Health Consultation

Marietta Area Air Investigation
Marietta, Ohio

July 1, 2009

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Regional Operations
Atlanta, Georgia 30333

Background and Statement of Issues

On May 22, 2000, the Agency for Toxic Substances and Disease Registry (ATSDR) was petitioned by United States Senator Mike DeWine (Ohio) to evaluate the health effects from air pollution on residents of Marietta, Washington County, Ohio (ATSDR, 2000).

Although many facilities are located along the Ohio River Valley, residents have expressed particular concern about an industrial complex just outside Marietta. This complex is the former site of a single facility, Union Carbide, which is currently occupied by four companies including: Eramet Marietta, Inc. (EMI), Eveready Battery, Solvay Advanced Polymers, and Chevron-Phillips Chemical Company. American Municipal Power (AMP) Ohio, originally built to provide power to Union Carbide, is located across the street from the complex.

The City of Marietta is located four miles northeast of the facility (see Appendix A). Marietta is a relatively small city, with an approximate population of 15,000 (U.S. Census, 2000). The land use in the area is mostly residential and agricultural, with heavy industry located to the south of the city along the Ohio and Muskingham Rivers.

ATSDR and the Ohio Department of Health (ODH) have released three previous health consultations for this site:

- 2004: A review of air data collected in 2001 and 2002 at the Washington County Career Center (WCCC). This health consultation determined that air modeling to identify areas of greatest risk for elevated ambient concentrations and additional monitoring in those locations was warranted.
- 2005: Evaluation of results from a cistern water sampling investigation.
- 2007: Evaluation of results from the modeling and additional air monitoring recommended in the first document, as well as the results of a “fingerprinting” analysis of Eramet and the WCCC. The fingerprinting was done to identify whether or not WCCC activities were generating some of the metals detected on the monitoring filters.

Note that fingerprinting analyses presented in this document represent the evaluation of sampling data collected in 2007-2008, and are exclusive of those evaluated in the 2007 health consultation.

Rationale for this air investigation

In the fall of 2005, ATSDR was asked by ODH to conduct additional air monitoring to document the potential for human exposure in populated areas. In 2006, ATSDR worked with the Ohio Environmental Protection Agency (Ohio EPA) to fund and establish a network of additional monitoring locations to better characterize airborne metal concentrations. Those monitoring stations began collecting data in April of 2007. This 2009 document presents the findings of our air investigation that includes one year of ambient data, collected between April 2007 and March 2008, and provides recommendations for future action at this site.

Environmental Data

The Ohio EPA has historically collected Total Suspended Particulate (TSP) data from two locations:

- **Washington County Career Center** (WCCC) - monitor located in suburban areas approximately 4.5 miles to the north-northeast of the former Union Carbide complex on the roof of the WCCC Center. Sampling at this location began in November 2000.
- **Blue Knob Road** (BKR) - monitor located one mile to the west-northwest of the complex. Sampling at this location began in December 2004.

Beginning in April of 2007, three additional monitoring locations were added to the sampling effort in the area:

- **Harmar Village Educational Services Center -** neighborhood monitor located near the confluence of the Muskingum and Ohio Rivers opposite downtown Marietta, approximately four miles northeast of the former Union Carbide complex.
- **Boaz Wastewater Treatment Plant**- monitor located in Boaz, West Virginia, directly across the Ohio River and east of the industrial complex.
- **Neale Elementary School/Vienna**- monitor located in the city limits of Vienna, West Virginia, approximately 4.5 miles southwest of the industrial complex.

At these locations, a 24-hour TSP filter sample was collected every 6 days, and a composite of the samples collected during each month was analyzed to represent a monthly average. The filters were analyzed for the following metals: arsenic, beryllium, cadmium, chromium, lead, manganese, nickel, and zinc.

Figure 1. Particulate Monitor

Samples were collected onto a filter with particulate monitors as a measurement of total dust (Figure 1). Each filter was first placed in a storage unit that provided a temperature controlled environment which removed all moisture (called a *desiccator*), and was pre-weighed before being installed into the monitor. The Ohio EPA Northeast District Office (NEDO) stores the filters and provides this service to field offices (ATSDR, 2007a).

The high volume ("HiVol") monitors used in this project have a negative flow of air that pulls ambient air through an orifice at the top of the monitor at a known flow rate (in this instance the design flow rate is a volume of 1.13 cubic meters per minute (m^3/min) or 40 cubic feet per minute (cfm)). The sampling period for each sample, 24 hours, was programmed into the monitor before data collection began.

After the sampling period, filters were removed and packaged for storage and shipping. The flow rate of the pump was verified and recorded, then used to calculate the concentration of dust on the filter. Filters were shipped back to the Ohio EPA NEDO for desiccation and weighing. The net weight (mass) of particulate matter deposited on the filter was determined as the difference in filter weight before and after sampling. The concentration of TSP was reported as mass of particulate collected per cubic meter of air sampled (micrograms per cubic meter) at normal sea level temperature and pressure (1 atm, 25°C).

Evaluation of Environmental Data

ATSDR used health-based guidelines and a review of scientific studies to identify and evaluate compounds of concern in the Health Implications section of this document. In our evaluation, the ambient air metals data were compared to ATSDR chronic environmental media evaluation guides (EMEGs) and cancer risk evaluation guides (CREGs), and U.S. EPA Reference Concentrations (RfCs) and inhalation unit risk factors. EMEGs are calculated from ATSDR minimal risk levels (MRLs) for chronic or intermediate exposures (those occurring longer than 365 days or from between 14-365 days, respectively). CREGs are estimated contaminant concentrations expected to cause no more than one excess cancer in a million persons exposed during their lifetime (70 years), and are calculated from EPA's cancer slope factors using default values for exposure rates. Both MRLs and RfCs are estimates of daily human exposure to a hazardous substance that are unlikely to cause health effects over a specified duration of exposure.

ATSDR also evaluates occupational and epidemiologic studies of human exposures, and may consider the lowest observed adverse effect level (LOAEL) and no observed adverse effect level (NOAEL) of individual compounds. The LOAEL is the lowest exposure in a study that resulted in a measurable health effect. A NOAEL is the highest exposure in a study that ***did not*** result in a measurable health effect. Often, ATSDR and EPA health based guidelines are based on LOAELs and NOAELs.

Discussion

Consistent with previous ATSDR/ODH Health Consultations reviewing data collected in this area, levels of arsenic, cadmium, and manganese continue to exceed the ATSDR and U.S. EPA health-based comparison values at all monitoring locations during the air investigation. Although chromium had been detected intermittently in previous air sampling, it was not detected in any samples during the 2007-2008 sampling period. However, the U.S. EPA National Enforcement Investigations Center (NEIC) performed a follow-up study on the sample filters from the air investigation (see Manganese Fingerprinting Study section), and did detect chromium using more sensitive analytical methods. No other metals collected during the sampling period exceed any ATSDR health based screening levels.

Arsenic and cadmium findings

The levels of cadmium (0.0002-0.0004 $\mu g/m^3$) and arsenic (0.0006-0.001 $\mu g/m^3$) exceeded their respective ATSDR cancer risk evaluation guides (CREGs) and U.S. EPA reference concentrations (RfCs). An additional step in evaluating the data is a comparison to what would be generally expected in ambient air in an urban environment. The concentrations of cadmium and arsenic were well below the normal, or *background*, levels of these metals in outdoor air (ATSDR 2007b, 2008a,b). Therefore, arsenic and cadmium were not considered to be contaminants of concern in this evaluation.

<u>*Manganese findings*</u>

Average manganese concentrations for all of the locations exceeded the current ATSDR health-based comparison value (0.04 $\mu g/m^3$) and were higher than background. In 1984, U.S. EPA reported that manganese concentrations usually range from 0.005 $\mu g/m^3$ in rural air samples to 0.03 $\mu g/m^3$ in air samples taken in urban areas in the United States; the World Health Organization reports that in general, manganese in outdoor air ranges from 0.01-0.07 $\mu g/m^3$ in areas of the world without significant manganese pollution (ATSDR, 2008b). At all locations, most average monthly air concentrations exceeded background levels. The range and average levels of manganese from April 2007 to March 2008 are presented in Table 1, below (Ohio EPA, 2008).

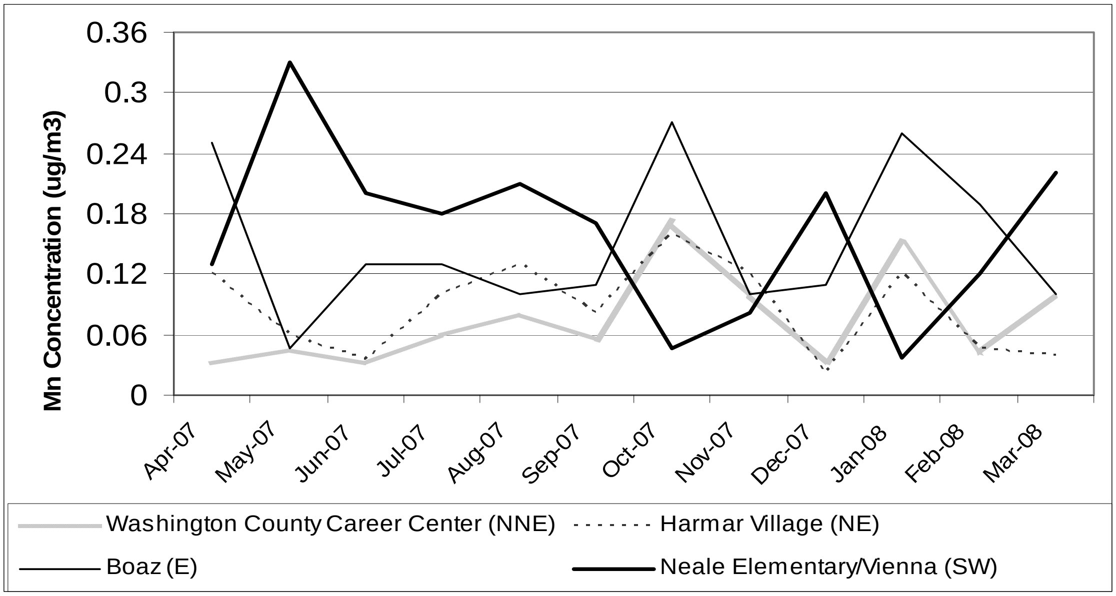
Table 1. Average monthly manganese concentrations at area monitoring stations: April 2007 to May 2008

Site	Location relative to Eramet facility	Average Mn conc. ($\mu g/m^3$)	Range Mn conc. ($\mu g/m^3$)
WCCC	NNE	0.07	0.03-0.17
Harmar	NE	0.09	0.02-0.16
Boaz	E	0.15	0.05-0.27
Neale Elementary/Vienna	SW	0.16	0.05-0.33

Filters were aggregated into monthly composites to yield a one-month average at each sampling location during the entire 12-month air investigation. In general, locations in the same direction from the former Union Carbide Complex had very similar data trends, and those located on opposite sides of the complex had inverse data trends. This observation supports the idea that a large source, located between the various monitors, is responsible for a large fraction of ambient manganese in the community.

Neale Elementary clearly has a different ambient manganese concentration trend than the other sites, which seem to have a more similar trend to one another. This trend is illustrated in Figure 2, below, as well in the evaluation of fingerprinting data in the following section.

Figure 2. Data trends of monthly averaged data-Manganese, all sites



<u>*Manganese Fingerprinting Study*</u>

As reported above, average monthly manganese concentrations consistently exceeded health based guidelines at all monitoring locations during this investigation. Interestingly, the highest concentrations detected were often at Neale Elementary in Vienna, WV, approximately 4.5 miles to the southwest of the former Union Carbide complex. This finding prompted ATSDR to ask the U.S. EPA's National Enforcement Investigations Center (NEIC) Lab to "fingerprint" the filters from five area sampling locations and compare them to one another for elemental abundances and particle similarities. ATSDR began working with NEIC to fingerprint particulates on the sampling filters collected from monitors operating in the Marietta area in spring 2008. In addition to the elemental abundance information discussed in this document, scanning electron microscopy and isotopic ratio analyses are currently in progress to gain information regarding the particle morphology, particle size, and isotopic composition. This analysis will yield more information about how the metals on the filters at various locations are related and how they compare to source samples. Source samples from Eramet and two other facilities that handle manganese in the area were collected the week of March 15th, 2009 and will be used to identify the source(s) of the manganese on the filters of area monitors.

The filters used in the NEIC fingerprinting investigation are the same filters analyzed by the Ohio EPA from April 2007-March 2008. However, unlike the ambient monitoring analysis comprised of monthly composite samples, data were evaluated *discretely* for the purposes of fingerprinting. All discrete 24-hour samples collected during the air investigation were evaluated for each site individually. At the time of the release of this report, the first six months of filters were analyzed and elementally fingerprinted. Thus, the fingerprinting analysis included 143 samples from the Boaz, Blue Knob Road, Harmar, Neale Elementary/Vienna, and WCCC sampling locations collected over the period of April 6 through October 3, 2007 (See Table 2, Appendix B for full dataset). All filters for the four air investigation locations were included in this fingerprinting effort in addition to the Blue Knob Road site. Although analyzing the filters for individual metals was discontinued in 2006 at this site, filters for Blue Knob Road were included in the fingerprinting efforts because they were still collected and archived during the air investigation period. Analysis of dusts from this location yielded important information about data trends in the community with closest proximity to the former Union Carbide Complex.

Elemental abundance counts were performed using a technique called “laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS)”. This laboratory procedure involves focusing high energy laser light onto the surface of air filter samples. The laser light interacts with the particulate collected on the filter forming an aerosol. The aerosol then enters a plasma mass spectrometer, where it is broken down into its basic atomic units. The atoms of different masses are separated and counted. The mass of an atom identifies the element, and *the number of atoms “counted”* ***is proportional to the element’s concentration***. This atomic count of a specific metal is referred to as its “*elemental abundance*”. Relative elemental abundances (the counts of different metals relative to each other) for the filters were determined by LA-ICP-MS. This is sometimes referred to as the *elemental fingerprint*.

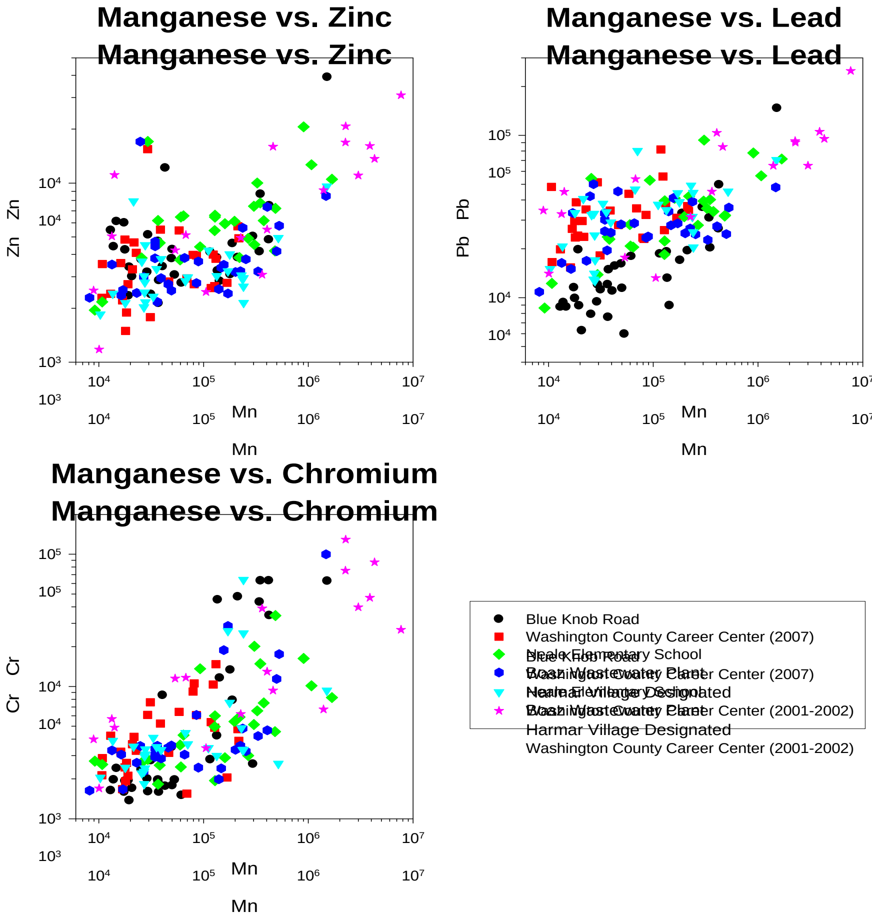
Data collected by LA-ICP-MS represent raw counts of different elements and were used to compare relative elemental responses between filters. The correlation between aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, silver, titanium, vanadium and manganese were evaluated using plots of elemental abundance counts and the calculation of Spearman’s rank correlation coefficients (r_S). An r_S of unity (1) indicates perfect correlation, and an r_S of zero indicates the absence of a correlation. In turn, an r_S close to one is a stronger correlation than an r_S close to zero. Generally, for of all the compounds analyzed by LA-ICP-MS, NEIC noted that the presence of manganese was related to the presence of chromium, lead, and zinc (U.S. EPA, 2008). Scatterplots of elemental abundances are illustrated in Figure 3, comparing manganese with each of these other metals. The specific r_S values for each of these comparisons are presented in Table 2.

Table 2. Spearman’s rank correlation coefficients: correlation between manganese and chromium, lead, or zinc [a]

Sampling location	Chromium	Lead	Zinc
BKR	0.729 (0.0000)	0.735 (0.0000)	0.169 (0.3389)
WCCC (2007)	0.496 (0.0072)	0.371 (0.0522)	0.336 (0.0809)
Neale Elementary	0.761 (0.0000)	0.645 (0.0003)	0.532 (0.0043)
Boaz	0.644 (0.0001)	0.230 (0.2218)	0.441 (0.0148)
Harmar	0.562 (0.0023)	0.502 (0.0076)	0.357 (0.0679)

[a] ***P-values are given in parentheses***

Figure 3. Plot of particle abundance of manganese versus chromium, lead, and zinc at all sampling locations (from U.S.EPA, 2008)



Preliminary scanning electron microscopy (SEM) analysis was used to evaluate a small subset of filters collected during the air investigation. This analysis indicates that manganese in ambient air in the Marietta area occurs generally as manganese-oxide. These manganese particles were mostly spherical (77%) and 21% have an aerodynamic diameter less than 2.5 micrometers (µm) (U.S. EPA, 2009). Particles less than 2.5 µm are considered "very fine" and are highly respirable.

Like the air monitoring data, the fingerprinting evaluation suggests opposite manganese concentration trends for upwind and downwind sites and remarkably similar trends for sites located in the same predominant wind direction, indicating a common large source in the area. From this study, NEIC concluded the following (U.S. EPA, 2008):

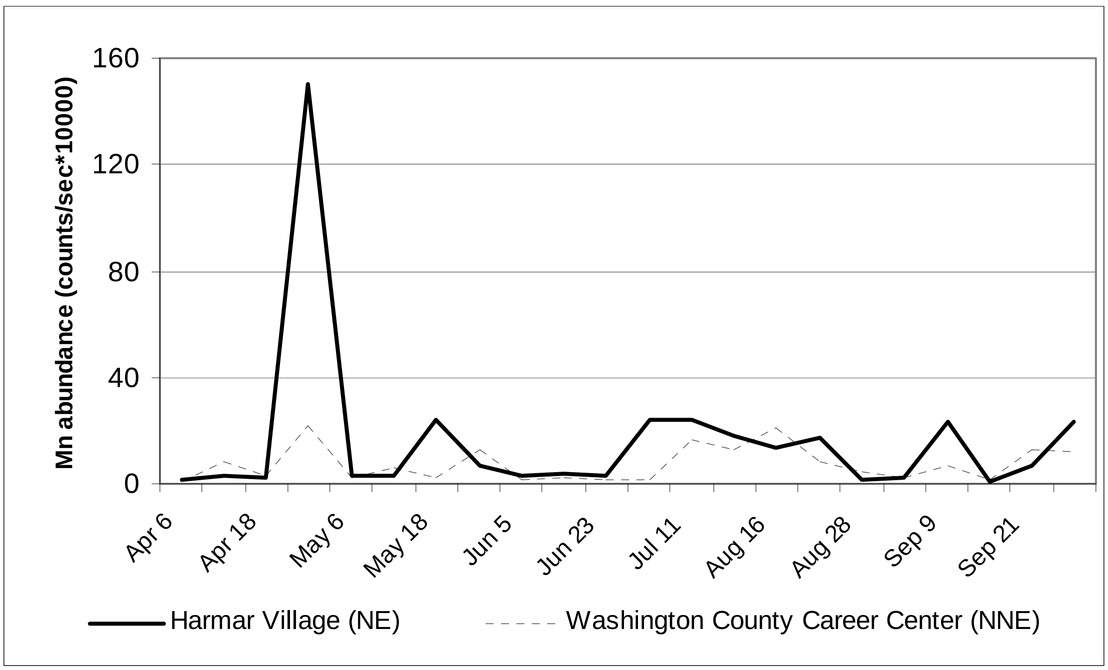
- LA-ICP-MS results show that most filters from all locations contain some common elements in similar proportion.
- LA-ICP-MS results indicate the presence of at least one large source origin of airborne manganese particles collected on TSP filters in the Marietta area.
- These results suggest that Eramet, the largest manganese emitter in the area, remains a

possible significant source of airborne manganese.

- Because Eramet is the largest manganese processor in the area and potentially the largest airborne manganese emitter, a comprehensive sampling event is necessary to determine its contribution to airborne manganese.
- In addition to the Eramet facility, sampling of other possible manganese emitting facilities in the Marietta area is necessary for a comprehensive fingerprinting analysis. Figures 4-6 illustrate the types of data trends observed during the fingerprinting analysis.

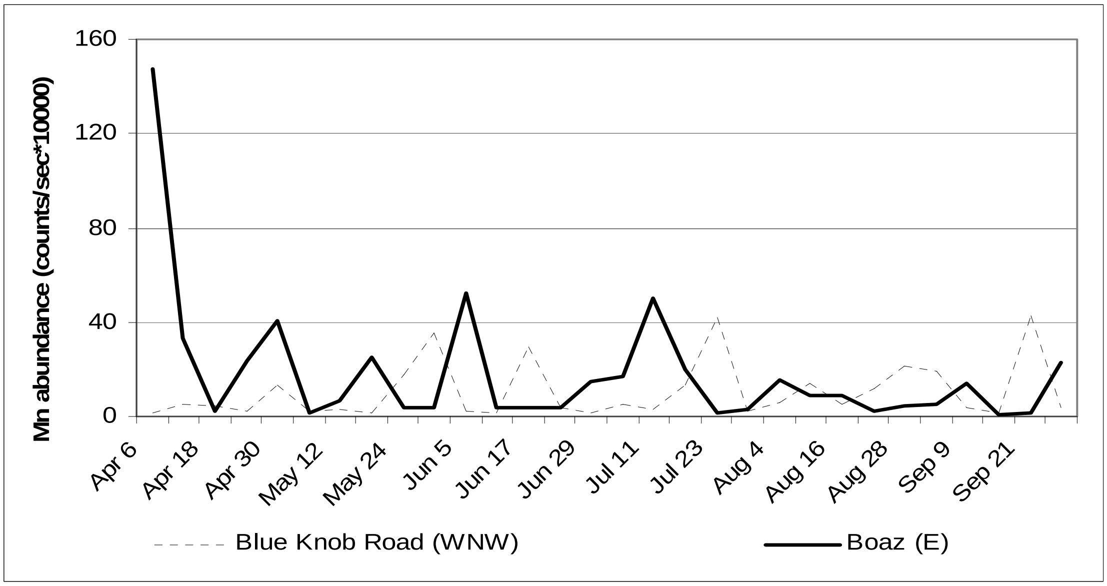
As with the monthly average samples discussed in the previous section, data indicate a similar time series trend for all locations except for Neale Elementary. Ambient manganese abundances at two sites in the same general direction of the former Union Carbide Complex have similar time series trends (Figure 4).

Figure 4. Similar manganese abundance trends of two sites predominantly downwind (NNE/NE) of the former Union Carbide Complex



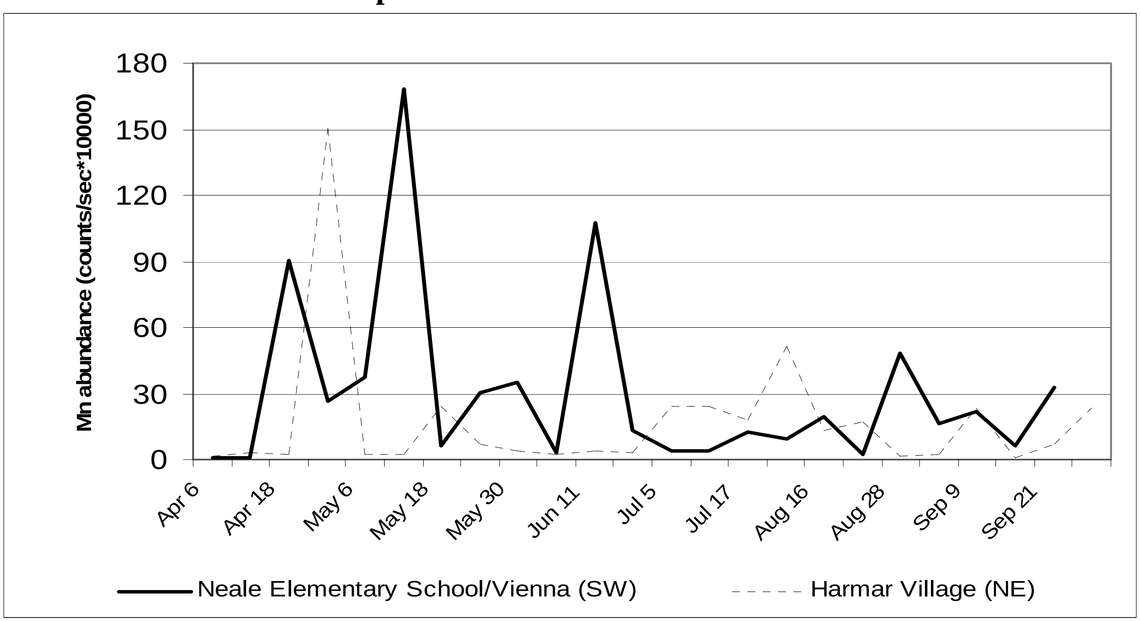
Blue Knob Road and the Boaz monitoring locations are in opposite directions from the former Union Carbide Complex, which lies between them (Figure 5). Each site is approximately equidistant (each within 1 mile) from the site in the west-northwest (Blue Knob Road) or east direction (Boaz site).

Figure 5. Trends of manganese abundance at a site west versus east of the former Union Carbide Complex



The trends of ambient manganese detected at sites on opposite sides of the former Union Carbide Complex seem to have an inverse trend to the other, suggesting a large source between the sites. This is also observed at the Neale Elementary/Vienna site and the Harmar Village site, which are much further apart (~9 miles). See Figure 6.

Figure 6. Trends of manganese abundance at a site northeast versus southwest of the former Union Carbide Complex

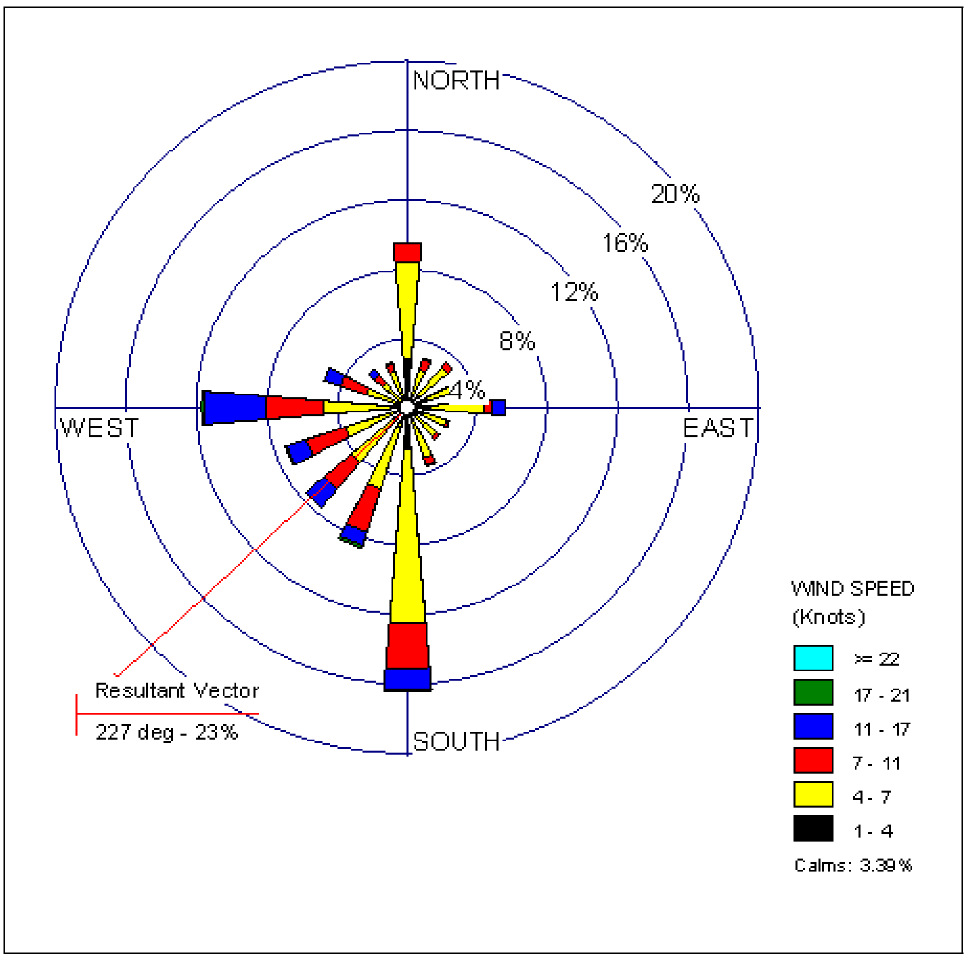


Meteorology and Manganese Concentrations-all sites

Weather data were obtained from the Parkersburg Regional Airport in Parkersburg, West Virginia for the entire sampling period. The predominant wind direction (the "resultant vector" noted in Figure 7) for this period was out of the southwest (approximately 23% of the time). This means that the predominant "upwind", or unaffected, location from the presumed source of ambient manganese, Eramet, is to the south and southwest of the site (Neale Elementary/Vienna). The sites directly downwind of the predominant wind direction would be those to the north and northeast (WCCC and Harmar Village).

It is important to note that the idea of predominant wind direction is different from day to day meteorology. Wind patterns are highly variable. During this analysis, we determined that in general, monitors downwind from Eramet had the highest manganese concentrations, regardless of what direction they were from the complex. This is explained in greater detail in the sections that follow.

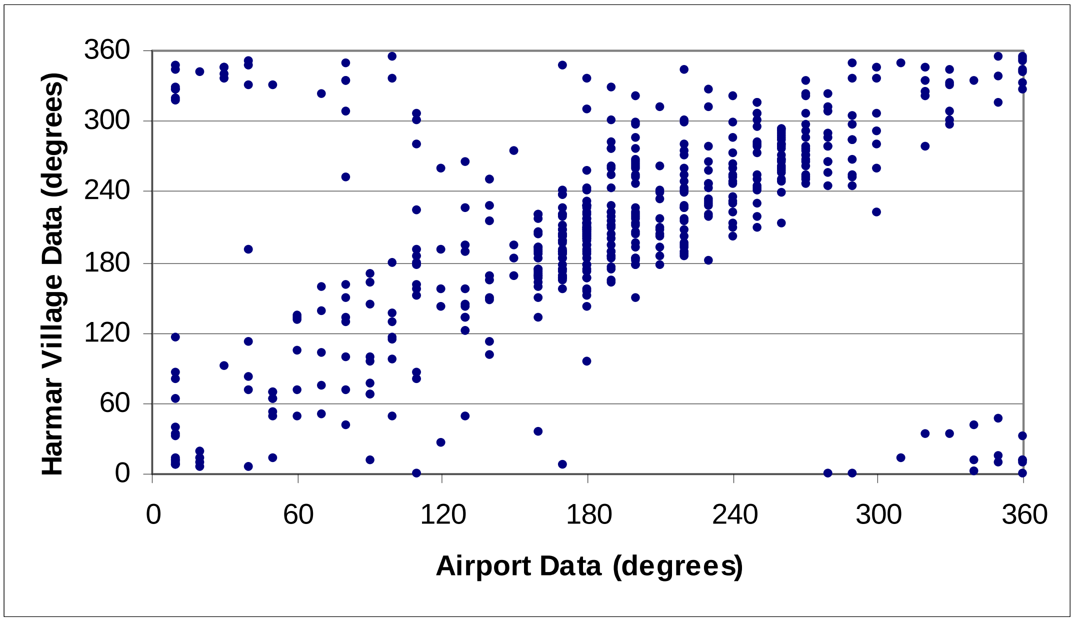
Figure 7. Wind rose for air investigation sampling dates



Ohio EPA also collected

weather data as part of the air investigation at the Harmar Village location. However, data at this location were only collected mid-September 2007 through March 2008. Due to missing data in the first few months of the sampling period, the Harmar Village data were not used in this analysis. Instead, the Parkersburg Airport data were used. A comparison of the Parkersburg Airport and Harmar Village data for dates during which both stations were collecting data demonstrate agreement (Figure 8). Thus, we believe Parkersburg data are appropriate for this analysis.

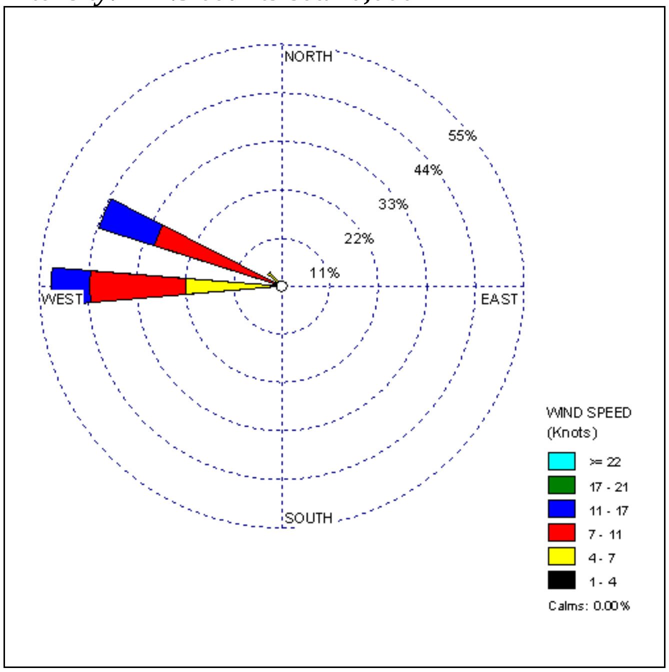
Figure 8. Correlation plot of Parkersburg Airport vs. Harmar Village wind direction data



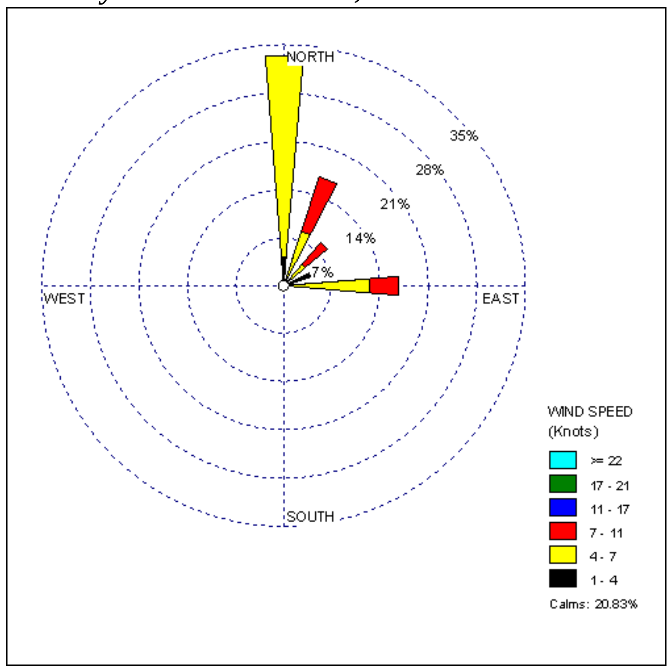
Although as previously mentioned, the predominant wind direction is out of the southwest, there was general agreement between the magnitude of downwind manganese abundance and wind direction. An evaluation of the relationship between facility emissions at the former Union Carbide Complex and particle abundance was conducted using 24-hour averaging for both datasets. The correlation between wind direction and downwind manganese abundance was poor on days where there was generally very low windspeeds (<1 mph), generally very high windspeeds (>22 mph), and when wind speeds and wind directions were highly variable. However, when wind speeds were moderate (4-17 mph) and wind direction was fairly consistent, the correlation was excellent. For example, the highest manganese abundances occurred on April 6 (147.5 counts-sec/10,000); April 18 (90.3 counts-sec/10,000); April 30 (150.6 counts-sec/10,000); May 12 (168.5 counts-sec/10,000); and June 11 (107.2 counts-sec/10,000). On all of these days, the monitoring station downwind of the Eramet facility experienced the highest ambient manganese abundances. The wind roses in Figure 9 are a visual representation of this information. Note that the “tails” are the directions *from which* the wind was blowing.

Figure 9. Wind roses and downwind manganese (Mn) abundance for highest five day counts (April-October 2007)

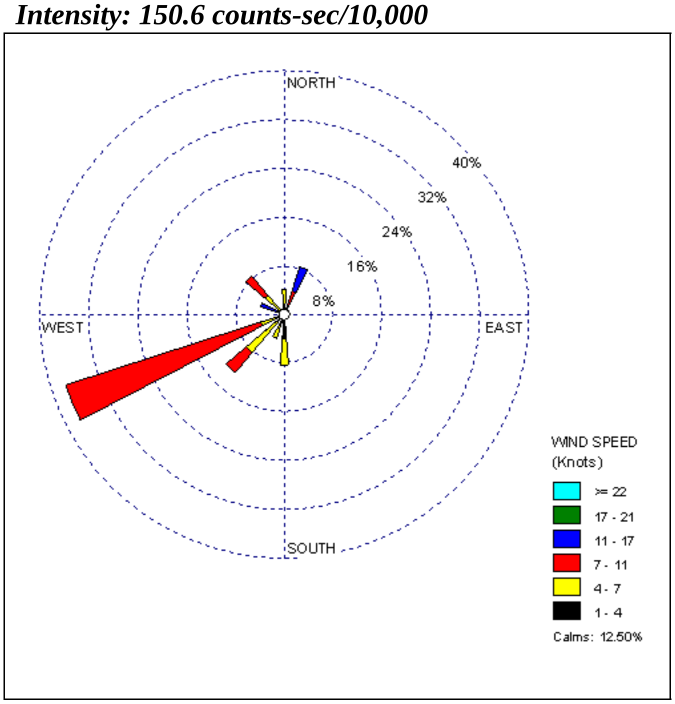
April 6, 2007
Predominant wind direction: out of the West
Site with highest Mn abundance: Boaz
Intensity: 147.5 counts-sec/10,000



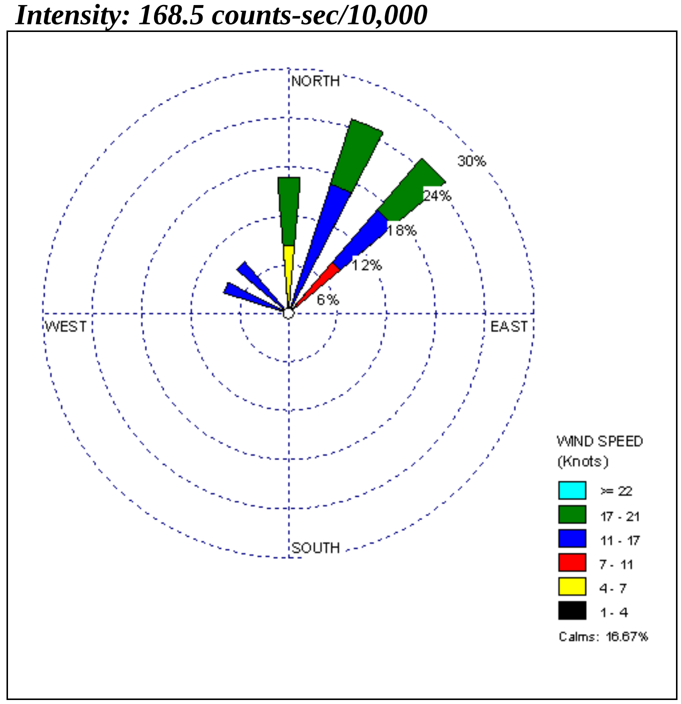
April 18, 2007
Predominant wind direction: out of the North/NE
Site with highest Mn abundance: Neale
Intensity: 90.3 counts-sec/10,000



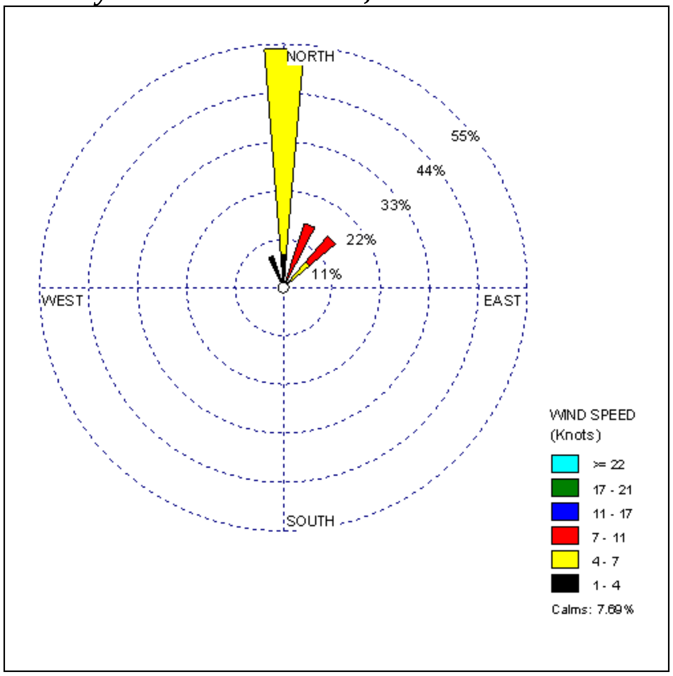
April 30, 2007
Predominant wind direction: out of the Southwest
Site with highest Mn abundance: Harmar
Intensity: 150.6 counts-sec/10,000



May 12, 2007
Predominant wind direction: out of the North/NE
Site with highest Mn abundance: Neale
Intensity: 168.5 counts-sec/10,000



June 11, 2007
Predominant wind direction: out of the North/NE
Site with highest Mn abundance: Neale
Intensity: 107.2 counts-sec/10,000



Health Implications

General Manganese Health Information
The primary concern about chronic human exposure to manganese via inhalation is the association with neurological effects. Occupational studies have found deficits in motor skills (such as finger tapping, reaction time, hand-eye coordination, etc.) with chronic exposures to manganese levels as low as 27 µg/m^3 (ATSDR, 2008b; Bowler et al., 2007; Iregren, 1990; Lucchini et al., 1995; Lucchini et al., 1999; Mergler et al., 1994; Roels et al., 1987).

The highest annual average concentration of manganese in this study was 0.16 µg/m^3. All annual averages for the monitoring sites exceed the ATSDR MRL for manganese inhalation of 0.04 µg/m^3, and the U.S. EPA RfC of 0.05 µg/m^3. The MRL and RfC are both based on an occupational study of workers exposed to manganese in a battery factory and unexposed control subjects (Roels, et al., 1992). These workers were exposed to an average of 215 µg/m^3 and 948 µg/m^3 manganese (respirable and total dust, respectively) for approximately 5 years. Neurobehavioral tests (short term memory, visual reaction time, motor skills) were performed on the exposed individuals (workers) and the unexposed control group. The exposed workers scored significantly worse on these tests. ATSDR conducted a “dose-response” analysis on the results of each worker (exposure vs. test scores), and a value of 74 µg/m^3 was chosen as a surrogate for a NOAEL, and was adjusted for continuous exposures instead of occupational exposures. This adjusted manganese exposure value was divided by 500 to account for variability among how people react to exposures, data uncertainties, and to be protective of children (10 for human variability, 10 for uncertainties (like reproductive and developmental effects) in available studies, and 5 for children's susceptibility) to yield the MRL. It should be noted that a draft revised MRL was proposed September 2008, that excludes the use of the uncertainty factor of 5 for children's susceptibility. This revision has been proposed because there are recent studies that indicate that the human variability factor sufficiently protects the increased uptake of manganese by children compared to adults (ATSDR, 2008b). The ATSDR Toxicological Profile for Manganese has been updated and is currently undergoing public comment. In that document, there is a proposed revision to the chronic inhalation MRL to a value of 0.3 $\mu g/m^3$. However, since this revised MRL value is still draft and not yet final, the existing chronic inhalation MRL (0.04 $\mu g/m^3$) is being used in evaluating data from our 2007-2008 air investigation. The process that U.S. EPA uses in deriving the RfC is described in more detail on the Integrated Risk Information System webpage (http://www.epa.gov/iris).

There are very few studies that have evaluated environmental exposures to manganese outside of the workplace. However, a limited number have been conducted in communities. A cross-sectional study was performed in two communities in Mexico that were located near a primary ore refining plant. Limited ambient particulate matter (PM_{10}) manganese concentrations (five 24-hour samples in each community) were detected on average between 0.03 and 0.10 $\mu g/m^3$. The investigators sampled ambient air, indoor dust, and well water to assess effects of environmental manganese exposure on cognitive function. They found a statistically significant risk of deficient cognitive performance in the subjects with increasing blood manganese levels (Burgoa et al., 2001). However, it is unknown to what degree ambient manganese concentrations contributed to the blood manganese concentrations when compared to dietary exposure. More importantly, many subjects in the study population had high levels of blood lead, which may also confound any association between manganese inhalation and cognitive function. Thus, the relationship between blood manganese and adverse health outcomes was not conclusive. Several articles were published in 1999 examining low-level environmental manganese exposures in southwest Quebec (Baldwin et al., 1999; Beuter et al., 1999; Bowler et al., 1999; Mergler et al., 1999). A limited three days of air sampling data were collected at four locations with TSP manganese concentrations in the range of 0.009 $\mu g/m^3$ to 0.035 $\mu g/m^3$ near a closed ferro and silico-alloy plant (Baldwin et al., 1999). The authors concluded that residents in areas with highest airborne manganese and highest consumption of leafy green vegetables and manganese-rich cereals also had the highest levels of blood manganese (Baldwin et al., 1999); they also concluded that elevated blood manganese was associated with deficits in nervous system function (Beuter et al., 1999; Bowler et al., 1999; Mergler et al., 1999). Manganese is an essential nutrient for neurological function, and the contribution of dietary sources to blood manganese levels is significant. It is unknown to what extent chronic, low level ambient manganese exposures contribute to blood manganese levels in residential settings. Further, as previously mentioned, the contribution of dietary manganese versus the effects of inhalation exposure is unknown.

Manganese Exposure in the Marietta Area

The highest average concentration of manganese at the Neale Elementary is hundreds of times lower than the lowest concentration of inhaled manganese which has caused measurable neurological health outcomes in occupational studies. However, given that communities are comprised of people of varying age and health status, uncertainty exists regarding the effect of measured exposures on the health residents of Marietta and other neighboring communities, particularly sensitive populations such as children. Most studies of manganese exposures in humans are from occupational settings, with significantly higher exposures and healthier populations than are typically observed in communities. Given the lack of information about the effects of chronic low level exposure to manganese and the well-characterized exposure of the community, it would be valuable to conduct a health study in this community to investigate whether there are health effects from this exposure.

V. Conclusions

- Manganese was the only metal identified which exceeded both background levels and health based guidelines.
- The air investigation suggests manganese concentrations in outdoor air are generally highest when stations are downwind of the former Union Carbide facility.
- Available data suggest that manganese exposures are higher for residents who live closer to the former Union Carbide facility, with the exception of the Vienna community.
- Fingerprinting and comparative time series analyses indicate that a single large source of manganese located between the sampling locations is likely. Additional source fingerprinting is necessary to identify the specific influence of potential sources on individual monitors.
- A data gap exists in the scientific literature regarding the effect of chronic, low level manganese exposures on the general population. There is limited evidence that these types of exposures can cause subtle neurological effects in communities.
- EPA has just announced funding of a health study of adult exposure to manganese in the Marietta community, which will be initiated in August/September 2009. This evaluation of health outcomes and any relationship they have to ambient concentrations of manganese will provide important information about the potential effect of manganese exposures in this community.

VI. Recommendations

- Source fingerprinting should be conducted to determine the relative effects of other potential area manganese sources.
- ATSDR should evaluate the findings from the planned EPA-funded health study, as well as any additional data, to determine if remaining data gaps exist regarding the effects of manganese exposure in this community that would require further investigation.

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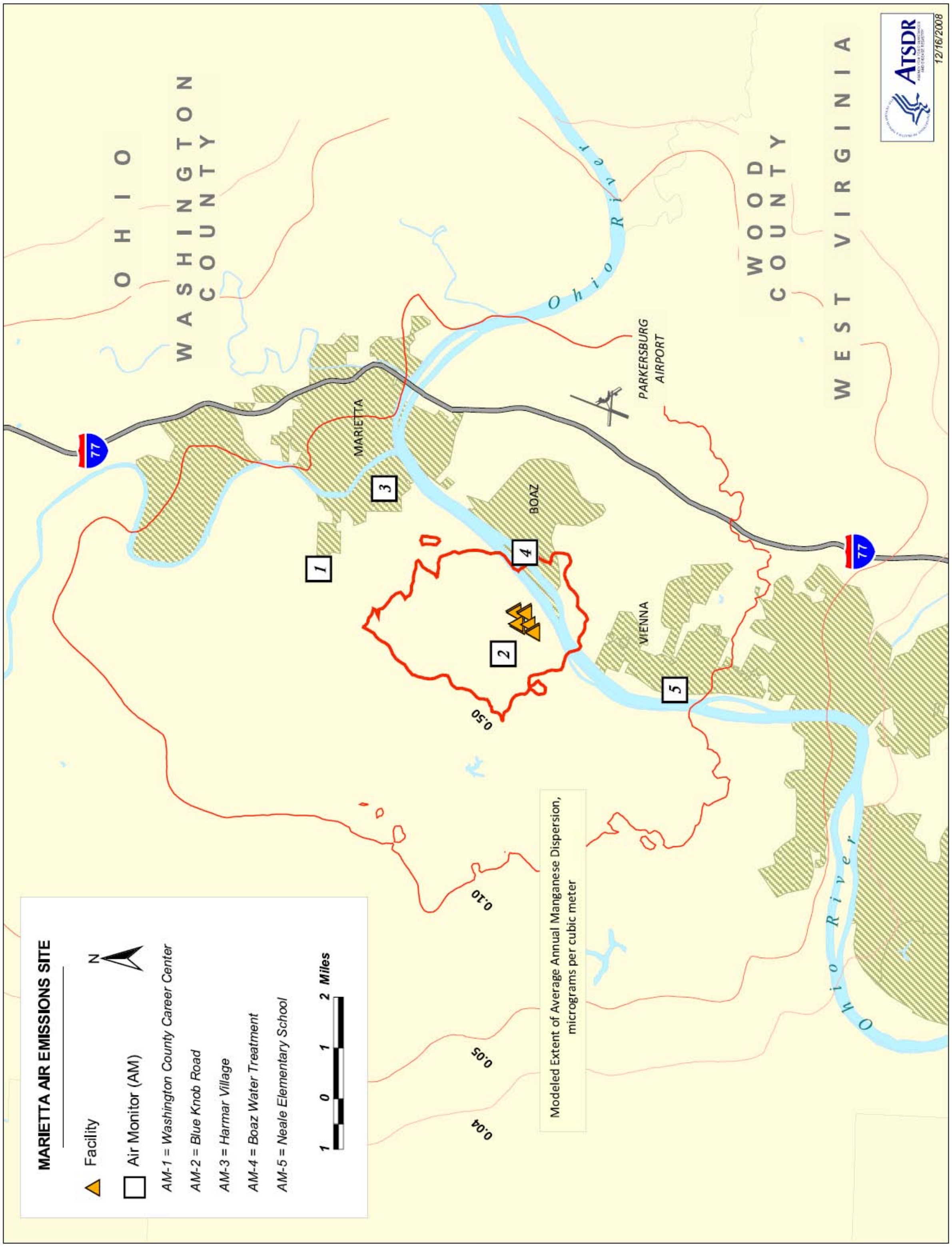
Appendix A

Area Map and Monitoring Locations


MARIETTA AIR EMISSIONS SITE
Facility
Air Monitor (AM)
AM-1 = Washington County Career Center
AM-2 = Blue Knob Road
AM-3 = Harmar Village
AM-4 = Boaz Water Treatment
AM-5 = Neale Elementary School
N
1 0 1 2 Miles
Modeled Extent of Average Annual Manganese Dispersion, micrograms per cubic meter
0.50
0.10
0.05
0.04
OHIO
WASHINGTON COUNTY
WOOD COUNTY
WEST VIRGINIA
Ohio River
PARKERSBURG AIRPORT
MARIETTA
BOAZ
VIENNA
77
1
2
3
4
5
ATSDR
12/16/2008

Appendix B

Ambient Air Data

Table 1. Data from Marietta Ambient Air Investigation (April 2007-March 2008) (µg/m³)

Manganese	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
WCCC	0.032	0.044	0.031	0.060	0.079	0.055	0.17	0.10	0.034	0.15	0.042	0.10
Harmar	0.12	0.059	0.035	0.10	0.13	0.082	0.16	0.12	0.023	0.12	0.047	0.039
Boaz	0.25	0.046	0.13	0.13	0.10	0.11	0.27	0.10	0.11	0.26	0.19	0.10
Neale	0.13	0.33	0.20	0.18	0.21	0.17	0.047	0.081	0.20	0.037	0.12	0.22
Arsenic	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
WCCC	0.00042	0.00074	0.00066	0.00085	0.00077	0.00076	0.00075	0.00066	0.00051	0.00052	0.00035	0.00047
Harmar	0.00057	0.0010	0.00093	0.00088	0.0012	0.0012	0.00078	0.00087	0.00070	0.00064	0.00040	0.00048
Boaz	0.00069	0.0012	0.0012	0.0012	0.0014	0.0012	0.00075	0.0013	0.00078	0.00090	0.00051	0.00059
Neale	0.0011	0.0014	0.00092	0.0013	0.0015	0.0014	0.00079	0.0013	0.0010	0.00052	0.00050	0.00087
Cadmium	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
WCCC	0.00014	0.00014	0.00019	0.00023	0.00017	0.00011	0.00040	0.00020	0.00014	0.00016	0.00013	0.00073
Harmar	0.0002	0.00034	0.00016	0.00019	0.00022	0.00015	0.00066	0.00029	0.00018	0.00012	0.00016	0.00016
Boaz	0.00032	0.0013	0.0011	0.00024	0.0018	0.00024	0.00024	0.00063	0.00022	0.00026	0.00017	0.00020
Neale	0.00020	0.0017	0.0011	0.00032	0.00021	0.00022	0.00013	0.00047	0.00023	0.00012	0.00012	0.00032

µg/m³= micrograms of metal per cubic meter of air

Sampling locations are as follows: WCCC= Washington County Career Center; Harmar=Harmar Village; Boaz= Boaz Wastewater Treatment Facility; Neale= Neale Elementary School; BKR= Blue Knob Road

Table 2. Manganese Particle Abundance (April-October 2007) (counts/sec*10000^{-1})†

Date	Neale	Blue Knob	Boaz	WCCC	Harmar
Apr 6	1.1	1.3	147.5	1.1	1.4
Apr 12	0.9	5.3	33.2	7.9	2.8
Apr 18	90.3	4.3	2.5	2.9	2.1
Apr 24	N/A	2.0	23.7	3.9	11.2
Apr 30	26.7	13.5	40.6	21.7	150.6
May 6	37.6	2.5	1.6	2.1	2.7
May 12	168.5	3.0	6.6	5.8	2.7
May 18	6.4	1.8	25.3	2.2	24.1
May 24	30.3	18.0	3.6	13.1	6.7
May 30	34.9	35.1	3.4	N/A	3.6
Jun 5	2.9	2.1	52.6	1.6	2.7
Jun 11	107.2	1.7	3.4	2.3	3.9
Jun 17	6	29.7	3.4	8.5	N/A
Jun 23	12.9	3.7	3.9	1.8	2.8
Jun 29	48.5	1.4	14.7	1.8	N/A
Jul 5	3.7	5.0	17.1	1.8	24.1
Jul 11	3.8	2.9	49.9	16.7	24
Jul 17	12.8	13.6	20.2	12.8	17.8
Jul 23	N/A	42.0	1.7	1.7	2.7
Jul 29	30.5	1.9	2.7	1.1	N/A
Aug 4	9.3	6.2	15.6	N/A	51.7
Aug 10	N/A	14.3	8.6	3.1	3.3
Aug 16	19.7	5.0	8.9	21.3	13.4
Aug 22	2.6	11.6	2.3	8.1	17.1
Aug 28	48.1	21.3	4.6	4.7	1.8
Sep 3	16	18.9	4.9	1.9	2.6
Sep 9	22	3.8	14	6.9	23
Sep 15	6.1	1.5	0.8	1.3	1
Sep 21	32.5	42.6	1.3	12.4	7.1
Sep 27	12.8	3.7	22.5	11.8	23.6
Oct 3	N/A	3.1	N/A	N/A	N/A

Sampling locations are as follows: WCCC= Washington County Career Center; Harmar=Harmar Village; Boaz= Boaz Wastewater Treatment Facility; Neale= Neale Elementary School; BKR= Blue Knob Road

[†]*These data are tabular representations of the trends charts presented in the text of this health consultation.*