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EXECUTIVE SUMMARY

A human health risk assessment (HHRA) was conducted on behalf of Mahoning Renewable Energy (MRE) to evaluate potential health risks associated with hypothetical worst-case emissions from the proposed Ohio advanced energy facility. The primary objective of the HHRA was to understand whether emissions from the proposed facility would result in non-cancer hazards and cancer risks that fall within the acceptable United States Environmental Protection Agency (USEPA) and Ohio Environmental Protection Agency (OEPA) risk limits.

The HHRA was conducted in accordance with USEPA and OEPA risk assessment guidance and included; an evaluation of the compounds of potential concern (COPCs) for which risks were calculated, an assessment of the types of human receptors exposed, identification of toxicity values for the COPCs and a characterization of non-cancer hazards and cancer risks.

For this evaluation, the HHRA estimated cumulative non-cancer hazards and/or cancer risks associated with inhalation of ambient (outdoor) air for two distinct exposure scenarios:

1) an acute (short-term) residential scenario, in which a resident is assumed to have a one-time exposure to the maximum one-hour ambient air concentration of each COPC; and

2) a chronic (long-term) residential scenario, in which a resident is assumed to be continuously exposed at the maximum annual concentration in ambient air over 70 years of exposure.

Ambient air concentrations were modeled for various compounds (generally, heavy metals, dioxins, and acids) using a USEPA air dispersion model (AERMOD) and conservative input parameters to estimate worst-case maximum one-hour and annual ambient air concentrations.

Results of the HHRA indicate that non-cancer hazards for both the short-term and long-term residential scenarios are below the USEPA and OEPA non-cancer hazard limit. The risk analysis also demonstrates that the incremental lifetime cancer risk for long-term residents is below the OEPA cancer risk threshold and within the USEPA acceptable risk range.

1. INTRODUCTION

On behalf of Mahoning Renewable Energy, LLC (MRE), Woodard and Curran, Inc. (W&C) conducted a focused human health risk evaluation for the proposed Mahoning, Ohio facility located at 12003 Oyster Road, Smith Township, Mahoning County, Ohio. A human health risk assessment (HHRA) is a tool used by regulators to assess the relative risk using conservative exposure scenarios for a proposed activity, which in this case, includes emissions from the thermal conversion of solid waste to energy. The results of the HHRA should not be considered to be absolute, but instead as an additional means to evaluate the operational characteristics of the proposed facility against established risk management criteria. This HHRA uses highly conservative assumptions that likely overstate actual risk. The results of the HHRA indicate that estimated emissions concentrations for the proposed MRE facility are below both OEPA and USEPA established risk management criteria and will not result in unacceptable risk.

This HHRA was conducted at the request of the OEPA to assist with their evaluation of the proposed MRE energy facility. The objective of the HHRA was to estimate potential risks based on worst case emissions and dispersion of emissions from the proposed facility. The focused risk evaluation, which is based on USEPA and OEPA risk assessment guidance (USEPA 1989, 1997a, 2003a, 2003b, 2004, 2005; OEPA 2004a, 2004b), consists of a quantitative analysis of modeled emissions data from the proposed stack and is organized in the following manner:

- Hazard Identification
- Exposure Assessment
- Dose-Response Assessment; and
- Risk Characterization

Results of this evaluation demonstrate that, using conservative data and exposure assumptions, calculated risks are within the range of acceptable risk established by OEPA and USEPA.

1.1 HAZARD IDENTIFICATION

The objective of the Hazard Identification is to present the relevant environmental data and select the Compounds of Potential Concern (COPCs). COPCs are those constituents that are carried through the risk assessment process. For this evaluation, stack emissions from combustion of solid waste and construction and demolition debris (processed into refuse-derived fuel, or RDF) were modeled using the AERMOD air dispersion model (Version 07026). Modeling parameters, assumptions and methods are described in detail in Appendix A to this document and in the MRE Air Permit–to-Install (PTI) Application (October 10, 2008) and are only briefly summarized here.

The receptor grid for the air dispersion modeling analysis consisted of receptors at 25 meter spacing out to a distance of 1 kilometer (km), 100 meter spacing from 1 km to 4 km, 500 meter spacing from 4 km to 10 km, and 1 km spacing from 10 km to 25 km in every direction. Land use within 3 km of the Facility is rural. Therefore, models with the rural dispersion coefficients were used in the modeling analysis. The model assumed a stack height of 241 feet, which is the height proposed in the permit application.

Modeling results used to complete the PTI application were also utilized to determine the maximum one-hour and annual modeled concentrations used in this risk analysis. Several conservative assumptions were made when performing the modeling for the PTI application. These assumptions are as follows:

- The facility operates 8760 hours per year (8784 hours per leap year)[1];
- The facility operates at flow rates (low flow conditions) that would minimize dispersion, thereby, maximizing concentrations[2]; and
- The facility operates at emission rates (high load conditions) that would maximize ambient air concentrations.[3]

These conservative assumptions resulted in a maximum one-hour concentration based on 43,824 hours of data and a maximum annual concentration based on five years (43,824 hours) of data. The one-hour concentration was then used to assess the acute risk and annual average concentration was used to assess a chronic, seventy (70) year risk exposure. Evaluation of a 70 year exposure duration is highly conservative, particularly since it is virtually impossible for an individual to continuously remain at a single location where the maximum air concentration occurs for 70 years. In addition, the MRE facility is designed to have an operating lifespan of approximately 30-40 years. It is likely that during the 30 to 40 year facility operating life that upgrades to the air quality system will be made and that end of operating life upgrades will result in reduced emissions as technological advances are developed.

Compounds considered by the USEPA to be "Air toxic contaminants" (i.e., the COPCs for this evaluation) were chosen to be analyzed based on data in the EPA WebFire Database, the OAC 3745-114 Air Toxic Contaminant List, and actual stack testing conducted at facilities employing similar technologies.

For the purposes of the Air PTI Application, only those air toxics with annual emissions exceeding one ton are required to be modeled for comparison to OEPA Maximum Allowable Ground Level Concentrations (MAGLC). However, at OEPA's request, dioxins/furans, lead and mercury (whose emissions were less than 1-ton per year) were included in the MAGLC assessment which was part of the Air PTI Application. This HHRA evaluated the potential risk from all of the compounds identified, regardless of the annual emission rate.

As noted above, ambient air concentrations were estimated for these COPCs for both a one-hour (short-term/acute) and annual (long-term) averaging period. To be conservative, maximum 1-hr and annual concentrations were used in the HHRA without regard to the location where maximum concentrations were predicted to occur.

Table 1 presents emission rates along with a summary of estimated one-hour maximum and maximum annual ambient air concentrations for the COPCs. Appendix A discusses the method used to develop the air contaminant emissions and emission rates used in both the permit-to-install air quality assessment and the HHRA. However, the dioxin emission rate used in the HHRA, unlike the permit-to-install air quality

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[1] It is not expected that the facility will operate continuously during the entire year. Units will be shut down, either individually or together, to conduct preventative or emergency maintenance. Therefore, this assumption of continuous operation is conservative.

[2] Modeling the lower flow rate resulted in concentrations approximately 15% higher than modeling at the highest flow rate encountered during maximum production (on which emission rates were based).

[3] Emissions represent 100% load rates, which overestimate long term facility emissions.

assessment, was based on the average emission rate for similar facilities using the Turbosorp air quality control system, which is the system proposed to be used at the MRE facility. Data for active facilities using the Turbosorp system show that a much lower emission rate is achievable, relative to the applicable USEPA standard for the MRE facility (40 CFR Part 60, subpart Eb).

1.2 EXPOSURE ASSESSMENT

The objective of the Exposure Assessment is to estimate the type and magnitude of potential exposure to emission of airborne COPCs. For this evaluation, two residential scenarios were evaluated, reflecting acute and chronic exposures, respectively: 1) a resident located downwind of the facility exposed one time to the 1-hour maximum concentration, and 2) a long-term resident, exposed to the maximum annual emissions.

To evaluate the acute/short-term exposure, residents were assumed to be exposed to the one hour maximum ambient concentration as a one-time event. For evaluation of long-term exposures, residents were assumed to be exposed 365 days per year, 24 hours each day, over the course of 70 years, which is the EPA-recommended lifetime (USEPA 1989).

The assumptions used for the long-term scenario reflect a maximum exposed individual (MEI) scenario, consistent with USEPA inhalation risk assessment guidance (2004). Use of a 70 year exposure duration is highly conservative, since the American population is generally mobile and residential tenure is typically much lower than 70 years. U.S Bureau of the Census data and other population mobility studies suggest a median residential tenure of approximately 9 years, with most of the population moving within approximately 30 years (USEPA 1997a). Thus, use of a 70 year exposure duration, coupled with the assumption that residents are exposed to the maximum annual emissions 24 hours per day, 365 days per year, is a highly conservative assumption that is intended to overestimate health risks.

For both the short-term and long-term exposure scenarios, the estimated ambient air concentrations (Table 1) are equivalent to the average daily exposure and are not time-adjusted. The exposure estimates are combined with dose-response (toxicity) information to characterize the potential risk to human receptors.

1.3 DOSE-RESPONSE ASSESSMENT

The dose-response assessment describes the relationship between the level of exposure and the likelihood and/or severity of an adverse effect. In other words, the dose-response assessment quantifies the toxicity of each COPC using information obtained from published literature describing epidemiologic or toxicological studies.

Inhalation hazards associated with noncarcinogenic (non-cancer) effects (e.g., liver or kidney toxicity, decreased birth weight, etc.) are derived assuming that an exposure concentration will not exceed a threshold concentration (“reference concentration”, or RfC), above which toxicity will occur.

Inhalation cancer risks are based on the inhalation unit risk (UR), which is the 95% Upper Confidence Limit of the mean incremental lifetime cancer risk estimated to result from lifetime exposure to an agent if it is in the air at a concentration of 1 microgram per cubic meter ($\mu g/m^3$).

Table 2 provides a summary of the inhalation toxicity values used in this assessment. Chronic toxicity information was primarily obtained from the USEPA Integrated Risk Information System (IRIS) (USEPA 2008), which generally provides chronic toxicity values. Where IRIS values were not available for a COPC, values were obtained from the Agency for Toxic Substances and Disease Registry (ATSDR)

Minimal Risk Levels (MRLs; ATSDR 2008), California Environmental Protection Agency (CalEPA) chronic Reference Exposure Levels (RELs; CalEPA 2005), or USEPA Health Effects Assessment Summary Tables (HEAST; USEPA 1997b), in accordance with the hierarchy suggested in USEPA and OEPA guidance (USEPA 2003b; OEPA 2004a). Because acute RfCs are generally not available from IRIS for the COPCs evaluated, ATSDR MRLs for acute or intermediate exposures, or CalEPA acute RELs were used where available. If an acute MRL or REL was not available, then chronic or subchronic RfCs were conservatively used as available to evaluate the short-term exposure scenario. Note that chronic and/or acute inhalation toxicity values were not available for several of the COPCs, including copper, lead, molybdenum and tin. Therefore, hazards/risks for these constituents were not estimated.

1.4 RISK CHARACTERIZATION

Characterization of the risk of harm to human health is the estimation of the incidence and severity of the adverse effects likely to occur in a human population due to chemical exposures, expressed as risk estimates. Risk estimates are based upon the comparison of the results of the exposure assessment and the dose-response assessment to EPA established risk management criteria and are indicative of the likelihood that adverse effects will occur.

The potential for non-carcinogenic health effects is characterized by the Hazard Quotient (HQ), which is the ratio of the estimated average daily exposure (ADE) of a chemical (the amount estimated to be the airborne exposure level which is inhaled.) to a threshold concentration at or below which adverse health effects would not be observed (e.g., the RfC), or:

$$HQ = ADE / RfC$$

Toxicity of non-carcinogens is assumed to be additive in nature; therefore, the HQ of each COPC is added to estimate a cumulative non-cancer hazard index (HI), or:

$$\text{Cumulative } HI_{\text{route-specific}} = \sum HQ_{\text{compound-specific}}$$

The cumulative HI may be calculated as the sum of individual route-specific HIs across all COPCs, assuming that toxicity of all COPCs is additive in nature, or may be calculated as the sum of route-specific HIs within a group of COPCs that share a common endpoint (e.g., liver toxicity or reproductive effects). In other words, HIs may be segregated by target organ or effect:

$$\text{Cumulative } HI_{\text{endpoint a}} = \sum HI_{\text{route-specific, endpoint a}}$$

The cumulative HI is then compared with the USEPA and OEPA acceptable noncancer hazard limit of 1 (USEPA 1989; OEPA 2004b). If the HI is less than or equal to 1, then concentrations of COPCs are not likely to cause adverse health effects. In other words, if the average daily exposure of a chemical is less than the reference concentration (resulting in a ratio of 1 or lower), then adverse effects are not likely to result from exposure to that chemical.

The potential for carcinogenic health effects is characterized as the Incremental Lifetime Cancer Risk (ILCR). The ILCR represents the incremental probability of an individual, above background, developing cancer over a lifetime as a result of exposure to a potential carcinogen. For a given compound, the ILCR is the product of the quantified exposure and the measure of carcinogenic potency (i.e., UR):

$$ICLR = ADE \times UR$$

The ILCR, which represents the probability of developing cancer relative to the background incidence of cancer in the general population, is presented in scientific notation. For example, the ILCR of a specific chemical might be expressed as 1×10^{-6} or one in one million, which means that the probability of an individual developing cancer over a lifetime, as a result of exposure to the potential carcinogen, is one in one million. To account for exposures that a receptor may receive from multiple constituents, the ILCRs for all COPCs are added together to derive a cumulative route-specific ILCR. Route-specific ILCRs are then summed to estimate a cumulative ILCR for an exposure scenario, as demonstrated by the following equations:

$$ILCR_{\text{route-specific}} = \sum ILCR_{\text{compound-specific}}$$

$$\text{Cumulative ILCR} = \sum ILCR_{\text{route-specific}}$$

It is assumed that carcinogenic effects are additive across all COPCs, and therefore, ILCRs are not segregated by target organ as may be done for noncancer hazards. The cumulative ILCR is compared to USEPA's cumulative receptor cancer risk limits, which range from one-in-one million (1×10^{-6}) to one in ten thousand (1×10^{-4}), as well as the OEPA ILCR threshold of 1×10^{-5} (OEPA 2004b). If the cumulative cancer risk is below the OEPA risk limit and within the USEPA ILCR range, then it may be concluded that significant risks are unlikely.

Calculation of noncancer hazards is presented on Table 3 for the short-term exposure scenario (because this scenario evaluates a one-time, acute exposure, no cancer risks are estimated). Calculation of noncancer hazard and cancer risk is presented on Tables 4-5 for the long-term exposure scenario. Risk estimates for both short-term and long-term exposure scenarios are summarized below in the following table:

Exposure Scenario	**Cumulative Hazard Index (HI)**	**Incremental Lifetime Cancer Risk (ILCR)**
Child/Adult Residents: Short Term Exposure	0.4	Not applicable
Child/Adult Residents: Long Term Exposure	0.09	2×10^{-6}
USEPA Cumulative Risk Limit	**1**	**1×10^{-4} to 1×10^{-6}**
OEPA Cumulative Risk Limit	**1**	**1×10^{-5}**

As shown on the table above, estimated cumulative non-cancer hazards for both the acute, short-term and the chronic, long term exposure scenarios are below the USEPA and OEPA risk limit of one. The cumulative cancer risk for the long-term exposure scenario is within the USEPA target cancer risk range of 1×10^{-6} and 1×10^{-4} and below the OEPA cancer risk threshold of 1×10^{-5}. Ninety percent of the cumulative cancer risk is attributable to dioxin; the individual ILCRs for all other COPCs were at or below 1 x 10^{-6}.

All estimates of hazard and risk include uncertainties and as such, the risk numbers are not intended to reflect an actual risk but instead are intended to be used to support risk management decisions. Because this HHRA is used to evaluate risk from a proposed facility, there is uncertainty in both emissions estimation and air dispersion modeling; however, to counter this uncertainty, conservative exposure assumptions were used in risk estimation, including:

- Use of maximum ambient air concentrations, which may not correlate with residential locations;
- Assumption that the proposed MRE facility would continuously operate at its maximum for 70 years;
- Assumption that a downwind resident would be exposed to maximum air concentrations for 24 hours/day, 365 days/year, over 70 years;
- Inclusion of uncertainty and modification factors, ranging from approximately 10 to 1000, that are incorporated into toxicity values; and
- Where acute toxicity values were not available, the use of chronic or subchronic toxicity values to evaluate acute exposures.

As discussed, chronic and/or acute inhalation toxicity information was not available for copper, lead[4], molybdenum and tin, and so cumulative risks may potentially be underestimated. However, since the risk estimates are based on highly conservative assumptions, and the cumulative risks estimates are below USEPA risk limits, it is not anticipated that exclusion of these constituents would underestimate risks to any appreciable degree such that the conclusions of this evaluation would not be valid.

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[4] The estimated ambient air concentration of lead (0.02 µg/m^3 for the maximum estimated 1 hour averaging period) is below the National Ambient Air Quality Standard (NAAQS) of 1.5 µg/m^3. Estimated ambient air concentrations for other constituents not presented in this evaluation (e.g., carbon monoxide, particulate matter, sulfur dioxide, nitrogen oxides) are also below NAAQS, as described in the MRE Permit-to-Install Application dated October 10, 2008.

2. CONCLUSIONS

A human health risk assessment (HHRA) was conducted on behalf of Mahoning Renewable Energy (MRE) to evaluate potential health risks associated with hypothetical worst-case emissions from the proposed Ohio advanced energy facility. The primary objective of the HHRA was to understand whether emissions from the proposed facility would result in non-cancer hazards and cancer risks that fall within the acceptable United States Environmental Protection Agency (USEPA) and Ohio Environmental Protection Agency (OEPA) risk limits.

Based on the results of this analysis, it is concluded that, emissions from the proposed MRE Facility will fall within the range of acceptable risk criteria established by the OEPA and USEPA.

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TABLE 1
Emission Rate and Air Dispersion Modeled Concentrations
Mahoning Renewable Energy

Pollutant	Emission Rates		Model Predicted Concentrations	
	(lbs/hr)	(g/s)	1-Hour (µg/m^3)	Annual (µg/m^3)
Ammonia	7.34E+00	0.92502	1.15E+00	5.40E-02
Antimony	6.55E-03	0.000825	1.02E-03	4.82E-05
Arsenic	2.96E-03	0.000373	4.63E-04	2.18E-05
Barium	6.53E-02	0.00823	1.02E-02	4.81E-04
Beryllium	1.96E-05	2.47E-06	3.07E-06	1.44E-07
Cadmium	1.80E-02	0.00227	2.81E-03	1.32E-04
Chromium (III)	4.55E-02	0.00574	7.12E-03	3.35E-04
Chromium (VI)	1.14E-02	0.00143	1.78E-03	8.37E-05
Chromium total*	5.69E-02	0.00717	8.90E-03	4.19E-04
Cobalt	1.05E-02	0.00133	1.65E-03	7.76E-05
Copper	5.49E-02	0.00692	8.59E-03	4.04E-04
Dioxin (2,3,7,8-TCDD) long term **	2.76E-07	3.47E-08	4.31E-08	2.03E-09
Fluoride (sodium)	2.69E-01	0.0339	4.21E-02	1.98E-03
Sulfuric acid	5.58E+00	0.703	8.73E-01	4.10E-02
Hydrogen chloride	1.43E+01	1.803	2.24E+00	1.05E-01
Lead	1.40E-01	0.0176	2.19E-02	1.03E-03
Manganese	4.93E-02	0.00622	7.72E-03	3.63E-04
Mercury	2.22E-01	0.0280	3.47E-02	1.63E-03
Molybdenum	2.34E-03	0.000295	3.66E-04	1.72E-05
Nickel	1.32E-01	0.0166	2.07E-02	9.72E-04
Selenium	5.38E-03	0.000677	8.41E-04	3.95E-05
Tin	6.22E-02	0.00784	9.73E-03	4.58E-04

Notes:

Toxic concentration = Emission rate * Modeled concentration

Modeled Concentration (1-hr):	1.24115	µg/m^3 - g/s (1-Hour Averaging Period) at 1 g/s
Modeled Concentratin (Annual):	0.05837	µg/m^3 - g/s (Annual Averaging Period) at 1 g/s

1 hr =	3600	secs
1 yr =	8760	hrs
1 lb =	453.5924	grams
1 ton =	2000	lbs

*Assumed chromium (VI) comprised 20% of total chromium, based on information from Adirondack Resource Recover Facility in Hudson Falls, NY in April 1992. For this facility, chromium VI comprised 19.7% of total chromium emissions.

**Emission rate based on Spittelau Thermal Waste Treatment Plant with dioxin concentration of 0.4 $^{ng}/_{dscm}$ (0.004 $^{µg}/_{dscm}$) I-TEQ.

TABLE 3
CALCULATION OF CHEMICAL NON-CANCER HAZARDS
Inhalation of Ambient Air: Short-term Exposures
Child/Adult Resident
Mahoning Renewable Energy

RISK EQUATIONS:

Inhalation of Ambient Air:

$$HQ = \frac{ADE_{inhalation}}{RfC}$$

Parameter	Definition	Units
HI =	Hazard index (sum of all HQs)	Unitless
HQ =	Hazard quotient	Unitless
ADE =	Average daily exposure (1-hr concentration in air)	mg/m^3
RfC =	Inhalation reference concentration (Acute)	mg/m^3

Chemical of Potential Concern (COPC)	CAS Number	ADE	Acute RfC	COPC-Specific Hazard Quotient HQ
Ammonia	7664-41-7	1.1E-03	3.2E+00	3.59E-04
Antimony	7440-36-0	1.0E-06	2.0E-04	5.12E-03
Arsenic	7440-38-2	4.6E-07	1.9E-04	2.44E-03
Barium	7440-39-3	1.0E-05	5.0E-03	2.04E-03
Beryllium	7440-41-7	3.1E-09	2.0E-05	1.54E-04
Cadmium	7440-43-9	2.8E-06	3.0E-05	9.38E-02
Chromium (III)	16065-83-1	7.1E-06	1.0E-04	7.12E-02
Chromium (VI)	18540-29-9	1.8E-06	3.0E-04	5.94E-03
Cobalt	7440-48-4	1.6E-06	1.0E-04	1.65E-02
Copper	7440-50-8	8.6E-06	1.0E-01	8.59E-05
Dioxin (2,3,7,8-TCDD)	1746-01-6	4.3E-11	NA	NA
Fluoride (sodium)	7681-49-4	4.2E-05	2.4E-01	1.75E-04
Sulfuric acid	7664-93-9	8.7E-04	1.2E-01	7.27E-03
Hydrogen chloride	7647-01-0	2.2E-03	2.1E+00	1.07E-03
Lead	7439-92-1	2.2E-05	NA	NA
Manganese	7439-96-5	7.7E-06	5.0E-05	1.54E-01
Mercury	7439-97-6	3.5E-05	1.8E-03	1.93E-02
Molybdenum	7439-98-7	3.7E-07	NA	NA
Nickel	7440-02-0	2.1E-05	6.0E-03	3.44E-03
Selenium	7782-49-2	8.4E-07	2.0E-02	4.20E-05
Tin	7440-31-5	9.7E-06	NA	NA
CUMULATIVE NONCANCER HAZARD INDEX (HI)				**4E-01**

Notes:
NA: toxicity information not available; therefore, risk value not calculated.

TABLE 2
SUMMARY OF INHALATION TOXICITY INFORMATION
Mahoning Renewable Energy

Chemical of Potential Concern	CAS No.	Chronic Reference Concentration				Acute Reference Concentration			USEPA Weight of Evidence Cancer Classification	Inhalation Unit Risk	
		Value (mg/m^3)	Source	UF x MF	Target Organ(s)	Value (mg/m^3)	Source	Target Organ(s)		Value (mg/m^3)$^{-1}$	Source
Ammonia	7664-41-7	1.00E-01	IRIS	30 x 1	Respiratory system	3.20E+00	CalEPA	Respiratory system; eye	Not assessed		
Antimony	7440-36-0	2.00E-04	IRIS (Value for antimony trioxide)	300 x 1	Respiratory system	2.00E-04	IRIS (chronic)	Respiratory system	Not assessed		
Arsenic	7440-38-2	3.00E-05	CalEPA		Developmental; Cardiovascular system; Nervous system	1.90E-04	CalEPA	Reproductive system; developmental system	A	4.30E+00	IRIS
Barium	7440-39-3	5.00E-04	HEAST	1000	Developmental	5.00E-03	HEAST (subchronic)	Developmental	D		
Beryllium	7440-41-7	2.00E-05	IRIS	10 x 1	Respiratory system	2.00E-05	IRIS (chronic)	Respiratory system	B1	2.40E+00	IRIS
Cadmium	7440-43-9	1.00E-05	ATSDR MRL	3 x 3	Kidney	3.00E-05	ATSDR	Respiratory system	B1	1.80E+00	IRIS
Chromium (III)	16065-83-1	1.00E-04	IRIS (Value for Chromium VI applied)	300 x 1	Respiratory system	1.00E-04	IRIS (chronic)	Respiratory system	D		
Chromium (VI)	18540-29-9	1.00E-04	IRIS	300 x 1	Respiratory system	3.00E-04	ATSDR (intermediate)	Respiratory system	A	1.20E+01	IRIS
Cobalt	7440-48-4	1.00E-04	ATSDR MRL		Respiratory system	1.00E-04	ATSDR (chronic)	Respiratory system			
Copper	7440-50-8					1.00E-01	CalEPA	Respiratory system	D		
Dioxin (2,3,7,8-TCDD)	1746-01-6								B2	3.80E+04	CalEPA
Fluoride	7681-49-4	1.30E-02	CalEPA		Bone/teeth; respiratory system	2.40E-01	CalEPA	Respiratory system; eye			
Hydrogen chloride	7647-01-0	2.00E-02	IRIS	300 x 1	Respiratory system	2.10E+00	CalEPA	Respiratory system; eye	Not assessed		
Lead	7439-92-1								B2		
Manganese	7439-96-5	5.00E-05	IRIS	1000 x 1	Central nervous system	5.00E-05	IRIS (chronic)	Central nervous system	D		
Mercury	7439-97-6	3.00E-04	IRIS	30 x 1	Central nervous system	1.80E-03	CalEPA	Reproductive system; developmental system	C		
Molybdenum	7439-98-7								Not assessed		
Nickel	7440-02-0	9.00E-05	ATSDR MRL	30 x 10	Respiratory system	6.00E-03	CalEPA	Respiratory system; immune system	A	4.80E-01	IRIS (value for nickel subsulfide)
Selenium	7782-49-2	2.00E-02	CalEPA		Alimentary, cardiovascular, nervous systems	2.00E-02	CalEPA (chronic)	Alimentary, cardiovascular, nervous systems	D		
Sulfuric acid	7664-93-9	1.00E-03	CalEPA		Respiratory system	1.20E-01	CalEPA	Respiratory system			
Tin	7440-31-5										

Notes:
mg/m3 = Milligrams per cubic meter.
Blank cells indicate no information is available.
UF = Uncertainty factor
MF = Modifying factor
IRIS = United States Environmental Protection Agency (USEPA) Integrated Risk Information System (IRIS), searched online at http://cfpub.epa.gov/ncea/iris/index.cfm in October 2008.
ATSDR = Agency for Toxic Substances and Disease Registry. Toxicological Profiles, obtained online at http://www.atsdr.cdc.gov/toxpro2.html. Values are ATSDR Minimal Risk Levels (MRLs).
CalEPA = California Environmental Protection Agency chronic and acute Reference Exposure Level (REL),
February 2005. http://www.oehha.ca.gov/air/chronic_rels/pdf/allchrels.pdf; http://www.oehha.ca.gov/air/acute_rels/allAcRELs.html
HEAST = USEPA Health Effects Assessment Summary Tables: FY-1997 Update. Office of Research and Development. EPA 540/R-97-036.
US EPA Weight-of-Evidence Classification of Carcinogenicity:
A: Human carcinogen
B: Probable human carcinogen
B1: Limited evidence of carcinogenicity in humans from epidemiological studies
B2: Sufficient evidence of carcinogenicity in animals, inadequate evidence in humans
C: Limited evidence of carcinogenicity in animals
D: Inadequate evidence of carcinogenicity.

TABLE 5
CALCULATION OF CHEMICAL CANCER RISKS
Inhalation of Ambient Air: Long-term Exposures
Resident (Child/Adult)
Mahoning Renewable Energy

RISK EQUATIONS:

Inhalation of Ambient Air:

$$ILCR = LADE_{inhalation} * IUR$$

Parameter	Definition	Units
ILCR =	Incremental lifetime cancer risk	Unitless
LADE =	Lifetime average daily exposure (carcinogenic effects)	mg/m^3
IUR =	Inhalation unit risk	$(mg/m^3)^{-1}$

Chemical of Potential Concern (COPC)	CAS Number	LADE	*IUR*	COPC-Specific ILCR
Ammonia	7664-41-7	5.4E-05	NA	NA
Antimony	7440-36-0	4.8E-08	NA	NA
Arsenic	7440-38-2	2.2E-08	4.3E+00	9.4E-08
Barium	7440-39-3	4.8E-07	NA	NA
Beryllium	7440-41-7	1.4E-10	2.4E+00	3.5E-10
Cadmium	7440-43-9	1.3E-07	1.8E+00	2.4E-07
Chromium (III)	16065-83-1	3.3E-07	NA	NA
Chromium (VI)	18540-29-9	8.4E-08	1.2E+01	1.0E-06
Cobalt	7440-48-4	7.7E-08	NA	NA
Copper	7440-50-8	4.0E-07	NA	NA
Dioxin (2,3,7,8-TCDD)	1746-01-6	2.1E-12	3.8E+04	7.9E-08
Fluoride (sodium)	7681-49-4	2.0E-06	NA	NA
Sulfuric acid	7664-93-9	4.1E-05	NA	NA
Hydrogen chloride	7647-01-0	1.1E-04	NA	NA
Lead	7439-92-1	1.0E-06	NA	NA
Manganese	7439-96-5	3.6E-07	NA	NA
Mercury	7439-97-6	1.6E-06	NA	NA
Molybdenum	7439-98-7	1.7E-08	NA	NA
Nickel	7440-02-0	9.7E-07	4.8E-01	4.7E-07
Selenium	7782-49-2	3.9E-08	NA	NA
Tin	7440-31-5	4.6E-07	NA	NA
TOTAL RISK (based on dioxin long term)*				**2E-06**

Notes:

NA: toxicity information not available; therefore, risk value not calculated.

TABLE 4
CALCULATION OF CHEMICAL NON-CANCER HAZARDS
Inhalation of Ambient Air: Long-term Exposures
Resident (Child/Adult)
Mahoning Renewable Energy

RISK EQUATIONS:

Inhalation of Ambient Air:

$$HQ = \frac{ADE_{inhalation}}{RfC}$$

Parameter	Definition	Units
HI =	Hazard index (sum of all HQs)	Unitless
HQ =	Hazard quotient	Unitless
ADE =	Average daily exposure (noncarcinogenic effects)	mg/m^3
RfC =	Inhalation reference concentration (chronic)	mg/m^3

Chemical of Potential Concern (COPC)	CAS Number	ADE	Chronic RfC	COPC-Specific Hazard Quotient HQ
Ammonia	7664-41-7	5.4E-05	1.0E-01	5.39E-04
Antimony	7440-36-0	4.8E-08	2.0E-04	2.40E-04
Arsenic	7440-38-2	2.2E-08	3.0E-05	7.26E-04
Barium	7440-39-3	4.8E-07	5.0E-04	9.60E-04
Beryllium	7440-41-7	1.4E-10	2.0E-05	7.21E-06
Cadmium	7440-43-9	1.3E-07	1.0E-05	1.32E-02
Chromium (III)	16065-83-1	3.3E-07	1.0E-04	3.34E-03
Chromium (VI)	18540-29-9	8.4E-08	1.0E-04	8.36E-04
Cobalt	7440-48-4	7.7E-08	1.0E-04	7.74E-04
Copper	7440-50-8	4.0E-07	NA	NA
Dioxin (2,3,7,8-TCDD)	1746-01-6	2.1E-12	NA	NA
Fluoride (sodium)	7681-49-4	2.0E-06	1.3E-02	1.52E-04
Sulfuric acid	7664-93-9	4.1E-05	1.0E-03	4.10E-02
Hydrogen chloride	7647-01-0	1.1E-04	2.0E-02	5.25E-03
Lead	7439-92-1	1.0E-06	NA	NA
Manganese	7439-96-5	3.6E-07	5.0E-05	7.25E-03
Mercury	7439-97-6	1.6E-06	3.0E-04	5.43E-03
Molybdenum	7439-98-7	1.7E-08	NA	NA
Nickel	7440-02-0	9.7E-07	9.0E-05	1.08E-02
Selenium	7782-49-2	3.9E-08	2.0E-02	1.97E-06
Tin	7440-31-5	4.6E-07	NA	NA
CUMULATIVE NONCANCER HAZARD INDEX				**9E-02**

Notes:
NA: toxicity information not available; therefore, risk value not calculated.