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Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities

Volume One

U.S. EPA, OFFICE OF SOLID WASTE

U.S. ENVIRONMENTAL PROTECTION AGENCY

DISCLAIMER

This document provides guidance to U.S. EPA Regions and States on how best to implement RCRA and U.S. EPA's regulations to facilitate permitting decisions for hazardous waste combustion facilities. It also provides guidance to the public and to the regulated community on how U.S. EPA intends to exercise its discretion in implementing its regulations. The document does not substitute for U.S. EPA's regulations, nor is it a regulation itself. Thus, it cannot impose legally-binding requirements on U.S. EPA, States, or the regulated community. It may not apply to a particular situation based upon the circumstances. U.S. EPA may change this guidance in the future, as appropriate.

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Jeff Yurk (U.S. EPA Region 6), the primary author/editor of this document, would like to acknowledge that the development of this document could not have been accomplished without the support, input, and work of a multitude of U.S. EPA and support contractor personnel. The foundation for the combustion-related guidance and methodologies outlined in this document were first developed by the Office of Research and Development (ORD) and the Office of Solid Waste (OSW) in previous versions of combustion risk assessment guidance. The State of North Carolinas' combustion risk assessment methodology was also evaluated in preparation of this document. The foundation for the ecological risk-related procedures and methodologies outlined in this document were based on previous guidance developed by the Office of Research and Development (ORD) and EPA's Superfund program. This version of the protocol was originally initiated in response to the desire of the Region 6 Multimedia Planning and Permitting Division to implement an up-to-date and technically sound hazardous waste combustion permitting program. The decision to incorporate guidance on a full range of national combustion risk assessment issues into the document was encouraged and supported by the Director of the Office of Solid Waste.

The development of this document was significantly enhanced by a number of capable organizations and personnel within U.S. EPA. Karen Pollard, Stephen Kroner and David Cozzie of the Economic Methods and Risk Analysis Division in conjunction with Rosemary Workman of the Permits and State Programs Division, Fred Chanania of the Hazardous Waste Minimization and Management Division, and Karen Kraus of the Office of General Council provided overall policy, technical and legal comment on this document. Anne Sergeant, Randy Bruins, David Reisman, Glenn Rice, Eletha Brady Roberts and Matthew Lorber of the National Center for Environmental Assessment (NCEA), Office of Research and Development, John Nichols of the National Health and Environmental Effects Research Laboratory, Vince Nabholtz of the Office of Prevention, Pesticides and Toxic Substances, and Dorothy Canter, Science Advisor to the Assistant Administrator for the Office of Solid Waste and Emergency Response, provided key input on breaking scientific developments in the areas of ecological risk assessment, mercury speciation, the dioxin reassessment, endocrine disruptors, toxicity factors, sulfur and brominated dioxin analogs, as well as technical comment on the overall methodologies presented in the document.

Contributions by Larry Johnson of the National Exposure Research Laboratory of ORD and Jeff Ryan and Paul Lemieux of the National Risk Management Research Laboratory of ORD were significant in

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Region 6 looks forward to the insight and input yet to be provided by the public and other interested parties during the full external peer review of the document.

REVIEWERS

Preliminary drafts of this ecological risk assessment document, as well as its companion human health risk assessment document, have received extensive internal Agency and State review. The following is a list of reviewers who have commented on these documents prior to their release as a peer review draft.

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LIST OF ACRONYMS

μg	Microgram
μg/kg	Micrograms per kilogram
μg/L	Micrograms per liter
μg/s	Micrograms per second
μm	Micrometer
μm/s	Micrometers per second
μm^2	Square micrometers
°C	Degrees Celsius
°F	Degrees Fahrenheit
°K	Degrees Kelvin
ADOM	Acid Deposition and Oxidant Model
AET	Apparent effects threshold
APCS	Air pollution control system
atm-m^3/mol-K	Atmosphere-cubic meters per mole-degrees Kelvin

LIST OF ACRONYMS (Continued)

DEHP	Diethylhexylphthalate (same as Bis(2-ethylhexl)phthalate)
DEM	Digital Elevation Model
DNOP	Di(n)octylphthalate
DOE	U.S. Department of Energy
DQL	Data quality level
DRE	Destruction and removal efficiency
EDQL	Ecological data quality levels
EEL	Estimated exposure level
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
EQL	Estimated quantitation limit
EQP	Equilibrium partitioning
ERA	Ecological risk assessment
ERL	Effects range low
ERT	Environmental Research and Technology

LIST OF ACRONYMS (Continued)

L	Liter
LC_{50}	Lethal concentration to 50 percent of the test population
LCD	Local Climatological Data Annual Summary with Comparative Data
LD_{50}	Lethal dose to 50 percent of the test population
LEL	Lowest effect level
LFI	Log fill-in
LOAEL	Lowest observed adverse effect level
LOD	Level of detection
LOEL	Lowest observed effect level
m	Meter
m/s	Meters per second
mg	Milligram
mg/kg	Milligrams per kilogram
mg/kg/day	Milligrams per kilogram per day
mg/L	Milligrams per liter
mg/m^3	Milligrams per cubic meter
MACT	Maximum achievable control technology
MDL	Method detection limit
MLE	Maximum likelihood estimation
MPRM	Meterological Processor for Regulatory Models
MPTER	Air quality model for multiple point source gaussian dispersion algorithm with terrain adjustments
MPTER-DS	Air quality model for multiple point source gaussian dispersion algorithm with terrain adjustments including deposition and sedimentation
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCDC	National Climatic Data Center
NCEA	National Center for Environmental Assessment
NEL	No effect level

LIST OF ACRONYMS (Continued)

OV	Deposition output values
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo(p)dioxin
PCDF	Polychlorinated dibenzofuran
PCRAMMET	Personal computer version of the meterological preprocessor for the old RAM program
PDF	Probability density function
PIC	Product of incomplete combustion
PM	Particulate matter
PM10	Particulate matter less than 10 micrometers in diameter
POHC	Principal organic hazardous constituent
PQL	Practical quantitation limit
PRC	PRC Environmental Management, Inc.
PU	Polyurethane
QA/QC	Quality assurance/Quality control
QAPjP	Quality assurance project plan
QSAR	Quantitative structure activity relationship
RCRA	Resource Conservation and Recovery Act
REACH	
RME	Reasonable maximum exposure
RTDM	Rough terrain diffusion model
RTDMDEP	Rough terrain diffusion model deposition
RTECS	Registry of Toxic Effects of Chemical Substances
SAMSON	Solar and Meterological Surface Observational Network
SCRAM BBS	Support Center for Regulatory Air Models Bulletin Board System
SFB	San Francisco Bay
SMDP	Scientific management decision point
SO	Source
SQL	Sample quantitation limit
SVOC	Semivolatile organic compound
TAL	Target analyte list
TCDD	Tetrachlorodibenzo(p)dioxin
TDA	Toluene diisocyanate
TEF	Toxicity equivalent factor
TG	Terrain grid
TIC	Tentatively i4n

LIST OF ACRONYMS (Continued)

UF	Uncertainty factor
UFI	Uniform fill-in
USGS	U.S. Geological Survey
USLE	Universal soil loss equation
UTM	Universal transverse mercator

LIST OF VARIABLES (Continued)

C_i = COPC concentration in *i*th plant or animal food item (mg COPC/kg)
C_I = COPC concentration in soil or benthic invertebrate (mg/kg)
C_{IW} = COPC concentration in soil or sediment interstitial water (mg/L)
C_M

LIST OF VARIABLES (Continued)

tD = Total time period over which deposition occurs (time period of combustion) (yr)
T_m = Melting point temperature (K)
TSS = Total suspended solids concentration (mg/L)
T_w = Water body temperature (K)

u = Current velocity (m/s)

V = Volume
Vdv = Dry deposition velocity (cm/s)
Vf_x = Average volumetric flow rate through water body (m^3/yr)
VG_{ag} = Empirical correction factor for aboveground produce (unitless)
VP = Vapor pressure (atm)

W = Average annual wind velocity (m/s)
WA_I = Area of impervious watershed receiving COPC deposition (m^2)
WA_L = Area of watershed receiving COPC deposition (m^2)
WA_w = Water body surface area (m^2)

X_e = Unit soil loss (kg/m^{2-}yr)

Yp = Standing crop biomass (productivity) (kg/m^2 DW)

Z_s = Soil mixing zone depth (cm)

CONVERSIONS

0.001 = Units conversion factor (g/mg)

10^6 = Units conversion factor (µg/g)

907.18 = Units conversion factor (kg/ton)

3.1536×10^7 = Conversion constant (s/year)

4,047 = Units conversion factor (m^2/acre)

100 = Units conversion factor (m^2-mg/cm^2-kg)

10^{-6} = Units conversion factor (g/µg)

0.12 = Dry weight to wet weight (plants) conversion factor (unitless)

Bioaccumulation: The net accumulation of a substance by an organism as a result of uptake directly from all environmental sources, including food. Bioaccumulation occurs through all exposure routes.

Bioaccumulation Factor (*BAF*): *BAF* represents the ratio of the concentration of a chemical to its concentration in a medium. The factor must be measured at steady-state when the rate of uptake is balanced by the rate of excretion. In this protocol a bioaccumulation factor (*BAF*) is estimated by multiplying a bioconcentration factor (*BCF*) by a food chain multiplier (FCM) derived based on the trophic level of the prey ingested by a measurement receptor.

Bioconcentration: A process by which there is a net accumulation of a chemical directly from an exposure medium into an organism.

Bioconcentration Factor (*BCF*): *BCF* represents the ratio of the concentration of a chemical in an aquatic organism to the concentration of the chemical in surface water, sediment, or soil. The factor must be measured at steady-state when the rate of uptake is balanced by the rate of excretion. BCFs are used in this protocol to estimate the body burden of a COPC in producers, primary consumers, and fish consumed by mid- or upper-trophic level measurement receptors.

Ecological Screening Quotient (ESQ): A quotient used to assess risk during the risk assessment in which protective assumptions are used. Generally, the numerator is the reasonable worst-case COPC

(1) guidance for personnel conducting risk assessments, and (2) an information resource for permit writers, risk managers, and community relations personnel.

The RCRA “omnibus” authority of §3005(c)(3) of RCRA, 42 U.S.C. §6925(c)(3) and 40 CFR §270.32(b)(2) gives the Agency both the authority and the responsibility to establish risk-based permit conbased environment. Under 40 C.F.R. §270.10(k), U.S. EPA may require a permit applicant to submit additional information (e.g., a site-specific risk assessment) that the Agency needs to establish permit conditions under the omnibus authority. In certain cases, the Agency may also seek additional testing or data under the authority of RCRA §3013 (where the presence or release of a hazardous waste "may present a substantial hazard to human health or the environment") and may issue an order requiring the facility to conduct monitoring, testing, analysis, and reporting. Any decision to add permit conditions based on a site-specific risk assessment under this authority must be justified in the administrative record for each facility, and the implementing agency should explain the basis for the conditions.

U.S. EPA promulgation of the Maximum Achievable Control Technology (MACT) standards for hazardous waste incinerators, cement kilns and light-weight aggregate kilns effectively upgraded the existing national technical standards for these combustion units. U.S. EPA intends to similarly upgrade the technical standards for other types of hazardous waste combustors in a later rulemaking. Since the MACT standards are more protective than the original standards for incinerators, cement kilns and light-weight aggregate kilns, U.S. EPA revised its earlier recommendation regarding site-specific risk assessments. As discussed in the preamble to the final MACT rule, U.S. EPA recommended that the permitting authority determine if a site-specific risk assessment is needed in addition to the MACT standards in order to meet the RCRA statutory obligation of protection of human health and the environment. For hazardous waste combustors not subject to the Phase I MACT standards, U.S. EPA continues to recommend that site-specific risk assessments be conducted as part of the RCRA permitting process. If the permitting authority determines a risk assessment is warranted, it should be conducted as part of the RCRA permitting process.

- particular site-specific considerations related to the exposure setting (such as physical, land use, presence of threatened or endangered species and special subpopulation characteristics) and the impact on potential risks

- the presence of significant ecological considerations (e.g., high background levels of a particular contaminant, proximity to a particular sensitive ecosystem)

- the presence of nearby off-site sources of pollutants

- the presence of other on-site sources of pollutants

- the hazardous constituents most likely to be found and those most likely to pose significant risk

- the identity, quantity, and toxicity of possible non-dioxin PICs

- the volume and types of wastes being burned

-

emissions from combustion units do not pose unacceptable risks. More protective assumptions may be

Potentially, unacceptable risks or other significant issues identified by collecting preliminary site information and completing risk assessment calculations can be addressed by the permitting process or during an iteration of the risk assessment. After the initial ecological risk assessment has been completed, it may be used by risk managers and permit writers in several ways:

- If the initial risk assessment indicates that estimated ecological risks are below regulatory levels of concern, risk managers and permit writers will likely proceed through the permitting process without adding any risk-based unit operating conditions to the permit.
- If the initial ecological risk assessment indicates potentially unacceptable risks, additional site-specific information demonstrated to be more representative of the exposure setting may be collected and additional iterations of risk assessment calculations can then be performed.
- If the initial risk assessment or subsequent iterations indicate potentially unacceptable risks, risk managers and permit writers may use the results of the risk assessment to revise tentative permit conditions (for example, waste feed limitations, process operating conditions, and expanded environmental monitoring). To determine if the subject hazardous waste combustion unit can be operated in a manner that is protective of the environment, an additional iteration of the risk assessment should be completed using the revised tentative operating conditions. If the revised conditions still indicate unacceptable risks, this process can be continued in an iterative fashion until acceptable levels are reached. In some situations, it may be possible to select target risk levels and back-calculate the risk assessment to determine the appropriate emission and waste feed rate levels. In any case, the acceptable waste feed rate and other appropriate conditions can then be incorporated as additional permit conditions.
- If the initial ecological risk assessment, or subsequent iterations, indicate potentially unacceptable risks, risk managers and permit writers may also choose to deny the permit.

This process is also outlined in Figure 1-1. As stated earlier, in some instances, a facility or regulatory agency may want to perform a pretrial burn risk assessment—following the procedures outlined in this document—to ensure that sample collection times during the trial burn or risk burn are sufficient to collect

1.3 REFERENCE DOCUMENTS

This section describes, in chronological order, the primary guidance documents used to prepare this guidance. Some of the guidance documents received a thorough review from EPA's Science Advisory Board, which mostly supported the work. Additional references used to prepare this guidance are listed in the References chapter of this document. These documents have been developed over a period of several years; in most cases, revisions to the original guidance documents address only the specific issues being revised rather than representing a complete revision of the original document. The following discussion lists and briefly describes each document. Overall, each of the guidance documents reflects a continual enhancing of the methodology.

This ecological assessment portion of this protocol is based on protecting the functions of ecological receptors in ecosystems and protecting special ecological areas around a hazardous waste combustion facility. It is generally consistent with current U.S. EPA guidance, including the Risk Assessment Forum's *Guidelines for Ecological Risk Assessment* (U.S. EPA 1998d), as well as the interim final *Ecological Risk Assessment Guidance for Superfund* (U.S. EPA 1997c) The most current methodology for assessing fate and transport of COPC's frequently referenced in this guidance is the U.S. EPA document, *Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions* (In Press).

The following document was the first U.S. EPA NCEA guidance document for conducting risk assessments at combustion units:

- U.S. EPA. 1990a. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Environmental Criteria and Assessment

Chapter 2
Facility Characterization

What's Covered in Chapter 2:

- Compiling Basic Facility Information
- Identif

RECOMMENDED INFORMATION FOR RISK ASSESSMENT REPORT

- Principal business and primary production processes
- Normal and maximum production rates
- Types of waste storage and treatment facilities
- Type and quantity of wastes stored and treated
- Process flow diagrams showing both mass and energy inputs and outputs
- Type of air pollution control system (APCS) associated with each unit

2.2 IDENTIFYING EMISSION SOURCES

Combustion of a hazardous waste generally results in combustion by-products being emitted from a stack. In addition to emissions from the combustion stack, additional types of emissions of concern that may be associated with the combustion of hazardous waste include (1) process upsets, (2) general RCRA fugitive emissions, (3) cement kiln dust (CKD) fugitive emissions, and (4) accidental releases. Each of these emission source types are defined below with regards to the context and scope of this guidance.

> ***Stack Emissions*** **-** Release of compounds or pollutants from a hazardous waste combustion unit into the ambient air while the unit is operated as intended by the facility and in compliance with a permit and/or regulation (for interim status).
>
> ***Process Upset Emissions*** **-** Release of compounds or pollutants from a hazardous waste combustion unit into the ambient air while the unit is not being operated as intended, or during periods of startup or shutdown. Upset emissions usually result from an upset in the hazardous waste combustion process and are often known as process upset emissions. Upset emissions are

U.S. EPA OSW expects that using data from a trial burn as a basis for estimating COPC emission rates will tend to overestimate risk. COPC emission rates measured during trial burns are expected to be greater than emission rates during normal unit operations, because a facility "challenges" its combustion unit during a trial burn to develop a wide range of conditions for automatic waste feed cutoff (AWFCO) systems. Trial burn tests are usually conducted under two conditions: (1) a high-temperature test, in which the emission rate of metals is maximized, and (2) a low-temperature test, in which the ability of the combustion unit to destroy principal organic hazardous constituents (POHCs) in the waste feed is challenged. The lessor of the 95th percentile of the mean or maximum stack gas concentration from the three trial burn runs should be used to develop the emission rate estimate used in the risk assessment.

High POHC feed rates and extreme operating conditions tested during the low-temperature trial burn test are usually expected to result in greater product of incomplete combustion (PIC) emission rates. However, this is not true in all cases. For example, the formation of PCDDs and PCDFs does not necessarily depend on "POHC incinerability" low temperature conditions. Polychlorinated dibenzo(p)dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) can be formed as a result of (1) catalytic formation in the low-temperature regions of the combustion unit or APCS during the low temperature test, or (2) catalytic

RECOMMENDED INFORMATION FOR RISK ASSESSMENT REPORT

- All (current and historical) stack sampling information regarding rates of emissions from the combustion unit during normal or trial burn conditions
- Description of the waste feed streams burned during the stack sampling, including chemical composition and physical properties, which demonstrate that the waste feeds are representative of worst case site-specific "real" wastes

*** * * NOTICE * * ***

Although U.S. EPA OSW will not require a risk assessment for every possible metal or PIC from a combustion unit, this does not imply that U.S. EPA OSW will allow only targeted sampling for COPCs during trial burn tests. Based on regional permitting experience and discussions with regional analytical laboratories, U.S. EPA OSW maintains that complete target analyte list analyses conducted when using U.S. EPA standard sampling methods (e.g., 0010 or 0030), do not subject facilities to significant additional costs or burdens during the trial burn process. Facilities conducting stack emission sampling should strive to collect as much information as possible which characterizes the stack gases generated from the combustion of hazardous waste. Therefore, every trial burn or "risk burn" should include, at a minimum, the following tests: Method 0010, Method 0030 or 0031 (as appropriate), total organic compounds (using the Guidance for Total Organics, including Method 0040), Method 23A, and the multiple metals train. Other test methods may be approved by the permitting authority for use in the trial burn to address detection limit or other site-specific issues.

2.2.1.2 Normal Operation Emission Rate Data

Facilities with limited waste feed characteristics and operational variability may be allowed to conduct risk testing at normal operational conditions (U.S. EPA 1994c). The collection of COPC data during normal operating conditions is referred to as a “risk burn” throughout the remainder of this guidance. It is important to note, however, that a risk burn does not replace a traditional trial burn conducted to measure DRE. Instead, U.S. EPA OSW considers a risk burn as an additional operating condition of the trial burn during which data is collected for the purpose of completing a risk assessment.

Because operational data collected during the risk burn would not normally be extrapolated to hourly rolling average AWFCO limits specified in an operating permit; the regulatory agency permit writer should craft the permit with conditions designed to ensure that the facility does not operate at conditions in "excess" of the normal conditions over the long-term operation of the facility (for example, waste feed rate or stack gas flowrate). These additional permit limits are anticipated to take the form of quarterly or annual mass feed limitations on the waste feed, quarterly or annual average temperatures or stack gas flow rates, and other appropriate limitations.

It may also be necessary for the permit to contain appropriate reporting requirements to ensure that the regulatory agency can verify that the facility does not normally operate at conditions in excess of those tested during the risk burn. Monthly, quarterly, or annual reports which document long-term operations will likely be required of the facility. If a facility violates a long-term permit condition, the permit writer may also include language that requires the facility to cease waste burning immediately until a new test, risk assessment, and/or revised permit are completed. More detailed guidance on the development of permit limits can be found in U.S. EPA Region 6's *Hazardous Waste Combustion Permitting Manual*; which can be obtained from the U.S. EPA Region 6 web page (www.epa.gov/region06/).

One of the most important criteria which should be evaluated when considering the collection of data during a risk burn rather than a trial burn is the ability of the facility to document that the test is conducted with "worst case" waste. Worst case waste should be the waste feed material or combination of materials that are most likely to result in significant emissions of COPCs. The potential for both PIC and metal emissions should be considered in the selection of the worst case waste. For example, if a facility burns two types of waste—one waste with a high chlorine content and a significant concentration of aromatic organic compounds and a second with a low chlorine content and a significant concentration of alkanes—the former waste should be considered to be the "worst case" for PIC formation and should be used during the risk burn. A similar evaluation should be considered when selecting the worst case waste for metal emissions.

If a facility chooses to develop—and the appropriate regulatory agency allows the use of—emission rate Isaititsem a-355i ti m aisk355i bum an355i m atith.m a th.tin355i ti tm aitil-9(i bum)1(an355i if8a th)1(.)-13(d)1(.t)-8(itt if the maximum rate is less than this value. U.S. EPA OSW also recommends that, where possible, the COPC emission rate value from the trial burn test and the risk burn test be compared in the risk assessment report along with a comparison of the operational conditions at these two test conditions. For example, if the POHC used for the DRE test in the trial burn is a semivolatile organic compound (SVOC), the facility should analyze for all SVOCs (Method 0010) during the trial burn, and compare these values to those reported for the risk burn. The difference between the emission rates from the trial burn and risk burn should be evaluated in the uncertainty section of the risk assessment.

RECOMMENDED INFORMATION FOR RISK ASSESSMENT REPORT

- Sampling and analytical data for trial burn and risk burn (if the risk assessment is completed by using risk burn data) operating conditions
- Description of the operating conditions, under which each set of emission rate data being used was developed
- Complete evaluation of the differences between trial burn and risk burn operating conditions, with an explanation of the expected resultant risk differences

2.2.1.3 Estimates of the Total Organic Emission (TOE) Rate

Organic compounds that cannot be identified by laboratory analysis will not be treated as COPC's in the risk calculations. However, these compounds still may contribute significantly to the overall risk, and therefore, should be considered in the risk assessment (DeCicco 1995; U.S. EPA 1994d). U.S. EPA developed the total organic emissions (TOE) test to account for unidentified organic compounds because existing methods, s ck as totahyd orca biod analyze, f ld8(e)10(t)-22(e)1 orme the tota0(m)1(a)-34(s)-23(s)-2on of organice

$$Q_{i,adj} = Q_i \cdot \frac{TO_{TOTAL}}{\Sigma_i C_i} \qquad \text{Equation 2-2A}$$

where

$Q_{i,adj}$ = adjusted emission rate of compound i (g/s)
$Q_{i\,,}$ = emission rate of compound i (g/s)
TO_{TOTAL} = total organic emission (mg/m^3)
C_i = stack concentration of the ith identified COPC (mg/m^3)

3. Require additional testing to identify a greater fraction of the organic compounds.

4. Specify permit conditions that further control total organic emissions or that further control the risks associated with known emissions.

Permitting authorities may use variations of the TOE factor to address site-specific concerns. For example, some permitting authorities may compute three separate TOE factors based on the apportioning provided by the TOE test (i.e., TO_{VOC}, TO_{SVOC}, and TO_{GRAV}). The unknowns associated with each separate fraction

EPA (1994d) indicates that upsets are not generally expected to significantly increase stack emissions over the lifetime of the facility.

Process upsets occur when the hazardous waste combustion unit is not being operated as intended, or during periods of startup or shutdown. Upset emissions are generally expected to be greater than stack emissions (over short periods of time) because the process upset results in incomplete destruction of the wastes or other physical or chemical conditions within the combustion system that promote the formation and/or release of hazardous compounds from combustion stacks. Upset emissions usually occur during events and times when the hazardous waste combustion unit is not operating within the limits specified in a permit or regulation.

This section contains guidance for quantitatively estimating fugitive emissions on the basis of procedures outlined by other U.S. EPA guidance. Guidance regarding air dispersion modeling of fugitive emissions is presented in Chapter 3.

2.2.6.1 Quantitative Estimation of RCRA Fugitive Emissions from Process Equipment

Quantitative estimation of RCRA fugitive emissions includes (1) identifying equipment to be evaluated as fugitive emission source(s), (2) grouping equipment, as appropriate, into a combined source, and (3) estimating compound specific emission rates for each source. Figure 2-1 is an example of a facility plot

TABLE 2-1
EXAMPLE CALCULATION

FIGURE 2-2

EX

The information required for estimating fugitive emission rates from storage tanks includes, but is not limited to, the following:

- Dimensions of the tanks
    - Shell height and diameter

- Characteristics of the tank roof
    - Color and shade
    - Condition (e.g., poor, good)
    - Type (e.g., cone, dome)
    - Height
    - Radius or slope
    - Fixed or floating

- Characteristics of the shell
    - Color and shade
    - Condition (e.g., poor, good)
    - Heated

- Settings on breathe vents
    - Vacuum setting
    - Pressure setting

- Characteristics of the stored liquids
    - Maximum and annual average liquid height
    - Working volume
    - Turnovers per year
    - Net throughput
    - Average annual temperature
    - Vapor pressures of speciated constituents (at annual average temperature)

Step 4: Estimating Fugitive Emissions from Process Equipment **-** Based on guidelines provided in U.S. EPA (1995f), *“Protocol for Equipment Leak Emission Estimates, EPA-453/R-93-017,”* fugitive emissions for each equipment listed under 40 CFR Part 265, Subpart BB can be estimated by the following four approaches, in order of increasing refinement and data requirements:

- Average Emission Factor Approach (AEFA)

- Screening Ranges Approach (SRA)

- U.S. EPA Correlation Approach (EPACA)

- Unit-Specific Correlation Approach (USCA)

- Summary of the step-by-step process conducted to evaluate fugitive emissions
- Facility plot map clearly identifying each fugitive emission source with a descriptor and the location denoted with UTM coordinates (specify if NAD27 or NAD83).
- Speciated emission rate estimates for each waste stream serviced by each source, with supporting documentation
-

RECOMMENDED INFORMATION FOR RISK ASSESSMENT REPORT

- Process design information and drawings (if necessary)
- Past operating data indicating the frequency, duration, and magnitude of combustion unit leaks
- Information regarding the probable cause of combustion unit leaks
- Summary of procedures in place to monitor or minimize fugitive emissions resulting from combustion unit leaks

2.2.7 RCRA Fugitive Ash Emissions

The combustion of hazardous waste materials may result in the production of flyash. Fugitive particle emissions may result from the subsequent collection, handling, and disposal of the flyash. Typically, fugitive emissions of flyash, collected from an air pollution control device (APCD) will occur during transfer into covered trucks or other conveyance mechanisms prior to disposal. Emissions generated during the loading process can be controlled by APCDs or other types equipment, however, a fraction of the flyash may still escape into the atmosphere as fugitive emissions.

2.2.7.1 Quantitative Estimation of RCRA Fugitive Ash Emissions

Steps for the quantitative estimation of RCRA fugitive ash emissions include (1) determining an empirical emission factor, (2) estimating the flyash generation rate, and (3) accounting for air pollution control equipment, if applicable. As demonstrated in the example calculation below, the fugitive ash emission rate from the combustion of coal (as in the study) was wetted. Flyash from the hazardous waste combustion facility may not be wetted depending on the facility.

Step 2: Estimating the Flyash Generation Rate - The flyash generation rate from the APCD can be obtained from the Part B Permit Application and the total ash content of the "generic" waste streams created from the waste profile. Both values should be approximately the same. Since a major portion of ash fed to the combustor is converted to bottom ash, it is likely that this value is a conservatively high estimate of the actual flyash generation rate.

Step 3: Accounting for Air Pollution Control Equipment - If an APCD is used for controlling emissions during flyash handling operations, an efficiency factor (e.g., 99.5 percent) can be applied to the emission rate. An efficiency factor of 99.5 percent is based on U.S. EPA (1995a) for typical collection efficiencies of particulate matter control devices, for the particle sizes in the range of 2.5 to 10 um.

Example Calculation

The fugitive ash emission rate is calculated by multiplying the empirical emission factor (Step 1) times the estimated flyash generation rate (Step 2) [(1.07 lb per ton) * (5,000 tons per year) = 5,350 lbs per year]. Accounting for the air pollution control equipment, the product of Steps 1 and 2 is multiplied times one minus the fabric filter efficiency (Step 3) to obtain the final RCRA fugitive ash emission rate for use in the risk assessment [(5,350 lbs per year) * (1 - 0.995) = 26.75 lbs per year].

2.2.8 Cement Kiln Dust (CKD) Fugitive Emissions

CKD is the particulate matter (PM) that is removed from combustion gas leaving a cement kiln. This PM is typically collected by an APCS—such as a cyclone, baghouse, ESP—or a combination of APCSs. Many facilities recycle a part of the CKD back into the kiln. Current and applicable guidance on evaluating CKD includes (1) the *Technical Background Document for the Report to Congress* (U.S. EPA

2.3 IDENTIFYING COMPOUNDS OF POTENTIAL CONCERN

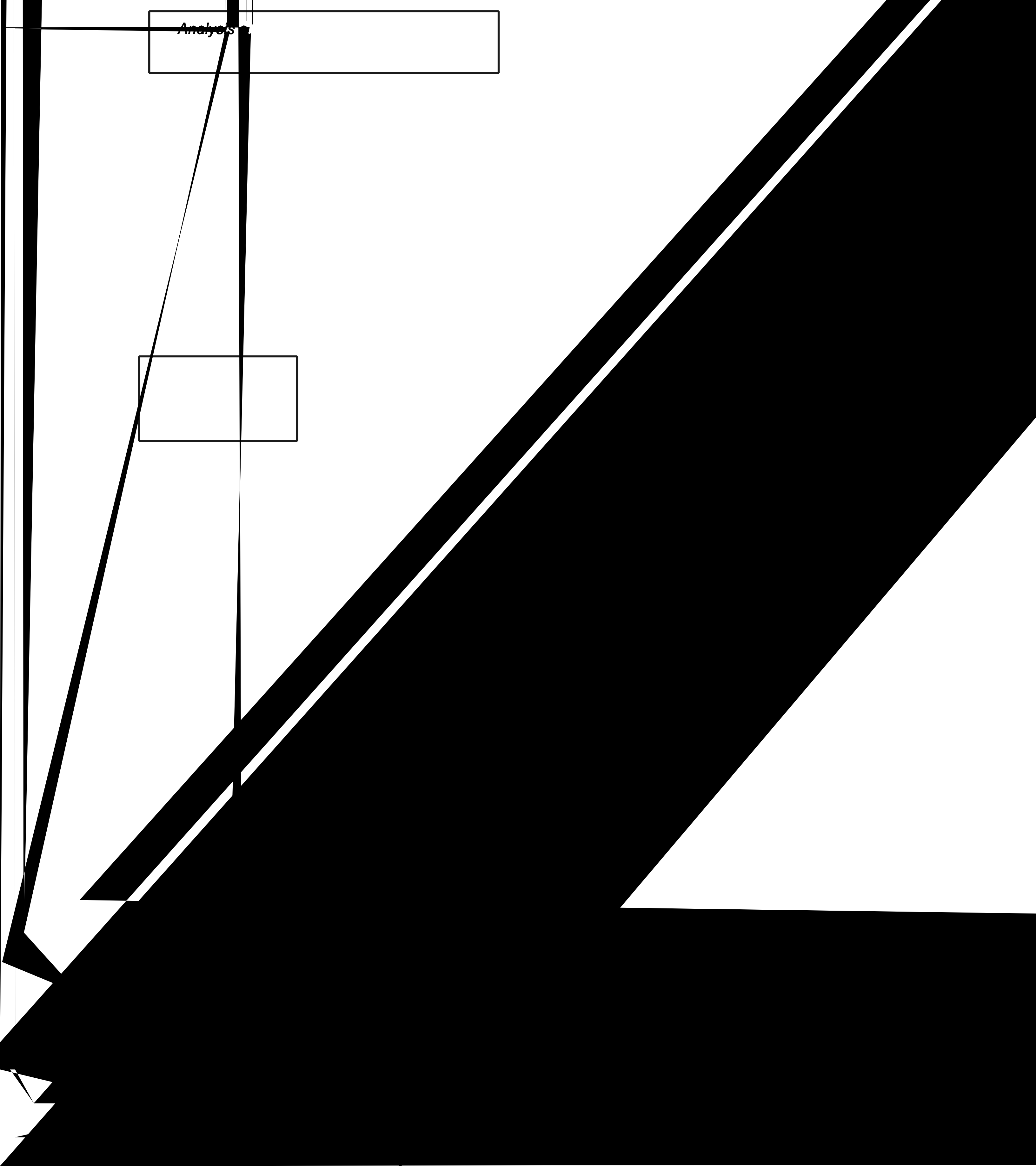
appropriate analytical method. Once the trial burn stack tests are completed, the COPC selection process is initiated based on the universe of stack test data, not Table A-1. The purpose of a risk assessment is not to arbitrarily evaluate every potential compound listed in Table A-1.

Based on U.S. EPA OSW review, COPCs previously identified in ecological isk assessments at combustion facilities are as follows:

- Polychlorinated dibenzo(p)dioxins (PCDD) and polychlorinated dibenzofurans (PCDF)
- Polynuclear aromatic hydrocarbons (PAH)
- Polychlorinated biphenyls (PCB)
- Pesticides
- Nitroaromatics
- Phthalates
- Other organics
- Metals

receptors, and/or (3) have a definite propensity for bioconcentrating in ecological receptors and bioaccumulating in food chains. Appendix E presents toxicity reference values of specific compounds to

COPC IDENTIFICATION



Step 3: Include as COPCs those compounds that are non-detect, but have a high potential to be emitted as PICs.

Although some compounds (nitroaromatics, pthalates, hexachlorobenzene, and petachlorphenol) have traditionally been automatically identified as PICs in previous U.S. EPA guidance, inclusion of these compounds should be based on consideration of potential to be emitted and waste feed composition (e.g., nitrogenated wastes, plastics, or highly chlorinated organic waste streams) (see Sections 2.3.4 through 2.3.6).

Step 4: Include as COPCs those compounds that are non-detect, but have a tendancy to bioaccumulate or bioconcentrate. This includes organic chemicals with log K_{ow} values equal to or greater than 4.0 (Connolly and Pederson 1987), and inorganic compounds with a whole-body *BCF*

RECOMMENDED INFORMATION FOR RISK ASSESSMENT REPORT

- Complete evaluation of hazardous wastes to be burned in the combustion unit
- Complete evaluation of any raw materials or primary fuels burned in the combustion unit
- Waste analysis procedures used to monitor the composition of hazardous waste feed streams
- Analytical data and calculations used to complete the COPC identification process

2.3.1 Polychlorinated Dibenzo(p)dioxins and Dibenzofurans

Based on their combustion properties and toxicity, U.S. EPA OSW recommends that PCDDs and PCDFs should be included in every risk assessment. The general combustion properties and guidance for addressing toxicity of PCDDs and PCDFs are discussed in the following paragraphs and subsections, respectively.

One mode in which PCDDs and PCDFs form in dry APCSs is fly ash catalyzed reactions between halogens and undestroyed organic material from the furnace. PCDDs and PCDFs were first discovered as thermal decomposition products of polychlorinated compounds, including (1) the herbicide 2,4,5-T, (2) hexachlorophene, (3) PCBs, (4) pentachlorophenol, and (5) intermediate chemicals used to manufacture these compounds. In recent years, as chemical analytical methods have become more sensitive, additional sources of PCDDs and PCDFs have been identified, including (1) effluent from paper mills that use chlorine bleaches, and (2) combustion sources, including forest fires, municipal waste and medical incinerators, and hazardous waste combustion units. Duarte-Davidson et al. (1997) noted that the combustion of chlorine-containing materials in municipal solid waste is responsible for about two-thirds of the total annual emissions of newly formed TCDDs and TCDFs in the United Kingdom. In the United States, U.S. EPA (1998a) estimated that emissions of dioxin TEQs from municipal solid waste incinerators accounted for 37 percent of all emissions of dioxins into the environment in 1995.

PCDDs and PCDFs are formed at these combustion sources from the reaction of chlorine-containing chemicals and organic matter. Predicting the production of PCDDs and PCDFs in a specific situation is

also noted that since these TEFs were determined from the toxicity of each congener in relation to concentration in eggs, site-specific differences in exposure and bioavailability, and species-specific differences in toxicokinetic factors (deposition and metabolism) are accomodated. TEFs for PCDD and PCDF congeners in fish are presented in Table 2-3.

Toxicity Equivalency Factors for Mammals

Current TEFs for mammals (for evaluating human health risk to PCDDs and PCDFs) are largely based on studies in rodents. To supplement existing rodent-based TEFs, WHO (1997) discussed a mink reproductive study (Tillitt et al. 1996) and a study which analyzed available data from mink reproductive toxicity tests (Leonard et al. 1994). WHO (1997) reported that the relative potencies of PCDD and PCDF congeners toward mink reproductive toxicity were similar to the rodent models. WHO (1997) also discussed recent information on *in vivo* tumor promotion and in *vivo* ethoxyresorufin-o-deethylase (EROD) induction potency. However, specific studies reporting this information were not cited. Based on their review, WHO (1997) reported updated TEFs for mammals, including new values for 1,2,3,7,8-PeCDD, OCDD, and OCDF. TEFs for PCDD and PCDF congeners in mammals are presented in Table 2-3.

Toxicity Equivalency Factors for Birds

The experimental design of studies on the overt toxicity of PCDDs and PCDFs to birds precluded determination of the relative potency of these congeners. Other types of studies evaluated included embryo mortality following egg injection, *in vivo* biochemical effects following egg injection, biochemical effects in *in vitro* systems (Kennedy et al. 1996), and quantitative-structure activity relationship (QSAR) studies (Tysklind et al. 1995). The reviewed information indicated no significant differences between the *TEF* ranges for EROD induction and embryo mortality. Based on these results, WHO (1997) reported *TEF*s determined from EROD induction and QSAR studies. *TEF*s for PCDD and PCDF congeners in birds are presented in Table 2-3.

2.3.1.2 Exposure Assessment for Community Measurement Receptors

To evaluate exposure of water, sediment, and soil communities to PCDDs and PCDFs, congener-specific concentrations in the respective media to which the community is exposed should be converted to a

2,3,7,8-TCDD *TEQ*; which allows for direct comparison to 2,3,7,8-TCDD toxicity benchmarks. A media-secific 2,3,7,8-TCDD *TEQ* is calculated and used in the exposure assessment because limited congener-specific toxicity information is available for community receptors (WHO 1997). The congener-specific concentrations in the media to which the community being evaluated is exposed, should be calculated consistent with the guidance presented in Chapters 4 and 5, and Appendix F, for assessing exposure of community measurement receptors to other COPCs. The concentration of each PCDD and PCDF congener in the media of exposure should then be multiplied by the congener-specific *TEF* for fish (see Table 2-3), and summed, to obtain the 2,3,7,8-TCDD *TEQ* (see Equation 2-3).

$$TEQ = \sum (C_{Mi} \cdot TEF_i) \qquad \text{Equation 2-3}$$

where

TEQ = 2,3,7,8-TCDD toxicity equivalence concentration (μ

$$BEF_i = \frac{BSAF_i}{BSAF_{TCDD}}$$ Equation 2-5

BEF values reported by U.S. EPA (1995k) for the 17 PCDD and PCDF congeners are provided in Table 2-4. Although developed based on concentration data of PCDDs and PCDFs in sediment and surface water for application of *TEF*s in fish, U.S. EPA OSW assumes that these *BEF*s are applicable to other pathways and receptors. The estimation of PCDD and PCDF congener-specific *BCF* values using *BEFs* is indicated in Equation 2-5. Further discussion and resulting numeric values for congener-specific *BCF*s are provided in Appendicies C and D.

$$BCF_i \ = \ BCF_{TCDD} \ \cdot \ BEF_i \qquad \text{Equation 2-6}$$

where

BCF_i = Media-to-animal or media-to-plant bioconcentration factor for *i*th congener (L/kg [water], unitless [soil and sediment])
BCF_{TCDD} = Media-to-receptor BCF for 2,3,7,8-TCDD (L/kg [aquatic receptor], unitless [soil and sediment receptor])
BEF_i = Bioaccumulation equivalency factor for *i*th congener (unitless)

TABLE 2-4

PCDD AND PCDF BIOACCUMULATION EQUIVALENCY FACTORS (*BEF*s)

PCDD Congener	Bioaccumulation Equivalency Factor (unitless)	PCDF Congener	Bioaccumulation Equivalency Factor (unitless)
2,3,7,8-TCDD	1.0	2,3,7,8-TCDF	0.80
1,2,3,7,8-PeCDD	0.92	1,2,3,7,8-PeCDF	0.22
1,2,3,4,7,8-HxCDD	0.31	2,3,4,7,8-PeCDF	1.6
1,2,3,6,7,8-HxCDD	0.12	1,2,3,4,7,8-HxCDF	0.076
1,2,3,7,8,9-HxCDD	0.14	1,2,3,6,7,8-HxCDF	0.19
1,2,3,4,6,7,8-HpCDD	0.051	2,3,4,6,7,8-HxCDF	0.67
OCDD	0.012	1,2,3,7,8,9-HxCDF	0.63
		1,2,3,4,6,7,8-HpCDF	0.011
		1,2,3,4,7,8,9-HpCDF	0.39
		OCDF	0.016

Source: U.S. EPA 1995k

2.3.1.5 Fluorine, Bromine, and Sulfur PCDD/PCDF Analogs

U.S. EPA (U.S. EPA 1996l; 1996m) is currently evaluating the potential for the formation of (1) fluorine- and bromine-substituted dioxins and furans, and (2) sulfur analogs of PCDDs and PCDFs. Available

generally requires conditions of high temperatures (at least 1,200 ºC) and an extended contact time (more than 2 seconds) in that temperature with adequate oxygen (Erickson 1992).

Limited data and studies, including laboratory and field, show that PCBs may be formed from the combustion of hazardous waste. Stack tests performed in U.S. EPA Region 10 on a boiler and an incinerator burning waste with 0.07 and 1.4 percent chlorine, respectively, confirmed the presence of PCBs in the stack gases (Kalama Chemical, Inc. 1996; Idaho National Engineering Laboratory 1997). The concentration of detected coplanar PCBs (see definition in Section 2.3.3.1) found in the boiler stack gas was 0.55 ng/dscm @ 7% O_2 at low temperature conditions (1,357° F) and 1.12 ng/dscm @ 7% O_2 at high temperature conditions (1,908° F). The concentration of total PCBs detected in the incinerator stack gas was 211 ng/dscm @ 7% O_2 at low temperature conditions (1,750 °F) and 205 ng/dscm @ 7% O_2 at high temperature conditions (2,075° F). PCBs with more than four chlorines comprised 51 percent of the total PCBs in the low temperature test and 59 percent of the total PCBs in the high temperature test.

High resolution gas chromatograph test methods (e.g., draft Method 1668), available at most commercial laboratories with dioxin/furan analytical capabilities, should be used to identify the specific concentration of individual coplanar PCBs in stack gas. U.S. EPA OSW recommends that permitting authorities estimate risks to community and class-specific guild measurement receptors from coplanar PCBs by computing a *TEQ* for PCBs, and then comparing to the appropriate toxicity benchmark for 2,3,7,8-TCDD.

two products: trinitrotoluene and TDA. TDA is, in turn, used to make TDI, which readily reacts with water and is, therefore, very unstable at ambient conditions; TDI is typically reacted with a polyol to form polyurethane (PU) plastics.

Combustion properties of these nitroaromatic compounds indicate that they will not be formed as PICs if they are not present in the waste feed stream, mainly because of the thermodynamic and chemical difficulty of adding a nitro group to an aromatic. The process requires that (1) nitronium ions be generated, and (2) an aromatic ring be reacted with the nitronium ion, resulting in the attachment of the nitronium ion to the ring. This reaction process is not likely to occur in a hazardous waste combustion unit because (1) the reaction is typically carried out by using a "nitrating acid" solution consisting of three parts concentrated nitric acid to one part sulfuric acid, and (2) nitronium ions are not usually formed in a combustion unit environment (if they areitrmIr735(onm)1on unir73t 735(onm)31(w)6(h)2(P(r)-36)5(i)-3(u)-21(o39(D)-34(h94)a)-33(rntu)-21 atmosphere (Howard 1990). Phthalate plasticizers are commonly found in the environment and are practically impossible to avoid, especially at the trace concentrations that modern analyses can detect.

Phthalates are synthesized by reacting alcohol with phthalic anhydride in the presence of an acidic catalyst in a nonaqueous solvent (ATSDR 1993; ATSDR 1995b). Phthalates and their predecessors are readily combusted compounds, as indicated by their flash points of 150 to 225 °C (NIOSH 1994). There is no apparent mechanism for phthalate PICs to be formed by the combustion of other chemical compounds. Therefore, phthalates are very unlikely to be emissions from a combustion unit, although some degradation products, such as PAHs, are likely to be emitted when phthalates are included in the waste feed. However, facilities that burn plastics or materials with phthalate plasticizers should carefully consider the potential for phthalate plasticizers to exist in the stack gas emissions due to incomplete combustion.

The evaluation of phthalate plasticizers in risk assessments should not be automatically discounted due to the toxicity and biaccumulative potential of these compounds. Moreover, the uncertainties associated with combustion chemistry suggest that the absence of these compounds from stack emissions should always be confirmed via stack gas testing rather than process knowledge or waste feed characterization data. U.S. EPA OSW recommends that careful consideration should be given to including phthalates as COPCs based on the information presented above.

2.3.6 Hexachlorobenzene and Pentachlorophenol

Careful consideration should be made before the automatic inclusion of hexachlorobenzene and pentachlorophenol in risk assessments for combustion units. Hexachlorobenzene and pentachlorophenol, like all chlorinated aromatics, are synthesized by the reaction of elemental chlorine with the parent aromatic (Deichmann and Keplinger 1981; Grayson 1985). The addition of the first chlorine atom to the benzene or phenol molecule is rapid, but further chlorination becomes progressively more difficult, requiring ferric chloride or another Lewis acid catalyst to complete the reaction (March 1985); therefore, these chlorinated compounds are difficult to make under controlled conditions. Hexachlorobenzene, but not pentachlorophenol, has been reported in emissions from the combustion of municipal solid waste and from

The assumdi [(T26(15(g)-19(u)15(s)-21(t)-12( )]TJ 40.3913 9 T 40.3)18(26(15 40.3 1(9(s)-1EP)-6(A)]TJ -47.c)-2168047.3

with no emissions of methylmercury assumed. The divalent fraction is split between vapor and particle-bound phases (Lindqvist et al. 1991). Much of the divalent mercury is thought to be mercuric chloride ($HgCl_2$) (U.S. EPA 1997b); this is particularly the case for the combustion of wastes containing chlorine.

It should be noted that data on mercury speciation in emissions exiting the stack is very limited, as well as, the behavior of mercury emissions close to the point of release has not been extensively studied. This results in a significant degree of uncertainty implicit in modeling of mercury emissions. Additional examples of uncertainties include the precision of measurement techniques, estimates of pollution control efficiency, limited data specific to source class and activity level. Discussions of uncertainty and sensitivity analyses of several of the assumptions used in the modeling of mercury emissions are presented in the *Mercury Study Report to Congress* (U.S. EPA 1997b).

Phase Allocation and Speciation of Mercury Exiting the Stack

As discussed above, stack emissions are thought to include both vapor and particle-bound forms; and speciated as both divalent and elemental mercury. Based on review of mercury emissions data presented for combustion sources in U.S. EPA (1997b) and published literature (Peterson et al. 1995), estimates for the percentage of vapor and particle-bound mercury emissions range widely from 20 to 80 percent. Therefore, at this time U.S. EPA OSW recommends a conservative approach that assumes phase allocation of mercury emissions from hazardous waste combustion of 80 percent of the total mercury in the vapor phase and 20 percent of total mercury in the particle-bound phase. This allocation is:

-

vapor phase or particle-bound, are thought to be subject to much faster atmospheric removal than elemental mercury (Lindberg et al. 1992; Peterson et al. 1995; and Shannon and Voldner 1994). In addition, vapor phase divalent mercury is thought to be more rapidly and effectively removed by both dry and wet deposition than particle-bound divalent mercury, as a result of the reactivity and water solubility of vapor divalent mercury (Lindberg et al. 1992; Peterson et al. 1995; and Shannon and Voldner 1994).

Vapor Phase Mercury

As illustrated in Figure 2-4, of the 80 percent total mercury in the vapor phase, 20 percent of the total mercury is in the elemental vapor form and 60 percent of the total mercury is in the divalent vapor form (Peterson et al. 1995). A vast majority (assumed to be 99 percent) of the 20 percent vapor phase elemental mercury does not readily deposit and is transported outside of the U.S. or is vertically diffused to the free atmosphere to become part of the global cycle (U.S. EPA 1997b). Only a small fraction (assumed to be one percent) of vapor-phase elemental mercury either is adsorbed to particulates in the air and is deposited or converted to the divalent form to be deposited (assumed to be deposited as elemental mercury, see Figure 2-4). Of the 60 percent vapor phase divalent mercury, about 68 percent is deposited and about 32 percent is transported outside of the U.S. or is vertically diffused to the free atmosphere to become part of the global cycle (U.S. EPA 1997b).

Particle-bound Mercury

Of the 20 percent of the total mercury that is particle-bound, 99 percent (assumed to be 100 percent in Figure 2-4) is in the divalent form. U.S. EPA (1997b) indicates that only 36 percent of the particle-bound divalent mercury is deposited, and the rest is either transported outside of the U.S. or is vertically diffused to the free atmosphere to become part of the global cycle.

Deposition and Modeling of Mercury

Consistent with U.S. EPA (1997b) and as shown in Figure 2-4, it is assumed that deposition to the various environmental media is entirely divalent mercury in either the vapor or particle-bound form. Without consideration of the global cycle, mercury speciations will result in 80 percent of the total mercury emitted being deposited as divalent mercury and the remaining 20 percent being deposited as elemental mercury.

exported to nearby water bodies and potentially bioaccumulated in the aquatic food chain (U.S. EPA 1997b). 19ic food ia he

Exposure Assessment for Mercury

For assessing exposure of community and class-specific guild measurement receptors to mercury, guidance on the SCRAM bulletin (see Chapter 3); and specific default parameter values for mercury are presented in U.S. EPA (1997b). While this guidance does not address what models should be used or how data to support such models should be collected, the decision to use site-specific mercury models in a risk assessment is not precluded just because it is different; nor does this guidance automatically approve the use of such models. A permitting authority that chooses to use complex mercury models should carefully identify and evaluate their associated limitations, and clearly document these limitations in the uncertainty section of the risk assessment report.

U.S. EPA OSW encourages all facilities to implement a combination of waste minimization and control technology options to reduce mercury emission rates on an ongoing basis. Realistic expectations for mercury emission reduction efforts may be established by considering various technology-based mercury emission limits that apply to waste combustors (for example, standards for European combustors, the proposed MACT standards for hazardous waste combustors, or the MACT standards for municipal waste combustors). U.S. EPA OSW acknowledges that site-specific risk assessments as currently conducted may not identify the entire potential risk from mercury emissions. Mercury that does not deposit locally will ultimately enter the global mercury cycle for potential deposition elsewhere.

2.3.8 Particulate Matter

PM is all condensed material suspended in air that has a mean aerodynamic diameter of 10 micrometers or less (PM10). PM can be classified as aerosols, dusts, fogs, fumes, mists, smogs, or smokes, depending on its physical state and origin. Anecdotal evidence suggests that uncontrolled particulate emissions from coal-burning industries has adversely affected local populations of wildlife (U.S. Fish and Wildlife Service [U.S. FWS] 1980). For wildlife, PM can adsorb to external surfaces or membranes, for example causing corneal damage. Wildlife exposure can also occur through ingested of contaminated food, water, and hair (through grooming) (U.S. FWS 1980). However, PM dose-response information to evaluate risk of particulate matter to ecological receptors is limited. For this reason, U.S. EPA OSW does not recommend that PM be evaluated as a separate COPC in a risk assessment. However, PM is useful as an indicator parameter for other contaminants because it can be measured in real time and is sensitive to changes in combustion conditions.

that are not released to the environment) does not need to be evaluated in the risk assessment. Risk from both radiological and non-radiological contaminants should be presented along side each other in a risk summary

Prescriptive methodology for calculating risk from combustion facilities burning mixed waste is beyond the scope of the current document. The above information is provided to outline the methodology recommended by U.S. EPA OSW

$$EDL = \frac{2.5 \cdot Q_{is} \cdot (H_n^1 + H_n^2) \cdot D}{V \cdot}$$

H_n^1 and H_n^2 = The peak heights of the noise for both of the quantitation ions of the isomer of interest
H_{is}^1 and H_{is}^2 = The peak heights of both the quantitation ions of the appropriate internal standards
D = Dilution factor - the total volume of the sample aliquot in clean solvent divided by the volume of the sample aliquot that was diluted (unitless)
V = Volume of sample extracted (L)
RF_n = Calculated relative response factor from calibration verification (unitless)

Common commercial laboratory practice: The EDL, generally reported by commercial laboratories, is defined as the detection limit reported for a target analyte that is not detected or presents an analyte response that is less than 2.5 times the background level. The area of the compound is evaluated against the noise level measured in a region of the chromatogram clear of genuine GC signals times an empirically derived factor. This empirical factor approximates the area to height ratio for a GC signal. This factor is variable between laboratories and analyses performed, and commonly ranges from 3.5 to 5. The equation is as follows:

$$EDL = \frac{2.5 \cdot Q_\beta \cdot (F \cdot H) \cdot D}{W \cdot A_\beta \cdot RRF_\sigma} \qquad \text{Equation 2-8}$$

where

EDL = Estimated detection limit
2.5 = Minimum response required for a GC signal
Q_β = The amount of internal standard added to the sample before extraction
F = An empirical factor that approximates the area to height ratio for a GC signal
H = The height of the noise
D = Dilution factor
W = The sample weight or volume
RRF_σ = The mean analyte relative response factor from the initial calibration

- Practical Quantitation Limit (PQL) is a quantitation level that is defined in 50 FR 46908 and 52 FR 25699 as the lowest level that can be reliably achieved with specified limits of precision and accuracy during routine laboratory operating conditions (U.S. EPA 1992g; 1995i). The PQL is constructed by multiplying the MDL, as derived above, by a factor (subjective and variable between laboratories and analyses performed) usually in the range of 5 to 10. However, PQLs with multipliers as high as 50 have been reported (U.S. EPA 1995i).

(1994i) guidance has recommended that emission rates for non-detects be developed using one-half of the "detection limit" and applied in conducting the risk assessment. However, which detection limit should be used has not been explicitly defined or presented in quantitative terms.

To increase consistency and reproducibility in dealing with non-detects, U.S. EPA OSW recommends application of the MDL-derived RDL to quantify non-detects for COPCs analyzed with non-isotope dilution methods, and application of the method-defined EDL to quantify non-detects for COPCs analyzed with isotope dilution methods. Procedures for these applications are as follows:

> ***Non-isotope Dilution Methods:*** Non-detects for COPCs analyzed with non-isotope dilution methods should be quantified for use in the risk assessment using an MDL-derived RDL. Commonly used non-isotope dilution methods include SW-846 Method 8260 (volatiles), SW-846 Method 8270 (semivolatiles),
>
> 1. Require the laboratory to report the actual MDL for every non-detect compound analyzed, in addition to the commonly used reporting limit, such as an EDL, EQL, or PQL. The MDL should be derived in a manner consistent with 40 CFR Part 136 Appendix B. This would also apply for analysis of each individual component of multiple component samples (e.g., front half rinse, XAD resin, condensate, Tenax tube).
>
>   **Note:** Laboratories typically produce MDLs specific to each non-isotope dilution method performed by the laboratory on an annual basis.
>
> 2. Calculate an MDL-derived RDL for each COPC non-detect for quantitative application in the risk assessment. This would be obtained by multiplying the MDL, as reported by the laboratory, times 2.623 (interim factor) (U.S. EPA 1995i).
>
> 3. Adjust the RDL, as appropriate, to account for sample-specific volumetric treatments (e.g.,

address false positives, the system required that 50 percent of the detects at the MDL would be false positives. This is a very conservative approach, and biased toward not missing any compounds of potential concern that may be present. The use of the MDL-derived RDL, and to a lesser extent the EDL, somewhat indirectly addresses the false positive issue. As described in defining the RDL (see Section 2.4.1), by the time the standard deviation has been multiplied by 8, the possibility of false positives is usually less than 1 percent.

2.4.3 Statistical Distribution Techniques

Many statistical distribution techniques are available for calculating a range of standard deviations to quantify non-detect concentrations of COPCs. These include random replacement scenarios, such as: (1) the uniform fill-in (UFI) method, in which each LOD value is replaced with a randomly generated data point by using a uniform distribution; (2) the log fill-in LFI method which is the same as UFI, except for using a logarithmic distribution; (3) the normal fill-in (NFI) method which is the same as UFI, except for using a log-normal distribution; and (4) the maximum likelihood estimation (MLE) techniques (Cohen and Ryan 1989; Rao et al. 1991). If determined to be applicable by the permitting authority, a Monte Carlo simulation may also be used to determine a wu15(e)33(m()r)-35(i)-3(b)-14(g0(t)-26(ena38on t)-2134(y a)-34(g)24(Oa)-34((s)-(o)1(21(m)

While this guidance does not address what forms or how such data may be used, the decision to use non-routine data in a risk assessment is not precluded just because it is different; nor does this guidance automatically approve the use of non-routine data. A permitting authority that chooses to use non-routine data should carefully identify and evaluate the limitations associated with non-routine data and clearly document this discussion in the uncertainty section of the risk assessment report.

For collection of data to be used in a risk assessment, U.S. EPA OSW recommends comprehensive sampling using typical sampling and analytical methods for VOCs, SVOCs, metals, PCDDs, PCDFs, total organics, and other appropriate constituents as necessary based on the type of waste that will be burned by the unit. A pretrial burn risk assessment can help to ensure that the desired quantitation limit (and, therefore, DREs and COPC stack gas emission rates) will be achieved during the trial burn test.

2.4.5 Estimated Maximum Possible Concentration (EMPC)

The EMPC, as defined in SW-846 Methods 8280A and 8290, is in most cases only used with the isotope dilution methods as stated. An EMPC is calculated for dioxin isomers that are characterized by a response with a signal to noise ratio of at least 2.5 for both the quantitation ions, and meet all the relevant identification criteria specified in the method, except the ion abundance ratio. Ion abundance ratios are affected by co-eluting interferences that contribute to the quantitative ion signals. As a result, one or both of the quantitative ions signals may possess positive biases.

An EMPC is a worst case estimate of the concentration. An EMPC is not a detection limit and should not be treated as a detection limit in the risk assessment. U.S. EPA OSW recommends that EMPC values be used as detections without any further manipulation (e.g., dividing by 2). However, because EMPCs are worst case estimates of stack gas concentrations, permitting authorities and facilities should consider techniques to minimize EMPCs when reporting trial and risk burn results, especially when the EMPC values result in risk estimates above regulatory levels of concern. Some techniques that may be applied to minimize EMPCs include performing additional cleanup procedures (as defined by the analytical method) on the sample or archived extract, and/or reanalyzing the sample under different chromatographic conditions.

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- Actual MDLs for all non-detect results
- Description of the method applied to quantify the concentration of non-detects

2.5 CONCENTRATIONS DETECTED IN BLANKS

Blank samples are intended to provide a measure of any contamination that may have been introduced into a sample either in the field while the samples were being collected, in transport to the laboratory, or in the laboratory during sample preparation or analysis. Blank samples are analyzed in the same manner as the site samples from the trail burn. In order to prevent the inclusion of non-site related compounds in the risk assessment, the concentrations of compounds detected in blanks should be compared to concentrations detected in site samples collected during the trial burn. Four types of blanks are defined in the *Risk Assessment Guidance for Superfund* (U.S. EPA 1989e): trip blanks, field blanks, laboratory calibration blanks, and laboratory reagent of method blanks. Detailed definitions of each are provided below.

> ***Trip Blank*** - A trip blank is used to indicate potential contamination due to migration of volatile organic compounds from the air on the site or in sample shipping containers, through the septum or around the lid of sampling vials, and into the sample. The blank accompanies the empty sample bottles to the field as well as with the site samples returning to the laboratory for analysis. The blank sample is not opened until it is analyzed in the lab with the site samples, thus making the laboratory "blind" to the identity of the blanks.
>
> ***Field Blank*** - A field blank is used to determine if field sampling or cleaning procedures (e.g., insufficient cleaning of sample equipment) result in cross-contamination of site samples. Like the trip blank, the field blank is transported to the field with empty sample bottles and is analyzed in the laboratory along with the site samples. Unlike the trip blank, however, the field blank sample is opened in the field and recovered in the same manner as the collected samples. As with trip blanks, the field blanks' containers and labels should be the same as for site samples and blind to the laboratory.
>
> ***Instrument Blank*** - An instrument blank is distilled, deionized water injected directly into an instrument without having been treated with reagents appropriate to the analytical method used to analyze actual site samples. This type of blank is used to indicate contamination in the instrument itself.

burn data should be carefully evaluated to ensure that the level of contamination present in the blanks does not compromise the integrity of the data for purposes of risk assessment, or result in retesting in order to properly address data quality issues.

When considering blank contamination in the COPC selection process, permitting authorities should ensure

Model (ISCST3). ISCST3 requires the use of the following information for input into the model, and consideration of output file development:

- Site-specific characteristics required for air modeling (Section 3.2)
    - Surrounding terrain (Section 3.2.1)
    - Surrounding land use (Section 3.2.2)
    - Facility building characteristics (Section 3.2.3)
- Unit emission rate (Section 3.3)
- Partitioning of emissions (Section 3.4)
- Meteorological data (Section 3.5)
- Source Characteristics (Section 3.7)

ISCST3 also requires the use of several preprocessing computer programs that prepare and organize data for use in the model. Section 3.6 describes these programs. Section 3.7 describes the structure and format of the input files. Section 3.8 describes limitations to be considered in executing ISCST3. Section 3.9

3.1 DEVELOPMENT OF AIR MODELS

This section (1) briefly describes the history of air model development, (2) introduces some data preprocessing programs developed to aid in preparing air model input files (these preprocessing programs are described in more detail in Sections 3.2.4 and 3.6, and (3) introduces ExInter Version 1.0, a preprocessor to ISCST3.

3.1.1 History of Risk Assessment Air Dispersion Models

Before 1990, several air dispersion models were used by U.S. EPA and the regulated community. These models were inadequate for use in risk assessments because they considered only concentration, and not the deposition of contaminants to land. The original U.S. EPA guidance (1990a) on completing risk assessments identified two models that were explicitly formulated to account for the effects of deposition.

- COMPLEX terrain model, version 1 (COMPLEX I), from which a new model—COMPLEX terrain model with DEPosition (COMPDEP)—resulted
- Rough Terrain Diffusion Model (RTDM), from which a new model—RTDMDEP—resulted

COMPDEP was updated to include building wake effects from a version of the ISCST model in use at the time. Subsequent U.S. EPA guidance (1993h; 1994b) recommended the use of COMPDEP for air deposition modeling. U.S. EPA (1993h) specified COMPDEP Version 93252, and U.S. EPA (1994b) specified COMPDEP Version 93340. When these recommendations were made, a combined ISC-COMPDEP model (a merger of the ISCST2 and COMPLEX I model) was still under development. The merged model became known as ISCSTDFT. U.S. EPA guidance (1994l) recommended the use of the ISCSTDFT model. After reviews and adjustments, this model was released as ISCST3. The ISCST3 model contains algorithms for dispersion in simple, intermediate, and complex terrain; dry deposition; wet deposition; and plume depletion.

The use of the COMPDEP, RTDMDEP, and ISCST models is described in more detail in the following user’s manuals; however, all models except the current version of ISCST3 are obsolete:

3.1.3 Expert Interface (ExInter Version 1.0)

ExInter is an expert interface system enhanced by U.S. EPA Region 6 for the ISCST3 model. By enhancing ExInter, the goal of U.S. EPA Region 6 was to support the in-house performance of air dispersion modeling by regional U.S. EPA and state agency personnel at hazardous waste combustion units necessary to support risk assessments conducted at these facilities. ExInter enables the user to build input files and run ISCST3 and its preprocessor programs in a Windows-based environment. Specific procedures for developing input files are stored in an available k01o26 dat1o2enha 14(P-23(o))-3 using ExInter components. ExInter requires a minimum of 15 megabytes of free hard disk space, Windows 3.1, 8 megabytes of system memory, and a 486 processor.

3.2 SITE-SPECIFIC INFORMATION REQUIRED TO SUPPORT AIR MODELING

Site-specific information for the facility and surrounding area required to support air dispersion modeling includes (1) the elevation of the surrounding land surface or terrain, (2) surrounding land uses, and (3) characteristics of on-site buildings that may affect the dispersion of COPCs into the surrounding

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- Description of the methods used to determine land use surrounding the facility
- Copies of any maps, photographs, or figures used to determine land use
- Description of the source of any computer-based maps used to determine land use

3.2.2.2 Land Use for Surface Roughness Height (Length)

Surface roughness height—also referred to as (aerodynamic) surface roughness length—is the height above the ground at which the wind speed goes to zero. Surface roughness affects the height above local ground level that a particle moves from the ambient air flow above the ground (for example in the plume) into a "captured" deposition region near the ground. That is, ISCST3 causes particles to be "thrown" to the ground at some point above the actual land surface, based on surface roughness height. Surface roughness height is defined by individual elements on the landscape, such as trees and buildings.

U.S. EPA (1995b) recommended that land use within 5 kilometers of the stack be used to define the average surface roughness height. For consistency with the method for determining land use for dispersion coefficients (Section 3.2.2.1), the land use within 3 kilometers generally is acceptable for determination of surface roughness. Surface roughness height values for various land use types are as follows:

Surface Roughness Heights for Land Use Types and Seasons (meters)

Land Use Type	Spring	Summer	Autumn	Winter
Water surface	0.0001	0.0001	0.0001	0.0001
Deciduous forest	1.00	1.30	0.80	0.50
Coniferous forest	1.30	1.30	1.30	1.30
Swamp	0.20	0.20	0.20	0.05
Cultivated land	0.03	0.20	0.05	0.01
Grassland	0.05	0.10	0.01	0.001
Urban	1.00	1.00	1.00	1.00
Desert shrubland	0.30	0.30	0.30	0.15

Source: Sheih, Wesley, and Hicks (1979)

If a significant number of buildings are located in the area, higher surface roughness heights (such as those for trees) may be appropriate (U.S. EPA 1995b). A specific methodology for determining average surface roughness height has not been proposed in prior guidance documents. For facilities using National Weather Service surface meteorological data, the surface roughness height for the measurement site may be set to 0.10 meters (grassland, summer) without prior approval. If a different value is proposed for the measurement site, the value should be determined applying the following procedure to land use at the measurement site. For the application site, the following method should be used to determine surface roughness height:

Step 1 Draw a radius of 3 kilometers from the center of the stack(s) on the site map.

Step 2 Inspect the maps, and use professional judgment to classify the areas within the radius according to the PCRAMMET categories (for example water, grassland, cultivated land, and forest); a site visit may be necessary to verify some classifications.

Step 3 Calculate the wind rose directions from the 5 years of meteorological data to be used for the study (see Section 3.4.1.1); a wind rose can be prepared and plotted by using the U.S. EPA WRPLOT program from the U.S. EPA's Support Center for Regulatory Air Models bulletin board system (SCRAM BBS).

Step 4 Divide the circular area into 16 sectors of 22.5 degrees, corresponding to the wind rose directions (for example, north, north-northeast, northeast, and east-northeast) to be used for the study.

Step 5 Identify a representative surface roughness height for each sector, based on an area-weighted average of the land use within the sector, by using the land use categories identified above.

Step 6 Calculate the site surface roughness height by computing an average surface roughness height weighted with the frequency of wind direction occurrence for each sector.

Alternative methods of d0.021 Tc 0.032 r t d0.021 Tc 0.031 Tc 0e 0.03mm9(A)26(W)9(R [(Alt)-2(ghne)9(3(s)]T4(d0.021

evaluating this phenomenon, which is also referred to as "building downwash." The downwash analysis should consider all nearby structures with heights at least 40 percent of the height of the shortest stack to be modeled. The 40 percent value is based on Good Engineering Practice (GEP) stack height of 2.5 times the height of nearby structures or buildings (stack height divided by 2.5 is equal to 0.40 multiplied by the stack height [40 CFR Part 51 Appendix W]). Building dimensions and locations are used with stack heights and locations in BPIP to identify the potential for building downwash. BPIP and the BPIP user's guide can be downloaded from the SCRAM web site and should be referred to when addressing specific questions. The BPIP output file is in a format that can be copied and pasted into the source (SO) pathway of the ISCST3 input file. The following procedure should be used to identify buildings for input to BPIP:

Step 1 Lay out facility plot plan, with buildings and stack locations clearly identified (building heights must be identified for each building); for buildings with more than one height or roof line, identify each height (BPIP refers to each height as a tier).

Step 2 Identify the buildings required to be included in the BPIP analysis by comparing building heights to stack heights. The building height test requires that only buildings at least 40 percent of the height of a potentially affected stack be included in the BPIP input file. For example, if a combustion unit stack is 50 feet high, only buildings at least 20 feet (0.40 multiplied by 50 feet) tall will affect air flow at stack top. Any buildings shorter than 20 feet should not be included in the BPIP analysis. The building height test is performed for each stack and each building.

Step 3

other building is 50 feet high. The buildings could be combined into one building for input to BPIP. For input to BPIP, the corners of the combined building are the outer corners of the two buildings. For unusually shaped buildings with more than the eight corners allowed by BPIP, approximate the building by using the eight corners that best represent the extreme corners of the building. The BPIP User's Guide contains additional description and illustrations on combining buildings, and BPIP model limitations (U.S. EPA 1995d).

Step 5 Mark off the facility plot plan with UTM grid lines. Extract the UTM coordinates of each building corner and each stack center to be included in BPIP input file. Although BPIP allows the use of "plant coordinates," U.S. EPA OSW requires that all inputs to the air modeling be prepared using UTM coordinates (meters) for consistency. UTM coordinates are rectilinear, oriented to true north, and in metric units required for ISCST3 modeling. Almost all air modeling will require the use of USGS topographic data (digital and maps) for receptor elevations, terrain grid files, location of plant property, and identification of surrounding site features. Therefore, using an absolute coordinate system will enable the modeler to check inputs at each step of the analysis. Also, the meteorological data are oriented to true north. Significant errors will result from ISCST3 if incorrect stack or building locations are used, plant north is incorrectly rotated to true north, or incorrect base elevations are used. With computer run times of multiple years of meteorological data requiring many hours (up to 40 hours for one deposition run with depletion), verification of locations at each step of preparing model inputs will prevent the need to remodel.

Several precautions and guidelines should be observed in preparing input files for BPIP:

- Before BPIP is run, the correct locations should be graphically confirmed. One method is to plot the buildings and stack locations by using a graphics program. Several commercial programs incorporating BPIP provide graphic displays of BPIP inputs.

- U.S. EPA OSW recommends, in addition to using UTM coordinates for stack locations and building corners, using meters as the units for height.

- Carefully include the stack base elevation and building base elevations by using the BPIP User's Guide instructions.

- Note that the BPIP User's Guide (revised February 8, 1995) has an error on page 3-5, Table 3-1, under the "TIER(i,j)" description, which incorrectly identifies tier height as base elevation.

- BPIP mixes the use of "real" and "integer" values in the input file. To prevent possible errors in the input file, note that integers are used where a count is requested (for example, the number of buildings, number of tiers, number of corners, or number of stacks).

- The stack identifications (up to eight characters) in BPIP must be identical to those used in the ISCST3 input file, or ISCST3 will report errors.

For example, the mean particle diameter of 5.5 μm in Table 3-1 is calculated from a lower bound cut size (assuming a cascade impactor is used to collect the sample) of 5.0 μm to an upper bound cut size of 6.15 μm. In this example, the mean particle diameter is calculated as:

$$D_{mean} = \left[0.25\ (5.0^3 + (5.0)^2(6.15) + (5.0)(6.15)^2 + 6.15^3)\right]^{0.33} = 5.5\ \mu m$$

TABLE 3-1

GENERALIZED PARTICLE SIZE DISTRIBUTION, AND PROPORTION OF AVAILABLE SURFACE AREA, TO BE USED AS A DEFAULT IN DEPOSITION MODELING IF SITE-SPECIFIC DATA ARE UNAVAILABLE

1	2	3	4	5	6
Mean Particle Diameter [a] (μm)	**Particle Radius (μm)**	**Surface Area/ Volume (μm^{-1})**	**Fraction of Total Mass[b]**	**Proportion Available Surface Area**	**Fraction of Total Surface Area**
> 15.0	7.50	0.400	0.128	0.0512	0.0149
12.5	6.25	0.480	0.105	0.0504	0.0146

or fabric filters, because the distribution is relatively typical of particle size arrays that have been measured at the outlet to advanced equipment designs (Buonicore and Davis 1992; U.S. EPA 1986a; U.S. EPA 1987a).

After developing the particulate size distribution based on mass, this distribution is used in ISCST3 to apportion the mass of particle phase COPCs (metals and organics with F_v values less than 0.05) based on particle size. Column 4 of Table 3-1 (as developed from actual stack test data) is used in the ISCST3 input file to perform a particulate run with the particle phase COPCs apportioned based on mass weighting.

3.4.3 Particle-Bound Modeling (Surface Area Weighting)

A surface area weighting, instead of mass weighting, of the particles is used in separate particle runs of ISCST3. Surface area weighting approximates the situation where a semivolatile organic contaminant that has been volatilized in the high temperature environment of a combustion system and then condensed to the surface of particles entrained in the combustion gas after it cools in the stack. Thus, the apportionment of emissions by particle diameter becomes a function of the surface area of the particle that is available for chemical adsorption (U.S. EPA 1993h).

The first step in apportioning COPC emissions by surface area is to calculate the proportion of available surface area of the particles. If particle density is held constant (such as 1 g/m^3), the proportion of available surface area of aerodynamic spherical particles is the ratio of surface area (*S*) to volume (*V*), as follows:

- Assume aerodynamic spherical particles.
- Specific surface area of a spherical particle with a radius, r—$S = 4\,\pi r^2$
- Volume of a spherical particle with a radius, r—

spherical particle having a diameter of 15 μm (Column 1) has a radius of 7.5 μm (Column 2). The proportion of available surface area (assuming particle density is constant) is 0.400 (S/V = 3/7.5), which is the value in Column 3. Column 4 shows that particles with a mean diameter of 15 μm, constitute

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- Copies of all stack test data used to determine particle size distribution
- Copies of all calculations made to determine particle size distribution, fraction of total mass, and fraction of total surface area

        (1) Wind direction (degrees from true north)
        (2) Wind speed (m/s)
        (3) Dry bulb (ambient air) temperature (K)
        (4) Opaque cloud cover (tenths)
        (5) Cloud ceiling height (m)

    b. Daily values

        (1) Morning mixing height (m)
        (2) Afternoon mixing height (m)

2. Deposition

    a. Dry particle deposition—hourly values for surface pressure (millibars)

    b. Wet particle deposition—hourly values
        (1) Precipitation amount (inches)
        (2) Precipitation type (liquid or frozen)

    c. Dry vapor deposition (when available)—hourly values for solar radiation (watts/m^2)

As shown in Figure 3-1, these data are available from several different sources. For most air modeling, five years of data from a representative National Weather Service station is recommended. However, in some instances where the closest NWS data is clearly not representative of site specific meteorlogical conditions, and there is insufficient time to collect 5 years of onsite data, 1 year of onsite meteorological data (consistent with GAQM) may be used to complete the risk assessment. The permitting authority should approve the representative meteorological data prior to performing air modeling.

The following subsections describe how to select the surface and upper air data that will be used in

RECOMMENDED INFORMATION FOR RISK ASSESSMENT REPORT

- Identification of all sources of meteorological data

FIGURE 3-1

SOURCES OF METEOROLOGICAL DATA

3.5.1 Surface Data

Surface data can be obtained from SAMSON in CD-ROM format. SAMSON data are available for 239 airports across the U.S. for the period of 1961 through 1990. The National Climate Data Center (NCDC) recently released the update to SAMSON through 1995 surface data. However, since the upper air (mixing height) data available from the U.S. EPA SCRAM web site has not been updated to cover this recent data period, it is acceptable to select the representative 5 years of meteorological data from the period up through 1990. SAMSON data contain all of the required input parameters for concentration, dry and wet particle deposition, and wet vapor deposition. SAMSON also includes the total solar radiation data required for dry vapor deposition, which may be added to ISCST3 in the future. Alternatively, some meteorological files necessary for running ISCST3 are also available on the SCRAM BBS for NWS stations located throughout the country (SCRAM BBS is part of the Office of Air Quality and Planning and Standards Technology Transfer Network [OAQPS TTN]). The meteorological data, preprocessors, and user's guides are also located on the SCRAM web site at "http://www.epa.gov/scram001/index.htm". However, these files do not contain surface pressure, types of precipitation (present weather), or precipitation amount. Although the ISCST3 model is not very sensitive to surface pressure variations, and

is used in ISCST3 in the buoyant plume rise equations developed by Briggs (U.S. EPA 1995c). The model results are not very sensitive to air temperature, except at extremes. However, buoyant plume rise is very sensitive to the stack gas temperature. Buoyant plume rise is mainly a result of the difference between stack gas temperature and ambient air temperature. Conceptually, it is similar to a hot air balloon. The higher the stack gas temperature, the higher will be the plume rise. High plume heights result in low concentrations and depositions as the COPCs travel further and are diluted in a larger volume of ambient air before reaching the surface. The temperature is measured in K, so a stack gas temperature of 450°F is equal to 505 K. Ambient temperature of 90°F is equal to 305 K, and 32°F is 273 K. A large variation in ambient temperature will affect buoyant plume rise, but not as much as variations in stack gas temperature.

3.5.1.3 Opaque Cloud Cover

PCRAMMET uses opaque cloud cover to calculate the stability of the atmosphere. Stability determines the dispersion, or dilution, rate of the COPCs. Rapid dilution occurs in unstable air because of surface heating that overturns the air. With clear skies during the day, the sun heats the Earth's surface, thereby causing unstable air and dilution of the stack gas emission stream. Stable air results in very little mixing, or dilution, of the emitted COPCs. A cool surface occurs at night because of radiative loss of heat on clear nights. With a cloud cover, surface heating during the day and heat loss at night are reduced, resulting in moderate mixing rates, or neutral stability. Opaque cloud cover is a measure of the transparency of the clouds. For example, a completely overcast sky with 10/10ths cloud cover may have only 1/10th opaque cloud cover if the clouds are high, translucent clouds kies du c cp8l72f21opng d8cu21(t)-26(hs)-23(c)-(r)-36(if)-14(t)-26(u)-

3.5.1.5 Surface Pressure

Surface pressure is required by ISCST3 for calculating dry particle deposition. However, ISCST3 is not very sensitive to surfp-11(e)-3(t)6 (pr)-15(e)e SAMSON p-11(en)22(d)22(NC)-7(DC)-7(C)-7(D)5(-)7(144 d)22(p-11(et

3.5.2 Upper Air Data

Upper air data, also referred to as mixing height data, are required to run the ISCST3 model. ISCST3 requires estimates of morning and afternoon (twice daily) mixing heights. PCRAMMET and MPRM use

3.6.1.1 Monin-Obukhov Length

The Monin-Obukhov length (*L*) is a measure of atmospheric stability. It is negative during the day, when surface heating causes unstable air. It is positive at night, when the surface is cooled with a stable atmosphere. In urban areas during stable conditions, the estimated value of *L* may not adequately reflect the less stable atmosphere associated with the mechanical mixing generated by buildings or structures. However, PCRAMMET requires an input for minimum urban Monin-Obukhov length, even if the area to be analyzed by ISCST3 is rural. A nonzero value for *L* must be entered to prevent PCRAMMET from generating an error message. A value of 2.0 meter for *L* should be used when the land use surrounding the site is rural (see Section 3.2.2.1). For urban areas, Hanna and Chang (1991) suggest that a minimum value of *L* be set for stable hours to simulate building-induced instability. The following are general examples of *L* values for various land use classifications:

Land Use Classification	**Minimum *L***
Agricultural (open)	2 meters
Residential	25 meters
Compact residential/industrial	50 meters
Commercial (19 to 40-story buildings)	100 meters
Commercial (>40-story buildings)	150 meters

PCRAMMET will use the minimum *L* value for calculating urban stability parameters. These urban values will be ignored by ISCST3 during the air modeling analyses for rural sites.

3.6.1.2 Anemometer Height

The height of the wind speed measurements is required by ISCST3 to calculate wind speed at stack top. The wind sensor (anemometer) height is identified in the station history section of the Local Climatological Data Summary available from NCDC for every National Weather Service station. Since 1980, most National Weather Service stations measure wind speed at the height of 10 meters. However, some stations operate at other heights or have valid representative data during years of operation at more than one height. The modeler must verify the correct measurement height for each year of data prior to processing with

PCRAMMET and running the ISCST3 model. ISCST3 modeled results are very sensitive to small variations in wind speed.

3.6.1.3 Surface Roughness Height at Measurement Site

Surface roughness height is a measure of the height of obstacles to wind flow. It is important in ISCST3 because it determines how close a particle must be above the ground before it is "captured" for deposition on the ground. Dramatic differences in ISCST3 calculations may result from slight variations in surface

3.6.1.6 Bowen Ratio

The Bowen ratio is a measure of the amount of moisture at the surface. The presence of moisture affects the heat balance resulting from evaporative cooling, which, in turn, affects the hourly Monin-Obukhov length calculated by PCRAMMET. Surface moisture is highly variable. Daytime Bowen ratios are presented in Table 3-3.

Bowen ratio values vary throughout the country. For example, in urban areas where annual rainfall is less than 20 inches, a single Bowen ratio value of 4.0 may be representative. For rural areas, a Bowen ratio value of 2.0 may be appropriate for grassland and cultivated land. For areas where annual rainfall is greater than 20 inches, U.S. EPA OSW recommends a single Bowen ratio value of 2.0 for urban areas; and 0.7 for rural forests, grasslands, and cultivated lands. The applicable permiting authority should review proposed values used in t18(e)32(3op)-21e 3op r

TABLE 3-3

DAYTIME BOWEN RATIOS BY LAND USE, SEASON, AND PRECIPITATION CONDITIONS

Land Use	**Season**[a]			
	Spring	**Summer**	**Autumn**	**Winter**
Dry Conditions				
Water (fresh and salt)	0.1	0.1	0.1	2.0
Deciduous forest	1.5	0.6	2.0	2.0
Coniferous forest	1.5	0.6	1.5	2.0
Swamp	0.2	0.2	0.2	2.0
Cultivated land	1.0	1.5	2.0	2.0
Grassland	1.0	2.0	2.0	2.0
Urban	2.0	4.0	4.0	2.0

TABLE 3-3

DAYTIME BOWEN RATIO BY LAND USE, SEASON, AND PRECIPITATION CONDITIONS (Continued)

Land Use	**Season[a]**			
	Spring	**Summer**	**Autumn**	**Winter**
Wet Conditions				
Water (fresh and salt)	0.1	0.1	0.1	0.3
Deciduous forest	0.3	0.2	0.4	0.5
Coniferous forest	0.3	0.2	0.3	0.3
Swamp	0.1	0.1	0.1	0.5
Cultivated land	0.2	0.3	0.4	0.5
Grassland	0.3	0.4	0.5	0.5
Urban	0.5	1.0	1.0	0.5
Desert shrubland	1.0	5.0	2.0	2.0

Note:

Source—Paine (1987)

[a] The various seasons are defined by Iqbal (1983) as follows:

Spring: Periods when vegetation is emerging or partially green; this is a transitional situation that applies for 1 to 2 months after the last killing frost in spring.

TABLE 3-4

ANTHROPOGENIC HEAT FLUX (Q_f) AND NET RADIATION (Q_*) FOR SEVERAL URBAN AREAS

Urban Area (Latitude)	Population (Millions)	Population Density (Persons/km^2)	Per Capita Energy Use (MJ x 10^3/year)	Q_f (Watts/m^2) (Season)	Q_* (Watts/m^2)
Manhattan (40° North)	1.7	28,810	128	117 (Annual) 40 (Summer) 198 (Winter)	93 (Annual)
Montreal (45° North)	1.1	14,102	221	99 (Annual) 57 (Summer) 153 (Winter)	52 (Annual) 92 (Summer) 13 (Winter)
Budapest (47° North)	1.3	11,500	118	43 (Annual) 32 (Summer) 51 (Winter)	46 (Annual) 100 (Summer) -8 (Winter)
Sheffield (53° North)	0.5	10,420	58	19 (Annual)	56 (Annual)
West Berlin (52° North)	2.3	9,830	67	21 (Annual)	57 (Annual)
Vancouver (49° North)	0.6	5,360	112	19 (Annual) 15 (Summer) 23 (Winter)	57 (Annual) 107 (Summer) 6 (Winter)
Hong Kong (22° North)	3.9	3,730	34	4 (Annual)	110 (Annual)
Singapore (1° North)	2.1	3,700	25	3 (Annual)	110 (Annual)
Los Angeles (34° North)	7.0	2,000	331	21 (Annual)	108 (Annual)
Fairbanks (64° North)	0.03	810	740	19 (Annual)	18 (Annual)

Note:

Source—Oke (1978)

3.6.2 MPRM

For on-site data, a new version of MPRM is used to mesh on-site data with NWS data in the preparation of the meteorological input file. MPRM performs the same meteorological file preparation as PCRAMMET, except the source of the surface data in MPRM consists of on-site measurements (U.S. EPA 1996e). MPRM includes extensive QA/QC for values that are out of range. MPRM also checks for missing data and summarizes values that require editing to fill missing data. After a complete surface file passes the quality checks, it is processed with NCDC mixing height data. NCDC data are purchased to correspond to the collection period of the on-site surface data. Mixing height data available on SCRAM's web site ends in 1991. A delay of about 3 months can occur for obtaining mixing height data from NCDC to process with recent on-site surface data.

Inputs to MPRM for preparing an ISCST3 meteorological file for concentration and deposition are the same as for PCRAMMET. Section 3.6.1 provides methods for determining values for these parameters.

Draft versions of ISCST3 and MPRM are available for review which implement dry vapor deposition. These versions are GDISCDFT (dated 96248) and GDMPRDFT (dated 96248), respectively. They may be found on the U.S. EPA SCRAM web site under "Topics for Review". These draft models are not the current regulatory versions and should not be used without approval from the appropriate permitting authority.

3.7 ISCST3 MODEL INPUT FILES

A thorough instruction of how to prepare the input files for ISCST3 is presented in the ISC3 User's Guide, Volume I (U.S. EPA 1995c), which is available for downloading from the SCRAM BBS. The example ISCST3 input file is provided in Figure 3-2 from the air dispersion modeling chapter (Chapter 3) of the U.S. EPA HHRAP (U.S. EPA 1998). This example illustrates a single year run (1984), for particle phase COPC emissions from a single stack, to compute acute (1-hour average) and chronic (annual average) and provide single year results in one hour and annual average plot files for post-processing. For ecological risk assessments, only the annual average air parameters are required, not the 1-hour values. However, by modeling both the 1-hour and annual averages in a single set of runs, the ISCST3 air dispersion model will

- Electronic and hard copies of ISCST3 input file for all air modeling runs

FIGURE 3-2

EXAMPLE INPUT FILE FOR "PARTICLE PHASE"

```
CO STARTING
CO TITLEONE Example input file, particle phase run
CO TITLETWO 1984 met data, Baton Rouge Surface, Boothville Upper Air
CO MODELOPT DFAULT CONC DDEP WDEP DEPOS DRYDPLT WETDPLT RURAL
CO AVERTIME 1 ANNUAL
CO POLLUTID UNITY
CO TERRHGTS ELEV
CO RUNORNOT RUN
CO SAVEFILE 84SAVE1 5 84SAVE2
** Restart incomplete runs with INITFILE, changing '**' to 'CO'
** INITFILE 84SAVE1
CO FINISHED

SO STARTING
SO LOCATION STACK1 POINT 637524. 567789. 347.
SO SRCPARAM STACK1 1.0 23.0 447.0 14.7 1.9
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29 18.29 18.29 18.29 18.29
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29 18.29 18.29 18.29 18.29
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29 18.29 18.29 18.29 18.29
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29 18.29 18.29 18.29 18.29
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29
SO BUILDWID STACK1 14.02 15.51 16.53 17.05 17.05 16.53 15.51 14.03
SO BUILDWID STACK1 12.10 14.02 15.51 16.53 17.05 17.05 16.53 15.51
SO BUILDWID STACK1 14.02 12.10 14.02 15.51 16.53 17.05 17.05 16.53
SO BUILDWID STACK1 15.51 14.02 12.10 14.02 15.51 16.53 17.05 17.05
SO BUILDWID STACK1 16.53 15.51 14.02 12.10
SO PARTDIAM STACK1 0.35 0.70 1.10 2.00 3.60 5.50 8.10 12.5 15.0
SO MASSFRAX STACK1 0.22 0.08 0.08 0.11 0.10 0.07 0.10 0.11 0.13
SO PARTDENS STACK1 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
SO PARTSLIQ STACK1 7E-5 5E-5 6E-5 1.3E-4 2.6E-4 3.9E-4 5.2E-4 6.7E-4 6.7E-4
SO PARTSICE STACK1 2E-5 2E-5 2E-5   4E-5   9E-5 1.3E-4 1.7E-4 2.2E-4 2.2E-4
SO SRCGROUP ALL
SO FINISHED

RE STARTING
RE ELEVUNIT METERS
RE DISCCART 630000. 565000. 352.
RE DISCCART 630500. 565000. 365.
RE DISCCART 631000. 565000. 402.
      ...
      (ARRAY OF DISCRETE RECEPTORS)
      ...
RE DISCCART 635000. 570000. 387.
RE FINISHED

ME STARTING
ME INPUTFIL 84BTR.WET
ME ANEMHGHT 10.0
ME SURFDATA 13970 1984 BATON_ROUGE
ME UAIRDATA 12884 1984 BOOTHVILLE
ME FINISHED

TG STARTING
TG INPUTFIL TERRAIN.TER
TG LOCATION 0.0 0.0
TG ELEVUNIT METERS
TG FINISHED

OU STARTING
OU RECTABLE ALLAVE FIRST
OU PLOTFILE 1 ALL FIRST BTR841.PLT
OU PLOTFILE ANNUAL ALL BTR84A.PLT
OU FINISHED
```

For each of the three runs for each emission source, 5 years of off-site (e.g., National Weather Service from SAMSON) meteorological data are completed. For sites with meteorological data collected on-site, the appropriate permitting authority should be notified for the data period required for a risk assessment. The averaging times (`AVERTIME`) should be specified as `‘ANNUAL’` to compute long-term (annual average) ecological risk. Optionally, the ‘1' may be specified for convenience in modeling for the maximum 1-hour averages used in computing acute human health risks. Each phase run may be repeated five times (one for each year, or a total of 15 ISCST3 runs) to complete a set of 15 runs for the full five years of meteorological data.

Alternatively, the modeler may combine the 5 years of meteorological data into a single meteorological data file and complete only 3 runs for each (a)-31 yet use t sou(op)-21(r)-34(c)-26(e)13(()-14(one)11(r)-36(u)-223(f)-14(o)1(r)-36 failure occurs during writing to the savefile, no more than 10 days will be lost. The `INITFILE` command should be used to restart the runs after the failure, as shown in the following example:

```
CO SAVEFILE SAVE1 5 SAVE2
** INITFILE SAVE1
```

ISCST3 will save the results alternately to `SAVE1` and `SAVE2` every 5 days. If the run fails after successfully writing to `SAVE1`, the ISCST3 run can be restarted by replacing the two asterisks (*) in the `INITFILE` line with `CO` and running ISCST3 again. The run will begin after the last day in `SAVE1`. The modeler should change the names of the save files (e.g., SAVE3 and SAVE4) in the 'CO SAVEFILE' command line prior to restarting ISCST3 to avoid overwriting the SAVE1 and SAVE2 files containing valid data from the interrupted run. Note that the `MULTYEAR` keyword is not used for computing long-term averages and should not be specified.

The following is an example of the COntrol pathway computer code for a single-year ISCST3 particle run:

```
CO STARTING
CO TITLEONE Example input file, particle pahse run, 1 year
CO TITLETWO 1984 met data, Baton Rouge Surface, Boothville Upper Air
CO MODELOPT DFAULT CONC DDEP WDEP DEPOS DRYDPLT WETDPLT RURAL
CO AVERTIME 1 ANNUAL
CO POLLUTID UNITY
CO TERRHGTS ELEV
CO RUNORRUN RUN
CO SAVEFILE 84SAVE1 5 84SAVE2
** Restart incomplete runs with INITFILE, changing '**' to 'CO'
** INITFILE SAVE1
CO FINISHED
```

Additional runs for the other 4 years are set up with the same COntrol pathway, except for the title description and `SAVEFILE` filenames.

3.7.2 SOurce Pathway

As discussed in Section 3.3, ISCST3 normally uses a unit emission rate of 1.0 g/s. Additional source characteristics required by the model (typically obtained from the Part B permit application and trial burn report) include the following:

surrounding a stack. The dimensions are calculated by using the U.S. EPA program BPIP, as described in Section 3.2.4.

The BPIP output file is input as follows:

```
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29 18.29 18.29 18.29 18.29
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29 18.29 18.29 18.29 18.29
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29 18.29 18.29 18.29 18.29
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29 18.29 18.29 18.29 18.29
SO BUILDHGT STACK1 18.29 18.29 18.29 18.29

SO BUILDWID STACK1 14.02 15.51 16.53 17.05 17.05 16.53 15.51 14.03
SO BUILDWID STACK1 12.10 14.02 15.51 16.53 17.05 17.05 16.53 15.51
SO BUILDWID STACK1 14.02 12.10 14.02 15.51 16.53 17.05 17.05 16.53
SO BUILDWID STACK1 15.51 14.02 12.10 14.02 15.51 16.53 17.05 17.05
SO BUILDWID STACK1 16.53 15.51 14.02 12.10
```

3.7.2.4 Particle Size Distribution

ISCST3 requires particle size distribution for determining deposition velocities. U.S. EPA OSW recommends site-specific stack test data for existing sources. New or undefined sources may use the particle size distribution presented in Table 3-1.

The following example is the ISCST3 input for particle phase run. From Table 3-1, the distribution for 9 mean diameter sizes includes the data required for the keywords of the SOurce pathway

limited to a maximum particle size of 10-μm, so all scavenging coefficients for particle sizes greater than or equal to 10-μ

When modeling air vapors using ISCST3, the following is an example of the SOurce pathway input for wet

The following is an example of the REceptor pathway for discrete receptor grid nodes at 500-meter spacing and including terrain elevations (in meters):

```
RE STARTING
RE ELEVUNIT METERS
RE DISCCART 630000. 565000. 352.
RE DISCCART 630500. 565000. 365.
RE DISCCART 631000. 565000. 402.
       ↓
RE DISCCART 635000. 570000. 387.
RE FINISHED
```

U.S. EPA OSW recommends that air modeling for each risk assessment include, at a minimum, an array of receptor grid nodes covering the area within 10 kilometers of the facility with the origin at the centroid of a polygon formed by the locations of the stack emission sources. This receptor grid node array should consist of a Cartesian grid with grid nodes spaced 100 meters apart extending from the centroid of the emission sources out to 3 kilometers from the centroid. For the distances from 3 kilometers out to 10 kilometers, the receptor grid node spacing can be increased to 500 meters. The single grid node array contains both grid node spacings. This same receptor grid node array is included in the REceptor pathway for all ISCST3 runs for all years of meteorological data and for all emission sources.

Terrain elevations should be specified for all receptor grid nodes. Several methods are available for assigning terrain elevations to grid nodes using digital terrain data. The 1:250,000 scale DEM digital data are available for download at the USGS Internet site:

Worldwide Web:	http://edcwww.cr.usgs.gov/pub/data/dem/250
FTP (two options):	ftp://edcwww.cr.usgs.gov/pub/data/dem/250 ftp://edcftp.cr.usgs.gov/pub/data/dem/250

This data has horizontal spacing between digital terrain values of approximately 90 meters which provides sufficient accuracy for air modeling.

In addition to the receptor grid node array evaluated for each facility out to 10 kilometers, other grid node arrays may be considered for evaluation of water bodies and their watersheds, ecosystems and special ecological habitats located beyond 10 kilometers. Grid node spacing of 500 meters between nodes is recommended for grid node arrays positioned at distances greater than 10 kilometers from the emission source. An equally spaced grid node array facilitates subsequent computation of area averages for deposition rates.

RECOMMENDED INFORMATION FOR RISK ASSESSMENT REPORT

- Summary of all information regarding the coordinates and placement of the receptor grid node array used in air modeling
- Copies of any maps, figures, or aerial photographs used to develop the receptor grid node array
- Map presenting UTM locations of receptor grid nodes, along with other facility information.

The location keyword of the TG pathway (`TG LOCATION`) identifies the x and y values to be added to the source and receptor grid to align with the terrain file coordinates. If the source and receptor grid nodes are in relative units such that the source is at location 0,0, the location keywords in the TG pathway would be the UTM coordinates of the source. U.S. EPA OSW requires that all emission sources and receptor grid nodes be specified in UTM coordinates (NAD27 or NAD83 format), and that the TG file, if used, be in UTM coordinates. Therefore, the location of the origin of the TG file relative to the source location will be 0,0. Also, U.S. EPA OSW recommends that the terrain elevations in the TG file be presented in meters. Following is an example of the TG pathway:

```
TG STARTING
TG INPUTFIL TERRAIN.TER
TG LOCATION 0.0 0.0
TG ELEVUNIT METERS
TG FINISHED
```

3.7.6 OUtput Pathway

ISCST3 provides numerous output file options in addition to the results in the output summary file specified in receptor tables (RECTABLE). The plot file is most useful for facilitating post-processing of the air parameter values in the model output. The plot file lists the x and y coordinates and the concentration or deposition rate values for each averaging period in a format that can be easily pulled into a post-processing program (or spreadsheet). Note that the ISCST3 generated ‘plot’ file is not the same format as the ISCST3 generated ‘post’ file. U.S. EPA OSW recommends using the plot file, not the post file.

Following is an example OUtput file specification for single-year run of 1-hour and annual average plot files:

```
OU STARTING
OU RECTABLE ALLAVE FIRST
OU PLOTFILE 1 ALL FIRST BTR841.PLT
OU PLOTFILE ANNUAL ALL BTR84A.PLT
OU FINISHED
```

For ecological risk assessments, the 1-hour average plot file is not needed. If the modeler has directed in the ISCST3 control pathway for 1-hour averages to be computed for use in a human health acute risk

3.9 USE OF MODELED OUTPUT

The ISCST3 modeled output (air concentrations and deposition rates) are provided on a unit emission rate (1.0 g/s) basis from the combustion unit or emission source, and are not COPC-specific. The estimating media equations presented in Section 3.11 and Appendix B require the model output (air parameters, see Table 3-5) directly without converting the unit based output to COPC-specific output. However, there may be some instances where the risk assessor will need to convert modeled output to COo 5219(A)31(i(s)-v) i(s)-v i(s3A)31(0)2(

$$\frac{\text{COPC-Specific Air Concentration}}{\text{COPC}}$$

3.9.1.1 Determination of the COPC-Specific Emission Rate (*Q*)

The COPC-specific emission rate can usually b(Eq)23(ua)-28((a)-34 TD 0.01 (e CO)-40(h)1(e)10(C)-28(O)-16(P)-30(C)-28(

$$Q = SGF \cdot \frac{SGC \cdot CFO_2}{1\times10^6} \qquad \text{Equation 3-4}$$

$$\begin{matrix}\text{COPC-Specific}\\ \text{Air Concentration}\end{matrix} = \frac{\text{Modeled Output Air Concentration} \cdot \text{COPC-Specific Emission Rate}}{\text{Unit Emission Rate}} \qquad \text{Equation 3-3}$$

Similar plot files are produced for the particle-boun can cvapor phase runs. The output for the vapor phase runs will be average concentrationcan cwet deposition. The output for the particlecan cparticle-boun cphase runscwill be average conce ration, dry deposition, wet deposition an ctoal deposition. Again, the 1-year valuescat each receptor grid node must be averaged to 5-year valuecat each node unlessca single five-year ISCST3 run using a combined meteorological file is used. If the 5-year combined file is used, the results from the ISCST3 plot file may be used directly in the risk assessment without averaging over the five years.

All valuescare defined as used in the estimating media conce ration equationsc(see Section 3.11).

3.9.3 Use of Model Output inc .-6(s)-1(t)8(i)18(m)51(a)23(t)8(i)18(n)35(g)1(M)10(e)10(d)14(i)18(a)23(c .-6(q)14(u

rates) to use in the estimating media concentrationcequations is based on this samecpartitioning theory.

3.9.3.1 Vapor Phase COPCs

ISCST3 output ge erated from vapor phase air modeling runscare vapor phase air conce rationsc(unitized Cyv an cunitized $Cywv$) an cwet vaporcdepositionsc(unitized$Dywv$ an cunitized $Dywwv$) for organic COPCscat receptor grid nodescbased on the unitcemission rate. These valuescare used in the estimating media concentrationcequations for all COPC organicscexcept the polycyclic aromatic hydrocarbons dibenzo(a,h)anhrace e an cindeno(1,2,3-cd)pyrene,cwhich have vapor phase fractions,c Fv, lesscthan five perce . The air conce rationc(unitized Cyv) an cwet vaporcdepositionc(unitized$Dywv$) from the vapor phase run iscalso used in the estimating media conce rationcequationscfor mercury. Valuescfor these COPCs are selectedcfrom the vapor phase runcbecause the mass of the COPC emittedcbycthe combustion unitciscassumed to have either all or a portioncof itscmasscin the vapor phase (see Appendix A-2).

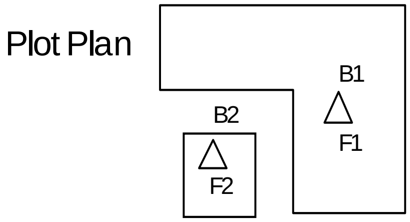
3.9.3.2 Particle Phase COPCs

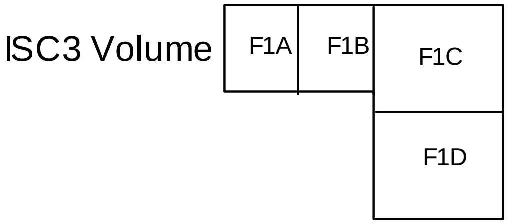
ISCST3 output generated from particle phase air modeling runs are air concentration (unitized *Cyp*), dry deposition (unitized *Dydp*), wet deposition (unitized *Dywp*), and combined deposition (unitized *Dytwp*) for inorganics and relatively non-volatile organic COPCs at receptor grid nodes based on the unit emission rate. These values are used in the estimating media concentration equations for all COPC inorganics (except mercury, see Chapter 2 and Appendix A-2) and polycyclic aromatic hydrocarbons with fraction of vapor phase, Fv , less than 0.05 (e.g., dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene). Values for inorganic and relatively non-volative COPCs are selected from the particle phase run because the mass of the COPC emitted by the combustion unit is assumed to have all of its mass in the particulate phase (see Appendix A-2), apportioned across the particle size distribution based on mass weighting.

3.9.3.3 Particle-Bound COPCs

ISCST3 output generated from particle-bound air modeling runs are air concentration (unitized *Cyp*), dry deposition (unitized *Dydp*), wet deposition (unitized *Dywp*), and combined deposition (unitized *Dytwp*) for organic COPCs and mercury (see Chapter 2 and Appendix A-2) at receptor grid nodes based on the unit

The following example is for organic fugitive emissions modeled as a volume source type. For a facility





for use in characterizing ecological risk. Selection of the appropriate ISCST3 modeled output for use in the equations is discussed in Section 3.9.

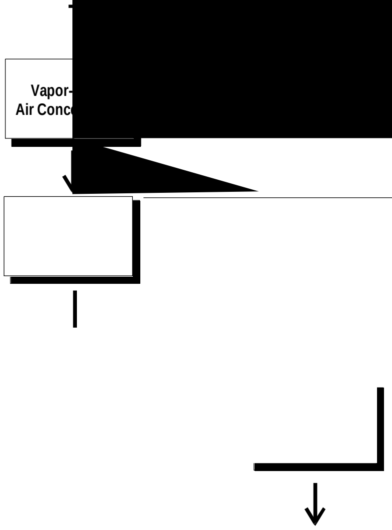
This section presents the estimating media concentration equations used for calculating, from the appropriate ISCST3 unitized model output and COPC-specific emission rates, COPC-specific media concentrations in soil, surface water, and sediment. Determining COPC media concentrations is relevant to estimating risks to potentially impacted ecosystems through exposure of ecological receptors to COPCs in air (plant only), soil, surface water, and sediment. This section also includes equations for calculating COPC-specific concentrations in terrestrial plants resulting from foliar and root uptake.

Section 3.11.1 describes the equations for calculating COPC-specific concentration in soils. Section 3.11.2 describes the equations for calculating COPC-specific concentrations in surface water and sediment. Section 3.11.3 describes the equations for calculating COPC-specific plant concentrations from foliar and root uptake. In addition, Appendix B also provides in more detail the media concentration equations and default input variables recommended by U.S. EPA OSW.

3.11.1 CALCULATION OF COPC CONCENTRATIONS IN SOIL

As depicted in Figure 3-4, COPC concentrations in soil are calculated by summing the particle and vapor phase deposition of COPCs to the soil. Wet and dry deposition of particles and vapors are considered, with dry deposition of vapors calculated from the vapor air concentration and the dry deposition velocity. Soil concentrations may require many years to reach steady state. As a result, the equations used to calculate the soil concentration over the period of deposition were derived by integrating the instantaneous soil concentration equation over the period of deposition. U.S. EPA OSW recommends that the highest 1-year annual average COPC concentration in soil be used as the soil concentration for estimating ecological risk, which would typically occur at the end of the time period of combustion (see Section 3.11.1).

[redacted]



COPC loss in soil can also follow zero or second-order reaction kinetics. Zero-order reaction kinetics are independent of reactant concentrations (Bohn, McNeal, and O'Connor 1985). Zero-order loss rates describe processes in which the reactants are present at very high concentrations. Under zero-order kinetics, a constant amount of a COPC is lost from the soil over time, independent of its concentration. Processes that follow second-order reaction kinetics depend on the concentrations of two reactants or the concentration of one reactant squared (Bohn, McNeal, and O'Connor 1985). The loss constant of a COPC following a second-order process can be contingent on its own concentration, or on both its concentration and the concentration of another reactant, such as an enzyme or catalyst.

Because COPC loss from soil depends on many complex factors, it may be difficult to model the overall rate of loss. In addition, because the physical phenomena that cause COPC loss can occur simultaneously, the use of Equation 3-8 may also overestimate loss rates for each process (Valentine 1986). When possible, the common occurrence of all loss processes should be taken into account.

The following subsections discuss issues associated with the calculation of the *ksl*, *kse*, *ksr*, *ksg*, and *ksv* variables. Appendix B, Tables B-1-2 through B-1-6 present the equations for computing the overall and individual soil loss constant, except for loss due to degradation, which is discussed below.

COPC Loss Constant Due to Biotic and Abiotic Degradation *(ksg)*

Soil losses resulting from biotic and abiotic degradation (*ksg*) are determined empirically from field studies and should be addressed in the literature (U.S. EPA 1990a). Lyman et al. (1982) states that degradation rates can be assumed to follow first order kinetics in a homogenous media. Therefore, the half-life of a compound can be related to the degradation rate constant. Ideally, *ksg* is the sum of all biotic and abiotic rate constants in the soil media. Therefore, if the half-life of a compound (for all of the mechanisms of transformation) is known, the degradation rate can be calculated. However, literature sources do not

$$kse = \frac{0.1 \cdot X_e \cdot SD \cdot ER}{BD \cdot Z_s} \cdot$$

ksr =ksr

Z_s = Soil mixing zone depth (cm)
Kd_s = Soil-water partition coefficient (mL/g)
BD = Soil bulk density (g/cm^3 soil)

COPC Loss Constant Due to Leaching (*ksl*)

Consistent with earlier U.S. EPA guidance (1993h and 1994l) and U.S. EPA (1998c), U.S. EPA OSW recommends that Equation 3-8 ***ksl*****)**Z

$$ksl = \frac{P + I - RO - E_v}{\theta_{sw} \cdot Z_s \cdot [1.0 + (BD \cdot Kd_s / \theta_{sw})]} \qquad \text{Equation 3-8C}$$

$$ksv = \left(\frac{3.1536 \times 10^{7} \cdot H}{Z_s \cdot Kd_s \cdot R \cdot T_a \cdot BD} \right) \cdot \left(\frac{D_a}{Z_s} \right) \cdot \left[1 - \left(\frac{BD}{} \right) \qquad \right]$$

associated with Equation 3-9. The proper use of this equation is also further described in Appendix B, Table B-1-1.

The average annual precipitation (*P*), irrigation (*I*), runoff (*RO*), and evapotranspiration (E_v) rates and other climatological data may be obtained from either data recorded on site or from the Station Climatic Summary for a nearby airport.

3.11.2 CALCULATION OF COPC CONCENTRATIONS IN SURFACE WATER AND SEDIMENTS

COPC concentrations in surface water and sediments are calculated for all water bodies selected for evaluation in the risk assessment. Mechanisms considered for determination of COPC loading of the water column are:

Total (Wet and Dry) Particle Phase and Wet Vapor Phase Contaminant Direct Deposition Load to Water Body (L_{DEP})

Consistent with U.S. EPA (1994l) and U.S. EPA (1998c), U.S. EPA OSW recommends Equation 3-11 to calculate the load to the water body from the direct deposition of wet and dry particles and wet vapors onto the surface of the water body (L_{DEP}). The equation is also further described in Appendix B, Table B-2-2.

Recommended Equation for Calculating:
Total Particle Phase and Wet Vapor Phase Direct Deposition Load to Water Body (L_{DEP})

$$L_{DEP} = Q \cdot [\ F_v \cdot Dywwv + (1 - F_v\ ) \cdot Dytwp\ ] \cdot A_W \qquad \text{Equation 3-11}$$

where

L_{DEP} = Total (wet and dry) particle phase and wet vapor phase COPC direct deposition load to water body (g/yr)
Q = COPC emission rate (g/s)
F_v = Fraction of COPC air concentration in vapor phase (unitless)
$Dywwv$ = Unitized yearly (water body and watershed) average wet deposition from vapor phase (s/m^2-yr)
$Dytwp$ = Unitized yearly (water body and watershed) average total (wet and dry) deposition from vapor phase (s/m^2-yr)
A_W = Water body surface area (m^2)

Section 3.9 describes the unitized air parameters, *Dywwv* and *Dywwv*, obtained as output from the ISCST3 air dispersion modeling. The determination of water body surface area, A_w, is described in Chapter 4. Appendix A-2 describes determination of the compound-specific parameter, F_v.

$$L_{dif} = \frac{K_v \cdot Q \cdot F_v \cdot Cywv \cdot A_W \cdot 1 \times 10}{}$$

Universal Soil Loss Equation - USLE

U.S. EPA OSW recommends that the universal soil loss equation (USLE), Equation 3-16, be used to calculate the unit soil loss (X_e) specific to each watershed. This equation is further described in Appendix B, Table B-2-7. Appendix B also describes determination of the site- and watershed-specific values for each of the variables associated with Equation 3-16. The use of Equation 3-16 is consistent with U.S. EPA (1994b; 1994l) and U.S. EPA (1998c).

Recommended Equation for Calculating:
Unit Soil Loss (X_e)

$$X_e = RF \cdot K \cdot LS \cdot C \cdot PF \cdot \frac{907.18}{4047} \qquad \text{Equation 3-16}$$

where

X_e = Unit soil loss (kg/m^2-yr)
RF = USLE rainfall (or erosivity) factor (yr^{-1})
K = USLE erodibility factor (ton/acre)
LS = USLE length-slope factor (unitless)
C = USLE cover management factor (unitless)
PF = USLE supporting practice factor (unitless)
907.18 = Units conversion factor (kg/ton)
4047 = Units conversion factor (m^2/acre)

The USLE *RF* variable, which represents the influence of precipitation on erosion, is derived from data on the frequency and intensity of storms. This value is typically derived on a storm-by-storm basis, but average annual values have been compiled (U.S. Department of Agriculture 1982). Information on determining site-specific values for variables used in calculating X_e is provided in U.S. Department of Agriculture (U.S. Department of Agriculture 1997) and U.S. EPA guidance (U.S. EPA 1985b).
Refer to Appendix B, Table B-2-7 for additional discussion of the USLE.

Sediment Delivery Ratio (*SD*)

U.S. EPA OSW recommends the use of Equation 3-17 to calculate sediment delivery ratio (*SD*). The use of this equation is further described in Appendix B, Table B-2-8.

Recommended Equation for Calculating:
Sediment Delivery Ratio *(SD)*

$$SD = a \cdot (A_L)^{-b} \qquad \text{Equation 3-17}$$

---

where

SD = Sediment delivery ratio (watershed) (unitless)
a = Empirical intercept coefficient (unitless)
b = Empirical slope coefficient (unitless)
A_L = Total watershed area (evaluated) receiving COPC deposition (m^2)

The sediment delivery ratio (*SD*) for a large land area, a watershed or part of a watershed, can be calculated, on the basis of the area of the watershed, by using an approach proposed by Vanoni (1975). Acea5(t)-27(h)0(eh)018(s)d ofhed,eeh32(usS434832(useEP4348)0(eh 0 8 -93(e)3223(e) r21(a)-3]TJs))32(d,)Tppe en is

however, U.S. EPA (1993h) recommended values ranging from 0.01 to 0.05. Consistent with U.S. EPA (1994l; 1998c), U.S. EPA OSW recommends a default value of 0.03, which represents the midpoint of the specified range. Issues related to the remaining parameters are summarized in the following subsections.

Fraction of Total Water Body COPC Concentration in the Water Column (f_{wc}) and Benthic Sediment (f_{bs})

Consistent with U.S. EPA (1998c), U.S. EPA OSW recommends using Equation 3-19 to calculate fraction of total water body COPC concentration in the water column (f_{wc}), and Equation 3-20 to calculate fraction of total water body contaminant concentration in benthic sediment (f_{bs}). The equations are also presented in Appendix B, Table B-2-10.

$$f_{wc} = \frac{(1 + Kd_{sw} \cdot TSS \cdot 1 \times 10^{-6}) \cdot d_{wc} / d_z}{(1 + Kd_{sw} \cdot TSS \cdot 1 \times 10^{-6}) \cdot d_{wc} / d_z + (\theta_{bs} + Kd_{bs} \cdot BS) \cdot d_{bs} / d_z} \qquad \text{Equation 3-19}$$

$$f_{bs} = 1 - f_{wc} \qquad \text{Equation 3-20}$$

Kd_{bs} = Bed sediment/sediment pore water partition coefficient (L water/kg bottom sediment)
BS = Benthic solids concentration (g/cm^3 [equivalent to kg/L])
d_{wc} = Depth of water column (m)
d_{bs} = Depth of upper benthic sediment layer (m)

U.S. EPA (1993h) and NC DEHNR (1997) recommended the use of Equations 3-19 and 3-20 to calculate the fraction of total water body concentration occurring in the water column (f_{wc}) and the bed sediments (f_{bs}). The partition coefficient Kd_{sw} describes the partitioning of a contaminant between sorbing material, such as soil, surface water, suspended solids, and bed sediments (see Appendix A-2). NC DEHNR (1997) also recommended adding the depth of the water column to the depth of the upper bent th Dmmpernt1 Tf 30.4565 0 T

$$TSS = \frac{X_e \cdot (A_L - A_I) \cdot SD \cdot 1x10^3}{Vf_x + D_{ss} \cdot A_W} \qquad \text{Equation 3-21}$$

SD = Sediment delivery ratio (watershed) (unitless)
Vf_x

$$\theta_{bs} = 1 - \frac{BS}{\rho_s}$$

Henry's Law constants generally increase with increasing vapor pressure of a COPC and generally decrease with increasing solubility of a COPC. Henry's Law constants are compound-specific and are presented in Appendix A-2. The universal ideal gas constant, *R*

$$K_L = \sqrt{\frac{(1 \times 10^{-4}) \cdot D_w \cdot u}{d_z}} \cdot 3.1536{\times}10^7 \qquad \text{Equation 3-25}$$

$$K_L = (C_d^{0.5} \cdot W) \cdot (\frac{\rho_a}{\rho_w})^{0.5} \cdot \frac{k^{0.33}}{\lambda_z} \cdot (\frac{\mu_w}{\rho_w \cdot D_w})^{-0.67} \cdot 3.1536{\times}10^7 \qquad \text{Equation 3-26}$$

ρ_a = Density of air (g/cm^3)
ρ_w = Density of water (g/cm^3)
k = von Karman's constant (unitless)
λ_z = Dimensionless viscous subla(o)242r74(e a3(ssr13(on (l)-1(a)7(n)10(n157 TDı˝(oX9(e)33(

Gas Phase Transfer Coefficient (K_G)

U.S. EPA OSW recommends using Equations 3-27 and 3-28 to calculate gas phase transfer coefficient (K_G). The equation is also discussed in Appendix B, Table B-2-15.

Recommended Equation for Calculating:
Gas Phase Transfer Coefficient (K_G)

For flowing streams or rivers:

$$K_G = 36500 \text{ m/yr} \qquad \text{Equation 3-27}$$

For quiescent lakes or ponds:

$$K_G = (C_d^{0.5} \cdot W) \cdot \frac{k^{0.33}}{\lambda_z} \cdot \left(\frac{\mu_a}{\rho_a \cdot D_a}\right)^{-0.67} \cdot 3.1536 \times 10^7 \qquad \text{Equation 3-28}$$

---

where

K_G = Gas phase transfer coefficient (m/yr)
C_d = Drag coefficient (unitless)
W = Average annual wind speed (m/s)
k = von Karman's constant (unitless)
λ_z = Dimensionless viscous sublayer thickness (unitless)
μ_a = Viscosity of air corresponding to air temperature (g/cm-s)
ρ_a = Density of air corresponding to water temperature (g/cm^3)
D_a = Diffusivity of COPC in air (cm^2/s)
3.1536×10^7 = Units conversion factor (s/yr)

U.S. EPA (1993h) indicated that the rate of transfer of a COPC from the gas phase for a flowing stream or river is assumed to be constant, in accordance with O'Connor and Dobbins (1958) (Equation 3-27).

For a stagnant system (quiescent lake or pond), the transfer coefficients are controlled by wind-induced turbulence. For quiescent lakes or ponds, U.S. EPA OSW recommends that the gas phase transfer coefficient be computed by using the equation presented in O'Connor (1983) (Equation 3-28).

Recommended Equation for Calculating:

$$C_{wctot} = f_{wc} \cdot C_{wtot} \cdot \frac{d_{wc} + d_{bs}}{d_{wc}}$$ Equation 3-31

Recommended Equation for Calculating:
Dissolved Phase Water Concentration (C_{dw})

$$C_{dw} = \frac{C_{wctot}}{1 + Kd_{sw} \cdot TSS \cdot 1 \times 10^{-6}} \qquad \text{Equation 3-32}$$

where

C_{dw} = Dissolved phase water concentration (mg COPC/L water)
C_{wctot} = Total COPC concentration in water column (mg COPC/L water column)
Kd_{sw} = Suspended sediments/surface water partition coefficient (L water/kg suspended sediment)
TSS = Total suspended solids concentration (mg/L)
1×10^{-6} = Units conversion factor (kg/mg)

The use of Equation 3-32 to calculate the concentration of COPC dissolved in the water column is consistent with U.S. EPA (1994l; 1998c).

The total COPC concentration in water column (C_{wctot}) is calculated by using the Equation 3-31 (see also Appendix B, Table B-2-17). The surface water partition coefficient (Kd_{sw}) and total suspended solids concentration (TSS) are discussed previously.

COPC Concentration in Bed Sediment (*Csed*)

U.S. EPA OSW recommends the use of Equation 3-33 to calculate COPC concentration in bed sediment (*Csed*

3.11.3.1 Calculating Plant Concentration Due to Direct Deposition (*Pd*)

Consitent with previous U.S. EPA guidance (1994l) and U.S. EPA (1998c), U.S. EPA OSW recommends the use of Equation 3-34 to calculate COPC concentration in plants due to direct deposition. The use of this equation is further described in Appendix B, Table B-3-1.

Recommended Equation for Calculating:
Plant Concentration Due to Direct Deposition (*Pd*)

$$Pd = \frac{1{,}000 \cdot Q \cdot (1 - Fv) \cdot [Dydp + (Fw \cdot Dywp)] \cdot Rp \cdot [1.0 - \exp(-kp \cdot Tp)] \cdot 0.12}{Yp \cdot kp} \qquad \text{Equation 3-34}$$

where

Pd = Plant concentration due to direct (wet and dry) deposition (mg COPC/kg WW)
1,000 = Units conversion factor (mg/g)
Q = COPC emission rate (g/s)
F_v = Fraction of COPC air concentration in vapor phase (unitless)
$Dydp$ = Unitized yearly average dry deposition from particle phase (s/m^2-yr)
Fw = Fraction of COPC wet deposition that adheres to plant surfaces (unitless)
$Dywp$ = Unitized yearly wet deposition from particle phase (s/m^2-yr)
Rp = Interception fraction of the edible portion of plant (unitless)
kp = Plant surface loss coefficient (yr^{-1})
Tp = Length of plant exposure to deposition per harvest of the edible portion of the *i*th plant group (yr)
012 = Dry weight to wet weight conversion factor (unitless)
Yp = Yield or standing crop biomass of the edible portion of the plant (productivity) (kg DW/m^2)

Section 3.9 describes the use of the unitized air parameters, *Dydp* and *Dywp*

3. The basis of the default parameter value, as understood by the requestor, including readable copies (printed in English) of the referenced literature or studies (if available);

4. A comparison of the weight-of-evidence between the competing studies (e.g., the proposed replacement parameter value is based on a study that is more representative of site conditions, a specific exposure setting being evaluated, or a more scientifically valid study than the default parameter value, the proposed replacement parameter is based on the analysis of 15 samples as opposed to 5 for the default parameter value, or the site-specific study used more stringent quality control/quality assurance procedures than the study upon which the default parameter value is based);

5. A description of other risk assessments or projects where the proposed replacement

Habitat types can typically be identified by reviewing hard copy and/or electronic versions of land use land classification (LULC) maps, topographic maps, and aerial photographs. Sources and general information associated with each of these data types or maps are presented below. Also, as noted in Chapter 3, the UTM coordinate system format (NAD27 or NAD83) for all mapping information should be verified to ensure consistency and prevent erroneous georeferencing of locations and areas.

> ***Land Use Land Cover (LULC) Maps*** **-** LULC maps can be downloaded directly from the USGS web site (http://mapping.usgs.gov./index.html), at a scale of 1:250,000 in a file type GIRAS format. LULC maps can also be downloaded from the EPA web site (ftp://ftp.epa.gov/pub), at a scale of 1:250,000, in an Arc/Info export format. These maps provide detailed habitat information based upon the classification system and definitions of Level II Land Use and Land Cover information. Exact boundaries of polygon land use area coverages, in areas being considered for evaluation, should be verified using available topographic maps and aerial photographic coverages.
>
> ***Topographic Maps*** **-** Topographic maps are readily available in both hard copy and electronic format directly from USGS or numerous other vendors. These maps are commonly at a scale of 1:24,000, and in a file type of TIFF format with TIFF World File included for georeferencing.
>
> ***Aerial Photographs*** **-** Hard copy aerial photographs can be purchased directly form USGS in a variety of scales and coverages. Electronic format aerial photographs of Digital Ortho Quarter Quads (DOQQs) can also be purchased directly form USGS, or from an increasing number of commercial sources. Properly georeferenced DOQQs covering a 3-km or more radius of the assessment area, overlays of the LULC map coverage, and the ISCST3 modeled receptor grid node array provide an excellent reference for identifying land use areas and justifying selection of exposure locations.

While these data types or maps do not represent the universe of information available on habitats or land use, they are readily available from a number of governmental sources (typically accessible via the Internet), usually can be obtained free or for a low cost, and, when used together, provide sufficient information to reliably identify and define boundaries of habitats to be considered for evaluation in risk characterization. However, while the use of these or other data can be very accurate, verifying identified habitats by conducting a site visit is recommended. Also, these data sources may be dated, and may not

Service (FWS), (3) U.S Department of Agriculture, (4) state natural resource, wildlife, and park agencies, and (5) local government agencies.

U.S. EPA OSW recommends that habitats identified during exposure setting characterization and selected for evaluation in the risk assessment be clearly mapped and include the following supporting information:

- Facility boundaries
- Facility emission source location(s)
- Habitat types and boundaries
- Water bodies and their asssociated watersheds
- Special ecological areas (see Section 4.1.1.2)

A facility location map, including land-use and land cover data, which allows for identification of habitats to support selection of habitat-specific food webs to be evaluated in the risk assessment. The map should also note the UTM coordinate system format (NAD27 or NAD83) for all information presented to ensure consistency and prevent erroneous georeferencing of locations and areas; including accurate identification of exposure scenario locations and water bodies within the habitat to be evaluated, as discussed in the following subsections.

4.1.1.1 Selection of Exposure Scenario Locations Within Terrestrial Habitats

Exposure scenario locations to be evaluated within the terrestrial habitats identified during the exposure setting characterization, are selected at specific receptor grid nodes based on evaluation of the magnitude of air parameter values estimated by ISCST3 (see Chapter 3). U.S. EPA OSW would like to note that the methodology and resulting selection of receptor grid nodes as exposure scenario locations is one of the most

Modeling of the above air parameter criteria for habitats at actual sites being evaluated in U.S. EPA Region 6, using actual modeled air parameters, indicates that only 1 to 3 receptor nodes are typically selected per habitat. This is because, in most cases, the location of some of the highest air concentration and deposition rate, within a habitat for several of the modeled air parameters, occurs at the same receptor grid node. The number of receptor grid nodes with maximum air parameters depends on many factors, including number of and distance between emissions sources, habitat size and shape, distance and direction from facility, topographic features, and meteorological patterns. It should also be noted, that while these criteria minimize overlooking maximum risk within a habitat, they do not preclude the risk assessor from selecting additional exposure scenario locations within that same habitat based on site-specific risk considerations.

Also, a water body and associated watershed in close proximity to the exposure scenario location being evaluated should be identified to represent a drinking water source for applicable receptors (see Appendix F). Although the locations and type of sources (i.e., free water, consumption of water as part of food items) of water ingested by an animal through diet are expected to vary depending on the receptor and availability, COPC intake by the receptor through ingestion of water can be estimated by assuming only water intake from a defined water body for which a COPC concentration can be calculated. Therefore, a representative water body should be defined and evaluated following the guidance provided in Section 4.1.1.2, and a COPC concentration in the water column, C_{wctot}, calculated as described in Chapter 3 and Appendix B.

If a definable water body is not located within or in close proximity to the terrestrial habitat being evaluated, receptor drinking water intake terms in the exposure equations presented in Appendix F should be adjusted accordingly (i.e., ingestion of drinking water set equal to zero). However, for sites where the permitting authority or risk manager identifies that receptor exposure through ingestion of drinking water may be significant, an available option is to assume that a small water body exists at the same receptor grid node as the exposure scenario location being evaluated. If multiple exposure scenario locations within the habitat are being evaluated, a single assumed water body can be located at the closest receptor grid node located equal distance from each of the exposure scenario locations being evaluated, and utilized as a drinking water source for evaluation of each exposure scenario location within the habitat. Since the assumed water body represents a pool or other drinking source too small for identification on an aerial photograph or map, it can be assumed to have a unit volume (i.e., surface area of 1 meter square, water column depth of 1 meter). The assumed water body should not have flow or an associated watershed.

4.1.1.2 Selection of Habitat Exposure Scenrario Locations Within Aquatic Habitats

Exposure scenario locations to be evaluated within the aquatic habitats identified during the exposure setting characterization may first require differentiating water bodies from land areas within aquatic habitiats not typically covered by water (e.g., flood plains or wetland areas transitioning to terrestrial and upland habitats). Exposure scenario locations within land areas of aquatic habitats not characteristic of a standing water body are selected following the same steps as for terrestrial habitats (see Section 4.1.1.1). However, exposure scenario locations for defined water bodies within aquatic habitats should be selected following the guidance provided in this section. The associated watershed contributing COPC loading to the water body being evaluated should also be defined.

U.S. EPA OSW recommends that, at a minimum, the following procedures be used in the selection of exposure scenario locations within defined water body areas of aquatic habitats as follows:

> ***Step 1: Define Aquatic Habitats To Be Evaluated -*** All habitats, identified during exposure setting characterization for evaluation in the risk assessment, should be defined and habitat boundaries mapped in a format (NAD 27 or NAD 83 UTM) consistent with that used to define locations of facility emission sources and modeled ISCST3 receptor grid nodes. Water body boundaries should reflect annual average shoreline elevations. The area extent of watersheds associated with water bodies to be evaluated should also be defined.
>
> ***Step 2: Identify Receptor Grid Node(s) Within Each Habitat To Be Evaluated -*** For each water body and associated watershed to be evaluated, the receptor grid nodes within that area and on the boundary of that area (defined in Step 1) should be considered. For water bodies, the risk assessor can select the receptor grid node that represent the locations of highest yearly average

- Identification and/or mapping of habitats, water bodies, and associated watersheds potentially impacted by facility emissions of COPCs, including surface area of the water body and area extent of the contributing watershed defined by UTM coordinates
- Rational for selection or exclusion from evaluation, habitats within the assessment area
- Description of rational and assumptions made to limit the watershed area to an "effective" area
- Copies of all maps, photographs, or figures used to define characteristics of habitats, water

of species based on geographic location, and are very helpful in identifying threatened or endangered species or areas of special concern.

General Literature (field guides) **-** Examples of information describing the flora and fauna of North America and useful in the development of habitat-specific food webs (see Section 4.2) include the following: Wharton 1982; Craig et al. 1987; Baker et al. 1991; Carr 1994; Ehrlich et al. 1988; National Geographic Society (1987, 1992); Whitaker 1995; Burt and Grossenheider 1980; Behler 1995; Smith and Brodie 1982; Tyning 1990; and Farrand Jr. 1989.

Private or Local Organizations **-** Additional private or professional organizations that are examples of sources of information include: National Audubon Society, National Geographic Society, Local Wildlife Clubs, State and National Parks Systems, and Universities.

Ecological receptor identification should include species both known and expected to be present in a specific habitat being evaluated, and include resident and migratory populations. Identification of flora should be based on major taxonomic groups represented in the assessment area. Natural history information may also be useful during food web development in assigning individual receptors to specific habitats and guilds based on feeding behavior (as discussed in Section 4.2.).

4.2 FOOD WEB DEVELOPMENT

Information obtained during exposure setting characterization should be used to develop one or more habitat-specific food web(s) that represent communities and guilds of receptors potentially exposed to emissions from facility sources. Food webs are interlocking patterns of food chains, which are the straight-line transfer of energy from a food source (e.g., plants) to a series of organisms feeding on the source or on other organisms feeding on the food source (Odum 1971). While energy and, therefore, transfer of a compound in a food chain, is not always linear, it is assumed in this guidance that energy and, thus, compounds, are always transferred to a higher trophic level. The importance of a food chain as an exposure pathway primarily depends on receptor dietary habits, the receptors in the food chain, and other

RECOMMENDED INFORMATION FOR RISK ASSESSMENT

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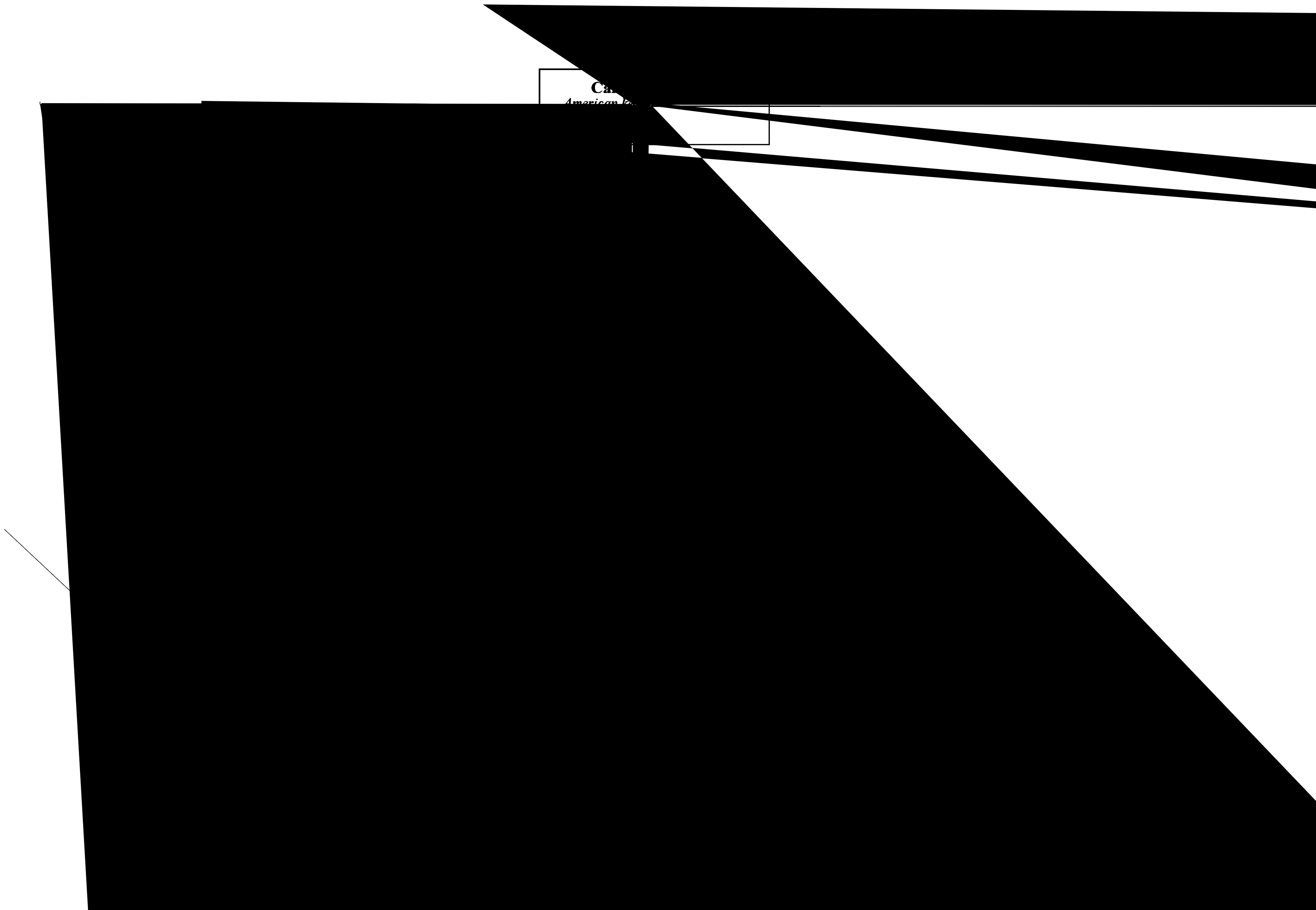
4.2.4 Example Habitat-Specific Food Webs

To better illustrate food web development as discussed in the previous sections (see Sections 4.2.1 through

FIGURE 4-1
EXAMPLE

FIGURE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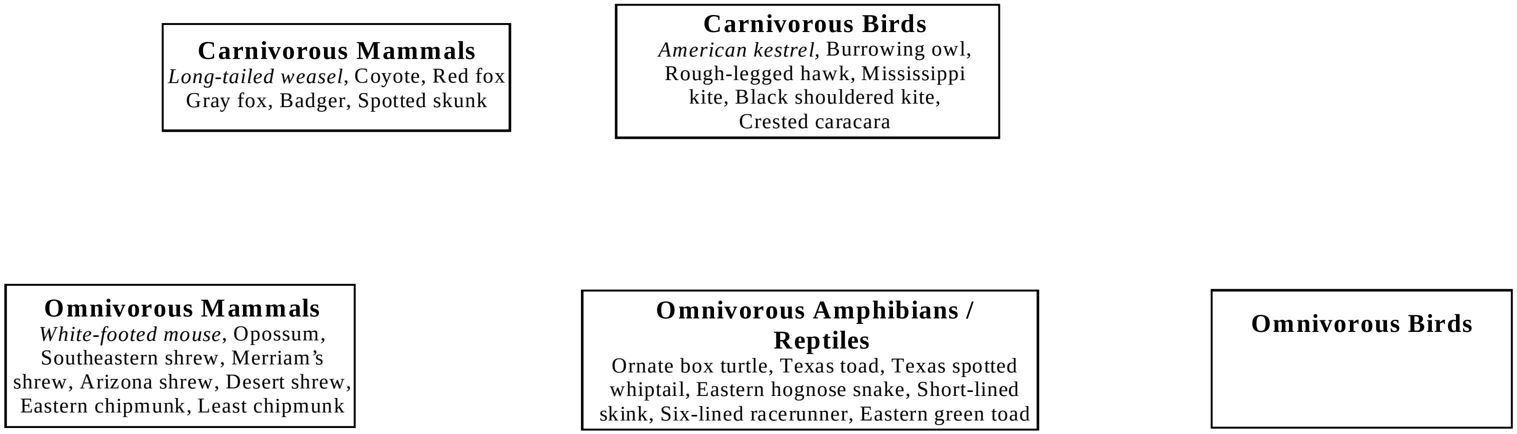

FIGURE 4-4
EXAMPLE
SHRUB/SCRUB FOOD WEB

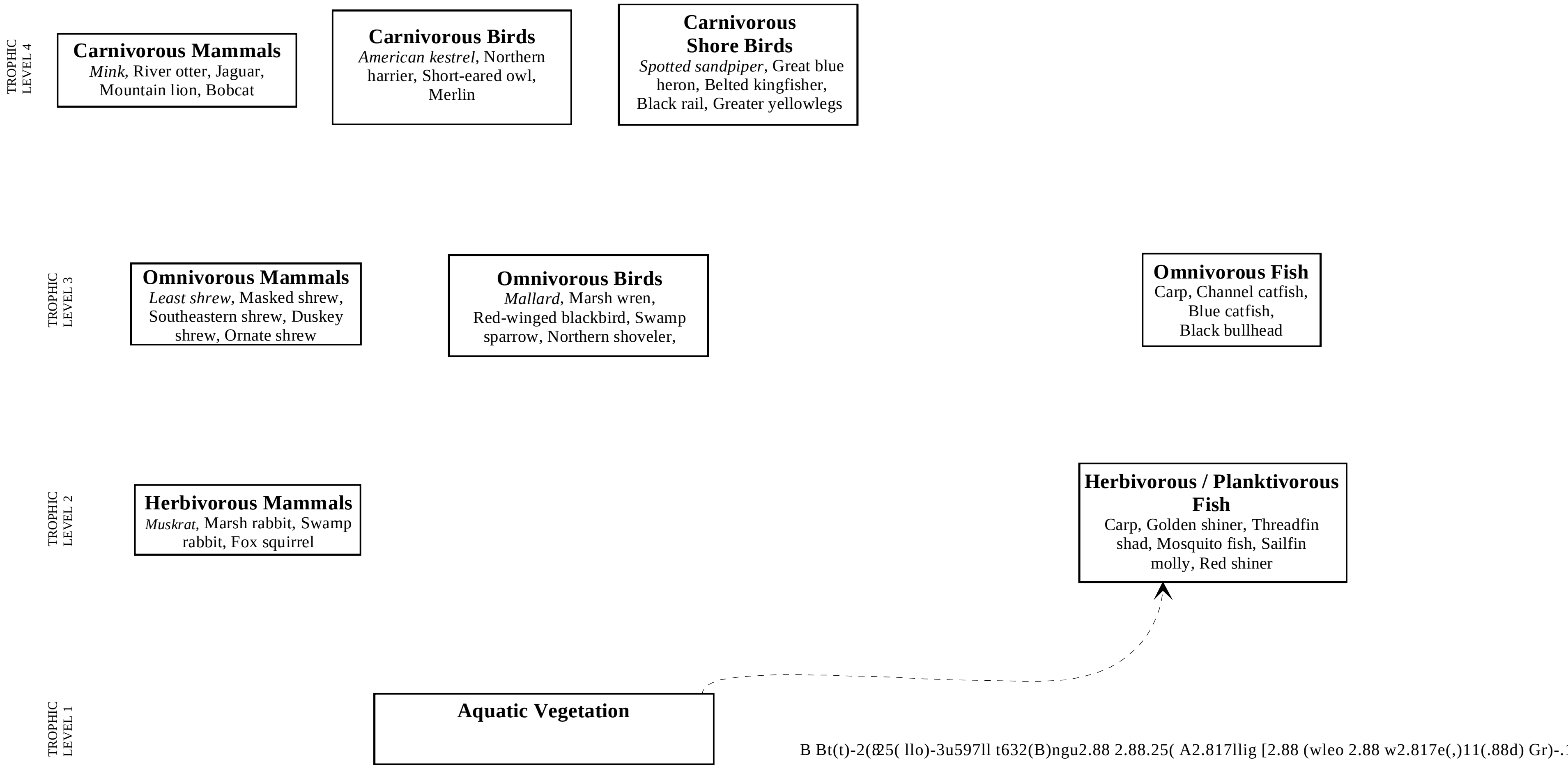

FIGURE 4-5
EXAMPLE
FRESHWATER FOOD WEB

NOTE: PATHWAYS NOT REPRESENTED MATHEMATICALLY IN EQUATIONS

RECEPTOR CASORD

FIGURE 4-6
EXAMPLE
BRACKISH / INTERMEDIATE
MARSH FOOD WEB

Screening Level Ecological Risk Assessment

TABLE 4-1
ASSESSMENT ENDPOINTS FOR GUILDS AND COMMUNITES IN EXAMPLE FOOD WEBS

Representative Receptors		Example Critical Ecological Attributes
Aquatic Receptors		
Aquatic Plants	Phytoplankton, Vascular plants	Primary producers convert light energy into biomass, and are the first link in aquatic food chains supporting higher trophic level aquatic consumers and wildlife. Rooted vegetation also provides habitat and bottom stability.
Water Invertebrates	Crustaceans, Rotifers, Amphipods	Aquatic invertebrates are an important food source for many higher trophic level consumers. Zooplankton regulate phytoplankton populations, and are a critical link in energy transfer to higher trophic levels in aquatic ecosystems.
Herbivorous / Planktivorous Fish	Carp, Gulf killifish, Threadfin shad, Molly, Golden Shiner, Goby, Mosquito Fish, Red Shiner	

TABLE 4-1 (Continued)
ASSESSMENT ENDPOINTS FOR GUILDS AND COMMUNITES IN EXAMPLE FOOD WEBS

Representative Receptors		Example Critical Ecological Attributes
Carnivorous Mammals	Grey fox, Swift fox, River otter, Bobcat, Mountain lion, Long-tailed weasel, American badger, Red fox, American mink, Red wolf	Carnivorous mammals provide an important functional role to the environment by regulating lower trophic level prey populations.
Carnivorous Birds	Red-tailed hawk, American kestrel, Marsh hawk, Great-horned owl, Barn owl, Burrowing owl, White-tailed hawk, Ferruginous hawk , Swansons hawk, Golden eagle, Mississippi kite, Prairie hawk, Merlin	Carnivorous Birds provide an important functional role to the environment by regulating lower trophic level prey populations.
Carnivorous Shore Birds	Great blue heron, Belted kingfisher, Spotted sandpiper, Black rail, Greater yellowlegs, Dunlin,	Carnivorous Shore Birds provide an important functional role to the environment by regulating lower trophic level prey populations, and influencing species composition in terrestrial and aquatic ecosystems. They also provide egg dispersal for some fish and aquatic invertebrates.
Carnivorous Reptiles	Eastern yellowbelly racer, Eastern coral snake, Texas rat snake, Western Diamondback rattlesnake, American alligator, Bullsnake, Alligator snapping turtle, Cotton mouth, Speckled king snake, Spiny softshell turtle, Gulf salt marsh snake,	Carnivorous Reptiles provide an important functional role to the environment by regulating lower trophic level prey and are an important prey item for other upper trophic level predators.

4.4 IDENTIFYING MEASUREMENT RECEPTORS TO EVALUATE MEASURES OF EFFECT

Measures of effect are measures used to evaluate “the response of the assessment endpoint when exposed to a stressor (formerly measurement endpoints)” (U.S. EPA 1997c). Measures of exposure are measures of how exposure may be occurring, including how a stressor may co-occur with the assessment endpoint (U.S. EPA 1997c). Measures of effect, in conjunction with measures of exposure, are used to make inferences about potential changes in the assessment endpoint (U.S. EPA 1997c).

Measures of effect are selected as: (1) toxicity values developed and/or adopted by federal or state agencies (e.g., ambient water quality criteria [AWQC], NOAA effects range low [ERL] values) for protection of media-specific communities, or (2) receptor-specific chronic no-observed-adverse-effects-levels (NOAELs) or their equivalent for ecologically relevant endoints (see Chapter 5) for this screening assessment. Measures of exposure are selected as the COPC concentrations in media or dose (e.g., ingestion of contaminated media and/or tissue) to which exposure occurs, and determined as discussed in Chapter 5.

The evaluation of the measure of effect to the assessment endpoint (see Chapters 5 and 6) requires identification of a measurement receptor representive of the assessment endpoint. The measurement receptor is selected based on consideration of factors such as (1) ecological relevance, (2) exposure potential, (3) sensitivity, (4) social or economic importance, and (5) availability of natural history information.

A measurement receptor, specific to each guild, may be selected as a species, population, community, or assemblage of communities. For communities (i.e., soil, surface water, sediment), the community or assemblage of communities is selected as the measurement receptor, and no specific species is selected. For guilds, individual species are selected as measurement receptors. Sections 4.4.1 and 4.4.2 discuss

raptorial birds are highly sensitive to the effects of chlorinated pesticides that bioaccumulate through the food chain.

- ***Social or Economic Importance* -** An assessment endpoint may also be based on socially or economically important receptors. These types of receptors include species valued for economic importance such as crayfish and game fish. For these receptors, critical attributes include those that affect survival, production, and fecundity characteristics. For example, swamp crayfish are highly sensitive to some heavy metals through adverse effects to behavioral characteristics.

- ***Availability of Natural History Information* -** Natural history information is essential to quantitaviliy evalate risk to measurement receptors. If this information such as body weight, food, water, soil, and sediment ingestion rates is unavailable for the desired measurement receptor, a surrogate species should be selected. Uncertainty associated with using a surrogate species should be discussed.

It should be noted that more than one measurement receptor can be selected per assessment endpoint. Also, although each of these factors should be evaluated when selecting the measurement receptor, at least one of the measurement receptors selected to represent a class-specific guild should have the highest exposure potential (i.e., ingestion rate on a body weight basis). This ensures that risk to other species in the guild is not underestimated.

U.S. EPA's *Wildlife Exposure Factors Handbook* (U.S. EPA 1993o) is an example of an excellent source of dietary and other natural history information. However, it is recommended that receptor information obtained from it or any source be verified and documented during measurement receptor identification.

4.4.3 Measurement Receptors for Example Food Webs

Consistent with the discussions presented in Section 4.4, measurement receptors were selected for the example food webs presented in Section 4.2. Receptor information documented in *Wildlife Exposure Factors Handbook* (U.S. EPA 1993o) and available literature was evaluated to determine suitable measurement receptors for each class-specific guild represented in the example food webs.

Ecological relevance, exposure potential, sensitivity, social or economic importance and availability of natural history information (see Section 4.4.3) were evaluated to identify measurement receptors for the example food webs. It should be noted that since these measurement receptors have been provided as examples to facilitate understanding of the previously described selection process, not every assessment

Least Shrew

The least shrew (*Cryptotis parva*) was selected as the measurement receptor for the omnivorous mammal guild in the example tallgrass prairie, shortgrass prairie, and freshwater wetland food webs based on the following information:

-

- The mallard serves as a valuable component in aquatic food webs providing dispersion of seeds for aquatic vegetation, and due to their role in the nutrient cycle of wetlands. In addition, the mallard is a major prey item for carnivorous mammals, birds, and snakes.

- The mallard is present in a diverse amount of aquatic habitats throughout the United States. Although their diet is considered omnivorous, 90 percent of their diet may be plant material at some times of the year. Mallards are surface feeders that will often filter through soft mud and sediment searching for food items.

- The mallard is very important game species, representing approximately one-third of all waterfowl harvested.

- The availability of natural history information (e.g., home range, ingestion rates, body weights) also support selection as a measurement receptor.

Marsh Rice Rat

The marsh rice rat (*Oryzomys palustris*) was selected as the measurement receptor for the omnivorous mammal guild in the example brackish/intermediate and salt marsh food web based on the following information:

- The marsh rice rat inhabits marsh and wetland areas where it feeds on crabs, insects, fruits, snails, and aquatic plants. The rice rat plays an important role in seed dispersal and is a major food item for many predators including raptors, cats, weasels and snakes.

- The marsh rice rat has a high potential for exposure due to their aquatic diet and direct contact with media.

- The availability of natural history information (e.g., home range, ingestion rates, body weights) also support selection as a measurement receptor.

Marsh Wren

The marsh wren (*Cistothorus palustris*) was selected as the measurement receptor for the omnivorous bird guild in the example salt marsh food web based on the following information:

- The marsh wren consumes large numbers of aquatic insects thus regulating their populations, which make it a valuable component of the ecosystem. Main predators are snakes and turtles which prey heavily upon the eggs.

- The marsh wren is common throughout the United States, inhabiting freshwater, brackish, and spiders may be taken. In addition, its diet of aquatic invertebrates makes it susceptible to accumulation and toxicity of bioaccumulative chemicals

-

- Mourning doves are an important game species, contributing significantly as a food and economic resource.

- The availability of natural history information (e.g., home range, ingestion rates, body weights) also support selection as a measurement receptor.

Muskrat

The muskrat (*Ondrata zibethicus*) was selected as the measurement receptor for the herbivorous mammal guild in the example freshwater wetland and brackish/intermediate marsh food webs based on the following information:

- The muskrat is important to the overall structure of the aquatic ecosystem by regulating aquatic vegetation diversity and biomass, resulting in stream bank stability and increased habitat diversity for aquatic organisms including fish. It was also chosen as the measurement receptor based on its value to the ecosystem including its large population densities and importance as a prey species (e.g., prey for hawks, mink, otters, owls, red fox, snapping turtles, alligators, and water snakes).

- The muskrat spends a large part of its time in the water, and is common in fresh, brackish, and saltwater habitats. It has relatively high food and water ingestion rates, and a diet that consists mainly of aquatic vegetation, clams, crayfish, frogs, and small fish.

- Due to the large numbers, the muskrat plays an important economic role in the fur industry, and as a food item for some cultures.

- The availability of natural history information (e.g., home range, ingestion rates, body weights) also support selection as a measurement receptor.

Northern Bobwhite•indutr bra(p1(ns)-2035(a)-33(l a)-335(r)-3-33(a)-33-ps)-22(o)2(m)19(ey33(4(a)-33(nd a)-33(s)-22 range may encompasses several hectares, including areas for foraging, cover, and a nest site. In non-breeding season, the bobwhite's home range can be as large as 16 hectares. It has a high potential for exposure through ingestion and dermal contact with soil during dust bathing.

- The availability of natural history information (e.g., home range, ingestion rates, body weights) also support selection as a measurement receptor.

Northern Harrier

The Northern harrier (*Circus cyaneus*), also called the Marsh hawk was selected as the measurement receptor for carnivorous bird guild in the example salt marsh food web based on the following information:

- The marsh hawk plays an important role in the ecosystem in regulating small mammal populations through predation.
- The marsh hawks diet consists of small mammals, birds, and occasionally snakes, frogs, and insects. Their habitat preferences include wetlands or marshes.
- In addition, the marsh hawk has demonstrated sensitivity to pesticides, which bioaccumulate through food chains.
- The availability of natural history information (e.g., home range, ingestion rates, body weights) also support selection as a measurement receptor.

Red Fox

The red fox (*Vulpes vulpes)* was selected as the measurement receptor for the carnivorous mammal guild in the example salt marsh food web based on the following information:

- Red fox have a high potential for exposure due to bioaccumulation though the food chain, and are a valuable component to ecosystem structure by regulating the abundance, reproduction, distribution, and recruitment of lower trophic level prey.
- Although omnivorous in dietary habits, the majority of the diet consists of cottontail rabbits, voles, mice, birds, and other small mammals. This animal was chosen because of ra   do(e)12(do(e)12Hc)-1210(s)-fsm(m) teb, inh-26Twı.E(,)-7-32(e)1(l)-126(rF)-14l(,)-31(26T6(h)1(e)10(

C

Red-tailed Hawk

The red-tailed hawk (*Buteo jamaicensis*) was selected as the measurement receptor in the carnivorous bird guild in the example forest food web based on the following information:

- The red-tailed hawks position as a high trophic level predator makes them a valuable component of terrestrial food webs through their regulation of populations of lower trophic level prey species.
- The red-tailed hawk is widely distributed in the United States among a diverse number of habitat types ranging from woodlands to pastures. Its diet includes small mammals (such as mice, shrews, voles, rabbits, and squirrels), birds, lizards, snakes, and large insects. It is an opportunistic feeder, preying on whatever species is most abundant. Red-tailed hawks are territorial throughout the year, and have home ranges that can be over 1,500 hectares.
- Red-tailed hawks have shown sensitivity to many chemicals which disrupt reproduction or egg development.
- The availability of natural history information (e.g., home range, ingestion rates, body weights) also support selection as a measurement receptor.

Salt Marsh Harvest Mouse

The salt marsh harvest mouse (*Reithrodontomys raviventris*) was selected as the measurement receptor for the herbivorous mammal guild in the example salt marsh food web based on the following information:

- The salt marsh harvest mouse plays an important functional role in aquatic habitats through seed dispersal for aquatic vegetation.
- Predators include owls, snakes, and many mammals including weasels, fox, and cats.
- The availability of natural history information (e.g., home range, ingestion rates, body weights) also support selection as a measurement receptor.

Short-tailed Shrew

The short-tailed shrew (*Blarina brevicauda*) was selected as the measurement receptor for the omnivorous mammal guild in the example forest food web based on the following information:

- The short-tailed shrews value as a prey species for many high level predators is very important to the health of an ecosystem. They also play an important role in soil recycling and aeration, through tunnel excavation.

Western Meadow Lark

The western meadow lark (*Sturnella neglecta*

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risk characterization (see Chapter 6) for lower trophic level communities are media specific; whereas

5.3 Assessing Exposure to Class-Specific Guild Measurement Receptors

Exposure to measurement receptors of class-specific guilds is assessed by quantifying the daily dose ingested of contaminated food items (i.e., plant and animal), and media. COPC daily dose ingested (expressed as the mass of COPC ingested per kilogram body weight per day) depends on the COPC concentration in plant and animal food items and media, the measurement receptor's trophic level (i.e., consumer), the trophic level of animal food items (i.e., prey), and the measurement receptor's ingestion rate of each food item and media. The complexity of the daily dose equation will depend on (1) the number of food items in a measurement receptor's diet, (2) the trophic level of each food item and of

$$DD = \sum IR_F \cdot C_i \cdot P_i \cdot F_i + \sum IR_M \cdot C_M \cdot P_M \qquad \text{Equation 5-1}$$

COPC concentration in the media ingested. Guidance on the calculation of COPC concentrations in media being ingested is provided in Chapter 3 and Appendix B.

The daily dose of COPC ingested by a measurement receptor should be determined by summing the contributions from each contaminated plant, animal, and media food item. Equation 5-1 and consumer specific equations in Appendix F, are derived to account for 100 percent of the measurement receptor's diet (total daily mass of food items ingested) which can potentially be contaminated. However, if a food item or media at an actual site location is not contaminated (i.e., the COPC concentration in the media or resulting food item is zero), then the daily mass of that food item or media ingested does not contribute to the daily dose of COPC ingested. Also, Equation 5-1 does not directly include a term for home range, as defined spatially. However, the term accounting for the proportion of plant or animal food item that is contaminated, P_i, numerically accounts for the fraction of a respective food item that may potentially be obtained from outside the geographical limits of the impacted habitat (i.e., outside the area of contamination) being evaluated.

For measurement receptors ingesting more than one plant or animal food item, U.S. EPA OSW recommends that exposure be separately quantified assuming that the measurement receptor ingests both "equal" and "exclusive" diets. Not only does this constitute the most complete evaluation of exposure potential for a measurement receptor; if warranted, it also identifies which pathways are driving risk specific to a COPC and measurement receptor, and allows risk management efforts to be prioritized. Guidance for calculating *DD* assuming "equal diet" and "exclusive diet" is provided below.

(U.S. EPA 1993o). Soil ingestion rates were calculated using the percent soil in estimated diets of wildlife as described in Beyer et al. (1994).

Species specific ingestion rates including food and water have been measured for few wildlife species. Therefore, allometric equations presented in the *Wildlife Exposure Factors Handbook* were used to calculate species specific food and media ingestion rates. Allometry is defined as the study of the relationship between the growth and size of one body part to the growth and size of the whole organism, including ingestion rates, and can be used to estimate species specific values for ingestion (U.S. EPA 1993o). Allometric equations should only be used for those taxonomic groups used to develop the allometric relationship. For example, equations developed for carnivorous mammals should not be used to calculate food ingestion rates for herbivorous mammals. For a detailed discussion on the development and limitations of the allometric equations used to obtain ingestion rate values presented in Table 5-1, see U.S. EPA (1993o) and Nagy (1987).

The use of individual species body weights may result in some uncertainty, since individual species usually exhibit values somewhat different from those predicted by allometric modeling derived using multiple species. However, this uncertainty is expected to be minimal since measurement receptors were selected to maximize exposure for each class-specific guild, as discussed in Section 4.4.2.

If species specific values are not available in U.S. EPA (1993o), or can not be represented by the allometric equations presented, other sources to evaluate include:

- U.S. Fish and Wildlife Service (FWS) publications (e.g., U.S. FWS 1979)
- State wildlife resource management agencies
- Published scientific literature
- Publications by wildlife conservation organizations (such as The National Audubon Society)

				[redacted]					

Receptor

TABLE 5-1

INGESTION RATES FOR EXAMPLE MEASUREMENT RECEPTORS

Measurement Receptor	Example Food Web[a]	Body Weight (kg)	Reference	Food IR [e] (kg WW/ kg BW-day)	Reference	Water IR (L /kg BW-day)	Reference	Soil/Sed IR [m] (kg DW/ kg BW-day)	Reference
Mourning Dove	F, SS, TG, SG	1.50E-01 [c]	U.S. EPA 1993o	3.49E-01 [f]	U.S. EPA 1993o; Nagy 1987	1.09E-01 [k]	U.S. EPA 1993o	7.01E-03 [o]	Beyer et al. 1994
Muskrat	BR, FW	1.09E+00	U.S. EPA 1993o	2.67E-01 [j]	U.S. EPA 1993o; Nagy 1987	9.82E-02 [l]	U.S. EPA 1993o	6.41E-04	Beyer et al. 1994
Northern Bobwhite	SG, SS	1.50E-01	U.S. EPA 1993o	3.49E-01 [f]	U.S. EPA 1993o; Nagy 1987	1.09E-01 [k]	U.S. EPA 1993o	1.20E-02 [t]	Beyer et al. 1994
Northern Harrier	SW	9.60E-01	U.S. EPA 1993o	1.85E-01 [f]	U.S. EPA 1993o; Nagy 1987	5.99E-02 [k]	U.S. EPA 1993o	9.95E-03 [n]	Beyer et al. 1994
Red Fox	SW	3.94E+00	U.S. EPA 1993o	1.68E-01 [i]	U.S. EPA 1993o; Nagy 1987	8.63E-02 [l]	U.S. EPA 1993o	1.51E-03	Beyer et al. 1994
Red-tailed Hawk	F	9.60E-01 [d]	U.S. EPA 1993o	1.85E-01 [f]	U.S. EPA 1993o; Nagy 1987	5.99E-02 [k]	U.S. EPA 1993o	9.95E-03 [n]	Beyer et al. 1994
Salt-marsh Harvest Mouse	SW	9.10E-03	U.S. EPA 1993o	7.41E-01 [g]	U.S. EPA 1993o; Nagy 1987	1.58E-01 [l]	U.S. EPA 1993o	1.78E-03 [q]	Beyer et al. 1994
Short-tailed Shrew	F	1.50E-02	U.S. EPA 1993o	6.20E-01 [h]	U.S. EPA 1993o	1.51E-01 [l]	U.S. EPA 1993o	1.36E-02 [o]	Beyer et al. 1994
Spotted Sandpiper	SW, BR, FW	4.00E-02	U.S. EPA 1993o	5.69E-01 [f]	U.S. EPA 1993o; Nagy 1987	1.74E-01 [k]	U.S. EPA 1993o	4.15E-02 [u]	Beyer et al. 1994
Swift Fox	SG	1.40E+00	U.S. EPA 1993o	1.93E-01 [i]	U.S. EPA 1993o; Nagy 1987	9.34E-02 [l]	U.S. EPA 1993o	1.73E-03 [r]	Beyer et al. 1994
Western Meadow Lark	TG	9.00E-02	U.S. EPA 1993o	4.21E-01 [f]	U.S. EPA 1993o; Nagy 1987	1.31E-01 [k]	U.S. EPA 1993o	1.39E-02 [o]	Beyer et al. 1994

TABLE 5-1

INGESTION RATES FOR EXAMPLE MEASUREMENT RECEPTORS

Measurement Receptor	Example								

5.3.2 COPC Concentrations in Food Items of Measurement Receptors

Determination of COPC concentrations in food items is required for calculating the daily dose of COPC ingested for each class-specific guild measurement receptor being evaluated. Since the risk assessment considers potential future exposure that may occur as a result of facility emissions over time, these concentrations are generally expected to be estimated mathmatically. The following subsections provide guidance for estimating COPC concentrations in the following groups of food items:

- Invertebrates, phytoplankton, and rooted aquatic plants;
- Terrestrial plants;
- Fish; and
- Mammals, birds, reptiles, and amphibians.

5.3.2.1 COPC Concentration in Invertebrates, Phytoplankton, and Rooted Aquatic Plants

COPC concentrations in invertebrate, phytoplankton, and rooted aquatic plants can be calculated by

$$BCF = \frac{C_i}{C_M}$$ Equation 5-2

$$C_i = C_M \cdot BCF$$ Equation 5-3

Equation 5-3 estimates a COPC concentration in an invertebrate, phytoplankton, and rooted aquatic plant to evaluate dose ingested to the measurement receptor. Calculation of COPC concentrations in media is further discussed in Chapter 3 and Appendix B. Media-to-receptor *BCF*s are receptor- and media-specific, and values along with supporting discussion are provided in Appendix C. Appendix F provides specific equations and supporting discussion for calculating COPC concentrations in plant and animal food items.

Equilibrium Partitioning (EqP) Approach

When adequate site-specific characterization data is available, specifically organic carbon fraction data for soil and sediment, the permitting authority may elect in some cases to allow the calculation of COPC concentrations in soil invertebrate (Connell and Markwell 1990) or sediment invertebrate (U.S. EPA 1993q) using the equilibrium partitioning (EqP) approach. However, the EqP approach is not prefered over use of measured BCF values multiplied by the COPC concentration in the media (i.e., sediment or soil), following the approach previously discussed.

The EqP approach utilizes the correlation of the concentrations of nonionic organic compounds in sediment, on an organic carbon basis, to their concentrations in the interstitial water, to determine the observed biological effects on sediment invertebrate (U.S. EPA 1993q). The EqP approach is only applicable for (1) hydrophobic nonionic organic compounds, (2) soil- and sediment-invertebrates, and (3) COPCs with empirical water bioconcentration factors (U.S. EPA 1993q). Also, the EqP approach assumes that the partitioning of the compound in sediment organic carbon and interstitial water are in equilibrium, and the sediment—interstitial water equilibrium system provides the same exposure as a water-only exposure (U.S. EPA 1993q).

To calculate the COPC concentration in an invertebrate using the EqP approach, the soil or sediment interstitial water concentration should be multiplied by the *BCF* determined from a water exposure for a benthic invertebrate:

$$C_I = C_{IW} \cdot BCF_{WI} \qquad \text{Equation 5-4}$$

5.3.2.3 COPC Concentration in Fish

The COPC concentration in fish is calculated by multiplying a COPC-specific *BCF* and trophic level-specific *FCM* by the dissolved water concentration, as follows:

$$C_F = BCF \cdot FCM \cdot C_{dw} \qquad \text{Equation 5-7}$$

where

C_F = COPC concentration in fish (mg/kg)
BCF = Bioconcentration factor for water-to-fish (L/kg)
FCM = Food-chain multiplier (unitless)
C_{dw} = Dissolved phase water concentration (mg/L)

The COPC concentration in fish is calculated using dissolved phase water concentrations, since

$$FCM = \frac{BAF_l}{K_{ow}} \qquad \text{Equation 5-8}$$

where

FCM = Food-chain multiplier (unitless)

BAF

$$FCM = \frac{BAF_l}{BCF_l}$$ Equation 5-9

TABLE 5-2

FOOD-CHAIN MULTIPLIERS

Log K_{ow}	Trophic Level of Consumer		
	2	**3**	**4**
2.0	1.0	1.0	1.0
2.5	1.0	1.0	1.0
3.0	1.0	1.0	1.0
3.1	1.0	1.0	1.0
3.2	1.0	1.0	1.0
3.3	1.0	1.1	1.0
3.4	1.0	1.1	1.0
3.5	1.0	1.1	1.0
3.6	1.0	1.1	1.0
3.7	1.0	1.1	1.0
3.8	1.0	1.2	1.0
3.9	1.0	1.2	1.1
4.0	1.0	1.3	1.1
4.1	1.0	1.3	1.1
4.2	1.0	1.4	1.1
4.3	1.0	1.5	12
4.4	1.0	1.6	1.2
4.5	1.0	1.8	1.3
4.6	1.0	2.0	1.5
4.7	1.0	2.2	1.6
4.8	1.0	2.5	1.9
4.9	1.0	2.8	2.2
5.0	1.0	3.2	2.6
5.1	1.0	3.6	3.2
5.2	1.0	4.2	3.9
5.3	1.0	4.8	4.7
5.4	1.0	5.5	5.8
5.5	1.0	6.3	7.1
5.6	1.0	7.1	8.6

TABLE 5-2

TABLE 5-2

FOOD-CHAIN MULTIPLIERS

Log K_{ow}	Trophic Level of Consumer		
	2	3	4

Omnivorous Mammals and Birds

As indicated in Equation 5-12, the COPC concentration in omnivorous mammals and birds is calculated by summing the contribution due to ingestion of contaminated animal and plant food items, and media. However, unlike herbivores which are TL2 consumers, omnivores are TL3 consumers of animal food items and a ratio of *FCM*s is applied to each animal food item ingested to account for the increase in COPC concentration occurring between the trophic level of the prey item (TLn) and the trophic level of the omnivore (TL3). In general, the COPC concentration in omnivores depends on the COPC concentration in each food item ingested, and the trophic level of each food item, as follows:

$$C_{OM} = \sum (C_{Ai} \cdot \frac{FCM_{TL3}}{FCM_{TLn-Ai}} \cdot P_{Ai} \cdot F_{Ai}) + \sum (C_{Pi} \cdot BCF_{Pi-OM} \cdot P_{Pi} \cdot F_{Pi})$$

Equation 5-12

$$+ (C_{s/sed} \cdot BCF_{S/BS-OM} \cdot P_{S/BS}) + (C_{wctot} \cdot BCF_{W-OM} \cdot P_{W})$$

where

C_{OM} = COPC concentration in omnivore (mg/kg)
C_{Ai} = COPC concentration in *i*th animal food item (mg/kg)
FCM_{TL3} = Food chain multiplier for trophic level 3 (unitless)
FCM_{TLn-Ai} = Food chain multiplier for trophic level of *i*th animal food item (unitless)
P_{Ai} = Proportion of *i*th animal food item in diet that is contaminated (unitless)
F_{Ai} = Fraction of diet consiting of *i*th animal food item (unitless)
BCF_{Pi-OM} = Bioconcentration factor for plant-to-omnivore for *i*th plant food item (unitless)
C_{Pi} = COPC concentration in *i*th plant food item (mg/kg)
P_{Pi} = Proportion of *i*th plant food item that is contaminated (unitless)
F_{Pi} = Fraction of diet consiting of *i*th plant food item (unitless)
$C_{s/sed}$ = COPC concentration in soil or bed sediment (mg/kg)
$BCF_{S/BS-OM}$ = Bioconcentration factor for soil- or bed sediment-to-omnivore (unitless)
$P_{S/BS}$ = Proportion of soil or bed sediment in diet that is contaminated (mg/kg)
C_{wctot} = Total COPC concentration in water column (mg/L)
BCF

Calculation of COPC concentrations in animal food items is further discussed in previous sections of Chapter 5. Calculation of COPC concentrations in plant food items and media is further discussed in previous sections of Chapter 5, and in Chapter 3 and Appendix B. The variables representing the diet fraction and proportion of diet contaminated are discussed in Section 5.3 and Appendix F. Appendix F also provides specific equations and supporting discussion for calculating the COPC concentration in omnivores.

Carnivorous Mammals and Birds

As indicated in Equation 5-13, the COPC concentration in carnivorous mammals and birds is calculated by summing the contribution due to ingestion of contaminated animal and media food items. In general, the equation for computing a COPC concentration for carnivorous food items is similar to the corresponding equation for omnivores; only without the component accounting for ingestion of plant food items. Similarly, a ratio of *FCM*

$$C_C \;=\; \sum \left(C_{Ai} \cdot \frac{FCM_{TL4}}{FCM_{TLn-Ai}} \cdot P_{Ai} \cdot F_{Ai} \right) + \left(C_{s/sed} \cdot BCF_{S/BS-C} \cdot P_{S/BS} \right) + \left(C_{wctot} \cdot BCF_{W-C} \cdot P_W \right)$$

Equation 5-13

$$BMF_{TL2} = FCM_{TL2} \quad \text{Equation 5-14}$$

$$BMF_{TL3} = FCM_{TL3}/FCM_{TL2} \quad \text{Equation 5-14A}$$

where

BMF_n = Biomagnification factor for *n*th trophic level
FCM_{TLn} = Food chain multiplier for *n*th trophic level

5.4 ASSESSMENT OF TOXICITY

Toxicity of a COPC is assessed by identifying toxicity reference values (*TRV*s) specific to a COPC and the measurement receptor being evaluated. As discussed in Chapter 6, *TRV*s are subsequently set as the denominator for computing COPC ecological screening quotients (*ESQ*s) during risk characterization. The available *TRV*s used in risk characterization for lower trophic level communities are media specific; whereas *TRV*s for upper trophic level class-specific guilds are provided in terms of dose ingested. *TRV*s for community and class-specific guild measurement receptors are further described below:

- Community (lower trophic level) *TRV*s are media specific and used to screen ecological effects to receptors inhabiting soil, surface water, and sediment. Community *TRV*s are expressed on a concentration basis, such as milligrams of COPC per kilogram of soil, and generally either:

  (1) a COPC media concentration that, based on its intended use by a regulatory agency, confers a high degree or protection to receptor populations or communities inhabiting the media (these include regulatory values such as federal ambient

characterizing adverse effects on ecologically relevant endpoints, such as growth, seed germination, reproduction, and survival. Study endpoints specified for reported toxicity values generally include the following:

- Soil, surface water, and sediment measurement receptors
    - No-observed-effect-level (NOEL) or no-observed-effect-concentration (NOEC)
    - Lowest-observed-effect-level (LOEL) or lowest-observed-effect-concentration (LOEC)
    - Median lethal concentration to 50 percent of the test population (LC50) or median effective concentration for 50 percent of the test population (EC50)
- Wildlife measurement receptors
    - No-observed-adverse-effect-level (NOAEL)
    - Lowest-observed-adverse-effect-level (LOAEL)
    - Median lethal dose to 50 percent of the test population (LD50)

Evaluation of toxicity test data is further discussed in Section 5.4.1.1.

When multiple studies are assessed equally under the criteria above, professional judgement can be applied to determine the most appropriate study and corresponding toxicity value to be selected as the *TRV* (see Section 5.4.1.2). As discussed in Section 5.4.1.3, toxicity values obtained from scientific literature may also require application of an UF to account for extrapolation uncertainty (due to differences in test endpoint and exposure duration) when considering use of the test value as a *TRV* in a screening level risk assessment.

5.4.1.1 Evaluation of Toxicity Test Data

A *TRV* should represent a COPC concentration or dose that causes no observed adverse effects to an ecologically relevant endpoint of a receptor exposed for a chronic (long-term) duration. As noted above, evaluation of test data from ecologically relevant studies should be further assessed based on exposure duration and study endpoint.

The following hierarchy, in terms of decreasing preference, should be followed to assess exposure duration and study endpoint:

1. Chronic NOAEL
2. Subchronic NOAEL
3. Chronic LOAEL
4. Subchronic LOAEL
5. Acute median lethality point estimate
6. Single dose toxicity value

The following guidelines should be used to generally determine exposure duration:

- For fish, mammals, and birds:
  - A chronic test lasts for more than 90 days
  - A subchronic test lasts from 14 to 90 days
  - An acute test lasts less than 14 days
- For other receptors:
  - A chronic test lasts for 7 or more days
  - A subchronic test lasts from 3 to 6 days
  - An acute test lasts less than 3 days

The logic followed to identify the a toxicity value should be fully documented. Sources of toxicity values include electronic databases, reference compendia, and technical literature. Toxicity values identified from secondary sources should be verified, wherever possible, by reviewing the original study. If an original study is unavailable, or multiple studies of similar quality are available, best professional judgment should be used to determine an appropriate toxicity value.

5.4.1.2 Best Professional Judgement for Evaluating Toxicity Values

If more than one toxicity study meets a set of qualifying criteria applicable for study endpoint and exposure duration, best professional judgement should be used to identify the most appropriate study and corresponding toxicity value for *TRV* selection. The most appropriate study is the one with the least uncertainty about the accuracy of the value of endpoint (i.e., NOAEL) that, ultimately, provides the should be identified by reviewing the experimental design of each study. Discussed below are important aspects of experimental design that should be evaluated.

- ***Number of treatments, spread between treatments, and number of replicates per treatment.*** The number of treatments and the spread between exposure concentrations (or dose groups) will affect the accuracy of the test endpoint (such as the NOAEL). That is, the smaller the spread between the NOAEL and LOAEL, the less the uncertainty is about the true concentration or dose at which there is no adverse effect. The statistical power of

5.4.1.3 Uncertainty Factors for Extrapolation From Toxicity Test Values to *TRV*s

Incomplete knowledge of the actual toxicity of a chemical leads to the use of UFs to reduce the likelihood that risk estimates do not underestimate risk. Historically, UFs have been used for various extrapolations, and their applications reflect policy to provide conservative estimates of risk (Chapman et al. 1998). As discussed below, UFs are used in the risk assessment to reduce the probability of underestimating ecological risk from exposures to combustor emissions. This is performed by multiplying a toxicity value by a UF to produce a *TRV* reflecting an NOAEL for a chronic exposure duration.

UFs should be used to convert a toxicity value to a chronic NOAEL-based *TRV*. In most cases, the UFs discussed below should be applicable to available toxicity values. In some cases, however, irregular toxicity data (such as, a subchronic LC50) may be the only available information. In these cases, the toxicity data should be thoroughly reviewed and professional judgment should be used to identify appropriate UFs that are consistent with those listed below. Special attention should be taken with toxicity values from single oral dose, intraperitoneal, and subchronic lethality tests.

Specifically, UFs should be used to account for extrapolation uncertainty due to differences in test endpoint and exposure duration:

- Test endpoint uncertainty—extrapolation from a non-NOAEL endpoint (e.g., LOAEL, LD50) to an NOAEL endpoint
- Duration uncertainty—extrapolation from a single dose, acute, or subchronic duration to a chronic duration

Except as noted above for irregular toxicity data, the following UFs (Calabrese and Baldwin 1993) should be used to convert a toxicity test endpoint to a *TRV* equivalent tathrN:ichr, LOA21(oint) f, OA2o(f)-14, OF0s should 23(s)-

where

$ESQ_{Receptor\ Total}$ = Total ecological screening quotient for receptor (unitless)
$ESQ_{COPC\ Specific}$ = COPC specific ecological screening quotient (unitless)

As for COPC-specific *ESQ*s, total *ESQ*s for class-specific guild measurement receptors should be calculated specific to equal and exclusive diets (see Chapter 5).

6.2 RISK DESCRIPTION

Risk description considers the magnitude and nature of potential risk for community and class-specific guild measurement receptors evaluated, and provides information for the risk manager and permitting authority to evaluate the significance of an *ESQ* value. Also, Section 6.2.2 recognizes some of the default exposure assumptions that may affect the magnitude of an *ESQ* value.

6.2.1 Magnitude and Nature of Ecological Risk

The magnitude and nature of potential risk should be further considered for each measurement receptor with a COPC-specific *ESQ* value equal to or above risk target levels specified by the appropriate permitting authority. Interaction between the risk assessor and the risk manager and permitting authority has been noted throughout the process (See Figure 1 for Scientific Management Decision Points). At the risk characterization phase of the risk assessment, most of the interaction between the risk assessor and the risk manager and permitting authority is through description of the certainty of the resulting risk estimates. Consistent with the NCP and current U.S. EPA guidance (1998c), the risk manager and permitting authority with input from the risk assessor should also consider the need to collect additional information to refine risk estimates and/or implement permit requirements (i.e., operating conditions, use of APCDs, waste feed conditions, or environmental monitoring) at combustion facilities where an *ESQ* exceeds risk target levels for ecological communities or guilds that may reasonably be expected to be exposed.

The magnitude and nature of potential risk should also be further considered for each measurement receptor with a total *ESQ* value greater than or equal to the target risk levels. While the total *ESQ* provides the risk manager and permitting authority with useful information regarding potential risk resulting from exposure of a measurement receptor to multiple COPCs at a specific location, potential limitations and uncertainties

6.2.2 Fate and Exposure Assumptions

As noted throughout this guidance, the screening level ecological risk assessment is based on numerous conservative assumptions affecting the potential for a receptor to be exposed to a compound emitted from a facility and the numeric magnitude of the resulting estimated risk. These fate and exposure assumptions are required as a result of current data gaps and uncertainties associated with available scientific information and data required for risk evaluation. However, U.S. EPA OSW recommends that as information is available to address data gaps and reduce uncertainties specific to ecological risks identified at a facility by the screening level risk assessment, it should be provided to the permitting authority for approval to be incorporated into evaluation of risk. Some of the fate and exposure assumptions utilized in this guidance to conduct a screening level risk assessment are listed below:

The relevance of fate and exposure assumptions specific to COPCs at a site, and their numerical bias to resulting *ESQ* values should be considered before application of results. Also, to facilitate the qualitative assessment of toxicokinetic and toxicodynamic factors (e.g., bioavailability, metabolism), toxicological profiles of numerous compounds often considered in combustion risk assessments (see Section 2.3) are included in Appendix H. U.S. EPA OSW prepared these profiles because it believes that these compounds (1) will be the principal compounds of ecological concern at combustion facilities, and (2) to promote consistency in presenting and evaluating relevant COPC-specific toxicity information.

6.3 UNCERTAINTY AND LIMITATIONS OF THE RISK ASSESSMENT PROCESS

This section describes how to interpret uncertainties associated with the risk assessment. The discussion of uncertainties in this section and in Section 6.3.1 was adopted from the U.S. EPA *1996 Risk Assessment Support to the Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Waste* (EPA Contract Number 68-W3-0028), dated February 20, 1996.

Uncertainty can be introduced into a risk assessment at every step of the process outlined in this document. Uncertainty occurs, because risk assessment is a complex process, requiring the integration of the following:

- Release of pollutants into the environment
- Fate and transport of pollutants, in a variety of different and variable environments, by

required to determine the degree of conservatism. This section discusses the types of uncertainty and the areas in which uncertainty can be introduced into an assessment. In addition, this section discusses methods for qualitatively and quantitatively addressing uncertainty in risk assessments.

It should also be noted, variability is often used interchangeably with the term "uncertainty," but this is not strictly correct. Variability may be tied to variations in physical and biological processes, and cannot be reduced with additional research or information, although it may be known with greater certainty (for example, the weight distribution of a species may be known and represented by the mean weight and its standard deviation). "Uncertainty" is a description of the imperfect knowledge of the true value of a particular variable or its real variability in an individual or a group. In general, uncertainty is reducible by additional information-gathering or analysis activities (that is, better data or better models), whereas real variability will not change (although it may be more accurately known) as a result of better or more extensive measurements (Hattis and Burmaster 1994).

6.3.1 Types of Uncertainty

Finkel (1990) classified all uncertainty into four types: (1) variable uncertainty, (2) model uncertainty, (3) decision-rule uncertainty, and (4) variability. Variable uncertainty and model uncertainty are generally recognized by risk assessors as major sources of uncertainty; decision rule is of greatest concern to the risk manager.

6.3.1.1 Variable Uncertainty

Variable uncertainty occurs when variables appearing in equations cannot be measured precisely or accurately, because of either (1) equipment limitations, or (2) spatial or temporal variances between the quantities being measured. Random, or sample, errors are common sources of variable uncertainty that are especially critical for small sample sizes. It is more difficult to recognize nonrandom, or systematic, errors that result from the basis for sampling, experimental design, or choice of assumptions. As stated in Section 6.3, true variability is something we can not do much about (except to know that it exists).

influence will not be considered in the risk assessment. Thus, the risk assessment results will likely be more conservative for tidally influenced waterbodies than for those waterbodies that are not tidally influenced. Permitting decisions based on risk estimates for estuarine environments should consider this uncertainty. The delineation of this uncertainty may be one area that could be addressed in a more refined site-specific risk assessment, if warranted.

6.3.1.3 Decision-rule Uncertainty

Decision-rule uncertainty is probably of greatest concern to risk managers. This type of uncertainty arises, for example, out of the need to balance different social concerns when determining an acceptable level of risk. The uncertainty associated with risk analysis influences many policy and risk management decisions. Possibly the most important aspect for the risk estimates is the selection of constituents to be included in the analysis. Constituents identified by this guidance will include compounds that have the potential to pose the greatest risk to ecological receptors through exposure. For example, many PICs are highly lipophilic and tend to bioaccumulate, thereby presenting a potentially high risk to upper trophic level receptors through the consumption of contaminated food items.

6.3.2 Description of Qualitative Uncertainty

Often, sources of uncertainty in a risk assessment can be determined but cannot be quantified. For example, this can occur when a factor is known or expected to be variable, but no data are available (e.g., presence of COPCs without toxicity data). In this case, default data may be available that can be useful in estimating a possible range of values. Uncertainty also often arises out of a complete lack of data. A process may be so poorly understood that the uncertainty cannot be quantified with any confidence. In addition, some sources of uncertainty (such as uncertainty in theories used to deduce models) are inherent qualifications reflecting subjective modes of confidence rather than probabilistic arguments. When uncertainty can be presented only qualitatively, the possible direction and orders of magnitude of the potential error should be considered.

key assumptions in that section, the rationale for those assumptions, their effect on estimates of risk (overestimation, underestimation, neutral), and the magnitude of the effect (high, medium, low). For example, it could explain that using a particular input variable, such as exit gas temperature, will under- or overestimate long-term emissions, and the resulting risks, by a factor of *x*. These tables can be used to evaluate the extent to which protective assumptions were used in the risk assessments. They can also help determine the nature of the uncertainty analysis to be performed. The assumptions listed in the risk characterization section, which synthesizes the data outputs from the exposure and toxicity analyses, should be the most significant assumptions from each of the previous sections.

Within this guidance, identification of uncertainties and limitations are also included with the discussion of specific technical issues (e.g., TOE, estimates of emission rates, COPC selection process, quantification of non-detects) as they are presented in their respective sections. Limitations associated with parameter values and inputs to equations are presented in the Appendices.

As an example discussion, the following summarizes some of the uncertainty involved in the air dispersion modeling component of the risk assessment process.

Although dispersion modeling is a valuable tool for estimating concentration and deposition impacts, it has many limitations. The accuracy of the models is limited by (1) the ability of the model algorithms to depict atmospheric transport and dispersion of contaminants, and (2) the accuracy and validity of the input data. For example, most refined models require input of reut of reutu) ter
aTJta ofly(c)-25(h)0m gh3(u)-255(t)-2(a(ha)-7ode)17(o()9(t)-2(a(down-23d.-3(go U.-3(goSu)-20.-3(go Eit)-2Pu)-20A -29(Ct

Uncertainties specific to other technical components (e.g., TOE, quantification of non-detects) of the risk

- The exposure potential of the measurement receptors.
- The representativeness of equal and exclusive diet assumptions for measurement receptors.
- The effect of COPC physicochemical properties on estimates of fate and bioavailability.
- The effect of site-specific environmental conditions affecting the fate, transport, and bioavailability of the COPCs.
- The assumption that once exposed, a measurement receptor does not metabolize or eliminate a COPC.
- The potential risk to measurement receptors of COPCs with no *TRV*s.

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