Using the National Emission Inventory Information to Conduct Residual Risk Assessments – the Pulp and Paper Industry Experience

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ABSTRACT

As required by the 1990 Clean Air Act Amendments, the U.S. Environmental Protection Agency (EPA) must evaluate residual risks from industrial source categories following implementation of maximum achievable control technology (MACT) standards. EPA began its post-MACT residual risk assessment of the pulp and paper industry in 2006, and initially used information from the 2002 National Emissions Inventory (NEI) to characterize the emission sources at pulp and paper mills. The preliminary analysis revealed there were a number of issues with the NEI database that had to be addressed before useful estimates of risks could be obtained. Resolving the database issues required an iterative multi-year collaborative process involving EPA, EPA's contractor, and industry representatives.

This paper describes several of the issues encountered and actions taken to resolve them. In particular, we address (1) accounting for the differing levels of detail in state and local agency inventories, (2) assignment of appropriate Source Classification Codes (SCCs) and MACT codes to process equipment and fugitive emission sources, (3) use of relevant emission factors, (4) handling of significant fugitive emission sources and process equipment with multiple vents, (5) appropriateness of NEI default source parameters and pollutant speciation profiles, (6) location of emission sources, (7) double counting of certain emissions, and (8) estimation of hourly emission rates for acute risk assessments.

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INTRODUCTION

The National Emission Standards for Hazardous Air Pollutants (NESHAP) for pulp and paper mills were issued in two parts. The first part, (40 CFR Part 63, Subpart S), was promulgated in 1998, covering emissions from sources in the pulping, pulping chemical recovery, bleaching, papermaking, and wastewater collection and treatment areas of mills. A unique feature of Subpart S was that compliance for some sources was required in three years, while compliance for other sources was required in eight years. The second part, (40 CFR Part 63, Subpart MM), was promulgated in 2001 with a 2004 compliance date, and covered the main combustion sources at mills producing pulps by kraft, soda, sulfite, and semi-chemical methods. Subpart MM sources include spent liquor recovery furnaces, their associated smelt dissolving tanks, and rotary kilns and calciners used to produce quicklime from recovered pulping chemicals.

EPA began assembling inventory data to review these two standards in 2006, using the 2002 NEI as the starting point for the residual risk component of the review. It quickly became obvious the 2002 NEI information could not be used ‘as is’ to produce credible estimates of concentrations of hazardous air pollutants (HAP) in areas surrounding individual mills due to mill emissions.

After an iterative multi-year collaborative effort to improve the quality of the emissions information, EPA ultimately used inventory information largely based on the 2005 National-Scale Air Toxics Assessment (NATA) NEI, with corrections and enhancements supplied by individual facilities and EPA, in its final 2011 Human Exposure Model (HEM3) risk calculations for pulp and paper mills. Several pulp and paper companies initially provided revisions to the NEI data voluntarily; however an EPA Information Collection Request (ICR) was ultimately used to obtain updates from all companies. This paper describes many of the problems encountered with the NEI data set and how EPA, RTI, and the pulp and paper industry (with assistance from NCASI) mutually resolved the problems so that a credible risk analysis could be conducted.

NATIONAL EMISSIONS INVENTORY BACKGROUND AND TIMING

The National Emissions Inventory (NEI) is prepared every three years by the EPA using emission estimates provided by State, Local, and Tribal air agencies for sources in their jurisdictions. However, there are many differences among state and local agencies with respect to the amount of information they collect on emission sources of HAP. When agencies do not provide values for various parameters, EPA uses other data sources or default values to fill the gaps. Other sources of data include the Toxics Release Inventory (TRI) database and data collected by EPA for regulatory development purposes. Data augmentation is necessary to create an emissions inventory that can be used for air quality modeling purposes.

Detailed stack-by-stack information is required for the NEI. Unlike the TRI which reports aggregated emission totals for an entire facility, in the NEI, emissions must be allocated to individual sources and individual release points. Each release point is assigned an associated flow rate, exit gas velocity, exit gas temperature and specific geographic location. Additionally, emissions are grouped by MACT code, source classification code (SCC), and manufacturing process. The resulting inventory contains hundreds, and in some cases thousands, of data records for large industrial facilities such as pulp and paper mills.

Given the considerable time required to compile each iteration of a large national inventory, there is typically a 3-year delay in availability of NEI data (i.e., the 2002 NEI data were the most recent NEI data compiled as of 2006; the 2005 NEI data were compiled by 2008; and 2008 NEI data were in the process of being compiled in 2011 at the same time when the pulp and paper risk modeling was being performed for the Subpart S residual risk and technology review [RTR] proposal).

Timing Issues

The 1990 Clean Air Act Amendments call for EPA to complete a residual risk review within eight years after a MACT standard is promulgated. As noted earlier, the Subpart S standards were issued in 1998 with a Phase I compliance date of 2001 and a Phase II compliance date of 2006, and the Subpart MM standards were issued in 2001. The residual risk review must reflect emissions of HAP after full implementation of the MACT standards. In the case of the pulp and paper industry, this would have been 2007 (or 2008 to account for mills receiving a one-year extension). Taking into account the time required to compile the emissions inventory for modeling purposes and the MACT implementation dates, a rational approach would have been to conduct the risk assessment using the 2008 NEI as the starting point. Meeting a 2006 deadline for reviewing the Subpart S standards would not have made sense since any risk assessment would have probably used the 1999 NEI as a starting point, and then an updated assessment could have been conducted using the 2002 NEI if it became available in time.

In the end, EPA had to meet a court-ordered deadline for completing the RTR which forced the use of emissions inventory data (the 2005 NEI) that did not reflect full implementation of the MACT standards. In an attempt to account for emission reductions achieved by Phase II of the Subpart S standards, EPA asked mills, as part of the mandatory ICR conducted in 2011, to update their 2005 NEI data to reflect 2009 emissions and current equipment configurations.

Use of the 2002 NEI for Pulp and Paper Mill Risk Estimates

In 2006, EPA conducted an initial sector-based screening assessment which included facility-wide emissions of HAPs from Subpart S and MM MACT sources, industrial boilers, other MACT sources, and non-MACT sources. Approximately 135 facilities were evaluated. The source of the data used in the initial screening was version 1 of the final 2002 NEI. Significant inconsistencies in both the quantity and the quality of the data were identified by EPA. Due to concerns that gaps and inconsistencies might cause EPA to overlook and underestimate potential health impacts from pulp and paper industry sources, EPA approached the industry with requests for additional information.

Identification of Emission Sources and Compounds not in Inventories

At the outset, one of EPA's major concerns was the inconsistency in the 2002 NEI information for mills located in different states. The number of records in the NEI for HAP for individual mills ranged from about 20 to over a thousand. The number of compounds, emission sources, and emissions points for mills with similar processes and equipment were also highly variable.

At one extreme, a few mills had one or two records for each of a small number of substances. It was determined the source of these emission estimates was the TRI, which has facility-wide totals for point and fugitive emission sources. In the NEI, these values were assigned a non-specific SCC, default stack parameters, and a single location. Obviously the TRI information was inadequate for risk modeling, so more detailed information on emission sources had to be obtained directly from the mills.

EPA recognized the NEI entries for mills with similar processes and emission units were not always comprehensive. A fairly common occurrence was lack of entries with SCCs for wastewater treatment. In some cases, emissions associated with wastewater were included under a generic SCC, while in others there were no estimates for this emission source. The situation was similar for paper machines. Entries for some emission sources found at kraft mills, such as lime mud slakers, oxygen delignification systems, tall oil recovery operations, pulp and liquor storage tanks, etc., were sometimes included under a generic SCC or not included at all. Again, the onus was put on mills to rectify these inconsistencies in the NEI file.

Another inconsistency was the number of compounds reported for emission sources with the same SCC. For example, the number of metals reported for a kraft recovery furnace ranged from zero to ten or more. The number of incomplete combustion products, e.g. formaldehyde, acetaldehyde, benzene, polycyclic aromatic hydrocarbons (PAHs), etc. reported was also highly variable, as were the number of volatile organic compounds emitted from wastewater treatment systems and paper machines. These inconsistencies had the potential to result in higher risks for the sources with more compounds reported as compared to similar sources with fewer reported compounds.

Many of these issues were corrected through voluntary updates to the emission inventories, and were also updated through the ICR as described below.

Voluntary Updates

In May 2007, EPA publicly distributed version 3 of the 2002 NEI database through its RTR website, asking pulp and paper companies to voluntarily review the data for their facilities and submit revisions prior to the next round of modeling. Due to the enormity of the task, the voluntary review focused on pulp and paper facilities that had a predicted cancer risk above 10 in a million based on the initial screening results.

Version 3 of the 2002 NEI database contained a great deal of supplementary data from the TRI, and in some cases, also included estimated emissions of previously unreported pollutants. Because the allocation of the supplementary emissions data to specific sources was not known, generic, not-elsewhere-classified SCC codes were assigned. These supplemented and previously unreported data were also frequently coded as either ground-level, mill-wide fugitive releases lacking buoyancy or as single point sources accounting for facility-level aggregate emissions. These initial default assumptions resulted in elevated risk screening assessments for many pulp and paper facilities.

For the voluntary update, EPA requested companies to review: (a) the magnitude of the reported annual emissions; (b) the geographical (latitudinal/longitudinal) coordinates of each emission release point; and (c) the stack height, flue gas temperature, and exit gas velocity for each release point. Most company representatives had never seen the NEI data set for their facilities and most were overwhelmed by the hundreds of data records that were distributed to them for their review. While they were accustomed to reporting estimated source emissions, they were not familiar with the coding conventions of the NEI nor were they accustomed to reporting the additional detail required in order to convert the emissions inventory information into a dispersion model emissions input file.

Revisions for approximately 70 mills were voluntarily submitted in the 2007 to 2008 timeframe. Revisions to more mill inventories and enhancements of previously revised inventories were voluntarily submitted to EPA through 2009 as additional information supporting further refinements became available (e.g., SCC revisions, additional pollutant detail).

EPA’s Information Collection Request

Even with all of the voluntary revisions submitted, substantial updates were still needed for a number of pulp and paper mills in order for EPA to accurately consider remaining risk after implementation of the pulp and paper NESHAP standards. In addition, there were thought to be some mills for which no pulp and paper MACT category HAP data were available in the NEI because EPA’s inventory of pulp and paper mills contained roughly 350 mills, but NEI data were only available for approximately 175 of these mills. As mentioned previously, court deadline pressures led to use of the 2005 NEI as the basis for RTR modeling, and notably, the 2005 NEI still contained a lot of 2002 NEI emission rates that had not been updated by States. Updates were needed from all mills to reflect post-NESHAP emission rates, and to better characterize emission points. Therefore, a requirement for all mills to review and update their NEI data sets was included as “Part II” of the pulp and paper ICR that was developed to support the RTR for Subparts S and MM, and review of the kraft mill New Source Performance Standard (NSPS). The ICR gathered updated information on processes, practices, controls, and compliance options implemented to meet the NESHAP standards and to determine if there had been technological updates of interest for the future NSPS review. Under Part II of the ICR, mills were asked to supply emission rates for the 2009 base year (consistent with the base year used in the ICR as a whole). Mills that had already recently supplied NEI updates were allowed to retain those updates without bringing them to the 2009 base year if the data remained representative.

The three-part phased response ICR was mailed out in February 2011 with a June 2011 due date for Part II responses. Mills were provided pre-populated spreadsheets containing their

2005 NATA NEI data set to be reviewed for Part II. The spreadsheets contained revision columns and note fields where mills could mark their revisions. Mills could also add rows or flag rows for removal as needed. An instruction document containing a list of equipment to be included in the NEI updates was provided. A lookup spreadsheet containing relevant NEI codes included in the pre-populated spreadsheets was also provided, along with a simplified crosswalk of the pulp and paper SCCs in order to ensure that valid NEI codes were used. Mills with no prior NEI data were asked to populate a blank spreadsheet with the NEI fields. Only mills with the potential to emit 10 tons per year of any HAP or 25 tons per year of any combination of HAPs (major sources) were required to provide NEI updates. Through the ICR, it was confirmed that nearly all of the mills for which NEI HAP data were not previously available were not major sources for HAP and were either area or synthetic area sources for HAP. Mill closures were also noted. The response rate for Part II of EPA's ICR was 100 percent, with respondents submitting NEI spreadsheets for 171 major sources (2 of which were new NEI data sets for mills not previously included in the NEI). RTI performed a substantial quality assurance (QA) effort on the Part II data in order to create the modeling files needed for the Subpart S residual risk assessment.[1] RTI used a checklist of expected emissions units and key pollutants to review the ICR responses for completeness. Elements of this QA effort are discussed in the sections below.

CHARACTERIZING EMISSIONS SOURCES

The residual risk analysis for the pulp and paper industry focused on mills that were major sources with respect to HAP. The majority of these mills have wood pulping and chemical recovery operations, boilers, paper machines, and wastewater treatment plants and are subject to multiple MACT standards. There are many emission units, several with multiple emission points. In order to link estimated source emissions to specific manufacturing processes, unit operations, and individual vents, many different codes are used in the NEI to identify and classify the data. In addition, detailed data must be supplied to describe how the emissions are released. These release parameters are necessary inputs to atmospheric dispersion models that predict pollutant concentrations at downwind locations.

Among the significant issues that had to be addressed were assignment of appropriate SCC and MACT codes to process equipment and fugitive sources and how best to model emission sources with multiple release points. These issues and their resolution are described in following sections.

SCCs and MACT Codes

In the NEI, every emission point must be assigned an SCC from a list developed by EPA. Initial review of the codes applicable to pulp and paper mill sources indicated many lacked clear descriptions and a few commonly found process groups such as oxygen delignification systems lacked an SCC. These inadequacies resulted in thousands of rows in initial (pre-ICR) versions of the nationwide pulp and paper file being assigned to a miscellaneous not-elsewhere-classified category, making it difficult to determine the validity of the associated emission rates, stack parameters, source characterization of the emission point (fugitive or point), and location. It also became apparent several emission points had inappropriate SCCs assigned. Because the SCCs were used to assign MACT codes, which were in turn used to do the risk modeling for the two pulp and paper MACT standards, it was essential to have the correct SCC and MACT codes assigned to all emission points.

Therefore, EPA and NCASI undertook a joint effort to revise and update the pulp and paper SCCs. Ultimately 31 codes were revised or eliminated, and 43 new codes were added to the pulp and paper mill source group. In addition, each SCC was assigned the proper MACT code. The revised codes were used by EPA and industry representatives to update their NEI information that was being used for risk modeling. In total there are about 100 codes in the 307xxxxx group relating to pulp and paper processes. In addition to the 307xxxxx SCC group, pulp mills operate industrial boilers that fall within the 102xxxxx group and various other industrial processes falling within other SCC groupings.

In the NEI, the same emission unit or emission point may have two or more SCCs if it is associated with combustion. For example, lime kilns at kraft pulp mills burn natural gas, residual oil, and/or petroleum coke; kraft recovery furnaces combust black liquor and also fire either natural gas or fuel oil or both for flame stabilization; paper machines with auxiliary dryers may burn natural gas or propane; and thermal oxidizers burning pulp mill gases may also burn natural gas, distillate oil, and/or liquid methanol. Additionally, a large number of pulp mills operate multi-fuel boilers, and separate NEI entries often appear for each SCC corresponding to each fuel type. Thus the NEI information had to be carefully screened to ensure emissions of HAP from combustion units were assigned the correct MACT code.

As an example, a kraft recovery furnace that burns black liquor, natural gas, and residual oil might have three entries in the NEI for each pollutant emitted – one with a SCC of 30700110 (kraft recovery furnace), one with 10200601 (external combustion/industrial/ natural gas/>100 million Btu/hr), and one with 10200401 (external combustion/industrial/ residual oil/Grade 6 oil). As a practical matter, it is not possible to apportion emissions of a HAP from a kraft recovery furnace to black liquor and fossil fuels since they are typically co-fired. This is reflected by the fact that available kraft recovery furnace emission factors for HAP have a single value. With respect to the NEI and risk modeling, emission points with multiple SCCs were combined and assigned to the appropriate pulp and paper unit process through proper emission unit and release point coding.

Process Unit Codes

Emissions units and emission points are identified in the NEI through a series of process unit codes. A Federal Information Processing Standard (FIPS) code is assigned to indicate the state and county location of each mill. Each mill has a unique NEI ID and each emission unit has an Emission Unit ID. A few mills in the pulp and paper industry have multiple NEI IDs for different portions of their overall facility (e.g., one mill has operations on two sides of a river in two different States). Emissions for a given Emission Unit ID can be further subdivided through use of a Process ID. For example, a multi-fuel fired boiler may have one Emissions Unit ID and separate Process IDs for the different fuels, or a non-condensable gas (NCG) collection system may have separate Process IDs for normal operations and excess emissions venting. A different Process ID is needed when multiple SCCs are applied to a given Emission Unit ID.

Individual emission points are represented by Emission Release Point IDs. There can be multiple Emission Release Point IDs for a given emission unit (e.g., a recovery furnace with two stacks). Stack parameters and latitude/longitude coordinates should be consistent for each FIPS code, NEI ID, and Emission Release Point ID.

Emission Unit ID and Process ID coding conventions in the pulp and paper NEI data set varied considerably from mill to mill and State to State. Fortunately, in addition to SCCs, the NEI also contains Emission Unit Description and Emission Release Point Description fields that, when adequately populated, help users navigate individual inventories. Considerable effort was required in both the screening reviews of the NEI data, and again following receipt of the NEI data sets obtained though the ICR to check the coding conventions used for each facility to ensure proper emission unit and release point characterization. Following receipt of the ICR data, RTI filled in missing IDs following the numbering schemes used in individual inventories and followed up with ICR respondents if the gaps could not otherwise be resolved. Several concatenations of codes in the NEI are needed to facilitate a review of records by unique emission unit and release point:

- NEI ID--Emission Unit ID--Process ID
- NEI ID--Emission Unit ID--Process ID--Emission Release Point ID
- State County FIPs--NEI ID--Emission Release Point ID
- State County FIPs--NEI ID--Emission Unit ID

Characterization of emission sources and emission releases using these various data fields is described further below.

Source Type and Release Parameters

Each emission release must be characterized as either a point or an area source. Emissions emanating from well-defined release points such as stacks and process vents are typically modeled as point sources. Emissions that do not emanate from a well-defined release point are modeled as area sources. As an example, emissions from wastewater treatment are typically modeled as area sources.

The point or area source classification establishes how the emissions are released and subsequently dispersed. If an emission release is described as a point source release, then information on the stack diameter, stack height above ground level, exit gas velocity, exit gas flow rate, and exit gas temperature must also be supplied. These release parameters are required in order to estimate plume rise and the effective plume height of a point source emission. If an emission release is described as an area source, information on the length and width of the area must be supplied along with an angle to indicate orientation of the source relative to a north-south axis. Within the dispersion model, area sources are treated as ground-level, quiescent surfaces without a vertical momentum flux.

If the release parameters are not specified, or are found to be invalid upon QA review, EPA substitutes default values. Default release parameters are available for more than 3600 SCCs, 125 MACT codes and more than 800 Standard Industrial Classification (SIC) codes.

These values were developed by EPA based on quality assured data from previous NEI compilations.[2] If no SCC, MACT code or SIC code match is possible, the default values listed in Table 1 are used for point and area source releases.

Table 1. Default release parameters for point and area sources.

Parameter	**Point Source**	**Area Source**
Stack height	10 ft	10 ft
Stack temperature	72 °F	72 °F
Stack diameter	1 ft	0.003 ft
Stack velocity	15 ft/sec	0.0003 ft/sec
Stack flow	12 cu ft/sec	0 cu ft/sec

SCC-default release parameters were not available for a number of pulp and paper industry-specific sources. Due to concerns that the generic release parameters listed in Table 1 would result in overly conservative, ground-level concentration predictions should a respondent fail to supply site-specific data, NCASI worked with EPA to develop more representative default release parameters for paper machines and wastewater treatment area sources.

Example of Processes with Multiple Vents: Paper Machines

As noted previously, multiple emission release points may exist for a given emission unit. Paper machines are one example of an emission unit with multiple vents. Paper machines are large pieces of equipment (e.g., up to 500 feet long) that are comprised of a wet end, pressing section, and a dry end. On-machine application of surface treatments (e.g., starch or coatings), calendering for smoothness, and spooling of the paper for storage also occurs on paper machines. Paper machines are located in enclosed buildings, and it is not uncommon for these buildings to have 10 or more vents, with some machines having more than 30 vents, located on the roof and sides of the building.

Ideally, every emission release point for a given emission unit would be included in the inventory with its own set of pollutant emission rates, emission release parameters (e.g., stack gas parameters or fugitive release parameters), and longitude/latitude coordinates. However, few paper machines have been tested for emissions and air flow rates from most paper machine vents have not been measured. Also, portions of paper machines may vent into buildings. Emissions estimates for paper machines are usually derived from machine-total emission factors (that do not distinguish between vents) so emissions would need to be apportioned to individual paper machine vents. Conventions for reporting paper machine emissions in the NEI vary from mill to mill, and include everything from: (a) all paper machine emissions attributed to one vent, to (b) every paper machine vent listed with emissions apportioned and unique release parameters reported for each vent. Paper machines were reported as fugitive emission sources for some mills, and as stack emission sources at other mills.

When identified as a fugitive source, paper machines were often assigned building dimensions (length, width, and height) for the paper machine building, or portion of the building housing the machine. Paper machine emissions test data collected by NCASI were used to develop a set of default stack parameters for paper machines identified as point emission sources.

The stack parameters shown in Table 2 were applied to paper machine vents when site-specific information was unavailable:

Table 2. Default stack parameters for paper machine vents.

Parameter	**Value**
Stack height	70 ft
Exit Gas Temperature (wet end)	104 ^{o}F
Exit Gas Temperature (dry end)	149 ^{o}F
Exit Gas Temperature (vent unspecified)	125 ^{o}F
Stack Diameter	4.6 ft
Exit Gas Velocity	30 ft/sec

Example of Fugitive Sources: Wastewater

The majority of emissions from most chemical pulp mill wastewater treatment operations come from aerated secondary treatment basins; i.e., aerated stabilization basins (ASBs) or activated sludge treatment systems (ASTs). In the case of ASBs which can cover many acres, the highest emissions are associated with areas of high surface aeration. These areas are typically the first zone of the basin where the mill effluent enters. NCASI assembled data on the dimensions of various wastewater treatment components and provided EPA with average dimensions for primary clarifiers and first zones of ASBs. Limited data were also available on average length-to-width ratios for industry ASTs. These data were made available so that more representative default values could be used for modeling when site-specific data were lacking.

Source Locations

The geographical location of each emission release point must be identified by its unique set of latitudinal and longitudinal coordinates. Downwind, off-site impacts cannot be correctly modeled without knowledge of the actual locations of the sources. Only sources that are co-located or have a common stack should share the same coordinates.

In the 2002 NEI, the emissions inventories for some mills had only one set of latitudinal and longitudinal coordinates specified for all emission releases within the mill. Not only is this an unrealistic representation of a mill’s emission sources, but the location of sources on top of each other cumulatively increases the modeled emissions from a given point. Not specifying unique latitudinal and longitudinal coordinates for each emission release results in a higher modeled downwind concentration than would be obtained if proper locations were specified for the sources.

Sometimes the latitudinal and longitudinal coordinates in the 2002 NEI data were based on the street address of the mill. This led to emissions from sources located well within the confines of mill property being modeled as though the emissions were released at the front gate fenceline. When the coordinates were based on zip code, process equipment locations were frequently not on mill property but could have been located in the middle of a town leading to an overestimate of risk.

Considerable efforts were required to obtain more accurate locations for the emission points. As part of the 2011 ICR, EPA requested that the latitudinal and longitudinal coordinates of each release point be reviewed and reported to six decimal places using the North American Datum of 1983 (NAD83) reference system. For point sources, the latitude and longitude were to be specified at the center of the stack; and for area sources, the coordinates were to be specified at either the southwest corner or the westernmost corner of the emission source depending on the orientation angle. Despite the desirability of identifying, locating, and estimating each and every emission release, emission sources were sometimes grouped or consolidated into either: (a) fewer point sources, or (b) into area sources in order to simplify reporting.

CHARACTERIZING POLLUTANT EMISSIONS

Emission Factors

Considering there are 187 HAP and a large number of emission points in pulp and paper mills, it is no surprise that emission factors are the primary means to estimate annual emissions. Most pulp and paper mills rely on factors developed by NCASI for estimating annual releases that are reported to states for emission inventory purposes. Extensive pre-MACT sampling programs for HAP conducted in the early to mid-1990s were the main source of data for these factors, but the factors have been continually updated as new measurements become available.

The HEM3 results prompted a closer look at some of emission amounts in the NEI for particular compounds and emission points. Since the NEI does not have production data, it is impossible to back-calculate an emissions factor. However, likely outliers could be identified for follow-up with mill personnel. Another area investigated was the quality of certain emission factors for compounds and sources predicted to have elevated risks. In some cases, the factor was based on only one or two measurements. In others, some or all of the measurements were below the method detection limit and the emission factor depended on how these values were statistically treated. This was of particular concern when the source had multiple vents with varying detection limits. In still others, compound identification was by gas chromatography and not confirmed by mass spectroscopy. There were also some situations where only “pre-MACT” sampling data were available and it was thought that “post-MACT” sampling would show lower emissions due to changes undertaken to come into compliance with the MACT standards. As a result of these uncertainties, NCASI conducted targeted sampling to improve the emission factors for paper machines, black liquor oxidation systems, and brownstock washers. This information was made available to mills so that they could revise the NEI information if appropriate.

Fugitive emissions of volatile organic compounds from wastewater treatment systems were especially difficult to address since they are very site-specific. EPA’s WATER9 simulation model was generally used for the estimates, but it was found many mills lacked their own effluent concentration data needed for the model. When acetaldehyde, formaldehyde, and naphthalene emissions from wastewater sources were initially identified as potentially significant contributors to risk, NCASI examined the available effluent concentration data for these compounds and concluded they were outdated and had method detection limit issues. Thus, interested mills collected wastewater samples which were analyzed by NCASI with a more sensitive analytical method. These mills were then able to do site-specific WATER9 modeling to obtain more realistic estimates of acetaldehyde, formaldehyde, and naphthalene releases to air. Mills without their own sampling data were able to use revised average effluent concentrations to make better estimates of air releases.

Examples of Pollutant-Specific Issues

Hexachlorocyclopentadiene (HCCPD)

Emissions data were available for HCCPD since it was one of numerous chemicals included in a multi-mill exploratory sampling program conducted in the early 1990s to determine which HAP were emitted from the major unit process operations at kraft mills. HCCPD concentrations were below method detection limits on 24 of 26 different sources sampled, roughly at the detection limit on one of six smelt dissolving tanks tested, and above detection limits in a single vent in a multi-vent bleach plant. However, HCCPD was only identified by its elution time on a gas chromatograph, and its identification was not confirmed by mass spectroscopy. NCASI included the HCCPD test results in its compilation of available measurement data for HAP.[3]

According to EPA, HCCPD is the key intermediate in the manufacture of some pesticides, including heptachlor and chlordane, and is also used in the manufacture of flame retardants.[4] Its presence in kraft mill sources is not expected. Nevertheless, this chemical was in the 2002 NEI for ten kraft mills, five of which were located in one state. It was subsequently determined that the state agency used NCASI emission factors and had added HCCPD to the five mill inventories for all of the process unit types that had been tested. The other five mills only had HCCPD emissions for smelt dissolving tanks and/or bleach plants.

In view of sampling method limitations and very high proportion of non-detect values, both the state agency and EPA decided to remove the HCCPD records from initial (pre-ICR) versions of the NEI files.

Hexachloroethane

Hexachloroethane (HCE) was also included in the multi-mill exploratory sampling program conducted in the early 1990s to determine which HAP were emitted from major unit process operations at kraft mills. Testing was conducted on three vacuum drum brownstock washer systems, two low-flow diffusion brownstock washer systems, one elemental chlorine-free (ECF) bleach plant vent and six non-ECF bleach plant vents. Flue gas samples were collected in heated canisters in accordance with EPA Method 18 and a portable flame ionization detector (FID) analyzer was used for in-field analysis.

In the pre-MACT testing, HCE was detected in the one ECF bleach plant vent and the two diffusion washer systems. HCE was not detected in the six non-ECF bleach plant vents or in the three vacuum drum brownstock washer vents. HCE emission factors were developed for all sources tested, even if HCE was not detected during the testing. For the two sources where HCE was not detected, emission factors were based on the lowest analytical detection limit and reported as <4.30E-02 pounds per air dried ton of unbleached pulp (lb/ADTUBP) for vacuum drum washer systems and as <2.20E-02 lb/ADTUBP for non-ECF bleach plant vents.

In the compilation of NCASI emission factors, the emission factor for the ECF bleach plant vent was flagged as suspect data since it was based on a single source at a single mill.[3] Additionally, the presence of HCE in the ECF bleach plant vent tested in 1993 was not confirmed by alternate methods, as is typical when unexpected values are obtained as part of a field test screening campaign. It was cautioned that further testing would be required to confirm the presence of HCE in ECF bleach plant vents.

Due to concerns about the limited test data upon which the pre-MACT emission factors for HCE were based, in March 2012, NCASI tested the exhaust vents of a vacuum drum brownstock washer, a pressure diffusion washer, and a bleach plant scrubber vent at a MACT-compliant, ECF-bleached kraft pulp mill. NCASI Method ISS-FP-105.01, "Impinger Source Sampling Method for Selected Aldehydes, Ketones and Polar Compounds," was employed for the sampling.[5] To aid in the capture of HCE, the method was modified with the addition of hexane to the impingers. The results of the March 2012 testing were as follows:

- For vacuum drum washers, HCE was detected in all three sample runs at a detection limit significantly lower than that achievable with EPA Method 18. The average emission factor developed for the post-MACT tests was 1.32E-05 lb/ADTUBP which is three orders of magnitude lower than the previous, pre-MACT emission factor based on non-detect values at the analytical detection limit.

- For diffusion washers, HCE was not detected in any of the three sample runs. In-stack detection limits for this testing ranged from 9.7 – 12.4 parts per billion dry volume (ppbdv), resulting in an average emission factor of <3.48E-06 lb/ADTUBP. Since HCE dechlorinates in a reducing environment, there is no potential for the formation of HCE in the kraft pulping process.[6] Thus, it is hypothesized that the source of HCE in brownstock washing systems (vacuum drum type or pressure diffusion type) is chlorinated water used in pulp washing. Prior to MACT implementation, many mills used recycled process water for pulp washing. The re-used process water would have contained many organic compounds and have required higher levels of chlorination than is required today. Lower emissions of HCE from diffusion washers are consistent with current MACT compliance strategies.

- For the ECF bleach plant scrubber vent, HCE was not detected in any of the three sample runs. In-stack detection limits for this testing ranged from 9.6 – 11.3 ppbdv, resulting in an average emission factor of <1.16E-04 pounds per air dried ton of bleached pulp (lb/ADTBP). This result confirms that the data quality of the pre-MACT testing was indeed suspect. In fact, an examination of the generation of HCE yields the result that HCE is not expected to be emitted from kraft bleach plant vents. HCE is a co-product in the production of tetrachloroethylene by pyrolysis of carbon tetrachloride at 800 - 900°C.[7] Modern kraft bleaching operations do not provide conditions that are conducive to the generation of HCE

> or the precursors of HCE. Furthermore, free chlorine is not available in ECF bleaching operations, so chlorinated precursors are even less likely in ECF bleaching processes than in non-ECF bleaching processes.

Chromium and Hexavalent Chromium

Chromium (Cr) compounds are on the list of 187 HAP. EPA Method 29 for multiple metals is typically used to measure emissions of metals, including Cr. Method 29 is only capable of measuring the total amount of Cr.[8] It cannot measure amounts of each compound containing chromium, nor can it measure how much of the Cr is trivalent (Cr^{+3}) versus hexavalent (Cr^{+6}). For the purposes of assessing risks from Cr emissions, one needs to know the amount of Cr^{+6}, not total Cr.

EPA established default Cr^{+6}/Cr ratios for estimating Cr^{+6} if only total Cr was in the NEI. Initially EPA did not have default ratios by SCC or MACT code for pulp and paper mill sources, so a generic default ratio of 0.34 was applied. EPA later modified the default ratios for kraft recovery furnaces, lime kilns and smelt dissolving tanks based on Cr^{+6} tests conducted in the late 1980s in California using California Air Resources Board Method 425 (CARB 425) and all available total Cr tests. There were very few Cr^{+6} tests as compared to total Cr tests.

There were concerns about using ratios developed from non-simultaneous testing of Cr^{+6} and Cr, and about the validity of using CARB 425 on kraft mill sources. To resolve these concerns, NCASI carried out simultaneous testing for Cr^{+6} with EPA Method 0061 and Cr with Method 29 on recovery furnaces and lime kilns. The results showed Cr^{+6} concentrations were below Method 0061 detection limits, which were higher than the total Cr concentrations being measured with Method 29.

Unfortunately, the NCASI study did not provide data that could be used to establish Cr^{+6}/Cr ratios. The question of Cr^{+6} emissions from kraft pulp mill sources remains open. The limited available data from NCASI Technical Bulletin 973 were used as the basis for Cr^{+6}/Cr ratios for lime kilns, smelt dissolving tanks, and recovery furnaces for purposes of the Subpart S RTR facility-wide risk modeling.[3]

Mercury Speciation

Like chromium, the different oxidation states of mercury compounds vary in toxicity, but also in exposure pathway (e.g., inhalation, ingestion). The most common mercury species are divalent mercury (Hg^{+2}) (including both particulate and gaseous forms) and elemental gaseous mercury (Hg^0). If not already speciated (e.g., as elemental mercury with pollutant code 200), mercury compounds found in the pulp and paper data set (pollutant codes 7439976 and 199) were speciated using the NEI default multipliers of 0.2 for particulate divalent mercury (pollutant code 202), 0.3 for gaseous divalent mercury (pollutant code 201), and 0.5 for elemental gaseous mercury (pollutant code 200) for all sources in the compiled ICR database file.[9]

Polycyclic Organic Matter

Polycyclic organic matter (POM) is comprised of a large number of individual compounds (POM species), each with their own toxicity levels and exposure pathways. Thus, speciation of POM is necessary for more accurate risk assessment results. Earlier versions of the NEI data set required POM speciation for some mills. Many of the ICR responses reported POM speciated into individual compounds. However, there remained several listings for POM in the compiled ICR file that were unspeciated (pollutant code 246) within the pulp and paper production category (MACT code 1626-1). Unspeciated (total) POMs were reported for some paper machines and direct-fired paper machine dryers (SCC 30700401). Since many mills provided speciated POM compounds, POM speciation profiles were developed from those mills to speciate total POM for mills with unspeciated POM data.[1]

Pollutant Coding and Duplicate Reporting Issues in the ICR

Each version of the pulp and paper inventory required review of the pollutants included to ensure any coding or duplicate issues were resolved. The NEI uses CAS numbers as pollutant codes. Even through a pollutant code lookup table was provided with the ICR instructions, the pollutant codes and names received with the Part II ICR responses required extensive QA and standardization. There were missing and invalid codes, as well as various permutations of pollutant names. RTI reviewed and made several specific changes to the pollutant codes where necessary to ensure consistency within the inventory. There were also many non-HAP pollutants included in the Part II responses that were not previously included in the NEI lookup table. CAS numbers were verified for these “new” pollutants and they were added to the NEI pollutant listing using standardized names.

Numerous duplicate pollutants appeared in the database for the same emission unit. Part II respondent error (e.g., respondents updating old data and including new data for the same pollutant but not necessarily the same emission rate) appeared to be the issue in some cases. The solution was to delete exact duplicate pollutants, or delete the lowest of two duplicates (e.g., if there was an order-of-magnitude difference in emissions such that the second duplicate didn’t add much). For a few mills, RTI found that it was necessary to sum up emissions after contacting the respondent.

There were also pollutant coding issues where only one code applied for what respondents considered a separate pollutant (e.g., cresols, xylenes, synonyms of pollutants). Duplication issues relating to xylene that resulted from the double-counting of mixed and individual xylene isomers required resolution. For example, some data for m,p–xylenes received pollutant code 1330207 [for “Xylenes (mixed isomers”)], which resulted in a problem if there was already data for total xylenes with pollutant code 1330207 (resulting in two rows with the same pollutant code and different emissions). Similar issues were noted for cresols.

Duplicate pollutants were also observed for multi-fuel fired boilers where emissions had been estimated separately for the various fuels. These emissions estimates were retained and the duplicates were addressed through additional coding of the emission unit to indicate a separate fuel was used (e.g., adding a process type code).

CHARACTERIZING RISK

Emission Process Groups

For purposes of interpreting residual risk modeling results it is necessary to assign descriptive emission process groups (EPGs) to each SCC to group similar emission units. This is particularly important for an industry, such as pulp and paper, where there are numerous emission unit types, numerous SCCs, and multiple MACT standards in play. Building on experience from initial risk screening iterations (which used EPGs based on fuel type without distinguishing between MACTs, and considerable consolidation of the different subpart S emission units), the post-ICR EPGs were developed to be more detailed for SCCs within the 1626-1 (Subpart S) MACT risk modeling category, but less detailed for emission units outside the category. For example, all boilers were combined into one EPG.

The emission unit descriptions, SCCs, and MACT codes in the NEI were reviewed to ensure consistent characterization of emission units within the inventory and to assign the EPGs. This exercise was required in prior versions of the NEI modeling file, and was repeated following receipt of the ICR responses. Using the ICR data set compiled from individual mill responses, RTI reviewed each SCC by the emission unit description (and other descriptive columns) to ensure SCCs were consistent throughout the data base. Next, RTI used cross-tab queries of SCC vs. MACT code to identify inconsistencies. Except for the not-elsewhere classified SCC (39999999), each SCC was affiliated with only one MACT code. The number of not-elsewhere classified SCCs (e.g., *****999s) was reduced by reviewing available process descriptions and assigning more specific SCCs where possible. After these data standardization steps, the pulp and paper ICR compiled file contained emissions units represented by 15 different MACT codes (including the 3 pulp and paper MACT codes, separate codes for paper and other web coating [POWC] and printing/publishing, 2 codes relating to stationary internal combustion engines, 4 codes relating to boilers and process heaters, 2 codes relating to combustion turbines, and 2 codes relating to gasoline or organic liquids distribution). Use of EPGs focused analyses of risk and emissions on 82 consolidated EPGs rather than on the 225 SCCs in the compiled ICR data file.

Short-Term Emission Rates

In addition to chronic (long-term) exposures, EPA also considers acute (short-term) exposures in residual risk reviews. For chronic exposures, the total annual emissions from the inventory are divided by 8,760 hours to obtain an hourly emission rate. It is possible that the maximum short-term hourly emission rate (the “peak” lb/hr) could differ from annual average emission rate (“mean” lb/hr) due to production swings or process variability. In the absence of short-term emissions data, EPA generally estimates peak (short-term) emissions using available annual emissions data in the inventory by applying an assumption to all source categories that the maximum one-hour emission rate from any source is 10 times the average annual hourly emission rate for that source. This default peak-to-mean ratio of 10 was determined to be unrepresentative of some pulp and paper processes. The pulp and paper industry conducted a study of peak-to-mean ratios for two pulp and paper emission sources—papermaking and wastewater—for EPA's consideration. The ICR data were analyzed to estimate peak hourly emission rates for other emission sources.

Paper machines

The degree to which paper machine emissions vary with production rate and other factors was examined in an industry white paper prepared by AECOM.[10] Sampling data for a mill demonstrating compliance with the Subpart S Clean Condensate Alternative were examined. Tests were conducted on five days for the 18 paper machine vents. The peak-to-mean ratio for methanol emission rate (1.15) was found to be less than the peak-to-mean ratio for paper machine production rate (1.26). This indicates that using the paper machine production rate to evaluate variability of HAP emissions from paper machines is suitably conservative. It was noted that other process-related factors that might affect emission rates are expected to be relatively constant (e.g., roof vent exhaust gas flow rates, dryer temperatures, pulp characteristics, whitewater recirculation rates).

It was also noted that there is no reason to suspect emission rates from paper machines would be higher during startup or shutdown conditions, and that paper machine malfunctions require prompt shutdown. Typically, paper machine upsets correspond to lack of production.

As part of the AECOM investigation, several paper companies surveyed their production records and computed the peak-to-mean production ratio for each paper machine for 20 mills over three years (2008, 2009 and 2010). The median peak-to-mean ratio of the mills surveyed was 1.3, the maximum ratio was 2.1, and the 95th percentile of the ratio values was less than 1.6.[10]

Emissions from all equipment in the paper mill are expected to be uncontrolled and have emissions somewhat related (either directly or indirectly) to paper machine production rate. Therefore, a paper machine peak-to-mean ratio of 1.6 for all equipment in the paper mill that is related to papermaking (e.g., stock preparation, repulping, dryers, etc.) was considered to be representative for purposes of the EPA's October 2011 risk modeling. This ratio was similar to the ratio observed in ICR responses.[1]

Wastewater

Emissions of a volatile organic compound from an aerated stabilization basin (ASB) depend upon the concentration of the compound in the entering wastewater, wastewater chemical and physical properties, the design and operating characteristics of the ASB, and ambient atmospheric conditions. Emissions are estimated with a model such as EPA's WATER9, which requires several input parameters including wastewater flow rate, wastewater temperature, compound concentration, basin area and depth, aeration rate, compound biodegradation rate, ambient temperature, and ambient wind speed.

Three sources of information were used in NCASI's analysis of peak-to-mean HAP emissions ratios for wastewater treatment systems:[11]

(1) Daily kraft condensate liquid flow and HAP concentration measurements from the "hard-pipe" that transfers regulated condensates to ASB wastewater treatment at 6 mills. The

number of daily samples ranged from 12 to 360, and the peak-to-mean ratios for methanol and acetaldehyde ranged from 1.1 to 2.1.

(2) Raw wastewater sampling for:
    a. Wastewater entering a primary clarifier over 16 days. The peak-to-mean ratio for methanol loadings was 1.3.
    b. Wastewater exiting a primary clarifier prior to entering an ASB. The peak-to-mean ratio for methanol ranged from 1.2 to 1.5 for random grab samples taken over a 5-year period.

(3) A sensitivity analysis using EPA's WATER9 model, comparing a baseline emission rate (of methanol, acetaldehyde, and formaldehyde) for a typical ASB to conditions of lower basin temperature by 10^{o}C, increased wind speed from 5 to 10 miles per hour (mph), lower ambient air temperature by 10^{o}C, and lower biological activity rate by 50% (e.g., a catastrophic event for a biotreatment system). None of these factors were found to increase emission rates by more than a factor of 2.

Based upon these analyses it was concluded that a peak-to-mean factor of 2 reasonably represents pulp and paper wastewater sources, and this factor was applied to all wastewater treatment units for the purposes of the October 2011 risk modeling.

Review of hourly emission rates provided in ICR responses

In order to refine the default-10 assumption, peak hourly lb/hr emission rates referred to as "routine emissions maximum hourly rate" were collected through the ICR. Under ideal circumstances, these data would be used directly to evaluate acute, short-term exposures. However, the data provided by respondents had considerable inconsistencies. When compared to the annual emissions reported in the ICR (assuming 8,760 hr/yr) the following problems were identified:

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

Various reasons are expected for these problems, including lack of understanding of the data request, decimal place errors, typos, etc. Most of the discrepancies appeared to be independent of annual operating hours (e.g., the discrepancies remained discrepancies even when tested at annual operating hours other than 8,760 hr/yr). Given the number of outliers at both the high and low end, the ICR data were used to develop acute (short-term) emissions multipliers (peak-to-mean ratios) for various groupings of equipment as opposed to directly modeling the maximum hourly emission rates provided in the ICR data set. The acute multipliers were also needed to fill data gaps where peak hourly rates were not provided by respondents.

To derive the acute multipliers for the October 2011 residual risk modeling, all HAP emissions data for the Subpart S category (MACT code 1626-1) from the ICR were compiled (over 57,000 records). A peak-to-mean ratio was calculated for each HAP compound from each emission source type. Zero emission rates and all peak-to-mean ratios less than one were removed from the data set. A peak-to-mean ratio less than one indicates that the peak value provided is incorrect (does not exceed the average hourly emission rate and is, therefore, not a peak). The median peak-to-mean ratio for each general equipment type was then determined. Removing peak-to-mean values less than one and using the median value reduced the effects of excessively low and unusually high outliers. The resulting peak-to-mean (acute) multipliers ranged from 1.0 to 3.1 depending on the emission source type.

In addition to the "routine emissions maximum hourly rate," the ICR requested maximum hourly emission rates for startup and shutdown periods. The startup and shutdown questions were optional, and therefore the startup and shutdown data received through the ICR were sparse. In all cases, the startup and shutdown hourly rates were the same as the rates provided for peak hourly emission rate. These data ultimately were not useful for analysis of peak-to-mean ratios.[1]

RECENT REFINEMENTS AND NEI REVISIONS

Revisions Resulting from Comments on Subpart S RTR

The EPA proposed the residual risk review for Subpart S in the Federal Register on December 27, 2011. Final amendments to Subpart S were required by court-order to be signed by the EPA Administrator by July 31, 2012. In the December 27, 2011 preamble (76 FR 81344), EPA proposed that the risks from the pulp and paper source category are acceptable and concluded that the current Subpart S rule protects public health with an ample margin of safety. Cancer risks to the most exposed individual for the Subpart S source category were estimated to be up to 10 in 1 million (considerably less than the presumptive upper limit of 100 in a million for risk acceptability). The maximum facility-wide cancer risks (considering equipment falling outside of the Subpart S MACT category) were estimated to be between 10 and 30 in 1 million for five mills, and four mills were estimated to have a maximum chronic noncancer target organ specific hazard index of between 1 and 2. The EPA solicited comment on the proposal, asking for any additional data that may help to reduce the uncertainties inherent in the risk assessments and other analyses.(76 FR 81349-51) The EPA was specifically interested in receiving corrections to the mill-specific HAP emissions data used in the risk modeling, but also accepted revisions to non-HAP emissions data. The mill-specific NEI emissions data were available for download on EPA's RTR web page at: http://www.epa.gov/ttn/atw/rrisk/rtrpg.html. Commenters on the Subpart S proposal (e.g., industry, states) were asked to determine whether any of the NEI data were unrepresentative or inaccurate and to submit their revisions to the data sets downloaded from the RTR web page to the docket for the Subpart S amendments (Docket ID No. EPA–HQ–OAR–2007–0544). An estimated 81 facilities (represented by 83 separate NEI IDs) provided NEI data revisions, out of 171 major source facilities in the source category. Fifty-three of the 68 facilities with estimated cancer risks equal to or greater than 1 in a million submitted revisions. The revisions submitted generally appeared to have the effect of lowering risk (e.g., due to reduced emissions, removed pollutants, emission release point types changed from fugitive to stack, and/or revised latitude and longitude and emission release parameters).

Future Efforts

The NEI revisions received in response to the Subpart S proposal will be incorporated into a newly revised version of the pulp and paper NEI data set, and will be used in the future for Subpart MM risk modeling. It is anticipated that there will be additional considerations for combustion-related pollutants that will need to be addressed prior to modeling for Subpart MM. For example, emissions of dioxins/furans were not present in the Subpart S category, and were omitted from the October 2011 facility-wide modeling because of data quality issues. These issues, including apportionment of facility-wide dioxin/furan emission estimates between combustion sources such as recovery furnaces and power boilers and application of congener and toxic equivalency profiles, will need to be addressed prior to modeling specific to the Subpart MM source category. It is also anticipated that speciation of compounds within the inventory (e.g., POM or Cr) and HCCPD emissions estimates submitted with the ICR responses may need to be reviewed again prior to risk modeling for Subpart MM.

CONCLUSIONS

EPA's approach to assessing public health risks remaining after a MACT standard has been promulgated involves doing facility-specific dispersion modeling using information on HAP emissions taken from the NEI. This paper focuses on the NEI information that was used to conduct the risk modeling for pulp and paper mills. Pulp and paper mills, particularly those with chemical wood pulping operations, have numerous unit processes, multi-fuel fired combustion sources, and on-site wastewater treatment systems. The effort needed to produce a comprehensive mill-wide inventory of HAP that includes all of the data elements required by the NEI for each emission point is very significant.

The 2002 NEI was found to be inadequate for producing meaningful facility-specific dispersion modeling results. This result led to a five-year collaborative process among EPA, RTI, and industry representatives to develop a more comprehensive and accurate inventory of HAP emissions reflective of full implementation of the pulp and paper MACT standards. Ultimately the 2005 NEI, with extensive additions, corrections, and updates provided by all parties, provided the requisite input for EPA's final HEM3 calculations. The significant problem areas that had to be resolved were:

(1) Inconsistencies among state inventories with respect to the number of emission points, number of HAP included, assigned SCCs, and stack parameter/area source level of detail;
(2) Incorrect or imprecise latitude/longitude coordinates and incorrect stack parameters for point sources and missing dimensions for fugitive area sources
(3) Inaccurate estimates of annual emissions due to use of outdated emission factors, reporting errors, or improper accounting for unit processes with multiple vents;
(4) Speciation issues for chromium, PAHs, and dioxin/furans.

The pulp and paper industry experience showed that an iterative, cooperative process is beneficial to improve the quality of the NEI information to the point where it can be used for consistent facility-specific risk assessments across an entire industry. A critical part of the process was the sharing of modeling results to identify those unit processes and compounds making the largest contributions to risk so that a targeted review of the inventory information could be conducted. This helped uncover many errors in the NEI files that had a significant impact on the risk estimates.

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KEY WORDS

Hexachlorocyclopentadiene
Hexachloroethane
Information Collection Request
National Emissions Inventory
National Emission Standards for Hazardous Air Pollutants
Pulp and Paper
Residual Risk
Source Classification Code