Health Consultation

East Liverpool Air Quality
East Liverpool, Ohio

September 24, 2010

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 February 4, 2008, the Agency for Toxic Substances and Disease Registry (ATSDR) was petitioned by the Director of the Ohio Environmental Protection Agency (Ohio EPA) to evaluate potential health impacts from metals measured in residential community air in East Liverpool, Columbiana County, Ohio.

Since 1999, the Ohio EPA has conducted fixed-site air monitoring at three locations in the East Liverpool community (Maryland Avenue, the Port Authority, and the Michigan Avenue Water Plant). The objective of the monitoring was to evaluate the potential impacts to ambient air quality from the Von Roll (now Heritage) Waste Technology Industries (WTI) Incinerator Facility in East Liverpool. Ohio EPA recently completed the East Liverpool Ohio Air Quality Study which indicated health risks from exposures to airborne manganese and chromium exposures (Ohio EPA, 2008a). Ohio EPA identified the SH Bell Company, a raw products storage and packaging facility, as the source of ambient manganese and chromium sampled in community air monitors (Ohio EPA, 2008b).

The City of East Liverpool is located 3.5 miles southwest of S.H. Bell (see Appendix A), though a relatively dense residential population exists near the facility. East Liverpool has an approximate population of 12,000 (U.S. Census, 2007). The land use in the area is mostly residential and agricultural, with industry located to the north and south of the city along the Ohio River.

Of the three ambient air monitors in the community, the site with the highest levels of metals over the past 10 years is the one located in closest proximity to the SH Bell Company. There are a number of other industries in the immediate area, but SH Bell handles the greatest volume of raw and processed metal products. The company has two locations approximately 1 mile apart in this area, the Little England facility and the State Line facility (Figure 1 and 2). The original location of company operations in the area was the Little England facility, which occupies 8.5 acres of land and began operations in 1963. The company purchased the larger State Line parcel of land for its main operations in the late 1960s. This facility occupies 92 acres of land. Both are located on the northern bank of the Ohio River, allowing easy access to the storage buildings by barge. Operations at both facilities are identical and both store, transfer, and warehouse ferrous and nonferrous materials for industry. Both sites are equipped to process, dry, crush, screen, and package materials for a wide variety of industrial customers. Receiving and shipping of materials at both sites occurs through river barge, truck, and rail (SH Bell, 2009).

Storage of materials at the State Line facility

Figure 1: Indoor storage

Figure 2: Outdoor storage areas

Raw metals handled by SH Bell come from mines all over the world. At a meeting with company officials in March 2009, ATSDR staff were told that a total of 26 employees staff both facilities. Prior to the economic crisis that began in December 2007, approximately a total of 52 employees staffed both facilities. Plant operations managers reported that most of the ore handled by SH Bell is processed before it reaches their facilities and that only approximately 10% of the ore is crushed or screened on-site. At this time, the facilities are predominantly a warehousing, packaging, and transfer operation (Figure 3). ATSDR was told a "good business day" would include 1.5 barges of materials delivered and 100-120 outbound trucks delivering bulk and packaged goods.

Figure 3. Packaged goods

In two separate 2008 Ohio EPA and United States Environmental Protection Agency (U.S. EPA) enforcement actions, SH Bell made a number of changes to operations to control dust emissions. These included, but are not limited to:

- Paving of 14,850 square feet of road on the State Line property;
- Creation and maintenance of a dust suppression program at both locations;
- Enclosing some storage piles and screening operations;
- Tarping of all trucks leaving either facility;

- Building of a truck load out building with dust collection; and
- Conducting an engineering study to identify other control measures to assist in dust management on site.

The site upgrades mentioned above were implemented by summer 2008.

Environmental Data

Air Sampling

Since March 2000, Ohio EPA has collected airborne Total Suspended Particulate (TSP) monitoring data from three locations in the community (Ohio EPA, 2009):

- **Water Plant -** monitor located on property adjacent to the State Line facility at the municipal water treatment plant on Michigan Avenue. This location is approximately 250 feet due west from the State Line facility property, and is the closest monitor to either the State Line or Little England facility.
- **Port Authority** - monitor located approximately 0.33 miles to the west-southwest of the Little England facility.
- **Maryland Avenue** - monitor located approximately 0.30 miles to the north-northwest of the Little England facility. This location is located on the roof of the East Liverpool City Schools Administration Building, adjacent to the East Elementary School.

Historically 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. Dust on the filters was analyzed for the following metals: arsenic, beryllium, cadmium, chromium, lead, manganese, nickel, and zinc. It should be noted that in 2005, Ohio EPA began analyzing every filter at the Water Plant in *discrete* (individual 24-hour samples) as well as monthly averaged composite samples to yield more information about the magnitude of manganese levels in community ambient air (Ohio EPA, 2009a). Thus, data at this location were evaluated as both discrete and composite samples (ATSDR, 2007).

Figure 4. Particulate Monitor

Samples were collected onto a filter within the particulate matter monitors, as a measurement of total dust (Figure 4) with particles of all sizes. 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, 2007).

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 (ATSDR, 2007).

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 matter collected per cubic meter of air sampled (micrograms per cubic meter) at normal sea level temperature and pressure (1 atm, 25°C) (ATSDR, 2007).

Results of the Ohio EPA East Liverpool Air Quality Study

In February of 2008, Ohio EPA conducted an analysis of air quality from data collected in the community from March 2000 through December 2007. An 8-year average air concentration for each of three ambient sampling sites was used to calculate cancer and non-cancer health risks for residents chronically exposed to chromium and manganese in ambient air. Of the metals that were sampled over the 8 year period, only chromium and manganese exceeded U.S EPA and ATSDR chronic health based guidance values (Ohio EPA, 2008). It should be noted that this analysis did not distinguish the specific chemical form of chromium. Chromium is generally found in either the valence state of chromium III (CRIII; more common in the environment) or chromium VI (CrVI; a rarer and more toxic form). As a conservative estimate in their risk assessment, all of the chromium was assumed to be in the more toxic form.

Additional analysis of the Ohio EPA samples was performed to determine the chemical form of chromium found in the ambient air. ATSDR requested that the U.S. EPA National Enforcement Investigations Center (NEIC) evaluate the valence state of chromium detected on the samples in East Liverpool to better assess cancer risk. Preliminary data suggest that none of the chromium detected on filters evaluated is CrVI, but rather it is all CrIII (USGS, 2009). The excess cancer risk calculated in the Ohio EPA risk assessment for chromium VI exposure is not considered to be a concern. ATSDR has determined that the health risk in the East Liverpool community for ambient air exposure is primarily associated with exposure to manganese.

Manganese does not cause cancer, so risk of non cancer health effects was calculated in the Ohio EPA study. This was accomplished through the calculation of a "hazard quotient" (HQ) that identifies risk based on dividing the ambient concentration by a level of exposure that is not associated with adverse health effects. A hazard quotient that is greater than one indicates that further evaluation may be needed. To evaluate the combined effect of exposure to multiple contaminants, the hazard quotients for noncancer risk can be added together for metals sampled to yield a cumulative noncancer risk called a "hazard index" (HI).

HQs and a corresponding HI were calculated for individual metals at all three sampling locations. As expected, the highest risk was calculated for individuals living near the Water Plant, where the highest concentrations of metals were detected. In each sampling location manganese presented the greatest noncancer risk. Of the total noncancer hazard index of 30 from all metals where HQs were calculated, more than 99% of risk was attributed to manganese exposure (Ohio EPA, 2008).

ATSDR 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 U.S.EPA reference concentrations (RfCs). 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). 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. MRLs and RfCs are calculated using lowest observed adverse effect levels (LOAELs) and no observed adverse effect levels (NOAELs). 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. ATSDR also evaluates occupational and epidemiologic studies of human exposures, and reviews health outcomes for individual compounds.

Results of Metals Analysis

Airborne manganese concentrations consistently exceeded the ATSDR and U.S.EPA health-based comparison values at all monitoring locations since sampling commenced in the community. No other metals collected during the sampling period exceed normal outdoor background levels and rarely exceeded ATSDR health based guidance values and are not evaluated in this document (Ohio EPA, 2009a).

Filters were aggregated into monthly composites to yield a one-month average at each sampling location during the entire 9-year air investigation. At all locations, most average monthly air concentrations from March 2000 to September 2009 exceeded background levels (range, 0.01-6.8 $\mu g/m^3$; Table 1). The averages of manganese concentrations for the discrete samples were 0.028 to 25.0 $\mu g/m^3$ (Table 2), which were higher than background and frequently exceeded ATSDR chronic health-based comparison values of 0.04 (ATSDR, 2008). Data collected in the 1980s by U.S. EPA indicated that manganese concentrations averaged 0.04 $\mu g/m^3$ in 102 urban areas in the United States. Similarly, in 2006 U.S. EPA reported that levels of manganese at 20 urban U.S. locations averaged approximately 0.05 $\mu g/m^3$. WHO also reports that manganese concentrations near source-dominated areas range from 0.2 to 0.3 $\mu g/m^3$ (ATSDR, 2008).

Table 1. Average monthly airborne manganese concentrations at area monitoring stations: March 2000 to September 2009

Site	Location relative to SH Bell facility	Average Mn –TSP conc. ($\mu g/m^3$)	Range Mn –TSP conc. ($\mu g/m^3$)	EPA RfC ($\mu g/m^3$)	MRL value ($\mu g/m^3$)*
Water Plant	W	1.30	0.10-6.8	0.05	0.04
Port Authority	WSW	0.18	0.01-1.0		
Maryland Ave	NNW	0.26	0.02-1.9		

**** See Health Implications section for discussion of ATSDR MRL value***

Figure 5. Distribution of monthly composite TSP data-all sites

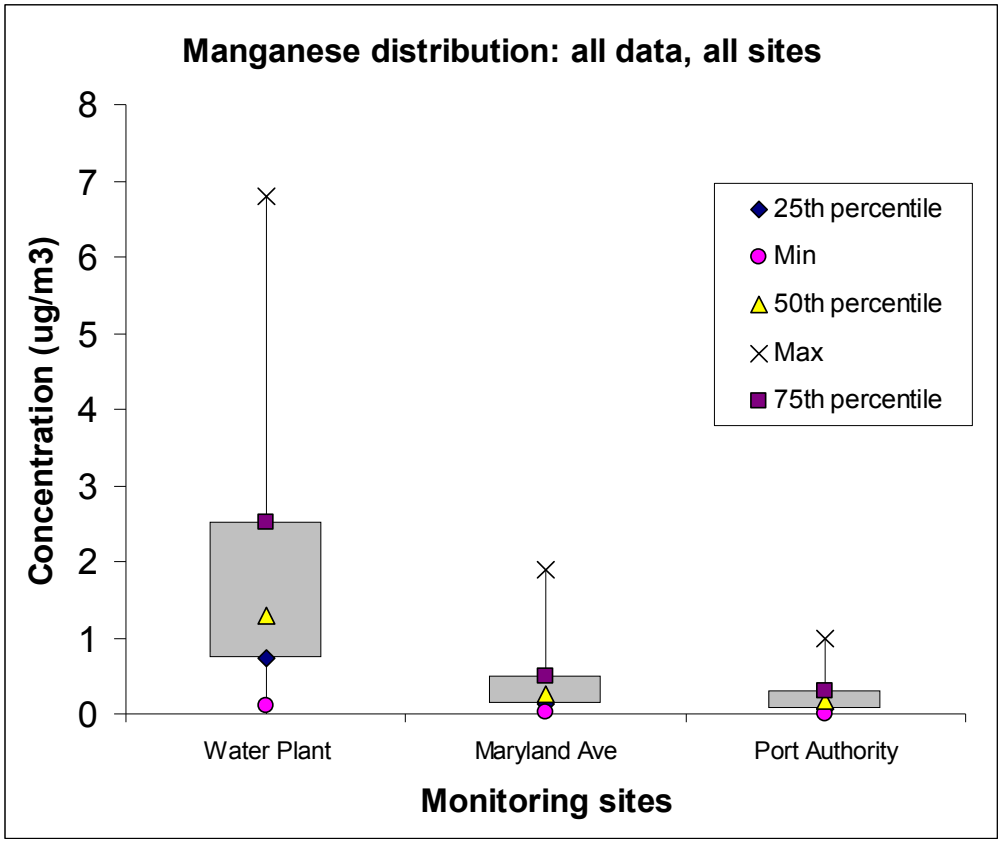


Table 2. Discrete airborne TSP manganese concentrations at the Water Plant sampling site: Jan 2005-September 2009

Type of Statistic	Result ($\mu g/m^3$)
Minimum concentration	0.03
25th percentile concentration	0.25
Average concentration	2.19
Geometric average concentration	0.81
75th percentile concentration	2.5
Maximum concentration	25.0

Reviewing the statistical distribution of monthly average airborne TSP manganese concentrations across all sites, it is clear that these are the highest and most variable at the Water Plant (Figure 5). TSP manganese levels at the Maryland Avenue site are slightly higher than the Port Authority, while those at the Port Authority appear to be the lowest of the three sites.

A graphical representation of the long term data trends of composite samples from the three sampling locations are presented on the following page in Figure 6. As stated previously, Ohio EPA began analyzing individual sample filters to yield discrete (1-day/24 hour) averages for the Water Plant location in January 2005. This was done to yield greater resolution to the ambient data since historical data indicated that this location has always had the highest readings of

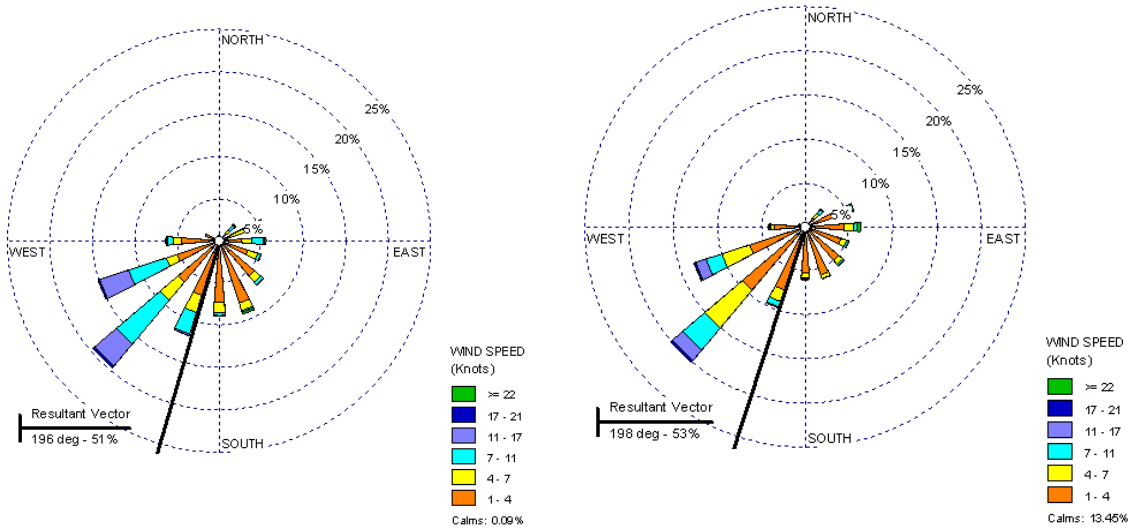
ambient metals of the three sites. The presentation of trends over time and statistical ranges of these data are presented in Figure 7. These data are presented annually, with greater resolution, in Appendix B.

Meteorology and Manganese Concentrations-all sites

Weather data were obtained from a meteorological station located at the Water Plant monitoring station that is owned and operated by the Ohio EPA. The predominant wind direction, or the "resultant vector" noted in Figure 6, for 2007 and 2008 was *out of* the southwest (approximately 53% of the time). It is important to note that the idea of predominant wind direction is different from day to day meteorology. Wind patterns are highly variable, but over the span of a year, general wind patterns were fairly stable for 2007 and 2008 (Ohio EPA, 2009b). During this analysis, we determined that filters collected on days when the monitor was downwind from the State Line Facility generally had the highest manganese concentrations, as illustrated later in this section.

Since significant variation can occur with meteorology over a month's time, combining weather data for composite sample days to create an "average weather day" would not yield an accurate analysis. Discrete data were only collected at the Water Plant sampling location, thus only data from this location were appropriate to compare to daily meteorological data trends.

Figure 6. 2007 and 2008 Wind Roses*



Note: North is 0 degrees; East is 90 degrees; South is 180 degrees; West is 270 degrees

Graphically plotting the direction from which the wind was blowing when a given ambient concentration was detected, can help identify the source of specific contaminants. These plots are called "*pollution roses*". Pollution roses were created for the 10 highest and 10 lowest manganese concentrations that were detected on days in which there was complete meteorological data (Figure 8). The data indicate that manganese concentrations are higher when the wind is blowing from the direction of the S.H. Bell State Line facility compared to when the wind was blowing from other directions.

Figure 7. Location of Water Plant Monitoring Station near Stateline Facility

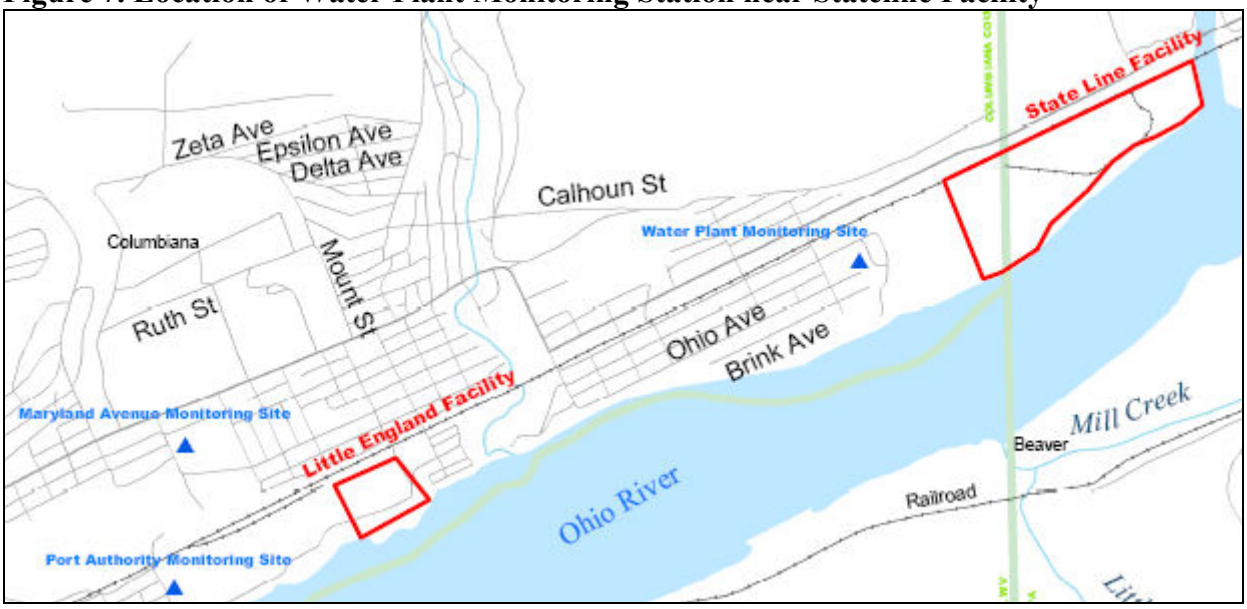
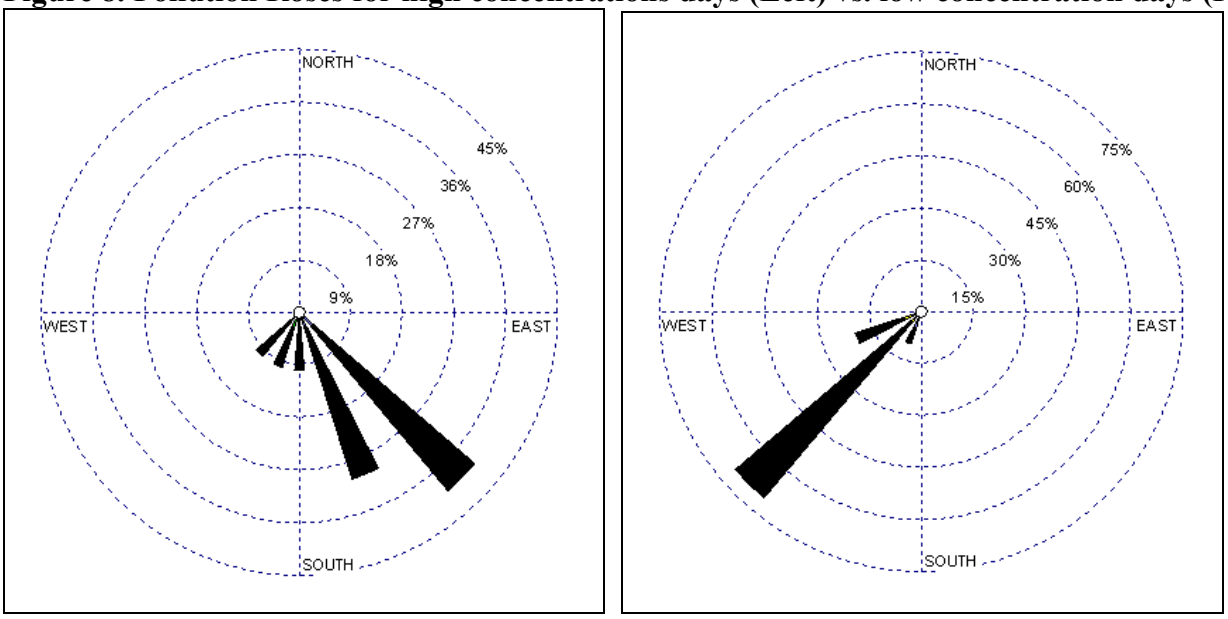


Figure 8. Pollution Roses for high concentrations days (Left) vs. low concentration days (Right)*



Note: North is 0 degrees; East is 90 degrees; South is 180 degrees; West is 270 degrees

These data are also presented numerically in Table 3.

Table 3. Meteorological parameters for highest 10 concentrations days and lowest 10 concentration days at the water plant monitoring station

Highest 10 airborne manganese concentration days			
Date	**Concentration (ug/m^3)**	**Avg wind direction (degrees)**	**Avg wind speed (m/s)**
8/3/2006	7.8	224	2.3
9/8/2006	7.6	163	1.8
12/13/2006	9.8	129	3.1
7/17/2007	15	192	1.8
7/23/2007	21	181	1.3
10/15/2007	11	148	1.5
11/8/2007	8.6	144	2.0
12/26/2007	16	165	1.1
1/31/2008	11	126	2.9
8/22/2008	8.3	129	1.2
Average	**11.61**	**160.1**	**1.9**
Lowest 10 airborne manganese concentration days			
Date	**Concentration (ug/m^3)**	**Avg wind direction (degrees)**	**Avg wind speed (m/s)**
1/24/2007	0.031	229	2.9
2/5/2007	0.12	252	5.3
2/23/2007	0.073	216	4
12/8/2007	0.056	200	1.3
5/18/2008	0.09	217	1.5
7/23/2008	0.12	220	1.5
10/21/2008	0.13	224	1.8
10/27/2008	0.062	231	1.9
11/8/2008	0.074	233	1.4
11/20/2008	0.032	239	2.1
Average	**0.0788**	**226.1**	**2.37**

Historical Environmental Data

Air Data

To assess the potential environmental and health impacts of the Von Roll Waste Technologies Industries (WTI) waste incinerator, the U.S. EPA conducted five rounds of air sampling between October 25 and December 10, 2000 at four locations in the community. The air sampling was conducted for metals, polycyclic aromatic hydrocarbons (PAHs), dioxins, volatile organic compounds (VOCs), and particulate matter. Meteorological conditions were recorded during each round of sampling. Of all the data collected, manganese was the only organic or inorganic substance that was detected above typical urban ambient air concentrations (U.S. EPA, 2001). The details of the sampling events and the results are provided below.

Table 4. Summary of U.S. EPA sampling conducted during the WTI Incinerator investigation

Sampling event	# of sampling sites	# samples/site	Duration of sampling	Mn range per sampling event (µg/m^3)
#1	6	2-3	8 hours	ND*-3.0
#2	6	3	8 hours	ND-7.3
#3	6	4	24 hours	ND-22.0
#4	5	4	24 hours	ND-9.5
#5	11	2-11	24 hours	ND-8.9

ND= not detected

Generally, the range of concentrations of manganese detected in ambient air during the U.S. EPA data analysis are consistent with those detected by Ohio EPA in sampling data they provided to ATSDR collected from 1999-2009. The data are also consistent with a preliminary NEIC evaluation of a limited number of filters characterized for manganese particle size. NEIC concluded that the manganese particle size in the community is fairly coarse, which is consistent with crushing operations. Limited $PM_{2.5}$ and PM_{10} particulate data were collected at two sites and analyzed for metals using Energy Dispersive X-ray Fluorescence (EDXRF) spectrometry. EDXRF analysis determined a concentration of less than 1 µg/m^3 of manganese on the $PM_{2.5}$ filters at the two sites, while PM_{10} filters had total manganese loads of 62 µg/m^3 and the fraction between 2.5-10 microns in aerodynamic diameter was 9.2 µg/m^3. Amid concerns regarding the presence of chromium on sample filters, EDXRF was also used to determine that the chromium detected in the community was almost exclusively CrIII, with less than 0.1% identified as CrVI. Given this small fraction of hexavalent chromium of total chromium detected, it was not identified as a health risk in the U.S. EPA WTI investigation.

Soil Data

Soil sampling (0-6" depth) was conducted on October 26 and November 15, 2000 at 10 locations by U.S. EPA at the East Elementary School grounds (U.S. EPA, 2001). Manganese levels (485-1600 ppm) were typical of background concentrations in Columbiana County (USGS, 2010) and none exceeded ATSDR health-based guidelines (3,000 ppm). All other analytes were detected at or below background levels, with the exception of slightly elevated levels of arsenic, chromium, and zinc.

Dust

Ohio EPA collected 32 dust samples on three different occasions (Nov 1, 2005; Apr 19, 2007; Nov 30, 2007) in the East Liverpool community and on SH Bell property (Ohio EPA, 2005; 2007). Samples were collected by sweeping piles of dust from paved surfaces and collecting a sample for metals analysis. Manganese levels on the SH Bell property ranged from 31,600-240,000 ppm. Samples taken from roadways in the community ranged from 808-11,300 ppm, many exceeding background levels for manganese in soil (210-1340 ppm; estimated geometric mean: 607 ppm; (USGS, 2010)).

Health Implications

General Manganese Health Information

Chronic human exposure to excessive manganese via inhalation is primarily associated with neurological effects. Occupational studies have found deficits in motor skills (such as finger tapping, reaction time, hand-eye coordination, etc.) in workers with chronic manganese

exposures between 27-1590 μg/m^3 (ATSDR, 2008; Lucchini et al., 1995; Lucchini et al., 1999).

The highest concentrations of manganese measured in the TSP filters during the monitoring period were at the Water Plant monitoring station; 6.8 μg/m^3 (monthly average) and 25 μg/m^3 (daily). All annual averages for this monitoring site from 1999 through 2009 exceed the ATSDR draft chronic inhalation MRLs for manganese of 0.04 μg/m^3 (ATSDR, 2000) and the U.S.EPA chronic RfC of 0.05 μg/m^3 (USEPA). The annual average values (Appendix B) at the Water Plant site range from 16 to 60 times the ATSDR chronic inhalation MRL. Further, nearly all of the annual average manganese levels at the Port Authority and Maryland Avenue sites exceed the health-based values. It should be noted that the MRL and RfC values are based on the respirable fraction of manganese-containing particulates (less than 10 microns in aerodynamic diameter). Although limited follow-up analysis of the TSP filters indicates that a significant portion of the particulates are in the respirable fraction, these concentrations are not directly comparable. However, estimates of the manganese concentration in the respirable fraction significantly exceed the health-based values.

The ATSDR MRL and EPA RfC are based on an occupational study of workers exposed to manganese in a battery factory (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 evaluation of manganese-exposed workers found that they scored significantly worse than the unexposed control group on tests of simple reaction time, eye-hand coordination, and hand steadiness. Using benchmark dose (BMD) analysis of the abnormal eye-hand coordination scores, the exposure concentration associated with a 5% response was determined to be 74 ug/m^3. After adjusting for continuous exposures from the intermittent to continuous exposure and the application of a 500-fold uncertainty factor [10 for human variability; 10 for database uncertainties including a lack of reproductive and developmental effects data; modifying factor of 5 for potentially increased susceptibility in children based on due to greater retention of manganese relative to adults] (ATSDR, 2000).

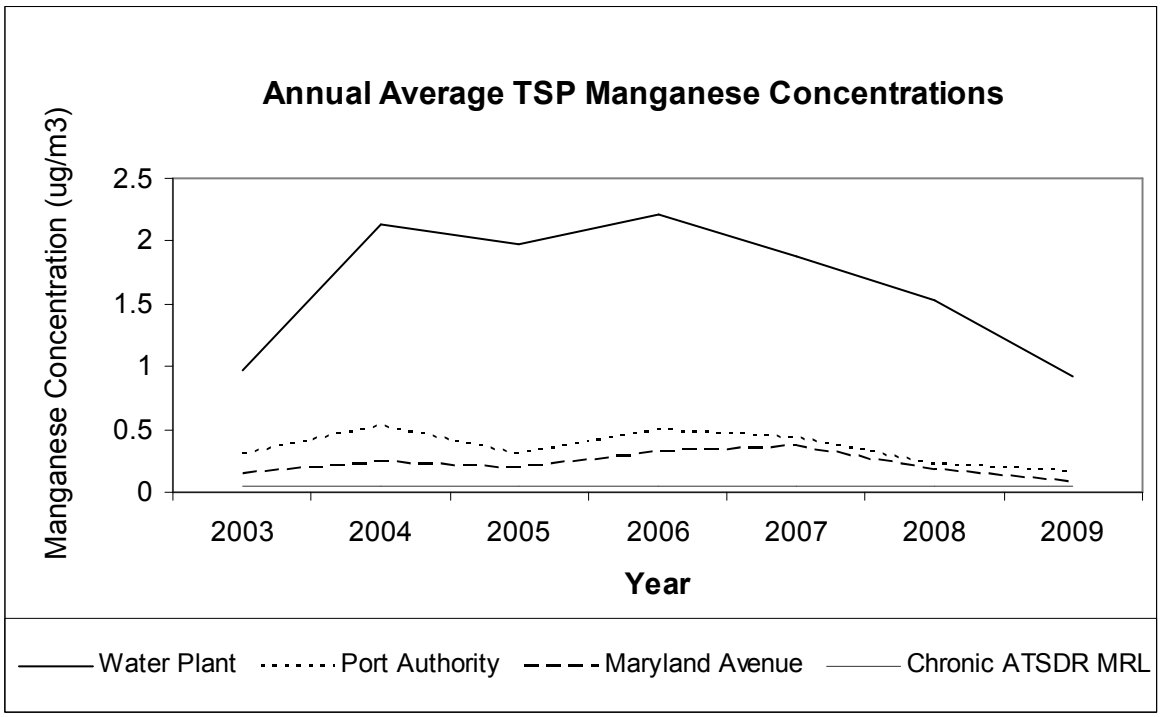
Only a few studies have evaluated non-occupational exposures to manganese, resulting from environmental exposures. A study of 8 communities in a mining district in Mexico found a statistically significant association between manganese concentrations in air and altered neuromotor function in the study population of 288 residents living at various distances from the mining operations (Rodriquez-Agudelo, 2006). Manganese concentrations in air ranged between 0.003 and 5.86 μg/m^3, with an average concentration of 0.42 μg/m^3. Interestingly, there was no correlation between blood manganese levels and the motor tests. However, since manganese is an essential nutrient for neurological function, intake from dietary sources is necessary to maintain normal health. Since the contribution of dietary sources to blood manganese levels is significant, distinguishing the impact of environmental manganese exposure can be a significant challenge.

Another study examined low-level environmental manganese exposures in southwest Quebec (Baldwin et al., 1999; Beuter et al., 1999; Bowler et al., 1999; Mergler et al., 1999). Limited TSP air sampling data at four locations near a closed ferro and silico-alloy plant over 4 days showed manganese concentrations in the range of 0.009-0.035 μg/m^3 (Baldwin et al., 1999). The study 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). Individuals with the

highest blood manganese levels were those living in areas with highest airborne manganese and having the highest consumption of leafy green vegetables and manganese-rich cereals (Baldwin et al., 1999).

The occupational study that is the basis of the MRL and RfC evaluated exposure for manganese particles less than 5 microns. These particle sizes are considered to be the "respirable fraction", which are travel past the nose and upper respiratory system to enter the lungs. The manganese air measurements collected in East Liverpool are total suspended particulate matter. Initial characterization of particles on the TSP filters from East Liverpool indicates an aerodynamic particle size range of 4.4-24.3 microns.

Manganese Exposure in East Liverpool



*****Note: 2003 was the first year where data were collected at all locations for 12 months of the year***

Although annual manganese concentrations has declined slightly the past few years, elevated manganese in ambient air is measured regularly in community air samples. The range of daily concentrations of manganese detected at the Water Plant is within the lower range of those reported in occupational studies of chronic exposures. Given that communities are comprised of people of varying age and health status, uncertainty exists regarding the impact of these measured air concentrations on the health of East Liverpool residents, particularly sensitive populations such as children. The data presented here can be used to make inferences about human exposures but are collected intermittently (one out of six days), and may not represent worst-case exposures. Most studies of manganese exposures in humans are from occupational settings, with significantly higher exposures and healthier populations than are typically observed in communities.

Conclusions

- The air data suggest manganese concentrations in outdoor air are generally highest when the Water Plant station is downwind of the S.H. Bell State Line facility. An assessment of the effects of meteorology on ambient concentrations at the other two monitoring sites was not possible due to composite analyses at those locations.
- Manganese was the only metal identified which exceeded both background levels and health based guidelines in ambient air.
- Exposure to manganese concentrations in this community poses a public health hazard because the highest measured concentrations approach the low end of manganese air concentrations that have been associated with neurological impacts in occupational studies.
- Although there are significant uncertainties in the scientific literature regarding the effects of chronic, low level airborne manganese exposures in the general population, there is evidence suggesting that these types of exposures can cause subtle neurological effects.

Recommendations

- Ohio EPA and/or U.S. EPA should take immediate actions to reduce community exposures to manganese from fugitive dust emissions from the SH Bell facility. [Ohio issued a Director's Findings and Orders to SH Bell on February 8, 2010 that requires specific actions to reduce manganese emissions]
- Ohio EPA and USEPA should continue an air monitoring program to verify that exposure to manganese is reduced in the East Liverpool community. The air monitoring objectives should be inclusive of the potential for residual exposure to air borne manganese-containing dust from contaminated surfaces (e.g. soil and roads).
- ATSDR and Ohio Department of Health should evaluate the incidence and/or mortality rates for neurodegenerative diseases in this community, in comparison to state-wide or national rates, as a potential indicator of health impacts from exposure to manganese.
- ATSDR should convene an Expert Scientific Panel, in consultation with state and federal agencies to make recommendations regarding further evaluation of manganese exposure and health impacts in this community.

Public Health Action Plan

Action	Objective	Taken by	Status
Ohio EPA issued a Director's Findings and Orders to SH Bell that requires specific actions to reduce manganese emissions	Reduce community exposures	Ohio EPA	Completed on February 8, 2010
Continuation of Air Monitoring for Manganese	Verification that Ohio EPA enforcement actions are effective in reducing emissions and community exposures to manganese.	Ohio EPA and USEPA	Ohio EPA will continue air monitoring in the East Liverpool community. USEPA will deploy monitors to assess the respirable fraction of manganese particles.
Evaluation of incidence, prevalence, and mortality for neurodegenerative disease in East Liverpool	Determine if serious health impacts from manganese exposure have been observed	Ohio Department of Health, CDC, ATSDR	ATSDR-Division of Health Studies is conducting an evaluation of mortality rates for neurodegenerative disease in this area.
Convene Expert Scientific Panel on Health Impacts of Manganese Exposure	To make recommendations regarding further evaluation of manganese exposure and health impacts in this community.	ATSDR	To be planned

Prepared by
Michelle A. Colledge, PhD, MPH
Environmental Health Scientist
Division of Regional Operations
Region 5

Rebecca Geyer
Environmental Scientist
Materials Management Branch
Land and Chemicals Division
U.S. EPA Region 5

Reviewed by
Tina Forrester, PhD
Director
Division of Regional Operations

Clement Welsh, PhD
Deputy Director
Division of Regional Operations

Mark Johnson, PhD, DABT
Senior Environmental Health Scientist
Division of Regional Operations
Region 5

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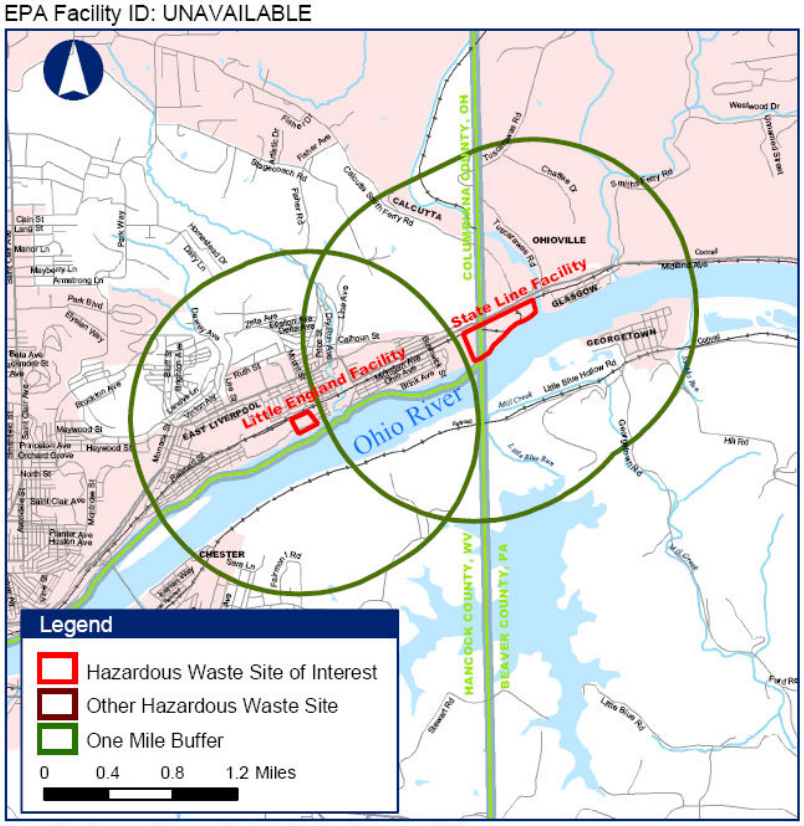
Appendix A

Area Map and Monitoring Locations

SH Bell
East Liverpool, OH

EPA Facility ID: UNAVAILABLE



Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Geospatial Research, Analysis, and Services Program, Current as of Generate Date (bottom left-hand corner).
Coordinate System (All Panels): NAD 1983 StatePlane Ohio North FIPS 3401 Feet

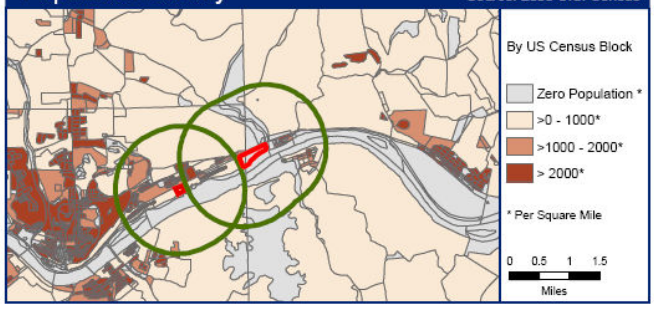
Site Location: Columbiana County, OH

Demographic Statistics Within One Mile of Site*	State Line Facility	Little England Facility
Total Population	1,495	3,584
White Alone	1,412	3,151
Black Alone	56	347
Am. Ind. /AKNative Alone	4	9
Asian Alone	4	9
Native Hawaiian & Other Pacific Islander Alone	0	1
Some Other Race Alone	0	4
Two or More Races	20	63
Hispanic or Latino**	12	22
Children Aged 6 & Younger	134	360
Adults Aged 65 & Older	237	609
Females Aged 15 to 44	317	723
Total Housing Units	612	1,528

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

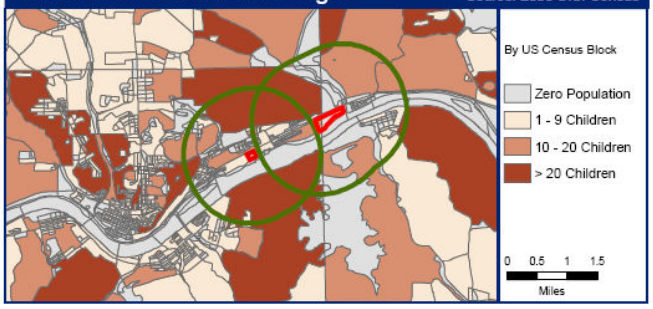
Population Density

Source: 2000 U.S. Census



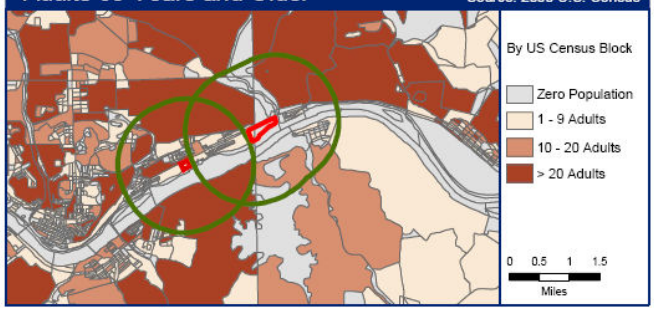
Children 6 Years and Younger

Source: 2000 U.S. Census



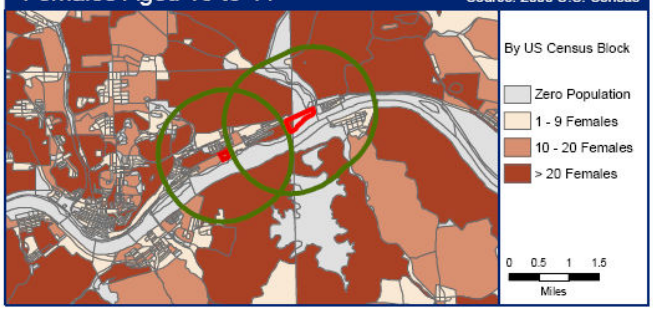
Adults 65 Years and Older

Source: 2000 U.S. Census



Females Aged 15 to 44

Source: 2000 U.S. Census



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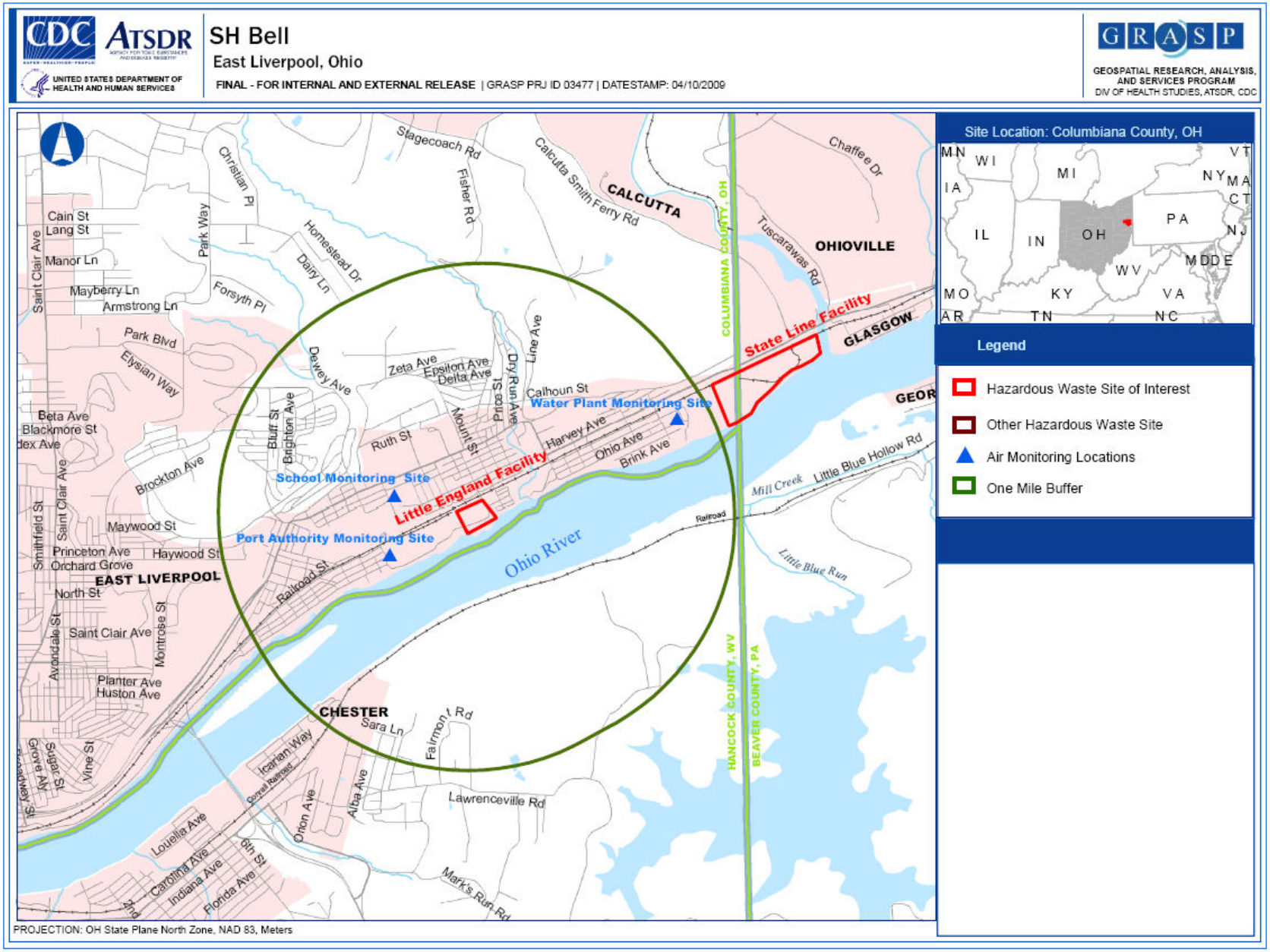


MAP AUTHOR: Jeri Anderson

Appendix B

Manganese Concentrations in Columbiana County (1999-2009): Composite Yearly Data

Table 1. Annual Average TSP Manganese Concentration by Sampling Location

Manganese in TSP, arithmetic average* (max month) [daily range], µg/m^3			
	Water Plant	**Port Authority**	**Maryland Ave**
1999	2.48 (3.29)	0.466 (0.97)	
2000	1.53 (3.00)	0.669 (1.74)	
2001	0.650 (0.92)	0.273 (0.50)	0.680 (0.86)
2003	0.969 (1.80)	0.299 (1.90)	0.144 (0.44)
2004	2.13 (3.90)	0.533 (1.40)	0.238 (0.55)
2005	1.97 (4.40) [0.093-23.0]	0.301 (0.73)	0.185 (0.50)
2006	2.216 (6.40) [0.10-25.0]	0.488 (1.70)	0.320 (0.95)
2007	1.88 (6.80) [0.056-21.0]	0.433 (0.96)	0.359 (1.00)
2008	1.53 (3.10) [0.03-11.0]	0.219 (0.44)	0.171 (0.28)
2009	0.929 (2.90) [0.05-5.6]	0.157 (0.43)	0.081 (0.26)

Note that data from 1999 were collected only Jan-March; for 2000 from March-Dec; and for 2001 in Nov-Dec only. Data were not collected at any location in 2002. Data from 2009 included measurements from Jan-Sept at the time this report was completed. Thus, "arithmetic average" may only include the average from a few observations for some years.

Figure 1. Manganese Concentration at the Water Plant (1999)

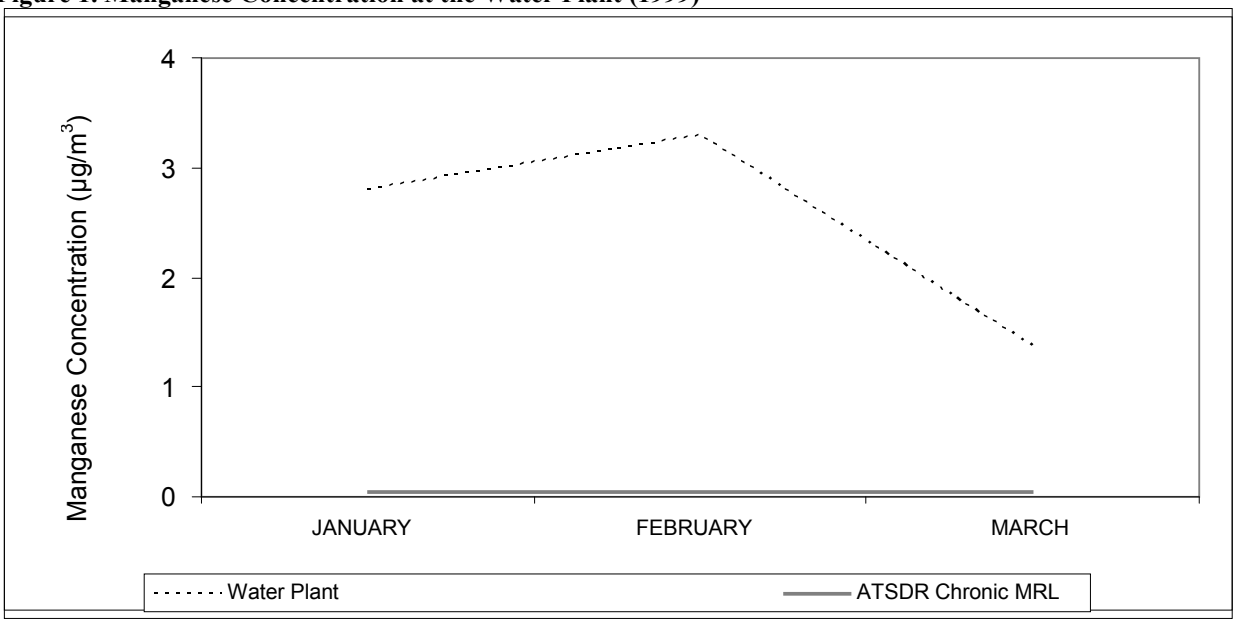


Figure 2. Manganese Concentration at the Port Authority (1999)

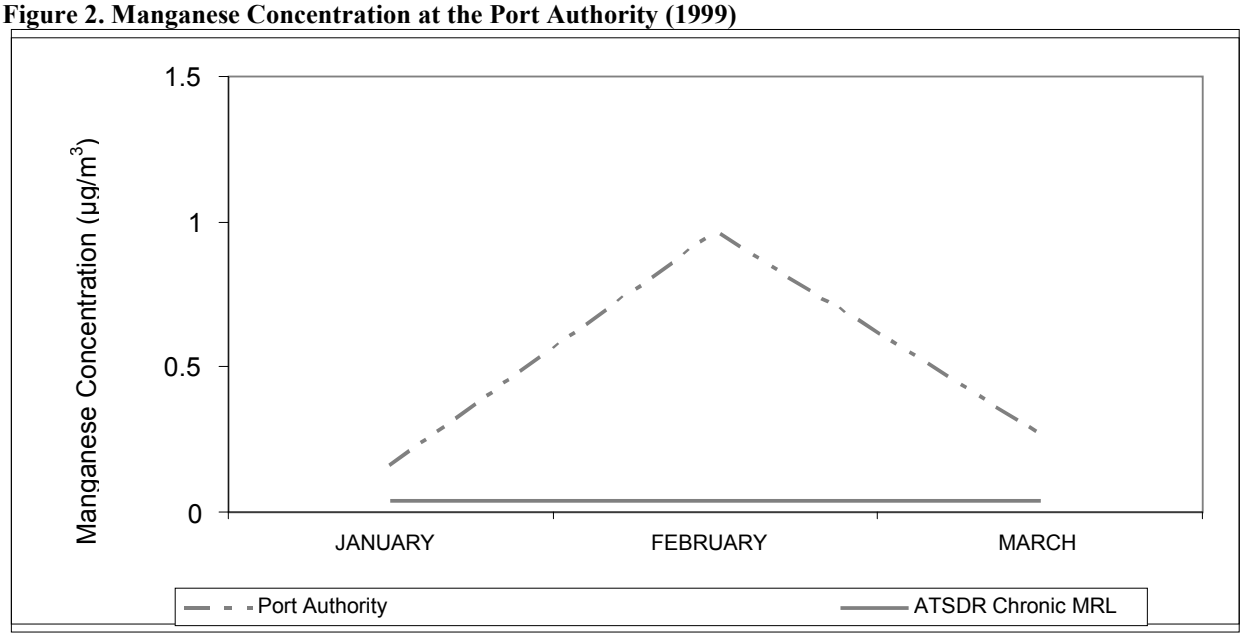


Table 2. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (1999)

Statistic	Water Plant	Port Authority
Min	1.36	0.163
Arithmetic average	2.48	0.466
Geometric average	2.32	0.349
25th percentile	2.08	0.216
50th percentile	2.8	0.269
75th percentile	3.05	0.618
90th percentile	3.19	0.827
95th percentile	3.24	0.896
99th percentile	3.28	0.952
Max	3.29	0.966
Std Deviation	1.00	0.436

Figure 3. Manganese Concentration at the Water Plant (2000)

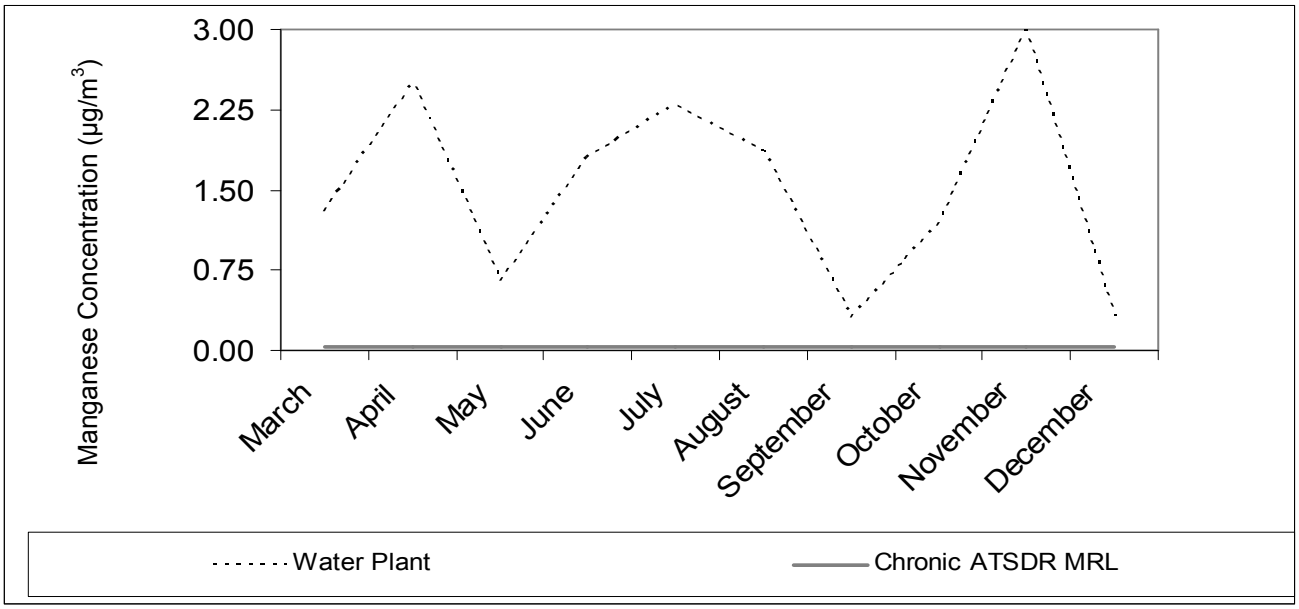


Figure 4. Manganese Concentration at the Port Authority (2000)

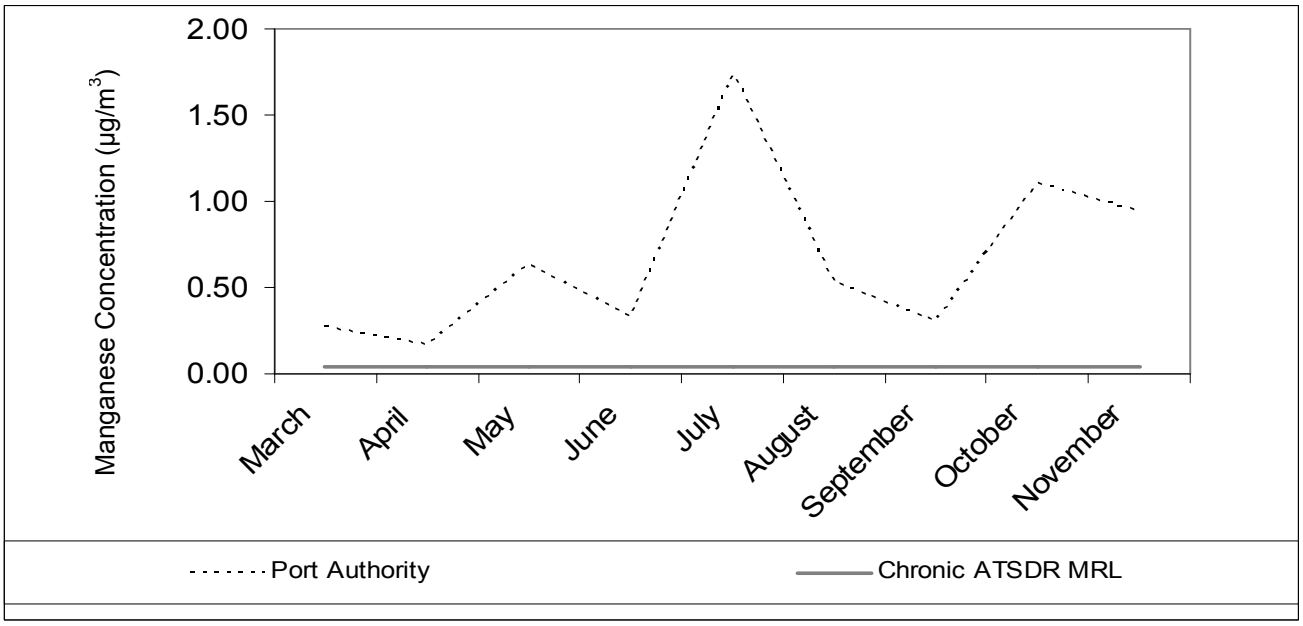


Table 3. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2000)

	Water Plant	Port Authority
Statistic		
Min	0.317	0.170
Arithmetic average	1.53	0.669
Geometric average	1.20	0.520
25th percentile	0.795	0.300
50th percentile	1.55	0.531
75th percentile	2.19	0.940
90th percentile	2.55	1.23
95th percentile	2.78	1.48
99th percentile	2.96	1.69
Max	3.00	1.74
Std Deviation	0.926	0.511

Figure 5. Manganese Concentration at the Water Plant (2001)

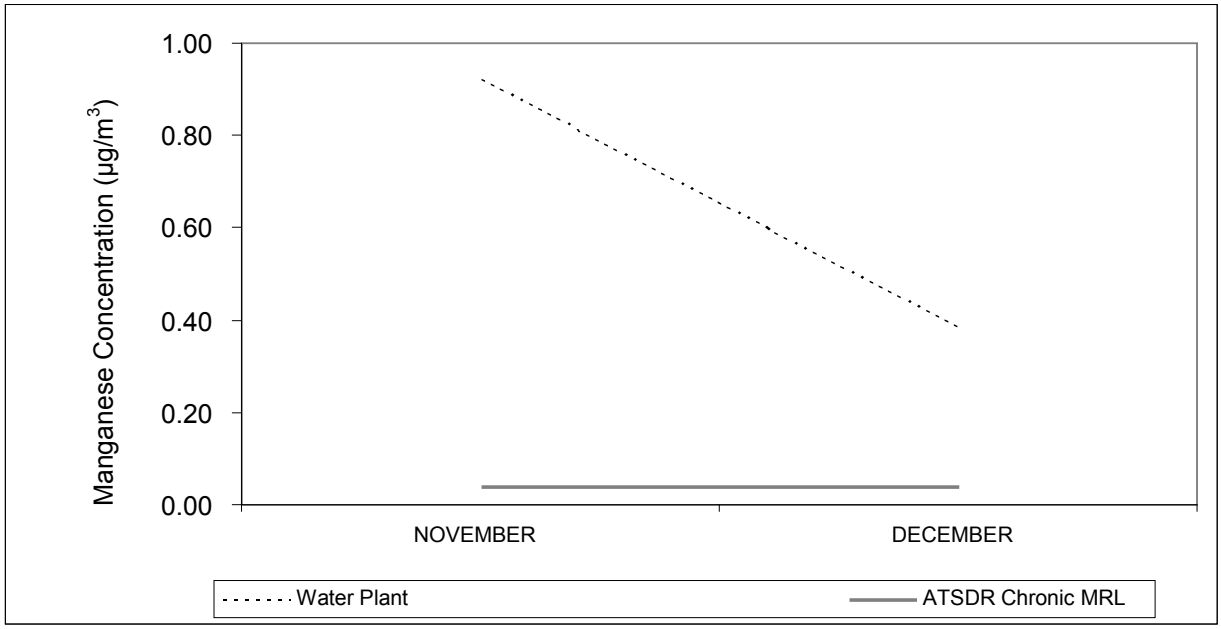


Figure 6. Manganese Concentration at the Port Authority and Maryland Ave (2001)

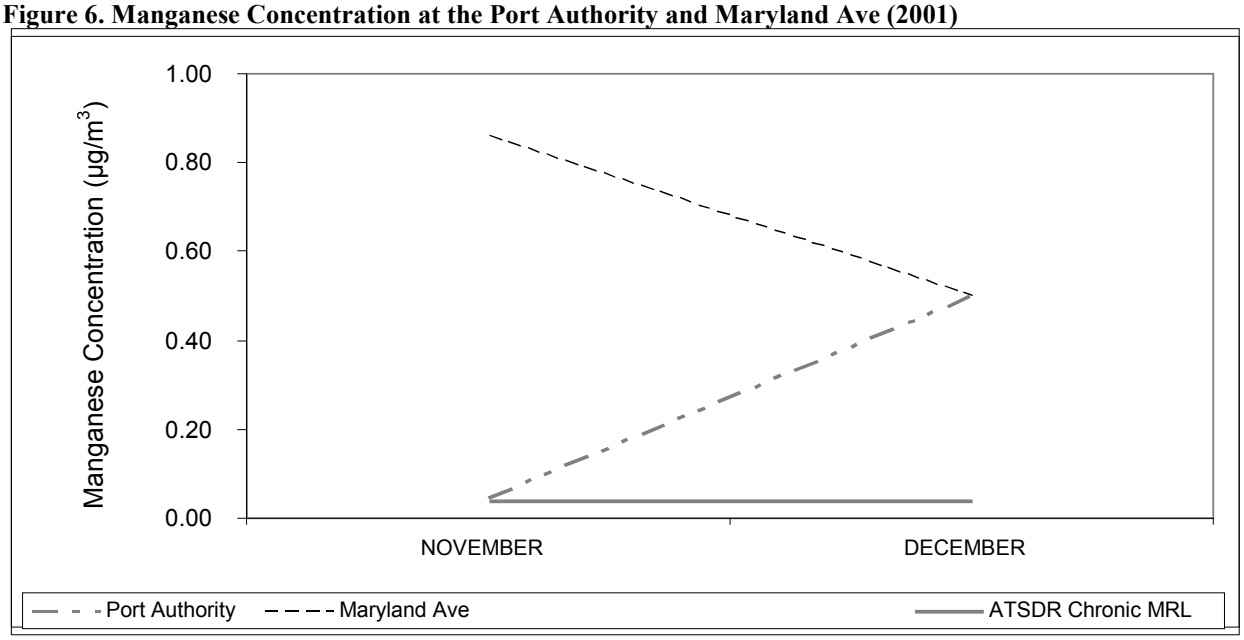


Table 4. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2001)

Statistic	Water Plant	Port Authority	Maryland Ave
Min	0.380	0.046	0.500
Arithmetic average	0.650	0.273	0.680
Geometric average	0.591	0.152	0.656
25th percentile	0.515	0.160	0.590
50th percentile	0.650	0.273	0.680
75th percentile	0.785	0.387	0.770
90th percentile	0.866	0.456	0.824
95th percentile	0.893	0.477	0.842
99th percentile	0.915	0.495	0.856
Max	0.920	0.500	0.860
Std Deviation	0.382	0.321	0.255

Figure 7. Manganese Concentration at the Water Plant (2003) (*no data were collected in 2002*)

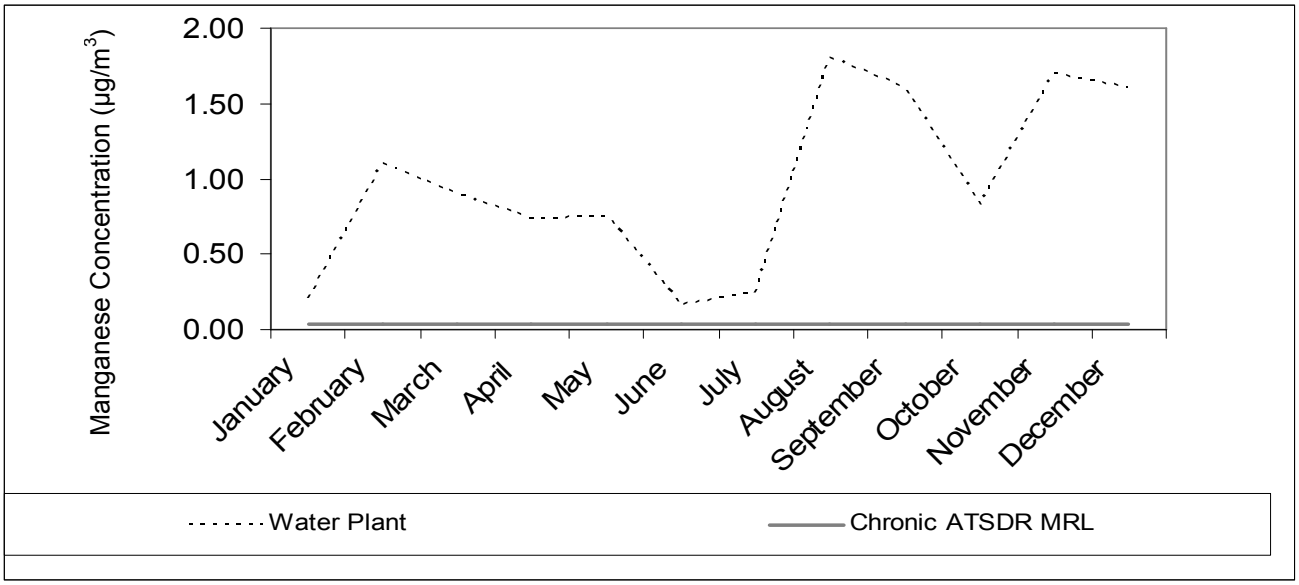


Figure 8. Manganese Concentration at the Port Authority and Maryland Ave (2003)

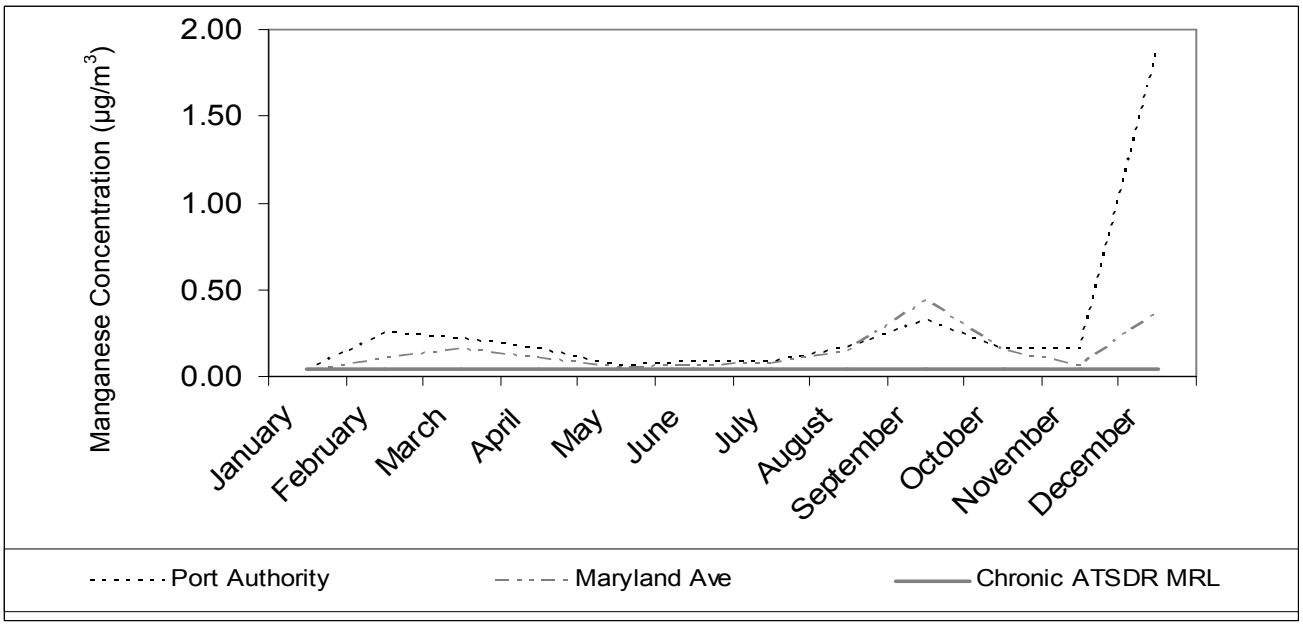


Table 5. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2003)

	Water Plant	Port Authority	Maryland Ave
Statistic			
Min	0.160	0.030	0.0300
Arithmetic average	0.969	0.299	0.144
Geometric average	0.744	0.160	0.106
25th percentile	0.615	0.085	0.062
50th percentile	0.865	0.160	0.099
75th percentile	1.60	0.228	0.145
90th percentile	1.69	0.313	0.349
95th percentile	1.75	1.03	0.402
99th percentile	1.79	1.73	0.432
Max	1.80	1.90	0.440
Std Deviation	0.597	0.511	0.129

Figure 9. Manganese Concentration at the Water Plant (2004)

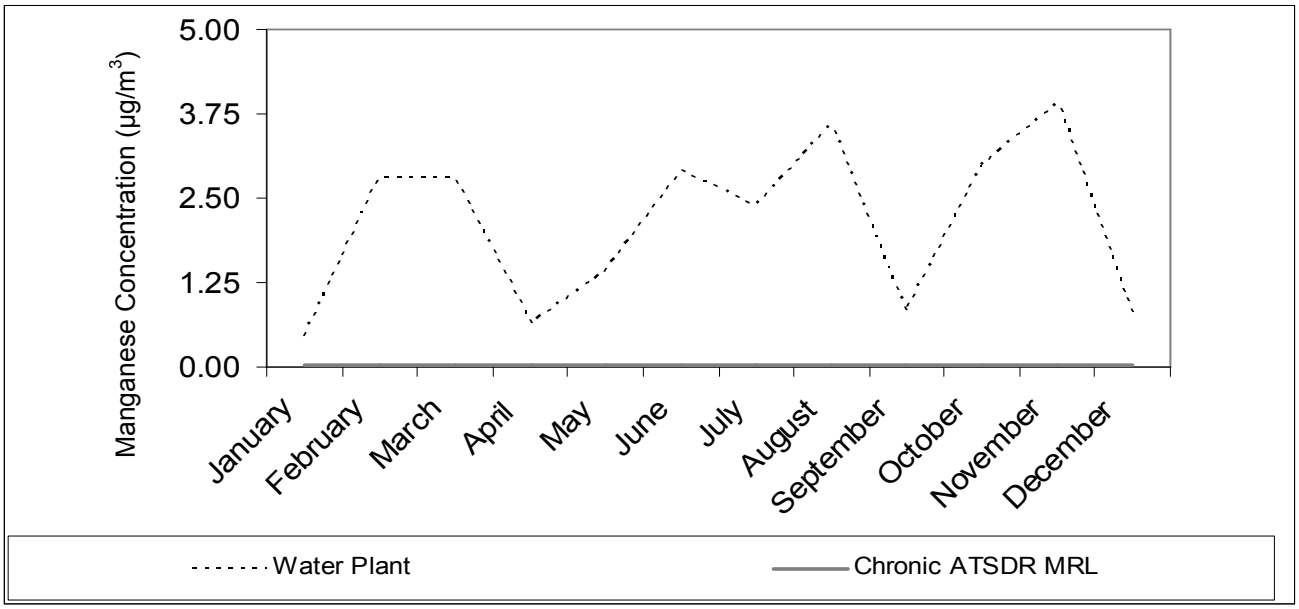


Figure 10. Manganese Concentration at the Port Authority and Maryland Ave (2004)

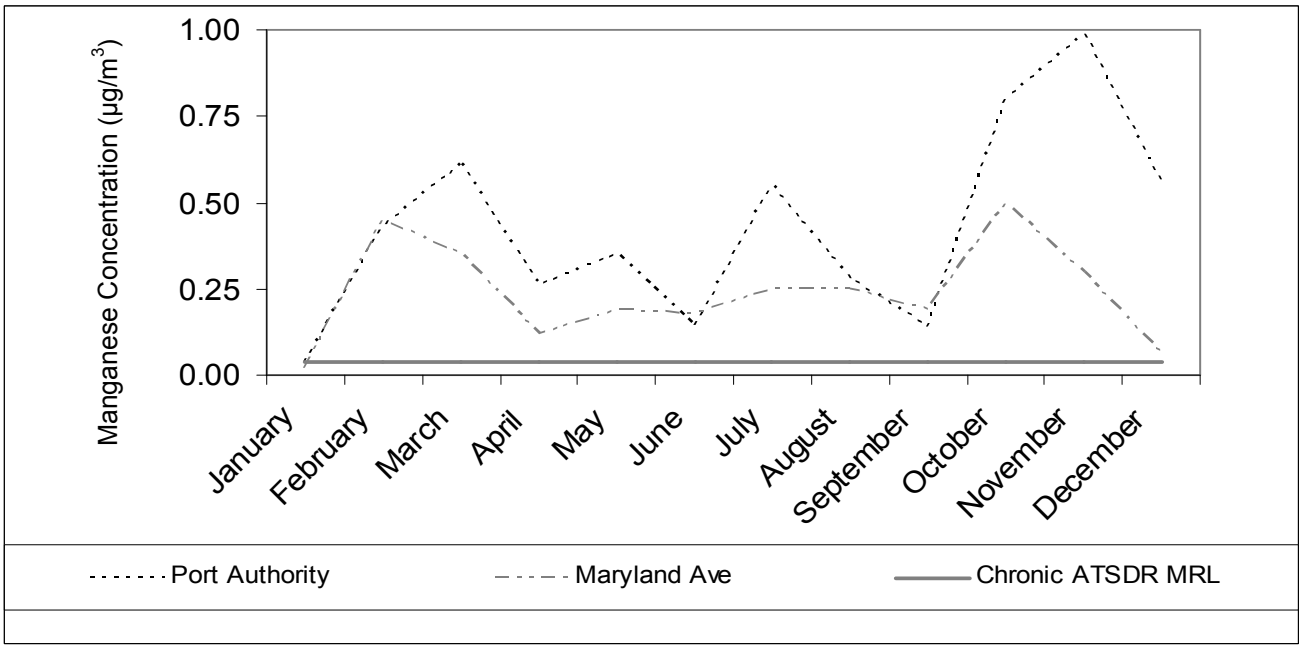


Table 6. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2004)

Statistic	Water Plant	Port Authority	Maryland Ave
Min	0.460	0.040	0.019
Arithmetic average	2.13	0.533	0.238
Geometric average	1.71	0.390	0.182
25th percentile	0.808	0.275	0.165
50th percentile	0.808	0.490	0.220
75th percentile	2.93	0.658	0.313
90th percentile	3.54	0.971	0.440
95th percentile	3.74	1.18	0.473
99th percentile	3.87	1.35	0.495
Max	3.90	1.40	0.500
Std Deviation	1.23	0.384	0.145

Figure 11. Manganese Concentration at the Water Plant (2005)

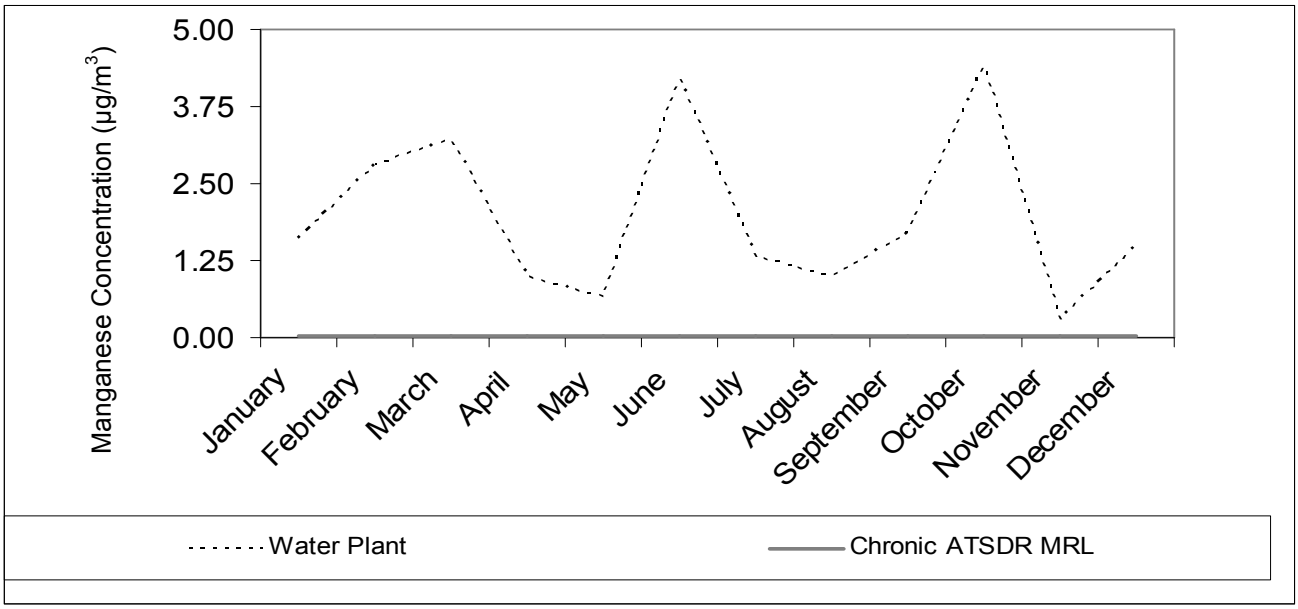


Figure 12. Manganese Concentration at the Port Authority and Maryland Ave (2005)

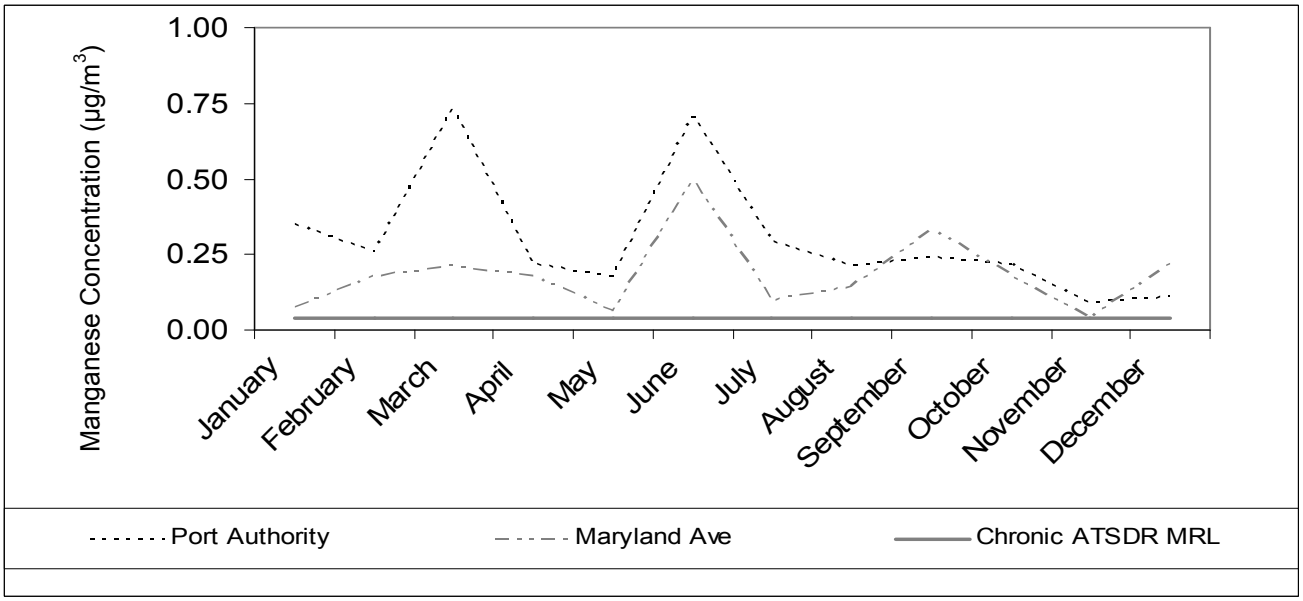


Table 7. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2005)

Statistic	Water Plant	Port Authority	Maryland Ave
Min	0.290	0.091	0.042
Arithmetic average	1.97	0.301	0.185
Geometric average	1.52	0.250	0.149
25th percentile	0.985	0.203	0.092
50th percentile	1.55	0.230	0.180
75th percentile	2.90	0.305	0.213
90th percentile	4.10	0.674	0.319
95th percentile	4.29	0.719	0.407
99th percentile	4.38	0.728	0.481
Max	4.40	0.730	0.500
Std Deviation	1.37	0.208	0.128

Figure 13. Manganese Concentration at the Water Plant (2006)

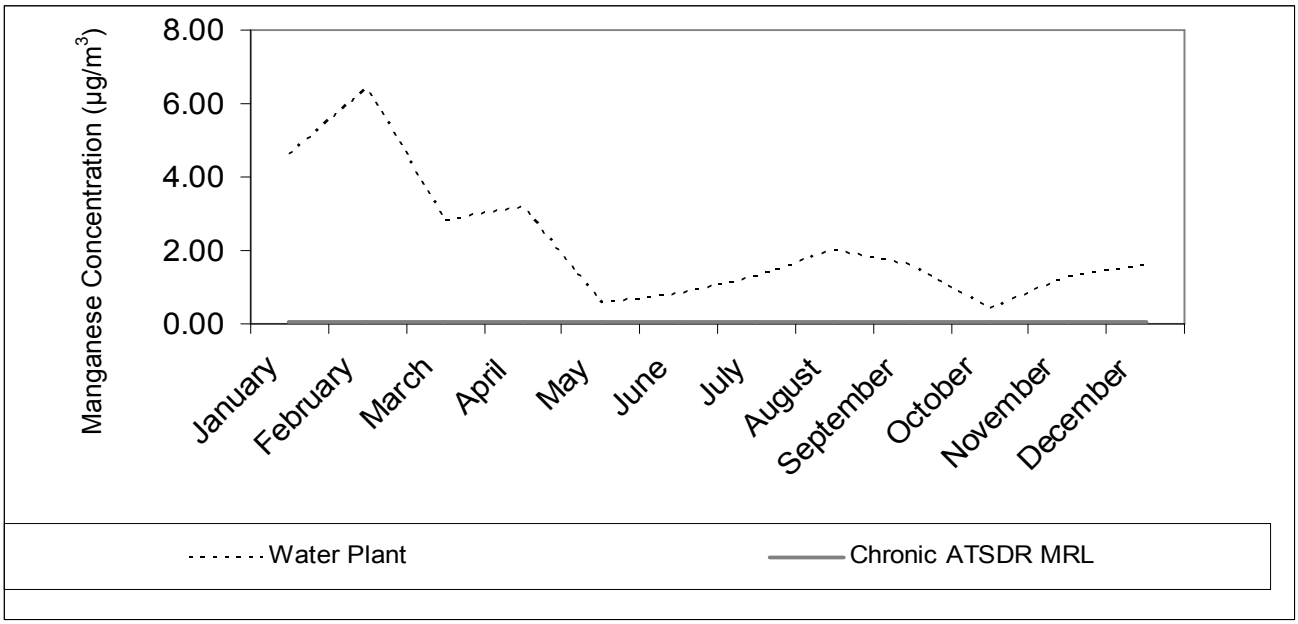


Figure 14. Manganese Concentration at the Port Authority and Maryland Ave (2006)

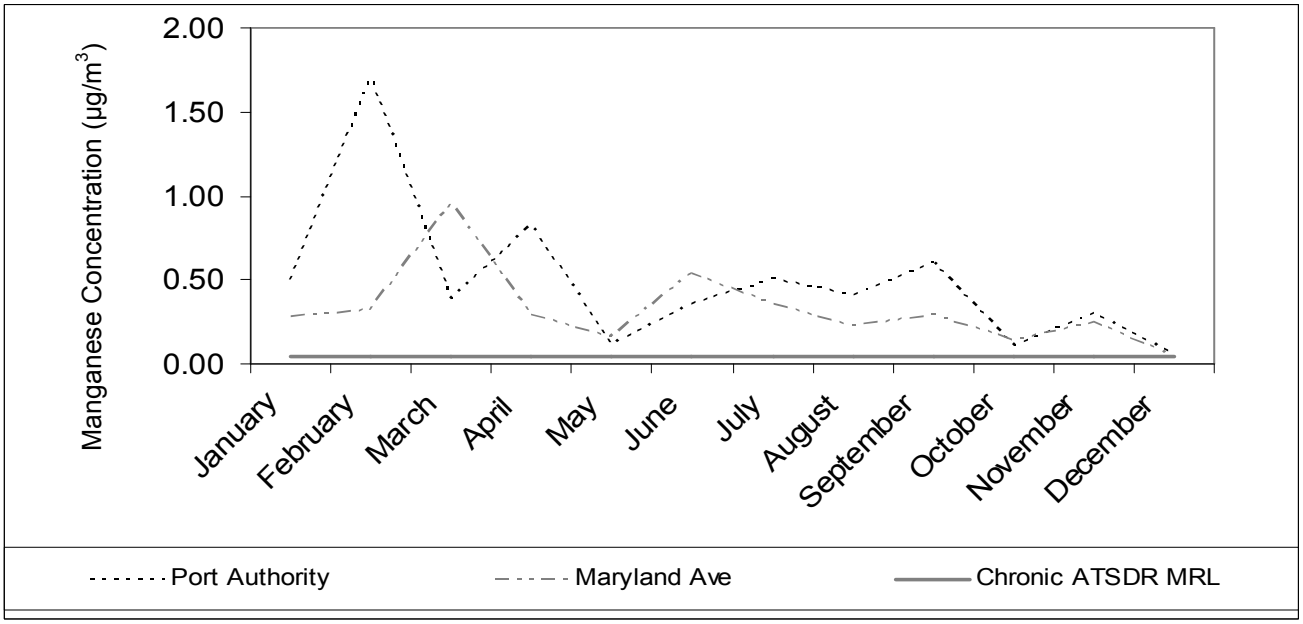


Table 8. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2006)

Statistic	Water Plant	Port Authority	Maryland Ave
Min	0.420	0.058	0.048
Arithmetic average	2.216	0.488	0.320
Geometric average	1.66	0.343	0.256
25th percentile	1.18	0.255	0.205
50th percentile	1.60	0.400	0.285
75th percentile	2.90	0.525	0.328
90th percentile	4.46	0.798	0.521
95th percentile	5.41	1.22	0.725
99th percentile	6.20	1.60	0.905
Max	6.40	1.70	0.950
Std Deviation	1.78	0.439	0.233

Figure 15. Manganese Concentration at the Water Plant (2007)

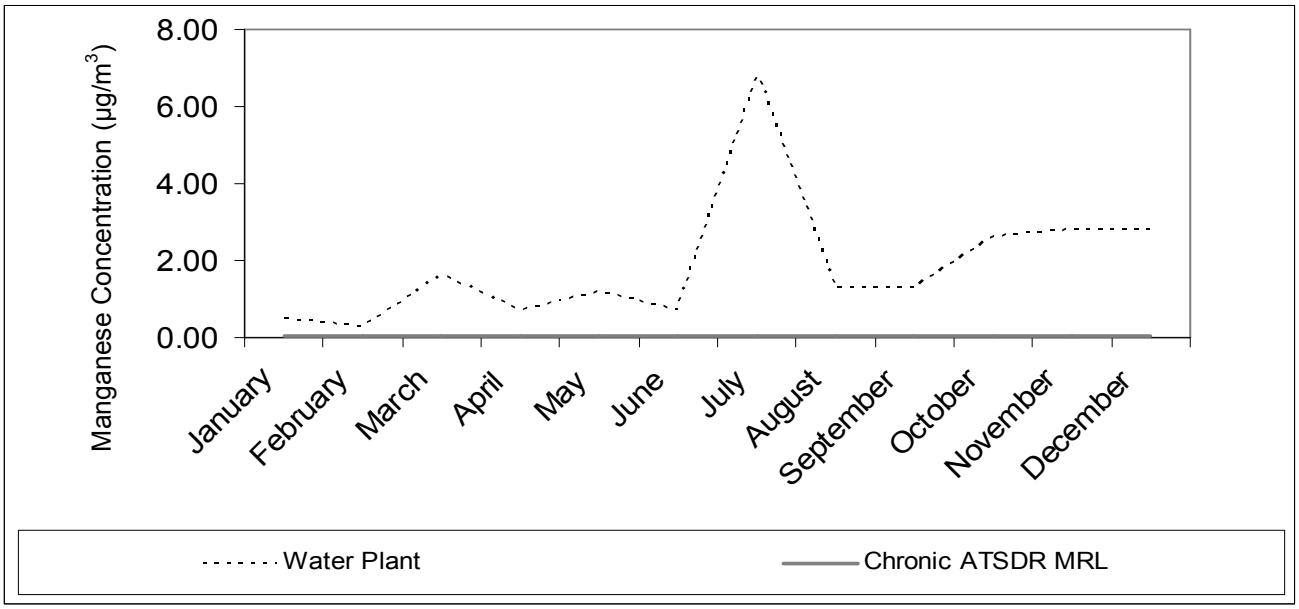


Figure 16. Manganese Concentration at the Port Authority and Maryland Ave (2007)

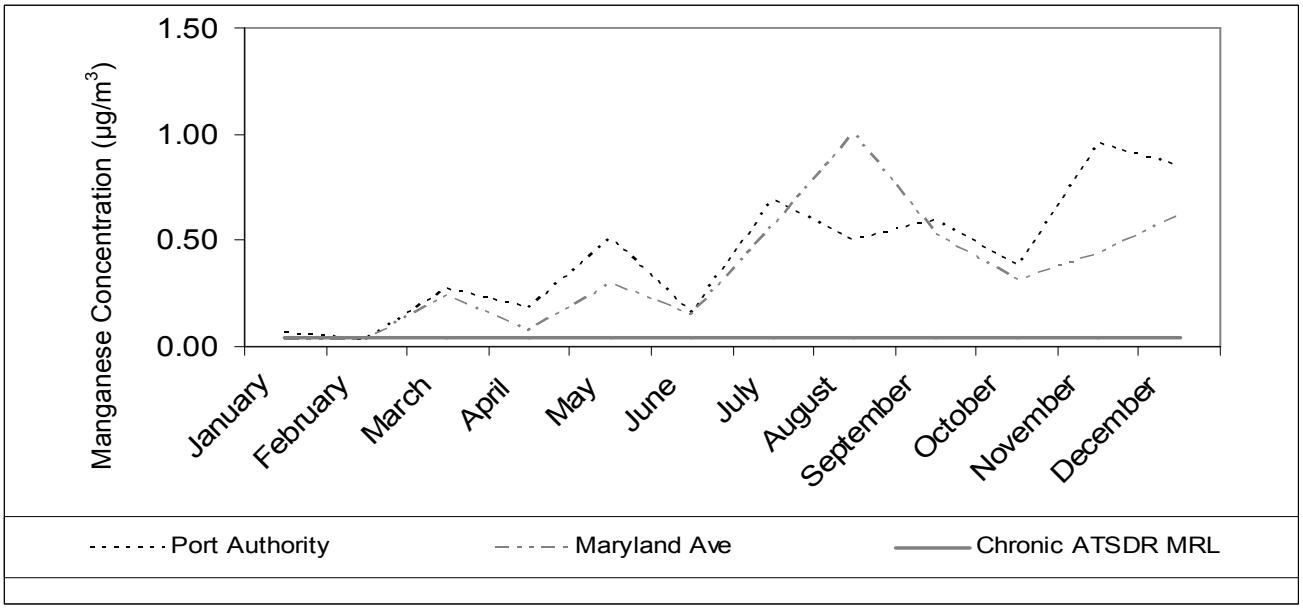


Table 9. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2007)

Statistic	Water Plant	Port Authority	Maryland Ave
Min	0.280	0.036	0.032
Arithmetic average	1.88	0.433	0.359
Geometric average	1.33	0.302	0.230
25th percentile	0.728	0.175	0.132
50th percentile	1.30	0.440	0.305
75th percentile	2.65	0.615	0.540
90th percentile	2.80	0.834	0.615
95th percentile	4.60	0.899	0.791
99th percentile	6.36	0.948	0.958
Max	6.80	0.960	1.000
Std Deviation	1.78	0.304	0.289

Figure 17. Manganese Concentration at the Water Plant (2008)

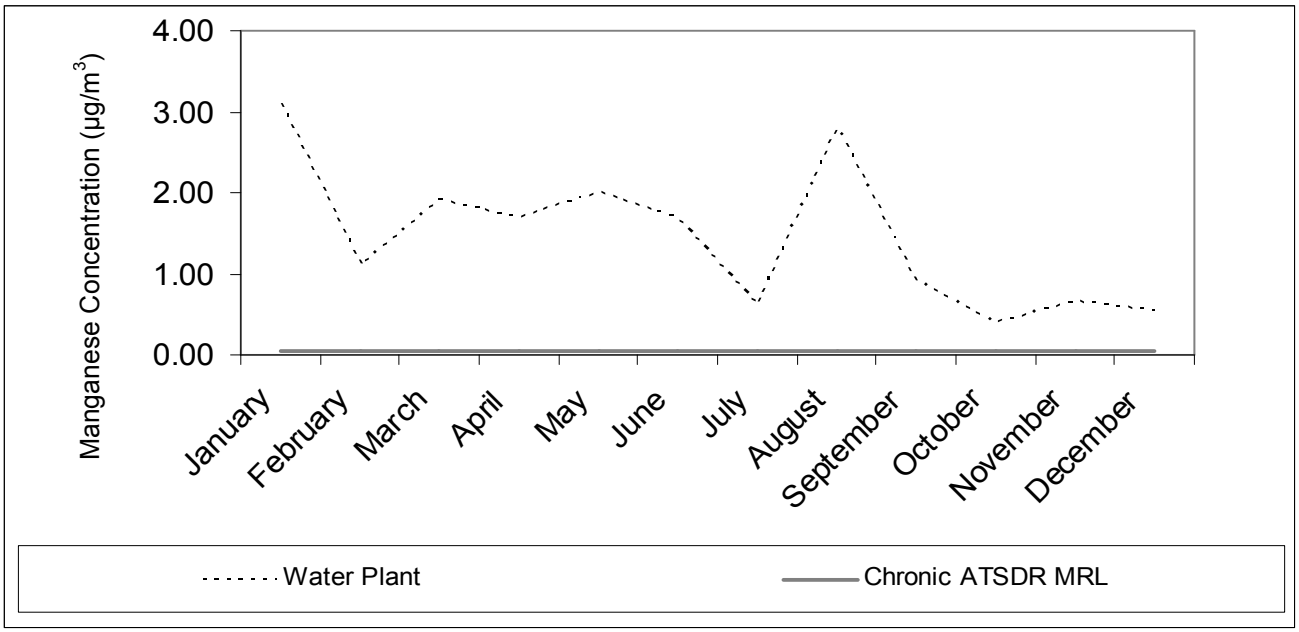


Figure 18. Manganese Concentration at the Port Authority and Maryland Ave (2008)

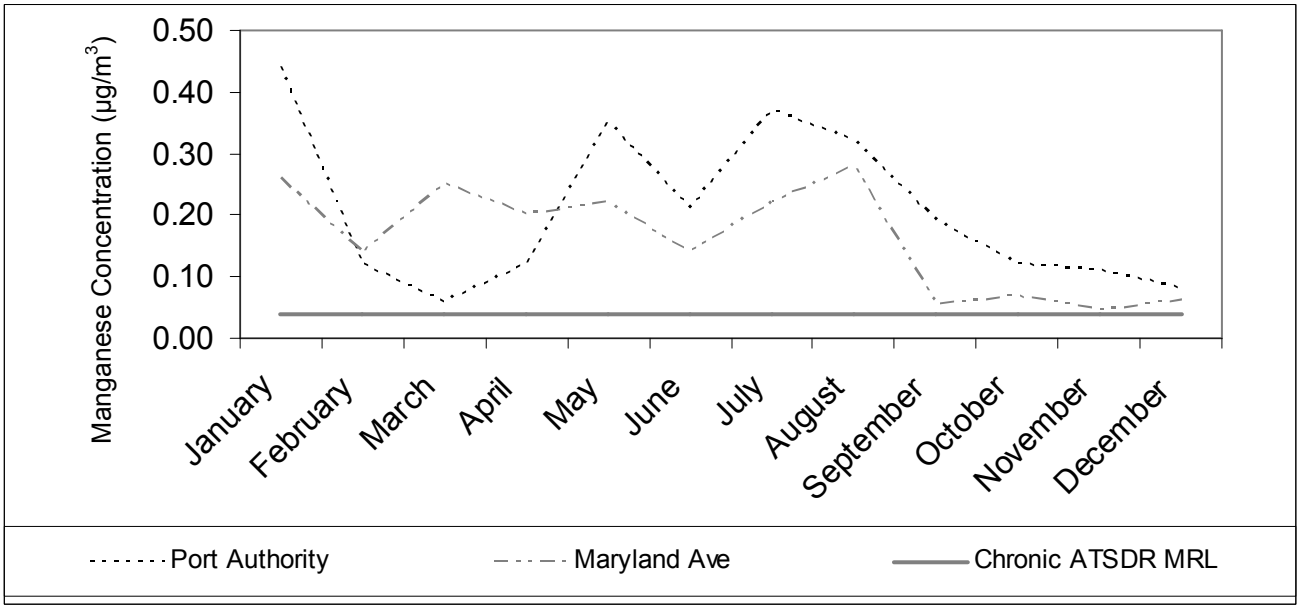


Table 10. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2008)

Statistic	Water Plant	Port Authority	Maryland Ave
Min	0.400	0.059	0.047
Arithmetic average	1.53	0.219	0.171
Geometric average	1.28	0.184	0.145
25th percentile	0.785	0.120	0.104
50th percentile	1.70	0.190	0.200
75th percentile	1.95	0.335	0.235
90th percentile	2.80	0.370	0.260
95th percentile	2.95	0.405	0.270
99th percentile	3.07	0.433	0.278
Max	3.10	0.440	0.280
Std Deviation	0.891	0.129	0.085

Figure 19. Manganese Concentration at the Water Plant (2009)

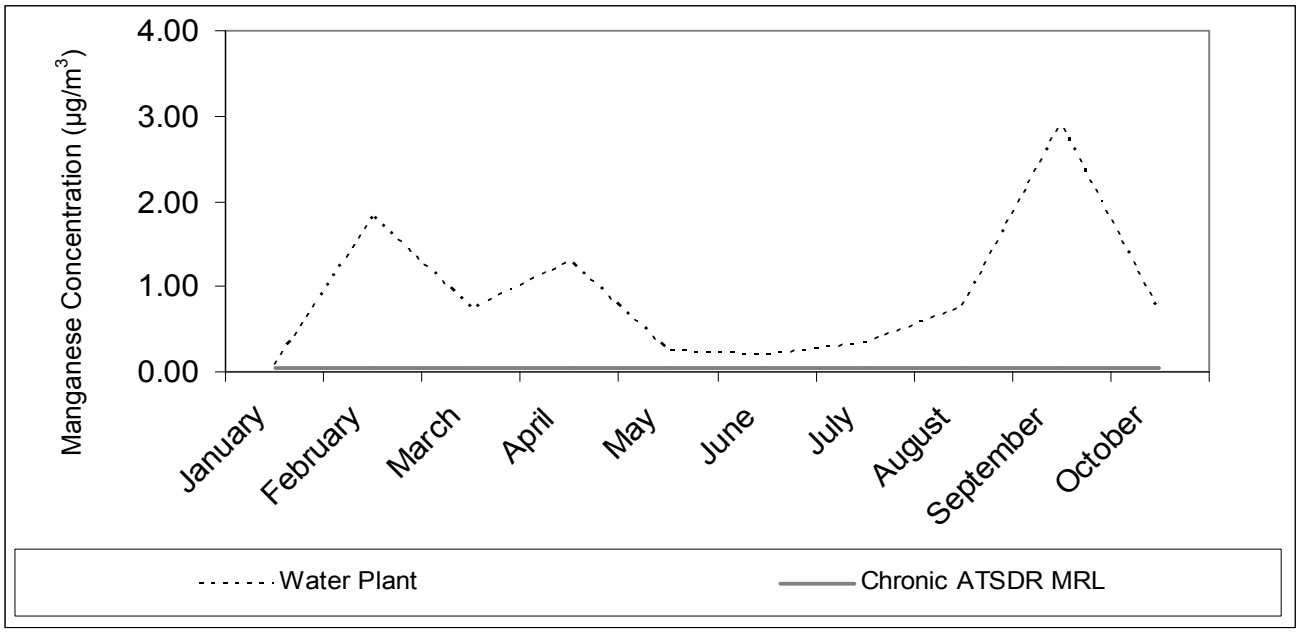


Figure 20. Manganese Concentration at the Port Authority and Maryland Ave (2009)

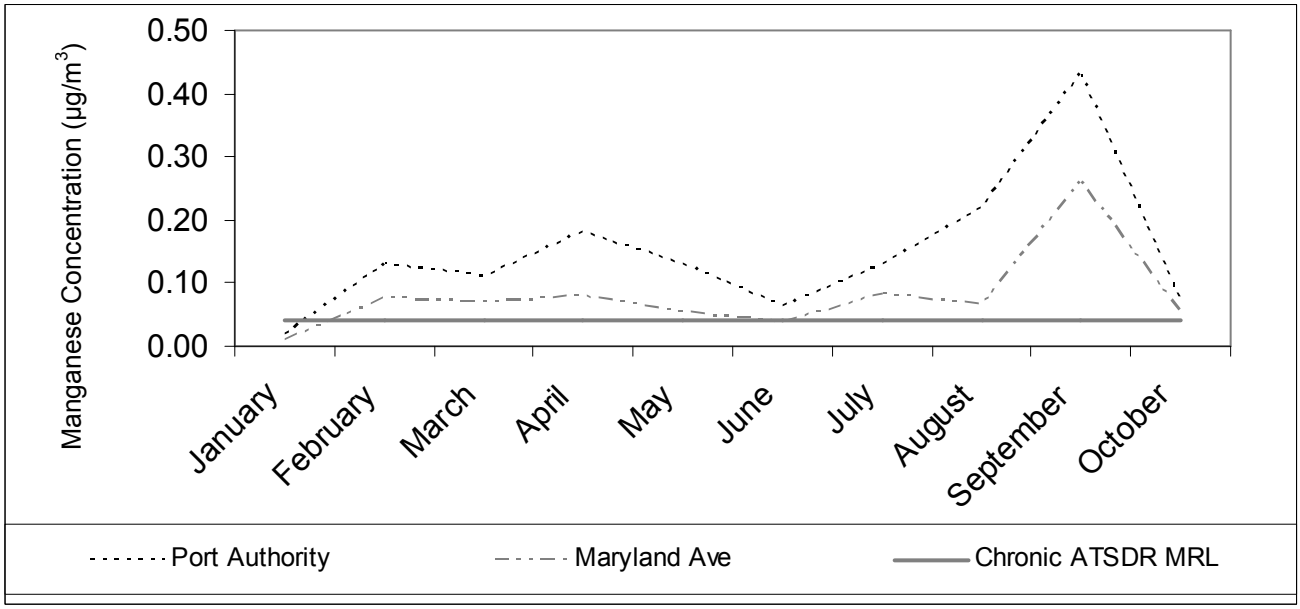


Table 11. Summary Statistics for Manganese Concentration (µg/m^3) in Columbiana County (2009)

Statistic	Water Plant	Port Authority	Maryland Ave
Min	0.100	0.018	0.009
Arithmetic average	0.929	0.157	0.081
Geometric average	0.565	0.119	0.061
25th percentile	0.240	0.110	0.055
50th percentile	0.730	0.130	0.069
75th percentile	1.30	0.180	0.079
90th percentile	2.02	0.262	0.117
95th percentile	2.46	0.346	0.188
99th percentile	2.81	0.413	0.246
Max	2.90	0.430	0.260
Std Deviation	0.929	0.118	0.071

Figure 21. Time series trend of monthly composite samples collected at the Water Plant monitoring station-all available data

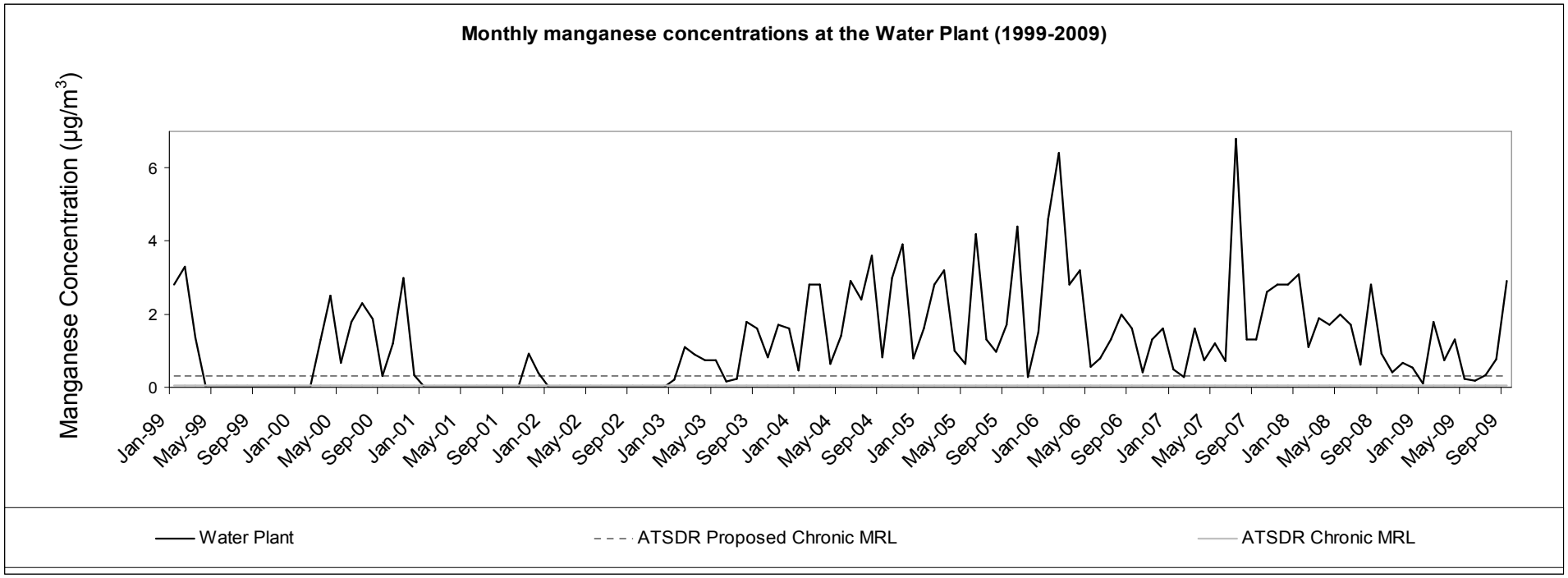


Figure 22. Time series trend of monthly composite samples collected at the Port Authority and Maryland Avenue monitoring station-all available data

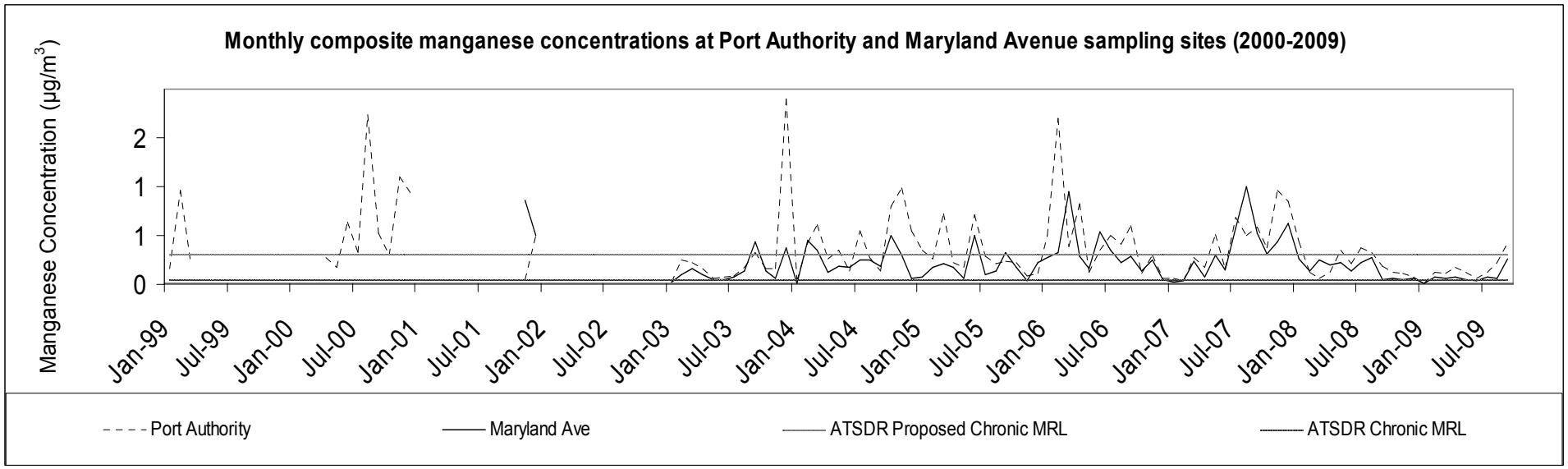
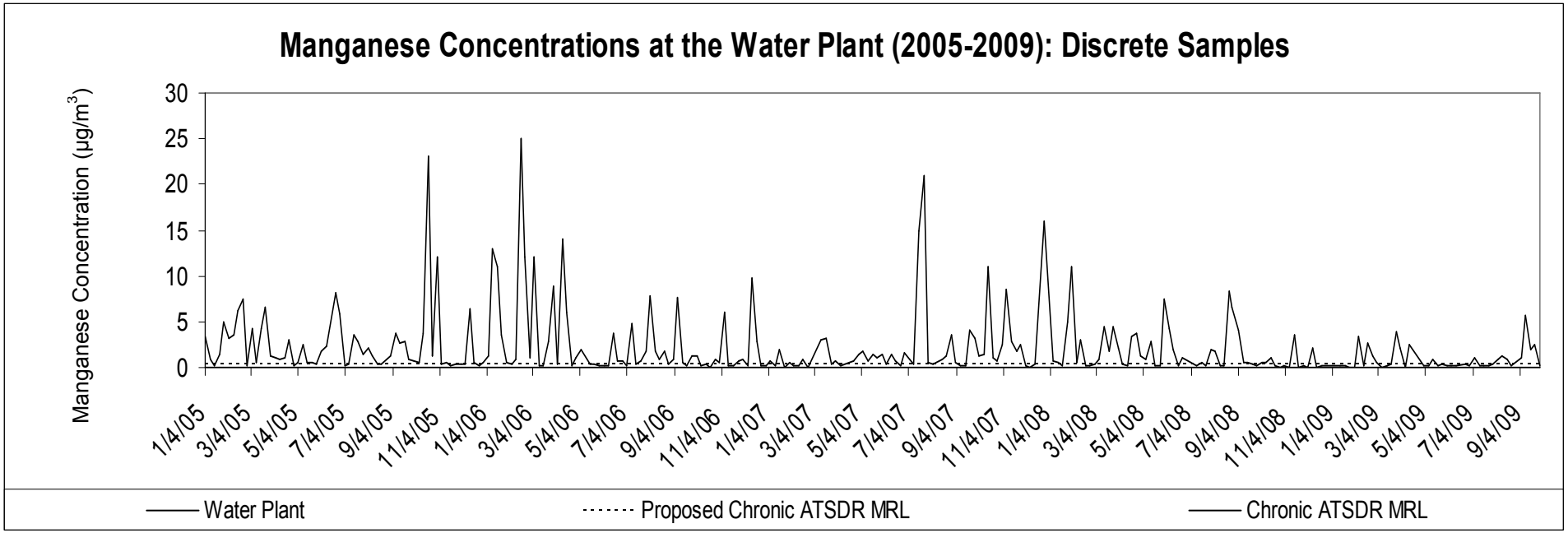


Figure 23. Time series trend of daily samples collected at the Water Plant monitoring station-all available data



Appendix C

Manganese Concentrations in Columbiana County (1999-2008) Raw Data

Table 1. Manganese Concentrations in Columbiana County Raw Data (1999-2009): Composite Samples

	MANGANESE in ug/m^3		
Date	**Water Plant**	**Port Authority**	**Maryland Avenue**
Jan-99	2.800	0.163	
Feb-99	3.290	0.966	
Mar-99	1.360	0.269	
Mar-00	1.300		
Apr-00	2.500	0.270	
May-00	0.660	0.170	
Jun-00	1.800	0.640	
Jul-00	2.300	0.330	
Aug-00	1.870	1.740	
Sep-00	0.317	0.531	
Oct-00	1.200	0.300	
Nov-00	3.000	1.100	
Dec-00	0.330	0.940	
Nov-01	0.920	0.046	0.860
Dec-01	0.380	0.500	0.500
Jan-03	0.210	0.030	0.030
Feb-03	1.100	0.250	0.099
Mar-03	0.900	0.220	0.160
Apr-03	0.740	0.160	0.100
May-03	0.750	0.058	0.053
Jun-03	0.160	0.081	0.057
Jul-03	0.240	0.086	0.072
Aug-03	1.800	0.170	0.140
Sep-03	1.600	0.320	0.440
Oct-03	0.830	0.160	0.140
Nov-03	1.700	0.160	0.064
Dec-03	1.600	1.900	0.370
Jan-04	0.460	0.040	0.019
Feb-04	2.800	0.430	0.450
Mar-04	2.800	0.610	0.350
Apr-04	0.640	0.260	0.120
May-04	1.400	0.350	0.190
Jun-04	2.900	0.140	0.180
Jul-04	2.400	0.550	0.250
Aug-04	3.600	0.280	0.250
Sep-04	0.810	0.140	0.190
Oct-04	3.000	0.800	0.500
Nov-04	3.900	0.990	0.300
Dec-04	0.800	0.550	0.061
Jan-05	1.600	0.350	0.074
Feb-05	2.800	0.260	0.180
Mar-05	3.200	0.730	0.210
Apr-05	0.990	0.220	0.180
May-05	0.640	0.180	0.064
Jun-05	4.200	0.710	0.500
Jul-05	1.300	0.290	0.098
Aug-05	0.970	0.210	0.140
Sep-05	1.700	0.240	0.330

Date	Water Plant	Port Authority	Maryland Avenue
Oct-05	4.400	0.220	0.180
Nov-05	0.290	0.091	0.042
Dec-05	1.500	0.110	0.220
Jan-06	4.600	0.500	0.280
Feb-06	6.400	1.700	0.320
Mar-06	2.800	0.390	0.950
Apr-06	3.200	0.820	0.290
May-06	0.570	0.120	0.160
Jun-06	0.800	0.350	0.540
Jul-06	1.300	0.500	0.350
Aug-06	2.000	0.410	0.220
Sep-06	1.600	0.600	0.290
Oct-06	0.420	0.110	0.140
Nov-06	1.300	0.300	0.250
Dec-06	1.600	0.058	0.048
Jan-07	0.480	0.065	0.032
Feb-07	0.280	0.036	0.033
Mar-07	1.600	0.270	0.240
Apr-07	0.730	0.180	0.077
May-07	1.200	0.510	0.300
Jun-07	0.720	0.160	0.150
Jul-07	6.800	0.690	0.570
Aug-07	1.300	0.500	1.000
Sep-07	1.300	0.590	0.530
Oct-07	2.600	0.380	0.310
Nov-07	2.800	0.960	0.440
Dec-07	2.800	0.850	0.620
Jan-08	3.100	0.440	0.260
Feb-08	1.100	0.120	0.140
Mar-08	1.900	0.059	0.250
Apr-08	1.700	0.120	0.200
May-08	2.000	0.350	0.220
Jun-08	1.700	0.210	0.140
Jul-08	0.610	0.370	0.220
Aug-08	2.800	0.320	0.280
Sep-08	0.910	0.190	0.056
Oct-08	0.400	0.120	0.067
Nov-08	0.660	0.110	0.047
Dec-08	0.530	0.080	0.063
Jan-09	0.100	0.018	0.009
Feb-09	1.800	0.130	0.075
Mar-09	0.730	0.110	0.069
Apr-09	1.300	0.180	0.079
May-09	0.240	0.130	0.055
Jun-09	0.190	0.063	0.039
Jul-09	0.340	0.130	0.081
Aug-09	0.760	0.220	0.066
Sep-09	2.900	0.430	0.260

Table 2. Manganese Concentration at the Water Plant Raw Data (2005-2009): Discrete Samples

Date	Water Plant	Date	Water Plant	Date	Water Plant
4-Jan-05	3.400	31-Oct-05	12.000		
10-Jan-05	0.830	6-Nov-05	0.420	27-Aug-06	0.290
16-Jan-05	0.093	12-Nov-05	0.560	2-Sep-06	0.960
22-Jan-05	1.500	18-Nov-05	0.160	8-Sep-06	7.600
28-Jan-05	4.900	24-Nov-05	0.300	14-Sep-06	0.480
3-Feb-05	3.200	30-Nov-05	0.370	20-Sep-06	0.260
9-Feb-05	3.600	6-Dec-05	0.280	26-Sep-06	1.300
15-Feb-05	6.300	12-Dec-05	6.400	2-Oct-06	1.300
21-Feb-05	7.400	18-Dec-05	0.610	8-Oct-06	0.210
27-Feb-05	0.170	24-Dec-05	0.210	14-Oct-06	0.310
5-Mar-05	4.200	30-Dec-05	0.490	20-Oct-06	0.075
11-Mar-05	0.470	5-Jan-06	1.200	26-Oct-06	0.840
17-Mar-05	4.200	11-Jan-06	13.000	1-Nov-06	0.530
23-Mar-05	6.600	17-Jan-06	11.000	7-Nov-06	6.100
29-Mar-05	1.200	23-Jan-06	3.500	13-Nov-06	0.240
4-Apr-05	0.990	29-Jan-06	0.600	19-Nov-06	0.110
10-Apr-05	0.970	4-Feb-06	0.320	25-Nov-06	0.690
16-Apr-05	1.100	10-Feb-06	0.920	1-Dec-06	0.900
22-Apr-05	3.100	16-Feb-06	25.000	7-Dec-06	0.170
28-Apr-05	0.190	22-Feb-06	12.000	13-Dec-06	9.800
4-May-05	0.560	28-Feb-06	1.000	19-Dec-06	2.800
10-May-05	2.400	6-Mar-06	12.000	25-Dec-06	0.250
16-May-05	0.470	12-Mar-06	0.250	31-Dec-06	0.220
22-May-05	0.480	18-Mar-06	0.190	6-Jan-07	0.680
28-May-05	0.310	24-Mar-06	2.900	12-Jan-07	0.150
3-Jun-05	1.700	30-Mar-06	8.800	18-Jan-07	1.900
9-Jun-05	2.300	5-Apr-06	0.420	24-Jan-07	0.031
21-Jun-05	8.200	11-Apr-06	14.000	30-Jan-07	0.560
27-Jun-05	5.800	17-Apr-06	6.100	5-Feb-07	0.120
3-Jul-05	0.140	23-Apr-06	0.100	11-Feb-07	0.160
9-Jul-05	0.280	29-Apr-06	1.100	17-Feb-07	0.850
15-Jul-05	3.500	5-May-06	1.900	23-Feb-07	0.073
21-Jul-05	2.800	17-May-06	0.340	13-Mar-07	3.000
27-Jul-05	1.500	23-May-06	0.410	19-Mar-07	3.200
2-Aug-05	2.200	29-May-06	0.120	25-Mar-07	0.410
8-Aug-05	1.300	4-Jun-06	0.110	31-Mar-07	0.680
14-Aug-05	0.290	10-Jun-06	0.200	6-Apr-07	0.260
20-Aug-05	0.370	16-Jun-06	3.800	24-Apr-07	0.680
1-Sep-05	1.300	22-Jun-06	0.740	30-Apr-07	1.400
7-Sep-05	3.700	28-Jun-06	0.680	6-May-07	1.800
13-Sep-05	2.600	4-Jul-06	0.120	12-May-07	0.740
19-Sep-05	2.900	10-Jul-06	4.800	18-May-07	1.400
25-Sep-05	0.830	16-Jul-06	0.380	24-May-07	1.100
1-Oct-05	0.630	22-Jul-06	0.760	30-May-07	1.400
7-Oct-05	0.490	28-Jul-06	1.800	5-Jun-07	0.360
13-Oct-05	3.700	3-Aug-06	7.800	11-Jun-07	1.500
19-Oct-05	23.000	9-Aug-06	1.700	17-Jun-07	0.630
25-Oct-05	1.300	15-Aug-06	0.940	23-Jun-07	0.140
29-Jun-07	1.600	21-Aug-06	1.800	5-Jul-07	0.840

Date	Water Plant	Date	Water Plant	Date	Water Plant
11-Jul-07	0.340	18-May-08	0.090	7-Apr-09	0.04
17-Jul-07	15.000	24-May-08	0.160	13-Apr-09	2.50
23-Jul-07	21.000	30-May-08	7.400	1-May-09	0.12
29-Jul-07	0.560	5-Jun-08	4.200	7-May-09	0.12
4-Aug-07	0.340	11-Jun-08	2.000	13-May-09	0.93
16-Aug-07	0.900	17-Jun-08	0.130	19-May-09	0.18
22-Aug-07	1.300	23-Jun-08	0.980	25-May-09	0.38
28-Aug-07	3.500	11-Jul-08	0.150	31-May-09	0.16
3-Sep-07	0.620	17-Jul-08	0.580	6-Jun-09	0.22
9-Sep-07	0.160	23-Jul-08	0.120	12-Jun-09	0.24
15-Sep-07	0.200	29-Jul-08	1.900	24-Jun-09	0.36
21-Sep-07	4.000	4-Aug-08	1.800	30-Jun-09	0.10
27-Sep-07	3.200	10-Aug-08	0.160	6-Jul-09	0.99
3-Oct-07	1.200	16-Aug-08	0.140	12-Jul-09	0.23
9-Oct-07	1.400	22-Aug-08	8.300	18-Jul-09	0.20
15-Oct-07	11.000	26-Aug-08	6.500	24-Jul-09	0.11
21-Oct-07	1.100	3-Sep-08	4.100	30-Jul-09	0.35
27-Oct-07	0.720	9-Sep-08	0.560	5-Aug-09	0.88
2-Nov-07	2.400	15-Sep-08	0.580	11-Aug-09	1.30
8-Nov-07	8.600	21-Sep-08	0.350	17-Aug-09	0.84
14-Nov-07	2.800	27-Sep-08	0.240	23-Aug-09	0.10
20-Nov-07	1.700	3-Oct-08	0.620	4-Sep-09	0.98
26-Nov-07	2.400	9-Oct-08	0.590	10-Sep-09	5.60
2-Dec-07	0.210	15-Oct-08	1.100	16-Sep-09	1.90
8-Dec-07	0.056	21-Oct-08	0.130	22-Sep-09	2.50
14-Dec-07	0.390	27-Oct-08	0.062	28-Sep-09	0.23
26-Dec-07	16.000	2-Nov-08	0.260		
7-Jan-08	0.720	8-Nov-08	0.074		
13-Jan-08	0.450	14-Nov-08	3.600		
19-Jan-08	0.190	20-Nov-08	0.032		
25-Jan-08	4.900	26-Nov-08	0.220		
31-Jan-08	11.000	2-Dec-08	0.03		
6-Feb-08	0.530	8-Dec-08	2.20		
12-Feb-08	3.100	14-Dec-08	0.06		
18-Feb-08	0.260	20-Dec-08	0.09		
24-Feb-08	0.160	13-Jan-09	0.11		
1-Mar-08	0.270	19-Jan-09	0.23		
7-Mar-08	0.830	25-Jan-09	0.08		
13-Mar-08	4.400	31-Jan-09	0.05		
19-Mar-08	1.700	6-Feb-09	3.40		
25-Mar-08	4.400	12-Feb-09	0.09		
31-Mar-08	2.100	18-Feb-09	2.60		
6-Apr-08	0.370	24-Feb-09	1.20		
12-Apr-08	0.260	2-Mar-09	0.49		
18-Apr-08	3.400	8-Mar-09	0.07		
24-Apr-08	3.800	14-Mar-09	0.19		
30-Apr-08	1.300	20-Mar-09	0.37		
6-May-08	0.840	26-Mar-09	3.90		
12-May-08	2.800	1-Apr-09	2.10		