GEORGIA
DEPARTMENT OF NATURAL RESOURCES

ENVIRONMENTAL PROTECTION DIVISION

2018 Ambient Air Surveillance Report
Risk Assessment

Prepared by Georgia Environmental Protection Division Risk Assessment Program
(RAP)
3-16-2020

Table of Contents

Due to file size, Appendices have not been included with this document. Appendices can be obtained by contacting the Air Protection Branch Ambient Monitoring Program. For questions concerning this document, please contact the Risk Assessment Program using the contact information on the Land Protection Branch website:

https://epd.georgia.gov/about-us/land-protection-branch

Acronyms

- µg/m^3 – micrograms per meter cubed
- AMDL – Alternate Method Detectable Limit
- AMP – Air Protection Branch Ambient Monitoring Program
- ATSDR- Agency for Toxic Substances and Disease Registry
- CA – Contaminant Concentration in Air
- CalEPA – California Environmental Protection Agency Office of Environmental Health Hazard Assessment
- COPCs – Constituents of Potential Concern
- EC – Exposure Concentration
- ELCR – Estimated Lifetime Carcinogenic Risk
- GAEPD – Georgia Environmental Protection Division
- HEAST - USEPA Superfund Program Health Effects Assessment Summary Table
- HHRA – Human Health Risk Assessment
- HI – Hazard Index
- HQ – Hazard Quotient
- IEUBK - USEPA Integrated Exposure Biokinetic Model
- IUR – Inhalation Unit Risk
- MC – Minimum Detected Concentration
- MDC – Maximum Detected Concentration
- MDL – Method Detectable Limit
- MRL – Minimal Risk Levels
- PAMS – Photochemical Assessment Monitoring Station
- ppb – parts per billion
- PRBSA – Preliminary Risk-Based Screening Analysis
- RfC – Reference Concentration
- RSL – Regional Screening Levels
- SVOCs – Semi-volatile Organic Compounds
- USEPA – United States Environmental Protection Agency
- UCL – Upper Confidence Limit of the Arithmetic Mean
- VOCs – Volatile Organic Compounds

Definitions

- Alternate Method Detectable Limit (AMDL): "*method detectable limit (MDL) defined for the sample by the QA agency, which supersedes the EPA-defined method detectable limit for the designated methodology*"[1]
- Constituents of Potential Concern (COPC): Constituents (chemicals) which could potentially present a risk/hazard and have been further evaluated in the HHRA
- Cumulative ELCR: A value which describes the total carcinogenic risk at a monitoring Site; derived by adding up the ELCR for individual constituents
- Estimated Lifetime Carcinogenic Risk (ELCR): additional risk of developing cancer on top of other factors that could put an individual at risk of developing cancer
- Exposure Concentration (EC): "*concentration of a chemical in the air at the point where a person breathes the air*" (USEPA, 2004, pg. 6-17)
- Hazard Index (HI): A value which describes the total noncarcinogenic hazard at a monitoring Site; derived by adding up the HQ of individual constituents
- Hazard Quotient (HQ): the ratio between a constituent's exposure concentration and reference Concentration. Hazard quotients above 1 indicate the potential for adverse noncarcinogenic health effects
- Hazard: the potential harm from exposure to noncarcinogens; the HQ and HI are specific estimates of hazard
- Inhalation Unit Risk (IUR): "*the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air*" (USEPA, 2009, pg. 10)
- MDL Criteria: is defined as the maximum value that is acceptable as the MDL for a constituent according to the MDL Acceptance Criteria in GAEPD (2019)
- Reference Concentration (RfC): "*defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer health effects during a lifetime*" (USEPA, 1994, pg. 1-2 to 1-4)
- Residential Air Regional Screening Levels (RSLs): conservative thresholds developed by USEPA under which constituents are not expected to present an adverse risk/hazard
- Risk: the potential harm from exposure to carcinogens; the ELCR and cumulative ELCR are specific estimates of risk
- Upper Confidence Limit of the Arithmetic Mean (UCL): given a specified confidence interval, the maximum value that can be used as a surrogate for the arithmetic mean

[1] Please see: https://aqs.epa.gov/aqsweb/documents/AQS_Data_Dictionary.html

Section 1: Introduction

This risk assessment was prepared on behalf of the Georgia Environmental Protection Division (GAEPD) Air Protection Branch Ambient Monitoring Program (AMP) by the GAEPD Land Protection Branch Risk Assessment Program (RAP). The scope of the following risk assessment is ambient air monitoring data that was collected at the following Sites in the year 2018:

Air Toxics Network Sites

- Georgia Forestry Commission, 5645 Riggins Mill Road, Dry Branch, Georgia, 31020 ["Macon-Forestry"]
- 2500 E. President Street, Bd-A, Savannah, Georgia, 31404 ["Savannah–E. Pres. St."]
- 46 John Coffee Road, Nicholls, GA, 31554 ["General Coffee"]

National Air Toxics Trends Station (NATTS)

- 2390-B Wildcat Road, Decatur, GA, 30034 ["South DeKalb"]

Near Road Monitoring Network Site

- 3073 Panthersville Road, Decatur, GA, 30034 ["NR-285"]

Section 2 provides a brief explanation about the data used to prepare the risk assessment.

Sections 3 and 4 comprise the risk assessment. Section 3 contains the preliminary risk-based screening analysis (PRBSA) on all constituents analyzed at each Site. The goal of the PRBSA was to create a "short-list" of constituents of potential concern (COPCs) by comparing maximum detected concentrations (MDCs) with conservative air screening levels, which are health-based standards below which there is expected to be no appreciable risk/hazard from exposure to ambient air. COPCs are constituents that can *potentially* present a risk/hazard to human health and are carried forward for further evaluation in the Human Health Risk Assessment (HHRA), found in Section 4. The HHRA was prepared following USEPA risk assessment guidance, including the *Air Toxics Risk Assessment Reference Library: Volume 1 Technical Resource Manual* (USEPA, 2004). Supporting information necessary to understand the conclusions of the PRBSA and HHRA have been referenced and/or included in the appendices.

It is important to stress that the risks/hazards determined in Section 4 are high-end *estimates* and that there are uncertainties in these estimates due to various reasons including data gaps and the use of conservative inputs to account for these data gaps. Section 5 contains a detailed Uncertainty Section to explain the uncertainties inherent to this risk assessment.

Section 2: Data Collection and Evaluation

Section 2.1 – Collection and Validation of Ambient Air Monitoring Data

The collection and validation of all ambient air monitoring data was previously conducted by the Ambient Monitoring Program (AMP). Details on the collection and validation of data can be found in the *Quality Assurance Project Plan for the Georgia Ambient Air Monitoring Program National Air Toxics Trends Station (NATTS)* (GAEPD, 2019), the *Standard Operating Procedure for Data Validation of Integrated Data* (GAEPD, 2018a), and the *2018 Ambient Air Monitoring Plan* (GAEPD, 2018b).

Section 2.2 –Processing of Ambient Air Monitoring Data

Ambient air monitoring data was collected and analyzed for metals, carbonyls, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), and photochemical assessment monitoring station (PAMS) compounds. Original data files are provided in Appendix A, and results organized by monitoring Site and constituent are provided in Appendix B. These constituents were converted to µg/m^3, when necessary, using the following formula:

$$\frac{\text{MW x ppb}}{24.45}$$

Where:

- MW = Molecular Weight
- ppb = Constituent concentration, in parts per billion
- 24.45 = Constant (see USEPA, 2004)

Converted data are included in Appendix A.

Section 2.3 – Detects and Nondetects

In order to statistically analyze the data, it was necessary to designate a sample datapoint as either a detect or nondetect. Detection status was determined based on the data qualifiers listed in Appendix C. The only datapoints that have been considered nondetects are those qualified with an ND ("No Value Detected, Zero Reported") or MD ("Value less than the MDL"). All other datapoints are concentrations present at detectable levels.

Section 3: Preliminary Risk-Based Screening Analysis (PRBSA)

Section 3.1 – Purpose

The purpose of Section 3 is to present a preliminary risk-based screening analysis (PRBSA) on the 2018 ambient air monitoring data. The "*basic concept behind this risk-based initial screening level methodology is to evaluate air monitoring data sets using a framework that is, by design, relatively simple to perform yet conservative (i.e., health protective) in nature*" (USEPA, 2010, pg. 2). A PRBSA allows risk assessors to focus on those constituents which could potentially present adverse effects.

For each constituent analyzed at each Site, the maximum detected concentration (MDC) is compared with conservative air screening levels. Any constituent which exceeds the screening level is considered a constituent of potential concern (COPCs) that "*at a minimum, will commonly require a more in-depth analysis (e.g., a more detailed risk assessment) to clarify the potential risks associated with the monitored concentrations*" (USEPA, 2010, pg. 4). All COPCs were further evaluated in the Human Health Risk Assessment (HHRA) in Section 4.

Section 3.2 – Scope of the PRBSA

Table 1 provides a summary of the constituents analyzed in the PRBSA. For a list of the individual constituents, please refer to the COPC Selection Tables in Appendix E.

Table 1: Summary of Constituent Classes. The following Table lists the number of constituents in each constituent class that will be assessed in the PRBSA.

Site	Constituents Analyzed
Macon-Forestry	Metals (11 analyzed) Semi-Volatiles (17 analyzed) Volatile Organic Compounds (43 analyzed)
Savannah-E. Pres. St.	Metals (11 analyzed) Semi-Volatiles (17 analyzed) Volatile Organic Compounds (43 analyzed) Carbonyls (6 constituents)
General Coffee	Metals (11 analyzed) Semi-Volatiles (17 analyzed) Volatile Organic Compounds (43 analyzed)
South DeKalb	Metals (11 analyzed) Semi-Volatiles (18 analyzed) Volatile Organic Compounds (43 analyzed) Carbonyls (6 analyzed) PAMS compounds (54 analyzed[2])
NR-285	Volatile Organic Compounds (43 analyzed)

[2] The sum of PAMS station target compounds (PAMSHC) and total non-methane organic compound (TNMOC) are not evaluated in the risk assessment since individual PAMS station constituents are evaluated. Screening levels are based on individual constituents and evaluating the PAMS constituents individually allows risk assessors to tease out which constituents are risks/hazards at Site from those that are not expected to be problematic at the Site.

Section 3.3 – Maximum Detected Concentration

Ambient air samples were collected every 24 hours at each Site's monitoring station every 12 days (every 6 days only at South DeKalb) over a one-year period. At each Site, the maximum detected concentration (MDC) is the highest concentration from all of a constituent's detected sample results. The MDC is considered to be a conservative surrogate for long-term exposure to ambient air constituents and "*is expected to result in a lessened chance that chemicals posing exposures of potential public health concern will be removed from further consideration*" (USEPA, 2010, pg. 7).

Section 3.4: Determining Constituents of Potential Concern

As recommended by USEPA (2018), Constituents of Potential Concern (COPCs) were determined by comparing the MDC of a constituent with the more conservative of that constituent's carcinogenic or noncarcinogenic USEPA Residential Air Regional Screening Level (RSL) (USEPA, 2019). RSLs are derived from risk equations that have been modified to obtain an ambient air concentration using conservative residential exposure parameters and USEPA-recommended toxicity values, and are based on a target carcinogenic risk level of 1-in-1-million (10^{-6}) and noncarcinogenic hazard quotient (HQ) of 0.1. A summary table of all residential air RSLs is included in Appendix D Table 1. For more information regarding RSLs, please see the RSL User's Guide (USEPA, 2019).

All analyzed constituents at each Site were screened to determine COPC status. If the MDC is above the RSL, the constituent is considered a COPC and further evaluated in the HHRA. Exceedances of screening levels do not necessarily indicate that an unacceptable risk exists, but rather indicates further evaluation in the HHRA. If the MDC is below the RSL, the constituent is not considered a COPC. Appendix E provides tables of COPCs determined at each Site.

Section 3.4.1 – Special Considerations Regarding Constituents of Potential Concern Status

For data with AMDLs, defined as the "*method detectable limit (MDL) defined for the sample by the QA agency, which supersedes the EPA-defined method detectable limit for the designated methodology*"[3], if the maximum AMDL was greater than the RSL, even when the MDC is below the RSL, the constituent was carried forward as a COPC. When the maximum AMDL is above the RSL even though the MDC of the constituent is below the RSL, it is possible that the constituent could have been present at a concentration above the RSL; however, the concentration cannot be reported as a detect as it is below the AMDL. To ensure that the HHRA will not underestimate risk/hazard, constituents where this is the case have been conservatively assumed to be COPCs and evaluated in the HHRA. This is in accordance with USEPA guidance, which states that "*chemicals with detection limits above health-based levels*" may be considered COPCs (USEPA, 2018, pg. 2-7).

For all other data, AMDLs were not available for use. Several metals, carbonyls, and SVOCs had MDL Criteria listed in units of $\mu g/m^3$ (GAEPD,2019, pg. 33, 38, 42). The MDL Criteria is defined as the maximum value that is acceptable as the MDL for a constituent. Put another way, the MDL Criteria is not the actual AMDL of the constituent but represents the highest value that could be

[3] Please see: https://aqs.epa.gov/aqsweb/documents/AQS_Data_Dictionary.html

set as the AMDL for a constituent. If the MDL criteria of a constituent is above the constituent's RSL, the constituent has been carried forward as a COPC.

Several analyzed constituents do not have RSLs. In this case, it is unclear whether the constituent could be a potential concern at the Site. To ensure that the HHRA will not underestimate risk/hazard, these constituents have been conservatively assumed to be COPCs to be further evaluated in the HHRA.

The frequency that a constituent was detected at the Site has been included on all Appendix E tables. However, frequency of detection was not used as a criterion to eliminate constituents from being assessed in the HHRA; this is based on the recommendation of USEPA Region 4 (USEPA, 2018 pg. 2-7). This may overestimate the number of COPCs at a Site but ensures that potential risks/hazards are not underestimated.

Many constituents did not have available AMDLs or MDL Criterion. For these constituents, AMDLs were not considered in the screening process. The effects of this on the risk assessment have been explained in the Uncertainty Section (Section 5).

Section 3.4.2 – Lead

On Appendix D Table 1, lead has a listed RSL of 0.15 µg/m^3; this is USEPA's National Ambient Air Quality Standard (NAAQS). However, this is not a risk-based value derived using equations and methodology as previously mentioned. Thus, this value was not used in the PRBSA. Lead was considered to not have a screening level, carried forward as a COPC, and evaluated in the HHRA using USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model. However, please note that the lead MDC at all Sites where lead was analyzed is below USEPA's NAAQS.

Section 4: Human Health Risk Assessment (HHRA)

Section 4.1 - Conceptual Model

The conceptual model "*explicitly identifies the sources, receptors, exposure pathways, and potential adverse human health effects that the risk assessment will evaluate*" (USEPA, 2004, pg. 6-1). This allows users of this risk assessment to better understand exactly what is being evaluated. USEPA (2004) recommends specific elements that should be included in a conceptual model, which has been graphically displayed in Figure 1 and further explained below. Please note that this conceptual model applies to each individual air monitoring Site.

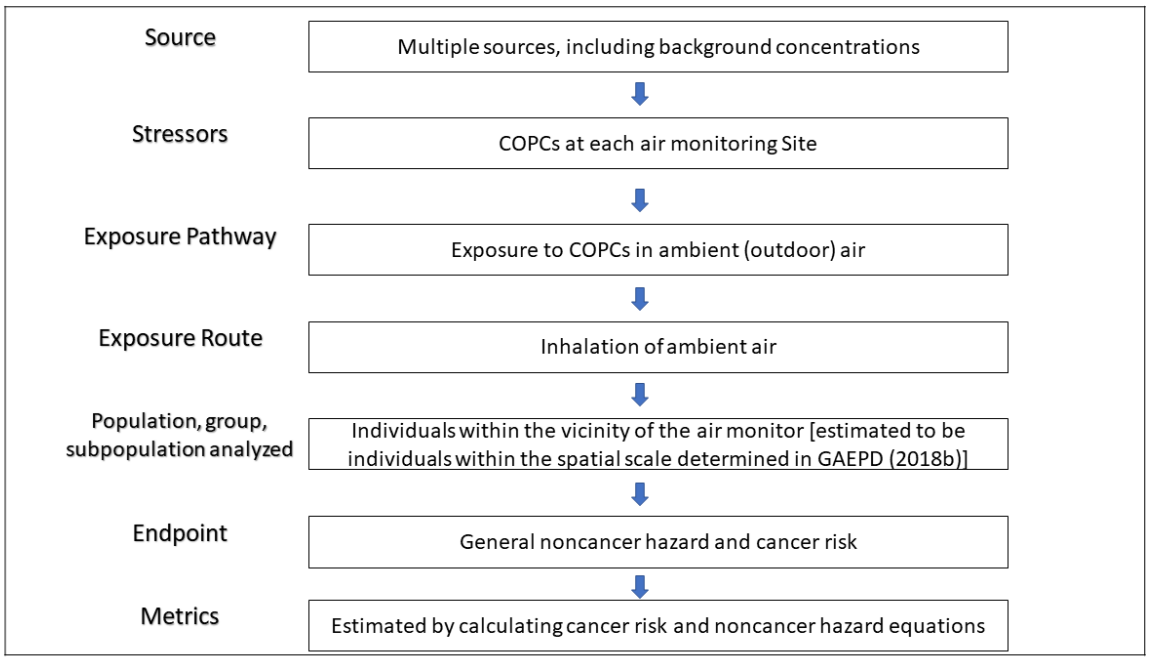

Figure 1: Conceptual Model, applies to each monitoring Site. This conceptual model was made similar to the conceptual model in Exhibit 6-1 of USEPA (2004).

Section 4.1.1 – Sources of Constituents

This risk assessment is evaluating ambient air, which is the outdoor air present in the vicinity of an air monitor at a Site. The exact sources of these constituents cannot be pinpointed from the air monitoring data used in the HHRA.

Section 4.1.2 – Stressors

The stressors are the specific constituents that will be evaluated in this risk assessment. At each air monitoring Site, the stressors will be the COPCs at each of those Sites.

Section 4.1.3 – Exposure Pathway/Exposure Route

This risk assessment will only evaluate exposure to air toxics because of breathing ambient (outdoor) air. Specific data on indoor air quality is not available. Therefore, this media is not specifically evaluated in this risk assessment since it is understood that indoor air constituent

concentrations "*are expected to be the same or lower than the outdoor concentrations"* (USEPA, 2004, pg. 11-2). The same residential exposure parameters used in the PRBSA (see Appendix D: Section 1) will be used so that the final risk/hazard represents risk/hazard to individuals in the vicinity of each air monitor. Residential exposure parameters are more conservative than nonresidential exposure parameters. Thus, the risk/hazard estimate developed would not underestimate risks/hazards to nonresidents.

An individual can be exposed to constituents in ambient air through inhalation of ambient air or by coming in contact with ambient air constituents that may have deposited out of the air onto water bodies, plants, soil, and other surfaces (USEPA, 2004, pg. 6-2). Only the inhalation route of exposure will be evaluated in this risk assessment since deposition data is not available.

Section 4.1.4 – Spatial Scale/Subpopulations

As discussed in Section 3.0 of GAEPD (2018b), each monitoring station has met specific siting criteria approved by USEPA. Additionally, GAEPD (2018b) determined the spatial scale for each monitoring Station. Table 2 summarizes this information.

Table 2: Spatial Scale of Each Air Monitoring Site

Monitoring Site	Spatial Scale
Macon-Forestry	Neighborhood scale – An area with dimensions in the 0.5 to 4 kilometer range
Savannah E. Pres St.	Neighborhood scale – An area with dimensions in the 0.5 to 4 kilometer range
General Coffee	Regional Scale – An entire rural area of the same general geography (this area ranges from tens to hundreds of kilometers).
South DeKalb	Neighborhood scale – An area with dimensions in the 0.5 to 4 kilometer range
NR-285	Micro Scale – An area of uniform pollutant concentrations ranging from several meters up to 100 meters.

The ambient air concentrations found at each Site are considered to represent concentrations that individuals within the spatial scale of each air monitor could be exposed to. However, it should be reiterated that from a risk assessment perspective, monitoring "*only provides estimates of concentrations at the point at which samples are taken, and it is often difficult to clearly define the spatial coverage that those measured concentrations represent"* (USEPA, 2004, pg. 10-7).

Subpopulations located within the spatial scale of each air monitoring Site have not been analyzed in this risk assessment since exposure to all individuals within the spatial scale is treated the same by using conservative residential exposure parameters. Additionally, inhalation risk/hazard is derived following USEPA's *Inhalation Dosimetry Methodology*, which "*recommends that when estimating risk via inhalation, risk assessors should use the concentration of the chemical in air as the exposure metric (e.g., mg/m^3), rather than inhalation intake of a contaminant in air*", the latter which would consider factors unique to specific subpopulations such as body weight, age,

and inhalation rate (USEPA, 2009, pg. 2). Please see Section 4.2 for more information on how the inhalation exposure concentration (EC) was derived for each constituent.

Section 4.1.5 – Endpoints and Metrics

Endpoints are specific harmful effects that could occur as a result of being exposed to ambient air constituents. This risk assessment will not evaluate specific endpoints but will evaluate general carcinogenic risk and noncarcinogenic hazard as a result of inhaling ambient air constituents. Estimated lifetime carcinogenic risk (ELCR) and noncarcinogenic hazard quotients (HQ) are estimated by calculating risk/hazard equations that incorporate both the EC and toxicity values. A cumulative ELCR/noncarcinogenic hazard index (HI) will also be reported for each monitoring Site.

Section 4.2 – Exposure Assessment

To characterize exposure, an inhalation risk assessment "*involves the estimation of exposure concentrations (ECs) for each receptor exposed to contaminants via inhalation in the risk assessment*" (USEPA, 2009, pg. 13). An exposure concentration (EC) is defined as the "*concentration of a chemical in the air at the point where a person breathes the air*" (USEPA, 2004, pg. 6-17). Since there is significant variability in the concentrations of ambient air constituents even within the spatial scale of an ambient air monitor, the true EC is unknown and is estimated using the following equation from USEPA (2009):

$$\mathbf{EC = (CA \times ET \times EF \times ED)/AT}$$

Where: EC ($\mu g/m^3$) = exposure concentration
CA ($\mu g/m^3$) = contaminant concentration in air
ET (hours/day) = exposure time
EF (days/year) = exposure frequency
ED (years) = exposure duration
AT: averaging time
AT for non-carcinogens: (ED in years x 365 days/year x 24 hours/day)
AT for carcinogens: (lifetime in years x 365 days/year x 24 hours/day)

This equation is consistent with USEPA's *Inhalation Dosimetry Methodology*, which asserts that the amount of a constituent that is inhaled and reaches the target site (i.e. where the constituent could have a toxic effect) is not simply based on body weight and inhalation rate but also must consider other factors such as the "*physiochemical characteristics of an inhaled constituent"* (USEPA, 2009, pg. 2). Thus, the EC is estimated as the contaminant concentration in air (CA) adjusted to reflect the time, frequency, and duration of exposure, except that the EC for carcinogens is also averaged over a lifetime since it is assumed that exposure to a high amount of carcinogen over a short time period is equivalent to exposure to a small amount of carcinogen over a lifetime (USEPA, 2005a, pg. 3-26).

Default, residential exposure parameters listed in Table 3 are used to calculate the EC. As previously stated, these residential assumptions "*account for daily exposure over the long term and generally result in the highest potential exposures and risk*" (USEPA, 1991, pg. 3). Since there are significant uncertainties as to the spatial scale of each air monitor, using conservative

residential assumptions ensures that risk/hazard will not be underestimated in the HHRA. Additionally, these residential parameters are recommendations from publicly available USEPA guidance, ensuring that the risk assessment is transparent and that exposure parameters haven't been arbitrarily determined.

Table 3: Default Residential Parameters used to Calculate the Exposure Concentration (EC)

ED	Exposure duration	26 years	26 years is a default exposure duration value used in the residential exposure scenario. The value is obtained from Table 16-108; 90th percentile for current residence time in USEPA (2011). 26 years could be thought to represent the total length of time in which an individual could inhale ambient air constituents at or in the vicinity of the air monitoring Site. This is considered a conservative assumption.
EF	Exposure frequency	350 days/year	This value is from page 15 of USEPA (1991) and is a residential exposure frequency. Though 365 days/year (every day per year) is a more conservative exposure frequency, USEPA believes that "*the common assumption that workers take two weeks of vacation per year can be used to support a value of 15 days per year spent away from home (i.e., 350 days/year spent at home)*" (USEPA, 1991, pg. 5). 350 days/year is still an upper-bound residential assumption and is used to be in line with recommended USEPA values. Thus, this value denotes that an individual is inhaling ambient air constituents at or in the vicinity of an air monitor for 350 days out of the year. This is considered a conservative assumption.
ET	Exposure time	24 hours/day	A resident is assumed to be able to be exposed to environmental constituents for a maximum of 24 hours a day (USEPA, 1989a, pg. 6-6). Using 24 hours/day as the ET ensures that the maximum amount of time per day that someone could be exposed to ambient air constituents at or in the vicinity of an air monitor is being captured. Thus, this exposure parameter is conservative.
LT	Lifetime	70 years	70 years is standard assumption used by USEPA (USEPA, 1989a, pg. 6-22) for an individual's lifetime. Though the carcinogenic risk equation assumes that an individual is exposed to an ambient air constituent for 24 hours/day, 350 days/year, for a period of 26 years, the equation averages the carcinogenic target risk level over a period of 70 years since for carcinogens, it is assumed that an individual can develop cancer even after they are no longer being exposed to ambient air constituents.

USEPA's Regional Screening Level (RSL) calculator (https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search), which is used to obtain risk/hazard estimates, automatically derives the EC using the contaminant concentration in air (CA) for each constituent, estimated according to the procedures discussed in Section 4.2.1.

Section 4.2.1 – Estimating the Contaminant Concentration in Air (CA)

In the PRBSA, the maximum detected concentration (MDC) was used to estimate the ambient air concentration of a constituent as a highly conservative measure to ensure that constituents which could potentially present a risk/hazard have not been eliminated from further evaluation in the HHRA. In risk assessment, the goal is to refine the PRBSA and obtain a more realistic estimate of the ambient air concentration. CAs for all constituents at all monitoring Sites are listed on tables in Appendix F.

The annual average ambient air concentration represents long-term (chronic) exposure to ambient air constituents. However, to remove "*the risk of underestimating the true exposure*" (USEPA, 2004, pg. I-4 to I-5), the HHRA uses the upper confidence limit (UCL) of the average (arithmetic mean) to estimate the CA. The UCL is the maximum value, given a specified confidence interval (confidence intervals greater than 95% are used to determine UCLs in this risk assessment), that is used as a surrogate for the arithmetic mean. UCLs are used to estimate the CA since they are a public health protective estimate of the true ambient air concentration.

ProUCL Version 5.1.002 (ProUCL) is a statistical software package that was used to calculate UCLs. ProUCL was used since it is publicly available and user-friendly. The dataset for individual constituents analyzed at each monitoring Site (please see the ProUCL inputs in Appendix G[4]) was imported into ProUCL, which then automatically recommends the appropriate UCL. If ProUCL recommends multiple UCLs, the greater of the UCLs was used to estimate the CA. All ProUCL inputs and outputs are in Appendix G. There were instances where either ProUCL could not calculate a UCL or ProUCL's recommended UCL was not used to estimate the CA and the MDC was used to estimate the CA. See ProUCL Users Guide (USEPA, 2015) for limitations on data usage.

Section 4.2.2 – Estimating the Contaminant Concentration in Air (CA) for Lead

For Lead, the arithmetic mean has been used to estimate the CA. Lead risk is evaluated using USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model, and the IEUBK Model recommends the use of an annual average ambient air concentration (UCLs are upper-bound estimates) as an input in the Model.

Section 4.3 – Toxicity Assessment

The purpose of the toxicity assessment is to identify the carcinogenic and noncarcinogenic effects of a constituent [hazard identification] and to quantify its toxicity [dose-response assessment]

[4] As mentioned in Section 2, Appendix B has all the cleaned-up data for each constituent at each monitoring Site and was coded so that it could be used in ProUCL. When this data was imported into ProUCL, separate ProUCL input files were saved in Microsoft Excel (.xlsx or.xls) format for each constituent at each monitoring Site. Statistical analyses were run in ProUCL from these input files and not directly from the Appendix B Excel files. The ProUCL inputs in Appendix G reflect how ProUCL "read" the data and ran statistical analyses from that data; the purpose of including Appendix B is to show how the data was organized from the original data files.

(USEPA, 2004, pg. 12-1). For many of the constituents, toxicity assessments have already been conducted by toxicologists either at USEPA or another Federal/State agency. Thus, the focus of this section is to briefly explain the toxicity information that is used for the HHRA.

Section 4.3.1 – Toxicity Values

During the toxicity assessment, the information from the hazard identification and dose-response assessment are translated into specific toxicity values that are used to prepare the HHRA. Two kinds of inhalation toxicity values are used in the risk assessment to evaluate inhalation: the reference concentration (RfC) and the inhalation unit risk (IUR).

The RfC "*is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncarcinogenic health effects during a lifetime*" (USEPA, 1994, pg. 1-2 to 1-4). Readers should consult USEPA (1994) and a constituent's noncarcinogenic toxicity assessment for more information on how a RfC is derived.

The IUR is defined as "*the upper-bound excess lifetime carcinogenic risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air*" (USEPA, 2009, pg. 10). Readers should consult USEPA (2005a) and a constituent's carcinogenic toxicity assessment for more information on how an IUR is derived.

Appendix H Table 1 lists the toxicity values for all constituents with available toxicity values. Since the purpose of this risk assessment is to understand long-term (chronic) exposure to ambient air constituents, only chronic toxicity values are listed.

Section 4.3.2 – USEPA Toxicity Values Hierarchy

Many different organizations publish toxicity values. To be consistent with USEPA Region 4 risk assessment guidance[5], the toxicity values used in the HHRA listed in Appendix H Table 1 were selected following USEPA's Toxicity Values Hierarchy as outlined in USEPA (2003):

- Tier 1 toxicity values: USEPA's Integrated Risk Information System (IRIS), found at: https://www.epa.gov/iris, is consulted first. USEPA considers IRIS to be its preferred source for toxicity information on constituents and "*IRIS health assessments contain [USEPA] consensus toxicity values*" (USEPA, 2003, pg. 2).

- Tier 2 toxicity values: If a constituent doesn't have a toxicity value listed in IRIS, USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) are consulted next. USEPA PPRTVs are developed by USEPA's Office of Research and Development Center for Public Health and Environmental Assessment and USEPA's Human Health Risk Assessment (HHRA) National Research Program. These values are peer-reviewed but are developed primarily for the Superfund program and not necessarily considered a consensus toxicity value within USEPA. For more information on PPRTVs, please refer to: https://www.epa.gov/pprtv/basic-information-about-provisional-peer-reviewed-toxicity-values-pprtvs.

[5] Both USEPA (2010) and USEPA (2018) discuss using the Toxicity Values Hierarchy in USEPA (2003).

- Tier 3 toxicity values: If a constituent doesn't have a PPRTV (or an IRIS toxicity value), then toxicity values from other sources may be used. Though USEPA's Toxicity Values Hierarchy doesn't have a clear criteria to rank the sources of Tier 3 toxicity values, USEPA generally recommends that these values be obtained from "*sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed*" (USEPA, 2003, pg. 3). The RSL Calculator, used to derive risk/hazard in this HHRA, has set a hierarchy for Tier 3 toxicity values in USEPA (2019). The hierarchy, described below, was used to select the toxicity values in Appendix H Table 1.

    - If a chronic RfC is not available from a Tier 1 or Tier 2 source, then chronic inhalation minimal risk levels (MRLs) from the Agency for Toxic Substances and Disease Registry (ATSDR), found at https://www.atsdr.cdc.gov/mrls/mrllist.asp[6], are selected. For the purposes of the HHRA, MRLs are considered as RfCs.

    - If an MRL is not available and/or there aren't Tier 1 or 2 IURs, the California Environmental Protection Agency Office of Environmental Health Hazard Assessment (CalEPA) publishes its own RfCs and IURs, which can be found here: https://oehha.ca.gov/chemicals.

    - For some constituents, the toxicity assessments used to obtain a PPRTV ("PPRTV Assessments") also contain screening toxicity values which although published are considered to have more uncertainty in their derivation than a PPRTV. These are used for constituents when an MRL or CalEPA toxicity value is not available.

    - If a constituent does not have a toxicity value in the aforementioned Tier 3 sources, then toxicity values listed in the USEPA Superfund program's Health Effects Assessment Summary Table (HEAST), found at https://epa-heast.ornl.gov/, can be used.

Section 4.3.3 – Toxicity Values Unavailable

Several constituents that were included in the HHRA do not have toxicity values in either a Tier 1, Tier 2, or Tier 3 source. Thus, it is not possible to derive risk/hazard for these constituents.

Section 4.3.4 – Using RPFs to Determine IUR for Select PAHs

The IUR for several polycyclic aromatic hydrocarbons (PAHs) listed on Appendix H Table 1 were derived by adjusting the IUR of benzo(a)pyrene with constituent-specific relative potency factors (RPF). Frequent Question #45 in USEPA (2019) provides a detailed justification and reasoning behind why this is done.

[6] Only the chronic inhalation MRLs from this table is used/listed on Appendix H Table 1.

Section 4.3.5 – RfC for m/p Xylene and o-Xylene

As stated in Frequent Question #54 in USEPA (2019), an IRIS RfC is only available for total xylenes and not individual congeners. Analytical laboratories tend to analyze congeners individually or analyze m- and p-xylenes as a single analyte (the result represents the concentration of both m- and p- congeners in the sample) and o-xylene as another analyte. For the HHRA, the total xylenes RfC is used to represent the toxicity of m/p xylene and o-xylene even though these are analyzed separately by the analytical laboratory.

Section 4.3.6 – Total Chromium Toxicity

Chromium is known to exist in two major valence states, hexavalent chromium (Cr^{6+}) and trivalent chromium (Cr^{3+}). Based on information received from the analytical laboratory, the total chromium analyzed at Macon-Forestry, Savannah E. Pres St, South DeKalb, and General Coffee was assumed to be 100% trivalent chromium. Thus, total chromium was assumed to be trivalent chromium and risk/hazard could not be determined because trivalent chromium does not have toxicity values from a Tier 1-3 source.

Section 4.4 – Risk Characterization

In the risk characterization step, the information from the exposure assessment and the toxicity assessment are integrated to obtain an excess lifetime carcinogenic risk (ELCR) and noncarcinogenic hazard quotient (HQ) for individual constituents and the cumulative ELCR and hazard index (HI) for all COPCs at each monitoring Site. USEPA's RSL calculator was used to obtain these estimates by inputting the CA determined in Section 4.2 (the toxicity values in Section 4.3 are automatically populated in the calculator). For more information on how the calculator was used to obtain risk/hazard estimates, please refer to USEPA (2019).

Section 4.4.1 – PAMS and VOC Data at South DeKalb

At South DeKalb, several VOCs were analyzed at the PAMS station at this Site (i.e. have sample results in the PAMS dataset). Thus, there are two CA concentrations for these constituents. In order to derive risk/hazard, the greater of the CA concentrations was entered into the RSL calculator to ensure that the risk/hazard estimates would be health conservative.

Section 4.4.2 – USEPA Integrated Exposure Biokinetic (IEUBK) Model for Lead

Though lead has an IUR from CalEPA[7], Lead is not evaluated in a risk assessment using toxicity values (USEPA, 2004, pg. 11-10). Thus, an ELCR or HQ is not calculated for lead. Instead, lead exposure is evaluated using USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model which at its core relates environmental lead exposure to plausible blood-lead concentrations that could be expected in a hypothetical child/population of children (defined as a child/children between 0-84 months of age) as a result of that exposure (USEPA, 1994b, pg. 1-1 to 1-4). The IEUBK Model also determines the probability that these blood-Lead concentrations will exceed a level of concern. In the HHRA, the IEUBK default level of concern, 10 µg/dL, was used.

The most current IEUBK Model (Windows Version 1.1 Build 11) was used to assess lead at all monitoring Sites where lead was analyzed. Since the IEUBK model considers all lead exposures (i.e. from soil, water, dietary, and not only ambient air), the default values for other exposure

[7] Please see: https://oehha.ca.gov/chemicals/Lead-and-Lead-compounds

pathways as currently entered in the model were used. USEPA (1994b) and other IEUBK Model guidance[8] can provide more information on how these default values were derived.

The annual arithmetic mean ambient air concentration of lead determined at each monitoring Site was inputted into the Model. Both the text file outputs and the distribution probability percent curves from the IEUBK Model have been included in Appendix I. At all monitoring Sites, the IEUBK Model suggests that the probability that the blood-lead concentration of a hypothetical child/children 0-84 months of age would be greater than 10 µg/dL is **approximately 0.24%**. This low probability indicates that ambient air exposure to lead is not expected to present a significant concern within the spatial scale of any of the monitoring stations where lead was analyzed.

Section 4.4.3 – Risk/Hazard Estimates

The Risk/Hazard estimates can be found in Appendix J. These tables list ELCRs and HQs for individual COPCs at each monitoring Site. All outputs from the RSL calculator have been included in Appendix K. The cumulative ELCR and HI determined at each monitoring Site has been summarized in Figures 2 and 3.

The cumulative ELCRs at all monitoring Sites are within USEPA's and EPD Air Protection Branch acceptable carcinogenic risk range of 10^{-4} to 10^{-6} (USEPA, 1989b). The HIs at all monitoring Sites exceed 1. Since the monitoring Sites do not have the same COPCs, the cumulative ELCR or HI determined at one monitoring Site should not be compared with those determined at other monitoring Sites.

[8] Please see: https://www.epa.gov/superfund/Lead-superfund-sites-frequent-questions-risk-assessors-integrated-exposure-uptake

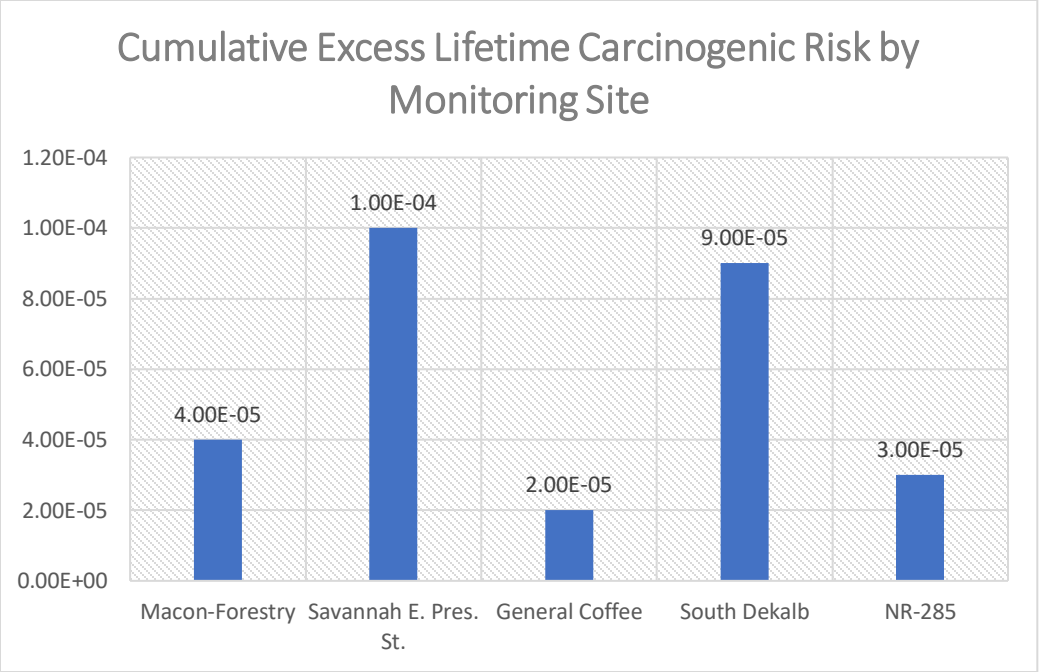

Figure 2: Cumulative Excess Lifetime Carcinogenic Risk by Monitoring Site

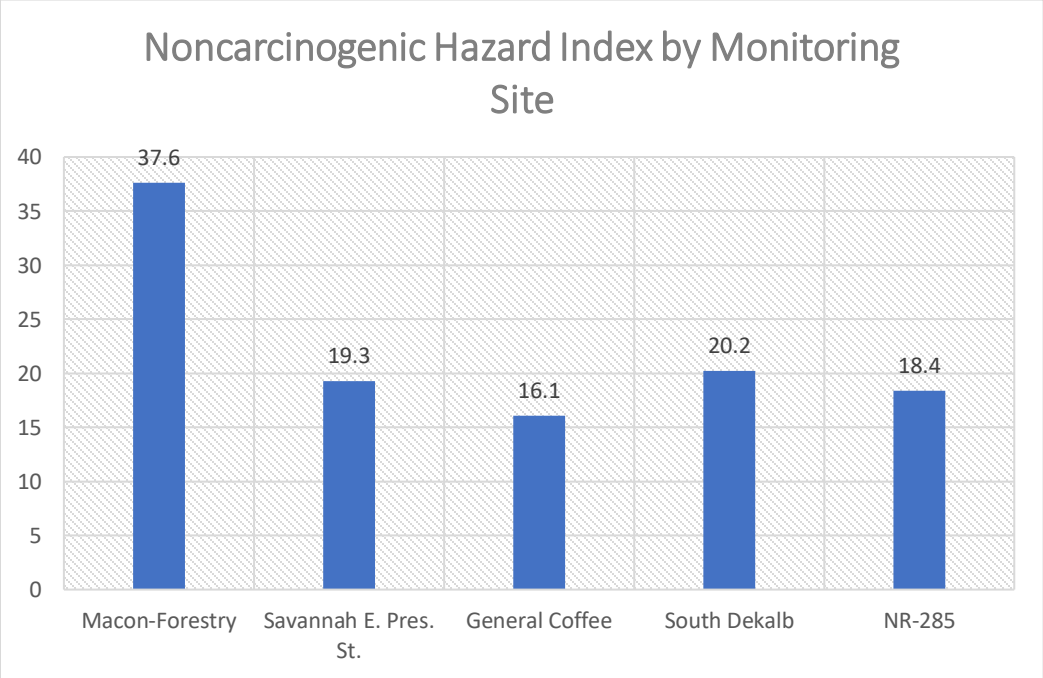

Figure 3: Noncarcinogenic Hazard Index by Monitoring Site

Section 4.5 – Limitations of the Risk Assessment

Due to the process of risk assessment, there are limitations as to the information that can be obtained from the risk/hazard estimates that have been provided. It is important to understand that these risk/hazard estimates:

- Only estimate risk/hazard within the spatial scale of each air monitoring Site
- Do not include potential risks/hazards from inhaling constituents that were not analyzed at each of the air monitoring Sites and for which toxicity values are not available from a Tier 1-3 source.
- Do not necessarily represent the risk/hazard to a specific individual; this point will be further explained in Section 5
- **Cannot** determine if an individual diagnosed with cancer or a noncarcinogenic disorder developed illness due to inhaling ambient air within the spatial scale of any of the monitoring Sites
- Cannot be used to estimate potential risks/hazards at any other location (e.g. the risk/hazard estimates developed for South DeKalb cannot estimate risks/hazards to residents in Augusta who may inhale ambient air constituents)
- Do not represent risks/hazards from generally inhaling ambient air constituents
- Cannot pinpoint the sources of the constituents present in ambient air, which are "*a combination of background concentrations and the same chemical released from possibly multiple sources*" (USEPA, 2004, pg. 10-37)

Section 5 – Uncertainty Section

An integral part of any risk assessment is the uncertainty section, where "*major uncertainties associated with determining the nature and extent of the risk are identified and discussed*" (USEPA, 2004, pg. 13-1). Uncertainties are inherent to all risk assessments due to the procedures used to obtain risk/hazard estimates. The purpose of this section is to discuss specific uncertainties so that the results of the risk assessment can be properly understood and utilized.

Section 5.1 – Dataset Gaps

Since the risk assessment was prepared only on the constituents that were analyzed at each monitoring Site and for which there is useable data, it is unknown how the cumulative ELCR/HI estimates determined at each monitoring Site would be affected if more constituents were analyzed at each monitoring Site and more datapoints were useable.

Section 5.2 – Constituents without AMDLs or MDL Criteria

AMDLs were not considered when determining COPCs for carbonyls, SVOCs, and metals and MDL Criteria was not available for most carbonyls, SVOCs, and metals. It is plausible that some of these constituents should have been carried forward into the HHRA as COPCs but were eliminated during the screening process. However, the analysis in Section 5.3 suggests that the procedure used for selecting COPCs did not have an appreciable effect on the conclusions of the risk assessment.

Section 5.3 – COPC Selection Uncertainty

Though the process for determining COPCs is highly conservative, there could be questions that the process is not conservative enough and that the risk assessment could have underestimated risks/hazards. Thus, a separate analysis was undertaken for each monitoring Site where cumulative ELCRs and HIs were derived for all constituents[9] analyzed at each Site. The same methodology outlined in the HHRA was used to derive CA, obtain toxicity values, and derive risk/hazard estimates for these constituents (please see Appendix L for all supporting information). As shown in Figure 4, cumulative ELCRs were greater at South DeKalb and Macon-Forestry but still within the USEPA and EPD Air Protection Branch cancer risk range of 10^{-4} to 10^{-6}. As shown in Figure 5, the HI did not change at Macon-Forestry and the HIs were only slightly greater at the other Sites. Thus, it does not appear that the selection of COPCs had an appreciable effect on the conclusions of this risk assessment.

[9] "all constituents" implies all constituents that were analyzed at each air monitoring Site, with useable data and for which there are available toxicity values.

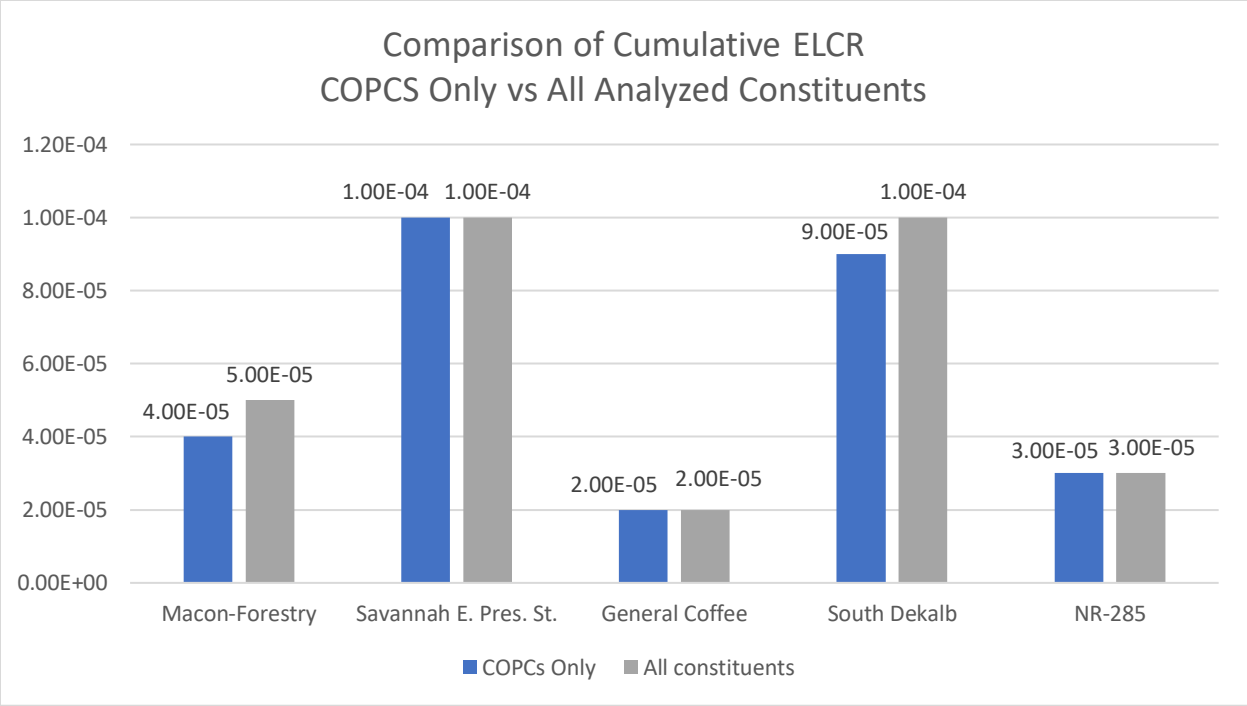

Figure 4: Comparison of Cumulative Excess Lifetime Carcinogenic Risk – COPCs Only vs. All Analyzed Constituents

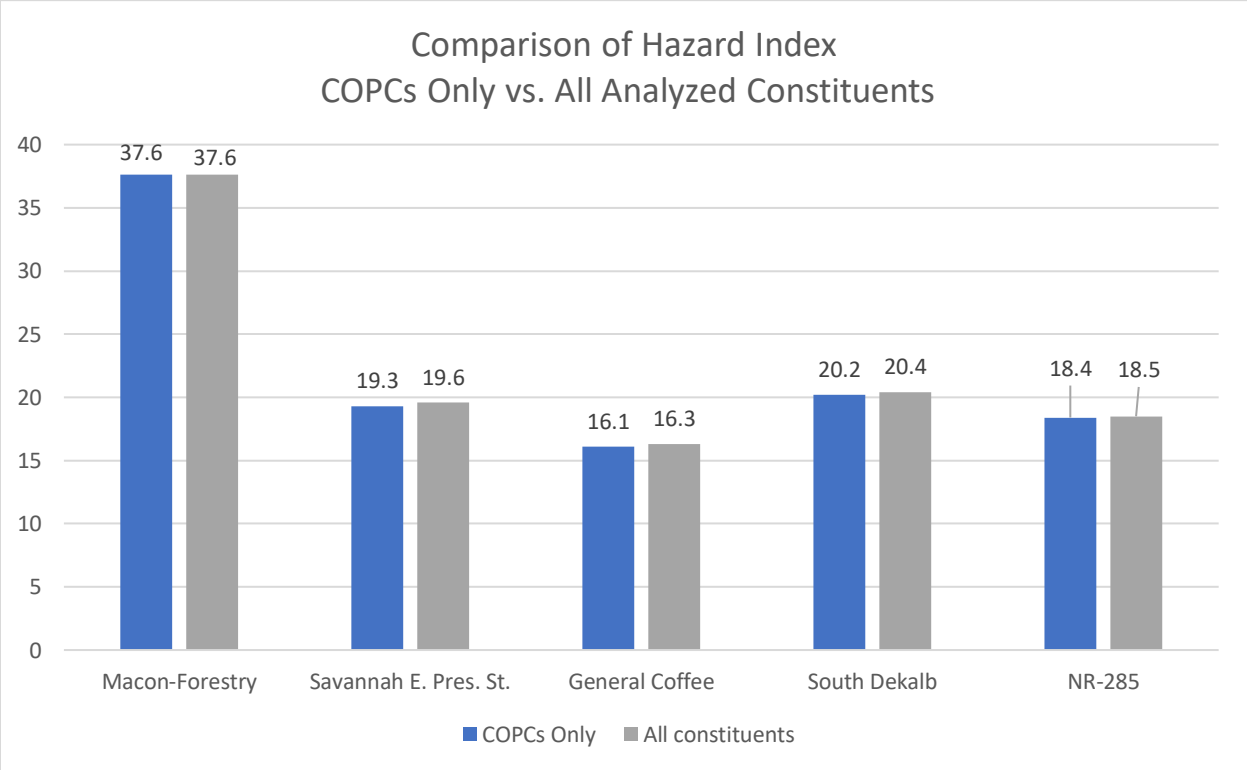

Figure 5: Comparison of Hazard Index – COPCs Only vs. All Analyzed Constituents

Section 5.4 – What an Air Monitoring Site Represents

Though GAEPD (2018b) has estimated the spatial scale of each air monitoring Site, ambient air monitoring "*only provides estimates of concentrations at the point at which samples are taken, and it is often difficult to clearly define the spatial coverage that those measured concentrations represent"* (USEPA, 2004, pg. 10-7). At a given point in time, the ambient air concentration of a constituent can vary within the spatial scale of an air monitor due to various factors, including:

- meteorological factors, such as wind speed and direction and ambient air temperature
- physical factors, such as buildings/structures or variability in terrain elevation
- chemical transformation of constituents which may attenuate or increase the concentrations of toxic air pollutants

Since ambient air monitoring data cannot adequately capture the variability of ambient air concentrations within the spatial scale of the air monitor, the EC is estimated to be a higher-end concentration of ambient air that an individual could be exposed to. Realistically, an individual could be exposed to ambient air concentrations at levels far less than the EC (or even above the EC).

Section 5.5 – Deriving High-End ECs Using Conservative Upper-Bound Estimates

ECs (except for Lead) are derived by using upper-bound estimates of default residential exposure parameters and ambient air concentrations and represent a higher-end exposure to ambient air. The toxicity values that are used in this risk assessment are derived in a conservative way and are also considered upper-bound estimates. Thus, the risks/hazards determined in Section 4 could be said to ***represent a high-end estimate of inhalation risk/hazard***. Since individuals may be exposed to ambient air concentrations at levels far less than an EC, the risk/hazard to a specific individual as a result of exposure to ambient air concentrations within the spatial scale of an air monitor could be far less. The purpose of using upper-bound exposure parameters and toxicity values to bias risk/hazard estimates upward is to ensure that risk/hazard will not be underestimated considering various gaps and unknowns in the air monitoring dataset.

Section 5.6 – Only Inhalation Exposure Route is Assessed

Since only ambient air monitoring data is available, only the inhalation exposure route has been assessed in the HHRA. As previously mentioned, it is possible for air constituents to deposit onto soil, water bodies, and other surfaces and for individuals to encounter these constituents. There could be risks/hazards associated with other routes of exposure that are not quantifiable in this risk assessment.

Section 5.7 – Constituents without Toxicity Values

At each monitoring Site, there were several COPCs that did not have a toxicity value in either a Tier 1, Tier 2, or Tier 3 source. The major examples are benzene 1-ethenyl-4-methyl, freon 114, and several PAMS station compounds analyzed at South DeKalb. Since an ELCR and/or HQ could not be determined for these constituents, there is no way to quantify the contribution that these constituents to the cumulative ELCR and/or HI at each Site. This may have underestimated the cumulative ELCR or HI derived at each monitoring Site; however, the extent of how much the cumulative ELCR/HI is underestimated is unclear. It is possible that exposure to these COPCs could result in adverse carcinogenic or noncarcinogenic effects.

Section 5.8 – Lead IEUBK Model

The risk assessment determined that lead in ambient air is not a concern since there is a small probability that a typical child/children would have a blood lead concentration greater than 10 µg/dL if the ambient air concentrations at each monitoring Site are assumed to be annual arithmetic mean lead concentrations and children are exposed to lead at USEPA default concentrations from other media sources.

However, it should be noted that a USEPA *Integrated Science Assessment* for Lead determined that there is "*evidence of cognitive function decrements (as measured by Full Scale IQ, academic performance, and executive function) in young children (4 to 11 years old) with mean or group blood [lead] levels measured at various lifestages and time periods between 2 and 8 µg/dL*" (USEPA, 2013, pg. 1-15). Thus, even blood lead concentrations below 10 µg/dL could be problematic from a health perspective. Even though the analysis in the HHRA did not find lead to be a concern in ambient air, it is recommended that an abundance of caution be taken when it comes to lead exposure by doing whatever it takes to minimize lead emissions so that ambient air lead concentrations can also be minimized.

Section 5.9 – Risk/Hazard Additivity

The methodology used to determine the cumulative ELCR/HI implies that COPCs exhibit their adverse effects independently of one another and that there are no chemical interactions between the COPCs that could intensify or attenuate adverse health effects (USEPA, 1989a, pg. 8-12). Thus, exposure to multiple constituents within the spatial scale of a monitoring Site could potentially present less/greater risk/hazard than the cumulative ELCR/HI estimates would suggest.

Section 6 – Conclusion

This risk assessment was prepared consistent with USEPA risk assessment guidance and professional judgment applied in a public health conservative manner. The risk/hazard estimates derived in the risk assessment are thought to represent a plausible estimate at the higher end of possible risk/hazard estimates. The risk assessment is a tool that should be considered along with other pieces of information in order to make risk management decisions and should never be the sole driver for decisions made on how to reduce concentrations of constituents in ambient air to health protective levels.

The cumulative ELCRs at all monitoring Sites are within the USEPA and EPD Air Protection Branch acceptable carcinogenic risk range of 10^{-4} to 10^{-6} (USEPA, 1989b). The HIs at all monitoring Sites exceed 1. It is important to stress that the risks/hazards determined in Section 4 are high-end *estimates* and that there are uncertainties in these estimates due to various reasons including data gaps and the use of conservative inputs to account for these data gaps.

A risk assessment cannot determine whether a specific individual developed cancer or a noncarcinogenic disorder due to inhaling the ambient air within the spatial scale of an air monitoring Site. The risk assessment needs to be evaluated along with other information (such as public health assessments, cancer statistics/trends, research literature, etc.) to generate informed conclusions.

References

Georgia Environmental Protection Division (GAEPD). 2018a. *Standard Operating Procedure for Data Validation of Integrated Data* (Revision 2). Atlanta, GA.: Georgia Environmental Protection Division, Air Protection Branch Ambient Air Monitoring Program

Georgia Environmental Protection Division (GAEPD). 2018b. *2018 Ambient Air Monitoring Plan*. Atlanta, GA.: Georgia Environmental Protection Division, Air Protection Branch Ambient Air Monitoring Program

Georgia Environmental Protection Division (GAEPD). 2019. *Quality Assurance Project Plan for the Georgia Ambient Air Monitoring Program National Air Toxics Trends Station (NATTS)* (Revision 1). Atlanta, GA.: Georgia Environmental Protection Division, Air Protection Branch Ambient Air Monitoring Program

United States Environmental Protection Agency (USEPA). 1989a. *Risk Assessment Guidance for Superfund (RAGS), (Part A) Volume I, Human Health Evaluation Manual*. EPA/540/1-89/002. Washington, D.C.: United States Environmental Protection Agency, Office of Emergency and Remedial Response.

United States Environmental Protection Agency (USEPA). 1989b. *National Emission Standards for Hazardous Air Pollutants; Radionuclides; Final Rule and Notice of Reconsideration (Part II)*. EPA-400-Z-89-100. Washington, D.C.: National Archives and Records Administration, Office of the Federal Register

United States Environmental Protection Agency (USEPA). 1991. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final.* OSWER 9285.6-03. Washington, DC.: United States Environmental Protection Agency, Office of Emergency and Remedial Response Toxics Integration Branch

United States Environmental Protection Agency (USEPA). 1994. *Methods For Derivation Of Inhalation Reference Concentrations And Application Of Inhalation Dosimetry.* EPA-600-8-90-066F. Research Triangle Park, NC: United States Environmental Protection Agency, Environmental Criteria and Assessment Office

United States Environmental Protection Agency (USEPA). 1994b. *Guidance Manual For The IEUBK Model For Lead In Children* - Chapter 1. EPA 540-R-93-081. Washington D.C.: United States Environmental Protection Agency, Office of Solid Waste and Emergency Response

United States Environmental Protection Agency (USEPA). 2003. *Human Health Toxicity Values in Superfund Risk Assessments*. OSWER 9285.7-53. Washington D.C.: United States Environmental Protection Agency, Office of Solid Waste and Emergency Response

United States Environmental Protection Agency (USEPA). 2004. *Air Toxics Risk Assessment Reference Library: Volume 1 Technical Resource Manual*. EPA-453-K-04-001A. Research Triangle Park, NC.: United States Environmental Protection Agency, Office of Air Quality Planning and Standards

United States Environmental Protection Agency (USEPA). 2005a. *Guidelines for Carcinogen Risk Assessment*. EPA-630-P-03-001F. Washington D.C.: United States Environmental Protection Agency, Risk Assessment Forum

United States Environmental Protection Agency (USEPA). 2005b. *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens*. EPA-630-R-03-003F. Washington D.C.: United States Environmental Protection Agency, Risk Assessment Forum

United States, Environmental Protection Agency (USEPA). 2009. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).* EPA-540-R-070-002. Washington, D.C.: United States Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation

United States Environmental Protection Agency (USEPA). 2010. *A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Data Sets* (Version 2). EPA-904-B-06-001. Atlanta, GA.: United States Environmental Protection Agency, Air, Pesticides, and Toxics Management Division

United States Environmental Protection Agency (USEPA). 2011. *Exposure Factors Handbook 2011 Edition (Final Report)*. EPA-600-R-09-052F. Washington D.C.: United States Environmental Protection Agency, Office of Research and Development's National Center for Environmental Assessments (NCEA)

United States Environmental Protection Agency (USEPA). 2013. *Integrated Science Assessment for Lead*. EPA-600-R-10-075F. Research Triangle Park, NC.: United States Environmental Protection Agency, Office of Research and Development's National Center for Environmental Assessments (NCEA)-RTP Division

United States Environmental Protection Agency (USEPA). 2015. *ProUCL Version 5.1 User Guide.* EPA-600-R-07-041 Atlanta, GA.: United States Environmental Protection Agency, Office of Research and Development Site Characterization and Monitoring Technical Support Center

United States Environmental Protection Agency (USEPA). 2018. *Region 4 Human Health Risk Assessment Supplemental Guidance*. Atlanta, GA.: United States Environmental Protection Agency, Scientific Support Section Superfund Division

United States Environmental Protection Agency (USEPA). 2019. *Regional Screening Levels (RSLs) - User's Guide and Frequently Asked Questions.* https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide#intro and https://www.epa.gov/risk/regional-screening-levels-frequent-questions