0.00E+00	4.07E-08	2.49E-07	3.68E-08
12089110000588551	Methyl chloride	0.00E+00	0.00E+00	4.03E-08	2.47E-07	3.65E-08
16069110009335905	1,3-Butadiene	0.00E+00	1.04E-08	1.30E-09	7.07E-07	3.53E-08
45043110000353466	Vinyl acetate	0.00E+00	3.46E-07	1.32E-08	4.61E-07	3.19E-08
41041110014206117	Vinyl acetate	0.00E+00	3.40E-07	1.30E-08	4.54E-07	3.14E-08
05069110000450878	Vinyl acetate	0.00E+00	3.32E-07	1.27E-08	4.43E-07	3.07E-08
22049110000597514	Methyl chloride	0.00E+00	0.00E+00	3.36E-08	2.06E-07	3.04E-08
12107110000588604	Methyl chloride	0.00E+00	0.00E+00	3.25E-08	1.99E-07	2.94E-08
13115110013763034	1,3-Butadiene	0.00E+00	8.24E-09	1.03E-09	5.62E-07	2.81E-08
45091110000355035	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.13E-07	2.80E-08
01113110017400711	Methyl chloride	0.00E+00	0.00E+00	3.06E-08	1.87E-07	2.77E-08
01001110011734935	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	5.34E-08	2.76E-08
26041110017408848	Methyl chloride	0.00E+00	0.00E+00	2.97E-08	1.82E-07	2.69E-08
01131110007233305	Methyl chloride	0.00E+00	0.00E+00	2.93E-08	1.80E-07	2.65E-08
28077110017416599	Trichloroethylene	0.00E+00	1.02E-07	2.97E-08	1.32E-07	2.64E-08
21007110000732173	Trichloroethylene	0.00E+00	9.82E-08	2.86E-08	1.27E-07	2.55E-08
13099110012384589	Methyl chloride	0.00E+00	0.00E+00	2.79E-08	1.71E-07	2.52E-08
13245110000359718	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	4.85E-08	2.51E-08
22073110017782568	Methyl chloride	0.00E+00	0.00E+00	2.76E-08	1.69E-07	2.50E-08
13305110007356422	Methyl chloride	0.00E+00	0.00E+00	2.70E-08	1.65E-07	2.44E-08
22117110001274521	Trichloroethylene	0.00E+00	9.40E-08	2.74E-08	1.22E-07	2.44E-08
53071110005312713	Methyl chloride	0.00E+00	0.00E+00	2.65E-08	1.62E-07	2.40E-08
27071110000427501	Trichloroethylene	0.00E+00	9.21E-08	2.69E-08	1.19E-07	2.39E-08
53053110000490558	Methyl chloride	0.00E+00	0.00E+00	2.63E-08	1.61E-07	2.38E-08
41007110013844563	Methyl chloride	0.00E+00	0.00E+00	2.63E-08	1.61E-07	2.38E-08
12005110000518002	1,3-Butadiene	0.00E+00	6.94E-09	8.67E-10	4.73E-07	2.37E-08
01053110012508580	Vinyl acetate	0.00E+00	2.53E-07	9.62E-09	3.37E-07	2.33E-08
12089110000588542	Methyl chloride	0.00E+00	0.00E+00	2.55E-08	1.56E-07	2.30E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
28149110000605220	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	4.45E-08	2.30E-08
05069110000450752	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	4.35E-08	2.25E-08
41007110013844563	1,3-Butadiene	0.00E+00	6.57E-09	8.21E-10	4.48E-07	2.24E-08
51101110007317484	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	4.30E-08	2.23E-08
12033110000362447	Vinyl acetate	0.00E+00	2.38E-07	9.08E-09	3.18E-07	2.20E-08
12033110000362447	Methyl chloride	0.00E+00	0.00E+00	2.41E-08	1.48E-07	2.18E-08
37083110000586447	Methyl chloride	0.00E+00	0.00E+00	2.41E-08	1.48E-07	2.18E-08
05081110000756352	Vinyl acetate	0.00E+00	2.35E-07	8.96E-09	3.14E-07	2.17E-08
22033110012384286	Vinyl acetate	0.00E+00	2.35E-07	8.94E-09	3.13E-07	2.17E-08
01121110000366121	Methyl chloride	0.00E+00	0.00E+00	2.35E-08	1.44E-07	2.12E-08
13099110012384589	Vinyl acetate	0.00E+00	2.29E-07	8.73E-09	3.06E-07	2.12E-08
21091110000380926	Acrylonitrile	0.00E+00	1.63E-07	1.36E-08	7.40E-08	2.11E-08
53011110000564586	Methyl chloride	0.00E+00	0.00E+00	2.33E-08	1.43E-07	2.11E-08
01113110017400711	Vinyl acetate	0.00E+00	2.23E-07	8.51E-09	2.98E-07	2.06E-08
05081110000756352	Methyl chloride	0.00E+00	0.00E+00	2.18E-08	1.33E-07	1.97E-08
51093110000560492	Methyl chloride	0.00E+00	0.00E+00	2.14E-08	1.31E-07	1.93E-08
12089110000588551	Trichloroethylene	0.00E+00	7.45E-08	2.17E-08	9.66E-08	1.93E-08
37049110000350478	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	7.79E-08	1.92E-08
22033110012384286	Methyl chloride	0.00E+00	0.00E+00	2.12E-08	1.30E-07	1.92E-08
53015110000490852	Methyl chloride	0.00E+00	0.00E+00	2.11E-08	1.29E-07	1.90E-08
36031110000325005	Methyl chloride	0.00E+00	0.00E+00	2.10E-08	1.29E-07	1.90E-08
13115110013763034	Vinyl acetate	0.00E+00	2.06E-07	7.85E-09	2.75E-07	1.90E-08
48361110008146130	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	3.61E-08	1.87E-08
12123110000362223	Trichloroethylene	0.00E+00	7.15E-08	2.09E-08	9.27E-08	1.85E-08
01047110002438103	Methyl chloride	0.00E+00	0.00E+00	2.03E-08	1.24E-07	1.83E-08
45041110019973493	Vinyl acetate	0.00E+00	1.93E-07	7.34E-09	2.57E-07	1.78E-08
13021110005666243	Vinyl acetate	0.00E+00	1.92E-07	7.30E-09	2.55E-07	1.77E-08
23025110017413468	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E-08
22049110000597514	Vinyl acetate	0.00E+00	1.83E-07	6.98E-09	2.44E-07	1.69E-08
01023110017428773	Methyl chloride	0.00E+00	0.00E+00	1.87E-08	1.14E-07	1.69E-08
42133110017404664	Acrylonitrile	0.00E+00	1.30E-07	1.08E-08	5.89E-08	1.68E-08
28077110017416599	Vinyl acetate	0.00E+00	1.72E-07	6.57E-09	2.30E-07	1.59E-08
12089110000588542	Vinyl acetate	0.00E+00	1.70E-07	6.49E-09	2.27E-07	1.57E-08
05003110000450921	Vinyl acetate	0.00E+00	1.62E-07	6.16E-09	2.16E-07	1.49E-08
22031110000450173	Methyl chloride	0.00E+00	0.00E+00	1.65E-08	1.01E-07	1.49E-08
41041110014206117	Methyl chloride	0.00E+00	0.00E+00	1.63E-08	9.98E-08	1.47E-08
12107110000588604	Vinyl acetate	0.00E+00	1.58E-07	6.04E-09	2.11E-07	1.46E-08
01053110012508580	Trichloroethylene	0.00E+00	5.61E-08	1.64E-08	7.28E-08	1.46E-08
13179110013498296	1,3-Butadiene	0.00E+00	4.25E-09	5.32E-10	2.90E-07	1.45E-08

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
42133110017404664	Vinyl acetate	0.00E+00	1.57E-07	5.98E-09	2.09E-07	1.45E-08
51101110007317484	Vinyl acetate	0.00E+00	1.56E-07	5.94E-09	2.08E-07	1.44E-08
01071110000589435	1,3-Butadiene	0.00E+00	4.16E-09	5.20E-10	2.84E-07	1.42E-08
45019110016966381	Methyl chloride	0.00E+00	0.00E+00	1.57E-08	9.60E-08	1.42E-08
21091110000380926	Vinyl acetate	0.00E+00	1.53E-07	5.82E-09	2.04E-07	1.41E-08
37049110000350478	1,3-Butadiene	0.00E+00	4.14E-09	5.17E-10	2.82E-07	1.41E-08
01113110017400711	1,3-Butadiene	0.00E+00	4.08E-09	5.10E-10	2.78E-07	1.39E-08
42133110017404664	Methyl chloride	0.00E+00	0.00E+00	1.53E-08	9.35E-08	1.38E-08
41043110000488142	Vinyl acetate	0.00E+00	1.48E-07	5.65E-09	1.98E-07	1.37E-08
28111110002217379	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	2.62E-08	1.36E-08
05069110000450878	Trichloroethylene	0.00E+00	5.22E-08	1.52E-08	6.77E-08	1.35E-08
22073110017782568	Vinyl acetate	0.00E+00	1.46E-07	5.56E-09	1.95E-07	1.35E-08
41043110000488142	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	5.43E-08	1.34E-08
01071110000589435	Vinyl acetate	0.00E+00	1.43E-07	5.45E-09	1.91E-07	1.32E-08
01091110000601965	Vinyl acetate	0.00E+00	1.42E-07	5.43E-09	1.90E-07	1.31E-08
47107110000605088	Vinyl acetate	0.00E+00	1.41E-07	5.38E-09	1.88E-07	1.30E-08
45091110000355035	Vinyl acetate	0.00E+00	1.40E-07	5.35E-09	1.87E-07	1.30E-08
01023110017428773	Vinyl acetate	0.00E+00	1.40E-07	5.34E-09	1.87E-07	1.29E-08
22031110000450173	Vinyl acetate	0.00E+00	1.38E-07	5.26E-09	1.84E-07	1.27E-08
55073110000422043	Methyl chloride	0.00E+00	0.00E+00	1.40E-08	8.60E-08	1.27E-08
53071110005312713	Vinyl acetate	0.00E+00	1.36E-07	5.20E-09	1.82E-07	1.26E-08
51580110012505397	Acrylonitrile	0.00E+00	9.68E-08	8.06E-09	4.40E-08	1.26E-08
53053110000490558	Vinyl acetate	0.00E+00	1.34E-07	5.09E-09	1.78E-07	1.23E-08
53015110000490852	1,3-Butadiene	0.00E+00	3.62E-09	4.52E-10	2.47E-07	1.23E-08
41007110013844563	Vinyl acetate	0.00E+00	1.30E-07	4.95E-09	1.73E-07	1.20E-08
45041110019973493	1,3-Butadiene	0.00E+00	3.42E-09	4.28E-10	2.34E-07	1.17E-08
22117110001274521	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	2.16E-08	1.12E-08
05003110000450921	1,3-Butadiene	0.00E+00	3.28E-09	4.10E-10	2.24E-07	1.12E-08
01091110000601965	Methyl chloride	0.00E+00	0.00E+00	1.23E-08	7.55E-08	1.11E-08
45091110000355035	Methyl chloride	0.00E+00	0.00E+00	1.23E-08	7.55E-08	1.11E-08
28111110002217379	Vinyl acetate	0.00E+00	1.19E-07	4.51E-09	1.58E-07	1.09E-08
51580110012505397	Trichloroethylene	0.00E+00	4.18E-08	1.22E-08	5.42E-08	1.08E-08
21091110000380926	Methyl chloride	0.00E+00	0.00E+00	1.20E-08	7.34E-08	1.08E-08
13127110000588365	Methyl chloride	0.00E+00	0.00E+00	1.19E-08	7.28E-08	1.07E-08
36113110000324845	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-08
13051110000740958	Vinyl acetate	0.00E+00	1.15E-07	4.40E-09	1.54E-07	1.07E-08
22073110017782568	1,3-Butadiene	0.00E+00	3.07E-09	3.84E-10	2.10E-07	1.05E-08
12089110000588542	1,3-Butadiene	0.00E+00	2.94E-09	3.67E-10	2.00E-07	1.00E-08
41039110000488552	Methyl chloride	0.00E+00	0.00E+00	1.09E-08	6.69E-08	9.88E-09

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
40089110000598639	Methyl chloride	0.00E+00	0.00E+00	1.07E-08	6.55E-08	9.67E-09
51580110012505397	1,3-Butadiene	0.00E+00	2.76E-09	3.45E-10	1.88E-07	9.41E-09
47107110000605088	Methyl chloride	0.00E+00	0.00E+00	1.02E-08	6.26E-08	9.25E-09
41039110000488552	Vinyl acetate	0.00E+00	9.66E-08	3.68E-09	1.29E-07	8.92E-09
12123110000362223	1,3-Butadiene	0.00E+00	2.57E-09	3.21E-10	1.75E-07	8.76E-09
53053110000490558	1,3-Butadiene	0.00E+00	2.57E-09	3.21E-10	1.75E-07	8.75E-09
05081110000756352	1,3-Butadiene	0.00E+00	2.55E-09	3.18E-10	1.74E-07	8.68E-09
21091110000380926	1,3-Butadiene	0.00E+00	2.46E-09	3.08E-10	1.68E-07	8.40E-09
28087110000590940	Methyl chloride	0.00E+00	0.00E+00	9.26E-09	5.67E-08	8.38E-09
13051110000740958	Methyl chloride	0.00E+00	0.00E+00	9.11E-09	5.58E-08	8.24E-09
48361110008146130	1,3-Butadiene	0.00E+00	2.33E-09	2.91E-10	1.59E-07	7.94E-09
22011110006020028	Methyl chloride	0.00E+00	0.00E+00	8.54E-09	5.24E-08	7.73E-09
13193110007356002	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.52E-09
45091110000355035	Trichloroethylene	0.00E+00	2.90E-08	8.46E-09	3.76E-08	7.52E-09
22069110039166390	Methyl chloride	0.00E+00	0.00E+00	8.30E-09	5.09E-08	7.51E-09
05069110000450878	1,3-Butadiene	0.00E+00	2.14E-09	2.68E-10	1.46E-07	7.31E-09
01053110012508580	1,3-Butadiene	0.00E+00	2.04E-09	2.55E-10	1.39E-07	6.95E-09
42133110017404664	1,3-Butadiene	0.00E+00	2.00E-09	2.50E-10	1.36E-07	6.82E-09
53015110000490898	Vinyl acetate	0.00E+00	7.33E-08	2.79E-09	9.78E-08	6.77E-09
48361110008146130	Trichloroethylene	0.00E+00	2.48E-08	7.24E-09	3.22E-08	6.44E-09
13185110005666421	Methyl chloride	0.00E+00	0.00E+00	7.11E-09	4.36E-08	6.43E-09
47163110017711289	Methyl chloride	0.00E+00	0.00E+00	6.92E-09	4.24E-08	6.26E-09
13127110000588365	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.45E-08	6.06E-09
51101110007317484	1,3-Butadiene	0.00E+00	1.78E-09	2.22E-10	1.21E-07	6.06E-09
01091110000601965	1,3-Butadiene	0.00E+00	1.76E-09	2.20E-10	1.20E-07	5.99E-09
45043110000353466	Acrylonitrile	0.00E+00	4.55E-08	3.79E-09	2.07E-08	5.91E-09
37117110013794000	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.76E-09
45019110016966381	Trichloroethylene	0.00E+00	2.06E-08	6.00E-09	2.67E-08	5.33E-09
53015110000490852	Trichloroethylene	0.00E+00	1.95E-08	5.68E-09	2.53E-08	5.05E-09
37049110000350478	Methyl chloride	0.00E+00	0.00E+00	5.26E-09	3.23E-08	4.76E-09
41043110000488142	Methyl chloride	0.00E+00	0.00E+00	5.26E-09	3.22E-08	4.76E-09
27017110000426263	Methyl chloride	0.00E+00	0.00E+00	5.23E-09	3.20E-08	4.73E-09
45069110016989669	Trichloroethylene	0.00E+00	1.81E-08	5.29E-09	2.35E-08	4.70E-09
13185110005666421	1,3-Butadiene	0.00E+00	1.37E-09	1.72E-10	9.36E-08	4.68E-09
37117110013794000	Methyl chloride	0.00E+00	0.00E+00	4.92E-09	3.02E-08	4.45E-09
23029110013359178	Trichloroethylene	0.00E+00	1.70E-08	4.97E-09	2.21E-08	4.42E-09
48361110008146130	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.69E-08	4.18E-09
13305110007356422	Trichloroethylene	0.00E+00	1.60E-08	4.67E-09	2.08E-08	4.16E-09
55141110000742796	Methyl chloride	0.00E+00	0.00E+00	4.58E-09	2.81E-08	4.14E-09

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
37047110009719304	Acrylonitrile	0.00E+00	3.02E-08	2.52E-09	1.37E-08	3.92E-09
42133110017404664	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	6.96E-09	3.60E-09
12089110000588542	Trichloroethylene	0.00E+00	1.37E-08	4.00E-09	1.78E-08	3.56E-09
16069110009335905	Trichloroethylene	0.00E+00	1.33E-08	3.88E-09	1.72E-08	3.45E-09
42047110000330400	Trichloroethylene	0.00E+00	1.17E-08	3.43E-09	1.52E-08	3.04E-09
53053110000490558	Trichloroethylene	0.00E+00	1.17E-08	3.42E-09	1.52E-08	3.04E-09
21091110000380926	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	5.87E-09	3.03E-09
05069110000450878	Acrylonitrile	0.00E+00	2.34E-08	1.95E-09	1.06E-08	3.03E-09
28077110017416599	Acrylonitrile	0.00E+00	2.26E-08	1.89E-09	1.03E-08	2.94E-09
53071110005312713	Trichloroethylene	0.00E+00	1.11E-08	3.23E-09	1.43E-08	2.87E-09
22033110012384286	1,3-Butadiene	0.00E+00	8.37E-10	1.05E-10	5.71E-08	2.85E-09
22117110001274521	1,3-Butadiene	0.00E+00	8.21E-10	1.03E-10	5.59E-08	2.80E-09
51670110012503781	1,3-Butadiene	0.00E+00	8.15E-10	1.02E-10	5.56E-08	2.78E-09
01023110017428773	1,3-Butadiene	0.00E+00	7.75E-10	9.69E-11	5.29E-08	2.64E-09
55141110000742796	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-09
53015110000490898	Methyl iodide	0.00E+00	0.00E+00	0.00E+00	4.98E-09	2.57E-09
42133110017404664	Trichloroethylene	0.00E+00	9.85E-09	2.87E-09	1.28E-08	2.55E-09
45043110000353466	Trichloroethylene	0.00E+00	9.81E-09	2.86E-09	1.27E-08	2.54E-09
16069110009335905	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.01E-08	2.50E-09
51580110012505397	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.01E-08	2.48E-09
12005110000518002	Acrylonitrile	0.00E+00	1.85E-08	1.54E-09	8.42E-09	2.41E-09
48241110000599594	Methyl chloride	0.00E+00	0.00E+00	2.65E-09	1.62E-08	2.40E-09
05069110000450878	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	9.50E-09	2.34E-09
05003110000450921	Trichloroethylene	0.00E+00	8.81E-09	2.57E-09	1.14E-08	2.28E-09
05069110000450752	Acrylonitrile	0.00E+00	1.72E-08	1.43E-09	7.80E-09	2.23E-09
45079110000351903	Trichloroethylene	0.00E+00	8.26E-09	2.41E-09	1.07E-08	2.14E-09
53011110000564586	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	8.45E-09	2.09E-09
12123110000362223	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	8.37E-09	2.07E-09
55141110017413547	Acrylonitrile	0.00E+00	1.49E-08	1.24E-09	6.77E-09	1.93E-09
13115110013763034	Trichloroethylene	0.00E+00	7.39E-09	2.16E-09	9.58E-09	1.92E-09
12033110000362447	Trichloroethylene	0.00E+00	7.16E-09	2.09E-09	9.29E-09	1.86E-09
53015110000490852	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	7.46E-09	1.84E-09
13127110000588365	Trichloroethylene	0.00E+00	7.01E-09	2.05E-09	9.09E-09	1.82E-09
51101110007317484	Trichloroethylene	0.00E+00	6.86E-09	2.00E-09	8.89E-09	1.78E-09
47163110017711289	1,3-Butadiene	0.00E+00	5.19E-10	6.49E-11	3.54E-08	1.77E-09
23025110017413468	Methyl chloride	0.00E+00	0.00E+00	1.85E-09	1.13E-08	1.67E-09
55141110017413547	Vinyl acetate	0.00E+00	1.81E-08	6.91E-10	2.42E-08	1.67E-09
01113110017400711	Trichloroethylene	0.00E+00	6.42E-09	1.87E-09	8.32E-09	1.66E-09
41041110014206117	Acrylonitrile	0.00E+00	1.25E-08	1.04E-09	5.67E-09	1.62E-09

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22117110001274521	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	6.49E-09	1.60E-09
41041110014206117	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	6.48E-09	1.60E-09
45041110019973493	Trichloroethylene	0.00E+00	6.10E-09	1.78E-09	7.91E-09	1.58E-09
05081110000756352	Trichloroethylene	0.00E+00	6.01E-09	1.75E-09	7.79E-09	1.56E-09
01001110011734935	Acrylonitrile	0.00E+00	1.19E-08	9.88E-10	5.39E-09	1.54E-09
13185110005666421	Vinyl acetate	0.00E+00	1.64E-08	6.24E-10	2.18E-08	1.51E-09
22033110012384286	Trichloroethylene	0.00E+00	5.75E-09	1.68E-09	7.45E-09	1.49E-09
48067110008148496	Trichloroethylene	0.00E+00	5.56E-09	1.62E-09	7.21E-09	1.44E-09
13245110000359718	Acrylonitrile	0.00E+00	1.08E-08	8.99E-10	4.90E-09	1.40E-09
28149110000605220	Acrylonitrile	0.00E+00	9.87E-09	8.23E-10	4.49E-09	1.28E-09
53015110000490852	Acrylonitrile	0.00E+00	9.75E-09	8.12E-10	4.43E-09	1.27E-09
55141110017413547	Trichloroethylene	0.00E+00	4.85E-09	1.41E-09	6.29E-09	1.26E-09
51101110007317484	Acrylonitrile	0.00E+00	9.57E-09	7.98E-10	4.35E-09	1.24E-09
22073110017782568	Trichloroethylene	0.00E+00	4.65E-09	1.35E-09	6.02E-09	1.20E-09
37117110013794000	1,3-Butadiene	0.00E+00	3.51E-10	4.38E-11	2.39E-08	1.20E-09
45069110016989669	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	4.69E-09	1.16E-09
05081110000756352	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	4.65E-09	1.15E-09
22033110012384286	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	4.63E-09	1.14E-09
01053110012508580	Acrylonitrile	0.00E+00	8.53E-09	7.11E-10	3.88E-09	1.11E-09
41007110013844563	Trichloroethylene	0.00E+00	4.22E-09	1.23E-09	5.47E-09	1.09E-09
01113110017400711	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	4.41E-09	1.09E-09
48361110008146130	Acrylonitrile	0.00E+00	8.03E-09	6.69E-10	3.65E-09	1.04E-09
22049110000597514	Trichloroethylene	0.00E+00	3.96E-09	1.16E-09	5.13E-09	1.03E-09
13115110013763034	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	4.08E-09	1.01E-09
01071110000589435	Methyl chloride	0.00E+00	0.00E+00	1.11E-09	6.80E-09	1.00E-09
12005110000518002	Trichloroethylene	0.00E+00	3.86E-09	1.13E-09	5.01E-09	1.00E-09
22031110000450173	Trichloroethylene	0.00E+00	3.66E-09	1.07E-09	4.74E-09	9.48E-10
45041110019973493	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.81E-09	9.41E-10
37049110000350478	Trichloroethylene	0.00E+00	3.62E-09	1.06E-09	4.69E-09	9.38E-10
28111110002217379	Trichloroethylene	0.00E+00	3.62E-09	1.06E-09	4.69E-09	9.38E-10
13179110013498296	Trichloroethylene	0.00E+00	3.57E-09	1.04E-09	4.63E-09	9.26E-10
01091110000601965	Trichloroethylene	0.00E+00	3.50E-09	1.02E-09	4.53E-09	9.07E-10
22049110000597514	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.63E-09	8.96E-10
41041110014206117	Trichloroethylene	0.00E+00	3.45E-09	1.01E-09	4.48E-09	8.95E-10
12089110000588542	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.37E-09	8.33E-10
28077110017416599	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.31E-09	8.17E-10
13051110000740958	Trichloroethylene	0.00E+00	3.07E-09	8.96E-10	3.98E-09	7.97E-10
05003110000450921	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.19E-09	7.88E-10
42133110017404664	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.18E-09	7.86E-10

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

		Maximum Hazard Quotient[1]				
Facility NEI ID	**Pollutant**	**REL**	**AEGL1**	**AEGL2**	**ERPG1**	**ERPG2**
41041110014206117	1,3-Butadiene	0.00E+00	2.29E-10	2.86E-11	1.56E-08	7.80E-10
51101110007317484	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.15E-09	7.77E-10
28111110002217379	Acrylonitrile	0.00E+00	5.84E-09	4.86E-10	2.65E-09	7.58E-10
21091110000380926	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.07E-09	7.58E-10
12005110000518002	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.02E-09	7.46E-10
53015110000490898	1,3-Butadiene	0.00E+00	2.16E-10	2.70E-11	1.47E-08	7.36E-10
53071110005312713	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.91E-09	7.19E-10
13099110012384589	Trichloroethylene	0.00E+00	2.68E-09	7.83E-10	3.48E-09	6.96E-10
01091110000601965	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.81E-09	6.95E-10
41039110000488552	Trichloroethylene	0.00E+00	2.64E-09	7.71E-10	3.42E-09	6.85E-10
53053110000490558	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.64E-09	6.51E-10
26043110017422467	Trichloroethylene	0.00E+00	2.46E-09	7.18E-10	3.19E-09	6.38E-10
41007110013844563	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.57E-09	6.34E-10
13245110000359718	Trichloroethylene	0.00E+00	2.44E-09	7.11E-10	3.16E-09	6.32E-10
22117110001274521	Acrylonitrile	0.00E+00	4.81E-09	4.01E-10	2.19E-09	6.25E-10
01023110017428773	Trichloroethylene	0.00E+00	2.37E-09	6.92E-10	3.08E-09	6.15E-10
41043110000488142	Trichloroethylene	0.00E+00	2.30E-09	6.70E-10	2.98E-09	5.96E-10
13021110005666243	Trichloroethylene	0.00E+00	2.24E-09	6.54E-10	2.90E-09	5.81E-10
28111110002217379	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.34E-09	5.77E-10
28149110000605220	Trichloroethylene	0.00E+00	2.12E-09	6.17E-10	2.74E-09	5.48E-10
01131110007233305	Trichloroethylene	0.00E+00	2.00E-09	5.83E-10	2.59E-09	5.19E-10
37047110009719304	Trichloroethylene	0.00E+00	1.98E-09	5.79E-10	2.57E-09	5.15E-10
27017110000426263	Trichloroethylene	0.00E+00	1.93E-09	5.64E-10	2.51E-09	5.01E-10
12107110000588604	Trichloroethylene	0.00E+00	1.85E-09	5.40E-10	2.40E-09	4.80E-10
01047110002438103	Trichloroethylene	0.00E+00	1.67E-09	4.87E-10	2.17E-09	4.33E-10
21091110000380926	Trichloroethylene	0.00E+00	1.66E-09	4.83E-10	2.15E-09	4.29E-10
47107110000605088	Trichloroethylene	0.00E+00	1.65E-09	4.83E-10	2.14E-09	4.29E-10
01001110011734935	Trichloroethylene	0.00E+00	1.62E-09	4.74E-10	2.11E-09	4.21E-10
37049110000350478	Vinyl acetate	0.00E+00	4.12E-09	1.57E-10	5.49E-09	3.80E-10
55073110000422043	Trichloroethylene	0.00E+00	1.44E-09	4.20E-10	1.87E-09	3.73E-10
36031110000325005	Trichloroethylene	0.00E+00	1.43E-09	4.18E-10	1.86E-09	3.72E-10
13185110005666421	Trichloroethylene	0.00E+00	1.42E-09	4.15E-10	1.84E-09	3.69E-10
28087110000590940	Trichloroethylene	0.00E+00	1.28E-09	3.74E-10	1.66E-09	3.32E-10
40089110000598639	Trichloroethylene	0.00E+00	8.86E-10	2.58E-10	1.15E-09	2.30E-10
22069110039166390	Trichloroethylene	0.00E+00	6.37E-10	1.86E-10	8.26E-10	1.65E-10
47163110017711289	Trichloroethylene	0.00E+00	4.66E-10	1.36E-10	6.04E-10	1.21E-10
45019110016966381	Beryllium compounds	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.87E-11
13185110005666421	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.30E-10	8.15E-11
53015110000490898	Trichloroethylene	0.00E+00	2.81E-10	8.20E-11	3.65E-10	7.29E-11

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

		Maximum Hazard Quotient[1]				
Facility NEI ID	**Pollutant**	**REL**	**AEGL1**	**AEGL2**	**ERPG1**	**ERPG2**
37087110009846480	Trichloroethylene	0.00E+00	2.66E-10	7.77E-11	3.45E-10	6.91E-11
23025110017413468	Trichloroethylene	0.00E+00	1.95E-10	5.69E-11	2.53E-10	5.06E-11
22011110006020028	Trichloroethylene	0.00E+00	1.71E-10	4.98E-11	2.21E-10	4.43E-11
22073110017782568	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.13E-10	2.79E-11
42047110000330400	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	9.68E-11	2.39E-11
23019110000581460	1,3-Butadiene	0.00E+00	6.48E-12	8.10E-13	4.42E-10	2.21E-11
01071110000589435	Trichloroethylene	0.00E+00	6.11E-11	1.78E-11	7.92E-11	1.58E-11
01071110000589435	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	3.06E-11	7.55E-12
51670110012503781	Vinyl acetate	0.00E+00	6.47E-11	2.47E-12	8.63E-11	5.98E-12
48067110008148496	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.03E-11	5.02E-12
36031110000325005	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.90E-11	4.70E-12
40089110000598639	Vinyl acetate	0.00E+00	5.04E-11	1.92E-12	6.71E-11	4.65E-12
13245110000359718	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.79E-11	4.42E-12
45079110000351903	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.75E-11	4.33E-12
13179110013498296	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.59E-11	3.92E-12
01047110002438103	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.57E-11	3.87E-12
13051110000740958	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.56E-11	3.85E-12
22031110000450173	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.44E-11	3.56E-12
40089110000598639	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.43E-11	3.54E-12
12033110000362447	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.23E-11	3.03E-12
37047110009719304	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	1.10E-11	2.72E-12
41039110000488552	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	8.67E-12	2.14E-12
01001110011734935	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	8.56E-12	2.12E-12
22069110039166390	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	6.14E-12	1.52E-12
01131110007233305	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	4.84E-12	1.19E-12
47163110017711289	Ethylene dichloride	0.00E+00	0.00E+00	0.00E+00	2.42E-12	5.98E-13
51670110012503781	Trichloroethylene	0.00E+00	1.40E-12	4.08E-13	1.81E-12	3.63E-13
13127110000588365	Hexachlorobutadiene	0.00E+00	0.00E+00	0.00E+00	2.59E-13	8.90E-14
13127110000588365	Vinyl acetate	0.00E+00	2.90E-13	1.10E-14	3.87E-13	2.70E-14
01001110011734935	Carbonyl sulfide	0.00E+00	0.00E+00	1.35E-05	0.00E+00	0.00E+00
28077110017416599	Carbonyl sulfide	0.00E+00	0.00E+00	1.10E-05	0.00E+00	0.00E+00
22117110001274521	Carbonyl sulfide	0.00E+00	0.00E+00	9.05E-06	0.00E+00	0.00E+00
05069110000450878	Carbonyl sulfide	0.00E+00	0.00E+00	7.62E-06	0.00E+00	0.00E+00
12123110000362223	Propionaldehyde	0.00E+00	4.08E-05	7.25E-06	0.00E+00	0.00E+00
28149110000605220	Carbonyl sulfide	0.00E+00	0.00E+00	5.97E-06	0.00E+00	0.00E+00
24001110007334072	Propionaldehyde	0.00E+00	2.69E-05	4.78E-06	0.00E+00	0.00E+00
51580110012505397	Carbonyl sulfide	0.00E+00	0.00E+00	4.06E-06	0.00E+00	0.00E+00
37047110009719304	Carbonyl sulfide	0.00E+00	0.00E+00	3.82E-06	0.00E+00	0.00E+00
13245110000359718	Carbonyl sulfide	0.00E+00	0.00E+00	3.80E-06	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
51019110000343922	n-Hexane	0.00E+00	0.00E+00	3.70E-06	0.00E+00	0.00E+00
01001110011734935	Propionaldehyde	0.00E+00	1.42E-05	2.53E-06	0.00E+00	0.00E+00
45043110000353466	Carbonyl sulfide	0.00E+00	0.00E+00	2.27E-06	0.00E+00	0.00E+00
53011110000564586	Propionaldehyde	0.00E+00	1.19E-05	2.12E-06	0.00E+00	0.00E+00
28077110017416599	Propionaldehyde	0.00E+00	9.67E-06	1.72E-06	0.00E+00	0.00E+00
42047110000330400	Propionaldehyde	0.00E+00	9.55E-06	1.70E-06	0.00E+00	0.00E+00
53015110000490852	Carbonyl sulfide	0.00E+00	0.00E+00	1.63E-06	0.00E+00	0.00E+00
22117110001274521	Propionaldehyde	0.00E+00	9.13E-06	1.62E-06	0.00E+00	0.00E+00
21007110000732173	Propionaldehyde	0.00E+00	8.50E-06	1.51E-06	0.00E+00	0.00E+00
12089110000588542	Propionaldehyde	0.00E+00	7.79E-06	1.38E-06	0.00E+00	0.00E+00
48361110008146130	Propionaldehyde	0.00E+00	7.43E-06	1.32E-06	0.00E+00	0.00E+00
28149110000605220	Propionaldehyde	0.00E+00	7.19E-06	1.28E-06	0.00E+00	0.00E+00
01053110012508580	Propionaldehyde	0.00E+00	6.68E-06	1.19E-06	0.00E+00	0.00E+00
16069110009335905	Propionaldehyde	0.00E+00	6.64E-06	1.18E-06	0.00E+00	0.00E+00
12123110000362223	Biphenyl	0.00E+00	0.00E+00	1.15E-06	0.00E+00	0.00E+00
45079110000351903	Propionaldehyde	0.00E+00	6.42E-06	1.14E-06	0.00E+00	0.00E+00
05069110000450878	Propionaldehyde	0.00E+00	5.86E-06	1.04E-06	0.00E+00	0.00E+00
13115110013763034	Propionaldehyde	0.00E+00	5.10E-06	9.05E-07	0.00E+00	0.00E+00
51580110012505397	Propionaldehyde	0.00E+00	5.03E-06	8.92E-07	0.00E+00	0.00E+00
12005110000518002	Propionaldehyde	0.00E+00	4.94E-06	8.77E-07	0.00E+00	0.00E+00
53015110000490852	Propionaldehyde	0.00E+00	4.94E-06	8.76E-07	0.00E+00	0.00E+00
13245110000359718	Propionaldehyde	0.00E+00	4.89E-06	8.67E-07	0.00E+00	0.00E+00
48067110008148496	Propionaldehyde	0.00E+00	4.47E-06	7.93E-07	0.00E+00	0.00E+00
37047110009719304	Propionaldehyde	0.00E+00	4.25E-06	7.54E-07	0.00E+00	0.00E+00
41007110013844563	Propionaldehyde	0.00E+00	3.95E-06	7.00E-07	0.00E+00	0.00E+00
51101110007317484	Propionaldehyde	0.00E+00	3.93E-06	6.98E-07	0.00E+00	0.00E+00
53015110000490852	Biphenyl	0.00E+00	0.00E+00	6.94E-07	0.00E+00	0.00E+00
13179110013498296	Propionaldehyde	0.00E+00	3.47E-06	6.16E-07	0.00E+00	0.00E+00
55141110017413547	Carbonyl sulfide	0.00E+00	0.00E+00	6.01E-07	0.00E+00	0.00E+00
45043110000353466	Propionaldehyde	0.00E+00	3.21E-06	5.69E-07	0.00E+00	0.00E+00
01113110017400711	Propionaldehyde	0.00E+00	3.18E-06	5.65E-07	0.00E+00	0.00E+00
45041110019973493	Propionaldehyde	0.00E+00	3.18E-06	5.65E-07	0.00E+00	0.00E+00
42133110017404664	Carbonyl sulfide	0.00E+00	0.00E+00	5.25E-07	0.00E+00	0.00E+00
53011110000564586	Cumene	0.00E+00	2.72E-06	4.54E-07	0.00E+00	0.00E+00
05003110000450921	Propionaldehyde	0.00E+00	2.43E-06	4.32E-07	0.00E+00	0.00E+00
01071110000589435	Propionaldehyde	0.00E+00	2.42E-06	4.30E-07	0.00E+00	0.00E+00
51580110012505397	Biphenyl	0.00E+00	0.00E+00	4.26E-07	0.00E+00	0.00E+00
53015110000490898	Carbonyl sulfide	0.00E+00	0.00E+00	4.04E-07	0.00E+00	0.00E+00
12033110000362447	Propionaldehyde	0.00E+00	2.25E-06	4.00E-07	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
45091110000355035	Carbonyl sulfide	0.00E+00	0.00E+00	3.75E-07	0.00E+00	0.00E+00
05081110000756352	Propionaldehyde	0.00E+00	2.11E-06	3.75E-07	0.00E+00	0.00E+00
22049110000597514	Propionaldehyde	0.00E+00	2.11E-06	3.74E-07	0.00E+00	0.00E+00
21091110000380926	Carbonyl sulfide	0.00E+00	0.00E+00	3.64E-07	0.00E+00	0.00E+00
48361110008146130	Biphenyl	0.00E+00	0.00E+00	3.60E-07	0.00E+00	0.00E+00
22073110017782568	Propionaldehyde	0.00E+00	1.95E-06	3.46E-07	0.00E+00	0.00E+00
01047110002438103	Propionaldehyde	0.00E+00	1.94E-06	3.44E-07	0.00E+00	0.00E+00
13305110007356422	Propionaldehyde	0.00E+00	1.91E-06	3.39E-07	0.00E+00	0.00E+00
53053110000490558	Propionaldehyde	0.00E+00	1.78E-06	3.15E-07	0.00E+00	0.00E+00
53015110000490898	Propionaldehyde	0.00E+00	1.74E-06	3.08E-07	0.00E+00	0.00E+00
45091110000355035	Cumene	0.00E+00	1.82E-06	3.04E-07	0.00E+00	0.00E+00
55141110017413547	Propionaldehyde	0.00E+00	1.67E-06	2.96E-07	0.00E+00	0.00E+00
21091110000380926	Propionaldehyde	0.00E+00	1.65E-06	2.93E-07	0.00E+00	0.00E+00
41041110014206117	Carbonyl sulfide	0.00E+00	0.00E+00	2.91E-07	0.00E+00	0.00E+00
21007110000732173	Cumene	0.00E+00	1.70E-06	2.84E-07	0.00E+00	0.00E+00
42133110017404664	Propionaldehyde	0.00E+00	1.59E-06	2.82E-07	0.00E+00	0.00E+00
01131110007233305	Propionaldehyde	0.00E+00	1.56E-06	2.76E-07	0.00E+00	0.00E+00
36031110000325005	Propionaldehyde	0.00E+00	1.55E-06	2.75E-07	0.00E+00	0.00E+00
01091110000601965	Propionaldehyde	0.00E+00	1.50E-06	2.67E-07	0.00E+00	0.00E+00
21091110000380926	Biphenyl	0.00E+00	0.00E+00	2.63E-07	0.00E+00	0.00E+00
37049110000350478	Propionaldehyde	0.00E+00	1.46E-06	2.59E-07	0.00E+00	0.00E+00
22031110000450173	Propionaldehyde	0.00E+00	1.42E-06	2.52E-07	0.00E+00	0.00E+00
22033110012384286	Propionaldehyde	0.00E+00	1.40E-06	2.48E-07	0.00E+00	0.00E+00
13051110000740958	Propionaldehyde	0.00E+00	1.39E-06	2.46E-07	0.00E+00	0.00E+00
40089110000598639	Propionaldehyde	0.00E+00	1.36E-06	2.42E-07	0.00E+00	0.00E+00
13099110012384589	Propionaldehyde	0.00E+00	1.35E-06	2.40E-07	0.00E+00	0.00E+00
41041110014206117	Propionaldehyde	0.00E+00	1.34E-06	2.38E-07	0.00E+00	0.00E+00
05069110000450878	Biphenyl	0.00E+00	0.00E+00	2.33E-07	0.00E+00	0.00E+00
42047110000330400	Cumene	0.00E+00	1.36E-06	2.26E-07	0.00E+00	0.00E+00
42133110017404664	Biphenyl	0.00E+00	0.00E+00	2.26E-07	0.00E+00	0.00E+00
45043110000353466	Biphenyl	0.00E+00	0.00E+00	2.22E-07	0.00E+00	0.00E+00
23007110000581415	Cumene	0.00E+00	1.33E-06	2.21E-07	0.00E+00	0.00E+00
53031110000490326	Propionaldehyde	0.00E+00	1.17E-06	2.08E-07	0.00E+00	0.00E+00
12089110000588542	Biphenyl	0.00E+00	0.00E+00	2.01E-07	0.00E+00	0.00E+00
55073110000422043	Propionaldehyde	0.00E+00	1.08E-06	1.92E-07	0.00E+00	0.00E+00
28111110002217379	Propionaldehyde	0.00E+00	1.02E-06	1.81E-07	0.00E+00	0.00E+00
01099110000589612	Propionaldehyde	0.00E+00	9.80E-07	1.74E-07	0.00E+00	0.00E+00
05069110000450878	Cumene	0.00E+00	1.03E-06	1.72E-07	0.00E+00	0.00E+00
41041110014206117	Biphenyl	0.00E+00	0.00E+00	1.66E-07	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
16069110009335905	Biphenyl	0.00E+00	0.00E+00	1.66E-07	0.00E+00	0.00E+00
41043110000488142	Carbonyl sulfide	0.00E+00	0.00E+00	1.57E-07	0.00E+00	0.00E+00
45079110000351903	Cumene	0.00E+00	8.81E-07	1.47E-07	0.00E+00	0.00E+00
13185110005666421	Propionaldehyde	0.00E+00	8.23E-07	1.46E-07	0.00E+00	0.00E+00
53011110000564586	Ethyl benzene	0.00E+00	4.99E-06	1.46E-07	0.00E+00	0.00E+00
22069110039166390	Propionaldehyde	0.00E+00	8.13E-07	1.44E-07	0.00E+00	0.00E+00
41039110000488552	Propionaldehyde	0.00E+00	7.98E-07	1.42E-07	0.00E+00	0.00E+00
41043110000488142	Cumene	0.00E+00	8.43E-07	1.41E-07	0.00E+00	0.00E+00
51670110012503781	Propionaldehyde	0.00E+00	7.85E-07	1.39E-07	0.00E+00	0.00E+00
53011110000564586	Biphenyl	0.00E+00	0.00E+00	1.38E-07	0.00E+00	0.00E+00
23017110000491940	Cumene	0.00E+00	8.10E-07	1.35E-07	0.00E+00	0.00E+00
01023110017428773	Propionaldehyde	0.00E+00	7.46E-07	1.32E-07	0.00E+00	0.00E+00
26041110017408848	Propionaldehyde	0.00E+00	7.44E-07	1.32E-07	0.00E+00	0.00E+00
55141110000742796	Propionaldehyde	0.00E+00	7.14E-07	1.27E-07	0.00E+00	0.00E+00
16069110009335905	Cumene	0.00E+00	7.50E-07	1.25E-07	0.00E+00	0.00E+00
26043110017422467	Propionaldehyde	0.00E+00	6.99E-07	1.24E-07	0.00E+00	0.00E+00
36031110000325005	Carbonyl sulfide	0.00E+00	0.00E+00	1.15E-07	0.00E+00	0.00E+00
28077110017416599	Biphenyl	0.00E+00	0.00E+00	1.14E-07	0.00E+00	0.00E+00
51101110007317484	Biphenyl	0.00E+00	0.00E+00	1.08E-07	0.00E+00	0.00E+00
12005110000518002	Cumene	0.00E+00	6.37E-07	1.06E-07	0.00E+00	0.00E+00
37047110009719304	Biphenyl	0.00E+00	0.00E+00	1.01E-07	0.00E+00	0.00E+00
01053110012508580	Biphenyl	0.00E+00	0.00E+00	9.83E-08	0.00E+00	0.00E+00
48067110008148496	Cumene	0.00E+00	5.88E-07	9.80E-08	0.00E+00	0.00E+00
13115110013763034	Cumene	0.00E+00	5.71E-07	9.52E-08	0.00E+00	0.00E+00
12033110000362447	Biphenyl	0.00E+00	0.00E+00	9.43E-08	0.00E+00	0.00E+00
53015110000490852	Cumene	0.00E+00	5.46E-07	9.11E-08	0.00E+00	0.00E+00
12005110000518002	Carbonyl sulfide	0.00E+00	0.00E+00	8.90E-08	0.00E+00	0.00E+00
48361110008146130	Cumene	0.00E+00	5.33E-07	8.89E-08	0.00E+00	0.00E+00
05003110000450921	Biphenyl	0.00E+00	0.00E+00	8.70E-08	0.00E+00	0.00E+00
01121110000366121	Propionaldehyde	0.00E+00	4.81E-07	8.54E-08	0.00E+00	0.00E+00
45091110000355035	Ethyl benzene	0.00E+00	2.76E-06	8.06E-08	0.00E+00	0.00E+00
12123110000362223	Chlorobenzene	0.00E+00	1.20E-06	7.97E-08	0.00E+00	0.00E+00
13179110013498296	Cumene	0.00E+00	4.76E-07	7.94E-08	0.00E+00	0.00E+00
47071110017418338	Cumene	0.00E+00	4.60E-07	7.67E-08	0.00E+00	0.00E+00
05081110000756352	Biphenyl	0.00E+00	0.00E+00	7.59E-08	0.00E+00	0.00E+00
22033110012384286	Biphenyl	0.00E+00	0.00E+00	7.58E-08	0.00E+00	0.00E+00
05003110000450921	Cumene	0.00E+00	4.43E-07	7.38E-08	0.00E+00	0.00E+00
41007110013844563	Cumene	0.00E+00	4.42E-07	7.37E-08	0.00E+00	0.00E+00
01113110017400711	Biphenyl	0.00E+00	0.00E+00	7.33E-08	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
47163110017711289	Propionaldehyde	0.00E+00	3.99E-07	7.09E-08	0.00E+00	0.00E+00
53071110005312713	Cumene	0.00E+00	4.19E-07	6.99E-08	0.00E+00	0.00E+00
45041110019973493	Cumene	0.00E+00	4.07E-07	6.79E-08	0.00E+00	0.00E+00
13115110013763034	Biphenyl	0.00E+00	0.00E+00	6.65E-08	0.00E+00	0.00E+00
51580110012505397	Aniline	0.00E+00	1.01E-07	6.61E-08	0.00E+00	0.00E+00
13305110007356422	Biphenyl	0.00E+00	0.00E+00	6.50E-08	0.00E+00	0.00E+00
37049110000350478	Cumene	0.00E+00	3.73E-07	6.21E-08	0.00E+00	0.00E+00
45041110019973493	Biphenyl	0.00E+00	0.00E+00	6.21E-08	0.00E+00	0.00E+00
01113110017400711	Cumene	0.00E+00	3.72E-07	6.19E-08	0.00E+00	0.00E+00
12005110000518002	Biphenyl	0.00E+00	0.00E+00	6.19E-08	0.00E+00	0.00E+00
01025110000369280	Propionaldehyde	0.00E+00	3.42E-07	6.08E-08	0.00E+00	0.00E+00
26043110017422467	Biphenyl	0.00E+00	0.00E+00	5.96E-08	0.00E+00	0.00E+00
22049110000597514	Biphenyl	0.00E+00	0.00E+00	5.93E-08	0.00E+00	0.00E+00
01023110017428773	Chlorobenzene	0.00E+00	8.89E-07	5.93E-08	0.00E+00	0.00E+00
24001110007334072	Cumene	0.00E+00	3.53E-07	5.88E-08	0.00E+00	0.00E+00
28111110002217379	Biphenyl	0.00E+00	0.00E+00	5.51E-08	0.00E+00	0.00E+00
01053110012508580	Cumene	0.00E+00	3.30E-07	5.49E-08	0.00E+00	0.00E+00
53011110000564586	n-Hexane	0.00E+00	0.00E+00	5.39E-08	0.00E+00	0.00E+00
53011110000564586	Chlorobenzene	0.00E+00	7.84E-07	5.23E-08	0.00E+00	0.00E+00
13305110007356422	Cumene	0.00E+00	3.11E-07	5.18E-08	0.00E+00	0.00E+00
28087110000590940	Ethyl benzene	0.00E+00	1.75E-06	5.09E-08	0.00E+00	0.00E+00
53053110000490558	Cumene	0.00E+00	2.94E-07	4.90E-08	0.00E+00	0.00E+00
13127110000588365	Cumene	0.00E+00	2.92E-07	4.87E-08	0.00E+00	0.00E+00
12123110000362223	Cumene	0.00E+00	2.85E-07	4.76E-08	0.00E+00	0.00E+00
12089110000588542	Cumene	0.00E+00	2.84E-07	4.74E-08	0.00E+00	0.00E+00
22073110017782568	Biphenyl	0.00E+00	0.00E+00	4.68E-08	0.00E+00	0.00E+00
01071110000589435	Biphenyl	0.00E+00	0.00E+00	4.63E-08	0.00E+00	0.00E+00
01091110000601965	Biphenyl	0.00E+00	0.00E+00	4.60E-08	0.00E+00	0.00E+00
22031110000450173	Biphenyl	0.00E+00	0.00E+00	4.46E-08	0.00E+00	0.00E+00
01071110000589435	Cumene	0.00E+00	2.65E-07	4.41E-08	0.00E+00	0.00E+00
53053110000490558	Biphenyl	0.00E+00	0.00E+00	4.31E-08	0.00E+00	0.00E+00
53015110000490898	Biphenyl	0.00E+00	0.00E+00	4.28E-08	0.00E+00	0.00E+00
41007110013844563	Chlorobenzene	0.00E+00	6.39E-07	4.26E-08	0.00E+00	0.00E+00
37087110009846480	Propionaldehyde	0.00E+00	2.38E-07	4.21E-08	0.00E+00	0.00E+00
45043110000353466	Cumene	0.00E+00	2.53E-07	4.21E-08	0.00E+00	0.00E+00
41007110013844563	Biphenyl	0.00E+00	0.00E+00	4.19E-08	0.00E+00	0.00E+00
05081110000756352	Cumene	0.00E+00	2.49E-07	4.15E-08	0.00E+00	0.00E+00
22073110017782568	Cumene	0.00E+00	2.47E-07	4.12E-08	0.00E+00	0.00E+00
22011110006020028	Cumene	0.00E+00	2.47E-07	4.11E-08	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22049110000597514	Cumene	0.00E+00	2.38E-07	3.96E-08	0.00E+00	0.00E+00
01001110011734935	Biphenyl	0.00E+00	0.00E+00	3.96E-08	0.00E+00	0.00E+00
13245110000359718	Biphenyl	0.00E+00	0.00E+00	3.83E-08	0.00E+00	0.00E+00
13051110000740958	Biphenyl	0.00E+00	0.00E+00	3.73E-08	0.00E+00	0.00E+00
41043110000488142	Ethyl benzene	0.00E+00	1.28E-06	3.72E-08	0.00E+00	0.00E+00
51580110012505397	Cumene	0.00E+00	2.14E-07	3.57E-08	0.00E+00	0.00E+00
01131110007233305	Cumene	0.00E+00	2.13E-07	3.55E-08	0.00E+00	0.00E+00
23007110000581415	Propionaldehyde	0.00E+00	2.00E-07	3.55E-08	0.00E+00	0.00E+00
51101110007317484	Cumene	0.00E+00	2.12E-07	3.53E-08	0.00E+00	0.00E+00
28149110000605220	Biphenyl	0.00E+00	0.00E+00	3.29E-08	0.00E+00	0.00E+00
53015110000490898	Cumene	0.00E+00	1.97E-07	3.28E-08	0.00E+00	0.00E+00
28149110000605220	Cumene	0.00E+00	1.95E-07	3.26E-08	0.00E+00	0.00E+00
13245110000359718	Cumene	0.00E+00	1.95E-07	3.26E-08	0.00E+00	0.00E+00
12033110000362447	Cumene	0.00E+00	1.93E-07	3.21E-08	0.00E+00	0.00E+00
41039110000488552	Biphenyl	0.00E+00	0.00E+00	3.12E-08	0.00E+00	0.00E+00
45043110000353466	Aniline	0.00E+00	4.77E-08	3.11E-08	0.00E+00	0.00E+00
01121110000366121	Cumene	0.00E+00	1.80E-07	3.01E-08	0.00E+00	0.00E+00
01091110000601965	Cumene	0.00E+00	1.74E-07	2.90E-08	0.00E+00	0.00E+00
22033110012384286	Cumene	0.00E+00	1.71E-07	2.86E-08	0.00E+00	0.00E+00
21091110000380926	Cumene	0.00E+00	1.71E-07	2.84E-08	0.00E+00	0.00E+00
28077110017416599	Cumene	0.00E+00	1.67E-07	2.78E-08	0.00E+00	0.00E+00
01099110000589612	Cumene	0.00E+00	1.63E-07	2.71E-08	0.00E+00	0.00E+00
22117110001274521	Chlorobenzene	0.00E+00	4.00E-07	2.67E-08	0.00E+00	0.00E+00
36031110000325005	Cumene	0.00E+00	1.53E-07	2.55E-08	0.00E+00	0.00E+00
01047110002438103	Cumene	0.00E+00	1.46E-07	2.44E-08	0.00E+00	0.00E+00
37117110013794000	Propionaldehyde	0.00E+00	1.37E-07	2.43E-08	0.00E+00	0.00E+00
01001110011734935	Cumene	0.00E+00	1.39E-07	2.32E-08	0.00E+00	0.00E+00
42133110017404664	Cumene	0.00E+00	1.38E-07	2.30E-08	0.00E+00	0.00E+00
01025110000369280	Cumene	0.00E+00	1.36E-07	2.27E-08	0.00E+00	0.00E+00
28111110002217379	Cumene	0.00E+00	1.34E-07	2.24E-08	0.00E+00	0.00E+00
24001110007334072	n-Hexane	0.00E+00	0.00E+00	2.24E-08	0.00E+00	0.00E+00
55073110000422043	Cumene	0.00E+00	1.27E-07	2.11E-08	0.00E+00	0.00E+00
22031110000450173	Cumene	0.00E+00	1.25E-07	2.09E-08	0.00E+00	0.00E+00
28077110017416599	Chlorobenzene	0.00E+00	3.11E-07	2.07E-08	0.00E+00	0.00E+00
37047110009719304	Aniline	0.00E+00	3.17E-08	2.07E-08	0.00E+00	0.00E+00
41041110014206117	Cumene	0.00E+00	1.21E-07	2.02E-08	0.00E+00	0.00E+00
55141110017413547	Cumene	0.00E+00	1.20E-07	2.00E-08	0.00E+00	0.00E+00
37083110000586447	Cumene	0.00E+00	1.15E-07	1.92E-08	0.00E+00	0.00E+00
51670110012503781	Cumene	0.00E+00	1.15E-07	1.91E-08	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
26043110017422467	Cumene	0.00E+00	1.15E-07	1.91E-08	0.00E+00	0.00E+00
01053110012508580	Chlorobenzene	0.00E+00	2.84E-07	1.89E-08	0.00E+00	0.00E+00
48361110008146130	Chlorobenzene	0.00E+00	2.84E-07	1.89E-08	0.00E+00	0.00E+00
55073110000422043	n-Hexane	0.00E+00	0.00E+00	1.89E-08	0.00E+00	0.00E+00
27071110000427501	Chlorobenzene	0.00E+00	2.83E-07	1.89E-08	0.00E+00	0.00E+00
01023110017428773	Cumene	0.00E+00	1.09E-07	1.82E-08	0.00E+00	0.00E+00
13185110005666421	Cumene	0.00E+00	1.08E-07	1.79E-08	0.00E+00	0.00E+00
22117110001274521	Biphenyl	0.00E+00	0.00E+00	1.62E-08	0.00E+00	0.00E+00
05069110000450878	Aniline	0.00E+00	2.45E-08	1.60E-08	0.00E+00	0.00E+00
28077110017416599	Aniline	0.00E+00	2.41E-08	1.57E-08	0.00E+00	0.00E+00
42047110000330400	Chlorobenzene	0.00E+00	2.30E-07	1.53E-08	0.00E+00	0.00E+00
12089110000588542	Chlorobenzene	0.00E+00	2.17E-07	1.44E-08	0.00E+00	0.00E+00
41039110000488552	Cumene	0.00E+00	8.66E-08	1.44E-08	0.00E+00	0.00E+00
55141110000742796	Cumene	0.00E+00	8.04E-08	1.34E-08	0.00E+00	0.00E+00
37047110009719304	Cumene	0.00E+00	7.99E-08	1.33E-08	0.00E+00	0.00E+00
12005110000518002	Aniline	0.00E+00	1.94E-08	1.27E-08	0.00E+00	0.00E+00
40089110000598639	Cumene	0.00E+00	7.56E-08	1.26E-08	0.00E+00	0.00E+00
05069110000450878	Chlorobenzene	0.00E+00	1.88E-07	1.25E-08	0.00E+00	0.00E+00
01001110011734935	Ethyl benzene	0.00E+00	4.20E-07	1.23E-08	0.00E+00	0.00E+00
13051110000740958	Cumene	0.00E+00	7.19E-08	1.20E-08	0.00E+00	0.00E+00
42047110000330400	n-Hexane	0.00E+00	0.00E+00	1.19E-08	0.00E+00	0.00E+00
40089110000598639	n-Hexane	0.00E+00	0.00E+00	1.18E-08	0.00E+00	0.00E+00
45079110000351903	Chlorobenzene	0.00E+00	1.59E-07	1.06E-08	0.00E+00	0.00E+00
55141110017413547	Aniline	0.00E+00	1.58E-08	1.03E-08	0.00E+00	0.00E+00
28077110017416599	Ethyl benzene	0.00E+00	3.44E-07	1.00E-08	0.00E+00	0.00E+00
22069110039166390	Cumene	0.00E+00	5.95E-08	9.91E-09	0.00E+00	0.00E+00
01001110011734935	n-Hexane	0.00E+00	0.00E+00	9.79E-09	0.00E+00	0.00E+00
16069110009335905	Chlorobenzene	0.00E+00	1.45E-07	9.63E-09	0.00E+00	0.00E+00
45019110016966381	Chlorobenzene	0.00E+00	1.43E-07	9.53E-09	0.00E+00	0.00E+00
13127110000588365	Chlorobenzene	0.00E+00	1.42E-07	9.43E-09	0.00E+00	0.00E+00
47163110017711289	Cumene	0.00E+00	5.56E-08	9.27E-09	0.00E+00	0.00E+00
22117110001274521	Cumene	0.00E+00	5.55E-08	9.25E-09	0.00E+00	0.00E+00
51580110012505397	Chlorobenzene	0.00E+00	1.38E-07	9.19E-09	0.00E+00	0.00E+00
21007110000732173	n-Hexane	0.00E+00	0.00E+00	9.06E-09	0.00E+00	0.00E+00
45043110000353466	n-Hexane	0.00E+00	0.00E+00	8.68E-09	0.00E+00	0.00E+00
41041110014206117	Aniline	0.00E+00	1.31E-08	8.54E-09	0.00E+00	0.00E+00
28149110000605220	n-Hexane	0.00E+00	0.00E+00	8.31E-09	0.00E+00	0.00E+00
13127110000588365	Ethyl benzene	0.00E+00	2.84E-07	8.29E-09	0.00E+00	0.00E+00
45043110000353466	Chlorobenzene	0.00E+00	1.23E-07	8.18E-09	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
22117110001274521	Ethyl benzene	0.00E+00	2.79E-07	8.13E-09	0.00E+00	0.00E+00
01001110011734935	Aniline	0.00E+00	1.24E-08	8.11E-09	0.00E+00	0.00E+00
45091110000355035	Chlorobenzene	0.00E+00	1.20E-07	8.01E-09	0.00E+00	0.00E+00
28077110017416599	n-Hexane	0.00E+00	0.00E+00	7.91E-09	0.00E+00	0.00E+00
05003110000450921	Chlorobenzene	0.00E+00	1.17E-07	7.78E-09	0.00E+00	0.00E+00
05069110000450752	Aniline	0.00E+00	1.14E-08	7.46E-09	0.00E+00	0.00E+00
37117110013794000	Biphenyl	0.00E+00	0.00E+00	7.39E-09	0.00E+00	0.00E+00
13245110000359718	Aniline	0.00E+00	1.13E-08	7.37E-09	0.00E+00	0.00E+00
37117110013794000	Cumene	0.00E+00	4.40E-08	7.34E-09	0.00E+00	0.00E+00
12033110000362447	Chlorobenzene	0.00E+00	1.09E-07	7.26E-09	0.00E+00	0.00E+00
48067110008148496	Chlorobenzene	0.00E+00	1.09E-07	7.24E-09	0.00E+00	0.00E+00
51101110007317484	Chlorobenzene	0.00E+00	1.07E-07	7.13E-09	0.00E+00	0.00E+00
53071110005312713	Ethyl benzene	0.00E+00	2.33E-07	6.80E-09	0.00E+00	0.00E+00
37047110009719304	n-Hexane	0.00E+00	0.00E+00	6.79E-09	0.00E+00	0.00E+00
28149110000605220	Aniline	0.00E+00	1.03E-08	6.74E-09	0.00E+00	0.00E+00
55141110017413547	n-Hexane	0.00E+00	0.00E+00	6.69E-09	0.00E+00	0.00E+00
53015110000490852	Aniline	0.00E+00	1.02E-08	6.67E-09	0.00E+00	0.00E+00
51101110007317484	Aniline	0.00E+00	1.00E-08	6.55E-09	0.00E+00	0.00E+00
48067110008148496	n-Hexane	0.00E+00	0.00E+00	6.16E-09	0.00E+00	0.00E+00
22117110001274521	n-Hexane	0.00E+00	0.00E+00	6.05E-09	0.00E+00	0.00E+00
37083110000586447	Ethyl benzene	0.00E+00	2.03E-07	5.93E-09	0.00E+00	0.00E+00
37117110013794000	n-Hexane	0.00E+00	0.00E+00	5.85E-09	0.00E+00	0.00E+00
01053110012508580	Aniline	0.00E+00	8.94E-09	5.83E-09	0.00E+00	0.00E+00
53053110000490558	Ethyl benzene	0.00E+00	1.98E-07	5.78E-09	0.00E+00	0.00E+00
13115110013763034	Chlorobenzene	0.00E+00	8.62E-08	5.75E-09	0.00E+00	0.00E+00
28149110000605220	Ethyl benzene	0.00E+00	1.97E-07	5.74E-09	0.00E+00	0.00E+00
27071110000427501	Ethyl benzene	0.00E+00	1.96E-07	5.72E-09	0.00E+00	0.00E+00
48361110008146130	Aniline	0.00E+00	8.42E-09	5.49E-09	0.00E+00	0.00E+00
45069110016989669	Chlorobenzene	0.00E+00	8.00E-08	5.33E-09	0.00E+00	0.00E+00
13185110005666421	Biphenyl	0.00E+00	0.00E+00	5.29E-09	0.00E+00	0.00E+00
05069110000450878	Ethyl benzene	0.00E+00	1.79E-07	5.22E-09	0.00E+00	0.00E+00
42133110017404664	Ethyl benzene	0.00E+00	1.75E-07	5.11E-09	0.00E+00	0.00E+00
53071110005312713	Chlorobenzene	0.00E+00	7.49E-08	4.99E-09	0.00E+00	0.00E+00
05069110000450878	n-Hexane	0.00E+00	0.00E+00	4.93E-09	0.00E+00	0.00E+00
01113110017400711	Chlorobenzene	0.00E+00	7.35E-08	4.90E-09	0.00E+00	0.00E+00
37087110009846480	Ethyl benzene	0.00E+00	1.65E-07	4.81E-09	0.00E+00	0.00E+00
45041110019973493	Chlorobenzene	0.00E+00	7.12E-08	4.75E-09	0.00E+00	0.00E+00
01053110012508580	Ethyl benzene	0.00E+00	1.62E-07	4.74E-09	0.00E+00	0.00E+00
27017110000426263	n-Hexane	0.00E+00	0.00E+00	4.63E-09	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
28087110000590940	Chlorobenzene	0.00E+00	6.78E-08	4.52E-09	0.00E+00	0.00E+00
53053110000490558	Chlorobenzene	0.00E+00	6.71E-08	4.47E-09	0.00E+00	0.00E+00
05081110000756352	Chlorobenzene	0.00E+00	6.67E-08	4.45E-09	0.00E+00	0.00E+00
22031110000450173	n-Hexane	0.00E+00	0.00E+00	4.41E-09	0.00E+00	0.00E+00
41007110013844563	n-Hexane	0.00E+00	0.00E+00	4.31E-09	0.00E+00	0.00E+00
13245110000359718	n-Hexane	0.00E+00	0.00E+00	4.26E-09	0.00E+00	0.00E+00
01053110012508580	n-Hexane	0.00E+00	0.00E+00	4.17E-09	0.00E+00	0.00E+00
12123110000362223	n-Hexane	0.00E+00	0.00E+00	4.14E-09	0.00E+00	0.00E+00
22033110012384286	Chlorobenzene	0.00E+00	6.04E-08	4.03E-09	0.00E+00	0.00E+00
28111110002217379	Aniline	0.00E+00	6.12E-09	3.99E-09	0.00E+00	0.00E+00
37047110009719304	Ethyl benzene	0.00E+00	1.34E-07	3.92E-09	0.00E+00	0.00E+00
01131110007233305	n-Hexane	0.00E+00	0.00E+00	3.81E-09	0.00E+00	0.00E+00
22031110000450173	Chlorobenzene	0.00E+00	5.69E-08	3.79E-09	0.00E+00	0.00E+00
48361110008146130	n-Hexane	0.00E+00	0.00E+00	3.70E-09	0.00E+00	0.00E+00
12005110000518002	Chlorobenzene	0.00E+00	5.50E-08	3.67E-09	0.00E+00	0.00E+00
41043110000488142	Chlorobenzene	0.00E+00	5.45E-08	3.63E-09	0.00E+00	0.00E+00
22049110000597514	n-Hexane	0.00E+00	0.00E+00	3.63E-09	0.00E+00	0.00E+00
53015110000490852	Chlorobenzene	0.00E+00	5.36E-08	3.58E-09	0.00E+00	0.00E+00
13245110000359718	Ethyl benzene	0.00E+00	1.20E-07	3.51E-09	0.00E+00	0.00E+00
51580110012505397	n-Hexane	0.00E+00	0.00E+00	3.49E-09	0.00E+00	0.00E+00
13051110000740958	Chlorobenzene	0.00E+00	5.18E-08	3.45E-09	0.00E+00	0.00E+00
22049110000597514	Chlorobenzene	0.00E+00	5.16E-08	3.44E-09	0.00E+00	0.00E+00
45043110000353466	Ethyl benzene	0.00E+00	1.18E-07	3.43E-09	0.00E+00	0.00E+00
55141110017413547	Ethyl benzene	0.00E+00	1.17E-07	3.42E-09	0.00E+00	0.00E+00
22117110001274521	Aniline	0.00E+00	5.05E-09	3.29E-09	0.00E+00	0.00E+00
53071110005312713	n-Hexane	0.00E+00	0.00E+00	3.20E-09	0.00E+00	0.00E+00
42133110017404664	Chlorobenzene	0.00E+00	4.79E-08	3.19E-09	0.00E+00	0.00E+00
13245110000359718	Chlorobenzene	0.00E+00	4.70E-08	3.13E-09	0.00E+00	0.00E+00
13179110013498296	Chlorobenzene	0.00E+00	4.69E-08	3.13E-09	0.00E+00	0.00E+00
23019110000581460	n-Hexane	0.00E+00	0.00E+00	3.08E-09	0.00E+00	0.00E+00
01091110000601965	Chlorobenzene	0.00E+00	4.23E-08	2.82E-09	0.00E+00	0.00E+00
13305110007356422	n-Hexane	0.00E+00	0.00E+00	2.68E-09	0.00E+00	0.00E+00
41039110000488552	Chlorobenzene	0.00E+00	3.90E-08	2.60E-09	0.00E+00	0.00E+00
01131110007233305	Chlorobenzene	0.00E+00	3.86E-08	2.57E-09	0.00E+00	0.00E+00
37087110009846480	n-Hexane	0.00E+00	0.00E+00	2.51E-09	0.00E+00	0.00E+00
36113110000324845	n-Hexane	0.00E+00	0.00E+00	2.50E-09	0.00E+00	0.00E+00
01047110002438103	Chlorobenzene	0.00E+00	3.70E-08	2.47E-09	0.00E+00	0.00E+00
53015110000490852	n-Hexane	0.00E+00	0.00E+00	2.44E-09	0.00E+00	0.00E+00
28111110002217379	Chlorobenzene	0.00E+00	3.65E-08	2.43E-09	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

		Maximum Hazard Quotient[1]				
Facility NEI ID	**Pollutant**	**REL**	**AEGL1**	**AEGL2**	**ERPG1**	**ERPG2**
42047110000330400	Ethyl benzene	0.00E+00	8.24E-08	2.40E-09	0.00E+00	0.00E+00
22073110017782568	Chlorobenzene	0.00E+00	3.60E-08	2.40E-09	0.00E+00	0.00E+00
22117110001274521	Ethylene dibromide	0.00E+00	3.26E-09	2.35E-09	0.00E+00	0.00E+00
28149110000605220	Chlorobenzene	0.00E+00	3.42E-08	2.28E-09	0.00E+00	0.00E+00
01047110002438103	Biphenyl	0.00E+00	0.00E+00	2.27E-09	0.00E+00	0.00E+00
01121110000366121	Chlorobenzene	0.00E+00	3.35E-08	2.24E-09	0.00E+00	0.00E+00
53053110000490558	n-Hexane	0.00E+00	0.00E+00	2.18E-09	0.00E+00	0.00E+00
42133110017404664	n-Hexane	0.00E+00	0.00E+00	2.15E-09	0.00E+00	0.00E+00
12005110000518002	n-Hexane	0.00E+00	0.00E+00	2.04E-09	0.00E+00	0.00E+00
53015110000490852	Ethyl benzene	0.00E+00	6.93E-08	2.02E-09	0.00E+00	0.00E+00
45019110016966381	Cumene	0.00E+00	1.19E-08	1.99E-09	0.00E+00	0.00E+00
36031110000325005	Chlorobenzene	0.00E+00	2.98E-08	1.98E-09	0.00E+00	0.00E+00
22069110039166390	n-Hexane	0.00E+00	0.00E+00	1.92E-09	0.00E+00	0.00E+00
41041110014206117	n-Hexane	0.00E+00	0.00E+00	1.86E-09	0.00E+00	0.00E+00
13099110012384589	n-Hexane	0.00E+00	0.00E+00	1.81E-09	0.00E+00	0.00E+00
01001110011734935	Chlorobenzene	0.00E+00	2.69E-08	1.79E-09	0.00E+00	0.00E+00
45019110016966381	n-Hexane	0.00E+00	0.00E+00	1.75E-09	0.00E+00	0.00E+00
16069110009335905	n-Hexane	0.00E+00	0.00E+00	1.72E-09	0.00E+00	0.00E+00
13099110012384589	Chlorobenzene	0.00E+00	2.45E-08	1.63E-09	0.00E+00	0.00E+00
13115110013763034	n-Hexane	0.00E+00	0.00E+00	1.59E-09	0.00E+00	0.00E+00
45031110000587491	n-Hexane	0.00E+00	0.00E+00	1.58E-09	0.00E+00	0.00E+00
01023110017428773	n-Hexane	0.00E+00	0.00E+00	1.52E-09	0.00E+00	0.00E+00
40089110000598639	Chlorobenzene	0.00E+00	2.21E-08	1.48E-09	0.00E+00	0.00E+00
45079110000351903	n-Hexane	0.00E+00	0.00E+00	1.37E-09	0.00E+00	0.00E+00
13051110000740958	n-Hexane	0.00E+00	0.00E+00	1.36E-09	0.00E+00	0.00E+00
37047110009719304	Chlorobenzene	0.00E+00	2.00E-08	1.33E-09	0.00E+00	0.00E+00
37049110000350478	Biphenyl	0.00E+00	0.00E+00	1.33E-09	0.00E+00	0.00E+00
48361110008146130	Ethyl benzene	0.00E+00	4.42E-08	1.29E-09	0.00E+00	0.00E+00
13021110005666243	Chlorobenzene	0.00E+00	1.87E-08	1.25E-09	0.00E+00	0.00E+00
01047110002438103	n-Hexane	0.00E+00	0.00E+00	1.24E-09	0.00E+00	0.00E+00
51101110007317484	n-Hexane	0.00E+00	0.00E+00	1.23E-09	0.00E+00	0.00E+00
12033110000362447	n-Hexane	0.00E+00	0.00E+00	1.20E-09	0.00E+00	0.00E+00
37049110000350478	n-Hexane	0.00E+00	0.00E+00	1.19E-09	0.00E+00	0.00E+00
01113110017400711	n-Hexane	0.00E+00	0.00E+00	1.17E-09	0.00E+00	0.00E+00
01025110000369280	n-Hexane	0.00E+00	0.00E+00	1.16E-09	0.00E+00	0.00E+00
12005110000518002	Ethyl benzene	0.00E+00	3.90E-08	1.14E-09	0.00E+00	0.00E+00
05003110000450921	n-Hexane	0.00E+00	0.00E+00	1.09E-09	0.00E+00	0.00E+00
01091110000601965	n-Hexane	0.00E+00	0.00E+00	1.09E-09	0.00E+00	0.00E+00
12089110000588542	n-Hexane	0.00E+00	0.00E+00	1.09E-09	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
41039110000488552	n-Hexane	0.00E+00	0.00E+00	1.09E-09	0.00E+00	0.00E+00
37083110000586447	Propionaldehyde	0.00E+00	6.09E-09	1.08E-09	0.00E+00	0.00E+00
45041110019973493	n-Hexane	0.00E+00	0.00E+00	1.06E-09	0.00E+00	0.00E+00
47071110017418338	n-Hexane	0.00E+00	0.00E+00	1.06E-09	0.00E+00	0.00E+00
21091110000380926	Chlorobenzene	0.00E+00	1.57E-08	1.05E-09	0.00E+00	0.00E+00
22069110039166390	Chlorobenzene	0.00E+00	1.50E-08	9.97E-10	0.00E+00	0.00E+00
41041110014206117	Ethyl benzene	0.00E+00	3.24E-08	9.46E-10	0.00E+00	0.00E+00
13185110005666421	Ethyl benzene	0.00E+00	3.01E-08	8.76E-10	0.00E+00	0.00E+00
13115110013763034	Ethyl benzene	0.00E+00	2.98E-08	8.68E-10	0.00E+00	0.00E+00
13127110000588365	n-Hexane	0.00E+00	0.00E+00	8.60E-10	0.00E+00	0.00E+00
45079110000351903	Ethyl benzene	0.00E+00	2.93E-08	8.53E-10	0.00E+00	0.00E+00
01071110000589435	Chlorobenzene	0.00E+00	1.27E-08	8.50E-10	0.00E+00	0.00E+00
51670110012503781	Chlorobenzene	0.00E+00	1.27E-08	8.48E-10	0.00E+00	0.00E+00
37049110000350478	Chlorobenzene	0.00E+00	1.26E-08	8.37E-10	0.00E+00	0.00E+00
28111110002217379	n-Hexane	0.00E+00	0.00E+00	8.21E-10	0.00E+00	0.00E+00
05081110000756352	n-Hexane	0.00E+00	0.00E+00	8.01E-10	0.00E+00	0.00E+00
22073110017782568	n-Hexane	0.00E+00	0.00E+00	7.99E-10	0.00E+00	0.00E+00
13179110013498296	n-Hexane	0.00E+00	0.00E+00	7.90E-10	0.00E+00	0.00E+00
13185110005666421	n-Hexane	0.00E+00	0.00E+00	7.83E-10	0.00E+00	0.00E+00
16069110009335905	Ethyl benzene	0.00E+00	2.56E-08	7.47E-10	0.00E+00	0.00E+00
45091110000355035	n-Hexane	0.00E+00	0.00E+00	7.47E-10	0.00E+00	0.00E+00
12107110000588604	Chlorobenzene	0.00E+00	1.11E-08	7.40E-10	0.00E+00	0.00E+00
13185110005666421	Chlorobenzene	0.00E+00	1.10E-08	7.35E-10	0.00E+00	0.00E+00
01071110000589435	n-Hexane	0.00E+00	0.00E+00	7.28E-10	0.00E+00	0.00E+00
53015110000490898	Chlorobenzene	0.00E+00	1.08E-08	7.20E-10	0.00E+00	0.00E+00
22033110012384286	n-Hexane	0.00E+00	0.00E+00	7.11E-10	0.00E+00	0.00E+00
41041110014206117	Chlorobenzene	0.00E+00	1.04E-08	6.96E-10	0.00E+00	0.00E+00
47107110000605088	n-Hexane	0.00E+00	0.00E+00	6.84E-10	0.00E+00	0.00E+00
13021110005666243	n-Hexane	0.00E+00	0.00E+00	6.69E-10	0.00E+00	0.00E+00
41007110013844563	Ethyl benzene	0.00E+00	2.25E-08	6.55E-10	0.00E+00	0.00E+00
51101110007317484	Ethyl benzene	0.00E+00	2.23E-08	6.50E-10	0.00E+00	0.00E+00
48067110008148496	Ethyl benzene	0.00E+00	2.05E-08	5.99E-10	0.00E+00	0.00E+00
01113110017400711	Ethyl benzene	0.00E+00	1.99E-08	5.80E-10	0.00E+00	0.00E+00
12107110000588604	n-Hexane	0.00E+00	0.00E+00	5.74E-10	0.00E+00	0.00E+00
45041110019973493	Ethyl benzene	0.00E+00	1.87E-08	5.45E-10	0.00E+00	0.00E+00
53015110000490898	n-Hexane	0.00E+00	0.00E+00	5.44E-10	0.00E+00	0.00E+00
45069110016989669	n-Hexane	0.00E+00	0.00E+00	5.26E-10	0.00E+00	0.00E+00
05003110000450921	Ethyl benzene	0.00E+00	1.77E-08	5.17E-10	0.00E+00	0.00E+00
13179110013498296	Ethyl benzene	0.00E+00	1.65E-08	4.82E-10	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3) with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
12123110000362223	Ethyl benzene	0.00E+00	1.59E-08	4.65E-10	0.00E+00	0.00E+00
22011110006020028	n-Hexane	0.00E+00	0.00E+00	4.61E-10	0.00E+00	0.00E+00
28087110000590940	n-Hexane	0.00E+00	0.00E+00	4.52E-10	0.00E+00	0.00E+00
36031110000325005	n-Hexane	0.00E+00	0.00E+00	4.43E-10	0.00E+00	0.00E+00
12089110000588542	Ethyl benzene	0.00E+00	1.52E-08	4.43E-10	0.00E+00	0.00E+00
12033110000362447	Ethyl benzene	0.00E+00	1.45E-08	4.24E-10	0.00E+00	0.00E+00
28111110002217379	Ethyl benzene	0.00E+00	1.42E-08	4.15E-10	0.00E+00	0.00E+00
01071110000589435	Ethyl benzene	0.00E+00	1.39E-08	4.05E-10	0.00E+00	0.00E+00
01091110000601965	Ethyl benzene	0.00E+00	1.38E-08	4.02E-10	0.00E+00	0.00E+00
37049110000350478	Ethyl benzene	0.00E+00	1.37E-08	4.00E-10	0.00E+00	0.00E+00
47163110017711289	Chlorobenzene	0.00E+00	5.81E-09	3.88E-10	0.00E+00	0.00E+00
23029110013359178	n-Hexane	0.00E+00	0.00E+00	3.77E-10	0.00E+00	0.00E+00
37083110000586447	Chlorobenzene	0.00E+00	5.56E-09	3.71E-10	0.00E+00	0.00E+00
55141110017413547	Chlorobenzene	0.00E+00	5.43E-09	3.62E-10	0.00E+00	0.00E+00
37083110000586447	n-Hexane	0.00E+00	0.00E+00	3.53E-10	0.00E+00	0.00E+00
26043110017422467	n-Hexane	0.00E+00	0.00E+00	3.46E-10	0.00E+00	0.00E+00
05081110000756352	Ethyl benzene	0.00E+00	1.17E-08	3.42E-10	0.00E+00	0.00E+00
01099110000589612	n-Hexane	0.00E+00	0.00E+00	3.40E-10	0.00E+00	0.00E+00
41043110000488142	n-Hexane	0.00E+00	0.00E+00	3.38E-10	0.00E+00	0.00E+00
22073110017782568	Ethyl benzene	0.00E+00	1.14E-08	3.34E-10	0.00E+00	0.00E+00
13051110000740958	Ethyl benzene	0.00E+00	1.14E-08	3.32E-10	0.00E+00	0.00E+00
13305110007356422	Chlorobenzene	0.00E+00	4.77E-09	3.18E-10	0.00E+00	0.00E+00
21091110000380926	n-Hexane	0.00E+00	0.00E+00	3.14E-10	0.00E+00	0.00E+00
51580110012505397	Ethyl benzene	0.00E+00	1.06E-08	3.10E-10	0.00E+00	0.00E+00
22033110012384286	Ethyl benzene	0.00E+00	1.06E-08	3.09E-10	0.00E+00	0.00E+00
22031110000450173	Ethyl benzene	0.00E+00	1.04E-08	3.04E-10	0.00E+00	0.00E+00
47107110000605088	Chlorobenzene	0.00E+00	4.52E-09	3.01E-10	0.00E+00	0.00E+00
53015110000490898	Ethyl benzene	0.00E+00	1.01E-08	2.96E-10	0.00E+00	0.00E+00
01047110002438103	Ethyl benzene	0.00E+00	9.61E-09	2.80E-10	0.00E+00	0.00E+00
27017110000426263	Chlorobenzene	0.00E+00	3.92E-09	2.62E-10	0.00E+00	0.00E+00
22049110000597514	Ethyl benzene	0.00E+00	8.90E-09	2.60E-10	0.00E+00	0.00E+00
36031110000325005	Ethyl benzene	0.00E+00	8.52E-09	2.49E-10	0.00E+00	0.00E+00
01121110000366121	n-Hexane	0.00E+00	0.00E+00	2.33E-10	0.00E+00	0.00E+00
40089110000598639	Ethyl benzene	0.00E+00	7.15E-09	2.09E-10	0.00E+00	0.00E+00
01131110007233305	Ethyl benzene	0.00E+00	7.11E-09	2.07E-10	0.00E+00	0.00E+00
55141110000742796	n-Hexane	0.00E+00	0.00E+00	2.02E-10	0.00E+00	0.00E+00
41039110000488552	Ethyl benzene	0.00E+00	6.51E-09	1.90E-10	0.00E+00	0.00E+00
51670110012503781	n-Hexane	0.00E+00	0.00E+00	1.64E-10	0.00E+00	0.00E+00
22069110039166390	Ethyl benzene	0.00E+00	4.13E-09	1.20E-10	0.00E+00	0.00E+00

Table 3 – Maximum Predicted Acute Risks (HEM-3)
with SCC Emissions Multiplier

Facility NEI ID	Pollutant	Maximum Hazard Quotient[1]				
		REL	AEGL1	AEGL2	ERPG1	ERPG2
21091110000380926	Ethyl benzene	0.00E+00	3.62E-09	1.06E-10	0.00E+00	0.00E+00
51670110012503781	Ethyl benzene	0.00E+00	3.52E-09	1.03E-10	0.00E+00	0.00E+00
01023110017428773	Ethyl benzene	0.00E+00	3.36E-09	9.79E-11	0.00E+00	0.00E+00
47163110017711289	n-Hexane	0.00E+00	0.00E+00	9.01E-11	0.00E+00	0.00E+00
47163110017711289	Ethyl benzene	0.00E+00	1.88E-09	5.48E-11	0.00E+00	0.00E+00
27071110000427501	n-Hexane	0.00E+00	0.00E+00	3.62E-11	0.00E+00	0.00E+00
13099110012384589	Cumene	0.00E+00	1.45E-10	2.42E-11	0.00E+00	0.00E+00
51670110012503781	Biphenyl	0.00E+00	0.00E+00	2.09E-11	0.00E+00	0.00E+00
13021110005666243	Cumene	0.00E+00	1.21E-10	2.02E-11	0.00E+00	0.00E+00
27017110000426263	Cumene	0.00E+00	1.05E-10	1.75E-11	0.00E+00	0.00E+00
12107110000588604	Cumene	0.00E+00	1.00E-10	1.67E-11	0.00E+00	0.00E+00
40089110000598639	Biphenyl	0.00E+00	0.00E+00	1.63E-11	0.00E+00	0.00E+00
47107110000605088	Cumene	0.00E+00	8.94E-11	1.49E-11	0.00E+00	0.00E+00
27071110000427501	Cumene	0.00E+00	7.96E-11	1.33E-11	0.00E+00	0.00E+00
28087110000590940	Cumene	0.00E+00	5.52E-11	9.21E-12	0.00E+00	0.00E+00
37117110013794000	Ethyl benzene	0.00E+00	1.54E-10	4.49E-12	0.00E+00	0.00E+00
23019110000581460	Ethyl benzene	0.00E+00	1.33E-10	3.88E-12	0.00E+00	0.00E+00
23025110017413468	Cumene	0.00E+00	1.06E-11	1.76E-12	0.00E+00	0.00E+00
24001110007334072	Biphenyl	0.00E+00	0.00E+00	5.10E-13	0.00E+00	0.00E+00
13099110012384589	Ethyl benzene	0.00E+00	1.34E-11	3.91E-13	0.00E+00	0.00E+00
13305110007356422	Ethyl benzene	0.00E+00	1.18E-11	3.43E-13	0.00E+00	0.00E+00
13021110005666243	Ethyl benzene	0.00E+00	1.12E-11	3.27E-13	0.00E+00	0.00E+00
27017110000426263	Ethyl benzene	0.00E+00	9.67E-12	2.82E-13	0.00E+00	0.00E+00
12107110000588604	Ethyl benzene	0.00E+00	9.26E-12	2.70E-13	0.00E+00	0.00E+00
47107110000605088	Ethyl benzene	0.00E+00	8.27E-12	2.41E-13	0.00E+00	0.00E+00
36113110000324845	Ethyl benzene	0.00E+00	1.66E-12	4.80E-14	0.00E+00	0.00E+00

Table 4: Acute Impacts Refined Analysis

Pulp and Paper Subpart MM did not require any refined analysis

Appendix 10

Detailed Multipathway Screening Results

Table 5a. Multipathway Cancer Screen Values

			Tier 2 Screen Values					
	Tier 1		Fisherman Scenario			Farmer Scenario		
NEI ID	Dioxin	PAH's	Dioxin	PAH's	Total	Dioxin	PAH's	Total
110000353466	2.0E+00	8.0E+01	6.0E-01	1.0E+01	1.1E+01	8.0E-02	9.5E+00	9.6E+00
110017416599	3.9E+00	6.8E+01	8.3E-01	9.3E+00	1.0E+01	1.9E-01	9.3E+00	9.5E+00
110000518002	2.8E+00	5.7E+01	4.8E-01	7.3E+00	7.8E+00	1.0E-01	6.1E+00	6.2E+00
110012505397	9.7E-04	4.2E+01	5.8E-05	1.1E+00	1.1E+00	1.4E-04	5.6E+00	5.6E+00
110008146130	2.2E+00	3.6E+01	3.6E-01	4.8E+00	5.2E+00	1.1E-01	5.3E+00	5.4E+00
110009719304	4.4E+00	3.5E+01	3.6E-01	2.0E+00	2.3E+00	1.6E-01	4.1E+00	4.2E+00
110000605220	1.8E+00	2.8E+01	3.9E-01	3.4E+00	3.8E+00	1.1E-01	5.3E+00	5.4E+00
110014206117	1.5E+00	2.8E+01	2.8E-01	2.0E+00	2.3E+00	8.9E-02	4.4E+00	4.5E+00
110000369280	2.8E-02	2.7E+01	3.3E-03	1.8E+00	1.8E+00	4.4E-03	4.1E+00	4.1E+00
110011734935	2.9E+00	2.5E+01	7.0E-01	3.2E+00	3.9E+00	1.1E-01	2.8E+00	3.0E+00
110012508580	2.8E+00	2.4E+01	2.6E-01	1.3E+00	1.5E+00	1.4E-01	3.3E+00	3.5E+00
110000490852	3.5E+00	2.1E+01	4.7E-01	1.9E+00	2.3E+00	1.3E-01	1.9E+00	2.1E+00
110001274521	2.4E+00	1.8E+01	5.5E-01	1.7E+00	2.3E+00	1.4E-01	3.1E+00	3.2E+00
110000589612	1.1E-01	1.7E+01	9.2E-03	8.3E-01	8.4E-01	1.8E-02	2.3E+00	2.4E+00
110007334072	7.0E-01	1.7E+01	9.2E-02	9.1E-01	1.0E+00	4.1E-02	2.5E+00	2.5E+00
110002217379	3.5E+00	1.3E+01	4.9E-01	9.4E-01	1.4E+00	1.7E-01	2.0E+00	2.2E+00
110000359718	3.1E+00	1.3E+01	6.1E-01	1.3E+00	1.9E+00	1.1E-01	1.2E+00	1.3E+00
110007317484	6.1E-01	1.3E+01	1.2E-01	1.3E+00	1.4E+00	5.6E-02	2.7E+00	2.7E+00
110000740958	9.8E-01	1.1E+01	2.2E-01	1.5E+00	1.8E+00	4.8E-02	1.5E+00	1.5E+00
110000450173	3.2E+00	1.1E+01	7.0E-01	1.2E+00	1.9E+00	1.6E-01	1.5E+00	1.6E+00
110009335905	3.4E+00	9.3E+00	3.2E-01	4.3E-01	7.4E-01	1.2E-01	5.8E-01	7.0E-01
110000362447	1.3E-01	8.6E+00	1.4E-02	4.3E-01	4.4E-01	7.4E-03	1.1E+00	1.1E+00
110000450752	4.2E-01	7.2E+00	1.1E-01	9.6E-01	1.1E+00	1.5E-02	8.0E-01	8.1E-01
110017413547	5.9E-03	7.1E+00	1.0E-03	5.8E-01	5.8E-01	2.3E-04	4.9E-01	4.9E-01
110000601965	2.3E+00	6.9E+00	3.1E-01	4.5E-01	7.6E-01	1.5E-01	1.2E+00	1.4E+00
110000362223	3.2E+00	6.8E+00	7.8E-01	1.5E+00	2.3E+00	1.4E-01	4.2E-01	5.6E-01
110000581415	1.7E-01	6.5E+00	3.7E-02	8.5E-01	8.9E-01	2.8E-02	1.2E+00	1.2E+00
110000450921	3.6E+00	5.8E+00	7.6E-01	6.6E-01	1.4E+00	1.8E-01	1.1E+00	1.3E+00
110000366121	3.9E-02	5.6E+00	6.7E-03	8.7E-01	8.8E-01	4.4E-03	6.0E-01	6.1E-01
110017408848	2.0E+00	5.5E+00	2.6E-01	3.4E-01	6.0E-01	8.1E-02	5.2E-01	6.0E-01
110000426263	2.4E+00	5.3E+00	5.4E-01	5.3E-01	1.1E+00	7.0E-02	4.1E-01	4.8E-01
110000488552	1.5E+00	4.9E+00	1.6E-01	2.7E-01	4.3E-01	8.8E-02	6.4E-01	7.2E-01
110013844563	2.0E+00	4.8E+00	1.9E-01	2.2E-01	4.1E-01	7.8E-02	5.2E-01	6.0E-01
110017413468	2.6E+00	4.5E+00	4.8E-01	3.3E-01	8.0E-01	1.3E-01	8.5E-01	9.8E-01
110009846480	3.4E+00	4.5E+00	2.3E-01	1.2E-01	3.5E-01	1.9E-01	6.6E-01	8.5E-01
110017428773	2.3E+00	4.5E+00	6.7E-01	7.8E-01	1.5E+00	1.5E-01	1.3E+00	1.4E+00
110000564586	1.6E+00	4.2E+00	6.9E-01	9.5E-01	1.6E+00	1.1E-01	8.4E-01	9.5E-01
110017422467	9.4E-02	4.1E+00	3.0E-02	7.2E-01	7.5E-01	4.8E-03	5.2E-01	5.2E-01
110000588604	2.9E+00	3.9E+00	6.4E-01	6.0E-01	1.2E+00	1.1E-01	6.2E-01	7.3E-01
110007356422	4.5E+00	3.9E+00	6.4E-01	3.7E-01	1.0E+00	1.5E-01	3.4E-01	4.9E-01
110012384286	3.9E+00	2.6E+00	9.2E-01	4.8E-01	1.4E+00	1.4E-01	1.7E-01	3.2E-01
110000732173	1.9E+00	2.2E+00	3.5E-01	2.2E-01	5.7E-01	9.5E-02	3.3E-01	4.2E-01
110000756352	2.9E-02	2.0E+00	6.4E-03	3.9E-01	4.0E-01	1.7E-03	1.7E-01	1.7E-01
110000351903	3.1E+00	1.5E+00	4.6E-01	1.5E-01	6.1E-01	1.6E-01	1.3E-01	2.9E-01
110017400711	3.9E+00	1.4E+00	8.2E-01	2.7E-01	1.1E+00	1.8E-01	1.2E-01	3.0E-01
110000599594	3.7E+00	1.4E+00	5.5E-01	1.8E-01	7.3E-01	1.8E-01	1.3E-01	3.1E-01
110013794000	3.5E+00	1.3E+00	2.9E-01	8.0E-02	3.7E-01	1.1E-01	7.0E-02	1.9E-01

110016989669	2.2E+00	1.3E+00	5.5E-01	1.6E-01	7.1E-01	1.1E-01	1.7E-01	2.9E-01
110008148496	2.8E+00	1.3E+00	1.1E+00	4.7E-01	1.6E+00	1.2E-01	1.0E-01	2.2E-01
110016966381	4.1E+00	1.3E+00	8.9E-01	2.4E-01	1.1E+00	1.4E-01	6.0E-02	2.0E-01
110000560492	3.0E+00	1.2E+00	6.5E-01	2.0E-01	8.5E-01	1.3E-01	9.1E-02	2.2E-01
110000605088	3.1E+00	1.1E+00	5.0E-01	1.7E-01	6.7E-01	1.9E-01	1.3E-01	3.2E-01
110000598639	4.0E+00	1.1E+00	1.4E+00	3.5E-01	1.8E+00	3.0E-01	1.6E-01	4.6E-01
110007356002	1.4E-01	1.1E+00	1.6E-02	1.2E-01	1.4E-01	2.8E-02	1.1E-01	1.4E-01
110000588542	3.0E+00	1.1E+00	1.9E-01	5.4E-02	2.4E-01	1.2E-01	8.1E-02	2.0E-01
110000597514	3.0E+00	1.1E+00	8.8E-01	3.0E-01	1.2E+00	2.0E-01	1.4E-01	3.4E-01
110000590940	2.8E+00	1.0E+00	4.4E-01	1.2E-01	5.7E-01	1.2E-01	8.6E-02	2.1E-01
110012384589	2.6E+00	9.8E-01	4.3E-01	1.3E-01	5.6E-01	9.0E-02	6.2E-02	1.5E-01
110000589435	9.6E-01	9.6E-01	2.8E-01	1.9E-01	4.7E-01	7.9E-02	2.5E-01	3.3E-01
110013763034	2.6E+00	9.1E-01	4.5E-01	1.3E-01	5.8E-01	1.0E-01	6.2E-02	1.7E-01
110000380926	2.4E+00	8.8E-01	2.7E-01	7.4E-02	3.5E-01	8.1E-02	5.0E-02	1.3E-01
110017782568	2.7E+00	8.3E-01	8.4E-01	1.9E-01	1.0E+00	1.9E-01	1.1E-01	2.9E-01
110002438103	2.3E+00	8.3E-01	4.2E-01	1.2E-01	5.4E-01	8.5E-02	6.0E-02	1.4E-01
110006020028	4.2E-02	8.2E-01	5.2E-03	1.0E-01	1.1E-01	6.3E-03	9.1E-02	9.8E-02
110000586447	1.8E+00	8.2E-01	4.9E-01	1.8E-01	6.6E-01	1.0E-01	7.6E-02	1.8E-01
110007233305	2.2E+00	8.1E-01	2.2E-01	6.3E-02	2.8E-01	1.1E-01	7.7E-02	1.9E-01
110000490326	4.5E-03	8.1E-01	6.2E-04	5.5E-02	5.6E-02	3.6E-04	1.2E-01	1.2E-01
110019973493	2.1E+00	7.8E-01	1.4E-01	3.5E-02	1.7E-01	1.0E-01	6.1E-02	1.6E-01
110005670336	1.9E-02	7.4E-01	3.4E-03	1.2E-01	1.2E-01	1.1E-03	6.1E-02	6.2E-02
110039166390	2.0E+00	7.3E-01	4.7E-01	1.5E-01	6.1E-01	1.0E-01	7.0E-02	1.7E-01
110005666243	2.4E+00	6.9E-01	7.1E-01	1.7E-01	8.7E-01	1.4E-01	5.2E-02	1.9E-01
110000491940	1.1E-02	6.6E-01	2.1E-03	9.8E-02	1.0E-01	1.9E-03	6.0E-02	6.2E-02
110000490558	1.8E+00	6.5E-01	2.7E-01	6.7E-02	3.4E-01	1.1E-01	6.5E-02	1.7E-01
110000427501	1.5E+00	5.6E-01	1.3E-01	2.6E-02	1.5E-01	5.3E-02	2.9E-02	8.2E-02
110000488142	1.5E+00	5.5E-01	2.5E-01	6.9E-02	3.1E-01	8.6E-02	5.3E-02	1.4E-01
110012503781	1.5E+00	5.5E-01	3.5E-01	8.7E-02	4.3E-01	7.7E-02	4.7E-02	1.2E-01
110012414985	1.5E+00	5.4E-01	2.7E-01	8.0E-02	3.5E-01	5.7E-02	4.0E-02	9.7E-02
110017404664	1.4E+00	5.4E-01	3.5E-01	7.0E-02	4.2E-01	8.3E-02	8.9E-02	1.7E-01
110000581460	4.3E-03	5.3E-01	4.6E-04	4.5E-02	4.6E-02	6.5E-04	5.5E-02	5.6E-02
110013359178	1.4E+00	5.1E-01	3.3E-01	8.1E-02	4.1E-01	8.4E-02	5.0E-02	1.3E-01
110000395117	1.3E+00	4.9E-01	2.1E-01	5.3E-02	2.6E-01	5.3E-02	3.2E-02	8.4E-02
110000588365	4.9E+00	4.9E-01	7.5E-01	5.3E-02	8.1E-01	1.6E-01	2.4E-02	1.9E-01
110000597890	1.3E+00	4.8E-01	2.7E-01	7.5E-02	3.4E-01	6.3E-02	4.4E-02	1.1E-01
110000325005	1.1E+00	3.9E-01	2.7E-01	6.5E-02	3.3E-01	5.4E-02	3.3E-02	8.7E-02
110013498296	1.0E+00	3.8E-01	2.4E-01	7.0E-02	3.1E-01	4.7E-02	3.2E-02	7.9E-02
110000420973	9.6E-01	3.5E-01	4.8E-02	1.1E-02	5.9E-02	3.5E-02	1.9E-02	5.5E-02
110043794374	1.6E+00	2.1E-01	4.7E-01	4.4E-02	5.1E-01	6.0E-02	2.2E-02	8.2E-02
110000332177	3.1E-03	1.7E-01	4.6E-04	1.5E-02	1.5E-02	1.8E-04	1.1E-02	1.1E-02
110000324845	1.1E-05	1.4E-01	3.8E-07	1.0E-02	1.0E-02	5.2E-06	3.4E-03	3.4E-03
110017711289	1.3E-01	1.0E-01	1.2E-02	7.5E-03	1.9E-02	1.8E-02	7.7E-03	2.6E-02
110017418338	3.7E+00	9.2E-02	5.9E-01	6.2E-03	5.9E-01	1.5E-01	1.8E-02	1.6E-01
110000350478	2.6E+00	5.3E-02	3.1E-01	2.7E-03	3.1E-01	1.3E-01	1.2E-02	1.5E-01
110000422043	4.4E-01	2.1E-02	1.1E-01	3.2E-03	1.1E-01	1.9E-02	2.2E-03	2.1E-02
110005312713	1.8E+00	1.5E-02	5.1E-02	9.3E-05	5.1E-02	6.7E-02	2.3E-03	6.9E-02
110000490898	2.9E+00	6.1E-03	4.4E-01	4.7E-04	4.4E-01	1.1E-01	9.8E-04	1.1E-01
110000355035	3.6E+00	6.0E-03	4.3E-01	5.2E-04	4.3E-01	2.0E-01	5.5E-04	2.0E-01
110005666421	2.1E+00	2.7E-03	6.8E-01	6.1E-04	6.8E-01	8.8E-02	3.1E-04	8.8E-02
110000343922		2.4E-04		1.4E-05	1.4E-05		7.4E-06	7.4E-06
110000330400	1.4E+00	3.8E-05	2.0E-01	1.9E-06	2.0E-01	6.6E-02	8.0E-06	6.6E-02

110000412045		2.6E-05		2.8E-06	2.8E-06		5.1E-06	5.1E-06
110000422267		3.1E-06		7.4E-07	7.4E-07		6.7E-08	6.7E-08
110000587491		8.4E-08		1.2E-08	1.2E-08		2.3E-09	2.3E-09
110000450878	1.7E+00		4.5E-01		4.5E-01	6.1E-02		6.1E-02
110000742796	8.3E-01		1.7E-01		1.7E-01	2.5E-02		2.5E-02
110020680306	5.6E-04		3.1E-05		3.1E-05	4.0E-05		4.0E-05
Multipathway Cancer Screen Values ≥ 10								

Table 5b. Multipathway Non-Cancer Screen Values

	Tier 1		Tier 2 Screen Values			
			Fisherman Scenario		Farmer Scenario	
NEI ID	Mercury	Cadmium	Mercury	Cadmium	Mercury	Cadmium
110000362223 *	20	0.600	5.0E+00	2.0E-01	1.0E-03	5.0E-03
110017400711 *	9	0.900	2.0E+00	2.0E-01	7.0E-04	8.0E-03
110043794374 *	8	0.200	3.0E+00	7.0E-02	5.0E-04	1.0E-03
110000351903	7	0.600	1.0E+00	1.0E-01	5.0E-04	5.0E-03
110000450173 *	6	0.500	2.0E+00	1.0E-01	5.0E-04	4.0E-03
110000564586 *	6	0.900	4.0E+00	5.0E-01	8.0E-04	1.0E-02
110000589612	6	0.600	8.0E-01	9.0E-02	5.0E-04	6.0E-03
110000740958 *	6	0.400	2.0E+00	1.0E-01	5.0E-04	3.0E-03
110007356422	6	0.700	1.0E+00	1.0E-01	3.0E-04	4.0E-03
110008148496 *	6	0.500	3.0E+00	2.0E-01	4.0E-04	4.0E-03
110009719304	6	0.600	7.0E-01	6.0E-02	4.0E-04	4.0E-03
110000359718	5	0.500	1.0E+00	1.0E-01	3.0E-04	3.0E-03
110000362447	5	0.400	7.0E-01	7.0E-02	4.0E-04	3.0E-03
110000598639 *	5	0.400	2.0E+00	2.0E-01	6.0E-04	5.0E-03
110000343922	4	0.900	6.0E-01	1.0E-01	3.0E-04	7.0E-03
110000756352	4	0.400	1.0E+00	1.0E-01	3.0E-04	4.0E-03
110002438103	4	0.300	9.0E-01	8.0E-02	3.0E-04	2.0E-03
110007233305	4		5.0E-01		3.0E-04	
110012384286	4	0.400	1.0E+00	1.0E-01	2.0E-04	3.0E-03
110017782568	4	0.400	2.0E+00	2.0E-01	5.0E-04	5.0E-03
110000330400	3	0.300	5.0E-01	5.0E-02	2.0E-04	2.0E-03
110000355035	3	0.500	5.0E-01	7.0E-02	3.0E-04	5.0E-03
110000450921	3	0.300	8.0E-01	8.0E-02	3.0E-04	3.0E-03
110000488552	3	0.200	4.0E-01	3.0E-02	2.0E-04	2.0E-03
110000490558	3	0.400	6.0E-01	8.0E-02	3.0E-04	4.0E-03
110000490898	3	0.300	5.0E-01	4.0E-02	2.0E-04	2.0E-03
110000518002	3	0.500	7.0E-01	1.0E-01	2.0E-04	3.0E-03
110000581415	3	0.300	1.0E+00	9.0E-02	2.0E-04	2.0E-03
110000588365	3	1.000	5.0E-01	2.0E-01	1.0E-04	7.0E-03
110000588542	3	0.300	3.0E-01	3.0E-02	2.0E-04	2.0E-03
110000597514	3	0.300	9.0E-01	1.0E-01	4.0E-04	4.0E-03
110000599594	3	0.300	6.0E-01	5.0E-02	3.0E-04	2.0E-03
110005666421	3	0.300	1.0E+00	1.0E-01	2.0E-04	2.0E-03
110005670336	3		7.0E-01		3.0E-04	
110009335905	3	0.300	3.0E-01	2.0E-02	1.0E-04	1.0E-03
110011734935	3	0.500	1.0E+00	1.0E-01	2.0E-04	3.0E-03
110013763034	3	0.600	6.0E-01	1.0E-01	2.0E-04	4.0E-03
110016989669	3		1.0E+00		2.0E-04	
110017404664	3	0.400	1.0E+00	1.0E-01	3.0E-04	3.0E-03
110017418338	3		6.0E-01		2.0E-04	
110017428773	3	0.300	1.0E+00	1.0E-01	3.0E-04	4.0E-03

110039166390	3	0.300	8.0E-01	7.0E-02	3.0E-04	3.0E-03
110000350478	2	0.040	4.0E-01	9.0E-03	2.0E-04	4.0E-04
110000366121	2	0.200	5.0E-01	5.0E-02	1.0E-04	1.0E-03
110000380926	2	0.200	3.0E-01	3.0E-02	1.0E-04	1.0E-03
110000490852	2	0.300	3.0E-01	5.0E-02	1.0E-04	2.0E-03
110000586447	2	0.900	5.0E-01	2.0E-01	2.0E-04	8.0E-03
110001274521	2	0.500	6.0E-01	2.0E-01	2.0E-04	5.0E-03
110005666243	2	0.400	6.0E-01	1.0E-01	2.0E-04	3.0E-03
110006020028	2	0.200	4.0E-01	4.0E-02	2.0E-04	2.0E-03
110007317484	2	0.300	5.0E-01	7.0E-02	2.0E-04	3.0E-03
110012414985	2	0.300	4.0E-01	9.0E-02	1.0E-04	2.0E-03
110012505397	2	0.500	2.0E-01	4.0E-02	2.0E-04	4.0E-03
110013794000	2	0.080	2.0E-01	8.0E-03	9.0E-05	4.0E-04
110013844563	2	0.200	2.0E-01	2.0E-02	1.0E-04	1.0E-03
110017408848	2		3.0E-01		9.0E-05	
110017422467	2	0.200	7.0E-01	4.0E-02	1.0E-04	9.0E-04
110017711289	2	0.200	2.0E-01	2.0E-02	1.0E-04	1.0E-03
110019973493	2	0.200	2.0E-01	2.0E-02	1.0E-04	2.0E-03
110000427501	1	0.100	1.0E-01	1.0E-02	6.0E-05	5.0E-04
110000490326	1	0.300	2.0E-01	4.0E-02	1.0E-04	2.0E-03
110000588604	1	0.300	4.0E-01	8.0E-02	1.0E-04	2.0E-03
110000590940	1	0.100	2.0E-01	3.0E-02	8.0E-05	1.0E-03
110012508580	1	0.200	2.0E-01	3.0E-02	1.0E-04	2.0E-03
110017413468	1	0.100	3.0E-01	3.0E-02	1.0E-04	1.0E-03
110000353466	0.9	0.300	4.0E-01	1.0E-01	6.0E-05	2.0E-03
110014206117	0.9	0.100	2.0E-01	3.0E-02	8.0E-05	1.0E-03
110000426263	0.8	0.400	2.0E-01	8.0E-02	3.0E-05	2.0E-03
110000490709	0.8		1.0E-01		8.0E-05	
110013498296	0.8	0.200	3.0E-01	5.0E-02	7.0E-05	2.0E-03
110016966381	0.8	0.003	2.0E-01	9.0E-04	5.0E-05	2.0E-05
110000332177	0.7	0.008	1.0E-01	1.0E-03	4.0E-05	5.0E-05
110000488142	0.7	0.300	1.0E-01	5.0E-02	6.0E-05	2.0E-03
110000589435	0.7	0.060	2.0E-01	2.0E-02	8.0E-05	7.0E-04
110000742796	0.7	0.006	2.0E-01	1.0E-03	3.0E-05	2.0E-05
110002217379	0.7	0.200	1.0E-01	4.0E-02	6.0E-05	2.0E-03
110000325005	0.5	0.090	1.0E-01	2.0E-02	4.0E-05	7.0E-04
110000420973	0.5	0.300	3.0E-02	2.0E-02	2.0E-05	2.0E-03
110000605220	0.5	0.200	1.0E-01	7.0E-02	5.0E-05	3.0E-03
110000732173	0.5	1.000	1.0E-01	3.0E-01	5.0E-05	1.0E-02
110005312713	0.5	0.080	2.0E-02	2.0E-03	2.0E-05	3.0E-04
110008146130	0.5	0.200	1.0E-01	5.0E-02	5.0E-05	2.0E-03
110000422043	0.4		1.0E-01		3.0E-05	
110000450878	0.4	0.300	2.0E-01	1.0E-01	3.0E-05	2.0E-03
110007334072	0.4		6.0E-02		3.0E-05	
110000369280	0.3	0.100	6.0E-02	3.0E-02	3.0E-05	1.0E-03
110000395117	0.3	0.060	5.0E-02	1.0E-02	2.0E-05	4.0E-04
110017416599	0.3	0.300	9.0E-02	9.0E-02	3.0E-05	3.0E-03

110000581460	0.2	0.040	4.0E-02	8.0E-03	2.0E-05	4.0E-04
110000605088	0.2	0.300	3.0E-02	6.0E-02	2.0E-05	3.0E-03
110009846480	0.2	0.200	2.0E-02	2.0E-02	1.0E-05	2.0E-03
110012384589	0.2	0.400	4.0E-02	8.0E-02	1.0E-05	2.0E-03
110017413547	0.2	0.300	4.0E-02	6.0E-02	7.0E-06	1.0E-03
110012503781	0.1	0.020	4.0E-02	4.0E-03	1.0E-05	1.0E-04
110000450752	0.06	0.008	2.0E-02	3.0E-03	4.0E-06	5.0E-05
110007356002	0.04	0.007	7.0E-03	1.0E-03	3.0E-06	7.0E-05
110000597890	0.02	0.100	7.0E-03	3.0E-02	2.0E-06	1.0E-03
110000422267	0.004		1.0E-03		2.0E-07	
110000587491	0.002	0.001	4.0E-04	8.0E-05	2.0E-07	4.0E-06
110000412045	0.0003		1.0E-04		2.0E-08	
110000324845		0.010		3.0E-03		1.0E-04
110000491940		0.070		2.0E-02		6.0E-04
110000560492		0.400		8.0E-02		3.0E-03
110000601965		0.400		9.0E-02		5.0E-03
110013359178		0.100		3.0E-02		1.0E-03

Multipathway Screen Values > 1

* - Selected for Tier 3 Screen based upon Tier 2 Screen Value.
Refer to Attachment 1 for a write-up of the Tier 3 Screen.

Table 5c. Multipathway Non-Cancer Screen Summary for Tier 2 facilities requiring a Tier 3 Screen

	Mercury Screening Values		Tier 3 Fisherman Scenario			
NEI ID	Tier 1[a]	Tier 2	Lake Assessment	Plume-rise	TRIM Hourly Run	Comment
110000362223	16	5	2	0.90		Plume rise and lake adjustment reduced screen value
110000564586	6	4	2	1.10		Plume rise and lake adjustment reduced screen value
110043794374	8	3	3	2.00	0.95	Plume rise and TRIM hourly model run reduced screen value
110008148496	6	3	1			Lake assessment evaluation reduced screen value
110017400711	9	2	1			Lake assessment evaluation reduced screen value
110000598639	5	2	1			Lake assessment evaluation reduced screen value
110000450173	6	2	1			Lake assessment evaluation reduced screen value
110000740958	6	2	0.5			Lake assessment evaluation reduced screen value
110017782568	4	2	1			Lake assessment evaluation reduced screen value

a -- Tier 1 screening values based upon a combined fish and farmer ingestion rate

Multipathway Screen Values ≤ 1

Table 6: Environmental Risk Analysis

Pulp and Paper Subpart MM did not have any Tier 2 exceedances of any ecological benchmarks

Attachment 1

Detailed Tier 3 Multipathway Screening Report

Technical Support Document: Tier 3 Screening Assessment of Human Health Multipathway Residual Risk for the Pulp Mill Combustion Source Category (Regulatory Code 63MM)

DRAFT

September 15, 2016

Prepared For:

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Under Contract No. EP-12-010, Work Assignment 4-49

Prepared By:

ICF International
2635 Meridian Pkwy.
Suite 200
Durham, NC 27713

[This page intentionally left blank.]

CONTENTS

TABLES

FIGURES

1. Introduction

This report provides a discussion on the Tier 3 screening-level assessment of human health risks, via the ingestion pathway, from exposure to persistent and bioaccumulative hazardous air pollutants (PB-HAPs)—specifically, those emitted to the air from pulp mill combustion sources under regulatory code 63MM (for simplicity, hereafter referred to as the pulp mill combustion source category). Appendix 10 to the Risk Report[1] provides a discussion on the Tier 1 and Tier 2 screening assessment results. While this report contains a discussion on some of the screening methods, a more detailed discussion on the development, methods, and implementation of the screening assessment can be found in Appendix 6 to the Risk Report.[2] Where appropriate, this discussion provides references to particular sections of Appendix 6 to the Risk Report, where further details on the subject matter can be found.

Cadmium, dioxins, mercury, and polycyclic organic matter (POM) were the evaluated PB-HAP groups,[3] selected from a larger list of PB-HAPs based in part on ranking their toxicity-weighted air emissions across all source categories. The evaluated exposure scenarios were a fisher scenario (i.e., consumption of fish from one or more lakes) and a farmer scenario (i.e., consumption of farm food chain [FFC] media such as animal products, fruits and vegetables, and incidental ingestion of soil). EPA evaluates the two scenarios together (i.e., the sum of fisher and farmer exposures and risks) in Tier 1 of the assessment, and EPA evaluates them separately in Tier 2 and Tier 3. EPA designed the screening scenarios to be health-protective in estimating exposures and risks. Specifically, they are intended to avoid underestimating ingestion exposure and risk due to the air emissions of these PB-HAPs from facilities nationwide evaluated in the Risk and Technology Review (RTR) program.

EPA uses the TRIM.FaTE[4] model to evaluate the environmental transport, transfer, and fate of PB-HAP air emissions, including uptake into fish. The MIRC[5] program then calculates FFC chemical uptake along with human exposure, human health cancer risks, and human health non-cancer hazard quotients (HQs) resulting from ingestion of fish and FFC media. For screening assessments of multipathway risk across the RTR program, EPA used these models with fate and transport parameter values, idealized spatial layouts, and generalized meteorology that overall create ingestion exposure scenarios that are unlikely to be exceeded at any actual facility evaluated in the RTR program.

ICF (hereafter "we") conducted these model runs to identify threshold emission rates (hereafter "thresholds") that correspond to levels of concern for cancer and non-cancer risks. We derived a threshold for each carcinogenic PB-HAP (i.e., dioxin and POM) at which the maximum excess lifetime cancer risk would be 1-in-1 million. For PB-HAPs that cause non-cancer health effects

---

[1] Appendix 10 to the Risk Report is the *Detailed Risk Modeling Results*.

[2] Appendix 6 to the Risk Report is the *Technical Support Document for the TRIM-Based Multipathway Tiered Screening Methodology for RTR*.

[3] The phrase "PB-HAP group" is used to distinguish the individual PB-HAP chemicals and congeners from the overall family (grouping) of those chemicals. For example, EPA's ingestion risk methods in its Risk and Technology Review (RTR) program evaluate emissions of 17 individual congeners of chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans in the "dioxin" PB-HAP group.

[4] TRIM.FaTE is the Fate, Transport, and Ecological Exposure module of the Total Risk Integrated Methodology modeling system. Additional TRIM.FaTE information can be found at: https://www.epa.gov/fera/total-risk-integrated-methodology-trim-trimfate.

[5] MIRC is the Multimedia Ingestion Risk Calculator.

(i.e., mercury and cadmium), we derived a threshold for which the maximum HQ would be 1. Exceeding the emission threshold in any of the tiered screening methods cannot be equated with a risk value or HQ (or hazard index). Rather, it represents a high-end estimate of what the risk or hazard might be. For example, facility emissions exceeding the emission threshold by a factor of 2 for a non-carcinogen can be interpreted to mean that EPA is confident that the HQ would be lower than 2. Similarly, exceeding the threshold by a factor of 30 for a carcinogen means that EPA is confident that the cancer risk would be lower than 30-in-1 million.

EPA uses the term “screening values” (SVs) to refer to the ratio of a facility’s emissions of a PB-HAP to that PB-HAP’s threshold. When rounded to one significant figure, an SV of 1 or less indicates that the emissions did not exceed the threshold and are unlikely to pose health risks above levels of concern (i.e., the emissions “screened out”). An SV of 2 or greater indicates that further assessment may be required (i.e., progress to the next Tier or stage of the assessment).

For the Tier 3 screening-level ingestion assessment described in this report (see Appendix 10 to the Risk Report[1] for details on Tier 1 and Tier 2), we assessed the potential for ingestion risks above levels of concern in the pulp mill combustion source category by comparing PB-HAP emissions from facilities within the source category to the thresholds.

The pulp mill combustion source category contains 108 facilities. As described in Appendix 10 to the Risk Report,[1] the mercury emissions at 9 facilities did not screen out of Tier 2 for the fisher scenario (the largest Tier 2 fisher non-cancer SV was 5 for mercury) and required further assessment in a Tier 3 screening (described in this report). Cadmium emissions at all facilities screened out in Tier 1 and required no further assessment. All dioxin emissions screened out in Tier 2. All Tier 2 SVs for POM were 10 or smaller, indicating that EPA is confident that the cancer risk is lower than 10-in-1 million, which EPA judged to be an acceptable level of risk and required no further assessment.

As described in this report, we used Tier 3 screening methods to assess mercury emissions from the nine facilities whose emissions did not screen out of the Tier 2 mercury screening. Mercury emissions at six facilities screened out of the Tier 3 lake assessment, leaving three facilities to screen further. Two additional facilities screened out of the Tier 3 plume-rise assessment for mercury, and mercury emissions from the remaining facility screened out of the Tier 3 time-series assessment. A refined, site-specific multipathway assessment was not necessary for the pulp mill combustion source category.

In Section 2, we briefly describe the Tier 3 screening methods and discuss the results of those screening assessments. We provide in Section 3 a summary comparison of the Tier 1 screening results with the screening results after the Tier 2 and Tier 3 assessments.

2. Tier 3 Emission Screening Assessment

Based on the Tier 2 SVs and other considerations regarding the source category and facilities being assessed, EPA may conduct Tier 3 screening assessments on some facilities. We discuss in this section the Tier 3 screening conducted for mercury hazards for the nine facilities in the pulp mill combustion source category whose mercury emissions did not screen out in Tier 2.

2.1 Lake Assessment

2.1.1 Approach

Other than verifying a facility's emission rates, one of the simplest assessments EPA can conduct (beyond the Tier 2 methods) is evaluating the existence, potential purpose, accessibility and fishability, and suitability of lakes for the models and methods used in the screening assessments. The full USGS dataset of lakes and reservoirs nationwide that EPA uses in Tier 2[6] does not contain information on lake accessibility or fishability. In addition, it occasionally identifies a lake that no longer exists (e.g., it has evaporated or been drained) or it uses a classification that might not accurately reflect the lake's purpose or type. EPA uses aerial and street-view imagery and internet searches to quickly ascertain if an assessed lake actually exists, if it is probably not fished on a regular basis (e.g., appears swampy or covered in algae), if it is likely used for industrial waste disposal/treatment purposes, or if it is adjacent to or connected to a river or saltwater body (the assessment methods and models are intended for freshwater systems that are relatively closed and that have watersheds that do not extend beyond about 50 km from the facility).

For example, the blue outlines in Figure 2-1 identify lakes from the USGS dataset that originally qualified for Tier 2 based on the information provided in that dataset, but aerial imagery suggested they meet one or more of the disqualifying criteria discussed in previous paragraphs. Figure 2-1a identifies a lake likely covered in algae and, according to historical photos, fluctuates substantially in size. Figure 2-1b identifies a lake directly adjacent to an industrial facility and likely used only for on-site industrial purposes such as wastewater treatment. Figure 2-1c identifies a lake that appears to no longer exist.

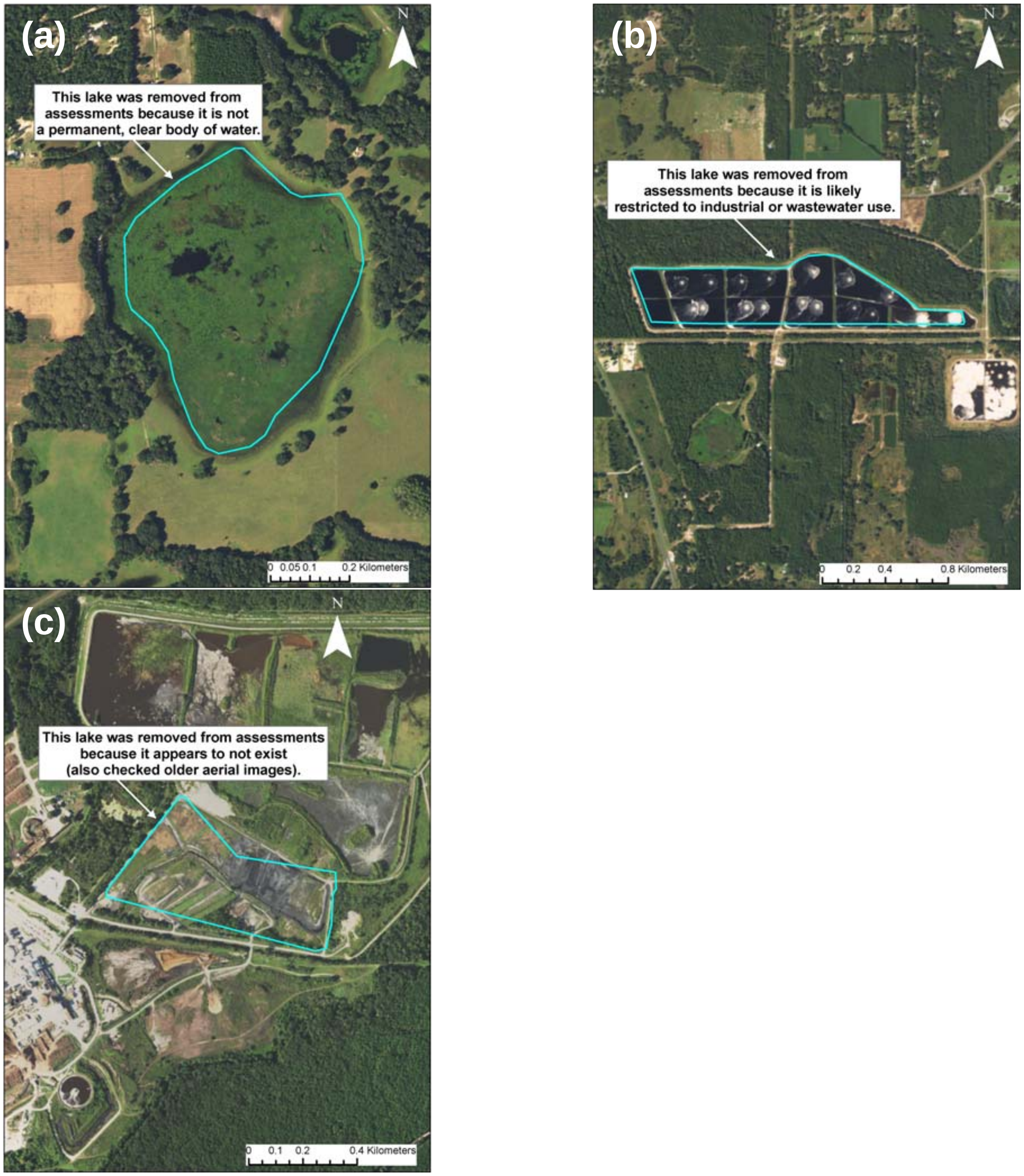
For facilities undergoing Tier 3 screening, EPA evaluates all lakes from which the fisher catches and consumes fish according to the Tier 2 fisher methods. EPA permanently removes from the screening assessment all lakes meeting the criteria discussed in the previous paragraphs so that they are no longer used in any future screening assessment. If EPA removes a lake from a facility's assessment, it might be necessary for the hypothetical fisher to catch and consume fish from additional lakes in order to satisfy the requirement that a total of 373 acres of fishable lake are assessed (i.e., to reach the screening-level adult fish-ingestion rate of 373 g/d)[7]. If this is the case, EPA evaluates additional lakes that were not fished originally in Tier 2, in descending order of Tier 2 fisher SV (at the 373 g/d adult ingestion rate) and, as a tiebreaker, in descending order of lake area.[7] If EPA removes any lakes from the screening, the screening assessment is performed again with the revised lake dataset—this is the Tier 3 lake assessment.

---

[6] See Section 3.4.1 of Appendix 6 to the Risk Report.[2]

[7] See Section 3.3.2.3 of Appendix 6 to the Risk Report.[2]

Figure 2-1. Examples of Lake Removed from Screening—(a) Algae-covered and Likely Non-permanent Lake, (b) Likely an Industrial Lake, (c) Likely a Non-existent Lake



Note: Aerial imagery from ESRI (2016).

2.1.2 Results

After we removed 67 lakes from the screening assessment, six facilities screened out and three facilities had screening values for mercury that warranted further refinement (as shown in Table 2-1). The assessed lakes near these nine facilities are listed in Table A-1 and shown in Figures A-1 through A-9 in Attachment A to this report. The 67 lakes removed during the Tier 3 assessment are listed in Table A-2.

Table 2-1. Results of Tier 3 Lake Assessments for Mercury Emissions

Facility FRS ID	Tier 2 Fisher SV	Tier 3 Fisher SV
110000362223	5	2
110000564586	4	2
110008148496	3	1
110043794374	3	3
110017400711	2	1
110000598639	2	1
110000450173	2	1
110000740958	2	0.5
110017782568	2	1

Note: Pink shading highlights emissions that did not screen out.

We then conducted a Tier 3 plume-rise assessment on the mercury emissions of the three facilities that did not screen out of the Tier 3 lake assessment, as discussed in Section 2.2.

2.2 Plume-rise Assessment

2.2.1 Approach

In Tiers 1 and 2, all chemicals are modeled as being emitted inside the mixing layer and are available for ground-level exposure. In reality, the physical height of an emission source, in combination with meteorological conditions and the temperature and velocity of the chemical plume as it leaves the source, can cause some of the chemical plume to reach areas above the mixing layer. In TRIM.FaTE modeling, the chemical mass deposited above the mixing layer (i.e., the model's upper-air layer) is unavailable for ground-level exposure (i.e., the upper-air layer functions as a chemical sink).

EPA uses methods summarized by Seinfeld and Pandis (1998) to estimate how often a facility's emissions reach the upper-air sink, which decreases ground-level exposure. The methods to estimate the amount of chemical lost to the upper-air sink require use of the facility's corresponding meteorology data (e.g., air temperature and vertical temperature gradient, wind speed, and atmospheric stability), the mass of the PB-HAP emitted from each source, the physical characteristics of the sources (i.e., release height, inside diameter at the release point, and exit gas temperature and velocity), and an estimate of the size of the facility property (to estimate the height of the plume when it moves beyond the facility property and over areas where people might live).

For each emission source, EPA estimates the hourly plume height and compares it to the hourly mixing height to determine the mass of chemical deposited into the mixing layer over the course of the exposure period. EPA compares the mass of chemical deposited into the mixing layer, summed across the sources, to the total emitted mass of the chemical. This results in an adjustment factor expressing the fraction of emissions deposited into the mixing layer after accounting for plume rise. EPA applies this final plume-rise adjustment factor to the SVs from the Tier 3 lake assessment—this is the Tier 3 plume-rise assessment.

2.2.2 Results

The Tier 3 lake assessment screened out six facilities for mercury emissions, and we conducted the Tier 3 plume-rise assessment on the remaining three facilities using the facility-specific emissions data and local meteorological data. Table 2-2 provides information on the mercury emissions and physical characteristics of the emission sources. For simplicity, if two or more facility sources had very similar physical characteristics, we aggregated their emissions and averaged their physical characteristics into a single source; the information shown in Table 2-2 is after this aggregation and averaging. The numbers in the third column correspond to the fraction of facility mercury emissions coming from each source. The numbers in the second-to-last column indicate the fraction of mercury emitted from each source that was deposited into the mixing layer (i.e., was not deposited into the upper-air sink). The numbers in the last column indicate the total fraction of emissions from all facility sources that was deposited into the mixing layer, calculated as the sum-product of the third and second-to-last columns.

Table 2-2. Fraction of Mercury Emissions Remaining in the Mixing Layer after the Tier 3 Plume-rise Assessment

			Physical Characteristics of Emiss. Source				Fraction of Emiss. Deposited into Mixing Layer	
Facility FRS ID	**Source Num.**	**Fraction of Emiss. From This Source**	**Height (m)**	**Exit Gas Temp. (K)**	**Inside Diameter (m)**	**Exit Gas Vel. (m/s)**	**By Source**	**Facility Total**
110000362223	1	0.47	38.1	555.3	2.2	12.8	0.54	0.50
	2	0.25	68.6	499.8	2.9	25.8	0.44	
	3	0.24	68.6	452.6	3.0	14.1	0.47	
	4	0.04	45.1	344.3	1.1	11.8	0.69	
110000564586	1	0.89	94.5	335.4	2.7	16.1	0.58	0.60
	2	0.11	72.1	345.6	1.8	3.8	0.74	
110043794374	1	1	42.7	463.7	2.1	20.5	0.83	0.83

While the numbers in the final column of Table 2-2 indicate the fraction of mercury emissions deposited into the mixing layer across all modeled hours, each assessed lake receives direct air-to-lake deposition only when the wind blows in its direction. Meteorological conditions including temperature, stability, and mixing height can vary by wind direction; therefore, the fraction of emissions deposited into the mixing layer varies by wind direction, and each lake required its own plume-rise adjustment factor. While 50 percent of mercury emissions deposited into the mixing layer across all times for facility 110000362223 (Table 2-2), as shown in Table A-1 (in Attachment A of this report) the percent deposited into the mixing layer varied between 47 percent and 62 percent depending on the location of the assessed lake (i.e., the plume-rise adjustment factors varied by lake between 0.47 and 0.62). While 60 percent of mercury emissions deposited into the mixing layer across all times for facility 110000564586, the assessed lakes received a plume-rise adjustment factor of 0.61. For facility 110043794374, 83 percent of mercury emissions deposited into the mixing layer across all times, but the plume-rise adjustment factors varied by lake between 0.65 and 0.93.

Each facility's Tier 3 plume-rise screening value is the sum-product of each lake's screening value (after the Tier 3 lake assessment) and its plume-rise adjustment factor (i.e., fraction of emissions deposited into mixing layer). Table 2-3 contains the SVs after the Tier 3 plume-rise assessments, for the three facilities of interest. Mercury emissions from two facilities screened out, but did not screen out for facility 110043794374. We conducted a Tier 3 time-series assessment on that remaining facility, as discussed in Section 2.3.

Table 2-3. Results of Tier 3 Plume-rise Assessments for Mercury Emissions

Facility FRS ID	Tier 3 Fisher SV
110000362223	1
110000564586	1
110043794374	2

Note: Pink shading highlights emissions that did not screen out.

2.3 Assessment of Time-series Meteorology and Plume-rise Heights

2.3.1 Approach

EPA bases the Tier 2 SVs on the average meteorological conditions prevailing at the facility being assessed.[8] The use of time-series meteorology data, which captures hour-by-hour changes in each of the assessed meteorological parameters instead of using constant average values, increases the accuracy of the estimates of potential risk by accounting for the effect of each hour's meteorological conditions on chemical fate and transport.

EPA also bases Tier 2 SVs on a constant emission release height that deposits all emitted chemical into the mixing layer. Including hourly plume-rise values (discussed in Section 2.2 above) along with hourly meteorology data further increases the accuracy of the estimates of potential risk.

For a facility undergoing a Tier 3 time-series assessment, and for each fished lake (or for each farm if farmer SVs are of concern), EPA conducts a run of TRIM.FaTE with

- the spatial configuration corresponding to that lake (e.g., the "lake at 5 km" screening configuration if the lake is 5–10 km from the facility[8]),
- facility-specific emissions from the same sources used in the Tier 3 plume-rise assessment (for mercury, using emissions of elemental and divalent mercury),
- the same source-specific hourly plume-rise values used in the Tier 3 plume-rise assessment, and
- the same facility-specific hourly meteorological conditions used in the Tier 3 plume-rise assessment.

This TRIM.FaTE modeling, and subsequent MIRC modeling, results in a screening value for each lake, corresponding to ingestion of fish exposed to the evaluated PB-HAP. If the farmer scenario is specifically being assessed, the modeling will result in a screening value for each farm. EPA multiplies the fisher screening value associated with each lake by the percent of daily

---

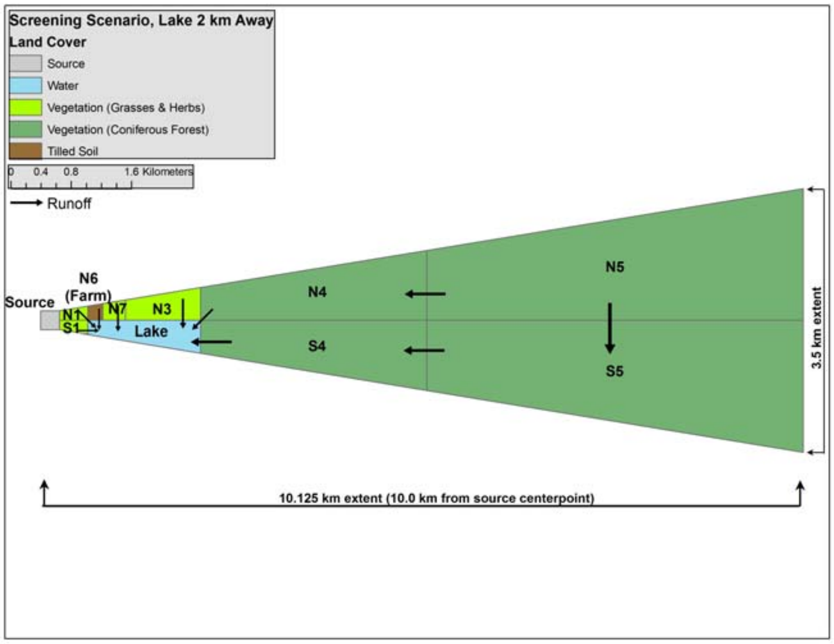
[8] See Section 3.3.1 in Appendix 6 to the Risk Report.[2]

ingested fish caught from the lake; summing those products across all modeled lakes results in the facility-total fisher screening value associated with the evaluated PB-HAP.

2.3.2 Results

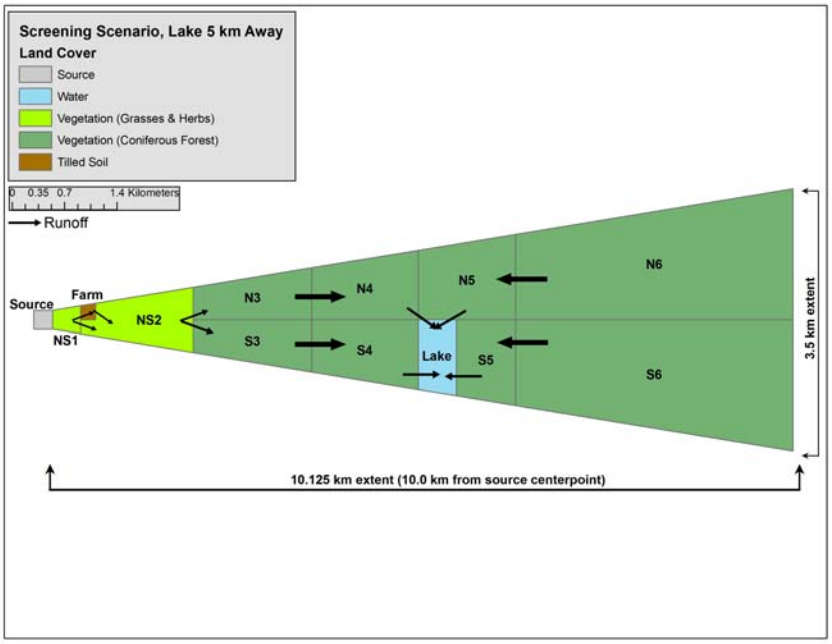
Facility 110043794374 did not screen out of the Tier 3 plume-rise assessment and we assessed it in the Tier 3 time-series assessment. The Tier 3 fisher caught and consumed fish from eight unique lakes from this facility. Two of the lakes were in the same direction from the facility and at the same evaluated distance, so one TRIM.FaTE model run applied to both lakes. In total, we ran seven TRIM.FaTE simulations. We used the “lake at 2 km” spatial configuration, shown in Figure 2-2, to model concentrations in the lakes listed in Table A-1 with fishing orders 2, 3, and 6. We used the “lake at 5 km” spatial configuration, shown in Figure 2-3, to model concentrations in the lakes listed in Table A-1 with fishing orders 1, 4, 5, 7, and 8.

Figure 2-2. The “Lake at 2 km” Modeling Spatial Configuration Used for Three of the Lakes (Fishing Orders 2, 3, and 6 in Table A-1)



Notes: Labels = surface parcel names for modeling. Shadings = ground cover type for modeling. Arrows = direction of runoff and erosion.

Figure 2-3. The “Lake at 5 km” Modeling Spatial Scenario Used for Five of the Lakes (Fishing Orders 1, 4, 5, 7, and 8 in Table A-1)



Notes: Labels = surface parcel names for modeling. Shadings = ground cover type for modeling. Arrows = direction of runoff and erosion.

Table 2-4 contains the fisher SV from the Tier 3 time-series assessment, the result of multiplying each lake’s fisher SV by the fraction of total fish consumed coming from that lake (see Table A-1) and summing those products across all eight lakes. The mercury emissions for facility 110043794374 screened out of this assessment.

Table 2-4. Results of Tier 3 Time-series Assessments for Mercury Emissions

Facility FRS ID	Tier 3 Fisher SV
110043794374	1

3. Summary of Tier 3 Screening Results

Emissions of mercury did not screen out for the Tier 2 fisher scenario for nine facilities in the pulp mill combustion source category (the largest Tier 2 fisher SV was 5), and these nine facilities advanced to the Tier 3 lake-assessment screening.

With the removal of unfishable lakes from the assessment (see Section 2.1), three of the nine facilities did not screen out (the largest fisher SV decreased to 3), and these three facilities advanced to Tier 3 plume-rise screening.

With an assessment of stack plume-rise characteristics (see Section 2.2), two of the three facilities screened out, leaving one facility advancing to the Tier 3 time-series screening.

With hour-by-hour modeling in TRIM.FaTE (see Section 2.3), the remaining facility screened out with a fisher SV of 1 and no further assessment was required.

4. References

ESRI. (2016). World Imagery. Retrieved July 21, 2016, from http://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9.

Seinfeld, J. H., & Pandis, S. N. (1998). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. New York: Wiley-Interscience.

Attachment A. Additional Information on the Tier 3 Assessments

Table A-1. Lakes Fished in the Tier 3 Lake Assessment, with Adjustment Factors for the Tier 3 Plume-rise Assessment

Facility FRS ID	Lake Name	Latitude	Longitude	Lake Area (acres)	Fishing Order	% of Ingested Fish Coming From This Lake	LAKE ASSESSMENT: % of Tier 3 Fisher SV Attributed To This Lake	PLUME-RISE ASSESSMENT: Fraction of Emiss. Deposited into Mixing Layer
110000362223	Name Not Provided	30.0458	-83.5344	35	1	9	16	0.51
	Bird Pond	29.9785	-83.6193	37	2	10	14	0.62
	Sampala Lake	30.3845	-83.5335	94	3	25	25	0.50
	Tenmile Pond	30.2855	-83.3150	124	4	33	27	0.47
	Brewer Lake	30.1960	-83.2964	64	5	17	14	0.47
	Riggins Lake	30.3932	-83.3609	47	6	5	4	0.47
110000564586	Jewit Lake	45.5753	-122.5014	82	1	22	53	0.61
	Name Not Provided	45.7376	-122.7953	3,289	2	78	47	0.61
110008148496	Kennedy Lake	33.3278	-94.0651	52	1	14	29	Not assessed
	Name Not Provided	33.3137	-94.0379	27	2	7	8	
	Wright Patman Lake	33.2693	-94.2153	29,494	3	79	62	
110043794374	Name Not Provided	30.6614	-91.3472	27	1	7	9	0.72
	Grand Lake	30.7007	-91.3362	84	2	23	25	0.72
	Name Not Provided	30.6802	-91.3523	35	3	9	10	0.72
	Name Not Provided	30.7396	-91.4170	57	4	15	16	0.85
	Grand Bay	30.6411	-91.3504	89	5	24	22	0.65
	Deep Lake	30.6744	-91.3101	32	6	9	8	0.65
	Name Not Provided	30.7464	-91.4062	27	7	7	6	0.93
	Name Not Provided	30.6603	-91.2681	35	8	6	4	0.77
110017400711	Bradley Lake	32.1120	-85.0087	30	1	8	21	Not assessed
	Name Not Provided	32.1985	-85.1849	27	2	7	15	
	Name Not Provided	32.2531	-85.4402	27	3	7	7	
	Name Not Provided	31.9714	-84.7481	104	4	28	22	
	Hodchodkee Pond	32.0316	-84.8012	52	5	14	11	
	Name Not Provided	31.8739	-84.9086	138	6	36	24	
110000598639	Wright Lake	33.9354	-95.2414	27	1	7	15	Not assessed
	Womack Lake	33.8592	-95.3905	230	2	62	57	

Facility FRS ID	Lake Name	Latitude	Longitude	Lake Area (acres)	Fishing Order	% of Ingested Fish Coming From This Lake	LAKE ASSESSMENT: % of Tier 3 Fisher SV Attributed To This Lake	PLUME-RISE ASSESSMENT: Fraction of Emiss. Deposited into Mixing Layer
	Name Not Provided	33.8137	-95.3235	37	3	10	9	
	Name Not Provided	33.8128	-95.4424	32	4	9	8	
	Name Not Provided	33.8692	-95.2702	27	5	7	7	
	Lake Raymond Gary	33.9969	-95.2589	269	6	5	4	
110000450173	Name Not Provided	32.3361	-93.5506	94	1	25	35	Not assessed
	Name Not Provided	32.1734	-93.5352	30	2	8	9	
	Name Not Provided	32.3001	-93.6650	35	3	9	11	
	Name Not Provided	32.1265	-93.6431	42	4	11	9	
	Name Not Provided	32.0896	-93.4884	96	5	26	21	
	"Ninock, Lake"	32.2547	-93.4783	158	6	21	14	
110000740958	Name Not Provided	32.0700	-81.1519	30	1	8	19	Not assessed
	Forest City Gun Club Lake	31.9807	-81.0953	32	2	9	13	
	Name Not Provided	31.9947	-81.0874	30	3	8	12	
	Name Not Provided	32.0433	-81.2652	27	4	7	10	
	Name Not Provided	32.3681	-81.1756	27	5	7	7	
	Name Not Provided	31.8311	-81.3779	59	6	16	11	
	Upper Lake George	31.8404	-81.3788	30	7	8	5	
	Name Not Provided	32.1601	-81.3940	64	8	17	10	
	Name Not Provided	32.1614	-81.3872	32	9	9	5	
	Name Not Provided	32.1365	-81.4940	32	10	9	5	
	Morgans Pond	32.1971	-81.3385	42	11	3	1	
110017782568	Name Not Provided	32.5559	-92.1722	35	1	9	20	Not assessed
	Name Not Provided	32.6388	-92.1055	52	2	14	16	
	Name Not Provided	32.4645	-92.2171	3,131	3	77	64	

Notes: Percentages might not sum to exactly 100% per facility, due to rounding. The lake information shown in this table is related only to the mercury emissions from these facilities; the information might be different for other PB-HAP groups emitted by these facilities.

Table A-2. Lakes Removed During the Tier 3 Lake Assessment

Facility FRS ID	Lake Name	Latitude	Longitude	Lake Area (acres)	Reason for Removal
110000362223	Name Not Provided	30.0722	-83.5166	44	Not a body of water
	Name Not Provided	30.0197	-83.5489	57	Not a permanent, clear body of water

Facility FRS ID	Lake Name	Latitude	Longitude	Lake Area (acres)	Reason for Removal
	Name Not Provided	29.9968	-83.5731	49	Not a permanent, clear body of water
	Name Not Provided	30.0053	-83.5628	47	Not a permanent, clear body of water
	Name Not Provided	30.0270	-83.5472	42	Not a permanent, clear body of water
	Name Not Provided	30.0220	-83.5647	42	Not a permanent, clear body of water
	Name Not Provided	30.0436	-83.5508	54	Not a body of water
	Name Not Provided	30.0645	-83.5282	49	Not a body of water
	Name Not Provided	30.0580	-83.5477	40	Marsh
	Name Not Provided	30.0470	-83.5445	32	Not a body of water
	Name Not Provided	30.0648	-83.5453	116	Industrial or wastewater
	Name Not Provided	30.0020	-83.5454	35	Not a permanent, clear body of water
	Name Not Provided	30.0336	-83.5243	49	Not a permanent, clear body of water
	Name Not Provided	30.0202	-83.6575	49	Not a body of water
	Indian Lake	30.4203	-83.5200	1,198	Not a permanent, clear body of water
	Name Not Provided	29.9364	-83.5650	86	Not a permanent, clear body of water
	Name Not Provided	29.9364	-83.5463	64	Not a permanent, clear body of water
	Name Not Provided	29.9396	-83.4742	64	Not a permanent, clear body of water
	Name Not Provided	29.9264	-83.4955	47	Not a permanent, clear body of water
	Name Not Provided	29.9246	-83.5657	40	Not a permanent, clear body of water
	Name Not Provided	29.9254	-83.5761	37	Not a permanent, clear body of water
	Name Not Provided	29.9125	-83.5370	37	Not a permanent, clear body of water
	Name Not Provided	29.9327	-83.5535	35	Not a permanent, clear body of water
	Name Not Provided	30.2053	-83.2327	89	Not a body of water
	Name Not Provided	30.3105	-83.3423	59	Not a permanent, clear body of water
110000564586	Name Not Provided	45.5580	-122.5029	190	Not a body of water
110008148496	Name Not Provided	33.2776	-94.0697	1,468	Industrial or wastewater
	Name Not Provided	33.2699	-94.0919	64	Industrial or wastewater
110043794374	Name Not Provided	30.7081	-91.3387	32	Industrial or wastewater
	Name Not Provided	30.7066	-91.3411	30	Industrial or wastewater
110017400711	Name Not Provided	32.1718	-85.0263	32	Industrial
	Name Not Provided	32.1529	-85.0435	262	Industrial
	Name Not Provided	32.0032	-85.0569	168	No body of water
	Name Not Provided	32.0054	-85.0476	37	No body of water
	Name Not Provided	32.2523	-84.9145	1,643	Flood plain
	Name Not Provided	31.9732	-84.7250	27	No body of water
	Name Not Provided	31.9790	-85.0755	64	No body of water
	Name Not Provided	32.1768	-84.6526	126	No body of water

Facility FRS ID	Lake Name	Latitude	Longitude	Lake Area (acres)	Reason for Removal
110000598639	Name Not Provided	33.9901	-95.1168	133	Industrial or wastewater
	Name Not Provided	34.0226	-95.3264	94	Industrial or wastewater
110000450173	Name Not Provided	32.2711	-93.5112	84	Part of river
	Caspiana Lake	32.2914	-93.5510	77	Part of river
	Name Not Provided	32.2916	-93.5152	42	Part of river
	Name Not Provided	32.3183	-93.5672	27	Part of river
	Name Not Provided	32.0810	-93.5420	42	Not a permanent, clear body of water
110000740958	Name Not Provided	32.1084	-81.0574	52	Industrial or wastewater
	Name Not Provided	32.0836	-81.0229	30	Industrial
	Name Not Provided	32.1709	-81.1103	42	Not a permanent body of water
	Name Not Provided	32.1123	-81.1183	86	Industrial or wastewater
	Name Not Provided	32.1614	-81.1595	59	Industrial or wastewater
	Name Not Provided	32.0597	-81.0205	27	Part of river
	Name Not Provided	31.9796	-81.2107	42	Part of river
	Name Not Provided	31.9964	-81.2129	35	Mucky swamp next to river
	Name Not Provided	32.0550	-81.2833	141	No apparent water body
	Name Not Provided	32.2931	-80.7922	35	Not a body of water
110017782568	Pace Lake	32.6441	-92.1262	217	Directly connected to river
	Blasingame Brake	32.6592	-92.1552	156	Not a permanent, clear body of water
	Name Not Provided	32.5945	-92.1399	133	Not a permanent, clear body of water
	Name Not Provided	32.6371	-92.1317	82	Directly connected to river
	Wall Lake	32.6264	-92.1332	74	Directly connected to river
	Horseshoe Lake	32.6197	-92.1046	72	Directly connected to river
	Whites Lake	32.6010	-92.1089	54	Directly connected to river
	Name Not Provided	32.4262	-92.2100	52	Industrial
	Name Not Provided	32.4341	-92.2067	37	Industrial
	Name Not Provided	32.4253	-92.2157	30	Industrial
	Moon Lake	32.6041	-92.0938	42	Directly connected to river
	Name Not Provided	32.5933	-92.0919	35	Directly connected to river

Figures A-1 to A-9 are aerial images delineating the lakes in Table A-1, with facility location indicated by a green star. The fished lakes are outlined in blue with labels corresponding to the numbering in the “Fishing Order” column of the table. Lakes outlined in yellow are qualifying lakes that were not fished because the fish ingestion rate was already met with the first set of lakes (i.e., by fishing those labeled 1, 2, and so on). Lakes outlined in red were removed from the lake dataset for the reasons listed in Table A-2. The map is focused on the fished lakes, so it does not show all removed or otherwise unfished lakes. All aerial imagery is from ESRI (2016).

Figure A-1. Lakes Assessed for FRS ID 110000362223

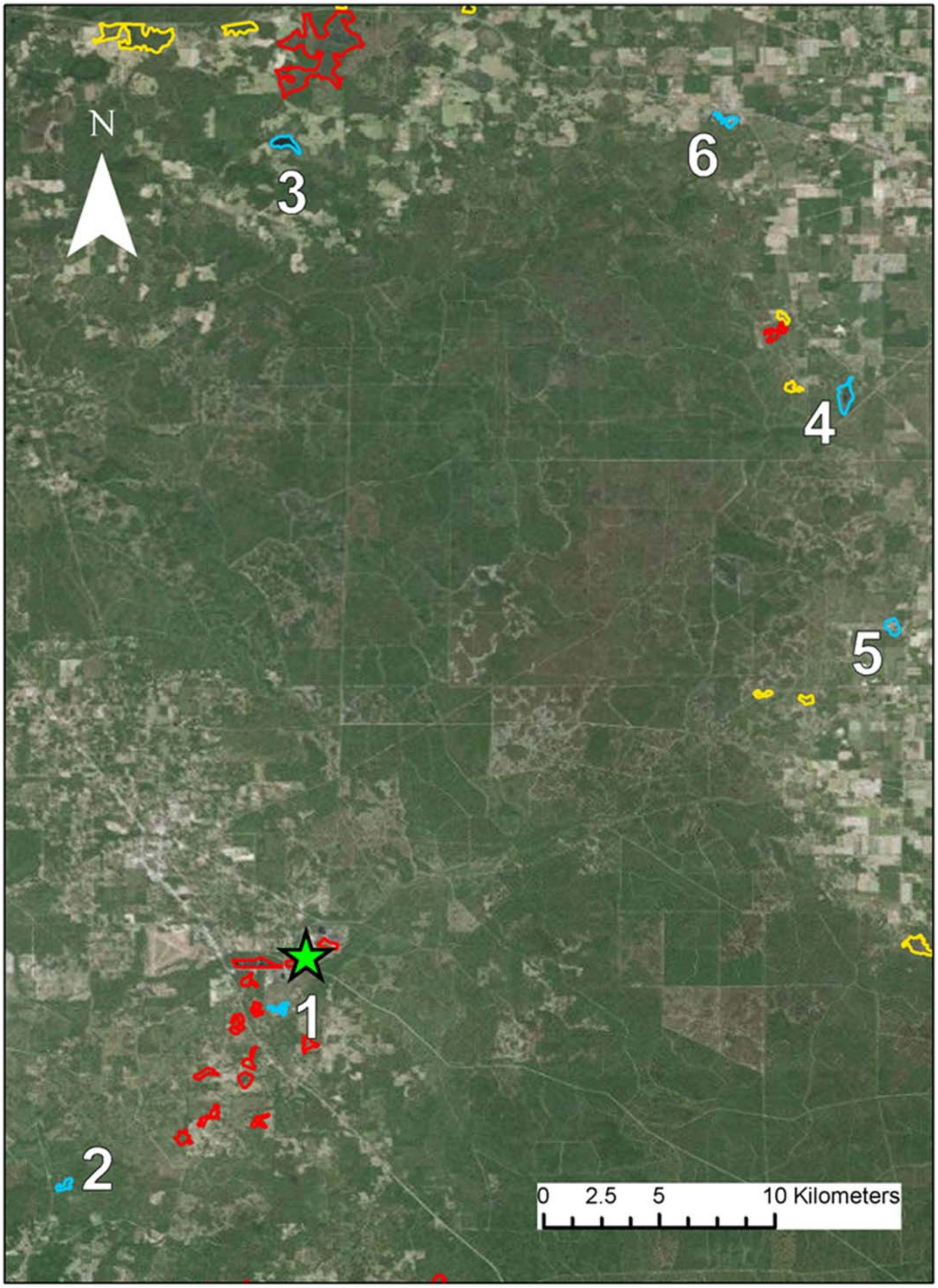


Figure A-2. Lakes Assessed for FRS ID 110000564586

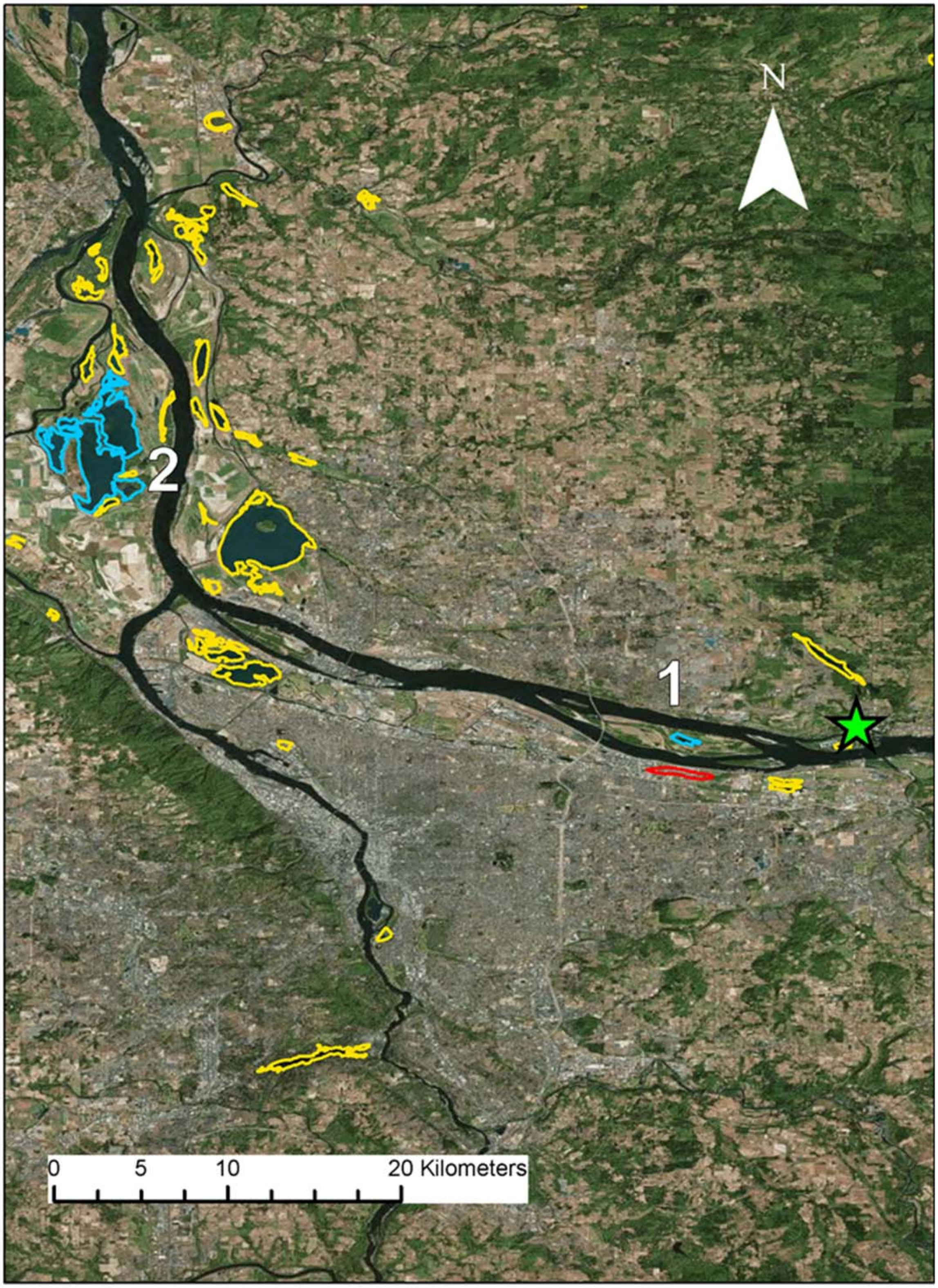


Figure A-3. Lakes Assessed for FRS ID 110008148496

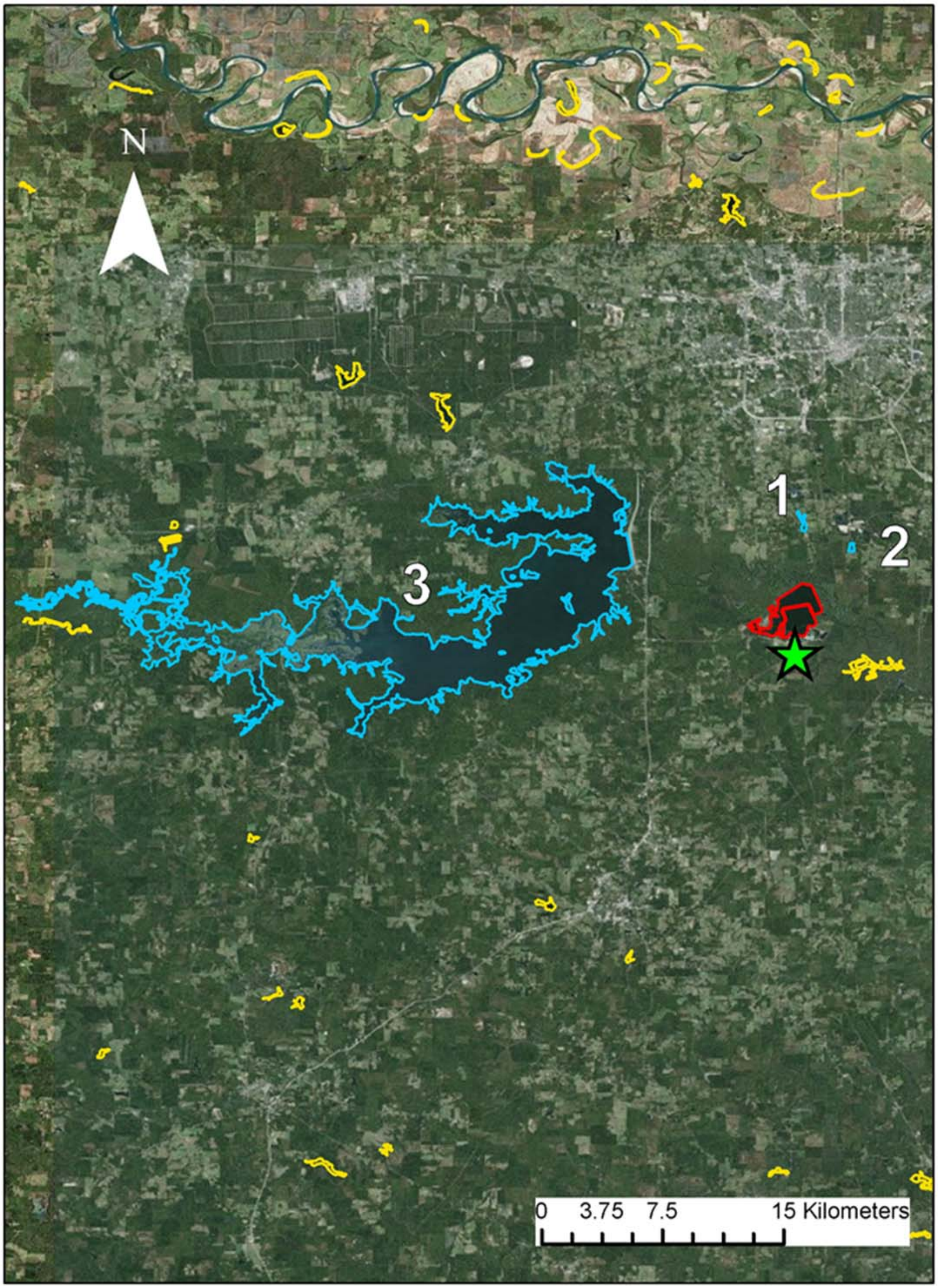


Figure A-4. Lakes Assessed for FRS ID 110043794374

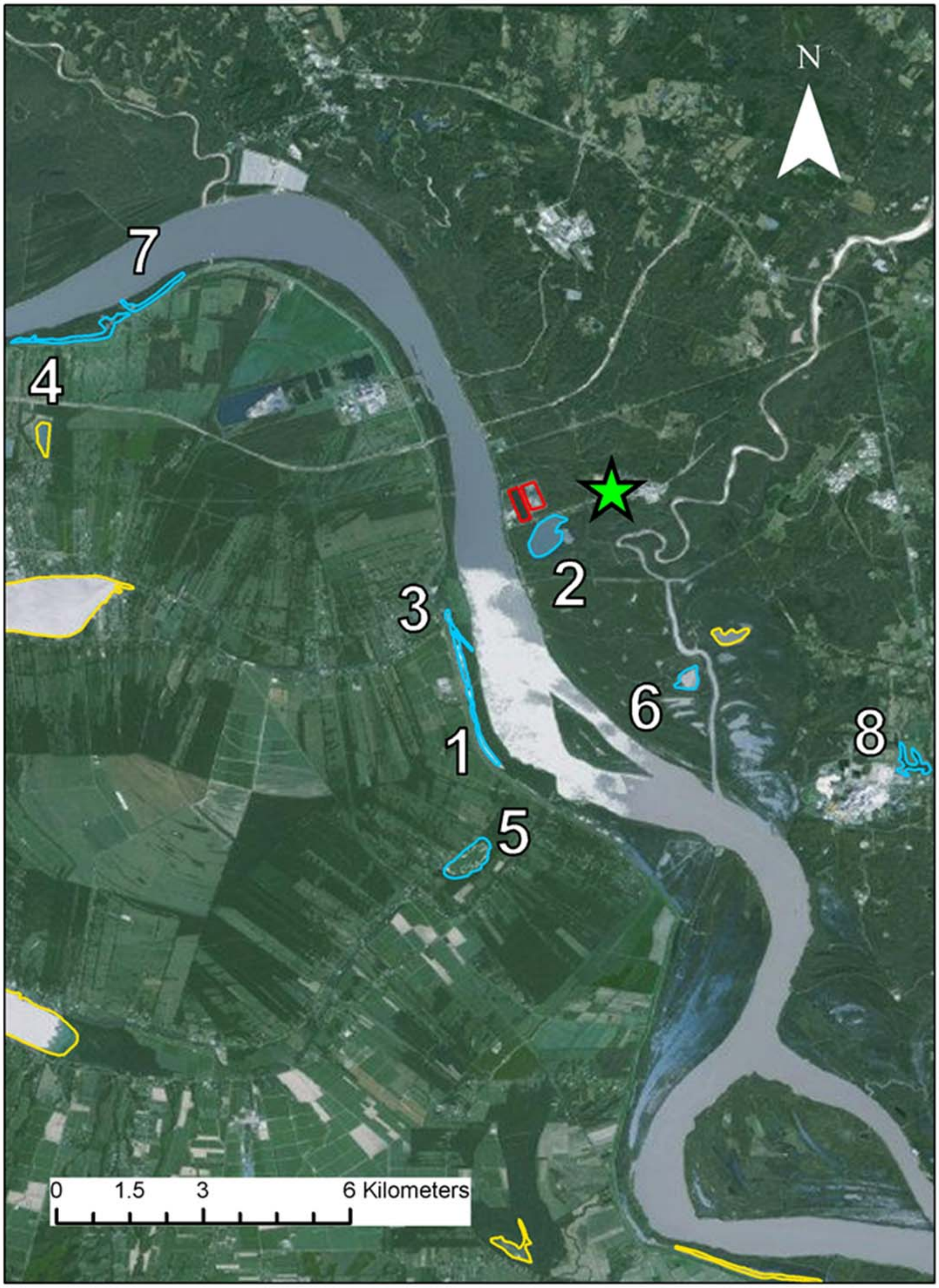


Figure A-5. Lakes Assessed for FRS ID 110017400711

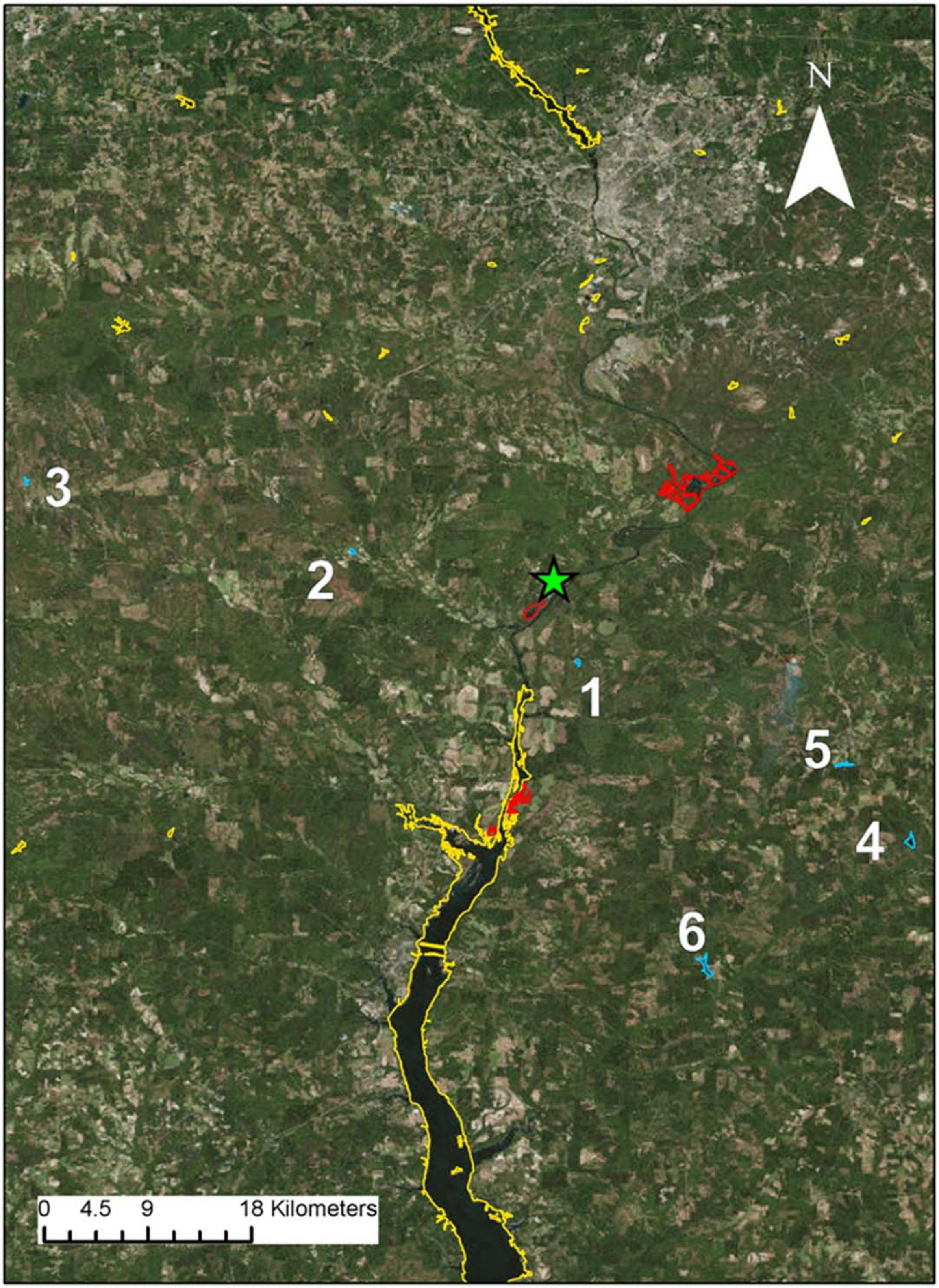


Figure A-6. Lakes Assessed for FRS ID 110000598639

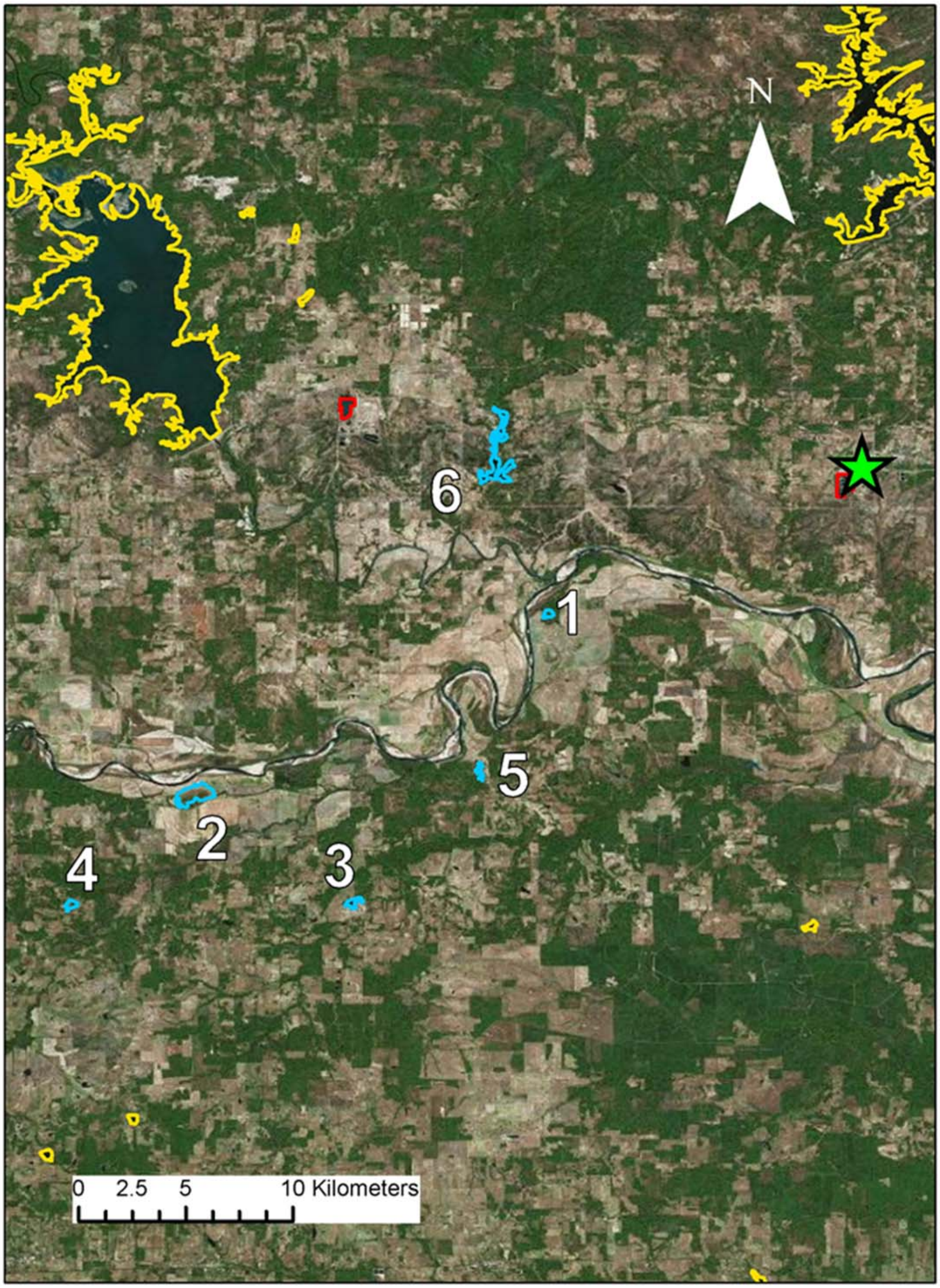


Figure A-7. Lakes Assessed for FRS ID 110000450173

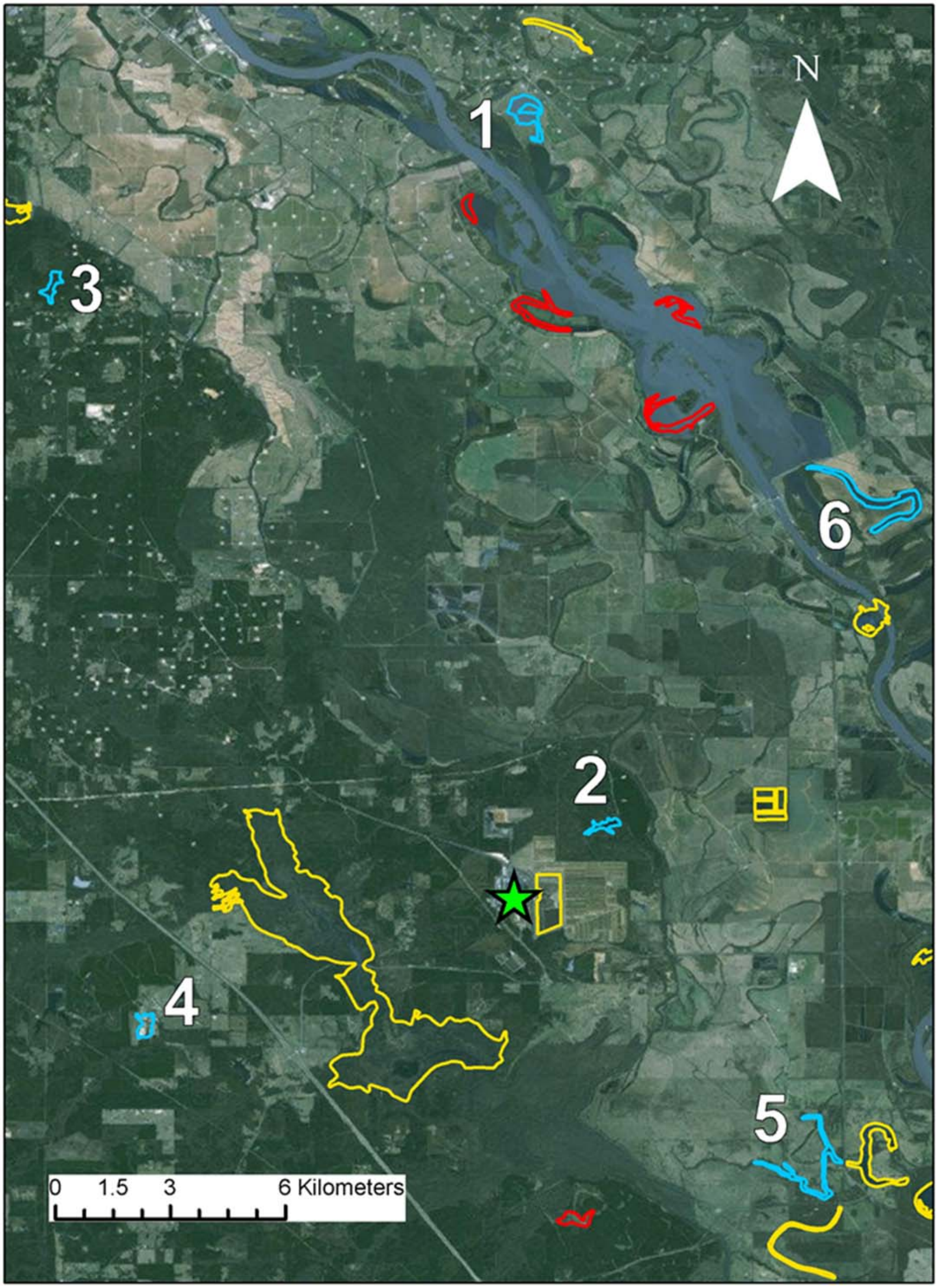


Figure A-8. Lakes Assessed for FRS ID 110000740958

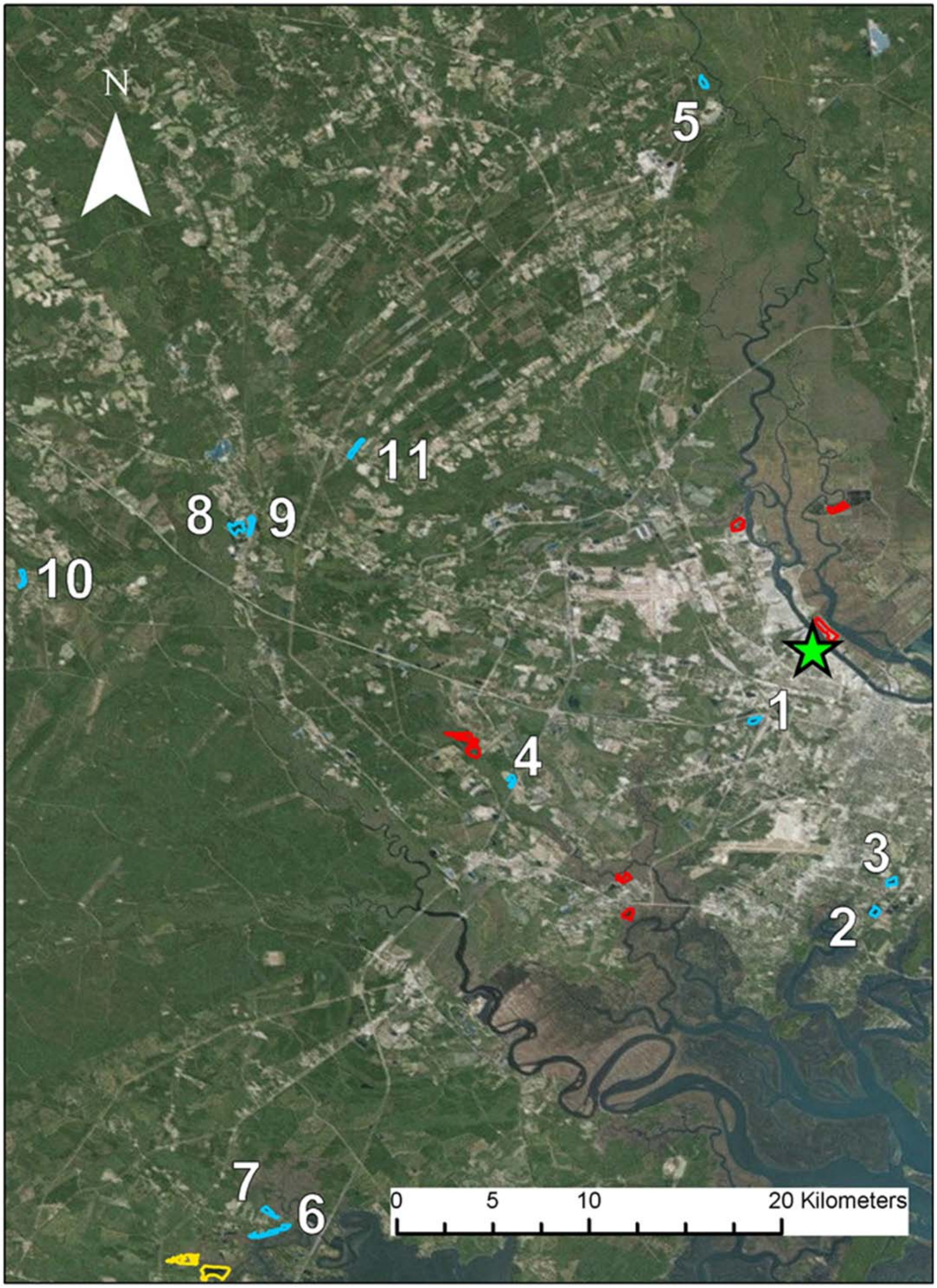
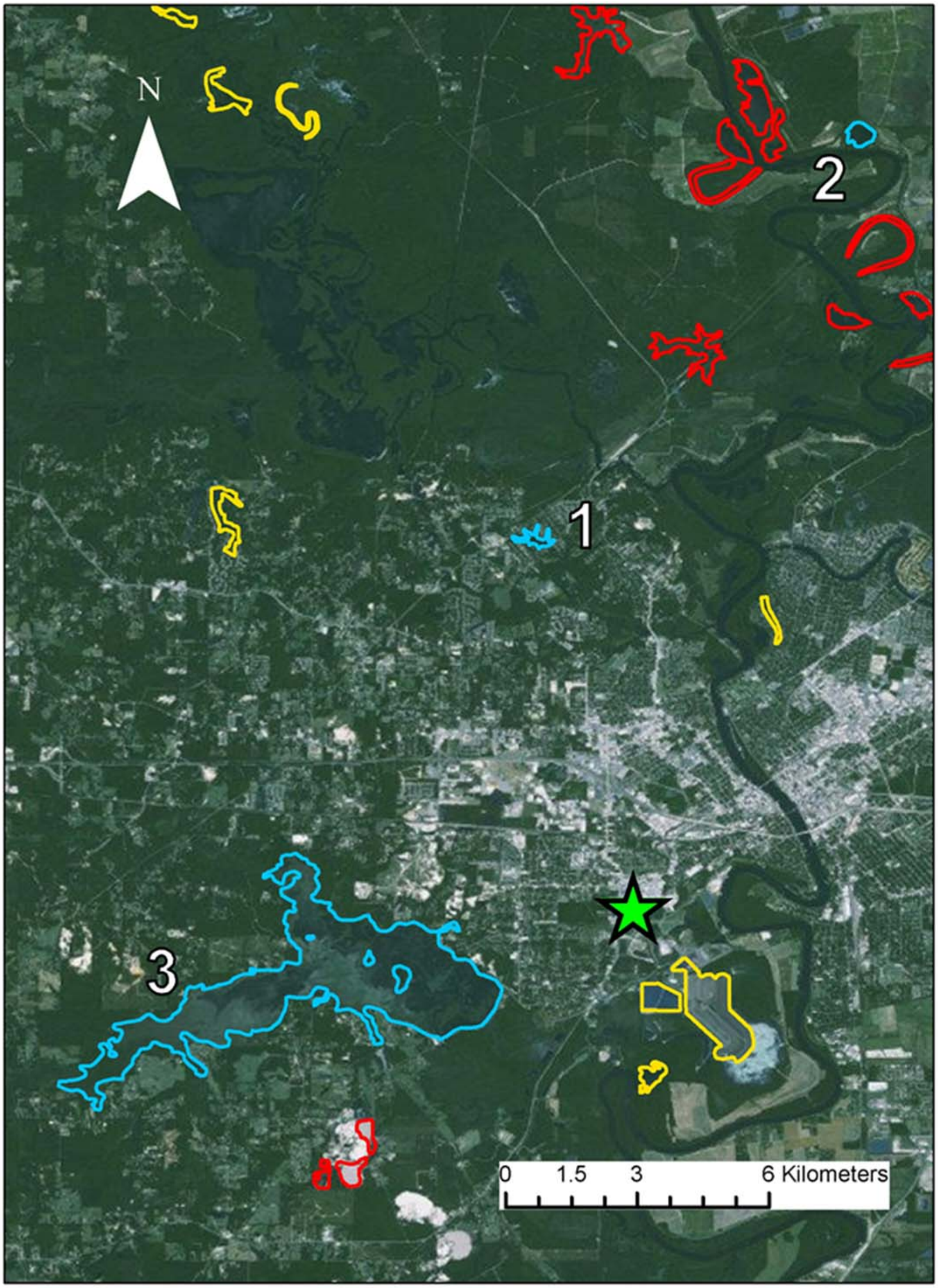


Figure A-9. Lakes Assessed for FRS ID 110017782568



Appendix 11

Site-Specific Human Health Multipathway Residual Risk Assessment Report

(No site-specific human-health multipathway residual risk assessment was conducted for this source category)