

Fifth Addendum to the 2010 Memorandum of Understanding

This Fifth Addendum to the October 7th, 2010 “Memorandum of Understanding Between Wisconsin Department of Natural Resources (“DNR”) and Forest County Potawatomi Community (“FCPC”) to Implement Forest County Potawatomi Class I Air Redesignation” (the “2010 MOU”), is effective as of May 1, 2015 (the “Effective Date”). The Fifth Addendum includes three appendices: (1) Appendix A, Framework for Implementing Vegetation AQRV and TEL, (2) Appendix B, FCPC Hg Deposition Implementation Framework, and (3) Appendix C, FCPC Class I Air Quality Related Values and Thresholds for Mercury Methylation and Vegetation.

I. The Vegetation AQRV, the Vegetation Ozone TEL, and the Mercury Methylation DATs for the Aquatic Systems and Water Quality AQRVs

The Vegetation AQRV, the Vegetation Ozone TEL, and the Mercury Methylation DATs (for Mercury and Sulfur) for the Aquatic Systems and Water Quality AQRVs, all of which are identified in the attached Appendices to the Fifth Addendum, are recognized and acknowledged by the DNR on the condition that the associated methods and tools for their implementation, also identified in the attached Appendices, are implemented as indicated.

The Fifth Addendum and its Appendices do not amend or otherwise modify the terms of the underlying agreements, including the 1999 Agreement, and the 2010 MOU. As such, FCPC shall have the right, among other things: to add or change AQRVs and TELs once every ten years, starting July 27, 2019; and to utilize the substantial harm framework discussed in Section IV.A.4 of the 1999 Agreement, and Section 4.d of the 2010 MOU. As provided for in Appendix C to this Addendum, FCPC shall have the right, after notification to and consultation with the DNR, to revise the identified implementation methods/tools.

FCPC agrees not to change the implementation methods/tools specified in Column 3, Appendix C for the time period specified in that column. DNR agrees not to challenge, through SRP, Column 3 methods/tools during the specified time period unless there is an improper use of identified implementation methods/tools. Until DNR has information indicating there are more reliable or scientifically defensible methods/tools, or that there is an improper use of identified implementation methods/tools, it agrees not to challenge, through SRP, Column 4 implementation methods/tools. Should DNR determine that there is a failure by FCPC to use a more reliable or scientifically defensible method/tool, DNR must provide written notice prior to challenge through SRP. FCPC agrees to notify and consult with DNR in regard to any proposed changes in the implementation methods/tools specified in Appendix C.

Except as expressly provided herein, nothing in the Fifth Addendum or its Appendices shall affect any right either party may have under the terms of the 1999 Final Agreement or the 2010 Memorandum of Understanding to invoke dispute resolution.

II. Remaining Terms

Except as expressly modified by this Fifth Addendum, the remaining terms in the 1999 Agreement, the 2010 MOU and the First, Second, Third and Fourth Addenda to the 2010 MOU shall remain unchanged.

III. Effective Date

The Fifth Addendum is of no effect unless signed by both parties on or before May 1, 2015.

IV. Counterparts

The Fifth Addendum may be executed in counterparts and/or by the exchange of original, facsimile and/or Portable Document Format (.PDF) signature pages, each of which shall be considered an original, but all of which taken together shall constitute one and the same agreement.

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IN WITNESS THEREOF the Parties hereto have caused this Fifth Addendum, which shall be effective as of the date set forth above when signed by both Parties, to be executed as follows:

FOREST COUNTY POTAWATOMI COMMUNITY

Dated: 4-30-15

By: Dale Frank

Title: Chairman

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Dated: _____

By: _____

Title: _____

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FOREST COUNTY POTAWATOMI COMMUNITY

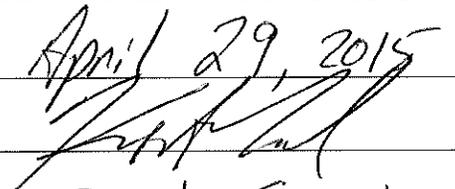
Dated: _____

By: _____

Title: _____

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

Dated: April 29, 2015

By: 

Title: Deputy Secretary

Framework for Implementing Vegetation AQRV and TELⁱ

April 1, 2015

Forest County Potawatomi Community ("FCPC") will take the following implementation approach for its Vegetation Air Quality Related Value ("AQRV") and Threshold Effect Level ("TEL"). This approach will be implemented in a manner that is consistent with the air permitting flow chart that is attached to the 2010 Memorandum of Understanding between the Wisconsin Department of Natural Resources, ("WDNR") and FCPC. The following approach is based on the current understanding of ozone impacts on vegetation and the available and/or accessible tools to model or otherwise evaluate such impacts. FCPC reserves the right to update this proposed approach based on updates or changes to either the understanding of ozone impacts on vegetation or the tools available to model or otherwise evaluate ozone impacts. In addition, nothing in this approach is intended to impact or limit, and will not impact or limit, FCPC's ability to apply the "substantial harm" provision (Section IV.A.4) of the 1999 Class I Final Agreement.

Determining and Implementing the Vegetation TEL

- The TEL is the three-year average 24-h W126 greater than or equal to 7.0 ppm-hr and N100 (number of hourly average concentrations \geq 100 ppb) greater than or equal to 4, for the three months of June, July and August, based on ozone monitoring data recorded at the FCPC ambient monitoring site. Both the W126 and N100 need to be greater than or equal to their respective values before the TEL is exceeded.
- The current status of the TEL is updated annually in May and available at the FCPC air pollution permitting web page; <http://www.fcpotawatomi.com/government/natural-resources/air-resource-program/air-pollution-permitting/>. The applicable TEL status (exceeded or not exceeded) will be determined for a proposed new or modified PSD source at the time the permit application is filed with WDNR. However, if the applicant requests that the permit application be placed on hold and WDNR grants such hold ("Hold Status"), WDNR will provide timely notice of such hold to FCPC. If a Hold Status exists at the one-year anniversary of the filing of the application, the TEL applicable at the time that Hold Status is removed will apply.
- The Vegetation TEL is considered no longer exceeded when the W126 and N100 rolling three-year average values are below the TEL for one year following the 3-year period when the exceedance occurred.

If the Vegetation TEL has not been exceeded, subject to the substantial harm framework, no action is required by the proposed new or modified PSD source for ozone. The WDNR will notify FCPC of all PSD permits within affected counties but sources will not be required to provide any additional information to determine their potential impacts to the vegetation AQRV.

Appendix A

In the event that the Vegetation TEL is exceeded

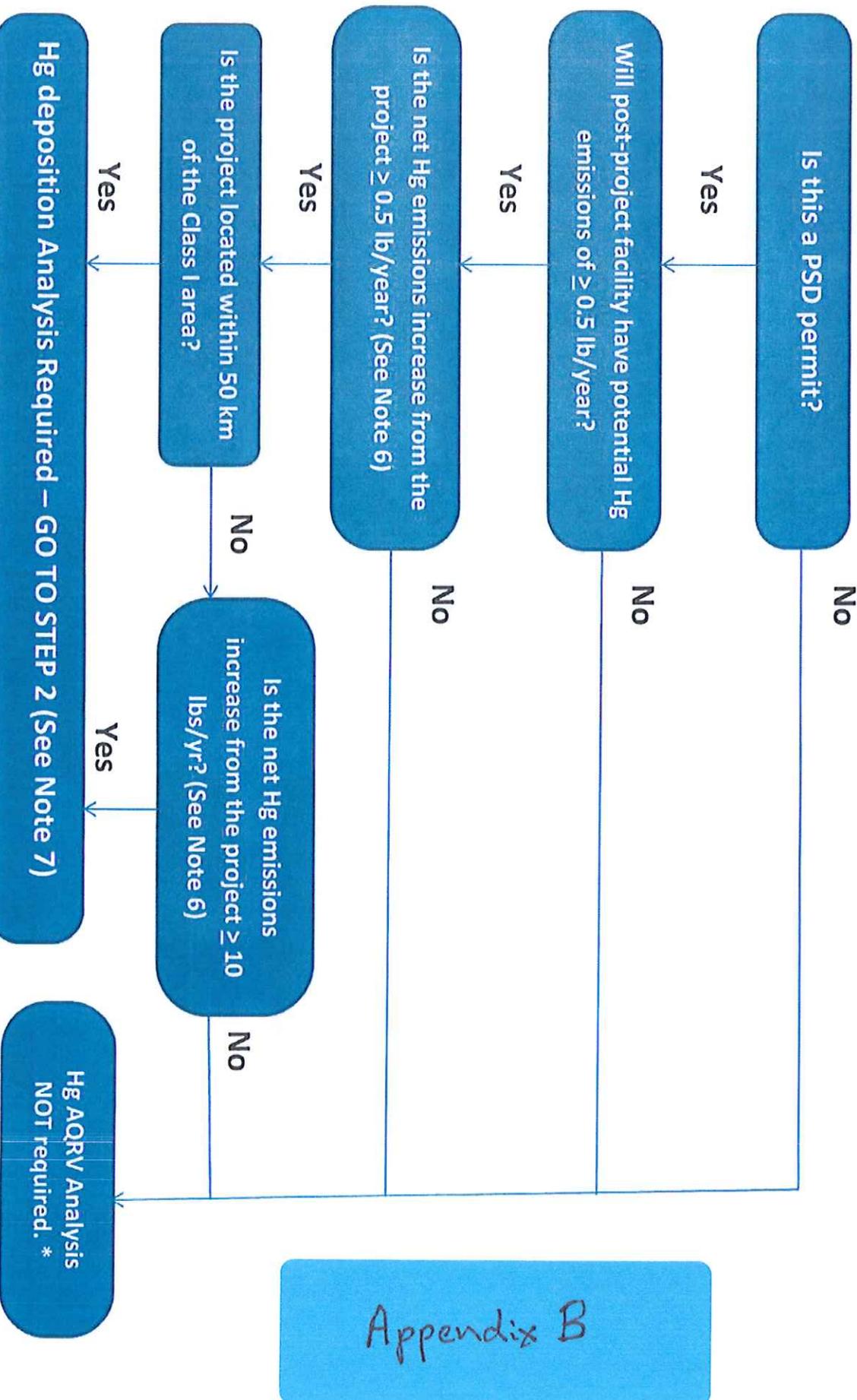
Foremost, FCPC will participate in discussions with Wisconsin on state/region wide ozone control plans to address approaches to decreasing ozone levels. Secondly, individual source PSD permit applications will be screened based on distance from Class I area, emission levels, and pollutant species. At such time as EPA approved air pollution modeling for estimating ozone from a single source becomes available, FCPC may require that an impact analysis include the vegetation AQRV. FCPC may also consider current trends in ozone exposure and meteorological conditions during the years in which peak ozone exposures occurred, as well as expected reductions in ozone precursor emissions. FCPC will solicit input from the NSR PSD permit applicant and the permitting authority regarding possible mitigation strategies (e.g., using more efficient emissions control technologies, obtaining emissions offsets, etc.- FLAG, 2010).

- Sources greater than 50km from FCPC's Class I Area- The "Initial Screening Criteria" of quantity (Q)/distance (D), adopted by federal agencies in the Federal Land Managers Air Quality Related Values Work Group (FLAG) 2010 document (section 3.2), will be used to determine those sources that may require further analysis. Wherein Q is the total SO₂, NO_x, PM₁₀, and H₂SO₄ annual emissions (in tons per year, based on 24-hour maximum allowable emissions) divided by D (in km) from the nearest boundary of the Class I area.
 - Q/D values ≤ 10 - a presumption of no adverse impact from a PSD source locating/located 50 km or greater distance from the Community's Class I boundary, and no further impact analysis would be necessary.
 - Q/D values $>$ than 10 - may require further screening and/or analysis particularly those projecting high NO_x emissions. FCPC will accept the use of the Weight-of-Evidence analysis proposed by WDNR until such time as FCPC selects an alternative, EPA-accepted analysis. FCPC will remain open to the implementation of advancing ozone modeling technology and protocols as they develop. This analysis will be conducted by FCPC if such analysis is not already being conducted for other Class I areas; however, the Community will carefully consider requests from sources who may wish to conduct the relevant screening/analysis.
- Sources 50km or less from FCPC's Class I Area - the Q/D screening tool does not apply for sources locating/located within 50 km or less of the Class I "boundary" and further screening and/or analysis may be necessary particularly for those projecting high NO_x emissions. FCPC will accept the use of the Weight-of-Evidence analysis proposed by WDNR until such time as FCPC selects an alternative, EPA-accepted analysis. FCPC will remain open to the implementation of advancing ozone modeling technology and protocols as they develop. This analysis will be conducted by FCPC; however, the Community will carefully consider any requests from sources who may wish to conduct the relevant screening/analysis.

FCPC Hg Deposition Implementation Framework

(See Attached Notes)

Step 1 – Is a Hg deposition analysis required?

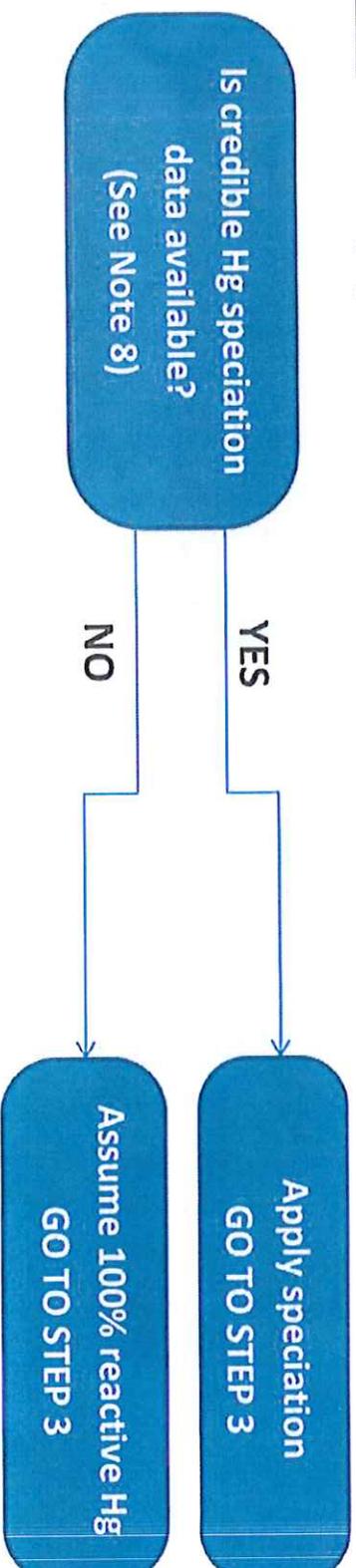


*Nothing in this framework restricts FCPC from implementing the Substantial Harm provision of the 1999 FCPC-DNR Agreement

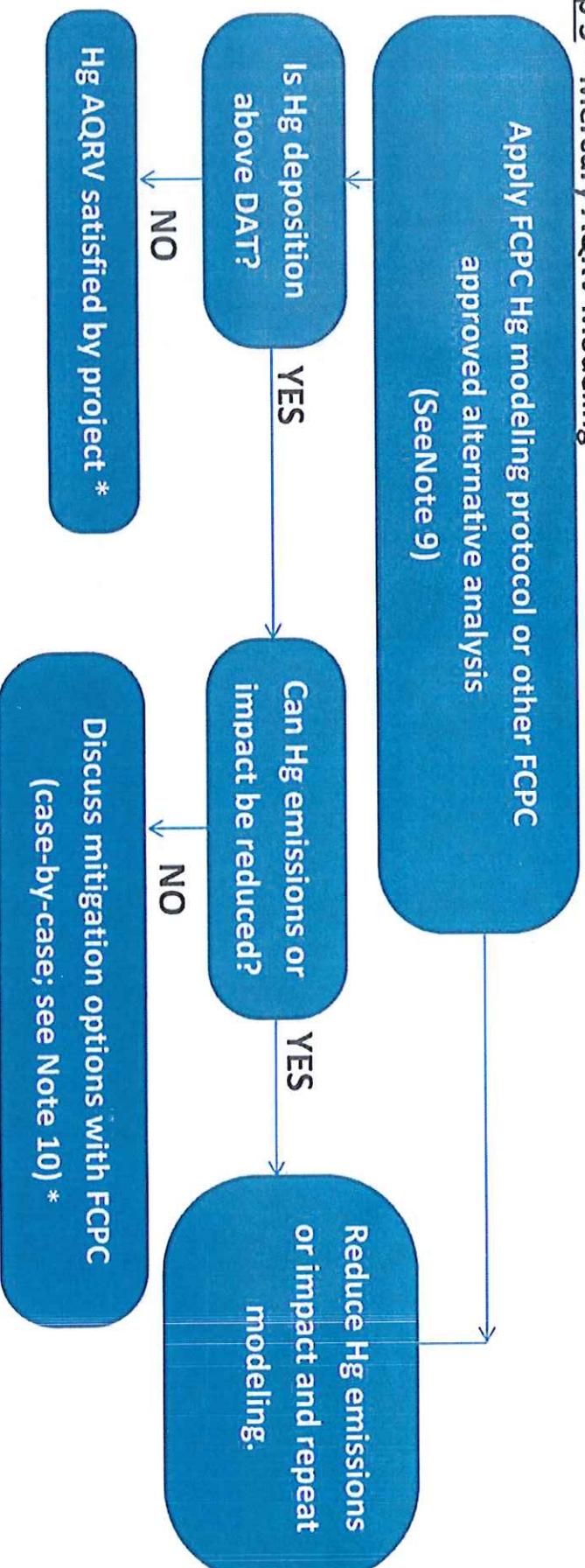
FCPC Hg Deposition Implementation Framework

(See Attached Notes)

Step 2 – Mercury Speciation



Step 3 – Mercury AQRV Modeling**



*Nothing in this framework restricts FCPC from implementing the Substantial Harm provision of the 1999 FCPC-DNR Agreement

** Emissions used in conducting the analysis must be incorporated as enforceable limits in the issued permit

Notes to FCPC Hg Deposition Implementation Framework

1. The fact that FCPC has provided a suggested proposed Mercury Implementation Framework should not be construed to be waiver of FCPC's right to modify this proposed framework at any time in the future should circumstances dictate. In particular, FCPC does not want this proposed protocol or the answer to any DNR inquiries during the implementation period regarding the protocol to foreclose FCPC from the right in the future to change this proposed protocol should circumstances dictate at any time during the next 10 years or at any other time in the future. FCPC may choose to modify this approach in the event of improved models or the availability of other scientifically relevant information.
2. FCPC is under no legal obligation to provide this detailed framework to the WDNR and has done so to demonstrate FCPC's commitment for a good working relationship on a government-to-government basis.
3. The standards in this document were recognized by the WDNR after extensive negotiations based on the FCPC's unique agreements with the WDNR, including the 1999 Agreement and the 2010 Memorandum of Understanding, and the unique facts and circumstances surrounding the adoption of the FCPC's AQRVs. The 1999 Agreement and 2010 Memorandum of Understanding are the controlling documents of record. Nothing in these notes or Framework should be construed to change the rights of the Parties with regard to implementation matters. Particularly, as identified by Exhibit A of the 2010 Memorandum of Understanding and subject to an actionable permit, the Parties shall retain the ability to seek SRP review in accordance with Exhibit A.
4. Nothing in this framework restricts FCPC from implementing the Substantial Harm provision of the 1999 FCPC-DNR Agreement.
5. Mercury emissions used in the analysis need to be enforceable limits in any required permit. Limits on emissions by restricting fuel consumption or other plant operations may be acceptable in lieu of specific mercury emission limits.
6. The Hg net emissions analysis at this step looks only at the project. There is no look-back to the "contemporaneous period" as would be done for a formal PSD netting analysis. Calculate the net emission increase from any proposed project in accordance with the following:
 - I. For construction of a new facility – The net emissions increase (NEI) is the sum of potential mercury emissions for each emissions unit proposed for the new facility. Any limitations on potential to emit for mercury used to avoid additional review need to be included in the PSD construction permit.
 - II. For modification of an existing source with possible addition of new mercury emission sources – The NEI is calculated as follows:
 - a. For existing emission unit affected by the project, the applicant determines future actual mercury emissions for each affected emissions unit at the existing facility.
 - Future actual emissions are the potential mercury emissions for an emissions unit. Any limitations on potential to emit for mercury used in the NEI calculation need to be included in the PSD construction permit.
 - Baseline (past actual) mercury emissions shall be calculated in accordance with s. NR 405.02(2m), Wis. Adm. Code

Notes to FCPC Hg Deposition Implementation Framework (Continued)

- The emission increase from the proposed project shall be the sum of the difference between future actual emissions for each emission unit and past actual (baseline) emissions for that unit
 - If a permit applicant proposes to “net” to show that the net emissions increase in mercury emissions is less than the threshold that will trigger additional review, only emission increases and emission reductions that happen simultaneously with the proposed project may be considered as part of the netting. Thus, the normal 5-year netting look back will not be applicable to any proposed project when evaluating the net emission increase for mercury emissions only.
- b. For a new emissions unit, the procedure identified in I. is used to determine the emissions increase.
 - c. The project “net emissions increase” is the sum of the emissions increases determined under II.a and II.b.
7. FCPC may elect, on a case-by-case basis, to exempt sources with clearly de minimis Hg emissions such as comfort heating units and emergency generators, where these units may be part of a larger PSD project.
 8. FCPC believes that credible Hg speciation data are available for coal combustion (http://www.epa.gov/ttn/chief/emch/speciation/EGU_Hg_speciation_summary_CAMR.pdf). FCPC also believes that most sources combusting clean fuels such as natural gas will not require Hg modeling based on Step 1.
 9. FCPC will consider alternative approaches to modeling that are reasonable, scientifically defensible and consistent with FCPC’s Class I goals and implementation standards.
 10. Mitigation options may include reductions in Hg emissions at other sources not part of the project under review including off-site sources. Required off-site Hg emissions reductions may exceed 1-to-1 depending on the relative source impact to FCPC resources. Off-site Hg emission reductions that are already required to meet other regulatory limits will not count as mitigation. FCPC is open to any ideas regarding mitigation and affected sources are encouraged to be creative in crafting possible mitigation strategies for presentation to FCPC.



**FOREST COUNTY POTAWATOMI COMMUNITY
AQRV PROJECT – DEPOSITION MODELING ASSESSMENT PROTOCOLS
(SULFUR, NITROGEN, & MERCURY)**

Prepared for:
**FOREST COUNTY POTAWATOMI COMMUNITY
CRANDON, WI**

Prepared by:

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March 31, 2015

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EXECUTIVE SUMMARY

FCPC DEPOSITION MODELING ASSESSMENT PROTOCOLS

The Forest County Potawatomi Community (FCPC) desires to establish air quality dispersion modeling guidance to be used by Wisconsin Department of Natural Resources (DNR) and Prevention of Significant Deterioration (PSD) applicants where a deposition modeling assessment for impacts to FCPC's Class I lands may be required. This protocol addresses acid deposition (sulfur and nitrogen) along with mercury deposition. A separate protocol exists for visibility assessment modeling.

The Federal Land Manager's Air Quality Related Values (AQRV) Workgroup Phase I Report – Revised 2010 (FLAG 2010) and two supplemental documents: Federal Land Manager's Interagency Guidance for Nitrogen and Sulfur Deposition Analysis – November 2011 and the 2014 Draft FLM Interagency Guidance for Near-Field Deposition Modeling (collectively, the FLAG Deposition Guidance) describes general modeling procedures for deposition-impacted air quality related values (AQRVs). However, not all model data inputs are described by the FLAG Deposition Guidance. In particular, the FLAG Deposition Guidance does not address procedures for mercury deposition modeling, which is of special interest to FCPC. This document provides FCPC's recommendations and additional guidance for developing the required modeling inputs for a deposition impact analysis at sources impacting FCPC Class I designated lands.

The FCPC guidance presented here is designed to supplement rather than replace the FLAG Deposition Guidance and other relevant agency guidelines on deposition modeling. FCPC has, to the extent practical, based its guidance on the FLAG Deposition Guidance. However, nothing requires FCPC to follow FLAG 2010 and/or the supplemental FLAG Deposition Guidance. As such, FCPC reserves the right to modify this guidance, including ways that may depart from the FLAG Deposition Guidance. Unless informed otherwise by FCPC, persons conducting deposition modeling analyses for FCPC lands are encouraged to consult the FLAG Deposition Guidance and other applicable modeling guidance documents, i.e., EPA's Guideline on Air Quality Models in 40 CFR 51 Appendix W. Any questions regarding appropriate modeling procedures for addressing deposition impacts to FCPC Class I lands should be directed to FCPC and the appropriate regulatory authority, i.e. Wisconsin DNR.

As a general rule, any emission source conducting a modeling assessment for deposition impacts to FCPC Class I lands (or impacts to other designated AQRVs such as visibility) should develop a formal written modeling protocol in advance of conducting the modeling study. The protocol should be provided to FCPC and the appropriate regulatory authority (i.e., Wisconsin DNR) for review and approval by all interested stakeholders. However, please note that FCPC is the final authority with respect to acceptable modeling procedures for impacts to FCPC-managed Class I lands.

In general, the recommendations in this document are specific to modeling analyses that address impacts only to FCPC's Class I area. Where a modeling analysis may need to address both FCPC and other nearby Class I areas, the appropriate Federal Land Manager (FLM) for the other Class I areas should also be consulted with regards to the modeling protocol. Based on the project-specific needs for the other Class I areas, FCPC may adjust at its discretion any of the recommendations presented here.

This guidance provides general advice regarding what FCPC would expect to see in a site-specific modeling protocol based on the current scientific understanding and availability of applicable air quality dispersion and deposition models. Although an applicant may propose departures from this framework, nothing shall obligate FCPC to accept or agree to any such departure. FCPC will consider and evaluate any such alternate proposal on a case-by-case basis taking into consideration the current science of dispersion/deposition modeling and the scientific merits of the alternate proposal. FCPC's goal is to make the most accurate scientific assessment possible using standard air quality dispersion/deposition models, but still err on the side of overestimating expected impacts where there is scientific uncertainty in the proposed modeling approach and/or data. FCPC recommends that an applicant discuss any modeling pursuant to this guidance with FCPC as early as possible in order to avoid possible delays in the permitting process.

Please note that nothing in the modeling protocol presented here restricts FCPC in any way from implementing the "Substantial Harm" provisions of the 1999 agreement between FCPC and the Wisconsin DNR.

1.0 GENERAL INFORMATION

1.1 Deposition Analysis Thresholds (DATs)

The relevant concern is whether or not the emission source in question will generate deposition levels above the FCPC-prescribed deposition analysis thresholds (DATs) at receptors representative of FCPC Class I lands, which are listed below (See Table 1-1):

Table 1-1
FCPC Deposition Analysis Thresholds (DATs)
Sulfur, Nitrogen, and Mercury

| Atmospherically Deposited Pollutant | Purpose of DAT | DAT Value (Units) |
|-------------------------------------|---|-----------------------------|
| Sulfur | Protect against water acidification or eutrophication and protect against mercury methylation | 0.01 kg/ha-yr |
| Nitrogen | Protect against water acidification or eutrophication | 0.01 kg/ha-yr |
| Mercury | Protect against mercury methylation | 0.098 ug/m ² -yr |

The derivations of the deposition DATs listed above are explained more fully in the FCPC deposition AQRV report (Sullivan 2012) with the exception that the mercury DAT has been set based on natural background instead of the minimum detection limit originally proposed by Dr. Sullivan.

1.2 Initial Screening Criteria – Sulfur and Nitrogen Deposition

For the modeling of air quality related values (AQRVs) including sulfur/nitrogen deposition, FLAG (2010) allows an initial “screening test” based on allowable emissions (Q) and distance (D) for the Class I area of concern. The Q/D screening test is applicable only to sources located 50 km or more from the Class I lands of interest. The FLAG deposition screening test is shown conceptually in Figure 1-1.

If the Q/D ratio is less than 10, then the emission source in question is assumed to have no adverse impact on visibility and other AQRVs, including sulfur/nitrogen deposition. The Q/D < 10 test is based on the past experience of the Federal Land Managers (FLMs) in conducting modeling of AQRV impacts to Class I areas. Additional detail on the FLM Class I screening test for sulfur and nitrogen deposition can be found in FLAG (2010).

In the Q/D test, allowable emissions (Q) are expressed in tons per year and the distance (D) in kilometers. Consistent with FLAG (2010), the emissions total (Q) is represented by the sum of the important visibility and deposition species precursor emissions, specifically, SO₂, NO_x, PM-10, and sulfuric acid mist (H₂SO₄). However, since certain AQRV impacts such as

represent the “worst-case 24-hour” emissions for each pollutant extrapolated to an annual emissions total.

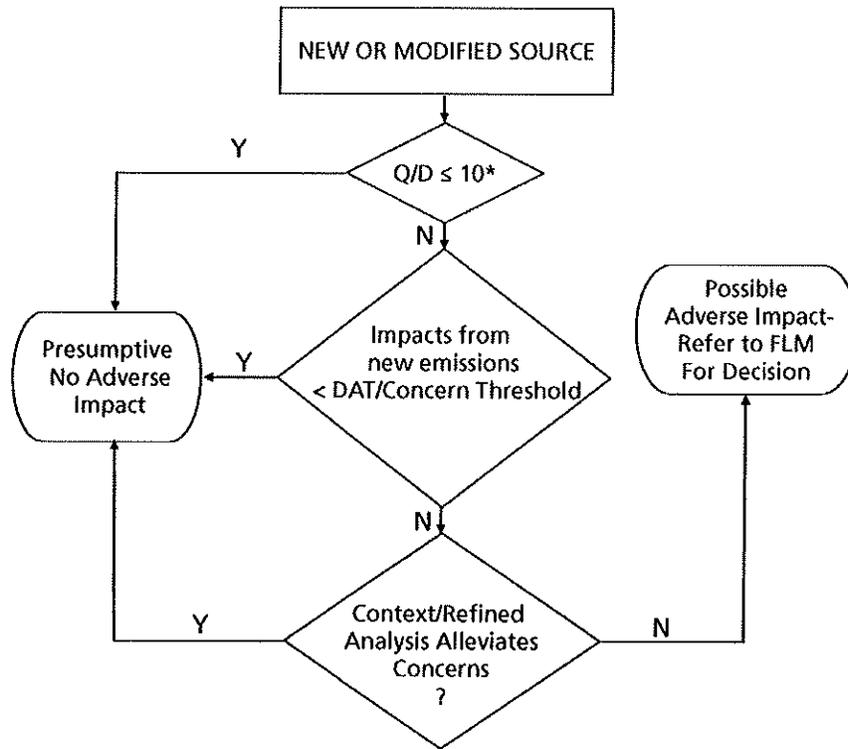


Figure 1-1
FLM Deposition Modeling Guidance (from FLAG 2010)

If the Q/D as calculated above is less than or equal to 10, and absent special circumstances then the emission source in question is assumed to have no adverse impact on AQRVs, including acid deposition, and a modeling analysis for sulfur/nitrogen deposition is not required. For the screening test on mercury emissions, please refer to Section 1.3 below.

Finally, consistent with FLAG (2010), if the source is less than 50 km from FCPC lands, the Q/D screening test is not applicable and the deposition modeling analysis will be required.

1.3 Initial Screening Criteria – Mercury Deposition

Mercury deposition is not addressed in FLAG. Nevertheless, to be consistent with the overall FLAG approach, FCPC has adopted a screening approach to filter out those emissions units with a de minimis increase in mercury emissions and/or emission units where initial modeling demonstrates that the applicable DAT is not likely to be exceeded. The FCPC mercury deposition screening test is shown conceptually in Figure 1-2.

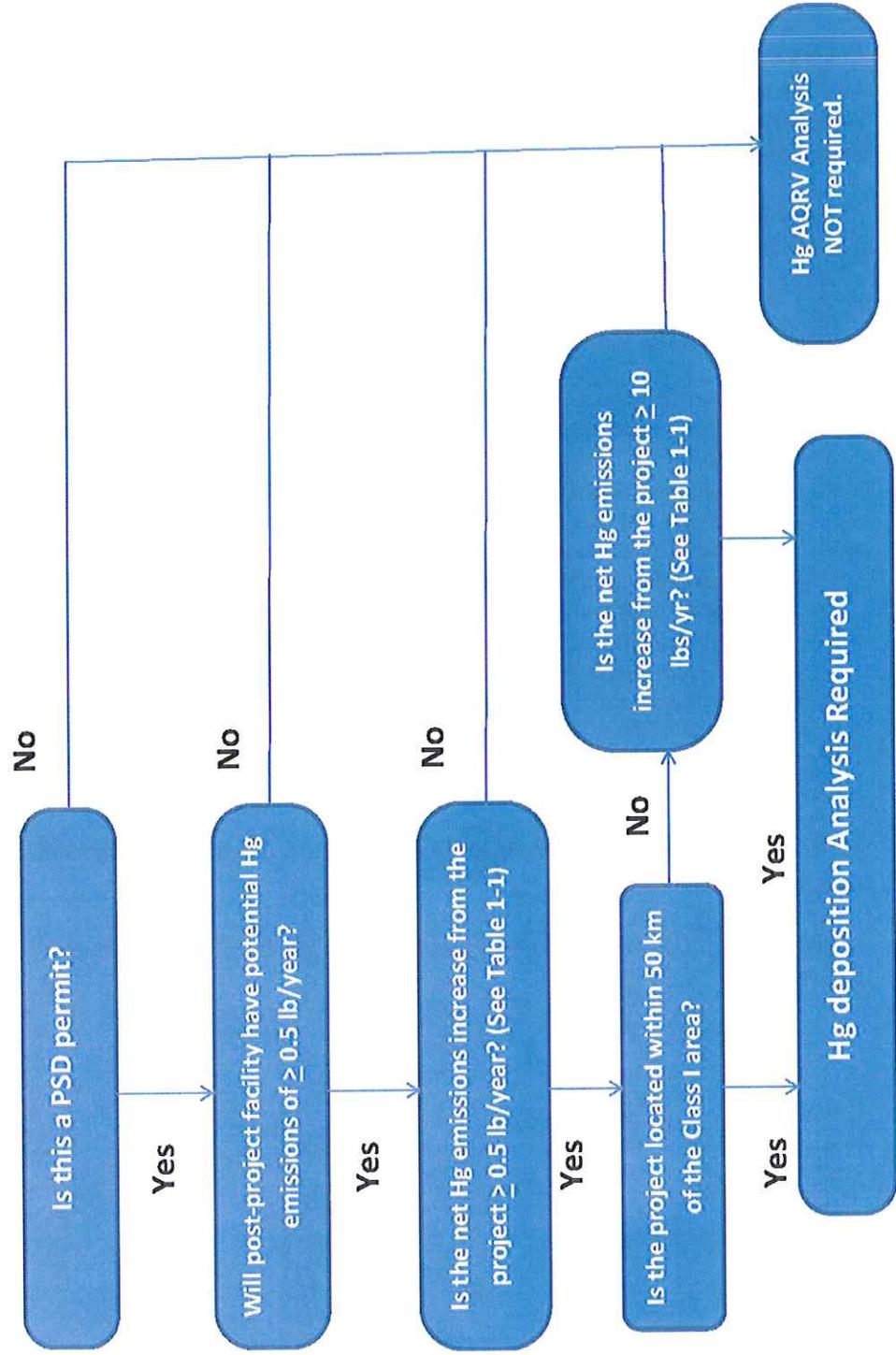
The mercury FCPC screening test establishes an emissions-based threshold for the net increase in mercury emissions based on distance from FCPC's Class I lands. For sources located closer than 50 km from FCPC's Class I lands, the de minimis mercury threshold is 0.5 pounds per year (lb/yr). Based on emissions data published in EPA's Compilation of Air Pollutant Emissions Factors or AP-42, mercury emissions at 0.5 lb/yr are generally equal to those released from a 200 MMBTU/hr natural gas-fired boiler operating continuously at maximum load. FCPC has selected this threshold as a de minimis emissions increase which will be currently accepted without further analysis against the FCPC mercury deposition DAT. For new/modified emission sources located 50 km or greater from FCPC Class I lands, the de minimis mercury emissions threshold is 10 lb/yr. FCPC has determined through a preliminary modeling analysis that a new mercury emissions source releasing 10 lb/yr or less will likely not exceed the DAT if the mercury emissions source is located more than 50 km from FCPC lands.

In the mercury deposition analysis, the emissions screening threshold is based on the concept of "net emissions increase". It is expected that the "net emissions increase" calculation would be generally consistent with practices approved for "emissions netting" in a PSD permit application (EPA 1990), with the exception that the analysis would look only at the net emissions increase from the project and would not consider any emissions changes over the five-year contemporaneous period from any other emission at the source that is not part of the project. Additional guidance on the "net emissions increase" calculations for mercury is available in the FCPC Mercury AQRV Implementation Framework available on the FCPC website and is summarized below (Table 1-2):

Table 1-2
Calculation of “Net Emissions Increase”
for the Purpose of FCPC Mercury Deposition Modeling

1. For construction of a new facility – The net emissions increase (NEI) is the sum of potential mercury emissions for each emissions unit proposed for the new facility. Any limitations on potential to emit for mercury used to avoid additional review need to be included in the PSD construction permit.
2. For modification of an existing source with possible addition of new mercury emission sources – The NEI is calculated as follows:
 - a. For existing emission unit affected by the project, the applicant determines future actual mercury emissions for each affected emissions unit at the existing facility.
 - Future actual emissions are the potential mercury emissions for an emissions unit. Any limitations on potential to emit for mercury used in the NEI calculation need to be included in the PSD construction permit.
 - Baseline (past actual) mercury emissions shall be calculated in accordance with NR 405.02(2m), Wis. Adm. Code
 - The emission increase from the proposed project shall be the sum of the difference between future actual emissions for each emission unit and past actual (baseline) emissions for that unit
 - If a permit applicant proposes to “net” to show that the net emissions increase in mercury emissions is less than the threshold that will trigger additional review, only emission increases and emission reductions that happen simultaneously with the proposed project may be considered as part of the netting. Thus, the normal 5-year netting look back will not be applicable to any proposed project when evaluating the net emission increase for mercury emissions only.
 - b. For a new emissions unit, the procedure identified in 1 is used to determine the emissions increase.
 - c. The project “net emissions increase” is the sum of the emissions increases determined under 2.a and 2.b.

Figure 1-2
FCPC Mercury Screening Test



1.4 Emissions Information

Emissions information used in the FCPC deposition modeling assessment should be representative of annual average emissions, generally expressed as the maximum allowable emissions over a rolling 12-month period. For a proposed new PSD source or major modification, the emissions modeled should be consistent with any proposed permit limits, i.e., ton/yr. Emissions for all precursor pollutants for deposition should be included in any modeling, i.e., SO₂, NO_x, and Hg.

1.5 Deposition Modeling Overview

Deposition modeling for acidic species (sulfur and nitrogen) is generally well established through FLAG 2010. The recommended FCPC modeling procedures for acid deposition mimic the FLAG protocols using the AERMOD and CALPUFF dispersion modeling systems.

Mercury deposition modeling procedures are not as well established. Some mercury deposition modeling studies that are available through the scientific literature apply the REMSAD model or other more sophisticated modeling tools. Also, many published mercury deposition modeling studies describe large global-scale or regional-scale modeling efforts and are not focused on assessing the possible mercury deposition impacts from an individual emission source. Lastly, REMSAD includes chemical transformations of mercury in the atmosphere between the various mercury species that may be present:

- Hg⁰: elemental mercury vapor
- Hg²⁺: divalent (or reactive) mercury compounds in the vapor phase
- Hg^p: divalent mercury compounds in the particulate phase

Notwithstanding the above, the more sophisticated modeling tools such as REMSAD are not well suited for the types of modeling studies contemplated by FCPC. REMSAD has large and detailed data requirements and persons with the required knowledge to successfully apply REMSAD and similar tools are limited. For the FCPC deposition modeling efforts, FCPC has recommended modeling tools that are readily available and can be applied by most regulated sources and consultants that provide permitting services to these companies. As such, FCPC has developed a reasonable scientific approach for modeling mercury deposition that applies dispersion models that are in common use today; i.e., AERMOD and CALPUFF. (See Table 1-2).

Table 1-3
Recommended FCPC Deposition Models

| Pollutant | Near Field Modeling (< 50 km) | Far Field Modeling (> 50 km) |
|-----------------|----------------------------------|---------------------------------|
| Sulfur/Nitrogen | AERMOD | CALPUFF |
| Mercury | AERMOD | CALPUFF |

1.6 Receptor Information

Receptors represent physical locations referenced to a map or other standard coordinate system where model calculations of concentrations and resulting impacts to AQRVs may occur.

A “standard” receptor package has been developed for the interior FCPC tribal lands designated as Class I. Having a standard receptor set ensures that all future projects assess impacts at the same receptor locations. The FLMs have already developed a “standard” receptor package for each mandatory Class I area. The standard FCPC receptor set follows the same principles advanced by FLMs for other Class I areas. A standard receptor set is available on the FCPC webpage under Natural Resources Department/Air Program/Air Pollution Permitting.



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2.0 NEAR-FIELD MODELING ANALYSES (WITHIN 50 KM)

This section provides guidance for the modeling of deposition impacts for emission sources located within 50 km of FCPC tribal lands designated as Class I. For the sulfur/nitrogen and mercury deposition modeling in the near-field, the model preferred by FCPC is the AERMOD dispersion model (USEPA 2004). AERMOD is the preferred EPA dispersion model for receptors within 50 km of the emission source, as per 40 CFR 51 Appendix W.

General guidance for atmospheric deposition modeling is also given in the FLAG Deposition Guidance and the FLM's Interagency Guidance for Near-Field Deposition Modeling (USDA Forest Service et al, 2014). The FCPC modeling guidance in this document should be considered as supplementary to the FLAG Deposition Guidance, especially with respect to sulfur and nitrogen deposition modeling. Readers conducting deposition modeling for impacts to FCPC Class I lands are encouraged to consult these and any other primary reference documents cited in the FCPC modeling protocol.

2.1 Deposition Calculations Using AERMOD – Overview

The original AERMOD model did not offer the user any options for simulating wet and dry deposition. However, an update to the AERMOD model released in 2006 included wet and dry deposition calculations. The AERMOD deposition calculations are explained more fully in an Addendum to the AERMOD User's Guide (EPA 2006) as well as a companion report (EPA 2003). The user should consult with the AERMOD User's Guide Addendum for specific instructions regarding the format and syntax of the AERMOD model inputs required for the deposition calculations described here.

When calculating deposition using AERMOD, the meteorological data file may require several additional parameters not normally used by the model. These data can be generated using AERMET (Version 04300 or newer). The additional variables are: 1) precipitation code, 2) precipitation amount (mm), 3) relative humidity (%), 4) surface pressure (mb), and 5) cloud cover (tenths). These data go at the end of each hourly record in the AERMET SFC file in the order presented above. The amended AERMET files are required to apply the FLM sulfur/nitrogen near-field deposition modeling approach (Level 2) and the FCPC recommended near-field mercury deposition modeling approach.

Hourly precipitation information for use in these calculations can be obtained from either SAMSON, HUSWO, or ISHD (TD-3505) formats, all of which are supported by AERMET.

2.2 Near-Field Sulfur and Nitrogen Deposition Modeling

For near-field sulfur/nitrogen deposition modeling, the FCPC recommends procedures for applying AERMOD following the DRAFT Federal Land Managers' Interagency Guidance for Near-Field Deposition Modeling (USDA Forest Service et al, 2014). Please note that at the time of preparing the FCPC deposition modeling protocol, the FLM near-field deposition guidance was only in draft form. Should a Final FLM guidance document become available for calculating

near-field sulfur/nitrogen deposition using AERMOD, users of the FCPC guidance should apply any changes to the guidance as recommended by the final FLM document.

In the FLM near-field deposition guidance, two modeling procedures (described as Level-1 and Level-2) are included. Either approach may be used to satisfy the FCPC sulfur/nitrogen near-field deposition analysis.

According to the FLM near-field deposition guidance, treatment of nitrogen oxide (NO_x) emissions as inert nitrogen dioxide (NO₂) will likely underestimate the near-field deposition of nitrogen because the deposition velocities for NO and NO₂ are low in comparison to other nitrogen species. While most emissions are released to the atmosphere as NO and NO₂ (or NO_x), chemical processes in the atmosphere can convert NO_x to other nitrogen species with higher deposition velocities. Nitric acid (HNO₃) is the nitrogen species of most concern because it has one of the higher deposition velocities for common nitrogen species. As such, when using non-reactive dispersion models such as AERMOD to simulate nitrogen deposition, a simplifying, yet conservative, assumption is made to treat all NO_x as if it were in the form of HNO₃.

Similar issues do not exist for sulfur dioxide (SO₂) emissions as SO₂ already has one of the higher deposition velocities for the sulfur species of importance.

Please note that as per the FLM near-field deposition guidance, the user should not employ any of the “Tier 3” procedures such as the ozone limiting method (OLM) for modeling NO_x emissions as described by current EPA modeling guidelines (40 CFR 51 Appendix W) as these procedures do not address conversion of NO_x to the species of interest for deposition (HNO₃).

For the Level-1 sulfur/nitrogen deposition analysis, follow the procedures below as described by the FLM near-field deposition guidance (USDA Forest Service et al, 2014). In the Level-1 analysis the concentration of the pollutant is calculated using AERMOD and the deposition is determined from the ambient air concentration using a deposition velocity.

1. In the AERMOD control file, specify the following options:
MODELOPT = DDEP
AVERTIME = ANNUAL
GASDEPVD, NO₂ (HNO₃) = 0.05 m/sec, SO₂ = 0.005 m/sec
2. Multiply the dry deposition flux of NO₂ (if applicable) by the ratio of molecular weight for the secondary species (HNO₃) to the primary species (NO₂). This ratio is 63/46 or 1.37 and converts the NO₂ deposition flux to the HNO₃ deposition flux.
3. Convert the SO₂ and HNO₃ deposition flux to sulfur/nitrogen as appropriate. This is based on the molecular weight of sulfur (S) and nitrogen (N) as compared to the molecular weight of the compound deposited (SO₂ or HNO₃). For SO₂, the ratio is 0.5 and for HNO₃, the ratio is 0.22. The result is the sulfur/nitrogen deposition flux.

- Convert the AERMOD output (grams per meter squared per year or gm/m²-yr) to the appropriate units for comparison to the sulfur/nitrogen DAT, which is expressed as kilograms per hectare per year (kg/ha-yr). The conversion from grams to kilograms is 0.001 and the conversion from square meters to hectares is 10,000. The net result is an increase in the model result by a factor of 10.

For the Level-2 analysis, the deposition velocity is calculated from other modeling inputs within AERMOD. For the Level-2 analysis, follow the procedure below as described by the FLM near-field deposition guidance (USDA Forest Service et al, 2014).

- In the AERMOD control file, specify the following options:
 MODELOPT = DDEP
 AVERTIME = ANNUAL
 GDSEASON & GDLANDUSE as per AERMOD User's Guide Addendum
 GASDEPOS as per Table 2-1 below:
- Multiply the dry deposition flux of NO₂ (if applicable) by the ratio of molecular weight for the secondary species (HNO₃) to the primary species (NO₂). This ratio is 63/46 or 1.37 and converts the NO₂ deposition flux to the HNO₃ deposition flux.
- Convert the SO₂ and HNO₃ deposition flux to sulfur/nitrogen as appropriate. This is based on the molecular weight of sulfur (S) and nitrogen (N) as compared to the molecular weight of the compound deposited (SO₂ or HNO₃). For SO₂, the ratio is 0.5 and for HNO₃, the ratio is 0.22. The result is the sulfur/nitrogen deposition flux.
- Convert the AERMOD output (grams per meter squared per year or gm/m²-yr) to the appropriate units for comparison to the sulfur/nitrogen DAT, which is expressed as kilograms per hectare per year (kg/ha-yr). The conversion from grams to kilograms is 0.001 and the conversion from square meters to hectares is 10,000. The net result is an increase in the model result by a factor of 10.

Table 2-1
 Recommended Gaseous Deposition Parameters
 AERMOD Deposition Modeling – Sulfur & Nitrogen
 From USDA Forest Service et al (2014)

| | Diffusivity in Air | Diffusivity in Water | Cuticular Resistance | Henry's Law Constant |
|------------------|---------------------------------------|---------------------------------------|------------------------|--------------------------|
| | D _a (cm ² /sec) | D _w (cm ² /sec) | R _{cl} (s/cm) | (Pa m ³ /mol) |
| HNO ₃ | 0.1041 | 1 | 13.33 | 2.1 x10 ⁵ |
| SO ₂ | 0.1119 | 1.83 x10 ⁻⁵ | 80 | 72.37 |

The FLM near-field deposition guidance also allows a “Level-3” modeling approach that would employ CALPUFF for the near-field nitrogen/sulfur deposition calculations. Any user desiring to apply CALPUFF in this setting should contact FCPC and the appropriate regulatory agency to develop a site-specific modeling protocol for applying CALPUFF at the community AQRV Report -- Deposition Modeling Assessment Protocols

distances less than 50 km. EPA (2008) provides official EPA guidelines regarding the use of CALPUFF in the near field for regulatory applications. The primary issue of interest in applying CALPUFF in the near-field is the specification of the meteorological fields and the need to generate data fields of adequate resolution for near-field analyses. General guidance on how to apply CALPUFF for sulfur/nitrogen deposition calculations may be found elsewhere in this document.

2.3 Near-Field Mercury Deposition Modeling

2.3.1 Overview

The preferred FCPC approach for near-field mercury deposition modeling uses the AERMOD model and is patterned after the use of AERMOD for addressing mercury deposition from sources located in Virginia (Douglas et al 2008). Similar methods were also applied in modeling mercury deposition for a proposed coal-fired electric generating station in South Carolina (Trinity Consultants 2008).

The user can select the deposition algorithms in AERMOD by using the MODELOPT keyword on the CO pathway. The user can select one of three options for deposition: DEPOS which calculates both wet and dry deposition fluxes, and/or DDEP and WDEP, which would select only dry deposition or wet deposition, respectively. In the FCPC recommended modeling approach, the user should select DEPOS in order to calculate both wet and dry deposition, although the user can also select DDEP and WDEP if separate AERMOD model output for dry and wet deposition is desired for any reason.

Although AERMOD is preferred by FCPC for near-field mercury deposition modeling, the applicant has the option of applying CALPUFF for this analysis, even when the FCPC Class I receptors are less than 50 km from the emission source. Any user desiring to apply CALPUFF in this setting should contact FCPC and the appropriate regulatory authority (i.e., Wisconsin DNR) and provide a site-specific modeling protocol for applying CALPUFF at distances less than 50 km. As per EPA guidance on the near-field application of CALPUFF, the applicant will need to demonstrate why CALPUFF would be superior to AERMOD for the specific case of interest before FCPC would approve this alternative. Another issue of interest in applying CALPUFF in the near-field is the specification of the meteorological fields in order to provide for adequate resolution of these data fields for near-field analyses. If CALPUFF is to be applied for the near-field mercury deposition modeling analysis, please also refer to Section 3 for the modeling procedures for deposition-related variables.

2.3.2 Deposition Calculations Using AERMOD – Specific User Selections

For gaseous deposition, AERMOD's deposition algorithms require data on the "seasonal category", which defines the type of vegetation present on a monthly basis. These data are input to AERMOD via the GDSEASON keyword on the CO pathway. There are five choices for this variable as described below:

Seasonal Category 1: Midsummer with lush vegetation

umn with un-harvested croplands

mmunity AQRV Report – Deposition Modeling Assessment Protocols

- Seasonal Category 3: Late autumn after frost or harvest, or winter with no snow
- Seasonal Category 4: Winter with snow on ground
- Seasonal Category 5: Transitional spring with partial green coverage or short annuals

The recommended monthly inputs for FCPC deposition modeling are listed in Table 2-2.

Table 2-2
FCPC Recommended Values for Seasonal Category – AERMOD Deposition Modeling

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 4 | 4 | 4 | 5 | 5 | 1 | 1 | 1 | 2 | 2 | 4 | 4 |

The AERMOD deposition algorithms also include a gas resistance deposition term based on the five seasonal categories described above and the selected land use category. The possible land use categories in AERMOD are shown below in Table 2-3.

Table 2-3
FCPC Recommended Values for Land Use Category – AERMOD Deposition Modeling

| Land Use Category | Description |
|-------------------|-----------------------------|
| 1 | Urban, no vegetation |
| 2 | Agricultural lands |
| 3 | Rangeland |
| 4* | Forest |
| 5 | Suburban areas, grassy |
| 6 | Suburban areas, forested |
| 7 | Bodies of water |
| 8 | Barren lands, mostly desert |
| 9 | Non-forested wetlands |

*Recommended for FCPC Class I Deposition Modeling Analyses

The land use category data are input to AERMOD through the GDLANDUSE keyword on the CO pathway. The data are entered for each of the 36 wind direction sectors starting with winds blowing toward 10 degrees (e.g., 5-15 degrees) and proceeding clockwise, ending with winds blowing toward 360 degrees (e.g., 355-5 degrees). For the FCPC deposition modeling analysis, the data of interest are only those sectors from the emission source toward the FCPC Class I receptors. Given that FCPC lands are largely forested, the recommended value for this parameter is “4”.

The AERMOD deposition algorithm also includes an option for the user to override the default model values for the reactivity factor (f_o) and the fraction (F) of maximum green leaf area index (LAI) for seasonal categories 2 and 5. If the user follows the recommended seasonal category listed above and selects “4”, then the selections for f_o and F are not relevant.

The input for source parameters for wet and dry deposition of gaseous pollutants is controlled by the GASDEPOS keyword on the SO pathway and must follow the individual source LOCATION card in the input file. These inputs may be applied for a single source, or for a range of sources. The recommended input values are shown in Table 2-4 below, derived from Douglas et al (2008):

Table 2-4
FCPC Recommended Gaseous Deposition Parameters
AERMOD Deposition Modeling - Mercury

| | Diffusivity in Air | Diffusivity in Water | Cuticular Resistance | Henry's Law Constant |
|---------------------------------|------------------------------|------------------------------|----------------------|--------------------------|
| | D_a (cm ² /sec) | D_w (cm ² /sec) | Rcl (s/cm) | (Pa m ³ /mol) |
| Elemental Hg (Hg ⁰) | 7.23×10^{-2} | 6.30×10^{-6} | 1.0×10^5 | 150 |
| Reactive Hg (Hg ²⁺) | 6.0×10^{-2} | 3.256×10^{-4} | 1.0×10^5 | 6.0×10^{-6} |

Please note that the mercury deposition calculations are different for elemental gaseous mercury (Hg⁰) and reactive gaseous mercury (Hg²⁺). As such, knowledge of the emissions profile for Hg⁰ and Hg²⁺ is required. Typically, AERMOD would be run separately for Hg⁰ and Hg²⁺ and the output for each summed to get the total Hg deposition at each receptor. If the mercury emissions profile is unknown, then all mercury can be assumed to be Hg²⁺, which should generate a worst-case result in the model.

The mercury speciation for a coal-fired emission source can be taken from mercury speciation profiles developed by EPA in support of the Clean Air Mercury Rule, which can be found at:

http://www.epa.gov/ttn/chief/emch/speciation/EGU_Hg_speciation_summary_CAMR.pdf

For most emission sources, the release of elemental mercury as particles would be a small fraction of the total emissions compared to releases of vapor-phase mercury. In this case, the gaseous deposition calculations dominate the total deposition and the particulate deposition can be ignored. If particulate deposition is to be considered for any individual source, AERMOD has two options for calculating particle deposition. Method 2 is the FCPC preferred method for mercury deposition calculations because nearly all of the particulate mercury emissions would be sized at 10 microns or smaller. These data are input using the METHOD_2 keyword on the SO pathway. The data required for each source are the Fine Mass Fraction (FMM) for particulate mass emitted as "fine" particles (less than 2.5 microns in diameter) and the representative mass mean diameter (d_{mm}) for the mercury particles. Based on Douglas et al (2008), the recommended values for particulate mercury are FMM = 0.8 and d_{mm} = 0.4 microns. If separate modeling for particulate mercury is planned, these results must be summed with the AERMOD output for gaseous mercury explained above in order to generate to total Hg deposition.

Once the model results are generated, the output needs to be converted to the proper units (micrograms per square meter per year or $\mu\text{g}/\text{m}^2\text{-yr}$) for comparison to the FCPC mercury DAT.

3.0 FAR-FIELD MODELING ANALYSES (OUTSIDE 50 KM) – CALPUFF

This section provides guidance for the modeling of deposition impacts for emission sources located 50 km or more from FCPC Class lands using the CALPUFF modeling system (Scire et al 2000). CALPUFF is the recommended air quality dispersion model in 40 CFR 51 Appendix W to assess air quality impacts for sources more than 50 km distant from the receptor of interest.

General guidance for atmospheric deposition modeling using CALPUFF is also given in the FLAG Deposition Guidance discussed previously. The FCPC modeling guidance in this document should be considered as supplementary to the FLAG report and other FLM guidelines. Readers conducting deposition modeling for impacts to FCPC Class I lands are also advised to consult the FLAG Deposition Guidance and any other primary reference documents cited in this modeling protocol.

An alternate analysis to use AERMOD in lieu of CALPUFF may be considered by FCPC upon request from the user. In the alternate AERMOD analysis, the FCPC receptor would be placed at a distance of 50 km, even if the actual source-to-receptor distance exceeds 50 km. The user would also apply the AERMOD deposition protocol guidance that was described earlier. However, FCPC will not approve the alternate user of AERMOD to replace CALPUFF if CALPUFF is already required by FCPC to address other AQRVs such as visibility and/or if CALPUFF is being used to address impacts to other Class I areas. Any user desiring the alternative approach using AERMOD should consult with FCPC in advance to assure that the alternative approach is suitable for the planned site-specific modeling.

3.1 CALPUFF Overview

The CALPUFF modeling system is an integrated set of air quality dispersion models designed to handle the complexities posed by long-range transport, chemical transformation, deposition, and other issues related to Class I area impacts. The CALPUFF modeling system has been approved by the U.S. Environmental Protection Agency (EPA) as a Guideline Model for source-receptor distances greater than 50 km, and is also approved for use on a case-by-case basis in complex flow situations for shorter distances (40 CFR Part 51, Appendix W and Federal Register, April 15, 2003).

The major components of the modeling system are CALMET and CALPUFF. CALMET is a diagnostic model that generates meteorological fields used to drive the CALPUFF dispersion model. It produces three-dimensional wind and temperature fields and two-dimensional fields of mixing heights and other meteorological fields. It allows the user to incorporate slope flow effects, terrain channeling, and kinematic effects of terrain. CALMET also links to a number of

other utility programs that format various input data including meteorological observations, land use data, and terrain data.

The diagnostic windfield module in CALMET uses a two-step approach for computation of the windfields. In the first step, an initial-guess windfield is optionally adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce the Step 1 windfield. MM5 data are normally used to define the initial guess data fields.

The second step consists of an objective analysis procedure to introduce observational data into the Step 1 initial-guess windfield to produce the final windfield. If the default model inputs are followed, an inverse-distance squared interpolation scheme is used which weighs observational data more heavily in the vicinity of the observational station, while the Step 1 windfield dominates the windfield in regions with no observational data.

CALPUFF is a non-steady-state Gaussian puff model that includes algorithms for building downwash effects as well as chemical transformation, wet deposition, and dry deposition. It generates estimates of concentration and/or deposition for a user specified list of pollutants and treats emissions from stacks as well as area, volume, and buoyant line sources.

The CALPUFF output can be analyzed and processed using other system utilities, most commonly POSTUTIL and CALPOST. POSTUTIL is used for combining and scaling the CALPUFF concentration output, generally for creating files of total sulfur and total nitrogen deposition. CALPOST computes averages and performs ranking for display of CALPUFF output data. CALPOST also performs the visibility impact calculations.

A summary of the technical capabilities and features commonly employed in CALPUFF modeling analyses is provided in Table 3-1.

Table 3-1
Major Features of CALPUFF

| |
|---|
| <p>Complex Terrain: The effects of complex terrain on puff transport are derived from the CALMET winds. In addition, puff-terrain interactions at receptor locations are simulated using a general “plume path coefficient” puff height adjustment similar to the Industrial Source Complex model (ISCST3).</p> |
| <p>Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines are included in CALPUFF which solve many of the computational difficulties encountered when applying a puff model to near-field releases. For near-field applications during rapidly-varying meteorological conditions, an elongated puff (slug) sampling function may be used. An integrated puff approach may be used during less demanding conditions. Both techniques reproduce continuous plume results under the appropriate steady state conditions.</p> |
| <p>Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains both overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes, which occur at the coastline along a major body of water.</p> |
| <p>Dry Deposition: A full resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. Options are provided to allow user-specified, diurnally varying deposition velocities to be used for one or more pollutants instead of the resistance model (e.g., for sensitivity testing) or to by-pass the dry deposition model completely. For particles, source-specific mass distributions may be provided for use in the resistance model.</p> |
| <p>Wet Deposition: An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen vs. liquid precipitation).</p> |
| <p>Wind Shear Effects: CALPUFF contains an optional puff splitting algorithm that allows vertical wind shear effects across individual puffs to be simulated. Differential rates of dispersion and transport among the “new” puffs generated from the original, well-mixed puff can substantially increase the effective rate of horizontal spread of the material.</p> |
| <p>Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO₂, SO₄, NO_x, HNO₃, and NO₃) employed in the MESOPUFF II model or a set of user-specified, diurnally-varying transformation rates. This feature computes secondary particle formation (sulfate and nitrate) that is important for visibility effects.</p> |

3.2 Recommended CALPUFF Deposition Modeling Procedures

3.2.1 CALPUFF Calculations and Recommended Inputs

The CALPUFF modeling procedures are documented in the FLAG Deposition Guidance and other reference documents such as the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase II Report (EPA 1998) and EPA's Air Quality Modeling Guidelines in 40 CFR 51 Appendix W. Users conducting CALPUFF AQRV modeling for impacts to FCPC Class I lands should also consult these primary reference documents for guidance. In general, the CALPUFF modeling should use the regulatory default switches (MREG = 1) and other standard default variables. Any deviations from the standard default values should be documented and approved in advance by FCPC and the appropriate regulatory authority (i.e.: Wisconsin DNR).

Development of the three-dimensional meteorological data fields using CALMET should be consistent with current EPA and FLM guidance in Fox (2009) and/or any newer guidance issued by EPA and or FLMs. The user should consult with FCPC and the reviewing authority (i.e., Wisconsin DNR) when preparing to modeling protocol to be sure that the current agency guidance is being applied when developing the CALMET meteorological data fields.

For CALPUFF, proper simulation of deposition impacts requires that all relevant species be modeled. All relevant species in the emissions profile should be included as "emitted" species (See CALPUFF Input Group 3). Also, secondary species such as HNO₃, NO₃, and SO₄ should be included as "modeled", unless any of these are already part of the "emitted" species list.

CALPUFF Input Group 11 contains data inputs for the background ozone and ammonia values. There are no model default values for background ozone (BCKO3) or background ammonia (BCKNH3), so FCPC's recommendations follow below for these variables.

For background ozone, the common choice is to apply actual hourly ozone measurements concurrent with the meteorological period being modeled through an OZONE.DAT file. Users applying this approach should be sure to include the FCPC ozone monitoring station data in the OZONE.DAT file. FCPC has operated an ozone monitoring station since January 2004. These data are believed to be the most representative background ozone for the region in and near FCPC. Users can obtain FCPC's ozone data through the EPA's AQS database by using the following site information: Tribal Code - 434, State - 55, County - 041, Site - 0007.

In the absence of an OZONE.DAT file, the background ozone can still be taken from the FCPC monitoring data. The monthly average peak-daily 8-hour average ozone concentrations for 2011 at the FCPC monitor are shown in Table 3-2. The user should consult with FCPC to determine if more recent ozone monitoring data are available to substitute for the concentrations listed in Table 3-2.

Table 3-2
 Recommended Monthly Ozone Concentrations (ppb) for CALPUFF Modeling
 (From FCPC 2011 Monitoring Data)

| | | | | | |
|-----------------|------|---------------|------|------------------|------|
| January | 37.9 | May | 44.6 | September | 30.2 |
| February | 42.5 | June | 42.2 | October | 38.3 |
| March | 46.1 | July | 36.5 | November | 31.1 |
| April | 49.5 | August | 31.2 | December | 29.9 |

The data in Table 3-2 provide a conservative estimate of the monthly mean FCPC ozone concentration and are also preferred in the event that the meteorological data do not overlap with the available FCPC ozone monitoring data.

For background ammonia concentrations, available monitoring data are generally limited. The general CALPUFF approach follows the IWAQM Phase II report, which suggests background ammonia concentrations ranging between 0.5 ppb and 10 ppb depending on the land use of the region. Consistent with prior CALPUFF modeling of emission sources in northern Minnesota, a background ammonia concentration of 1.0 ppb for all months is recommended at the present time.

Users desiring to use alternative background ammonia levels may petition FCPC and the regulatory authority to use such alternative data by supplying appropriate technical justification. FCPC may also alter the recommended background ammonia levels at its discretion if newer monitoring information representative of FCPC lands is obtained. The desire is to use the most accurate ammonia concentration data, keeping in mind that that any uncertainty is to err on the side of a conservative analysis.

It is preferable that ammonia be carried in CALPUFF through the background concentration rather than modeling ammonia emissions directly. Any plans to model ammonia emissions directly within CALPUFF must be technically justified and approved in advance by FCPC and the appropriate regulatory authority. Such an approach may be considered by FCPC if the source in question directly releases ammonia emissions in significant quantities.

Once the CALPUFF modeling is completed, users at their discretion may apply the ammonia limiting approach in POSTUTIL (MNITRATE = 1). The MNITRATE option compensates for an inherent conservatism in the CALPUFF model that all background ammonia is available to each and every puff tracked in the modeling domain. In reality, when discrete puffs overlap, these puffs need to compete for the available ammonia. The ammonia limiting option within POSTUTIL adjusts for this inherent conservatism and is a permissible adjustment for CALPUFF modeling.

The deposition calculations within CALPUFF are based on an approach where the deposition velocity is expressed as the inverse of the sum of various “resistances”, plus a gravitational settling term for particle deposition. For gasses, the deposition velocity (v_d) is computed as: $v_d = 1/(r_a + r_d + r_c)$, where the resistances are listed as:

- r_a atmospheric resistance (s/m) through the surface layer
- r_d deposition layer resistance (s/m)
- r_c canopy (vegetation layer) resistance (s/m)

The atmospheric resistance (r_a) is a function of the surface roughness length, friction velocity, and the Monin-Obukhov length and is not pollutant-specific. These parameters are a function of the predominant land use of each grid cell in CALPUFF and are passed to the modeling via the CALMET meteorological processor.

The deposition layer resistance (r_d) varies between different pollutants and is dependent on the molecular diffusivity of the pollutant in question.

The canopy resistance (r_c) is determined from the various resistances for gasses in the vegetation layer. There are three primary pathways for uptake/reaction of pollutants with the vegetation and/or ground surface: 1) transfer through the stomatal pore and dissolution or reaction in the mesophyll cells, 2) reaction with or transfer through the leak cuticle, and 3) transfer to the ground or water surface.

CALPUFF computes r_c following the three pathways listed above:

$$r_c = 1 / (LAI/r_f + LAI/r_{cut} + 1/r_g)$$

where: r_f is the internal foliage resistance (Pathway 1), r_{cut} is the cuticle resistance (Pathway 2), and r_g is the ground or water surface resistance (Pathway 3).

LAI is the leaf area index (the ratio between the leaf surface area and the ground surface area), which is specified in the model as a function of land use type. Areas with thick vegetation have a high LAI value.

The first pathway is usually the dominant pathway for uptake of soluble pollutants in vegetated areas. In CALPUFF, these calculations are a function of the molecular diffusivity of the pollutant in question and the mesophyll resistance (or the ability of the plant to absorb the pollutant in question), which in turn depends in part on the solubility and reactivity of the individual pollutant.

The cuticle resistance (2nd pathway) is controlled by the pollutant reactivity. CALPUFF calculates this resistance based on the reactivity of the pollutant as compared to the reference reactivity of sulfur dioxide (SO₂).

The final pathway is the ground/water resistance (r_g). This pathway is typically only important for land use categories where the vegetation is sparse. However, over water surfaces, deposition of soluble pollutants can be quite rapid.

In CALPUFF, the dry deposition parameters for gasses are found in Input Group 7. The FCPC recommended values for the pollutants of interest are listed in Table 3-3.

Table 3-3
Recommended Gaseous Dry Depositions Values for CALPUFF – Input Group 7

| Pollutant | Diffusivity (cm ² /sec) | Alpha Star - Solubility Enhancement Factor | Reactivity | Mesophyll Resistance (s/cm) | Henry's Law Coefficient (dimensionless) |
|------------------|------------------------------------|--|------------|-----------------------------|---|
| SO ₂ | 0.1509 | 1.0 x 10 ³ | 8 | 0 | 4.0 x 10 ⁻² |
| NO _x | 0.1656 | 1.0 | 8 | 5 | 3.5 |
| HNO ₃ | 0.1628 | 1.0 | 18 | 0 | 8.0 x 10 ⁻⁸ |
| Hg ²⁺ | 0.1628 | 1.0 x 10 ⁹ | 800 | 0 | 2.7 x 10 ⁻⁷ |

The values in Table 3-3 are the standard CALPUFF default values for sulfur and nitrogen species. For mercury, the values are taken from EPA (1997). Since the reactive form of mercury dominates the dry deposition, only values for Hg²⁺ are provided in the available scientific literature. If the emissions profile for mercury is unknown, then all mercury emissions should be treated as Hg²⁺.

For dry deposition of particles, the required data for CALPUFF are the mass mean diameter for the particles and the geometric standard deviation for the particles. For sulfur and nitrogen deposition, these data are input for SO₄ (sulfate) and NO₃ (nitrate). The recommended values for FCPC deposition modeling are listed in Table 3-4, which are taken from the CALPUFF default values. For mercury, particulate mercury emissions are usually small compared to vapor-phase emissions and can be ignored if all emissions are assumed to be Hg²⁺. However, lacking detailed information on the size profile for mercury particulate emissions, the CALPUFF default values for sulfate and nitrate are assumed to be representative of any particulate mercury that may be present.

Table 3-4
Recommended Gaseous Dry Depositions Values for CALPUFF – Input Group 8

| Pollutant | Geometric Mass Mean Diameter (microns) | Geometric Standard Deviation (microns) |
|----------------|--|--|
| All Pollutants | 0.48 | 2.0 |

In CALPUFF, wet deposition is determined using the scavenging coefficient (λ). This parameter varies by pollutant and precipitation type (liquid vs. frozen). The recommended scavenging coefficients for wet deposition are shown in Table 3-5. The FCPC recommended values for sulfur and nitrogen deposition are the CALPUFF default values.

Table 3-5
Recommended Wet Depositions Values for CALPUFF – Input Group 10

| Pollutant | Scavenging Coefficient – Liquid (1/sec) | Scavenging Coefficient – Frozen (1/sec) |
|------------------|--|--|
| SO ₂ | 3.0 x 10 ⁻⁵ | 0.0 |
| SO ₄ | 10.0 x 10 ⁻⁵ | 3.0 x 10 ⁻⁵ |
| NO _x | 0.0 | 0.0 |
| HNO ₃ | 6.0 x 10 ⁻⁵ | 0.0 |
| NO ₃ | 10.0 x 10 ⁻⁵ | 3.0 x 10 ⁻⁵ |
| Hg ²⁺ | 4.48 x 10 ⁻⁴ | 1.49 x 10 ⁻⁴ |
| Hg ⁰ | 3.36 x 10 ⁻⁷ | 1.12 x 10 ⁻⁷ |

For mercury, EPA (1997) lists the wet deposition parameters in terms of the washout ratio (w_r) as opposed to the scavenging coefficient. EPA (1997) lists 1.6 x 10⁶ as the washout ratio for Hg²⁺ and 1200 as the washout ratio for Hg⁰.

However, the scavenging coefficient can be calculated from w_r . In terms of the washout ratio, the wet deposition velocity (V_w) can be defined as follows:

$$V_w = w_r * p_o, \text{ where } p_o \text{ is the precipitation intensity.}$$

Also, in terms of the scavenging coefficient (λ), V_w can be defined as follows:

$$V_w = \lambda * H, \text{ where } H \text{ is the depth of the polluted layer}$$

Solving the above equations yields a mathematical relationship between the scavenging coefficient (λ) and the washout ratio (w_r):

$$\lambda = w_r * p_o / H$$

If p_o is assumed to be 2.8 x 10⁻⁷ m/sec (representative of light precipitation at an approximate rate of 1 mm/hr) and H is assumed to be 1,000 meters, the above relationship becomes:

$$\lambda = 2.8 \times 10^{-10} * w_r$$

The above relationship determined the mercury species scavenging coefficients listed in Table 3-5 using the washout ratios reported by EPA (1997). The scavenging coefficients from frozen precipitation were estimated at 1/3rd of the calculated value for liquid precipitation.

3.2.2 Deposition Results Processing Using POSTUTIL and CALPOST

The POSTUTIL model is one of the CALPUFF modeling system post-processing models and is used to compute the total sulfur and total nitrogen deposition calculated for the individual species using the CALPUFF results. The POSTUTIL calculations assume that total sulfur deposition is derived from SO₂ and SO₄ deposition and that total nitrogen deposition is derived from NO_x, HNO₃, NO₃, and SO₄ (based on NO₃ and SO₄ deposition being in the form of ammonium nitrate and ammonium sulfate, respectively).

POSTUTIL is applied as follows to generate the total deposition for a given species.

Under Subgroup 2b, POSTUTIL lists the new output species being created by the user, e.g., S for sulfur and N for nitrogen. The number of new species being determined by the user should match the corresponding values from POSTUTIL Input Group #1.

Under Subgroup 2c, POSTUTIL lists the species being used to compute S and N along with any “scaling factors” applies to each species. The scaling factors are determined based on the molecular weight of S and/or N in each compound compared to the total molecular weight of the compound. For NO_x, it is assumed that all NO_x is in the form of nitrogen dioxide (NO₂). The recommended POSTUTIL scaling factors for sulfur and nitrogen deposition are listed in Table 3-6.

Table 3-6
POSTUTIL Scaling Factors for Sulfur and Nitrogen Deposition Calculations

| Pollutant | Sulfur | Nitrogen |
|------------------|--------|----------|
| SO ₂ | 0.5 | |
| SO ₄ | 0.33 | 0.29167 |
| NO _x | | 0.30435 |
| HNO ₃ | | 0.22222 |
| NO ₃ | | 0.45161 |

If more than one mercury species is modeled with CALPUFF, a similar approach is used to combine the total mercury deposition from the individual species. However, the mercury scaling factor is 1.0 in POSTUTIL assuming that the emissions used in the model account for only the mercury mass in any given compound.

Once POSTUTIL is applied, the resulting file is processed in the CALPOST program to generate the results for the deposition modeling analysis at each FCPC receptor. Generally, CALPOST provides output in grams per second per square meter (gm/sec-m²). In order to convert these units to kg/ha-yr for comparison with the sulfur and nitrogen deposition DATs, the

appropriate conversion factor is 3.1536×10^8 . For mercury, the deposition DAT units are micrograms per meter squared per year, and the appropriate conversion factor is 3.1536×10^{13} .

4.0 TECHNICAL REFERENCES

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APPENDIX C TO FIFTH ADDENDUM
FCPC Class I Air Quality Related Values and Thresholds for Mercury Methylation and Vegetation

| Column 1 AQRV | Column 2 TEL/DAT | Column 3 Implementation Methods/Tools FCPC May Modify Only After July 27, 2019 | Column 4 Other Implementation Methods/Tools ¹ |
|--|--|--|---|
| <p>Aquatic Systems; Water Quality (<i>recognized 1999</i>)</p> | <p><u>Acidification TEL</u> (<i>recognized 2014</i>) Nitrogen ≥ 0.01 kg/ha/yr Sulfur ≥ 0.01 kg/ha/yr</p> <p><u>Mercury Methylation DATs:</u> (<i>recognized 2015</i>) <u>Mercury ≥ 0.098 ug/m²/yr</u></p> <p><u>Sulfur ≥ 0.01 kg/ha/yr</u></p> | <p><u>For Mercury Methylation DATs</u></p> <ul style="list-style-type: none"> • Exemption for projects that trigger PSD requirements (i.e., at least one PSD pollutant subject to BACT requirement as a result of the project) which have a project net emissions increase for Hg of less than 0.5 lbs/year and the source is < 50 km from FCPC Class I lands. • Exemption for projects that trigger PSD requirements (i.e., at least one PSD pollutant subject to BACT requirement as a result of the project) which have a project net emissions increase for Hg less than 10 lbs/yr and the source is located > 50 km from FCPC Class I lands. <p>Sulfur Q/D screening test shall be done for sources > 50 km from the Class I boundary.²</p> | <p><u>For Mercury Methylation DATs:</u></p> <p>To be implemented in accordance with the attached “FCPC Deposition Implementation Framework” and “Deposition Modeling Assessment Protocols” (3-3-155), including:</p> <ul style="list-style-type: none"> • Modeling or analyses to be done: <ul style="list-style-type: none"> ◦ Per the Protocols, AERMOD ≤ 50 km; CALPUFF > 50 km; or ◦ By other EPA accepted or scientifically defensible approaches, subject to SRP review if disputed.³ • Credible Hg speciation data to be considered as described in Deposition Framework, including its note #8. • Hg emissions used in analysis to be enforceable limits in any required permits. |

¹ Column 4 implementation methods and tools can be revised at any time but prior to revising any implementation methods/tools FCPC shall notify and consult with the Department.

² At this point the parties have agreed not to resolve the question of what constitutes the Class I boundary.

| | | | |
|--|---|--|---|
| <p>Vegetation (<i>recognized 2015</i>)</p> | <p><u>Ozone:</u> (<i>recognized 2015</i>)</p> <ul style="list-style-type: none"> • TEL exceeded at FCPC site when three-year average 24-hr W126 \geq 7.0 ppm/hr and N100 \geq 4 for the months of June, July and August based on ozone monitoring data recorded at the FCPC ambient monitoring site. | <ul style="list-style-type: none"> • The TEL is considered no longer exceeded when both of the W126 and N100 rolling three-year average values are below TEL levels for one year following the 3-year period when the exceedance occurred. • TEL status determined at time permit application filed with WNDR and exists during “hold status” (for maximum of one year). • Ozone Q/D screening test shall be done for sources > 50 km from the Class I boundary.⁴ | <p><u>For the Ozone TEL:</u> To be implemented in accordance with the attached “Framework for Implementing Vegetation AQRV and TEL,” (April 1, 2015), and in particular:</p> <ul style="list-style-type: none"> • The Weight-of-Evidence Analysis shall be done for sources \leq 50 km from the Class I area until and unless FCPC selects an alternative, EPA-accepted analysis. • The Weight-of-Evidence Analysis shall be done for sources > 50 km from the Class I boundary which have a Q/D value of > 10 until and unless FCPC selects an alternative, EPA-accepted analysis. • Status of the TEL updated every May |
|--|---|--|---|

³ The Parties have agreed not to resolve the question of whether SRP can be used to challenge Implementation Methods/Tools in the absence of the filing of a permit application.

⁴ At this point the parties have agreed not to resolve the question of what constitutes the Class I boundary.