Health Consultation

PUBLIC COMMENT VERSION

Assessing the Public Health Implications of the Criteria
(NAAQS) Air Pollutants and Hydrogen Sulfide

MIDLOTHIAN AREA AIR QUALITY

MIDLOTHIAN, ELLIS COUNTY, TEXAS

NOVEMBER 16, 2012

COMMENT PERIOD ENDS: JANUARY 18, 2013

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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MIDLOTHIAN AREA AIR QUALITY

MIDLOTHIAN, ELLIS COUNTY, TEXAS

Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry (ATSDR)
Division of Community Health Investigations

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean-up of the sites.

Since 1986, ATSDR has been required by law to conduct public health assessment activities at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR, and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations - the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicological and epidemiological studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Public Comments:

ATSDR will accept public comments on this health consultation until January 18, 2013. Comments must be made in writing. Comments (without the names of persons who submitted them) and ATSDR's responses will appear in an appendix to the final health consultation. Names of those who submit comments will be subject to release in answer to requests made under the U.S. Freedom of Information Act (FOIA).

Send comments to ATSDRRecordsCenter@cdc.gov, or mail to:
ATSDR Records Center
Attn: Rolanda Morrison
Re: Midlothian Area Air Quality—*Assessing the Public Health Implications of the Criteria (NAAQS) Air Pollutants and Hydrogen Sulfide*
4770 Buford Highway, NE (MS F-09)
Atlanta, Georgia 30341

For more information about ATSDR's work in Midlothian visit http://www.atsdr.cdc.gov/sites/midlothian/ or call 1-800-CDC-INFO.

Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
EPA	Environmental Protection Agency
H_2S	hydrogen sulfide
MRL	Minimal Risk Level
NAAQS	National Ambient Air Quality Standard
NCDC	National Climatic Data Center
NEI	National Emissions Inventory
PM	particulate matter
PM_{10}	particulate matter with aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with aerodynamic diameter of 2.5 microns or less
ppb	parts per billion
ppm	parts per million
PSEI	Point Source Emissions Inventory
TCEQ	Texas Commission on Environmental Quality
TDSHS	Texas Department of State Health Services
TNRCC	Texas Natural Resources Conservation Commission
TRI	Toxics Release Inventory
TSP	total suspended particulate
$\mu g/m^3$	micrograms per cubic meter
UT-Arlington	University of Texas at Arlington
WHO	World Health Organization

Table of Contents

SUMMARY

INTRODUCTION

The Agency for Toxic Substances and Disease Registry (ATSDR) and the Texas Department of State Health Services (TDSHS) are conducting an extensive review of environmental health concerns raised by community members in Midlothian, Texas. The goal of this review is to determine if chemical releases from local industrial facilities could affect or have affected the health of people and animals in the area. The facilities of concern are three cement manufacturing facilities and a steel mill. ATSDR plans to achieve this goal through a series of projects.

This Health Consultation documents ATSDR's findings from the project: assessing the public health implications of exposures to the National Ambient Air Quality Standard (NAAQS) pollutants (particulate matter, ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, and lead) and hydrogen sulfide (H_2S).

ATSDR has already released a Health Consultation (ATSDR, 2012a) to address community members' concerns about the various air pollution measurements that have been collected in Midlothian since 1981. The purpose of that Health Consultation was to take a careful look at the available monitoring data and determine which measurements are—and are not—suitable for use in ATSDR's future health evaluations like this one. The previous Health Consultation identified pollutants, time frames, and locations for which the available data provide a sufficient basis for reaching health conclusions; it also identifies important gaps in the data. These findings are incorporated into this Health Consultation's evaluation of NAAQS pollutants and H_2S.

CONCLUSIONS

ATSDR reached six conclusions in this Health Consultation:

CONCLUSION 1—Sulfur Dioxide (SO_2 Exposures

In the past (1997–late 2008), breathing air contaminated with sulfur dioxide (SO_2) for short periods (5 minutes) could have harmed the health of sensitive individuals (e.g., people with asthma), particularly when performing an activity (such as exercising or climbing steps) that raised their breathing rate. *SO_2* levels that might have harmed sensitive individuals were infrequent and limited to areas primarily in Cement Valley and possibly areas east, south, and southeast of the TXI Operations, Inc (TXI) fence line. These exposures occurred primarily from about 5 p.m. to 6 a.m. Harmful exposures also could have occurred before 1997; however, monitoring data are not available to confirm this conclusion. ***Breathing air contaminated with SO_2 in the past (during the period 1997 to late 2008) was not expected to harm the health of the general population.***

Reductions in SO_2 levels in Cement Valley have occurred since late 2008 resulting in exposures to both sensitive individuals and the general public that are not expected to be harmful. These reductions may be caused, in part, by declining production levels at local industrial facilities. Future harmful exposures in Cement Valley could occur if production rises to at least previous levels and actions are not taken to reduce SO_2 emissions.

No SO_2 data are currently available to evaluate exposures to individuals who live downwind of the Ash Grove Cement and Holcim facilities where the SO_2 emissions have been similar to those from TXI in the past that produced harmful exposures in Cement Valley and possibly elsewhere. Therefore, ***ATSDR cannot determine if harmful exposures to SO_2 have been occurring downwind of the Holcim and Ash Grove facilities.***

BASIS FOR DECISION

Past SO_2 exposures were not above the Environmental Protection Agency (EPA) standard in place at that time but were above the current standard.

When SO_2 concentrations exceed 400 ppb (parts per billion), sensitive individuals may experience symptoms such as coughing, wheezing, and chest tightness. At lower SO_2 concentrations (200 ppb to 400 ppb), sensitive individuals functioning at elevated breathing rates may experience asymptomatic effects (e.g., mild constriction of bronchial passages). Adverse health effects from exposures to SO_2 concentrations less than 200 ppb are uncertain, but may occur in some people more sensitive or vulnerable than people participating in clinical studies.

People with asthma, children, and older adults ($\geq$65 years) have been identified as groups susceptible to the health problems associated with breathing SO_2. Human scientific studies (clinical investigations and epidemiologic studies) have provided evidence of a causal relationship between SO_2 and respiratory disease (morbidity) in people with asthma and other more limited human studies (epidemiologic) have consistently reported that children and older adults may be at increased risk for SO_2-associated adverse respiratory effects. Groups potentially sensitive to air pollutants include the obese, people with preexisting cardiopulmonary disease, and people with a pro-inflammatory condition such as diabetes, but some of these relationships have not been examined specifically in relation to SO_2.

CONCLUSION 2—Particulate Matter Exposures

Breathing air contaminated with $PM_{2.5}$ (particulate matter with aerodynamic diameter of 2.5 microns or less) downwind of TXI and Gerdau Ameristeel for 1 year or more is not likely to have harmed people's health, except in a localized area just north of the Gerdau Ameristeel fence line during 1996-1998. $PM_{2.5}$ is both a local and regional air quality concern. The $PM_{2.5}$ levels observed in the Midlothian area are not considerably different from levels measured in multiple locations throughout the Dallas— Fort Worth metropolitan area. These $PM_{2.5}$ levels are caused by emissions from mobile (e.g., cars and trucks) and industrial sources in the Midlothian area and beyond. Nevertheless, for people, especially those with preexisting respiratory and cardiac disease, who lived in a localized area of Cement Valley (just north of the Gerdau Ameristeel fence line during 1996–1998), public health concern is warranted for adverse health effects from long-term exposure to $PM_{2.5}$. ***Short-term potentially harmful levels of $PM_{2.5}$ have been infrequent in Midlothian. These infrequent exposures could have resulted in harmful cardiopulmonary effects, especially in sensitive individuals, but not the general public.***

ATSDR noted several data gaps in relation to PM exposures. In general, monitoring stations in the Midlothian area have been placed near or at locations believed to have either high air-quality impacts from facility operations or a high potential for exposure. However, ***ATSDR is uncertain about $PM_{2.5}$exposures downwind of Ash Grove and Holcim because of a lack of data and information.*** In addition, ambient air monitoring data are more limited for the residential neighborhoods in immediate proximity to the cement manufacturing facilities' limestone quarries. PM exposure is the primary concern for these localized residential areas.

BASIS FOR DECISION

Most measured annual average $PM_{2.5}$ levels in the Midlothian area were not above EPA's current or proposed standard. In the past (1996–2008), annual average $PM_{2.5}$ levels measured were just below the range of concentration proposed by EPA for lowering the annual average standard, except for the estimated exposure levels just north of Gerdau Ameristeel fence line during the period 1996–1998. Although no $PM_{2.5}$ measurements were collected north of Gerdau Ameristeel, other data ATSDR has reviewed suggest that this area most likely had the highest $PM_{2.5}$ concentrations in the area, particularly in the years 1996–1998. These estimated $PM_{2.5}$ levels were at the upper end of the risk range in several epidemiologic studies.

Infrequent, short-term $PM_{2.5}$ levels in Midlothian have been in the range considered by the EPA (based on the Air Quality Index or AQI) to be a concern for sensitive populations, but not the general public. However, as defined by EPA, short-term levels of $PM_{2.5}$ in the Midlothian area have not exceeded the current standard.

No $PM_{2.5}$ monitoring data are available to evaluate exposures downwind of the Ash Grove facility. Furthermore, although annual average $PM_{2.5}$ levels detected at the Holcim monitor indicate possible harmful levels, ATSDR is uncertain about what actual off-site exposures are occurring downwind of Holcim.

CONCLUSION 3— Ozone Exposures

Several of the levels of ozone detected in Midlothian since monitoring began in 1997 indicate that sensitive individuals have an increased likelihood of experiencing harmful respiratory effects (respiratory symptoms and breathing discomfort). This likelihood is true primarily for active children and adults and for people with respiratory diseases, such as asthma. The general population of Midlothian is not expected to experience harmful effects from ozone exposure except on rare occasions when ozone levels reach approximately 100 ppb or more.

Ellis County is one of 11 counties that make up the Dallas–Fort Worth ozone non-attainment area, which means that ozone levels in the metropolitan area occasionally exceed EPA's health-based standards. Ozone levels also have exceeded the World Health Organization (WHO) health guidelines. Emissions from industrial sources, mobile sources, and natural sources throughout the area contribute to this problem.

BASIS FOR DECISION

Scientific studies indicate that breathing air containing ozone at concentrations similar to those detected in Midlothian can reduce lung function and increase respiratory symptoms, thereby aggravating asthma or other respiratory conditions. Ozone exposure also has been associated with increased susceptibility to respiratory infections, medication use by persons with asthma, doctor's visits, and emergency department and hospital admissions for individuals with respiratory disease. Ozone exposure also might contribute to premature death, especially in people with heart and lung disease. School absenteeism and cardiac-related effects may occur, and persons with asthma might experience greater and more serious responses to ozone that last longer than responses among people without asthma.

CONCLUSION 4—Mixture Exposures

ATSDR believes that sufficient information exists to warrant concern for multiple air pollutant exposures to sensitive individuals, especially in the past (during the period 1997 to late 2008) when SO_2 levels were higher and when these persons were breathing at higher rates (e.g., while exercising). ATSDR believes the severity of health effects from a mixture exposure is not likely to exceed those discussed for SO_2, $PM_{2.5}$, or ozone exposure alone. For past SO_2 exposures, however, the number of sensitive individuals affected may have been greater because effects may have occurred at a lower SO_2 concentration when combined with exposure to ozone, $PM_{2.5}$, or both. Potential effects to a larger sensitive population, especially in the past, may be limited to the same locations but during the warmer months when $PM_{2.5}$ and ozone levels are usually the highest. In addition, potential effects to this larger sensitive population may also have resulted from multiple exposures that occurred during several consecutive days.

BASIS FOR DECISION

The current state of the science limits our ability to make definitive conclusions on the significance of simultaneous exposures to multiple criteria air pollutants. ATSDR's conclusions are based on our best professional judgment related to our understanding of the possible harmful effects of air pollutant exposures in Midlothian and our interpretation of the current scientific literature; therefore, these conclusions are presented with some uncertainty.

CONCLUSION 5—Lead Exposures

Past lead air exposures during the period 1993 to 1998, in a localized area just north of the Gerdau Ameristeel fence line, could have harmed the health of children who resided or frequently played in this area. The estimated health effect of these exposures would have been a slight lowering of IQ (Intelligence quotient) levels (1-2 points) for some children living in the area. Since 1998, air lead levels in this area decreased, resulting in estimated childhood blood lead levels below the Centers for Disease Control's (CDC) reference level (currently 5 µg/dL). Monitoring data do not indicate that lead levels in air have occurred above EPA's current standard (0.15 $\mu g/m^3$) in other areas of Midlothian, either now or in the past.

BASIS FOR DECISION	Past lead air exposures were not above the EPA standard at that time but were above the current standard. ATSDR evaluated past lead exposures in air using a model developed by the EPA to estimate childhood blood lead levels. Based on our current knowledge of the health effects of lead exposures in children, ATSDR used a blood lead reference level of 5 µg/dL in the model to account for the risk of adverse health effects at levels below below 10 µg/dL, which had been used as a level of concern. ATSDR also ran the model using 10 µg/dL. Using a combination of default parameters in the EPA lead model and using the highest annual and quarterly average air lead levels from the Gerdau Ameristeel monitor during the period 1993–1998, the model estimates that children in that area of Cement Valley could have had, on average, approximately an18%–21% risk of a blood lead level between 5-10 µg/dL because of breathing outdoor air. Stated another way, if 100 children lived in the vicinity of the Gerdau Ameristeel monitors during the period 1993–1998, the model predicts that approximately 21 or fewer children would have blood lead levels between 5-10 µg/dL, a level that might result in small IQ deficits (1-2 points). The model also predicted that there was not an appreciable risk (less than 5%) of these exposures resulting in a childhood blood lead level of 10 µg/dL or more. Some uncertainty exists with these findings given that we do not know what the lead levels in air were downwind of the Gerdau monitor and we do not know if small children were exposed at all in this sparsely populated area of Cement Valley.
CONCLUSION 6-- **Exposure to Other Contaminants**	***ATSDR does not expect harmful effects in Midlothian from current or past exposures to the air pollutants carbon monoxide, nitrogen dioxide, or hydrogen sulfide***.
BASIS FOR **DECISION**	Based on available monitoring data and other information (emission reports, knowledge of what might be emitted from cement or steel operations, and worst-case computer air modeling), the levels of carbon monoxide, nitrogen dioxide, and hydrogen sulfide are below health-protective comparison values developed by EPA, WHO, or ATSDR.
NEXT STEPS—All Conclusions	***Sulfur Dioxide Specific:*** To reduce current or future peak exposures to sulfur dioxide, ATSDR recommends the following: • Reduce emissions—Texas Commission on Environmental Quality (TCEQ) should take actions to reduce future SO_2 emissions from TXI to prevent harmful exposures. • Evaluate and reduce exposures—TCEQ should conduct ambient air monitoring to characterize exposures to persons located

downwind of the Ash Grove and Holcim facilities and take actions to reduce SO_2 emissions from these facilities if harmful exposures are indicated.

PM Specific: To reduce current or future $PM_{2.5}$ exposures, ATSDR recommends the following:

- Reduce emissions—TCEQ should take actions to reduce future $PM_{2.5}$ emissions from TXI and Gerdau to prevent harmful exposures.
- Evaluate and reduce exposures—TCEQ should conduct appropriate ambient air monitoring to characterize exposures to persons located downwind of the Ash Grove and Holcim facilities and take actions to reduce $PM_{2.5}$ emissions from these facilities if harmful exposures are indicated. In addition, particulate matter monitoring is needed in residential areas that are in immediate proximity to the facilities' limestone quarries.

ATSDR will issue two other Health Consultations that will further evaluate cement kiln dust (CKD): one document will consider the specific chemicals within CKD and whether those pose a health hazard when inhaled; another document will consider the extent to which CKD has contaminated soils and waterways through atmospheric deposition.

Mixtures Specific: To reduce and prevent multiple contaminant exposures, ATSDR recommends the following:

- TCEQ should evaluate and prevent harmful $PM_{2.5}$ and sulfur dioxide exposures from local sources.
- TCEQ should continue efforts to reduce regional ozone exposures.

All Air Pollutants:

- TCEQ should ensure that the levels of the air pollutants, carbon monoxide and nitrogen dioxide, do not increase to levels of concern in the future.
- ATSDR and the Texas Department of State Health Services (TDSHS)will distribute health education material related to exposures to SO_2, $PM_{2.5}$, and ozone specifically for sensitive and potentially sensitive populations. These materials will include information on health effects and ways to minimize harmful exposures to air pollution.
- ATSDR and TDSHS will provide educational material specifically for health professionals on air pollution and patient health.

- ATSDR will work with TCEQ to address the recommendations of this Health Consultation and will evaluate any additional data that might become available in relation to these recommendations.

FOR MORE INFORMATION

If you have questions about this document or ATSDR's ongoing work on the Midlothian facilities, please call ATSDR at 1-800-CDC-INFO and ask for information about the "Midlothian, Texas evaluations." If you have concerns about your health, you should contact your health-care provider.

1. Purpose and Statement of Issues

Purpose of this Document
This Health Consultation documents ATSDR's findings from the project: assessing the public health implications of exposures to the National Ambient Air Quality Standard (NAAQS) pollutants (particulate matter, ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, and lead) and hydrogen sulfide (H_2S). The findings from ATSDR's first Health Consultation (ATSDR, 2012a) are incorporated into this document's evaluation of the public health implications of potential exposures to the NAAQS pollutants and H_2S.

Readers should note that ATSDR's role in evaluating ambient air in Midlothian is as a *public health* agency, which is considerably different from the roles of other agencies, particularly those charged with addressing *environmental* issues. In this document, ATSDR evaluates the public health implications of the levels of air pollutants in the Midlothian area. These evaluations are not meant to address the region's compliance, or lack thereof, with state and federal standards, such as EPA's NAAQS, even though this Health Consultation uses the NAAQS as a means for the first step in evaluating the air monitoring data collected in the Midlothian area. State and federal environmental agencies are responsible for evaluating the area's compliance with the NAAQS and other environmental standards.

In July 2005, a group of residents of Midlothian, Texas, submitted a petition to the Agency for Toxic Substances and Disease Registry (ATSDR). The petition expressed multiple concerns, but primarily that nearby industrial facilities were emitting air pollutants at levels that were affecting the health of residents. ATSDR accepted this petition, and the Texas Department of State Health Services (TDSHS), under a cooperative agreement with ATSDR, prepared a response.

Specifically, in December 2007, TDSHS, with ATSDR concurrence, issued a public comment draft Health Consultation that attempted to respond to concerns outlined in the original petition. Many comments were received on the draft Health Consultation.

During the process of evaluating these comments, ATSDR and National Center for Environmental Health Director requested that the ATSDR and TDSHS team take a more comprehensive look at the site. This new evaluation would review the initial petitioner's concerns, which questioned whether data generated by air monitors were being collected in a manner that could provide pertinent answers to the community health concerns. ATSDR and TDSHS are now looking at all available data to determine if there is a relationship between air emissions and health concerns in the community. As outlined in its Midlothian Public Health Response Plan (ATSDR, 2011), ATSDR will complete this reevaluation in a series of projects.

The first ATSDR Health Consultation (ATSDR, 2012a) assessed the utility of existing ambient air monitoring data for addressing Midlothian residents' concerns regarding air emissions from four industrial facilities, while also considering additional air quality impacts from other sources (e.g., motor vehicle traffic).

To evaluate these concerns, ATSDR gathered relevant information on facility emissions, local meteorological conditions, and ambient air monitoring data. The findings in this document are based on all validated ambient air monitoring data and related information available to ATSDR as of late 2011 (except for some SO_2 data that became available in 2012). ATSDR accessed information from multiple parties, including the petitioner, local community groups, industry, and consultants; scientists from the University of Texas at Arlington (UT-Arlington); TDSHS; the Texas Commission on Environmental Quality (TCEQ); and the U.S. Environmental Protection Agency (EPA).

This Health Consultation documents ATSDR's findings from the project: assessing the public health implications of exposures to the National Ambient Air Quality Standard (NAAQS) pollutants (particulate matter, ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, and lead) and hydrogen sulfide (H_2S). The findings from the first Health Consultation (ATSDR, 2012a) are incorporated into this document's evaluation of the public health implications of potential exposures to the NAAQS pollutants and H_2S.

2. Background

This section presents background information that ATSDR considered when evaluating the utility of the ambient air-monitoring studies previously conducted in the Midlothian area. Refer to Section 3 of this Health Consultation for ATSDR's interpretations of this background information and assessment of the ambient air monitoring conducted in the Midlothian area.

2.1. Air Emission Sources

Air Emissions in Midlothian
The air exposure pathway begins with air emission sources—processes that release pollutants into the air. Once released, these pollutants move from their sources to locations where people may be exposed. This section presents background information on the air emission sources of interest in the Midlothian area: a steel mill and three cement manufacturing facilities that operate multiple kilns. Other local emission sources also are identified and discussed.

Midlothian is located in Ellis County, Texas, approximately 30 miles south of the Dallas-Fort Worth metropolitan area. Figure 1 shows the location of Midlothian and the four industrial facilities of interest. This section provides background information on the various emission sources that affect air quality in Midlothian, with a focus on the four industrial facilities shown in Figure 1.

Operations at all four facilities of interest have changed over the years. Some changes would have increased air emissions (e.g., increased production levels in certain years, use of different fuels in the kilns) whereas others would have decreased air emissions (e.g., installation of pollution control devices). In some cases, changes at the facilities might have simultaneously decreased emissions of certain pollutants and increased emissions of others. These changing operations are important to consider when evaluating the air quality concerns in the Midlothian area. Emissions also can change considerably from one hour to the next—a topic addressed later in this Health Consultation.

The four facilities of interest in Midlothian emit several pollutants at rates that have consistently ranked among the highest for industrial facilities in Ellis County that submit data to TCEQ's Point Source Emissions Inventory. Accordingly, this section presents detailed summaries of emission data for the four facilities. Other emission sources (e.g., motor vehicles) are briefly acknowledged and characterized for completeness.

2.2. Background on Relevant Industrial Processes

This section presents general information on the relevant manufacturing processes for the facilities of interest in Midlothian, with a focus on the types of air emissions commonly found at cement kilns and steel mills. Please refer to the ATSDR Health Consultation *Assessing the Adequacy of the Ambient Air Monitoring Database for Evaluating Community Health Concerns* for more details (ATSDR, 2012a)

2.2.1. Air Emissions from Cement Kilns

Cement is a commercial product that is used to make concrete. Although cement manufacturing facilities employ various production technologies, most facilities share some common design features. A very simplified account of common elements of cement manufacturing follows.

Cement is typically manufactured by feeding crushed limestone, shale, and other ingredients into kilns that operate at high temperatures, typically at least 2,700^{o} F (EPA, 1993). Facilities burn various fuels to sustain these kiln temperatures. Fuels used across industry include coal, oil, natural gas, hazardous waste, and tires. When the raw materials are heated to the temperatures achieved in the kilns, they form a material known as "clinker," which is the solid output from the kilns that is cooled and mixed with gypsum to form the cement product.

Many by-products also are formed and exit the kiln in air exhaust. The primary by-product is cement kiln dust, which is a highly alkaline dust of fine particle size. Air pollution control equipment, such as baghouses and electrostatic precipitators, are typically used to reduce emissions of cement kiln dust in the exhaust air from the kilns. Cement kiln dust not collected in the controls or otherwise captured for further processing is emitted by the stacks typically found at cement kilns, along with combustion by-products, which include carbon monoxide, nitrogen oxides, sulfur dioxide, and various volatile organic compounds (e.g., formaldehyde) and semi-volatile organic compounds (e.g., dioxins and furans).

Besides their kilns, cement manufacturing facilities have other operations that process materials. These operations might include mining for limestone at on-site quarries, crushing and blending raw materials, and other material handling processes. Air emissions from these and various other operations tend to occur at ground level and are not always vented through air pollution controls.

Detailed information specific to the Midlothian facilities is presented later in this section.

2.2.2. *Air Emissions from Steel Mills*

Most steel in the United States is manufactured in either basic oxygen furnaces or in electric arc furnaces (EPA, 2000a). Electric arc furnaces are the manufacturing technology of choice at facilities that manufacture steel from scrap metal, as occurs in Midlothian. With this technology, scrap metal and, if necessary, alloys are loaded into the furnace. Electrical energy is then used to melt the scrap metal. During the melting process, impurities in the steel react with the air in the furnace to form various by-products that are vented to the air, typically after passing through some form of air pollution control device. These emissions can include inorganics (i.e., metals and elements) originally found in the scrap and volatile organic compounds (VOCs) that can form from the impurities present in the melting process.

After each batch of scrap metal is melted, the electric arc furnace is tilted and the desired contents are poured into a mold, in which the molten steel gradually cools and takes its final form. The steel then usually undergoes additional finishing processes (e.g., rolling, beam straightening) to make the final product. Slag is a solid by-product from the melting process. Steel mills employ various strategies for managing slag, including disposal and beneficial reuse.

Pollutants typically emitted from steel mills that melt scrap in electric arc furnaces include particulate matter (PM) or dust, VOCs, carbon monoxide, nitrogen oxides, and sulfur dioxide. The PM emitted from these facilities contains various inorganic compounds.

2.3. Air Emissions Sources in Midlothian

- **Overview.** Information is provided on the facilities' history, ownership, location, and main production processes, including types and amounts of fuels used to power their furnaces and kilns.

- **Annual estimated air emissions.** The facilities' self-reported estimated annual air emissions are summarized, using data they submitted to TCEQ's Point Source Emissions Inventory.

  These data were accessed for *criteria pollutants* (e.g., carbon monoxide, lead, particulate matter [PM], sulfur dioxide, nitrogen oxides) and precursors to some criteria pollutants (e.g., VOCs). As with the Toxics Release Inventory (TRI) data, the criteria pollutant emission data in the Point Source Emissions Inventory are self-reported. However, annual emission data for some criteria pollutants are based on continuous emission monitoring data at the facilities of interest. Continuous emission monitors are devices that continuously measure air emissions inside stacks and other process areas. In other words, these devices directly measure emissions, so facilities do not need to estimate their emissions. This section also identifies whether any of the facilities' annual emissions rank among the state's top 25 emitters in the Point Source Emissions Inventory.

- **Short-term estimated air emissions.** This section summarizes the frequency and magnitude of certain short-term air contaminant releases, which annually averaged emission data do not characterize. TCEQ regulations require industrial facilities to disclose information associated with certain *scheduled* activities that lead to excess emissions (e.g., process maintenance, planned shutdowns) and *unscheduled* emission events (e.g., following process upsets or accidental releases). Whether reporting is required depends on several factors, such as the nature of the release and the amount of pollutants emitted.

  Facility-specific information on short-term estimated air emissions is based on data that facilities submitted to TCEQ's "Air Emission Event Reports" database. TCEQ subsequently makes these reports publicly available in summary form on its Web site. ATSDR accessed the entire history of online emission event data, which dates back to 2003 (TCEQ, 2010a). All information provided by the facilities (including the pollutant emission rates) is self-reported and typically estimated. Short-term events may have occurred at the facilities of interest but were never reported to TCEQ; however, the environmental impacts of these events would likely be detected by nearby offsite monitoring devices, especially those that operate continuously.

  Understanding the short-term contaminant emissions is an important consideration for at least two reasons. First, several community members have voiced concern specific to acute (or short-term) exposures. Second, tabulations of annual average emissions and air pollution levels might mask important peaks in facility releases. Therefore, this document and ATSDR's future Health Consultations consider the implications of both short-term and long-term air pollution levels.

2.3.1. Ash Grove Cement

Facility Profiles
The following pages in this document present brief profiles for the four facilities of interest. The purpose of this section is to document some of the most relevant background information that ATSDR collected. These profiles should not be viewed as comprehensive summaries of the individual facilities and their histories.

Although this section, by design, focuses on the individual facilities separately, this Health Consultation considers the combined air quality impacts from all four facilities and additional air emission sources throughout the Midlothian area.

- **Overview.** Ash Grove Texas L.P. is a business entity that operates a Portland cement manufacturing facility located north of Midlothian, referred to in this document as "Ash Grove Cement."[1] The parent company of this facility is Ash Grove Cement Co. From 1990 until 2003, the facility in Midlothian was owned and operated by another entity called North Texas Cement Company, L.P.; and before 1990, the facility was owned and operated by Gifford Hill Cement Company. The facility was constructed in 1965 and began operating in 1966, and it currently operates three rotary kilns to manufacture cement. These kilns began operating in 1966, 1969, and 1972 (TNRCC, 1995). Cement is manufactured by feeding limestone, shale, and other raw materials into the rotary kilns, which operate at temperatures reaching 4,000 degrees Fahrenheit (^{o}F). Most of the raw materials used in the process are from an onsite quarry, but some materials come from offsite sources via truck and rail. The solid product from the kilns is subsequently ground together with gypsum to make Portland cement.

  Various fuels have been used at the facility over the years to fire its kilns. For example, only natural gas was used to fire the kilns after the facility was first built. In the 1970s, fuel oil handling equipment was added, and other fuels (e.g., coal, coke, wood chips) were added in subsequent years. As described further below, waste-derived fuel was burned in the mid-1980s into the early-1990s, and whole tires were allowed as a fuel starting in the 1990s. The facility is currently not able to use tire chips and has never used tire chips. The facility has not used wood chips extensively or used oil in the last decade. This facility employs a combination of coal, petroleum coke, and tires to fire its kilns; natural gas was typically used only for startup of the kilns but usage has expanded in recent years.

  From 1986 to 1991, the facility also was authorized to burn waste-derived fuel in its kilns as a supplemental energy source. Starting in 1989, industrial facilities managing hazardous waste were required to submit biannual reports to EPA on the quantities of waste that were managed. In 1989, a total of 55,000 tons of hazardous waste were reportedly used for purposes of energy recovery; and in 1991, a total of 14,200 tons of hazardous waste were used for this purpose (EPA, 2010b). The practice of burning hazardous waste ceased in 1992.

[1] This document primarily uses "Ash Grove Cement" to refer to the cement manufacturing facility located in Midlothian. Ash Grove Texas L.P. is the business entity that currently operates that facility. References to "the facility" throughout this document refer to the cement manufacturing plant, which was owned and operated by different entities over the years.

At the time, hazardous waste combustion in cement kilns was regulated under an EPA regulation that addressed combustion of hazardous waste in boilers and industrial furnaces. That regulation required affected facilities to conduct compliance tests to determine allowable waste feed rates, use of automatic waste feed cutoffs to prevent feed rates from exceeding these limits, and other safeguards. In 1995, the facility received authorization to burn whole tires in its cement kilns and the facility is required to report to TCEQ its ongoing usage of tire-derived fuel (TCEQ, 2009a). Annual statistics for the facility's usage of tire-derived fuel follow (Ash Grove Cement, 2010):

1996	5,500 tons	**2003**	39,400 tons
1997	18,400 tons	**2004**	43,300 tons
1998	33,400 tons	**2005**	43,000 tons
1999	37,100 tons	**2006**	43,400 tons
2000	38,200 tons	**2007**	42,400 tons
2001	38,200 tons	**2008**	44,800 tons
2002	37,400 tons	**2009**	29,300 tons

These data show varying annual usage of tire-derived fuel, including a substantial decrease in usage in 2009. According to Ash Grove Cement's air permit, the facility is currently allowed to fire its kilns with multiple fuels. The facility is reportedly in the process of decommissioning two of its kilns and reconstructing the third. These changes have been reflected in the air permit amended in May 2012.

Ash Grove Cement's production processes have numerous sources of air emissions. Exhaust air from the three kilns, for example, vents to the atmosphere through 150-foot tall stacks, after first passing through electrostatic precipitators designed to capture PM and other pollutants before being released to the air. Selective non-catalytic reduction technology has recently been implemented in all three kilns to reduce air emissions of nitrogen oxides. These air pollution controls collect a large portion of the kiln's emissions, including cement kiln dust, but are not 100 % efficient, and every kiln at Ash Grove Cement emits various pollutants through its stacks. The facility is required to continuously monitor emissions of carbon monoxide, nitrogen oxides, and sulfur dioxide (and the facility was previously required to monitor emissions of VOCs), although many other pollutants are released from this source. These continuous monitors are placed directly in the kiln stacks.

Emissions also occur from the facility's quarry activities, physical processing of raw materials (e.g., crushing, grinding, milling), materials handling operations, stockpiles, and other storage areas. Many of these other emission sources are also equipped with air pollution controls to help reduce releases. For example, dust collectors capture PM from many of the materials handling operations. Facility-wide emissions can vary considerably with time, because Ash Grove Cement occasionally changed its fuel sources and the design of its unit operations; new equipment has been added over the years, and some older equipment has been taken out of service.

industrial facilities of interest. An estimated 38,908 people live within 3 miles of any of these facilities, and some people are life-long residents. The main population center of Midlothian is located between the facilities of interest, although several residential developments and individual properties are located throughout the area. According to the census data, approximately 11 % of the population within 3 miles of these facilities, are children; 6 % are elderly; and 22 % are women of childbearing age. Please refer to ATSDR's earlier health consultation (ATSDR 2012a) for a map and details on the demographic characteristics of the area.

- **Residents closest to the facilities.** All four main industrial facilities in Midlothian own large tracts of land which helps ensure that no one lives in immediate proximity to the facilities' main industrial operations, where air quality impacts from some emission sources would be greatest. Observations from site visitors and review of aerial photographs, however, confirm that numerous residents live just beyond the four facilities' property lines. For instance, several dozen homes are located along the eastern boundary of TXI Operations. Multiple homes along Ward Road, Wyatt Road, Cement Valley Road, and other streets are located across U.S. Highway 67 from TXI Operations and Gerdau Ameristeel. Similarly, a residential area and Jaycee Park are located along the southeastern boundary of Ash Grove Cement, and another residential area is near the facility's northeastern boundary. Holcim has nearby residential receptors; the closest ones live near the facility's northwestern and southeastern boundaries.

- **Nearest areas with potential for elevated short-term exposures.** In addition to the residential neighborhoods and areas listed above, ATSDR considered short-term exposures that residents, visitors, and passers-by might experience when they are in close proximity to the four industrial facilities. These short-term exposures can occur at many places, such as along U.S. Highway 67, which passes along the boundary of all four facilities; at recreational facilities near the facility boundaries (e.g., Jaycee Park, Pecan Trails Golf Course, Massey Lake); and at various nearby business establishments.

2.5. Local Climatic and Meteorological Conditions

ATSDR reviewed climatic and meteorological conditions in the Midlothian area because these factors affect how air emissions move from their sources to downwind locations. The Midlothian area is flat with gently rolling terrain. The National Climatic Data Center (NCDC) collects climatic data at multiple locations in Ellis County, and the Waxahachie weather station has the longest period of record. From 1971 to 2000, the average temperature in this area ranged from 46.0° F in January to 84.6° F in July, and the area received an average of 38.81 inches of precipitation a year, almost entirely in the form of rain (NCDC, 2004).

To assess the prevailing wind patterns, ATSDR obtained wind speed and wind direction data for multiple meteorological stations in the Midlothian area. ATSDR summarized data for two of these stations in a format known as a wind rose (see ATSDR, 2012a). A wind rose displays the statistical distribution of wind speeds and directions observed at a meteorological station. The wind roses indicate that the prevailing wind direction in the Midlothian area is from south to north, although pronounced contributions also are observed from north to south and from southeast to northwest. For example, the Wyatt Road and Old Fort Worth Road monitors are

2008 caused ammonia emissions to exceed allowable levels for 3 hours. None of these emission events occurred on days when TCEQ received complaints about TXI Operations' emissions.

2.3.5. Other Emission Sources

Air quality in Midlothian is affected by emissions from all local (and some distant) sources and not only by emissions from the four main facilities of interest. Consequently, the ambient air monitors in the area measure air pollution levels that reflect contributions from several emission sources.

Most industrial facilities, like the cement kilns and steel mill in Midlothian, are referred to as point sources. Other emission sources are typically classified into two categories: area sources and mobile sources. Area sources are small air pollution sources that individually do not emit enough pollutants to be considered a point source, but collectively throughout an area can account for a considerable quantity of emissions. Examples of area sources include agricultural tilling, dry cleaners, and gasoline stations. Mobile sources refer to any vehicle or equipment with a gasoline or diesel engine (e.g., on-road and off-road motor vehicles, construction equipment), and aircraft and recreational watercraft. The following paragraphs briefly review information on emissions from sources other than the four facilities of interest.

EPA's National Emissions Inventory (NEI) estimates the relative magnitude of annual emissions from point, area, and mobile sources for every county across the nation. According to the 2005 NEI, the most recent release available when ATSDR started this evaluation, the four industrial facilities of interest emit approximately 85 % of the sulfur dioxide and 60 % of the nitrogen oxides released to the air throughout all of Ellis County, and they account for approximately 20 % of the countywide emissions of carbon monoxide and fine PM (EPA, 2010b). NEI does not present emission data for short-term emission events.

These data offer some insights on the different types of emission sources found in and near Midlothian but must be interpreted in proper context. Although the NEI data suggest that sources other than the facilities of interest might account for the majority of countywide emissions for certain pollutants, that suggestion does not necessarily mean air pollution levels at a given location are dominated by these other sources. On the contrary, emissions from the four facilities of interest are expected to have considerably greater air quality impacts at locations nearest these facilities, especially considering their proximity to each other.

2.4. Demographics

ATSDR examines demographic data to determine the number of people who are potentially exposed to environmental contaminants and to consider the presence of sensitive populations, such as young children, women of childbearing age (aged 15–44 years) and the elderly (aged 65 years and older). This section considers general population trends for residents in the city of Midlothian and also identifies residential areas closest to the facilities.

- **General population trends.** Information compiled in the 2000 U.S. Census, provides demographic data for areas within 3 miles of the property boundaries of the four

Following is a summary of the total amount of hazardous waste that TXI Operations burned for purposes of energy recovery, according to the facility's BRS reports:[2]

1991	40,600 tons	**2001**	62,400 tons
1993	56,200 tons	**2003**	31,600 tons
1995	90,700 tons	**2005**	50,000 tons
1997	57,700 tons	**2007**	42,100 tons
1999	74,700 tons		

On average, across the years listed, TXI Operations burned approximately 56,200 tons of hazardous waste annually for purposes of energy recovery (EPA, 2010a)—an amount roughly equivalent to burning more than 150 tons of hazardous waste per day, assuming continuous operations. The quantities burned since 2001 are low in comparison with other years because of permit restrictions that limited the number of kilns that could operate simultaneously. This waste has come almost entirely from offsite sources. Examples of the specific types of waste burned at TXI Operations include, but are not limited to, organic liquids and sludge, waste oils, and solvents. During the years TXI Operations burned hazardous waste, automatic waste feed cutoff systems were employed to ensure that the quantities of waste-derived fuel did not exceed pre-established input limits that were based on compliance testing. Further, continuous emissions monitoring for total hydrocarbons provided data that could be used to assess the adequacy of fuel combustion. Various other requirements were mandated under an EPA regulation affecting combustion of hazardous waste in boilers and industrial furnaces.

TCEQ's web site documents 84 complaints that residents submitted to the agency between from 2002 to 2010 regarding TXI Operations' air emissions (TCEQ 2010b). More than half of these complaints were filed because of odors, when residents and passers-by reported smelling strong chemical and chlorine-like odors. Some odor complaints referenced odors of sulfur and burning tires, and nearly every odor complaint occurred at night. The other complaints pertained to primarily dust and smoke coming from the facility. In some cases, the complainants reported symptoms (e.g., cough, burning sensation in nostrils) believed to result from facility emissions.

- **Annual estimated air emissions.** Section 3 reviews the history of TXI Operations' annual emissions for the pollutants considered in this Health Consultation.
- **Short-term estimated air emissions.** From 2003 to 2011, TXI Operations submitted 36 air emission event reports to TCEQ. Thirty-five were excess opacity events and emission events and the other one was a scheduled maintenance event. Four emission events in the database were reported for the following: the safety valve in a storage tank ruptured in April 2005, releasing several VOCs; a dislodged brick in a rotary kiln in August 2006 caused increased emissions reported as excess opacity; a kiln shutdown in February 2008 led to excess emissions of sulfur dioxide; and problems encountered with a pump in April

[2] The BRS data are presented for all years with available information. Data shown are for the amount of hazardous waste burned for purposes of energy recovery. TXI Operations did not report any data to BRS for 1989. All data points are rounded to three significant figures.

one event reportedly lasted approximately 9 hours. Opacity measurements appeared to trigger most of these reportable events, and none were apparently triggered by an excessive pollutant-specific emission rate.

2.3.4. TXI Operations

- **Overview.** TXI Operations, the largest of the three Portland cement manufacturing facilities in Midlothian, is located southwest of the city center, adjacent to Gerdau Ameristeel. The facility was formerly known as Midlothian Cement Plant. TXI Operations began operating in 1960 and operates five cement kilns that came online in 1960, 1964, 1967, 1972, and 2002. Four of these are "wet kilns," and the newest is a "dry kiln." An onsite quarry provides the limestone and shale used to manufacture cement. Other raw materials are delivered via truck. The kilns are fired at temperatures that reach 2,800 ^{o}F and produce clinker, which is ground together with gypsum to make the Portland cement product.

  TXI Operations has used multiple fuels to fire its kilns, originally natural gas. In 1974, TXI Operations was also permitted to fire its kilns with fuel oil. In 1980, 1983, and 1987, the facility was authorized to fire kilns using coal, petroleum coke, and waste-derived fuel, respectively. In the past, the four wet kilns were authorized to fire natural gas, fuel oil, coal, petroleum coke, and waste-derived fuel. The dry kiln is authorized to fire natural gas and coal as fuel. Although TXI Operations was permitted to burn hazardous waste since 1987, the facility has not used this fuel continuously over the years. Data summarized later in this section indicate that the facility burned hazardous waste during 1991 to 2007. TXI no longer burns hazardous waste in its wet kilns; TXI has permanently shut down its wet kilns and the authority to operate these kilns has been removed from its permit.

  TXI Operations has many air emission sources that are typically found at cement manufacturing facilities. Exhaust air from the active kiln passes through a high-efficiency fabric filter baghouse to reduce emissions of PM and a wet scrubber to reduce emissions of sulfur dioxide, nitrogen oxides, and other pollutants. This exhaust gas then passes through a regenerative thermal oxidizer, which reduces emissions of carbon monoxide and VOCs. Ultimately, the exhaust from the kilns exits through 200-foot or 310-foot tall stacks, which TXI Operations continuously monitors emissions of several pollutants, including carbon monoxide, nitrogen oxides, and sulfur dioxide. The specific monitoring requirements varied across the kilns, although only a single kiln operates. In addition to pollution controls for kiln emissions, the facility has equipped several other process operations with baghouses and other types of dust collectors to reduce PM emissions.

  Every other year, TXI Operations is required to provide EPA information on the amount of waste-derived fuel (i.e., hazardous waste) that the facility feeds to its kilns for energy recovery purposes (EPA, 2010a). That information is loaded into EPA's Biennial Reporting System (BRS) database, which can be queried by the public. Currently, BRS waste management statistics are available for every other year during 1989 through 2009.

1994	5,313 tons	**2002**	15,480 tons
1995	18,722 tons	**2003**	25,629 tons
1996	18,513 tons	**2004**	8,403 tons
1997	11,076 tons	**2005**	13,137 tons
1998	1,647 tons	**2006**	14,464 tons
1999	417 tons	**2007**	9,918 tons
2000	829 tons	**2008**	9,256 tons
2001	1,015 tons	**2009**	10,430 tons

According to Holcim's air permit, the facility is currently allowed to fire its kilns with natural gas, coal, tire chips, oil, non-hazardous liquids, non-hazardous solids, and petroleum coke.

Holcim's cement manufacturing operations emit air pollutants from multiple sources, and various measures are in place to reduce facility emissions. Both kilns now operate with selective non-catalytic reduction (SNCR) technology to reduce emissions of nitrogen oxides. Exhaust air from the two kilns (and other production areas) passes through baghouses (to reduce PM in emissions) and wet scrubbers (to reduce sulfur dioxide emissions). Process gases from the kilns eventually vent to the atmosphere through 250-foot and 273-foot tall stacks, in which the facility continuously monitors emissions of sulfur dioxide, carbon monoxide, nitrogen oxides, and ammonia. Emissions also occur from the facility's quarry activities, physical processing of raw materials, materials handling operations, and storage areas, and some of these emission sources are also equipped with baghouses to remove PM from process exhaust streams.

In July 2005, following an application to increase nitrogen oxide emissions, Holcim reached a settlement agreement with DFW Blue Skies Alliance and Downwinders at Risk. This agreement led to Holcim funding several projects to reduce emissions and monitor local air quality. For example, Holcim agreed to continuously measure downwind ambient air concentrations of fine PM—a project that operated from 2006 to early 2010.

According to queries run on TCEQ's Web site, the agency received 11 complaints from residents about air emissions from Holcim between 2002 and 2010 (TCEQ, 2010b). Five of these complaints were filed during the period May 2005 to April 2006. Most of the complaints pertained to a strong burning plastic or burning chemical odor emanating from the facility. The odor reportedly caused headaches in some residents and forced others to stay indoors.

- **Annual estimated air emissions.** Section 3 below reviews the history of Holcim's annual emissions for the pollutants considered in this Health Consultation

- **Short-term estimated air emissions.** From 2003 to 2010, Holcim submitted 17 air emission event reports to TCEQ. Of these, six were scheduled maintenance or startup activities. The remaining 11 events were excess opacity events and emission events. All but one of these were of short duration (i.e., roughly between 5 minutes and 2.5 hours);

2011a). Currently, Gerdau Ameristeel is not required to continuously monitor pollutant emission rates from any of its main stacks.

According to queries run on TCEQ's Web site, the agency received 52 complaints from residents about air emissions from Gerdau Ameristeel during the period 2002 to 2010 (TCEQ, 2010b). These complaints were filed for various reasons: odor was cited as a reason for 24 of these complaints. The most frequently cited odor was a burning plastic smell (for 12 of the complaints). Residents also reported detecting diesel, metal, sulfur, and chemical odors. Other reasons that residents filed complaints included deposition of dust, visible smoke, and excessive industrial activity. Nearly every complaint specific to Gerdau Ameristeel occurred during nighttime hours.

- **Annual estimated air emissions.** Section 3 below reviews the history of Gerdau Ameristeel's annual emissions for the pollutants considered in this Health Consultation.

- **Short-term estimated air emissions.** During the period 2003 to 2011, Gerdau Ameristeel submitted 30 air contaminant emission event reports to TCEQ: 28 excess opacity events and two emission events. One of the emission events involved approximately 800 excess pounds of PM released to the air over a 32-hour time frame, when dust control measures for unpaved roads were suspended related to a failed water supply well.

2.3.3. Holcim

- **Overview.** Holcim Texas Limited Partnership (LP) (referred to in this document as "Holcim") is a Portland cement manufacturing facility located northeast of Midlothian. The facility began its operations as Box Crow Cement Company and subsequently became Holnam Texas LP before being renamed to Holcim Texas LP. Holcim operates two dry kilns; the first began operating in 1987 and the second in 2000. An onsite quarry provides limestone and other raw materials used to feed the rotary kilns, which operate at temperatures reaching 3,000^{o} F. Raw materials are crushed and milled onsite before being fed to pre-heaters that precede the kilns. The solid product from the kilns, or clinker, is cooled and ground together with gypsum to make Portland cement.

  Since 1987, Holcim has used multiple fuels to fire its kilns. The facility was originally permitted to use coal and natural gas. In 1994, Holcim was also authorized to burn tire chips as supplemental fuel in pre-processing operations. Data that the facility reported to TCEQ indicate that the amount of tire scraps burned at Holcim varies from one year to the next (TCEQ, 2009a). Annual statistics for the facility's usage of tire-derived fuel follow (TCEQ 2009a, 2010c):

According to queries run on TCEQ's Web site, the agency received no complaints from residents about air emissions specifically from Ash Grove Cement between 2002 and 2010 (TCEQ, 2010b).

- **Annual estimated air emissions.** Section 3 below reviews the history of Ash Grove Cement's annual emissions for the pollutants considered in this Health Consultation.

- **Short-term estimated air emissions.** According to data ATSDR accessed in 2011, Ash Grove Cement submitted 257 air emission event reports to TCEQ dating back to 2003. Of these, 87 were scheduled maintenance, startup, or shutdown activities. The remaining 170 events were excess opacity events and emission events. Only one of these event reports included a pollutant-specific emission rate. On February 16, 2005, Ash Grove Cement experienced an hour-long emission event that released 106 pounds of carbon monoxide into the air; no other pollutants were identified in the excess emission event report. Some reports made by Ash Grove Cement were reportedly based on an expectation that there was a chance that the type of event (i.e., startup, shutdown, or maintenance) could result in emissions of one or more pollutants over a permit limit. However, reporting of such information should not be inferred to indicate that emissions above permitting limits automatically occurred.

2.3.2. erdau Ameristeel

- **Overview.** Gerdau Ameristeel—sometimes referred to as Chaparral Steel—operates a secondary steel mill located southwest of Midlothian and adjacent to TXI Operations (see Section 2.3.4). The facility began operating in 1975 (TNRCC, 1995) and currently uses two electric arc furnaces and three rolling mills to melt and recycle scrap steel. The scrap steel is obtained from an automobile shredder and junkyard, also located at the facility. The two electric arc furnaces melt scrap steel, and then casting operations form the material into structural steel beams, reinforcing bars, and other shapes and forms. The facility does not operate coke ovens to generate energy; therefore, coke oven emissions will not be considered in this investigation.

  Gerdau Ameristeel's production processes have multiple emission sources. Air emissions from the two furnaces are controlled through the use of positive and negative pressure baghouses, which collect airborne particles that would otherwise be released to the environment. Exhaust air from these baghouses vents to the atmosphere through any of three stacks; two are 150 feet tall and the third is 80 feet tall. Emissions also occur from the facility's automobile shredding operation, melt shop, and scrap and slag handling. Many of these operations also are equipped with air pollution controls. For example, the slag crusher and alloy processes have baghouses that capture PM from exhaust streams that would otherwise be emitted to the air. The extent of air pollution controls changed over time. For instance, in 1988, Gerdau Ameristeel installed a new baghouse that considerably reduced emissions of particulate matter, and further reductions occurred in the early 1990s when another new baghouse was installed and the facility's "roof vents" in certain production areas were removed. A complete list of these controls is available from the facility's submissions to TCEQ's Point Source Emission Inventory (TCEQ, considered downwind of TXI and Gerdau Ameristeel when the winds are blowing in the prevailing directions. However, on occasion, the Midlothian Tower might be downwind of these facilities when the wind is blowing from the north to the south. (See ATSDR 2012a for details on this analysis.)

ATSDR then examined the extent to which prevailing wind patterns in the Midlothian area vary by month and time of day. At the Old Fort Worth Road and Midlothian Tower meteorological stations, average wind speeds were highest in March and April and lowest in August and September; wind speeds, on average, were also highest during the early afternoon (2:00 p.m. to 4:00 p.m.); wind speeds at both stations tended to be lightest around sundown (6:00 p.m. to 8:00 p.m.) and sunup (4:00 a.m. to 6:00 a.m.). In nearly every month of the year, winds blew most frequently from south to north. Contributions from the other main directions in the area varied slightly from month to month. Wind direction did not vary considerably with time of day.

2.6. eneral Air Quality in Ellis County

For more than 20 years, EPA and state environmental agencies have evaluated general air quality in populated areas by measuring ambient air concentrations of six common air pollutants, also known as criteria pollutants. These pollutants are carbon monoxide, lead, nitrogen dioxide, ozone, two forms of PM, and sulfur dioxide. For every criteria pollutant, EPA has established a health-based National Ambient Air Quality Standard. In cases where air quality does not meet the standard, states are required to develop and implement plans to bring air pollution levels into attainment with the health-based standards. The following paragraphs review the general air quality near Midlothian, as gauged by measured levels of criteria pollutants:

- **Ozone.** Currently, numerous ambient air monitoring stations measure ozone levels throughout selected summer and fall months in the Dallas-Fort Worth metropolitan area. Measured ozone levels at several of these stations have exceeded EPA's health-based standards, suggesting that the air quality in this area is at times unhealthy. As a result, EPA currently designates the Dallas-Fort Worth area as a "non-attainment area" for ozone. All of Ellis County is included in this non-attainment area. Air quality warnings are typically issued when ozone levels are expected to be elevated. The Dallas-Fort Worth area is considered one of three "serious" non-attainment areas for ozone in the United States. This designation is lower than the two "extreme" and three "severe" non-attainment areas but higher than the numerous other "moderate" non-attainment areas nationwide. Residents can learn more about ozone at http://www.AirNow.gov.

  The ozone air quality issues in Dallas-Fort Worth are complex and result from numerous industrial and motor vehicle emissions over a broad geographic region. The exact contribution of any single source to elevated ozone levels is difficult to assess.

- **Other pollutants.** For the remaining criteria pollutants (carbon monoxide, lead, nitrogen dioxide, PM, and sulfur dioxide), the Dallas-Fort Worth area is considered to be in attainment with EPA's health-based air quality standards. In June 2010, EPA strengthened its health-based standard for sulfur dioxide, but the agency recently reported that air quality in the Dallas-Fort Worth metropolitan area currently meets the stricter (and more health-protective) standard (EPA, 2010c).

3. Measured and Estimated Air Pollution Levels

This section summarizes data on air pollution levels measured in Midlothian. For each pollutant considered in this Health Consultation, this section presents background information on the pollutant and why it is expected to be found in the facilities' emissions. The section also documents reported emission rates for the pollutants of interest, including how those emissions vary across facilities and with time. Finally, the section documents the measured air pollution levels and how those vary from one location to the next. Modeling results are presented only for the pollutant for which no direct measurements are available (i.e., carbon monoxide). Data summaries and maps are used throughout this section to document the air pollution measurements and where they were collected.

As an initial step in the health evaluation, the measured air pollution levels are compared with health-based air quality standards and guidelines published by EPA, TCEQ, or the World Health Organization (WHO). These values have been developed to protect the health of all individuals, including sensitive populations (e.g., persons with asthma, children, and the elderly). Sections 3.1 through 3.6 present detailed data evaluations for the individual pollutants, and Section 3.7 summarizes these findings. Section 4 of this Health Consultation presents ATSDR's detailed health evaluations for each pollutant above health-based guidelines or standards.

3.1. Carbon Monoxide

Carbon monoxide is released by many sources, typically when carbon-containing fuels do not burn completely. On a national scale, motor vehicles account for approximately 90 % of carbon monoxide emissions from manmade sources (EPA, 2008a). However, emissions from industrial sources can dominate in areas with extensive manufacturing activity, like Midlothian.

Environmental exposure to CO can occur while traveling in motor vehicles, working, visiting urban locations associated with combustion sources, or cooking and heating with domestic gas, charcoal, or wood fires, and by inhaling environmental tobacco smoke. WHO (1999) summarized environmental concentrations as follows: CO concentrations in ambient air monitored from fixed-site stations are usually below 9 ppm (8 h average). However, short-term peak concentrations up to 50 ppm are reported on heavily traveled roads. The CO levels in homes are usually lower than 9 ppm; however, the peak value in homes could be up to 18 ppm with gas stoves, 30 ppm with wood combustion, and 7 ppm with kerosene heaters. The CO concentrations inside motor vehicles are generally 9–25 ppm and occasionally over 35 ppm. Similar exposure levels were reported by EPA (2000b).

Table 1 summarizes CO emissions data available from TCEQ's Point Source Emissions Inventory (PSEI) for the four facilities of interest. According to this inventory, these four facilities have consistently had the highest CO emissions among the industrial facilities found in Ellis County. The emissions also rank high among facilities statewide. For example, in 2005, the PSEI includes carbon monoxide emissions for more than 1,600 facilities. In that year, emissions from the Midlothian facilities ranked 13th (Holcim), 28th (Gerdau Ameristeel), 63rd (TXI Operations), and 99th (Ash Grove Cement) when compared with the other facilities across the state.

Other emissions trends are evident from Table 1. For instance, during the last 15 years of inventory data shown, Holcim's annual carbon monoxide emissions were the highest of the four facilities, followed by emissions from Gerdau Ameristeel, TXI, and Ash Grove Cement. During this 15-year period, emissions were lowest in 2009 and 2010. Emissions in these 2 years were particularly low for the three cement manufacturing facilities, consistent with an industry-wide decline in production that occurred during this same time (USGS, 2011).

ATSDR has compiled all publicly available ambient air monitoring data for the Midlothian area. However, no monitors in or near Midlothian have measured air pollution levels for carbon monoxide. To fill this gap in the environmental data, ATSDR used models to estimate past air quality impacts for this pollutant. Appendix A of this report documents the modeling analysis, which was based on assumptions generally designed to assess worst-case air quality impacts. For example, the emissions data used in the model were based on the highest years of emissions documented in Table 1. The model included the carbon monoxide emissions data for Ash Grove Cement from 1990, for Gerdau Ameristeel from 1994, for Holcim from 2004, and for TXI from 1990. Further, to assess the worst case scenario, ATSDR assumed that these emissions all occurred at the same time. The model was run to predict air pollution levels from all four sources combined, and the main results were as follows:

- The highest 1-hour average carbon monoxide concentration estimated by the model was 0.85 parts per million (ppm) at a location north of the Gerdau Ameristeel property line, near the intersection of Wyatt Road and U.S. Highway 67. In contrast, EPA's standard for this concentration is 35 ppm, and TCEQ has also adopted this standard. Further, WHO's health guideline for 1-hour levels is 26 ppm (WHO, 2000). Thus, the highest estimated air quality impact attributed to the facilities is more than 30 times lower than the corresponding health-based standards and guidelines.

- The highest 8-hour average carbon monoxide concentration estimated by the model was 0.55 ppm, again at a location north of Gerdau Ameristeel. Both EPA's standard (which TCEQ has adopted) and WHO's health guideline for this variable is 9 ppm—more than 15 times higher than the estimated air quality impacts from the facilities.

- The model used in this analysis does not estimate air concentrations for averaging periods shorter than 1 hour. Therefore, ATSDR could not compare estimated concentrations with WHO's health guidelines derived for 15-minute and 30-minute averaging periods. This lack is not considered a major limitation in the health evaluation because even if we assume that the highest 1-hour CO value increased by a factor of four to simulate what a 15-minute value might be, the levels would all be below the WHO guideline.

- ATSDR has not developed a Minimal Risk Level for CO. Given the physiologic role of endogenous carbon monoxide (i.e., natural production of CO by the human body), an exposure threshold for carbon monoxide actions, if one exists at all, is likely at or near the endogenous production rate. Therefore, any exogenous source of carbon monoxide exposure would have the potential for exceeding the threshold and producing potentially adverse effects. Although there might be an exposure level that can be tolerated with minimal risk of adverse effects, the currently available toxicologic and epidemiologic data do not identify such minimal risk levels. The lowest levels of effects have been seen in epidemiologic studies. These studies indicate an increased risk of arrhythmias in coronary artery disease patients and exacerbation of asthma when the concentration range is about 0.5-10 ppm (ATSDR, 2012b). ATSDR estimated 1 and 8 hour CO concentrations in Midlothian at 0.85 and 0.55, respectively. Although ATSDR cannot rule out a harmful effect in some very sensitive persons, the estimated worst-case exposure levels are at the low end of the range that showed these effects in epidemiologic studies. Moreover, the estimated levels are below the background level for the Dallas-Fort Worth metropolitan area and what might be typically found in a home or automobile.

The modeling results are estimates of carbon monoxide air quality impacts from the four Midlothian facilities, and do not consider contributions from other sources. To assess potential contributions from other sources (e.g., motor vehicles), ATSDR considered carbon monoxide monitoring data collected in two high motor vehicle traffic areas in the Dallas–Fort Worth metropolitan area. These data are accessible from EPA's "AirData" database, which is a clearinghouse of air pollution measurements collected nationwide. According to that database, the highest 1-hour average carbon monoxide concentration over the last 5 years at the two long-term monitoring stations in Dallas and Fort Worth was 3 ppm (EPA, 2012a). Therefore, carbon monoxide levels in the Midlothian area caused by mobile sources are likely substantially less than this amount, but no measurements are available to support this judgment.

Overall, no carbon monoxide monitoring has occurred in Midlothian, and Ellis County is not designated as a non-attainment area for EPA's air quality standards. ATSDR's modeling analysis indicates that the greatest air quality impacts from carbon monoxide are lower than EPA's health-based air quality standards. Even when considering reasonable estimates for contributions from mobile sources, carbon monoxide levels throughout Midlothian likely do not exceed health-based air quality standards.

ATSDR acknowledges that estimated air quality impacts for carbon monoxide are based entirely on a modeling analysis, which has inherent uncertainties and limitations. The main sources of uncertainty are the model inputs for local meteorology, the model inputs for facility emission rates, and inherent limitations in air dispersion models. As Appendix A indicates, the meteorologic data used in this assessment were developed specifically for modeling air quality concerns in Ellis County, and the prevailing wind patterns in that data set are consistent with those recently observed in the Midlothian area. Further, the modeling considers 5 years of meteorologic data—the number of years of data that EPA recommends be included in air quality modeling analyses to ensure that worst-case meteorologic conditions are adequately captured (EPA, 2005). Further, ATSDR believes the model inputs do not underestimate actual annual emissions for three reasons. First, the values entered into the model were the highest facility-specific emissions data from 1990 to 2011. Second, the model assumed that the highest emission rate from all four facilities occurred in the same year, even though that was not the case. Third, the emissions data for the three cement manufacturing companies are measured directly with continuous emissions monitors and are therefore expected to be highly accurate. Taken together, these observations all suggest that the modeling analysis offers a reasonable account of carbon monoxide air pollution levels attributable to the facilities' emissions. However, the principal limitation in the assessment is that the modeling is based on annual average emission rates, and not peak hourly releases, as discussed in Appendix A. Nonetheless, given that the estimated air quality impacts are more than 15 times lower than the corresponding air quality standards and health guidelines, ATSDR has confidence in basing its health conclusions on the carbon monoxide modeling results.

Based on the above analyses, ATSDR will not further evaluate carbon monoxide in the Public Health Implications Section below.

3.2. Lead

Lead is a naturally occurring metal. Typically found at low levels in soils, lead is processed for many industrial and manufacturing applications, and it is found in many metallic alloys. Lead was previously found in many gasoline additives, but this use was gradually phased out starting in the 1970s. On a national level, many different sources emit lead, including boilers, electricity-generating facilities, and incinerators. A recent EPA assessment found that iron and steel foundries (which includes Gerdau Ameristeel) accounted for approximately 7.7 % of the nation's total manmade emissions in 2002, whereas emissions from Portland cement manufacturing facilities (which includes the other three Midlothian facilities) accounted for approximately 1.5 % of the nation's total emissions (EPA, 2006a).

Table 2 summarizes lead emissions data available from TCEQ's PSEI and for EPA's Toxics Release Inventory (TRI) for the four facilities of interest. In any given calendar year, a facility's emissions data reported to PSEI are not always the same as those reported to TRI because of differences in these two programs' reporting requirements. When compiling data for display in Table 2, ATSDR selected the higher value for annual emissions reported in either inventory.

Table 2 reveals two important trends in the facilities' lead emissions. First, air emissions of lead from Gerdau Ameristeel far exceeded emissions from the other facilities over the entire period of record. For the past 20 years, this facility's lead emissions accounted for at least 80 % of the total emissions from all four facilities. In fact, emissions from Gerdau Ameristeel have consistently ranked high among other industrial facilities in Texas. For example, according to the PSEI data for 1995, lead emissions from Gerdau Ameristeel ranked 2nd out of the 67 facilities in the state for which emissions data are in the inventory (TCEQ, 2011a). Second, a substantial decrease in lead emissions occurred in the late 1980s; the total emissions summed across all four facilities decreased by more than 95 % during this time. Two improvements in capturing lead emissions occurred at Gerdau Ameristeel in 1988 and 2003 (Personal Communication, Dale Harmon, Gerdau Ameristeel, 2/15/12). Information about these improvements helps in interpreting the ambient air monitoring data.

Table 3 summarizes the ambient air monitoring data collected for lead in the Midlothian area. ATSDR's first Health Consultation for this site concluded that these data were collected with scientifically defensible methods and met standard data quality objectives (ATSDR, 2012a). During the past 30 years, airborne lead levels have been measured at 16 monitoring locations in the Midlothian area (Figure 1). Table 3 organizes the lead summary statistics by decade to illustrate how air quality impacts have changed with time:

EPA's Lead Air Quality Standards

EPA issued its first health-based NAAQS for lead in 1978. That standard required that ambient air concentrations of lead averaged over a calendar quarter must not exceed 1.5 µg/m^3. This standard is based on lead in air samples for total suspended particulate (TSP) matter.

In 2008, EPA issued a new NAAQS for lead, based on a more current health-effects review. The 2008 standard requires lead concentrations for any 3-month rolling average not to exceed 0.15 µg/m^3. The new standard still applies to lead in TSP; however, monitoring for lead in other particle sizes is permitted in some circumstances when assessing compliance with the standard. TCEQ requires lead levels to meet EPA's standards.

Note: The WHO health guideline for lead is 0.5 µg/m^3 based on annual average concentrations (WHO, 2000). This document uses EPA's health-based NAAQS for evaluating lead concentrations, because that value is more health protective.

- *Lead data from the 1980s.* The only monitoring station in the Midlothian area that measured lead in the 1980s was located on the roof of Midlothian City Hall. From 1981 to 1983, 24-hour average samples were collected every sixth day, following standard sampling frequencies applied throughout Texas and the United States. The highest 3-month rolling average lead concentration at this site was 0.237 µg/m^3. This 3-month average occurred in October-November-December, 1981. Therefore, the highest quarterly average lead concentration at this station was below the health-based NAAQS that was active at the time (1.5 µg/m^3) but higher than the current version (0.15 µg/m^3).

  However, the Midlothian City Hall monitoring station is not located directly downwind from the largest industrial lead emission source in the area (Gerdau Ameristeel). In fact, winds in this area rarely blow from the southwest to the northeast, which suggests that measurements at Midlothian City Hall likely do not reflect the highest air quality impacts associated with the local industrial emission sources. ATSDR compared measurements from Midlothian City Hall with other measurements statewide, which were made in 1981 by the Texas Air Control Board and other agencies. To do so, ATSDR accessed all lead monitoring data archived on TCEQ's Texas Air Monitoring Information System (TCEQ, 2012). In 1981, ambient air monitoring for lead occurred at more than 100 sites statewide. This monitoring was conducted using consistent methods, and 89 of these sites had a sufficient number of samples to calculate quarterly average concentrations.[3] Across these 89 sites, the highest quarterly average lead concentration ranged from 0.04 to 1.96 µg/m^3. Further, the highest quarterly average concentration at Midlothian City Hall (0.23 µg/m^3) ranked 45th of the 89 stations considered for this analysis, which included a mix of stations in urban, suburban, and rural locations.

  Considered together, these factors suggest that the lead levels measured in 1981 and 1983 do not capture the greatest air quality impacts from nearby industrial sources, but instead reflect contributions from sources common to populated areas. Emissions from mobile sources likely were a major contributor to the lead levels measured at Midlothian City Hall. Although the United States began phasing out use of lead additives in gasoline in

[3] For purposes of this evaluation, ATSDR considered only those monitoring sites that had at least 10 valid 24-hour average samples per calendar quarter.

the late 1970s, these additives continued to be used into the 1990s, and mobile sources accounted for most of the nation's lead emissions up through 1990 (EPA, 2006a).

- *Lead data from the 1990s.* As Table 3 indicates, five ambient air monitoring stations in the Midlothian area measured airborne lead levels at some time during the 1990s. Some of the stations measured lead in TSP, but others measured lead in particulate matter with aerodynamic diameter of 10 microns or less (PM_{10}). Total suspended particles are considered inhalable—meaning there can be exposure via inhalation and by ingestion when cilia remove lead from lung (thorax) and the lead is subsequently swallowed and ingested. This smaller particle size fraction is often applied in air quality studies because PM_{10} is commonly viewed as "respirable" particles—those that tend to pass through the nose and mouth and enter the lungs. ATSDR reviews the two types of measurements separately.

  The Gerdau Ameristeel site that measured lead in TSP was located at 2060 South Highway 67. As Figure 1 shows, this site is located directly north of the Gerdau Ameristeel facility. At this site, 24-hour average samples were collected every sixth day, and 319 valid lead sampling results are available from January 1993 to August 1998. Data are available for 23 consecutive calendar quarters. None of the quarterly average concentrations exceeded EPA's health-based NAAQS at the time (1.5 $\mu g/m^3$). However, 18 of the 23 quarterly average concentrations are greater than EPA's current standard (0.15 $\mu g/m^3$). The highest average lead concentration for any calendar quarter was 0.443 $\mu g/m^3$, and this was observed for the months of April, May, and June in 1995. This site also recorded some of the highest quarterly average concentrations of lead in the state. For example, according to the Texas Air Monitoring Information System, 35 lead monitoring stations operated statewide in 1993. That year, the highest quarterly average lead concentration at the Gerdau Ameristeel site was 0.239 $\mu g/m^3$, and only one other monitoring station in the state had higher quarterly average lead concentrations (TCEQ, 2012). The measurements at this site occurred during 1993 –1998, after Gerdau Ameristeel's emissions had decreased considerably from their highest levels on record (see Table 2). Therefore, this monitoring station likely did not capture the facility's highest air quality impacts. Annual average lead concentrations detected at the Gerdau Ameristeel monitor during this timeframe are as follows:

1993	0.239 $\mu g/m^3$
1994	0.176 $\mu g/m^3$
1995	0.251 $\mu g/m^3$
1996	0.205 $\mu g/m^3$
1997	0.197 $\mu g/m^3$
1998	0.192 $\mu g/m^3$ (based on samples taken from January through August)

  As Table 3 shows, four other lead monitoring stations operated in the 1990s. These stations were located throughout the Midlothian area and measured lead in PM_{10} in the 1991–1993 period. During this time, the highest average lead concentrations were at the monitoring station (Cement Valley Road) closest to and downwind from the Gerdau Ameristeel facility; lower concentrations occurred at the other three stations. The highest quarterly average lead concentration (0.035 $\mu g/m^3$) observed across all four stations is lower than EPA's current and former health-based lead standards, but the measured concentrations were in the PM_{10} size fraction, and the health standard is based on the TSP size fraction. However, a recent statistical analysis conducted by EPA indicates that, on average, lead concentrations in TSP are usually no more than twice as high as lead concentrations in PM_{10}.[4] Applying this result to Midlothian suggests that airborne lead levels at these four monitoring stations were not above the level of the current health-based standard; however, we do not know what the levels were before monitoring began.

In summary, quarterly average lead concentrations immediately north of Gerdau Ameristeel exceeded EPA's current health-based standard, but not the standard in place at that time, throughout much of the 1990s, but the available data suggest that this was a highly localized effect. ATSDR's modeling analysis (see Appendix A) also confirms that air quality impacts from Gerdau Ameristeel would decrease rapidly with downwind distance.

- *Lead data from the 2000s.* Table 3 lists the ten monitoring sites that measured ambient air concentrations of lead since 2000. The monitoring data from these sites continue to exhibit the same spatial variations; lead levels are highest at locations immediately downwind from Gerdau Ameristeel. TCEQ's recent air quality study in Midlothian found that lead levels at the Wyatt Road monitoring station were higher than at the three other fixed stations considered in that program, a finding that was statistically significant (TCEQ, 2010d). However, the magnitude of the lead concentrations during this period was considerably lower than what was observed in earlier years. The highest quarterly average lead concentration during this period was 0.026 $\mu g/m^3$ in PM_{10}. Based on the statistical analysis previously cited, such lead levels in PM_{10} are almost certainly lower than EPA's current health-based standard for lead in TSP.

  Overall, the data presented in this section highlight important spatial and temporal variations for airborne lead levels in Midlothian. Spatially, the highest lead concentrations were observed at the monitoring station closest to Gerdau Ameristeel—the facility with the highest lead emissions in the Midlothian area (see Table 2). Temporally, the highest ambient air concentrations of lead were observed in the mid- to late-1990s, but even higher lead concentrations likely occurred during earlier years, when emissions from Gerdau Ameristeel were higher.

  Considering that lead was detected at the Gerdau Ameristeel monitoring station for the years 1993–1998 above the current EPA standard, lead will be further evaluated in the Public Health Implications Section below.

[4] When EPA proposed the current health-based standard for lead, agency officials conducted a statistical analysis of the relative amounts of lead in PM_{10} and TSP. This was done by obtaining monitoring data from all sites nationwide that concurrently measured both lead in PM_{10} and lead in TSP. EPA's statistical analysis of the data from these 23 sites found that the average concentration of lead in TSP was never more than twice the average concentration of lead in PM_{10} (EPA, 2008b).

3.3. Nitrogen Dioxide

Nitrogen oxides are a group of nitrogen-containing pollutants typically found in urban air. Nitrogen dioxide accounts for most nitrogen oxides and is the pollutant for which EPA has developed its health-based NAAQS. Most airborne nitrogen oxides come from combustion-related sources, including mobile sources, industrial sources, and electricity generating facilities. Cement manufacturing facilities and steel mills are known to emit nitrogen oxides.

Table 4 presents nitrogen oxides emissions data available from TCEQ's Point Source Emissions Inventory (PSEI) for the four Midlothian facilities from 1990 to 2010. These four facilities have consistently had the highest nitrogen oxides emissions among the industrial facilities in Ellis County. The emissions also rank high among the industrial facilities statewide. For example, in 2005, the PSEI contains nitrogen oxides emissions for more than 1,600 facilities in Texas. In that year, emissions from the Midlothian facilities ranked 14th (Holcim), 19th (TXI Operations), 38th (Ash Grove Cement), and 195th (Gerdau Ameristeel) when compared with other facilities across the state.

Other emissions trends are evident from Table 4. For instance, the highest nitrogen oxides emissions in any given year in the Midlothian area were from Ash Grove Cement, Holcim, or TXI Operations; emissions from Gerdau Ameristeel were considerably lower. Across all four facilities, the years with the highest total emissions were 1994 to 2005. Of the 20 inventory years shown in Table 4, 2009 and 2010 had the lowest combined nitrogen oxides emissions . The decreased emissions in these years is consistent with the trend for carbon monoxide emissions and again likely results from a decline in production in the cement manufacturing industry that occurred during this same time (USGS, 2011).

Table 5 summarizes the ambient air monitoring data collected for nitrogen dioxide in the Midlothian area, and Figure 2 shows where the monitors were located. ATSDR's first Health Consultation for this site concluded that these data were collected with scientifically defensible methods and met standard data quality objectives (ATSDR, 2012a). Continuous monitors operate at these sites and output a series of 1-hour average concentrations from which annual average concentrations can be calculated. As Table 5 shows, the annual average nitrogen dioxide concentrations at the three stations of interest ranged from 4.50 to 10.87 parts per billion (ppb). These values are lower than 53 ppb, which is EPA's health-based standard, and TCEQ has adopted the same standard. The range of annual average concentrations measured in Midlothian (4.50 to 10.87 ppb) is also lower than 21 ppb—the corresponding health guideline published by WHO (WHO, 2006). Similarly, the highest 1-hour average concentration measured during this time was 78.61 ppb. EPA's health-based standard for 1-hour average concentrations is 100 ppb, based on the 98th percentile concentration averaged over 3 consecutive calendar years; TCEQ has adopted this standard. The measured 1-hour average levels are also lower than the WHO health guideline for 1-hour concentrations (106 ppb). Therefore, all short-term and long-term nitrogen dioxide concentrations measured in the Midlothian area were lower than current air quality standards and within health guidelines.

These observations are notable because the monitoring data span the years 2000 to 2011, which include many years when the combined emissions from the four facilities were highest. Further, two of these monitoring stations were located in residential neighborhoods immediately downwind from the Gerdau Ameristeel and TXI Operations facilities. These stations are therefore expected to provide a reasonable indication of the highest exposures that might have occurred during 1990–2011. Inferences about air quality impacts before 1990 are difficult to make without information on nitrogen dioxide emission rates for these years.

Based on the above analyses, ATSDR will not further evaluate nitrogen dioxide exposures in the Public Health Implications Section below.

3.4. Ozone

Ozone is commonly found in urban air pollution. Ozone levels are typically highest during the afternoon of the summer months, when the influence of direct sunlight is the greatest. The Midlothian facilities do not release ozone directly into the air. Rather, ozone forms in air when emissions of nitrogen oxides and volatile organic compounds mix together and react with sunlight. Although the Midlothian facilities emit these pollutants (e.g., see Table 4), mobile sources and numerous other industrial sources throughout the area also contribute to the local ozone air quality issues.

Ellis County, where Midlothian is located, is one of 11 counties that together constitute the Dallas–Fort Worth ozone non-attainment area. This designation means that airborne ozone levels in these counties do not meet, or are expected not to meet, EPA's health-based air quality standard for this pollutant. The current version of EPA's standard is 0.075 ppm for 8-hour average ozone concentrations, and compliance with the standard is calculated based on statistical analyses of three consecutive years of measurements. TCEQ has adopted the EPA health-based standard, and WHO has established a health guideline of 0.05 ppm for 8-hour average ozone concentrations (WHO, 2006). The measured concentrations of ozone throughout the metropolitan area have occasionally exceeded all of these levels.

The Dallas-Fort Worth metropolitan area has not met EPA's ozone standards for approximately 20 years, although EPA has revised the standard multiple times during this time. TCEQ monitors ozone throughout this area and has operated two ozone monitoring stations in the vicinity of Midlothian (see Figure 3): the Midlothian Tower site monitored ozone from 1997 to 2007, and the Old Fort Worth Road site monitored ozone from 2006 to 2011. The Midlothian Tower site recorded ozone concentrations above the level of the NAAQS for several years (TCEQ, 2011b), and the Old Fort Worth Road site has been measuring ozone concentrations close to the level of the NAAQS. Based on the data from both monitors, from August 1997 to September 2011, the 8-hour EPA ozone standard has been exceeded 236 times. The range of maximum 8-hours values at the Midlothian Tower station during 1997–2007 was 78–120 ppb, and the range at the Old Fort Worth Road station was 75–96 ppb. The levels above the standard tended to be highest during May through September, although April and October have also had 8-hour periods above the standard.

Some additional observations regarding ozone in the Midlothian area deserve mention. First, the ozone air quality issues in the Dallas-Fort Worth area are not unique; the area is one of many metropolitan areas nationwide that does not meet EPA's ozone standard. EPA has recently estimated that more than 100 million people nationwide live in areas that do not meet the agency's health-based ozone standard (EPA, 2010d). Second, the ozone issues near Midlothian cannot be attributed to a single emissions source. Emissions from the Midlothian facilities certainly contribute to the ozone found throughout the metropolitan area, as do emissions from industrial sources, motor vehicles, and natural sources over a broad geographic region. For example, planning documents suggest that total nitrogen oxides emissions throughout the Dallas-Fort Worth non-attainment area were 519 tons per day in 2006 (TCEQ, 2011b); however, the combined emissions of nitrogen oxides across all four Midlothian facilities in 2006 (see Table 4) was approximately 25 tons per day—less than 5 % of the areawide nitrogen oxides emissions.

For these and other reasons, this Health Consultation addresses ozone as a general air quality issue that is only partly affected by emissions from the Midlothian facilities and will be further evaluated in the Public Health Implications Section below.

3.5 Particulate Matter

Particulate matter (PM), which refers to airborne droplets and particles, comes from many sources, including wind-blown dust, other natural sources, and manmade sources. For more than 30 years, various government agencies have regulated air concentrations of PM, and those regulations have been based on a scientific understanding of how different sizes of PM affect human health. The text box (see next page) explains how EPA regulations have changed over the years and documents the current WHO PM health guidelines. The remainder of this section is organized by the three PM size fractions most often used when evaluating outdoor air quality.

3.4.1. Total Suspended Particulates (TSP)

Ambient air monitoring for TSP occurred at one place in Midlothian. During May 1981–December 1984, the 24-hour average TSP samples were collected once every 6 days at the monitoring station located on the rooftop of Midlothian City Hall (see Figure 4). During this time, the highest individual 24-hour measurement was 194 $\mu g/m^3$, which is below EPA's health-based standard at the time. The highest annual average TSP concentration at this location (86.3 $\mu g/m^3$) occurred in 1982. This concentration was higher than EPA's health-based standard at the time, and ranked high among annual average TSP levels observed statewide. Specifically, in 1982, nearly 150 TSP monitoring stations collected enough data to calculate annual average concentrations, and the value observed at Midlothian City Hall ranked 22nd among these sites (TCEQ, 2012).[5] The extent to which emissions from the Midlothian facilities contributed to these measured concentrations is unclear, especially considering that the prevailing wind direction in the area would not have blown emissions from the facilities to this monitor. Another complication is that TSP includes larger particles of natural origin (e.g., wind-blown dust), which typically do not factor as much into the finer particle sizes. Since the scientific community currently believes that $PM_{2.5}$ and PM_{10} are better indicators of exposure to particles than TSP and that the former TSP monitoring station was not located where facility emissions would likely have the greatest impact, the majority of this evaluation focuses on PM_{10} and $PM_{2.5}$—the size fractions that currently have health-based standards. ***Based on the above information, TSP exposures during 1981–1984 will not be further evaluated in the Public Health Implications Section below.***

[5] This comparison was based on all sites documented in TCEQ's TAMIS database that had at least 40 valid 24-hour average TSP measurements during calendar year 1982.

PM: Particle Size and Public Health

For more than 30 years, EPA has regulated airborne concentrations of PM. Health studies have documented that the size of airborne particles is related to types of adverse health effect. This Health Consultation classifies emissions and air concentrations of PM according to their size, using the following three categories:

Total suspended particulate (TSP). EPA issued its first health-based air quality standards for PM in 1971, and the health-based standard required that annual average concentrations of TSP not exceed 75 $\mu g/m^3$ and that 24-hour average concentrations not exceed 260 $\mu g/m^3$ more than once per year. TSP includes particles up to approximately 40 microns in diameter.

Particulate matter smaller than 10 microns (PM_{10}). PM_{10} is the subset of TSP composed of particles and droplets with aerodynamic diameters of 10 microns or less—a diameter much smaller than that of human hair. Regulators began focusing on PM_{10} because research started to indicate that these particles were more likely to pass through the nose and mouth and enter the lungs. In other words, these particles were respirable. In 1987, EPA's health-based air quality standards shifted focus from TSP to PM_{10}. At the time, EPA issued standards based on annual average and 24-hour average PM_{10} concentrations. However, the agency recently revoked the annual standard, and only the short-term standard remains: 24-hour average PM_{10} concentrations are not to exceed 150 $\mu g/m^3$ more than once per year (on average) over a 3-year period. WHO's health guidelines are much lower: the annual average health guideline for PM_{10} is 20 $\mu g/m^3$, and the 24-hour health guideline for PM_{10} is 50 $\mu g/m^3$.

Particulate matter smaller than 2.5 microns ($PM_{2.5}$). $PM_{2.5}$—or "fine particulate"—is the subset of TSP composed of particles and droplets with aerodynamic diameters of 2.5 microns or less. By definition, $PM_{2.5}$ is also a subset of PM_{10}. EPA started regulating air concentrations of $PM_{2.5}$ in 1997, after research demonstrated that exposure to these smaller particles can be associated with a range of adverse health effects (see Section 4). EPA's health-based standards require that annual average concentrations of $PM_{2.5}$, averaged over three consecutive calendar years, do not exceed 15 $\mu g/m^3$. Further, the 98th percentile of 24-hour average $PM_{2.5}$ concentrations, averaged over three consecutive calendar years, must not exceed 35 $\mu g/m^3$. WHO's health guidelines for $PM_{2.5}$ are even lower: the annual average health guideline is10 $\mu g/m^3$, and the 24-hour health guideline is 25 $\mu g/m^3$.

3.4.2. Particulate Matter Smaller than 10 Microns (PM_{10})

Table 6 presents PM_{10} emissions data available from TCEQ's Point Source Emissions Inventory (PSEI) for the four Midlothian facilities from 1990 to 2010. The PM_{10} emissions listed for these facilities have consistently ranked among the highest for industrial facilities in Ellis County. The emissions also rank high among industrial sources statewide. In 2005, the PSEI contains PM_{10} emissions data for more than 1,600 facilities in Texas. In that year, emissions from the Midlothian facilities ranked 43rd (Holcim), 44th (TXI Operations), 53rd (Ash Grove Cement), and 91st (Gerdau Ameristeel) when compared with the other facilities across the state. Since 1995, estimated annual PM_{10} emissions from the three cement manufacturing facilities were always higher than those from Gerdau Ameristeel. During that time, the highest PM_{10} emissions across all four facilities occurred during 1996– 2002—years when air monitoring also occurred; the lowest PM_{10} emissions from the cement manufacturing facilities occurred in 2009 and 2010, consistent with the timing of an industry-wide decline in production (USGS, 2011).

As Figure 5 shows, PM_{10} monitoring has occurred at 13 locations in the immediate vicinity of the Midlothian facilities. These sites operated at different periods during 1991– 2004. No PM_{10} monitoring data was identified for earlier years, which most likely indicates that air pollution levels of this pollutant were not regulated at the federal level until 1987. ATSDR's first Health Consultation for this site concluded that these data were collected with scientifically defensible methods and met standard data quality objectives (ATSDR, 2012a). All sites employed the same sampling schedule: 24-hour average samples were collected every sixth day. Across all sites, more than 2,500 valid sampling results are available for review. The following paragraphs and Tables 7 and 8 summarize these monitoring data for annual and 24-hour averaging periods:

- *Annual average concentrations.* As Table 7 shows, the highest annual average PM_{10} concentration observed across all 13 monitoring locations was 50.8 µg/ m^3, which is marginally higher than the level of EPA's former health-based NAAQS.[6] This former standard was withdrawn by EPA because new scientific information indicated that it was not a good indicator of long-term health effects from PM exposures (EPA, 2006a). This highest annual average was based on data from the Gerdau Ameristeel monitor from 1996. The annual average levels for 1997 and 1998 from this same station were 48.1 and 50.2 µg/m^3, respectively, which are above or close to the former EPA PM_{10} annual average standard. All but one of these monitoring locations had at least one annual average PM_{10} concentration higher than the WHO health guideline. However, it is not uncommon for PM_{10} levels to exceed 20 µg/m^3. A recent EPA study evaluated air quality trends at more than 2,000 ambient air monitoring stations and found that more than half of these stations had annual average concentrations greater than 20 µg/m^3 (EPA, 2009). Another important insight comes from Table 8, which indicates that, except for the immediate vicinity north of the Gerdau Ameristeel fenceline, annual average PM_{10} concentrations upwind from the Midlothian facilities did not differ from PM_{10} concentrations downwind from Gerdau Ameristeel and TXI Operations. This observation suggests that many sources contribute to the PM_{10} levels in the area. Furthermore, the following data suggest that the highest PM_{10} levels were likely localized in an area just north of the Gerdau Ameristeel fence line (which is consistent with ATSDR's modeling results):

Annual Average PM_{10} (µg/m^3), 1996–1998

Station	1996	1997	1998
Gerdau Ameristeel	50.8	48.1	50.2
Old Fort Worth Road	20.9	19.9	24.9
Midlothian Tower	22.0	21.4	26.0
Tayman Drive Treament Plant	21.9	No data	No data

- *24-Hour average concentrations.* Across all 13 monitoring stations, more than 2,500 PM_{10} measurements were collected during 1991–2004. The highest 24-hour average

[6] The former NAAQS was based on annual arithmetic mean concentrations, averaged over 3 consecutive calendar years. Although the highest annual average concentration for a single calendar year at the Gerdau Ameristeel site was greater than 50 µg/m^3, none of the arithmetic mean concentrations averaged over 3 consecutive calendar years exceeded this value.

PM_{10} concentration recorded to date (127 µg/m^3) occurred at the monitoring station directly downwind from Gerdau Ameristeel. The highest 24-hour average levels at nearly every station were greater than the corresponding WHO health guideline (50 µg/m^3), but this level is not uncommon for monitoring stations in Texas and other arid environments. To determine whether PM_{10} concentrations were higher on days when sampling was not conducted or to quantify how high those concentrations might have been is impossible.

Most of the data summarized in Tables 7 and 8 suggest that PM_{10} concentrations measured in the Midlothian area meet EPA's current and former health-based standards, but are greater than WHO's health guidelines, which are highly protective. Further, annual average PM_{10} concentrations did not vary considerably between locations upwind and downwind from Gerdau Ameristeel and TXI Operations except for the immediate vicinity north of the Gerdau Ameristeel fenceline. Although annual average PM_{10} levels numerically exceeded the EPA's former health-based standard for 2 years at the monitoring station located just north of Gerdau Ameristeel (the standard was not exceeded as defined by EPA), the available data suggest that this was a highly localized effect. ATSDR's modeling analysis (see Appendix A) also confirms that air quality impacts from Gerdau Ameristeel would decrease rapidly with downwind distance. Inferences about PM_{10} levels before1990 are difficult to make because of the lack of emissions and ambient air monitoring data for those years. Possible exposures to fine particulate matter, based on measured and estimated levels from measured $PM_{2.5}$, are discussed below.

Based on the above analysis, ATSDR will further evaluate long-term PM_{10} exposures (as a proxy for $PM_{2.5}$) in the immediate vicinity north of the Gerdau Ameristeel fenceline in the Public Health Implications Section below.

3.5.3 Particulate Matter Smaller than 2.5 Microns ($PM_{2.5}$)

Table 9 presents $PM_{2.5}$ emissions data available from TCEQ's Point Source Emissions Inventory (PSEI) for the four Midlothian facilities. Unlike other pollutants, which had extensive emissions data documented back to 1990, the available $PM_{2.5}$ emissions data is complete from only 2000 to 2010. The lack of emissions data for earlier years most likely reflects that federal regulation of $PM_{2.5}$ air concentrations was not implemented until 1997. Consistent with the other pollutants discussed earlier, the estimated annual $PM_{2.5}$ emissions listed for these facilities are among the highest for Ellis County and also rank high among industrial sources statewide. In 2005, the PSEI contains $PM_{2.5}$ emissions data for more than 1,500 facilities in Texas. In that year, emissions from the Midlothian facilities ranked 25th (Holcim), 33rd (Ash Grove Cement), 57th (Gerdau Ameristeel), and 58th (TXI Operations) when compared with the other facilities across the state. During 2000–2008, the total $PM_{2.5}$ emissions across the four facilities did not change considerably. However, the total $PM_{2.5}$ emissions decreased in 2009 and 2010.

As Figure 6 shows, $PM_{2.5}$ monitoring has occurred at four locations in the immediate vicinity of the Midlothian facilities. These sites operated at different periods during 2000–2011. Two different monitoring methods are used at these sites: some collect 24-hour average samples every sixth day, and others operate continuously with real-time measured concentrations recorded every hour. ATSDR's first Health Consultation for this site concluded that these data were collected with scientifically defensible methods and met standard data quality objectives; however, a slight negative bias was noted in the continuous $PM_{2.5}$ monitoring data (ATSDR, 2012a). The following paragraphs and Table 10 summarize these monitoring data for two averaging periods:

Annual average concentrations. The scientific community now believes that the current standard (15 µg/m^3) for fine PM (measured by $PM_{2.5}$) is a better indicator of possible long-term health effects from PM exposures than was the former EPA annual average standard for PM_{10} (EPA, 2006b). As Table 10 shows, the highest full year annual average $PM_{2.5}$ concentration observed across all four monitoring locations was 11.9 µg/m^3(except for a partial-year value of 12.4 µg/m^3 at Midlothian Tower in 2005), which is lower than EPA's current standard and proposed range of 12–13 µg/m^3 for a lowered standard (EPA, 2012d). The highest annual average concentration in Midlothian was observed at the Wyatt Road site that operated a continuous monitor. In ATSDR's first Health Consultation (ATSDR, 2012a), a negative bias was identified in data from continuous monitors versus data from 24-hour monitors at the TCEQ monitors located on Old Fort Worth Road. TCEQ had previously identified this concern and began adjusting all its continuous monitoring data by 2 µg/m^3 in 2005 (Personal Communication, Tracie Phillips, TCEQ, 9/27/2012). To be consistent with this approach, ATSDR adjusted all TCEQ continuous monitoring data before 2005 by this same value. ATSDR is uncertain about the magnitude of the negative bias for the Holcim continuous monitoring data, which was not operated by TCEQ, because these data were not adjusted (Personal Communication, Kate Gross, Trinity Consultants, 10/5/12). If the Holcim data are adjusted in the same manner as the TCEQ data, these would represent the highest ***measured*** annual average $PM_{2.5}$ levels detected in Midlothian and be in the range proposed by EPA for lowering the $PM_{2.5}$ annual average standard. Moreover, many of the annual average $PM_{2.5}$ concentrations in Table 10 were above the more conservative WHO health guideline (10 µg/m^3). Exposures downwind of Ash Grove are uncertain because we do not have any monitoring data. In addition, ATSDR is uncertain whether harmful exposures actually occurred downwind of Holcim because of the potential negative data bias (discussed above) and because the monitor is located at the fence line in a sparsely populated area. Table 10 also documents that the highest annual average $PM_{2.5}$ concentrations were nearly identical across the four monitoring stations, which included stations south of TXI Operations and north of Holcim, indicating some regional contributions.

ATSDR evaluated concurrent PM_{10} and $PM_{2.5}$ data from the Midlothian area and determined that the long-term ratio of $PM_{2.5}$ to PM_{10} ranged from about 0.47 to 0.52. Given this, we estimated that annual average $PM_{2.5}$ levels in the vicinity of the Gerdau Ameristeel monitor, from 1996 to 1998, could have ranged from about 22.6 to 26.4 µg/m^3, which is above both the current and proposed EPA standard. Using EPA's approach, the 3-year average level might have been above the NAAQS standard of 15 µg/m^3 for these years in the vicinity of the Gerdau Ameristeel monitor. Applying this same approach to annual average PM_{10} data from other monitors suggests that $PM_{2.5}$ levels could have been close to the current and proposed $PM_{2.5}$ standard, especially for the Wyatt Road, Old Fort Worth Road, Gorman Road, and Midlothian Tower monitors. However, ATSDR is uncertain whether these estimated levels could have resulted in harmful exposures because we do not have measured $PM_{2.5}$ data and our estimates were close to the current or proposed EPA standard.

For these reasons, long-term exposures to $PM_{2.5}$, in a localized area north of the Gerdau fence line during 1996–1998 will be further evaluated in the Public Health Implications Section below.

24-hour average concentrations. Across all four monitoring stations, the highest 24-hour average $PM_{2.5}$ concentration recorded to date (52.1 µg/m^3) occurred at the Wyatt Road monitoring station, which is downwind from Gerdau Ameristeel and TXI Operations. All four monitoring stations recorded at least one 24-hour average concentration greater than the level of EPA's health-based standard (35 µg/m^3). Because of the possible negative bias in data from the continuous $PM_{2.5}$ monitors, a level above the standard or even higher may have occurred on additional days; however, ATSDR cannot determine how many days or what the highest levels could have been. Although EPA scientific staff concluded that consideration should be given to revising the current annual average $PM_{2.5}$ standard of 15 µg/m^3, they also concluded that support for revising the current 24-hour $PM_{2.5}$ standard level (EPA, 2011b) is limited.

Based on the highest concentrations on record from all monitoring stations (Table 10), the EPA 24-hour average health-based standard was exceeded infrequently (about 22 times during 2000–2011, and several of these high concentrations occurred on the same day at different monitors). Several of these levels slightly exceeded the standard. It is important to note that although the standard was exceeded several times on a numerical basis, it did not exceed the standard as defined by EPA. ***Based on this analysis, short-term exposures to $PM_{2.5}$ will be further evaluated in the Public Health Implications Section in relation to the overall air exposures to the community.***

ATSDR's previous health consultation noted a data gap which primarily relates to particulate matter. The monitoring that has been conducted in Midlothian clearly does not characterize air pollution levels at every single residential location over the entire history of facility operations. In ATSDR's judgment, one notable gap in monitor placement is the lack of monitoring data for residential neighborhoods in immediate proximity to the four industrial facilities, where fugitive emissions (those not accounted for in stack emissions) likely have the greatest air quality impacts. Current and past monitoring locations might not adequately characterize particulate matter levels for all residents located immediately adjacent to certain onsite operations, such as limestone quarry activity (ATSDR 2012a). In addition, as stated above, another important data and information gap is in our understanding of $PM_{2.5}$ exposures downwind of the Ash Grove and Holcim facilities.

3.5. Sulfur Dioxide

Sulfur dioxide is a gas formed when fuels containing sulfur (e.g., coal) are burned, and during metal smelting and other industrial processes. On a national level, manmade sulfur dioxide emissions are dominated by contributions from fuel combustion at electricity-generating facilities and other industrial sources; fuel combustion in mobile sources accounts for smaller amounts (EPA, 2008a). Cement manufacturing facilities and steel mills are both known to emit sulfur dioxide.

Table 11 presents sulfur dioxide emissions data available from TCEQ's Point Source Emissions Inventory (PSEI) for the four Midlothian facilities from 1990 to 2010. The three cement manufacturing facilities have consistently had the highest sulfur dioxide emissions among the industrial facilities in Ellis County. Emissions from these three facilities also have ranked high among the industrial facilities statewide. For example, in 2005, the PSEI contains sulfur dioxide emissions data for approximately 1,400 facilities in Texas. In that year, emissions from the cement manufacturing facilities in Midlothian ranked 22nd (Ash Grove Cement), 31st (TXI Operations), and 34th (Holcim) when compared with the other facilities across the state. In that year, sulfur dioxide emissions from Gerdau Ameristeel did not rank among the top 100 facilities statewide.

Other trends are evident from Table 11. For instance, in any given year, the three cement manufacturing facilities accounted for at least 98 % of the sulfur dioxide emissions across all four facilities combined; Gerdau Ameristeel always accounted for less than 2 %. Before 2000, TXI Operations tended to have the highest sulfur dioxide emissions, but since that time the highest values were reported for Ash Grove Cement. Finally, of the 20 inventory years shown in Table 11, the years with the lowest sulfur dioxide emissions combined across all four facilities were 2009 and 2010—a trend consistent with the emissions data reported in this section for other pollutants.

Tables 12 and 13 summarize the ambient air monitoring data collected for sulfur dioxide in the Midlothian area. ATSDR's first Health Consultation for this site concluded that these data were collected with scientifically defensible methods and met standard data quality objectives (ATSDR, 2012a). As Figure 7 shows, sulfur dioxide monitoring has occurred at four locations. Continuous monitors operate at these sites and provide 1-hour average concentrations, from which concentrations can be calculated for different averaging periods. These monitors can provide data for averaging times as short as 5-minutes. The EPA does not have a standard for this short averaging time, but the WHO has a 10-minute guideline of 200 ppb (WHO, 2006). This section focuses on data from the three stations with at least 1 full calendar year of data.[7] ATSDR evaluated summary statistics for three different averaging periods:

- *Annual average concentrations.* The highest annual average sulfur dioxide concentration measured was 5.47 ppb. This occurred in 2000 at the Old Fort Worth Road monitoring station, located downwind from the stacks at TXI Operations. From 1971 to 2010, EPA's health-based NAAQS for annual average sulfur dioxide concentrations was 30 ppb. However, that standard was revoked in 2010, following EPA's most recent health effects review of long-term exposures to sulfur dioxide (EPA, 2008c). The purpose of including annual average concentrations in this Health Consultation is to indicate how air quality impacts changed over time. As Table 12 shows, annual average sulfur dioxide concentrations were typically higher at locations downwind from TXI Operations, as compared with the upwind monitoring location. Further, the highest annual averages occurred during 1999–2001, when emissions from TXI Operations were high.

- *1-Hour average concentrations.* The highest 1-hour average sulfur dioxide concentration was 211.54 ppb in 2001 at the Old Fort Worth Road monitoring station. Before 2010, EPA did not have a health-based air quality standard for 1-hour averages, which was then set at 75 ppb. Specifically, for every monitoring station, the standard requires that the 99th percentile of 1-hour daily maximum sulfur dioxide concentrations averaged over 3 consecutive years to not exceed 75 ppb. Table 13 displays these values for the Midlothian

[7] In 1986, a sulfur dioxide monitoring station at Cedar Drive operated for 4 months. Sulfur dioxide was rarely detected at the station, and the average concentrations were lower than all health-based screening levels discussed in this section.

data for the two stations that had at least 3 years of data. Elevated 1-hour SO_2 concentrations began to increase around 5 p.m. and taper off around 6 a.m.; the highest frequency of elevations were between 7 pm and 3 am. All months of the year have experienced 1-hour SO_2 levels above the standard; however April, May, and October have the highest frequency, and June, August, November, and December have the lowest frequency.

Based on EPA's approach, Table 13 shows that the 1-hour measurements at the upwind station (Midlothian Tower) were all lower than the 2010 EPA NAAQS value; however, individual measurements exceeded the standard 24 times between 1997 and 2005. Short-term average concentrations of sulfur dioxide measured at Old Fort Worth Road between 1997 and 2008 would not have met EPA's current air quality standards, but they met the standard at the time. The current EPA 1-hour standard was exceeded 312 times at the Old Fort Worth Road monitor during 1997 to early 2008 and six times at the Wyatt Road station during 2005 to early 2006. After annual sulfur dioxide emissions from TXI fell below 2,000 tons per year, the measured concentrations were lower than EPA's current standard. Definitive conclusions regarding SO_2 exposures north of TXI before 1997 cannot be made because of the lack of monitoring data. Exposures could have been similar to or greater than the highest levels detected during 1997–2011 at the Old Fort Worth Road and Wyatt Road monitors. We base this possibility on SO_2 emissions from TXI, which during 1997 to 2011were similar to or greater than the levels before 1997. In addition, 1-hour measurements were location specific. For example, on days when the SO_2 levels exceeded the standard at the Old Fort Worth Road station, they did not exceed it at the Midlothian Tower station (except for 1 day in March 2005). This information suggests that elevated SO_2 levels are likely from a specific source rather than a regional effect. The number of SO_2 exceedances at the Old Fort Worth Road monitor were consistent with trends for TXI. That is, the years having the most concentrations above the standard of 75 ppb were the same as those when TXI emissions were high.

To evaluate this trend further, we compared the hourly wind direction measurements at the Old Forth Worth Road monitor and similar hourly SO_2 measurements (see Figure 9). The highest SO_2 levels were downwind from TXI. Figure 9 also shows some minor SO_2 peaks downwind from Ash Grove and Holcim. ATSDR evaluated the wind direction during the 24 instances of exceedances of the standard at the Midlothian Tower station. The peaks occurred almost exclusively when the wind was blowing from the main sources at TXI (i.e., in a downwind direction from TXI). ATSDR cannot rule out a minor contribution of SO_2 from Gerdau Ameristeel to the peak levels found at the Old Fort Worth and Midlothian Tower monitors; however, based on reported emissions data, the main contributor is likely to be TXI.

- *24-Hour average concentrations.* At Midlothian Tower, 24-hour average concentrations of sulfur dioxide varied; the highest 24-hour average concentration in a given year ranged from 11 ppb in 2007 to 25 ppb in 1997. At Old Fort Worth Road, the highest 24-hour average levels were between 15 ppb and 49 ppb during 1997–2008, and then declined to 5 ppb and less in recent years.

During 1971–2010, EPA's health-based standards for sulfur dioxide included a 24-hour average concentration of 140 ppb, not to be exceeded more than once per year. All 24-hour values in Midlothian were lower than EPA's former standard. However, the WHO's health comparable guideline is 8 ppb (WHO, 2006). This value was exceeded at both the Midlothian Tower and Old Fort Worth Road stations in most years of monitoring through 2008, but levels were below that level after 2008. The significance of this observation will be discussed further in Section 4.

For additional context, ATSDR compared the 24-hour average concentrations of sulfur dioxide measured in the Midlothian area with those measured elsewhere in Texas. This comparison was done for 2 years: the year with the highest measured sulfur dioxide concentrations (2001) and the most recent year of complete data (2010) in Midlothian. In 2001, only one of 21 other monitoring stations in Texas recorded 24-hour average sulfur dioxide concentrations higher than those at Old Fort Worth Road (EPA, 2012a). In 2010, 28 sulfur dioxide monitoring stations in Texas were submitting data to EPA's Air Quality System, and 13 of those stations recorded 24-hour average concentrations higher than those at Old Fort Worth Road. Overall, in the years 1999 to 2001, Old Fort Worth Road ranked among the stations with the highest 24-hour average sulfur dioxide concentrations in the state. As sulfur dioxide emissions from TXI Operations decreased in following years, so did the measured concentrations at this station.

In summary, ambient air monitoring for sulfur dioxide in the Midlothian area has focused on areas southwest of Midlothian, near Gerdau Ameristeel and TXI Operations. The highest concentrations were consistently observed at the Old Fort Worth Road monitoring station, which is located immediately downwind from TXI Operations. Sulfur dioxide levels at this station were highest during 1997–2008 and have decreased since then—consistent with the decreasing emissions at the TXI Operations facility. ***Based on the data and information above, short-term exposures to SO_2, especially downwind of the TXI operations, will be further evaluated in the Public Health Implications Section below.***

A data gap in this evaluation is the lack of sulfur dioxide monitoring data at locations north of Midlothian. As Figure 7 shows, sulfur dioxide has never been monitored at locations immediately downwind from the Ash Grove Cement and Holcim facilities. Of these two facilities, Ash Grove Cement continues to have higher annual emissions and has emitted more than 4,000 tons of sulfur dioxide in recent years (except for 2009). Another data gap is that no inferences can be made about sulfur dioxide concentrations before 1990 because of the lack of information on facility emissions.

3.6. Hydrogen Sulfide

Hydrogen sulfide is a gas released from many natural and manmade sources. Some industrial sources include sewage treatment facilities, manure-handling operations, pulp and paper mills, petroleum refineries, and food processing plants (ATSDR, 2006). Steel mills and cement manufacturing facilities can have operations (e.g., wastewater treatment) known to release hydrogen sulfide gases. However, these two industries are not listed among the largest emissions sources of hydrogen sulfide documented in various recent environmental health reviews (e.g., ATSDR, 2006; WHO, 2003).

Reliable estimates of hydrogen sulfide emissions from the Midlothian facilities are not available. TCEQ's emissions inventory has no hydrogen sulfide emissions data for the four facilities, and TRI has only recently required industrial facilities to report releases of hydrogen sulfide. A recent rule added hydrogen sulfide to the list of TRI chemicals, and industrial facilities that meet the reporting thresholds will be required to disclose emissions that occurred in 2012 and thereafter. Accordingly, the first TRI air emissions data for hydrogen sulfide will not be publicly available until late in 2013.

Ambient air monitoring for hydrogen sulfide has occurred at four locations in the Midlothian area (see Figure 8), at the same locations where sulfur dioxide monitoring took place. The monitoring focused on air quality impacts southwest of Midlothian, near the Gerdau Ameristeel and TXI Operations facilities. ATSDR's first Health Consultation for this site concluded that the data collected generally followed scientifically defensible methods and met data quality objectives (ATSDR, 2012a). However, two limitations were noted: (1) monitoring results from the Cedar Drive monitoring station are not considered because they were collected by using an insensitive device that never detected hydrogen sulfide; and (2) monitoring results from 1997 to 1999 had a detection limit of approximately 5 to 10 ppb and therefore are not sufficient for evaluating long-term exposures at levels comparable to EPA's Reference Concentration of 1.4 ppb. Table 14 summarizes all remaining data, which highlight the following trends:

- *Annual average concentrations.* The highest annual average concentration of hydrogen sulfide was 0.60 ppb, which occurred in 2005 at the Wyatt Road monitoring station. This value—and all other annual average concentrations shown in Table 14—is lower than EPA's Reference Concentration (1.4 ppb) for long-term hydrogen sulfide exposures. ATSDR has an intermediate Minimal Risk Level (exposures from 15-364 days of 20 ppb) but does not have a long-term or chronic MRL. Further, the data in Table 14 indicate that annual average hydrogen sulfide concentrations were not different between upwind and downwind monitoring stations. In some years, the monitoring station upwind from the industrial facilities (Midlothian Tower) exhibited higher annual average concentrations than the station downwind from these facilities. This finding is consistent with a statement made earlier about steel mills and cement manufacturing facilities not typically being the largest emissions sources for this pollutant.

- *1-Hour average concentrations.* Table 14 shows that the highest 1-hour average hydrogen sulfide concentrations were measured between 2000 and 2011. The highest individual hourly measurement—14.4 ppb—is lower than the health-based screening values. For short-term exposures, the most relevant screening values are ATSDR's acute inhalation Minimal Risk Level (70 ppb for exposure durations of less than 2 weeks), TCEQ's air quality standard (80 ppb averaged over a 30-minute period), and WHO's health guideline (106 ppb averaged over a 24-hour period).

Overall, all short-term and long-term average hydrogen sulfide concentrations recorded for the Midlothian area have been lower than corresponding health-based air quality standards and guidelines. Hydrogen sulfide has not been monitored in the vicinity of Ash Grove Cement or Holcim. However, trends in the available monitoring data suggest that cement manufacturing facilities likely have limited air quality impacts —a finding that is consistent with ATSDR's broad research for this pollutant. ***Based on the above evaluation, ATSDR will not further evaluate hydrogen sulfide exposures in the Public Health Implications Section below.***

3.7. Summary

The following paragraphs summarize the air quality data for the pollutants considered in this Health Consultation. Refer to Section 4 for ATSDR's public health evaluation for these pollutants. In addition, please see Table 15 for a summary of health comparison values considered in the above evaluation and which air pollutants are determined to be a contaminant of concern for further evaluation in the Public Health Implications Section below.

Carbon monoxide. The estimated carbon monoxide concentrations attributed to the Midlothian facilities are lower than EPA's health-based standards and WHO's health guidelines. This finding is based on ATSDR's modeling analysis, which considered the highest carbon monoxide emission rates reported for the four facilities of interest during 1990–2010. No inferences can be made about carbon monoxide levels before 1990, because of the lack of information on facility emissions in those years. ***Based on the above analyses, ATSDR will not further evaluate carbon monoxide in the Public Health Implications Section below***

Lead. The highest airborne lead levels in the Midlothian area were measured downwind from Gerdau Ameristeel—the facility that consistently had the highest lead emissions of the four facilities of interest. Measured lead concentrations were typically greatest immediately north of this facility. In the mid-1990s, the lead levels measured in this area ranked among the highest lead concentrations measured statewide. This appears to be a highly localized effect, with lead concentrations decreasing rapidly with downwind distance from the facility.

In the 1990s, measured lead concentrations immediately north of the facility were below EPA's health-based lead standard at the time (1.5 $\mu g/m^3$), but were greater than EPA's current standard (0.15 $\mu g/m^3$). In 18 of 23 consecutive calendar quarters with sufficient data during 1993–1998, the quarterly average lead concentrations at the Gerdau Ameristeel monitoring station exceeded the standard that EPA issued in 2008. The highest downwind quarterly average lead concentration (0.443 $\mu g/m^3$) was observed in 1995. No annual average measurements were greater than WHO's current health guideline (0.5 $\mu g/m^3$). Lead emissions from Gerdau Ameristeel were notably higher before ambient air monitoring for lead took place at locations downwind from the facility, especially in 1987, 1988, and 1989 (see Table 2). A logical inference is that lead concentrations downwind from the facility in those years were likely higher than the highest level measured in the monitoring programs. Because of the lack of emissions data available for this period, commenting on lead levels near Gerdau Ameristeel during its first years of operation (1975-1986) is difficult.

In 1981 and 1983, quarterly average lead concentrations at Midlothian City Hall exceeded the health-based standard that EPA issued in 2008, but did not exceed the WHO health guideline. This most likely reflected influences from mobile sources, because numerous monitoring stations throughout Texas exhibited comparable lead levels during the early 1980s. No inferences can be made about lead levels before 1987, because information on facility emissions in those years is lacking. ***Given that lead was detected at Gerdau Ameristeel monitoring station for the years***

1993–1998 above the current EPA standard, lead will be further evaluated in the Public Health Implications Section below.

Nitrogen dioxide. All measured nitrogen dioxide concentrations in the Midlothian area have been lower than EPA's health-based standards and WHO's health guidelines, considering both long-term (annual) and short-term (1-hour) exposure durations. The monitoring data from 2000 to 2011 and emissions data from 1990 to 2010 suggest that nitrogen dioxide levels have not exceeded health-based standards or guidelines in residential areas dating back to 1990. No inferences can be made about nitrogen dioxide levels before 1990, because information on facility emissions in those years is lacking. ***Based on the above analyses, ATSDR will not further evaluate nitrogen dioxide in the Public Health Implications Section below.***

Ozone. Ellis County is one of 11 counties that make up the Dallas–Fort Worth ozone non-attainment area, which means that ozone levels in the metropolitan area occasionally exceed EPA's health-based standards. Levels in Ellis County also have been above WHO's health guidelines. Emissions from industrial sources, mobile sources, and natural sources throughout the area contribute to this problem. ***For these and other reasons, this Health Consultation addresses ozone as a general air quality issue that is only partly affected by emissions from the Midlothian facilities and will be further evaluated in the Public Health Implications Section below.***

Particulate matter. Ambient air monitoring of particulate matter has occurred for many years in Midlothian, with the particle size fraction measured—TSP, PM_{10}, and $PM_{2.5}$—changing from one year to the next. Unlike other pollutants, which showed distinct spatial variations and peak concentrations downwind from certain facilities, the PM concentrations were uniform across the locations where sampling occurred except for the PM sampling that occurred at the Gerdau Ameristeel monitor during the years 1996–1998. ATSDR's evaluation focuses on the particle sizes that are most likely to be inhaled (PM_{10} and $PM_{2.5}$). The available data suggest that measured annual average $PM_{2.5}$ concentrations were all below EPA's current health-based standard (except for a partial year at Midlothian Tower for 2005), most were below the EPA proposed range for lowering the standard, and many were greater than WHO's protective health guideline. Based on ATSDR's estimate of $PM_{2.5}$ levels from annual average PM_{10} data, detected at the Gerdau Ameristeel monitor for the years 1996–1998, average $PM_{2.5}$ levels could have exceeded the current and proposed standard. None of the measured 24-hour PM_{10} levels were above the EPA standard but some were above the WHO standard that is designed to protect against harmful $PM_{2.5}$ exposures.

Based on the highest concentrations on record from all monitoring stations (Table 10), the EPA 24-hour average health-based standard was exceeded infrequently (about 22 times during 2000–2011, and several of these high concentrations occurred on the same day at different monitors). Several of these levels slightly exceeded the standard. It is important to note that although the standard was exceeded several times on a numerical basis, it did not exceed the standard as defined by EPA. This finding is considerable because much of the monitoring occurred in areas expected to have the greatest air quality impacts; therefore, the data suggest that short-term PM exposures, especially for fine particles, were likely from a combination of regional and local sources with an exact contribution from each uncertain. However, localized PM elevations found north of the Gerdau Ameristeel fence line, during the years 1996–1998, were likely from emissions from Gerdau as a primary contributor. Additional days when the 24-hour $PM_{2.5}$ standard was exceeded could have occurred, but this was not indicated from the continuous monitors because of the negative bias found versus the 24-hour monitors (ATSDR, 2012a). As with the other pollutants, no inferences can be made about PM concentrations for years before 1990, because available emissions and ambient air monitoring data for those times was limited. ***For these reasons, ATSDR will further evaluate long-term PM_{10} exposures (as a proxy for $PM_{2.5}$) in the immediate vicinity north of the Gerdau Ameristeel fence line for the years 1996–1998 and short-term exposures to $PM_{2.5}$ will be further evaluated in the Public Health Implications Section below.***

Sulfur dioxide. Ambient air concentrations of sulfur dioxide were extensively measured at three locations southwest of Midlothian during 1997–2011. The measured air quality impacts were consistently highest at the monitoring station directly north of—and downwind from—TXI Operations. The concentrations at this station generally tracked with the facility's emissions: air quality impacts were highest in years when emissions were high, and air quality impacts were lowest after the facility's emissions began to decrease. During 1997–2008, some 1-hour sulfur dioxide concentrations at Old Fort Worth Road exceeded the health-based standard that EPA implemented in 2010, but met EPA's health-based standards that were in place at the time. Similarly, until 2008, 24-hour average concentrations of sulfur dioxide at both the upwind and downwind stations were above WHO's health guideline. No inferences can be made about sulfur dioxide levels before 1990, because of the lack of information on facility emissions in those years. ***Based on the data and information above, short-term past exposures to SO_2, especially in the area downwind of the TXI and Gerdau Ameristeel operations, will be further evaluated in the Public Health Implications Section below.***

Hydrogen sulfide. All measured hydrogen sulfide concentrations in the Midlothian area have been lower than health-based standards and guidelines published by ATSDR, EPA, TCEQ, and WHO. This finding applies to both long-term (annual) and short-term (1-hour) exposure durations. The concentrations measured at the monitoring station downwind from Gerdau Ameristeel and TXI Operations were not different from those measured at the monitoring station upwind from these facilities, suggesting that emissions from these facilities are not the primary influence on local hydrogen sulfide levels. No quantitative data are available for assessing hydrogen sulfide levels before 2000, because of the lack of information on facility emissions in those years. However, the available information suggests that these facilities have minimal impacts on local hydrogen sulfide levels—a finding that likely applies to earlier years of operation. ***Based on the above analyses, ATSDR will not further evaluate hydrogen sulfide exposures in the Public Health Implications Section below.***

4. Public Health Implications Discussion

4.1. Sulfur dioxide

EPA's 1-hour standard of 75 ppb is designed to protect people from exposures to high, short-term peaks of SO_2 (from 5-minutes to 24-hour exposures). In addition, EPA determined that little health evidence suggests an association between long-term low-level exposure to SO_2 and public health effects (EPA, 2010e).

ATSDR believes that the best data available for evaluating the health implications of exposure to sulfur dioxide is peak concentrations, such as 5-minute average measurements (measured by TCEQ from 1997 to present). The remainder of this section uses this averaging period, even though EPA's and TCEQ's short-term health-based standards are based on 1-hour average levels.

Conclusions for Sulfur Dioxide

For the *general population,* breathing sulfur dioxide at measured concentrations from 1997 to 2011 in the Cement Valley and in areas east and south of the TXI facility boundary for peak (5-minute) exposures is not expected to be harmful.

Sensitive populations (e.g., individuals with asthma) may experience respiratory symptoms if they are exposed to peak sulfur dioxide concentrations higher than 400 ppb, specifically during times of elevated inhalation rates, such as while exercising. Exposures above 400 ppb have occurred very infrequently (three times in 2005 and once in 2008 in Cement Valley and once at the Midlothian Tower monitor in 1997). Symptoms may include coughing, wheezing, or chest tightness, and are likely reversible. For concentrations lower than 400 ppb sulfur dioxide, sensitive individuals at elevated inhalation rates may experience effects such as bronchoconstriction without developing symptoms.

People with asthma, children, and older adults (65+ years) have been identified as groups susceptible to the health problems associated with breathing SO_2. Clinical investigations and epidemiologic studies have provided strong evidence of a causal relationship between SO_2 and respiratory diseases (morbidity) in people with asthma and more limited epidemiologic studies have consistently reported that children and older adults (65+ years) may be at increased risk for SO_2-associated adverse respiratory effects. Potentially susceptible groups to air pollutants include obese individuals, those with preexisting cardiopulmonary disease, and those with a pro-inflammatory condition such as diabetes, but some of these relationships have not been examined specifically in relation to SO_2.

Outdoor vs. Indoor Exposures--outdoor SO_2 can enter indoor settings, primarily when residents have their windows open. No valid SO_2 indoor air monitoring data are, however, available at this site. Indoor air concentrations likely will not exceed the peak outdoor concentrations noted in this section, unless a resident has a substantial indoor source. When windows are open, we expect the same conclusions presented here for outdoor settings to apply to indoor settings.

SO_2 peak (5-minute) exposure summary

ATSDR grouped the 5-minute peak SO_2 concentrations into categories based on health endpoints (Appendix B provides a detailed discussion and additional references). Clinical studies reported in peer-reviewed scientific literature provided the basis for the health endpoint derivations.

ATSDR bases its public health evaluation of sulfur dioxide exposures largely on previous clinical studies that involved recruitment of volunteers who were exposed to sulfur dioxide and monitored for effects. These studies required informed consent and were closely monitored to ensure they were conducted ethically. For sulfur dioxide, these clinical studies have been conducted on healthy volunteers, including some who had mild to moderate asthma. However, the studies did not include children or people with severe asthma or. Some people who live in Midlothian might be more sensitive to sulfur dioxide than were the volunteers who participated in these clinical studies. For sensitive people at increased breathing rates, effects of exposure to SO_2 concentrations below 200 ppb are uncertain because studies have not been conducted at this level. In general, these clinical studies have controlled exposure conditions that include humidity and temperature. Cold and dry air, which occurs in real-world exposure conditions, has been reported to induce effects at lower SO_2 concentrations.

People with asthma, children, and older adults (65+ years) have been identified as groups sensitive to the health problems associated with breathing SO_2 (EPA, 2010d; EPA, 2008c). Human health studies (clinical investigations and epidemiologic studies) have provided strong evidence of a causal relationship between SO_2 and respiratory diseases (morbidity) in people with asthma and more limited epidemiologic studies have consistently reported that children and older adults may be at increased risk for SO_2-associated adverse respiratory effects (EPA, 2010e). Potentially sensitive groups to air pollutants include obese individuals, those with preexisting cardiopulmonary disease, and those with a pro-inflammatory condition such as diabetes (EPA, 2008c), but some of these relationships have not been examined specifically in relation to SO_2.

Analysis of the sampling conducted during 1997–2011 resulted in the following average exposure estimates by concentration category (see Figure 10 for a scatterplot of peak 5-minute average SO_2 data and health endpoints and Table 16 for the percentages of peak [5-minute] SO_2 concentrations by monitoring station and year during 1997–2011).

Greater than (>) 400 ppb

During this period, 5-minute SO_2 concentrations >400 ppb occurred only five times. Of these five occasions, three occurred in 2005 and one in 2008 in Cement Valley and once in the area of the Midlothian Tower in 1997. One 5-minute SO_2 detections >500 ppb (Wyatt Road) and four 5-minute SO_2 detections (Wyatt Road, Old Fort Worth Road, and Midlothian Tower) between 400-500 ppb also occurred. None have occurred since 2008.

Sensitive individuals, especially when at increased breathing rates, to levels above 400 ppb could result in bronchoconstriction resulting in *symptoms* such as coughing, wheezing, or chest tightness. For concentrations >500 ppb, exposure to sensitive individuals may result in more frequent use of medication, seeking medical assistance, or cessation of physical activity. These exposures are estimated to have occurred infrequently and were temporally and spatially limited to the area north of TXI and Gerdau Ameristeel in the Cement Valley area.

200 ppb - 400 ppb

During this period, 129 5-minute SO_2 levels between 200–400 ppb occurred at the Old Fort Worth Road and Wyatt Road monitors; eight occurred at the Midlothian Tower.

When exposed to SO_2 at this concentration range, sensitive individuals breathing at an increased rate could have effects such as mild bronchoconstriction *without* experiencing *symptoms* such as coughing, wheezing, or chest tightness. Affected individuals may not be aware of the bronchoconstriction, which is estimated as mild and transient. Based on available data and information, exposure occurred infrequently and was temporally and spatially limited primarily to individuals living in the Cement Valley and, secondarily, those residing in the areas just east, south, and southeast of the TXI fence line (see Figure 7).

10 ppb - 200 ppb

Detections between 100–200 ppb SO_2 were- multiple and widespread, especially in the Cement Valley area. During this period, 2,603 5-minute SO_2 measurements between 100–200 ppb occurred at the Old Fort Worth Road and Wyatt Road monitors and 225 at the Midlothian Tower. The 5-minute SO_2 level was between ATSDR's chronic MRL of 10 ppb and 100 ppb was 59,820 times at Old Fort Worth Road and Wyatt Road monitors and 22,895 times at the Midlothian Tower monitor.

In clinical studies, sensitive individuals (such as those with mild to moderate asthma) using a mouthpiece have experienced effects when exposed to sulfur dioxide concentrations less than 200 ppb (Sheppard et al., 1981). The lowest observed adverse effect level (LOAEL) from this study was 100 ppb. ATSDR has determined that a reasonable acute Minimal Risk Level (MRL), based on this study, should be ten times below the LOAEL or 10 ppb. Whether exposures below 200 ppb might cause effects in sensitive individuals at increased ventilation rates under normal environmental conditions is uncertain, given that clinical investigations have not been conducted in free-breathing asthmatics at concentrations below 200 ppb. Individuals who lived in Cement Valley likely experienced exposures above the LOAEL every year from 1997 to 2008 and possibly those living east, south and southeast of the TXI facility, likely experienced exposures above the LOAEL during 1997–2006 (except 2004). No exposures above the LOAEL were likely during 2009–2011 in Cement Valley, and starting in 2007, not in areas south, east, and southeast of the TXI facility boundaries (although this is somewhat uncertain because we do not have data from the Midlothian Tower after 2007 but we base our assessment on lower TXI emissions and the much lower levels in the Cement Valley).

4.2. Fine Particulate Matter ($PM_{2.5}$)

Mortality and cardiovascular and respiratory morbidity have been associated with both short-and long-term exposure to $PM_{2.5}$ (EPA, 2009). Most measured annual average $PM_{2.5}$ levels since 2000 in the Midlothian area are not above EPA's current or proposed standard. Moreover, ATSDR estimates that $PM_{2.5}$ exposures in a localized area of Cement Valley, just north of Gerdau Ameristeel during 1996–1998, were above the current EPA standard and might have been about twice the proposed EPA standard. In addition, also based on ATSDR estimates of past annual average $PM_{2.5}$ levels, exposures above the EPA current or proposed standard could have occurred occasionally for several years in the 1990s, especially among people who lived in other areas of Cement Valley, east and south of the TXI property line, and in the Gorman Road area. However, as stated previously, ATSDR is uncertain whether exposures above the current or proposed EPA standard actually occurred in these areas. In addition, short-term $PM_{2.5}$ levels infrequently exceeded the current standard of 35 $\mu g/m^3$ numerically during the period 2000-2011; however, as defined by EPA, short-term levels of $PM_{2.5}$ in the Midlothian area have not exceeded the current standard.

As PM health effect thresholds have not been identified, and given a substantial interpersonal variability in exposure and subsequent harmful effects, that any standard or guideline value will lead to complete protection for everyone against all possible adverse health effects is unlikely (WHO, 2006). Population subgroups that may be more sensitive to the effects of PM exposure include infants, older adults (65+ years), individuals with asthma, COPD or cardiovascular disease, diabetics, lower socioeconomic status, and those with certain genetic polymorphisms (EPA 2009).

Several health studies have investigated potential health effects resulting from long-term exposure to particulate matter. The historical mean $PM_{2.5}$ concentration was 18 µg/m^3 (range 11.0 - 29.6 µg/m^3) in the Six-Cities Study and 20 µg/m^3 (range 9.0 – 33.5 µg/m^3) in the American Cancer Society (ACS) study (Dockery et al., 1993; Pope et al., 1995, 2002; HEI, 2000; Jerrett, 2005). Thresholds (exposure levels where health effects are first seen) are not apparent in these studies. In the ACS study, statistical uncertainty in the risk estimates becomes apparent at concentrations of about 13µg/m^3, below which the confidence bounds significantly widen because of the variability in the exposure concentrations. According to the results of the Dockery et al. (1993) study, the risks are similar in the cities with the lowest long-term $PM_{2.5}$ concentrations (i.e., 11 and 12.5 µg/m^3). Increases in risk are apparent in the city with the next-lowest long-term $PM_{2.5}$ average concentration (i.e., 14.9 µg/m^3), indicating that when annual mean concentrations are in the range of 11–15 µg/m^3, health effects can be expected (WHO 2006).

Results from using the EPA AirNow AQI Calculator, indicate that the highest 24-hour $PM_{2.5}$ levels recorded in Midlothian show in an increased likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in individuals with cardiopulmonary disease and the elderly but not for the general population (EPA, 2012b).

4.3. Ozone

Conclusions for Ozone:
Ellis County is one of 11 counties that make up the Dallas–Fort Worth ozone non-attainment area, which means that ozone levels in the metropolitan area occasionally exceed EPA's health-based standards and WHO's health guidelines. Emissions from industrial sources, mobile sources, and natural sources throughout the area contribute to this problem.
The *general population* of Midlothian is not expected to experience harmful effects from ozone exposure except on rare occasions when ozone levels reach around 100 ppb or more.
Many of the levels of ozone detected in Midlothian since monitoring began in 1997 indicate that *sensitive individuals* have an increased likelihood of experiencing harmful respiratory effects (respiratory symptoms and breathing discomfort). This is primarily true for active children and adults and people with respiratory diseases, such as asthma.

Breathing air containing ozone can reduce lung function and increase respiratory symptoms, thereby aggravating asthma or other respiratory conditions. Ozone exposure also has been associated with increased susceptibility to respiratory infections, more frequent medication use by people with asthma, doctor's visits, and emergency department and hospital admissions for individuals with respiratory disease. Ozone exposure also might contribute to premature death, especially in people with heart and lung disease. More recent information indicates that other outcomes such as school absenteeism, cardiac-related effects, and greater, more serious, and more long-lasting symptoms among people with asthma may occur (EPA, 2008d). Moreover, a controlled exposure study of healthy young volunteers to ozone at levels similar to the EPA standard resulted in cardiovascular changes that could put a sensitive individual at risk for an adverse cardiovascular event. These results provide biological plausibility and support to the previous findings in other types of human health studies (epidemiologic) of an association between ozone exposures and increased risk of death and disease (Devlin et al., 2012).

Many of the 8-hour ozone levels reported in the Midlothian area since monitoring began in late 1997, indicate that sensitive individuals have an increased likelihood of respiratory symptoms and breathing discomfort. These reactions are true for primarily active children and adults and people with respiratory disease, such as asthma. On rare occasions during this period, levels reached 100 ppb or more, indicating that even non-sensitive individuals from the general population may have experienced harmful effects (EPA, 2012b).

4.4. Lead

4.4.1 *Recent Human Studies on the Effects of Lead*

Until recently, the CDC had established a level of concern for case management of 10 µg/dL. This means that when blood lead levels in children exceed 10 µg/dL, CDC recommends that steps be taken to lower their blood lead levels. More information about CDC's recommendations can be found in *Preventing Lead Poisoning in Young Children* (CDC, 2005). CDC also provides tips for preventing exposure to lead. These tips can be found at this web address: http://www.cdc.gov/nceh/lead/tips.htm.

Many people have mistakenly used this level in blood as a safe level of exposure or as a no effect level. Recent scientific research, however, has shown that blood lead levels below 10 µg/dL can cause serious harmful effects in children. As a result, there is no identified "safe" blood lead level for children. Blood lead levels below 10 µg/dL have been shown to cause neurological, behavioral, immunological, and developmental effects in young children. Specifically, lead causes or is associated with decreases in (IQ; attention deficit hyperactivity disorder (ADHD); deficits in reaction time; problems with visual-motor integration and fine motor skills; withdrawn behavior; lack of concentration; issues with sociability; decreased height; and delays in puberty, such as breast and pubic hair development, and delays in menarche (ATSDR, 1999).

On January 4, 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended that CDC adopt the 97.5 percentile for children aged 1–5 years as the reference value for blood lead levels to identify children and environments associated with lead-exposure hazards. The 97.5% currently is 5 ug/dL (CDC, 2012a). The full report is available at http://www.cdc.gov/nceh/lead/ACCLPP/Final_Document_011212.pdf. On June 7, 2012, the CDC released a statement concurring with the recommendations of the ACCLPP (CDC, 2012b). The full statement can be found at: http://www.cdc.gov/nceh/lead/ACCLPP/CDC_Response_Lead_Exposure_Recs.pdf. Based on CDC's concurrence, there is no longer a blood lead "level of concern."

4.4.2 Estimating children's lead dose from air levels just north of the Gerdau Ameristeel facility

The 2008 EPA lead standard for air was developed to prevent the loss of 1–2 IQ points in young children (EPA, 2008e). In addition, the U.S. EPA developed a model to estimate the contribution of lead in air (and other media, including soil) to children's blood lead level. The model is called the integrated exposure uptake biokinetic (IEUBK) model (http://www.epa.gov/superfund/lead/products.htm#guid). The model estimates the percentage of children aged 6 months to 7 years that exceed a specified blood lead level at certain air lead concentrations. In most situations, the EPA's goal is to limit exposure to lead in a child or group of similarly exposed children that would have an estimated risk of no more than 5% chance of exceeding a blood lead level of 10 µg/dL (EPA, 2002).

Conclusions for Lead:
Past air lead exposures, during 1993–1998, in a localized area just north of the Gerdau Ameristeel fence line, could have harmed the health of children who resided or frequently played in these areas. The estimated health effect of these exposures would have been a slight lowering of IQ levels (1–2 points) for some children living in this area. There is some uncertainty with these findings given that we do not know what the lead levels in air were downwind of the Gerdau monitor, and we do not know if small children were exposed at all in this sparsely populated area of Cement Valley.

Since 1998, lead levels in this localized area have decreased sharply. Monitoring data do not indicate that lead exposures above EPA standards have occurred in other areas of Midlothian currently or in the past.

ATSDR has run the model using EPA's default parameters for lead in food, in water, and from soil ingestion. ATSDR also ran the model using the updated reference value of 5 µg/dL to account for the risk of adverse health effects in children with levels below 10 µg/dL. Using a combination of default parameters for the IEUBK model and using the highest annual (1995) and quarterly average levels from the Gerdau Ameristeel monitor during 1993–1998, the model estimates children have, on average, about a 18.5-21.4 % risk of having blood lead concentrations between 5 and 10 µg/dL. Stated another way, if 100 children lived on properties in the vicinity of the Gerdau Ameristeel monitors during 1993–1998, and lead in air concentrations were 0.251-0.443 $\mu g/m^3$, the IEUBK model predicts that about 21 or fewer children out of 100 will have a blood lead level between 5-10 µg/dL, a level that might result in small IQ deficits. Because no blood lead levels are safe in children, measures to reduce lead in the environment will reduce the risk of health effects.

The model did not predict an increased risk of childhood blood levels to reach 10 µg/dL or more. Although the results for the model run at 10 µg/dL may appear inconsistent with the 2008 NAAQS for lead, the NAAQS is not strictly based on the IEUBK model. In fact, the 2008 NAAQS for lead is based on air-related exposure and IQ loss that was established to prevent a loss of 1-2 IQ points. This evidence-based framework was established by a quantitative exposure/risk assessment process that relied on an air to blood ratio (Personal Communication, Mark Follansbee, EPA IEUBK Contractor, March 14, 2012). Moreover, uncertainty in these findings exist because of the following:

1) We do not know what the air levels were downwind of the Gerdau monitor.
2) That a small population was exposed is likely, given the low-population density in Cement Valley near the Gerdau monitor.

Evaluation of the actual childhood blood lead data in the Midlothian area will be conducted in a future ATSDR Health Consultation.

4.5 Mixtures (including ozone)

Throughout this section, the health evaluations have focused on individual pollutants. This analysis is consistent with the toxicological literature, which focuses on health effects following single pollutant exposures. In the Midlothian area, however, as with many industrial sites, real-world environmental exposures occur simultaneously and involve multiple pollutants. This section considers the public health implications of such exposures, focusing particularly on the potential for co-exposures to ozone, $PM_{2.5}$, and sulfur dioxide. Many gaps exist in our understanding of the full range of health impacts of air pollution (i.e., the mixture of pollutants) and scientific and regulatory communities are at least 10 years away from being able to implement changes to address these issues (Mauderly et al., 2010).

Conclusions for Mixtures:
ATSDR believes that sufficient information exists to warrant concern for sensitive individuals simultaneously exposed to multiple air pollutants, especially in the past (1997 to late 2008) when SO_2 levels were higher and when these persons were breathing at higher rates (e.g., while exercising, etc.). ATSDR believes the severity of health effects from a mixture exposure is not likely to exceed those discussed for SO_2, $PM_{2.5}$, or ozone exposure alone. For past SO_2 exposures, it is possible that the number of sensitive individuals affected may have been greater because effects may have occurred at a lower SO_2 concentration when combined with exposure to ozone, $PM_{2.5}$, or both. Potential effects to a larger sensitive population, especially in the past, may be limited to an exposure to those contaminants present at sufficient concentration during the same time and at the same locations during the warmer months when $PM_{2.5}$ and ozone levels are generally the highest. In addition, potential effects to this larger sensitive population may also have resulted from multiple exposures occurring during several consecutive days. These conclusions are based on our best professional judgment and ATSDR recognizes the uncertainty associated with them.

Using the available ambient air monitoring data, ATSDR first notes where and when individual pollutants reached their peak levels:

- **Ozone.** Ambient air concentrations of ozone tend to peak in the summer with the highest levels likely in the afternoons primarily during May and September with some elevations reported in April and October.
- **$PM_{2.5}$.** Levels in the Midlothian area tend to be highest during warm months. All of the numerical exceedances of the 24-hour $PM_{2.5}$ standard occurred between May and September. However, as defined by EPA, the 24-hour standard has not been exceeded in Midlothian.

- **Sulfur dioxide.** Monitoring data from the Old Fort Worth Road, Wyatt Road, and Midlothain Tower indicated elevated sulfur dioxide concentrations (i.e., above the EPA 1-hour standard of 75 ppb). Elevated concentrations begin to increase around 5 p.m. and taper off around 6 a.m.; the highest frequency of elevations occurred between 7 p.m. and 3 a.m. In all months of the year, 1-hour SO_2 levels were above the standard; however April, May, and October had the highest frequency and June, August, November, and December had the lowest. As noted previously, the populations exposed lived primarily in the Cement Valley area and, secondarily, east, southeast, or south of the TXI property boundary.

Taken together, the previous observations suggest that the timeframe of greatest concern for past exposures to mixtures was during the late afternoon hours or early evening hours from late spring to early fall. This concern would be greatest for the Cement Valley, where the highest and most frequent sulfur dioxide concentrations are estimated to have occurred. In this area, co-exposures were possible between elevated levels of sulfur dioxide and ozone or sulfur dioxide and $PM_{2.5}$, or possibly all three pollutants combined. However, the effects of ozone, sulfur dioxide, and $PM_{2.5}$ may have a lag effect, and a direct relationship to co-exposures around the same hour or on the same day is not likely to tell the whole story regarding the total effects of the past and current mixtures exposures. For example, a sensitive person may be exposed to harmful levels of one NAAQS constituent on one day only but may not exhibit the effect until the next day or several days later. Meanwhile, this person could then be exposed again to harmful levels of the same or other NAAQS constituents during subsequent days.

Some sulfur-dioxide sensitive individuals functioning at elevated ventilation rates may have experienced enhanced effects from exposure to a mixture of sulfur dioxide and ozone or $PM_{2.5}$. The number of sensitive individuals affected in the past may have increased because effects may have occurred at a lower sulfur dioxide concentration. Scientific information is insufficient to allow meaningful quantitative analysis, but is sufficient to warrant concern for sensitive populations, especially those who are at higher ventilation rates (e.g., exercising, etc.). Nevertheless, past exposure to the mixture of all three constituents is limited temporally and spatially by sulfur dioxide, primarily in the Cement Valley and secondarily to areas south, east, and southeast the TXI boundary. However, other areas may have had concurrent $PM_{2.5}$ and ozone exposures without elevated SO_2 exposures. Given the infrequent elevations of SO_2 above 200 ppb and the spatial and temporal limitations identified here, ATSDR believes the severity of health effects from a mixture exposure is not likely to exceed those discussed for SO_2, $PM_{2.5}$, or ozone exposure alone. Because, however, effects may have occurred at a lower SO_2 concentration, the number of affected individuals might have increased beyond what would be expected from exposure to a single air pollutant.

4.6 Gaps and Limitations

In this health consultation, ATSDR considered the public health implications of the measured and estimated air pollution levels in the Midlothian area relating to the NAAQS constituents and hydrogen sulfide. Furthermore, ATSDR considered whether the available data form an adequate basis for reaching conclusions. The following discussion does not focus on gaps and limitations for those timeframes in the past where ATSDR will never be able to evaluate exposures; however, it focuses on the gaps in our understanding of current and future exposures and the limitations of our evaluation. A more in-depth discussion can be found in ATSDR's previous health consultation (ATSDR, 2012a).

4.6.1 SO_2 Limitation

ATSDR's conclusions for sulfur dioxide were based primarily on data from a monitoring network that indicate exposures to person living in the Cement Valley or east, south, or southeast of the TXI facility boundary. While TXI SO_2 emissions have declined in recent years, the SO_2 emissions from Ash Grove and Holcim have been comparable to TXI emissions in the late 1990s and early 2000s that produced harmful levels of SO_2 in several locations, primarily Cement Valley. Additional monitoring data are needed to determine exposures of people who live downwind of the Ash Grove and Holcim facilities.

4.6.2 PM Limitations

In ATSDR's judgment, the most notable gap is the lack of monitoring data for residential neighborhoods in immediate proximity to the four industrial facilities, where fugitive emissions would be expected to have the greatest air quality impacts. Current and past monitoring locations likely do not adequately characterize particulate matter levels for all residents located immediately adjacent to certain onsite operations, such as limestone quarry activity. Particulate matter monitoring is needed in these areas to evaluate exposures.

4.6.3 Mixtures Limitations

ATSDR notes that a limitation inherent in the public health assessment process is that scientists do not have a complete understanding how simultaneous exposures to several environmental contaminants may cause health effects. For the pollutants considered in this analysis—especially sulfur dioxide, ozone and particulate matter, however, hundreds of toxicologic and epidemiologic studies have examined how exposures are possibly related to health effects in humans. Therefore, the evaluations of individual pollutants considered in this health consultation are based on extensive scientific research, but the scientific understanding of the health effects of exposures to pollutant mixtures is less advanced. ATSDR's conclusions regarding the health implication of exposures to a mixture of air pollutants is based on our best professional judgment related to our understanding of the possible harmful effects of air pollutant exposures in Midlothian and our interpretation of the current scientific literature; therefore, these conclusions are presented with some uncertainty.

As with most site-specific environmental health evaluations ATSDR conducts, the findings and conclusions in this health consultation have some inherent gaps and limitations. But for the reasons cited above, ATSDR concludes that this assessment does not have major limitations that would preclude scientifically defensible conclusions.

5. Child Health Considerations

In communities with air pollution issues, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances. Children frequently play outdoors, especially during the summertime or after school during the warm months, which can increase their exposure potential. Further, a child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Further, children are dependent on adults for access to housing, access to medical care, and risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

When preparing this health consultation, ATSDR considered these and other children's health concerns. For instance, when selecting health-based comparison values for the exposure evaluation, ATSDR identified, when available, comparison values protective of children's exposure and of health conditions, such as asthma, more common in children. As one example, ATSDR used the most recent EPA's National Ambient Air Quality Standards to screen air pollution levels for lead, ozone, particulate matter, and sulfur dioxide. EPA developed these standards to protect the health of sensitive populations, including children. In addition, ATSDR compared the environmental data to other guidelines, such as those fromWHO, and investigated whether current NAAQS standards are protective—given our current scientific knowledge. For example, we determined that the current annual average $PM_{2.5}$ standard of15 $\mu g/m^3$ might not be protective of children and that EPA is proposing to lower the standard to 12-13 $\mu g/m^3$.

It is not clear that children are more toxicologically sensitive to SO_2 but might be more vulnerable because of increased exposure. While physiologically based pharmacokinetic modeling has suggested that children might be more vulnerable in the pulmonary region to fine particulate matter, it also suggests that children's airways might not be more sensitive than adults to reactive gases such as SO_2 (Ginsberg et al., 2005).

Factors that might contribute to enhanced lung deposition in children include higher ventilation rates, less contribution from nasal breathing, less efficient uptake of particles in the nasal airways, and greater deposition efficiency of particle and some vapor phase chemicals in the lower respiratory tract. A child breathes faster than an adult, which might result in increased uptake (Koenig et al., 2000). Children spend 3 times as much time outdoors as adults and engage in 3 times as much time playing sports and other vigorous activities (EPA, 1997). Based on these parameters, children are more likely to be exposed to more outdoor air pollution than adults. Epidemiologic evidence suggests that air pollution effects (lung function decrements) in children might not be fully reversible, even if the exposure stops, although SO_2 was not a major contaminant in these studies (Gauderman et al., 2004).

Recent literature suggests that exposure to air pollution during pregnancy causes adverse birth outcomes and health problems for the mother and child. Two of the pollutants of concern for these outcomes, particular matter and ozone, are also considered a concern in Midlothian. Research shows that prenatal exposure to these pollutants can increase the risk of preterm delivery and low birth weight, which contribute substantially to infant death and developmental disabilities (EPA, 2010f).

ATSDR identified other environmental health concerns specific to children for this site: elevated airborne levels of ozone and fine particulate matter. Many children who live in the Midlothian area, like children who live in numerous urban and suburban areas in Dallas-Fort Worth Metropolitan area and across the country, have a greater risk of suffering from ozone-related adverse health effects than do adults.

ATSDR's concern for this subject is based partly from the fact that ozone and $PM_{2.5}$ levels are generally highest during the afternoon hours on sunny summer days, when most children are not in school and might be playing outdoors. Another reason for concern is that people with asthma have been identified as a sensitive population for both ozone and $PM_{2.5}$ exposure, and asthma is more prevalent among children than among adults (Mannino et al., 2002). Finally, some families with children might not seek or understand information in air quality forecasts. These factors are of concern because children with asthma or children who engage in moderate to strenuous exercise (e.g., swimming and running) during poor air quality days are at risk for respiratory problems.

Many resources are available to help prevent children from exposure to unhealthful levels of ozone and $PM_{2.5}$. On days with the most elevated air pollution levels, TCEQ issues air quality alerts or forecasts, which are typically broadcast by the local media. Parents should encourage their children, especially children with asthma, to play indoors on days when air pollution levels are predicted to be unhealthful. EPA's Web site now includes a substantial amount of information on ozone, $PM_{2.5}$, and related air quality problems. Adults are encouraged to access this information, whether from their home computers or those at local libraries, at www.epa.gov/airnow. Additionally, EPA recently launched a Web site that presents air pollution information related to children's health. The site, "Air Quality Index for Kids!", is available in English and Spanish at www.epa.gov/airnow/aqikids.

6. Community Concerns Evaluation

Since 2005, ATSDR and TDSHS have been collecting and documenting community concerns regarding the Midlothian facilities. The agencies have learned of these concerns through various means, including a door-to-door survey of residents, a community survey, and multiple public meetings and availability sessions in Midlothian. The concerns expressed by community members have addressed many topics, including human health, animal health, and the adequacy and reliability of ambient air monitoring data collected in the Midlothian area.

Concerns Addressed in This Document:

This Health Consultation addresses community concerns regarding the potential exposures to the NAAQS constituents and H_2S related to the Midlothian facilities and for potential exposures to these air pollutants from other sources. Future ATSDR evaluations will evaluate community concerns related to exposures to other air pollutants, animal concerns and health-outcome data.

The following are responses to community concerns related to the evaluation of the NAAQS constituents:

1. Protectiveness of the regulatory health-based screening guidelines

Response: ATSDR used several sources for health-screening guidelines (EPA, ATSDR, and WHO) to evaluate which air pollutants to further evaluate. In addition, ATSDR evaluated how current each health screening value is in relation to the most recent scientific information. For example, EPA is considering lowering the annual average $PM_{2.5}$ value to around 12-13 µg/m^3 from its current level of 15 µg/ m^3. This information was taken into account in this health consultation.

2. Persistence of emissions and the effects of continuous low-level exposure to individual chemicals and/or mixtures

Response: The ability of the scientific community to fully and quantitatively evaluate the health effects from the mixture of air pollutants people are exposed to is at least ten years away (Mauderly et al., 2010). However, in this health consultation, in addition to evaluating the health effects of exposure to single air pollutants, we attempted to evaluate the combined effect of the three major air pollutants that may be harmful to the health of a person living in Midlothian (particularly sensitive individuals). ATSDR believes that sufficient information exists to warrant concern for multiple air pollutant exposures to sensitive individuals, especially in the past (1997-late 2008). However, current scientific knowledge does not allow for a definitive and quantitative conclusion. See more information above in the Public Health Implications for individual air pollutants and in the Mixtures section.

3. Impact on pregnant women, infants, children, the elderly, the immune-suppressed

Response: Infants, children, the elderly, and immune-suppressed individuals are all considered populations sensitive to the effects of exposures to air pollutants. Recent literature suggests that exposure to air pollution during pregnancy causes adverse birth outcomes and health problems for the mother and child. The specific concerns of children are discussed above in the Child Health Considerations section. In a future health consultation, ATSDR will evaluate data on birth defects and adverse birth outcomes for the Midlothian area.

4. Confounding circumstances (i.e., Ellis Co. is an ozone non-attainment area)

Response: This health consultation evaluated the public health implications of all NAAQS constituents whether they were primarily related to the major industries (sulfur dioxide), partially related ($PM_{2.5}$), or primarily unrelated (ozone). See the Mixtures discussion above for details.

5. Health effects of air quality. Are there air quality issues in Midlothian?

Response: ATSDR believes that current exposures to ozone and infrequent short-term levels of $PM_{2.5}$ and past exposures to these, long-term levels of $PM_{2.5}$ and sulfur dioxide could harm the health of sensitive individuals who currently and previously resided in Midlothian. In addition, ATSDR believes that potential future exposures to sulfur dioxide and $PM_{2.5}$ also could harm the health of sensitive individuals if actions are not taken to monitor and to prevent harmful exposures.

6. - **Strong smell in air. Smell of rotten eggs around sunset**

Response: Hydrogen sulfide and not SO_2 is usually associated with the smell of rotten eggs. Sulfur dioxide odors have been described as having a very pungent smell. ATSDR did not identify hydrogen sulfide levels as a concern but did determine that past sulfur dioxide levels could have harmed the health of some community members. In addition, ATSDR did not identify a major source of hydrogen sulfide but did determine that the local cement industries are major sources of sulfur dioxide emissions. The timing of the concern (sunset) is consistent with when SO_2 elevations did begin to occur and it is possible that people are smelling sulfur dioxide and not hydrogen sulfide.

7. Transportation contribution to air quality problem

Response: Throughout the country, air pollution is affected by many sources of emissions including large industrial facilities like the cement manufacturing operations and steel mills in Midlothian, smaller industrial and commercial operations typically found in populated areas (e.g., gasoline stations, dry cleaners, auto refinish shops), and mobile sources (e.g., automobiles, trucks, locomotives, and aircraft). Some emission sources are of natural origin, such as wildfires and wind-blown dust. All of these sources combined will affect air pollution levels at a given location. Midlothian is no exception in this regard.

Quantifying precisely the extent to which different sources affect air pollution levels can be difficult. However, some insights can be gleaned from EPA's National Emissions Inventory (NEI), which includes estimates of the relative magnitude of annual emissions from different types of manmade emission sources for every county across the nation. To comment on the contribution of "transportation sources" to local air quality, ATSDR compiled the 2008 NEI data for several different pollutants (EPA, 2012a). For inventory year 2008, this analysis showed that transportation sources accounted for an estimated: 72 % of the total carbon monoxide emissions in Ellis County; 39 % of the total nitrogen oxides emissions in Ellis County; and less than 5 % of the total emissions for sulfur dioxide and fine particulate matter.

Therefore, for certain pollutants (e.g., carbon monoxide, nitrogen oxides), transportation sources account for a considerable portion of the emissions in Ellis County; but for other pollutants (e.g., sulfur dioxide, particulate matter), transportation sources are less important. However, focusing strictly on Midlothian—and not all of Ellis County—the emissions from the four large industrial sources account for most emissions of most pollutants of interest in this Health Consultation.

8. Need to address cement kiln dust

Response:

At cement manufacturing facilities, the high-temperature kilns are designed to manufacture clinker, which is used to make cement. During this process, the kilns also generate fine-grained particles that are carried in the cement kiln exhaust gas. These fine-grained particles are referred to as cement kiln dust (CKD). CKD is a highly alkaline material. The primary constituent is calcium oxide, which can account for almost half of CKD by weight; with lesser quantities of silicon dioxide, sulfur trioxide, aluminum oxide, and potassium oxide (EPA, 1993; KDOT, 2004).

Cement kiln dust may cause dry skin, discomfort, irritation, severe burns, and dermatitis. Exposure of sufficient duration to wet kiln dust, or dry kiln dust on moist areas of the body, can cause serious, potentially irreversible damage to the skin, eye, respiratory and digestive tracts because of chemical (caustic) burns, including third-degree burns. Kiln dust is also capable of causing dermatitis by irritation and allergy. Skin affected by dermatitis may include symptoms such as redness, itching, rash, scaling, and cracking. Breathing CKD may cause nose, throat, or lung irritation and choking, depending on the degree of exposure. Inhalation of high levels of dust can cause chemical burns to the nose, throat, and lungs (Lafarge, 2011; Ash Grove, ND).

Most of the CKD generated in cement kilns is captured in air pollution control devices (e.g., electrostatic precipitators, baghouses), but some is emitted to the air through the kiln stacks. CKD that is collected in air pollution controls can then be used for various purposes. For instance, this material is often recycled into the cement manufacturing process or collected and used for commercial purposes: CKD is used to stabilize soils in construction projects, for landfill cover, and as a filler for mine reclamation activities. However, some CKD generated is still disposed of in landfills and other disposal units. CKD can enter ambient air through the stacks and also as releases from handling captured CKD. Although facilities typically take measures to reduce the amount of CKD released to the air, some of the material inevitably escapes.

In this Health Consultation, the consideration is the extent to which CKD contributes to airborne particulate matter. CKD includes particles of many sizes, and the particle size distribution depends on the specific production processes and air pollution controls at a given cement manufacturing facility. Some CKD will have particles small enough that they can blow from open surfaces into the air and that they can also be respirable—meaning, they are small enough to be inhaled and enter the lungs. Specifically, EPA has reported that between 22 % and 95 % of CKD can be found in the respirable range (EPA, 1993). Therefore, any CKD that the Midlothian facilities release in the respirable size fraction should be reflected in the ambient air monitoring data collected from offsite locations.

ATSDR evaluated pictures and videos of emissions from TXI and Gerdau Ameristeel (we do not expect CKD emissions from Gerdau) which were provided by local citizens. These videos and pictures confirm that many fugitive dust emission events have occurred at these facilities. Some videos also show emission events where large plumes of dust appear to be originating from the ground level and not from the stacks. These events do not appear to be normal. ATSDR cannot determine from these videos and pictures whether any of the releases shown contain CKD or dust from other materials (for example, limestone).

In summary, airborne CKD needs to be evaluated from many perspectives. This Health Consultation considers the extent to which CKD contributes to particulate matter found in outdoor air. ATSDR will be issuing two other Health Consultations that will further evaluate CKD: one document will consider the specific chemicals in CKD and whether those pose a health hazard when inhaled and another document will consider the extent to which CKD has contaminated soils and waterways through atmospheric deposition.

9. Cars are dusty all the time – thick/white dust

Response: Baghouse ruptures or operational upsets at local facilities could have resulted in dust being deposited on area automobiles (either on the facilities or off). Moreover, releases of dust that could blanket automobiles is not inconsistent with the operations at the three cement plants operating in Midlothian, especially in relation to cement kiln dust (see answer to #8 above). At least one other community near a cement processing plant also has noted that their cars frequently have a coat of thick, white, dust covering their cars, which they believe is cement kiln dust (Boulder Weekly, n.d). A future ATSDR health consultation will more thoroughly evaluate the extent to which airborne particles have deposited to, and possibly contaminated, other media.

10. Concern for specific health effects, such as:

- **Respiratory diseases (e.g., respiratory infections, asthma that improves when out of area, etc.)**
- **Allergies**
- **Sinus problems**
- **Cancer**
- **Autoimmune diseases (e.g., Graves disease and sarcoidosis involving lungs and eye lids)**

Response: Certain respiratory illnesses, including sinus problems and allergies, are consistent with what might be expected from exposures to SO_2, ozone, or $PM_{2.5}$, but this statement does not suggest that any given incident of these health outcomes is caused solely by inhalation of ozone, $PM_{2.5}$, or sulfur dioxide in the Midlothian area. Rather, causality of any given disease is usually a result of multiple factors, such as smoking, lifestyles, eating habits, occupational exposures, etc. In addition, the air pollutants of concern are known to aggravate conditions such as asthma and these conditions could alleviate once individuals are outside the Midlothian area. Long-term particulate matter exposures have been associated with lung cancer. However, particulate matter is composed of many different combinations of chemicals, depending on the sources in any given area. Therefore, particulate matter itself might not be carcinogenic, but an individual constituent may be. Potential cancer effects of these constituents (e.g., metals) will be evaluated by ATSDR in a future health consultation. No studies have been conducted to assess the relationship between air pollutants and the specific autoimmune diseases of concern to the public. Exposures to particulate matter air pollution is a concern for sensitive populations, which includes individuals with diabetes (type-1 diabetes is an autoimmune disease). However, no studies have associated particulate matter exposures with cause of diabetes. ATSDR will evaluate data for cancer, respiratory and cardiovascular disease, diabetes, and other diseases in the Midlothian area in a future health consultation.

7. Conclusions and Recommendations

Sulfur dioxide exposures : sensitive (e.g., individuals with asthma) and general populations

Conclusions

In the past (1997–late 2008), breathing air contaminated with sulfur dioxide (SO_2) for short periods (5 minutes) could have harmed the health of sensitive individuals (e.g., people with asthma), particularly when performing an activity (such as exercising or climbing steps) that raised their breathing rate. *SO_2* levels that might have harmed sensitive individuals were infrequent and limited to areas primarily in Cement Valley and possibly areas east, south, and southeast of the TXI Operations, Inc (TXI) fence line. These exposures occurred primarily from about 5 p.m. to 6 a.m. Harmful exposures also could have occurred before 1997; however, monitoring data are not available to confirm this conclusion. ***Breathing air contaminated with SO_2 in the past (during the period 1997 to late 2008) was not expected to harm the health of the general population.***

Reductions in SO_2 levels in Cement Valley have occurred since late 2008 resulting in exposures to both sensitive individuals and the general public that are not expected to be harmful. These reductions may be caused, in part, by declining production levels at local industrial facilities. Future harmful exposures in Cement Valley could occur if production rises to at least previous levels and actions are not taken to reduce SO_2 emissions.

No SO_2 data are currently available to evaluate exposures to individuals who live downwind of the Ash Grove Cement and Holcim facilities where the SO_2 emissions have been similar to those from TXI in the past that produced harmful exposures in Cement Valley and possibly elsewhere. Therefore, ***ATSDR cannot determine if harmful exposures to SO_2 have been occurring downwind of the Holcim and Ash Grove facilities.***

When sulfur dioxide concentrations exceed 400 ppb, sensitive individuals may experience symptoms such as coughing, wheezing, and chest tightness. At lower sulfur dioxide concentrations (200 ppb to 400 ppb), sensitive individuals functioning at elevated breathing rates may experience asymptomatic effects (e.g., mild constriction of bronchial passages). Adverse health effects from exposures to sulfur dioxide concentrations less than 200 ppb are uncertain, but may occur in some individuals more sensitive or vulnerable than those participating in clinical investigations.

People with asthma, children, and older adults (65+ years) have been identified as groups sensitive to the health problems associated with breathing SO_2. Human scientific studies (clinical investigations and epidemiologic studies) have provided evidence of a causal relationship between SO_2 and respiratory morbidity in people with asthma and other more limited human studies (epidemiologic) have consistently reported that children and older adults might be at increased risk for SO_2-associated adverse respiratory effects. Potentially sensitive groups to air pollutants include obese individuals, those with preexisting cardiopulmonary disease, and those with a pro-inflammatory condition such as diabetes, but some of these relationships have not been examined specifically in relation to SO_2.

Recommendations

To reduce current and potential future peak exposures to sulfur dioxide, ATSDR recommends the following:

- Reduce emissions—TCEQ should take actions to reduce future SO_2 emissions from TXI to prevent harmful exposures.
- Evaluate and reduce exposures—TCEQ should conduct ambient air monitoring to characterize community exposures to SO_2 downwind of the Ash Grove and Holcim facilities and take actions to reduce emissions from these facilities if harmful exposures are indicated.

Fine particulate matter ($PM_{2.5}$) exposures

Conclusions

Breathing air contaminated with $PM_{2.5}$ downwind of TXI and Gerdau Ameristeel for 1 year or more is not likely to have harmed people's health, except in a localized area just north of the Gerdau Ameristeel fence line during 1996-1998. $PM_{2.5}$ is both a local and regional air quality concern. The $PM_{2.5}$ levels observed in the Midlothian area are not considerably different from levels measured in multiple locations throughout the Dallas— Fort Worth metropolitan area. These $PM_{2.5}$ levels are caused by emissions from mobile (e.g., cars and trucks) and industrial sources in the Midlothian area and beyond. Nevertheless, for people, especially those with preexisting respiratory and cardiac disease, who lived in a localized area of Cement Valley (just north of the Gerdau Ameristeel fence line during 1996–1998), public health concern is warranted for adverse health effects from long-term exposure to $PM_{2.5}$. ***Short-term potentially harmful levels of $PM_{2.5}$ have been infrequent in Midlothian. These infrequent exposures could have resulted in harmful cardiopulmonary effects, especially in sensitive individuals, but not the general public.***

Most measured annual average $PM_{2.5}$ levels in the Midlothian area were not above EPA's current or proposed standard. For many years in the past (1996–2008), annual average $PM_{2.5}$ levels measured were just below the range of concentration proposed by EPA for lowering the annual average standard except for the estimated exposure levels just north of Gerdau Ameristeel fence line during 1996–1998. Although no $PM_{2.5}$ measurements were collected north of Gerdau Ameristeel, other data ATSDR has reviewed suggest that this area most likely had the highest $PM_{2.5}$ concentrations in the area, particularly in the years 1996–1998. These estimated $PM_{2.5}$ levels were at the upper end of the risk range in several important scientific (epidemiologic) studies. ***Infrequent, short-term $PM_{2.5}$ levels in Midlothian have been in the range considered by the EPA (based on the Air Quality Index or AQI) to be a concern for sensitive populations, but not the general public. However, as defined by EPA, short-term levels of $PM_{2.5}$ in the Midlothian area have not exceeded the current standard.***

ATSDR noted several data gaps in relation to particulate matter exposures. In general, monitoring stations in the Midlothian area have been placed near or at locations believed to either have high air quality impacts from facility operations or a high potential for exposure. However, ***ATSDR is uncertain about $PM_{2.5}$ exposures downwind of Ash Grove and Holcim because of a lack of data and information.*** In addition, ambient air monitoring data are more limited for the residential neighborhoods in immediate proximity to the cement manufacturing facilities' limestone quarries. Particulate matter exposure is the primary concern for these localized residential areas.

Recommendations

To reduce current or future $PM_{2.5}$ exposure, ATSDR recommends the following:

- Reduce emissions—TCEQ should take actions to reduce future $PM_{2.5}$ exposures from TXI and Gerdau Ameristeel to prevent harmful exposures.
- Evaluate and reduce exposures—TCEQ should conduct appropriate ambient air monitoring to characterize exposures to persons located downwind of the Ash Grove and Holcim facilities and take actions to reduce $PM_{2.5}$ emissions from these facilities if harmful exposures are indicated. In addition, particulate matter monitoring is needed in residential areas that are in immediate proximity to the facilities' limestone quarries.

Ozone Exposures

Conclusions

Several of the levels of ozone detected in Midlothian since monitoring began in 1997 indicate that sensitive individuals have an increased likelihood of experiencing harmful respiratory effects (respiratory symptoms and breathing discomfort). This is primarily true for active children and adults and people with respiratory diseases, such as asthma. The general population of Midlothian is not expected to experience harmful effects from ozone exposure except on rare occasions when ozone levels reach approximately 100 ppb or more.

Ellis County is one of 11 counties that make up the Dallas–Fort Worth ozone non-attainment area, which means that ozone levels in the metropolitan area occasionally exceed EPA's health-based standards. Levels detected also exceed the WHO's health guidelines. Emissions from industrial sources, mobile sources, and natural sources throughout the area contribute to this problem. Scientific studies indicate that breathing air containing ozone can reduce lung function and increase respiratory symptoms, thereby aggravating asthma or other respiratory conditions. Ozone exposure also has been associated with increased susceptibility to respiratory infections, medication use by persons with asthma, doctor's visits, and emergency department and hospital admissions for individuals with respiratory disease. Ozone exposure also may contribute to premature death, especially in people with heart and lung disease. More recent information indicates that other outcomes such as school absenteeism, cardiac-related effects, and an indication that persons with asthma may experience larger and more serious responses to ozone that last longer than responses for healthy individuals.

Recommendations-- See Mixtures below.

Mixtures Exposure (including ozone)

Conclusion

ATSDR believes that sufficient information exists to warrant concern for multiple air pollutant exposures to sensitive individuals, especially in the past (1997 to late 2008) when SO_2 levels were higher and when these persons were breathing at higher rates (e.g., while

exercising, etc.). ATSDR believes the severity of health effects from a mixture exposure is not likely to exceed those discussed for SO_2, $PM_{2.5}$, or ozone exposure alone. For past SO_2 exposures, it is, however, possible that the number of sensitive individuals affected may have been greater because effects may have occurred at a lower SO_2 concentration when combined with exposure to ozone, $PM_{2.5}$, or both. Potential effects to a larger sensitive population, especially in the past, may be limited to an exposure to those contaminants present at sufficient concentration during the same time and at the same locations during the warmer months when $PM_{2.5}$ and ozone levels are generally the highest. In addition, potential effects to this larger sensitive population also may have resulted from multiple exposures occurring during several consecutive days.

The current state of the science limits our ability to make definitive conclusions on the significance of simultaneous exposures to multiple criteria pollutants. ATSDR's conclusions are based on our best professional judgment related our understanding of the possible harmful effects of air pollutant exposures in Midlothian and our interpretation of the current scientific literature; therefore, these conclusion are presented with some uncertainty.

Recommendations
To reduce and prevent multiple contaminant exposures, ATSDR recommends the following:

- TCEQ should evaluate and prevent harmful sulfur dioxide and $PM_{2.5}$ exposures from local sources.
- TCEQ should continue efforts to reduce regional ozone exposures.

Lead Exposures

Conclusions

Past lead air exposures during 1993 and 1998, in a localized area just north of the Gerdau Ameristeel fence line, could have harmed the health of children who resided or frequently played in these areas. The estimated health effect of these exposures would have been a slight lowering of IQ levels (1–2 points) for some children living in this area.

Since 1998, lead levels in this localized area decreased sharply, and have fallen below the NAAQS standard. Monitoring data do not indicate elevated air lead levels have occurred or are occurring in other areas of Midlothian currently or in the past.

ATSDR evaluated past lead exposures in air using a model developed by the EPA to estimate childhood blood lead levels. Based on our current knowledge of the health effects of lead exposures in children, ATSDR used an updated blood lead reference level of 5 µg/dL in the model to account for the risk of adverse health effects below 10 µg/dL, which has traditionally been used as a level of concern. ATSDR also ran the model using 10 µg/dL. Using a combination of default parameters for the EPA lead model and using the highest annual and quarterly average air lead levels from the Gerdau Ameristeel monitor from 1993 to1998, the model estimates children in that area of Cement Valley could have had, on average, about an 18%–21% risk of a blood lead level between 5-10 µg/dL caused by breathing outdoor air. Stated another way, if 100 children lived on properties in the vicinity of the Gerdau Ameristeel monitors during 1993–1998 the model predicts that about 21 or fewer children of 100 would have blood lead levels between 5-10 µg/dL, a level, which might result in small IQ deficits. The model also predicted that there was not an appreciable risk of these exposures resulting in a childhood blood lead level of 10 µg/dL or more. There is some uncertainty with these findings given that we do not know what the lead levels in air were downwind of the Gerdau monitor and we do not know if small children were exposed at all in this sparsely populated area of Cement Valley.

Recommendations

Because there is no known safe blood lead level for children, we emphasize the importance of environmental assessments to identify and mitigate lead hazards before children demonstrate BLLs above the reference value. Continue existing prevention strategies to reduce environmental exposures from lead in soil, dust, paint and water before children are exposed. Educate families, service providers, advocates, and public officials on primary prevention of lead exposure in homes and other child-occupied facilities, so that lead hazards are eliminated before children are exposed. Clinicians should monitor the health status of all children with a confirmed BLL ≥5 µg/dL for subsequent increase or decrease in BLL until all recommended environmental investigations and mitigation strategies are complete, and should notify the family of all affected children of BLL test results in a timely and appropriate manner.

Exposure to Other NAAQS Air Contaminants

Conclusion

ATSDR does not expect harmful effects in Midlothian from current or past exposures to the air pollutants carbon monoxide, nitrogen dioxide, and hydrogen sulfide. If these air pollutant concentrations remain at these levels, future exposures should not result in adverse effects.

Based on available monitoring data and other information (emission reports, knowledge of what might be emitted from cement or steel operations, and worst-case computer air modeling) the levels of carbon monoxide, nitrogen dioxide, hydrogen sulfide are below health-protective comparison values developed by the EPA, WHO, or ATSDR.

Recommendation

TCEQ should insure that levels of these air pollutants do not increase to levels of concern in the future.

8. Public Health Action Plan

This health consultation is one of the several evaluations being conducted by ATSDR under the overall Public Health Response Plan developed to address community concerns. The following are public health actions planned specifically related to the findings from this health consultation:

ATSDR or TDSHS will:

- Distribute health education material related to exposures to SO_2, $PM_{2.5}$, and ozone specifically for sensitive and potentially sensitive populations. This material will include information on health effects and ways to minimize harmful exposures to air pollution;
- Provide educational material specifically for health professionals on air pollution and patient health;
- Work with TCEQ to address the recommendations of this health consultation and evaluate any additional data that might become available in relation to these recommendations; and
- Issue two other Health Consultations that will further evaluate cement kiln dust (CKD): one document will consider the specific chemicals in CKD and whether they pose a health hazard when inhaled, and another document will consider the extent to which CKD has contaminated soils and waterways through atmospheric deposition.

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11. Tables

Table 1. Estimated Annual Carbon Monoxide Emissions from Midlothian Facilities[a,b]

Year	Ash Grove Cement (tons per year)	Gerdau Ameristeel (tons per year)	Holcim (tons per year)	TXI Operations (tons per year)
1990	627	1,835	—[d]	1,052
1991	—[c]	—[c]	—[c]	—[c]
1992	181	2,063	—[d]	89
1993	506	2,046	—[d]	1,046
1994	281	2,139	433	747
1995	364	2,136	1,502	741
1996	327	1,736	3,091	844
1997	506	1,873	2,798	1,032
1998	425	1,781	3,399	966
1999	466	1,602	2,332	982
2000	530	1,719	4,383	818
2001	587	1,582	5,375	716
2002	418	1,608	5,052	763
2003	382	1,578	5,100	692
2004	362	1,642	6,088	613
2005	505	1,590	3,536	779
2006	477	1,736	4,173	1,017
2007	497	1,700	3,354	774
2008	413	1,503	5,365	653
2009	175	906	2,520	294
2010	275	1,315	1,776	306

Notes: [a] All data are shown in units of tons per year (tpy).
[b] Emissions data are taken from TCEQ's Point Source Emissions Inventory (TCEQ, 2011), with all data points rounded to the nearest ton.
[c] No Point Source Emissions Inventory were available for calendar year 1991.
[d] In the earliest years of the Point Source Emissions Inventory, Holcim reported data for numerous pollutants, but has entries of zero emissions for carbon monoxide.

Table 2. Estimated Annual Lead Emissions from Midlothian Facilities[a,b]

Year	Ash Grove (tons per year)	Gerdau Ameristeel (tons per year)	Holcim (tons per year)	TXI Operations (tons per year)
1987	—[c]	***17.55***	—[c]	—[c]
1988	—[c]	***11.21***	—[c]	—[c]
1989	—[c]	***9.42***	—[c]	—[c]
1990	0.06	0.68	—[d]	—[d]
1991	—[c]	***1.45***	—[c]	—[c]
1992	0.10	***1.60***	—[d]	0.12
1993	0.02	2.45	—[d]	0.02
1994	0.02	3.00	—[d]	0.01
1995	0.02	3.00	—[d]	0.01
1996	0.02	0.99	—[d]	< 0.01
1997	0.02	***2.16***	—[d]	0.02
1998	0.02	***1.93***	—[d]	0.01
1999	0.02	1.95	—[d]	***0.13***
2000	0.02	2.11	0.07	***0.13***
2001	*0.02*	1.93	0.09	***0.01***
2002	*0.02*	1.97	***0.03***	***0.01***
2003	*0.02*	1.28	0.13	***0.01***
2004	***0.02***	0.52	0.08	***< 0.01***
2005	***0.02***	0.50	0.08	0.02
2006	***0.01***	0.55	0.08	0.02
2007	***0.01***	0.54	0.08	0.03
2008	***0.01***	0.47	0.08	0.03
2009	***0.01***	***0.28***	0.04	0.02
2010	***0.01***	***0.41***	***0.01***	***0.01***

Notes: [a] All data are shown in units of tons per year (tpy).

[b] Emissions data were accessed from both TCEQ's Point Source Emissions Inventory (TCEQ, 2011) and EPA's Toxics Release Inventory (EPA, 2011). The table displays the higher annual emissions number from these inventories. Numbers displayed in plain font are from the Point Source Emissions Inventory, and numbers shown in bold italic font are from the Toxics Release Inventory. All data are rounded to the second decimal place. When summarizing TRI data, emissions for both "lead" and "lead compounds" were considered in the tallies.

[c] No Point Source Emissions Inventory were available for calendar years 1987, 1988, 1989, and 1991. TRI emissions data are shown for these calendar years.

[d] In the earliest years of the Point Source Emissions Inventory, Holcim reported data for numerous pollutants, but has entries of zero emissions for lead for several years; and TXI has an entry of zero emissions for lead for inventory year 1990.

Table 3. Summary of Ambient Air Monitoring Data for Lead, 1981-2011[a]

Name of Monitoring Station	Time Frame	Number of Samples	Particle Size	Highest 24-Hour Average Concentration ($\mu g/m^3$)	Highest Quarterly Average Concentration ($\mu g/m^3$)
Monitors operating in the 1980s					
City Hall Roof	5/1981-12/1981, 1/1983-12/1983	94	TSP	0.46	0.233
Monitors operating in the 1990s					
Auger Road	1/1991-10/1992	68	PM_{10}	0.034	0.006
Auger Road Water Treatment Plant	1/1991-12/1991, 2/1993-6/1993	56	PM_{10}	0.034	0.009
Cedar Drive	1/1992-6/1993	14	PM_{10}	0.009	0.004
Cement Valley Road	1/1992-5/1992	13	PM_{10}	0.068	0.035
Gerdau Ameristeel	**1/1993-8/1998**	**319**	**TSP**	**1.51**	**0.443** [c]
Monitors operating in the 2000s					
CAMS 302 – Wyatt Road	1/2001-6/2004	196	PM_{10}	0.125	0.026
J.A. Vitovsky Elementary School	5/5/2009-5/9/2009	5	PM_{10}	0.0023	—[b]
Jaycee Park	12/2008-7/2009	20	PM_{10}	0.0077	0.001
Midlothian High School	7/3/2009-7/7/2009	5	PM_{10}	0.0027	—[b]
Midlothian Tower	5/2002-8/2005	197	$PM_{2.5}$	0.0294	0.007
Mountain Peak Elementary School	2/26/2009-3/2/2009	5	PM_{10}	0.0025	—[b]
Old Fort Worth Road	12/2008-7/2009	20	PM_{10}	0.0117	0.002
	9/2005-9/2011	366	$PM_{2.5}$	0.0331	0.006
Tayman Drive Water Treatment Plant	12/2008-7/2009	20	PM_{10}	0.0138	0.004
Triangle Park	12/6/2008-12/10/2008	5	PM_{10}	0.0060	—[b]
Wyatt Road	12/2008-7/2009	29	PM_{10}	0.0741	0.015

Notes: [a] Lead monitoring data were either downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2012) or taken from TCEQ's recent air quality study in Midlothian (TCEQ, 2010).
[b] Quarterly average concentrations were not calculated for sites that collected 24-hour average lead samples on five consecutive days.
[c] Two health-based screening values were used to evaluate these data. EPA's current NAAQS is a 3-month rolling average concentration of 0.15 $\mu g/m^3$, and WHO's health guideline is an annual average concentration of 0.5 $\mu g/m^3$. The row shown in bold font had quarterly average lead concentrations above EPA's current NAAQS, though these values met EPA's NAAQS that were in effect at the time the measurements were collected.

Table 4. Estimated Annual Nitrogen Oxides Emissions from Midlothian Facilities[a,b]

Year	Ash Grove Cement (tons per year)	Gerdau Ameristeel (tons per year)	Holcim (tons per year)	TXI Operations (tons per year)
1990	2,999	388	731	3,022
1991	—[c]	—[c]	—[c]	—[c]
1992	3,359	310	1,341	3,321
1993	3,668	299	1,353	2,268
1994	4,027	346	1,680	5,430
1995	3,771	307	750	5,910
1996	3,908	601	1,975	5,506
1997	3,164	924	2,134	5,819
1998	2,724	653	1,893	6,226
1999	3,005	515	1,222	5,267
2000	2,905	510	3,475	4,515
2001	2,923	479	3,078	4,444
2002	2,572	490	4,204	4,221
2003	2,625	456	3,728	3,472
2004	2,350	471	4,228	4,347
2005	2,250	461	4,867	4,323
2006	2,220	498	3,055	3,446
2007	1,757	481	2,862	2,916
2008	1,385	438	3,184	2,877
2009	1,266	209	951	1,022
2010	1,291	297	694	1,154

Notes: [a] All data are shown in units of tons per year (tpy).
[b] Emissions data are taken from TCEQ's Point Source Emissions Inventory (TCEQ, 2011), with all data points rounded to the nearest ton.
[c] No Point Source Emissions Inventory were available for calendar year 1991.

Table 5. Summary of Ambient Air Monitoring Data for Nitrogen Dioxide, 2000–2011[a]

Year	Nitrogen Dioxide Concentrations (ppb)		
	Upwind Stations	Downwind Stations	
	Midlothian Tower	Old Fort Worth Road	Wyatt Road
Annual average concentrations, by year			
EPA NAAQS = 53 ppb; WHO health guideline = 21 ppb			
2000	9.47[b]	—[c]	—[c]
2001	4.50	—[c]	—[c]
2002	4.52	—[c]	—[c]
2003	6.92	10.37[b]	—[c]
2004	7.55	10.75	9.23[b]
2005	6.85	10.87	8.78
2006	5.56	9.99	9.31[b]
2007	4.75[b]	9.34	—[c]
2008	—[c]	10.02	—[c]
2009	—[c]	7.24	—[c]
2010	—[c]	7.24	—[c]
2011	—[c]	6.72[b]	—[c]
Highest 1-hour average concentrations, by year			
EPA NAAQS = 100 ppb; WHO health guideline = 105 ppb			
2000	40.49[b]	—[c]	—[c]
2001	46.53	—[c]	—[c]
2002	45.94	—[c]	—[c]
2003	51.17	52.41[b]	—[c]
2004	56.23	66.93	41.79[b]
2005	78.61	49.93	49.83
2006	59.35	58.62	47.83[b]
2007	56.19[b]	49.78	—[c]
2008	—[c]	72.79	—[c]
2009	—[c]	54.96	—[c]
2010	—[c]	52.59	—[c]
2011	—[c]	50.29[b]	—[c]

Notes: [a] Data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2012).
[b] Monitoring site did not operate during the entire calendar year; data are based on all valid measurements from the calendar year.
[c] Monitoring data were not collected at these sites during these years.

Table 6. Estimated Annual PM_{10} Emissions from Midlothian Facilities[a,b]

Year	Ash Grove (tons per year)	Gerdau Ameristeel (tons per year)	Holcim (tons per year)	TXI Operations (tons per year)
1990	235	129	119	26
1991	—[c]	—[c]	—[c]	—[c]
1992	210	135	90	371
1993	228	137	78	331
1994	259	123	53	332
1995	282	140	47	295
1996	830	114	306	270
1997	541	134	305	291
1998	565	119	361	296
1999	549	151	361	305
2000	505	166	393	310
2001	445	155	356	366
2002	451	157	379	301
2003	271	150	342	300
2004	274	155	341	309
2005	276	156	328	327
2006	290	167	502	273
2007	277	163	399	301
2008	274	148	338	291
2009	169	109	198	163
2010	217	129	130	141

Notes: [a] All data are shown in units of tons per year (tpy).
[b] Emissions data are taken from TCEQ's Point Source Emissions Inventory (TCEQ, 2011), with all data points rounded to the nearest ton.
[c] No Point Source Emissions Inventory were available for calendar year 1991.

Table 7. Summary of Ambient Air Monitoring Data for PM_{10}, 1991-2004[a]

Name of Monitoring Station	Time Frame	Number of Samples	Highest 24-Hour Average Concentration ($\mu g/m^3$)	Highest Annual Average Concentration ($\mu g/m^3$)
Auger Road	1/1991-1/1993	118	84	21.0
Auger Road Water Treatment	1/1991-1/1992, 1/1993-11/1994	148	70	23.2
Box Crow	11/1993-1/1995	66	79	23.5
CAMS 302 – Wyatt Road	1/2000-6/2004	256	73	27.4
Cedar Drive	1/1992-10/1994	168	79	21.0
Cement Valley Road	1/1992-6/1992	24	30	—[b]
Gerdau Ameristeel	**1/1996-12/1998**	**181**	127	**50.8**[d]
Gorman Road	3/1992-4/1993	66	99	31.0
Hidden Valley	9/1992-10/1993	68	72	22.0
Midlothian Tower	11/1994-6/2004	569	94	26.0
Mountain Creek	3/1992-4/1993	62	52	19.0
Old Fort Worth Road	11/1994-6/2004	566	126	29.5
Tayman Drive Water Treatment Plant	1/1993-12/1996	279	83	23.6

Notes: [a] PM_{10} monitoring data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2012) and obtained from an air quality study published in 1995 by the Texas Natural Resource Conservation Commission (TNRCC, 1995).

[b] Annual average concentrations were only calculated for sites that recorded at least 30 valid 24-hour average PM_{10} measurements in a calendar year.

[c] The following health-based screening values were used to evaluate these data:

For *24-hour average concentrations*, EPA's health-based NAAQS is 150 $\mu g/m^3$, not to be exceeded more than once per year on average over 3 years; and WHO's health guideline is 50 $\mu g/m^3$.

For *annual average concentrations*, EPA's former health-based NAAQS is 50 $\mu g/m^3$; and WHO's current health guideline is 20 $\mu g/m^3$.

[d] Bold font is used to indicate measured concentrations above the level of EPA's current or former NAAQS for PM_{10}.

Table 8. Annual Average PM_{10} Concentrations at Selected Monitoring Stations[a,b]

Year	Annual Average PM_{10} Concentrations ($\mu g/m^3$)			
	Upwind Stations	Downwind Stations		
	Midlothian Tower	Old Fort Worth Road	Wyatt Road	Gerdau Ameristeel
1995	22.5	22.7	—[c]	—[c]
1996	22.0	20.9	—[c]	50.8
1997	21.4	19.9	—[c]	48.1
1998	26.0	24.9	—[c]	50.2
1999	22.7	24.6	—[c]	—[c]
2000	24.8	26.9	27.4	—[c]
2001	21.7	24.7	25.1	—[c]
2002	23.2	23.7	23.6	—[c]
2003	24.7	29.5	27.1	—[c]
2004	19.6[b]	20.5[b]	26.1[b]	—[c]

Notes: [a] Data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2012).
[b] Monitoring site did not operate during the entire calendar year; data are based on all valid measurements from the calendar year.
[c] Monitoring data were not collected at these sites during these years.

Table 9. Estimated Annual $PM_{2.5}$ Emissions from Midlothian Facilities[a,b]

Year	Ash Grove (tons per year)	Gerdau Ameristeel (tons per year)	Holcim (tons per year)	TXI Operations (tons per year)
2000	258	136	393	101
2001	96	128	355	143
2002	348	130	378	115
2003	234	125	300	114
2004	239	135	323	127
2005	241	136	309	131
2006	247	145	465	141
2007	235	140	356	155
2008	234	128	292	151
2009	145	97	167	76
2010	183	119	106	70

Notes: [a] All data are shown in units of tons per year (tpy).
[b] Emissions data are taken from TCEQ's Point Source Emissions Inventory (TCEQ, 2011), with all data points rounded to the nearest ton. The earliest year with $PM_{2.5}$ data available for all four facilities is 2000.

Table10. Summary of Ambient Air Monitoring Data for $PM_{2.5}$, 2000-2011[ab]

Name of Monitoring Station	Year	Type of Sampling	Annual Average Concentration (µg/m³)[c]	Highest 24-Hour Average Concentration (µg/m³)[c]
CAMS 302—Wyatt Road (8/2000-3/2006)	2001	Continuous	10.2	**52.1**
	2002		11.4	
	2003		11.7	
	2004		10.9	
	2005		11.9	
Holcim Facility Boundary (1/2006-1/2010)	2006	Continuous	11.5	**42.2**
	2007		10.2	
	2008		11.8	
	2009		10.5	
Midlothian Tower (2/2000-12/2006)	2000	Continuous	10.0	**50.2**
	2001	Continuous	10.4	
	2002	24-hour	11.8 (partial)	
	2003	24-hour	11.5	
	2004	24-hour	11.5	
	2005	24-hour	***12.4(partial)***	
	2006	24-hour	10.2	
Old Fort Worth Road (9/2005-12/2011)	2006	24-hour	11.0	**50.6**
	2007		11.4	
	2008		11.8	
	2009		9.2	
	2010		9.7	
	2011		10.3	

Notes: [a] $PM_{2.5}$ monitoring data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2012) and obtained from researchers at the University of Texas at Arlington (UT-Arlington, 2008-2010). ATSDR adjusted the annual average $PM_{2.5}$ TCEQ data from the continuous monitors before 2005 by 2 µg/m³ to account for the negative bias from these types of monitors. TCEQ reported all annual average continuous monitoring data from 2005 forward by including this adjustment (Personal Communication, Tracie Phillips, TCEQ, 2012); therefore, ATSDR did not do this adjustment for TCEQ continuous monitoring data for this timeframe. ATSDR does not have side-by-side 24-hour data to determine what the magnitude of the negative bias might have been for the Holcim continuous monitoring data; therefore, it is possible that the values presented may underestimate $PM_{2.5}$ exposure downwind of Holcim. If data were available from both continuous and 24-hour sampling, ATSDR reports the highest value. ATSDR did not report partial year data unless at least 50% of the data were available for that year.

[b] The following health-based screening values were used to evaluate these data:

For *24-hour average concentrations*, EPA's health-based NAAQS is 35 µg/m³, based on the 98th percentile concentration averaged over 3 years; and WHO's health guideline is 25 µg/m³.

For *annual average concentrations*, EPA's health-based NAAQS is 15 µg/m³ averaged over 3 years; the EPA proposed range for lowering the annual average $PM_{2.5}$ is 12-13 µg/m³, and WHO's health guideline is 10 µg/m³.

[c] Bold font is used to indicate which maximum concentrations are above the level of EPA's NAAQS for daily $PM_{2.5}$; refer to Section 4.5.3 for further insights on the magnitude of the 98th percentile concentrations, which are more relevant for comparing to the health-based standards. Bold and italicized font is used to indicate which annual average concentrations were above the EPA proposed range for lowering the standard—none of the reported values are above the current EPA NAAQS for annual average $PM_{2.5}$.

Table 11. Estimated Annual Sulfur Dioxide Emissions from Midlothian Facilities[a,b]

Year	Ash Grove Cement (tons per year)	Gerdau Ameristeel (tons per year)	Holcim (tons per year)	TXI Operations (tons per year)
1990	2,796	1[d]	3,053	13,068
1991	—[c]	—[c]	—[c]	—[c]
1992	4,388	1[d]	3,756	4,398
1993	2,284	1[d]	2,967	4,357
1994	3,577	1[d]	4,116	4,983
1995	2,083	1[d]	3,643	6,111
1996	3,134	144	5,864	5,109
1997	3,633	142	3,903	5,317
1998	3,872	129	3,691	5,490
1999	4,830	121	2,522	5,129
2000	4,368	131	4,483	6,303
2001	4,927	120	2,427	4,339
2002	4,434	122	3,167	2,099
2003	5,026	120	2,501	2,333
2004	6,216	125	2,658	2,324
2005	6,013	122	2,655	3,356
2006	6,263	133	3,330	2,551
2007	6,227	130	2,481	2,497
2008	4,776	115	2,706	1,721
2009	2,697	74	1,661	550
2010	4,115	108	1,089	493

Notes: [a] All data are shown in units of tons per year (tpy).
[b] Emissions data are taken from TCEQ's Point Source Emissions Inventory (TCEQ, 2011), with all data points rounded to the nearest ton.
[c] No Point Source Emissions Inventory were available for calendar year 1991.
[d] In the earliest years of the Point Source Emissions Inventory, emissions data for Gerdau Ameristeel were considerably lower than what the facility reported in subsequent years. The reason for this is not known.

Table 12. Annual Average Sulfur Dioxide Concentrations, 1997-2011[a]

Year	Annual Average Sulfur Dioxide Concentrations (ppb)		
	Upwind Stations	Downwind Stations	
	Midlothian Tower	Old Fort Worth Road	Wyatt Road
Annual average concentrations, by year			
No health-based standards available from EPA, TCEQ, or WHO			
1997	2.47[b]	1.82[b]	—[c]
1998	1.41	2.61	—[c]
1999	1.13	3.87	—[c]
2000	1.60	5.47	—[c]
2001	1.35	3.51	—[c]
2002	0.92	0.88	—[c]
2003	1.15	1.22	—[c]
2004	1.08	1.02	0.46[b]
2005	1.53	2.65	0.93
2006	1.11	2.11	0.48[b]
2007	0.82[b]	0.87	—[c]
2008	—[c]	0.87	—[c]
2009	—[c]	0.54	—[c]
2010	—[c]	0.87	—[c]
2011	—[c]	0.65[b]	—[c]

Notes: [a] Data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2012).
[b] Monitoring site did not operate during the entire calendar year; data are based on all valid measurements from the calendar year.
[c] Monitoring data were not collected at these sites during these years.

Table 13. Additional Trends in 1-Hour Average Sulfur Dioxide Monitoring Data[a,b]

Evaluation Based on EPA's Health-Based NAAQS: 75 ppb		
3-Year Period	**99th Percentile of Daily Maximum 1-Hour Sulfur Dioxide Concentrations (ppb), Averaged over Three Consecutive Calendar Years**	
	Midlothian Tower	**Old Fort Worth Road**
1997-1999	54.3	**122.7**
1998-2000	56.7	**139.7**
1999-2001	62.7	**158.7**
2000-2002	71.7	**125.3**
2001-2003	65.7	**92.0**
2002-2004	58.3	62.3
2003-2005	51.7	**81.0**
2004-2006	49.3	**93.3**
2005-2007	52.3	**101.3**
2006-2008	—[c]	**85.7**
2007-2009	—[c]	57.3
2008-2010	—[c]	31.0
2009-2011	—[c]	15.3

Notes: [a] Data were accessed using queries on EPA's AirData system, including exceptional events (EPA, 2012). The 99th percentile values were downloaded for individual years, from which averages were calculated over three consecutive years.

[b] Summaries are shown for only those sites with three consecutive years of sulfur dioxide monitoring data.

[c] Monitoring data were not collected at these sites for the entire 3-year periods.

[d] Entries in bold font are higher than the level of EPA's current health-based standard, which the agency passed in 2010.

Table 14. Summary of Ambient Air Monitoring Data for Hydrogen Sulfide, 2000-2011[a]

Year	Hydrogen Sulfide Concentrations (ppb)		
	Upwind Stations	Downwind Stations	
	Midlothian Tower	Old Fort Worth Road	Wyatt Road
Annual average concentrations, by year			
EPA RfC = 1.4 ppb			
2000	0.28	0.31	—[c]
2001	0.39	0.29	—[c]
2002	0.35	0.34	—[c]
2003	0.58	0.55	—[c]
2004	0.33	0.60[b]	0.59[b]
2005	0.23	—[c]	0.60
2006	0.13	0.20[b]	0.48[b]
2007	0.01[b]	0.47	—[c]
2008	—[c]	0.42	—[c]
2009	—[c]	0.35	—[c]
2010	—[c]	0.28	—[c]
2011	—[c]	0.27	—[c]
Highest 1-hour average concentrations, by year			
ATSDR Acute MRL = 70 ppb; TCEQ standard = 80 ppb; WHO health guideline = 106 ppb			
2000	2.82	2.88	—[c]
2001	10.08	2.82	—[c]
2002	4.77	6.98	—[c]
2003	7.27	13.95	—[c]
2004	2.85	3.72[b]	3.16[b]
2005	2.66	—[c]	14.36
2006	4.05	2.92[b]	2.15[b]
2007	2.13[b]	7.25	—[c]
2008	—[c]	4.32	—[c]
2009	—[c]	4.16	—[c]
2010	—[c]	3.60	—[c]
2011	—[c]	3.97	—[c]

Notes: [a] Data were downloaded from TCEQ's Texas Air Monitoring Information System (TCEQ, 2012).
[b] Monitoring site did not operate during the entire calendar year; data are based on all valid measurements from the calendar year.
[c] Monitoring data were not collected at these sites during these years.

Table 15. Summary of Health Comparison Values Used and Selection of NAAQS/H_2S Air Pollutants as a Contaminant of Concern[a]

Air Pollutant	EPA HCV	WHO HCV	ATSDR HCV	COC (Y/N)
Carbon monoxide	35 ppm (1-hour) 9 ppm (8-hour)	26 ppm (1-hour) 9 ppm (8-hour)	NA	N
Lead	0.15 µg/ m^3	0.5 µg/ m^3 (annual)	NA	**Y**
Nitrogen dioxide	100 ppb (1-hour) 53 ppb (annual)	106 ppb (1-hour) 21 ppb (annual)	NA	N
Ozone	75 ppb (8-hour)	50 ppb (8-hour)	NA	**Y**
PM (as TSP)	260 µg/m^3 (24-hour)[b] 75 µg/m^3 (annual)[b]	NA	NA	N
PM_{10}	150 µg/ m^3 (24-hour 50 µg/m^3 (annual)[b]	50 µg/m^3 (24-hour) 20 µg/m^3 (annual)	NA	**Y**
$PM_{2.5}$	35 µg/m^3 (24-hour) 15 µg/m^3 (annual) 12-13 µg/m^3 (proposed annual)	25 µg/m^3 (24-hour) 10 µg/m^3(annual)	NA	**Y**
Sulfur dioxide	75 ppb (1-hour)	8 ppb (24-hour) 190 ppb (10-minute)	10 ppb (chronic, 1 year or greater)	**Y**
Hydrogen sulfide	1.4 ppb (annual)	106 ppb (24-hour)	70 ppb (acute, 1-14 days)	N

Notes: [a] A Contaminant of Concern is defined as one that is selected for further evaluation in the Public Health Implications Section because it is above a HCV.
[b] Previous EPA standard which has since been revoked.
EPA-United States Environmental Protection Agency
HCV-Health Comparison Value
WHO-World Health Organization
COC-Contaminant of Concern
ppm-parts per million
NA-none available
µg/m^3-micrograms per meter cubed
ppb-parts per billion
PM-particulate matter
TSP-total suspended particulates

Table 16: Percentage Peak (5-Minute Average) Sulfur Dioxide Concentrations by Monitoring Station (1997-2011)

Monitoring Station (Timeframe)	Sulfur Dioxide Concentration (ppb)			
	% > 400	% >200-400	% >100-200	% >10-100
OFWR (1997-2008)	<<0.001	0.01	0.23	5.1
OFWR (2009-2011)	0	0	0	0.58
Wyatt Road (2004-2006)[a]	0.002[b]	0.008	0.04	1.3
Midlothian Tower (1997-2007)	<<0.001	<<0.001	0.2	2.3

ppb-parts per billion
>-Greater than
OFWR-Old Fort Worth Road
<<-Much less than
a-The only full year of data available for the Wyatt Road monitor was 2005—data for 2004 and 2006 accounted for about 20-25% of all possible measurements for those years.
b-Three 5-minute SO_2 measurements above 400 ppb occurred at the Wyatt Road Monitor during 2005. The highest SO2 level recorded for all monitors and timeframes (568 ppb) was one of these measurements.

12. Figures

Figure 1

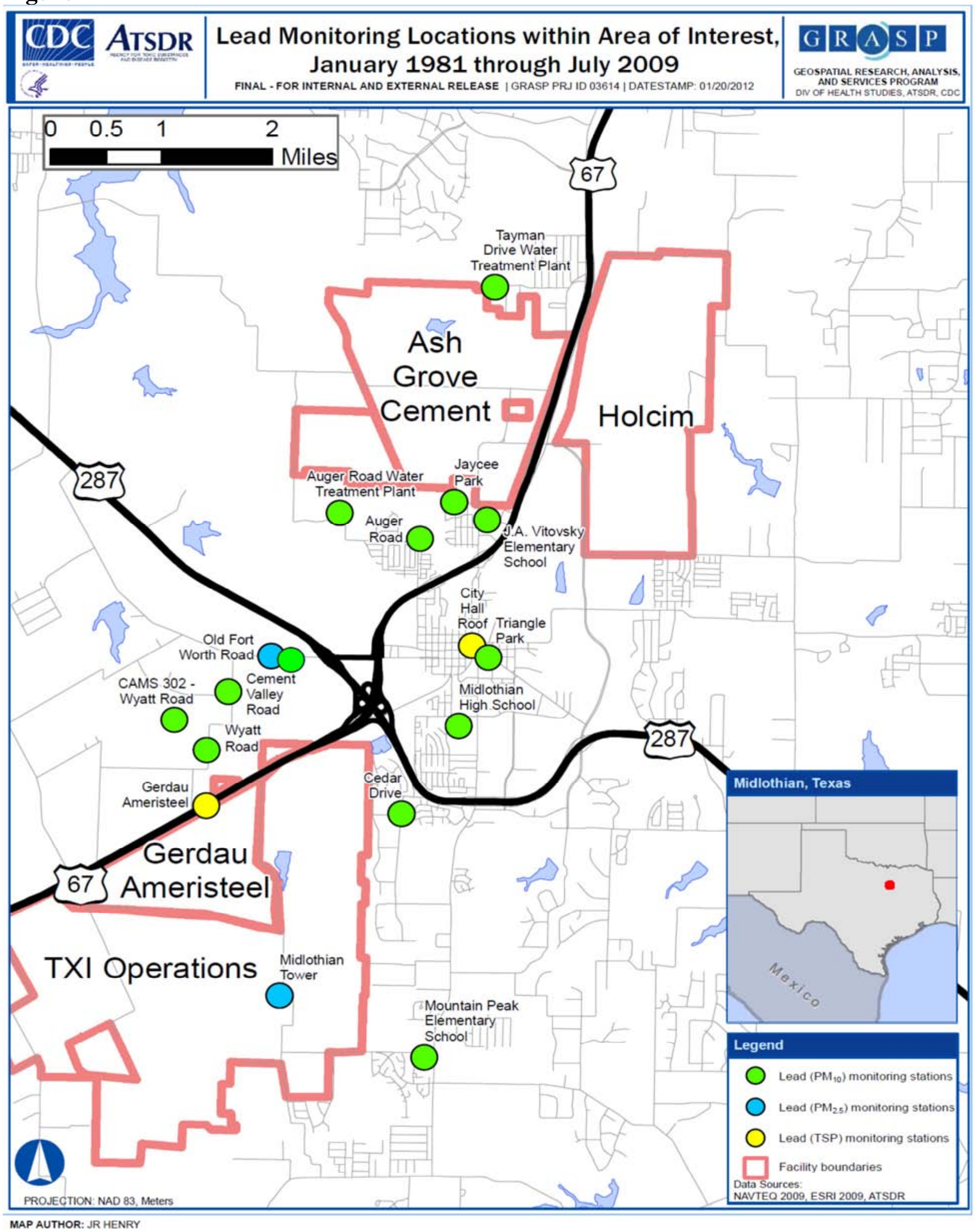
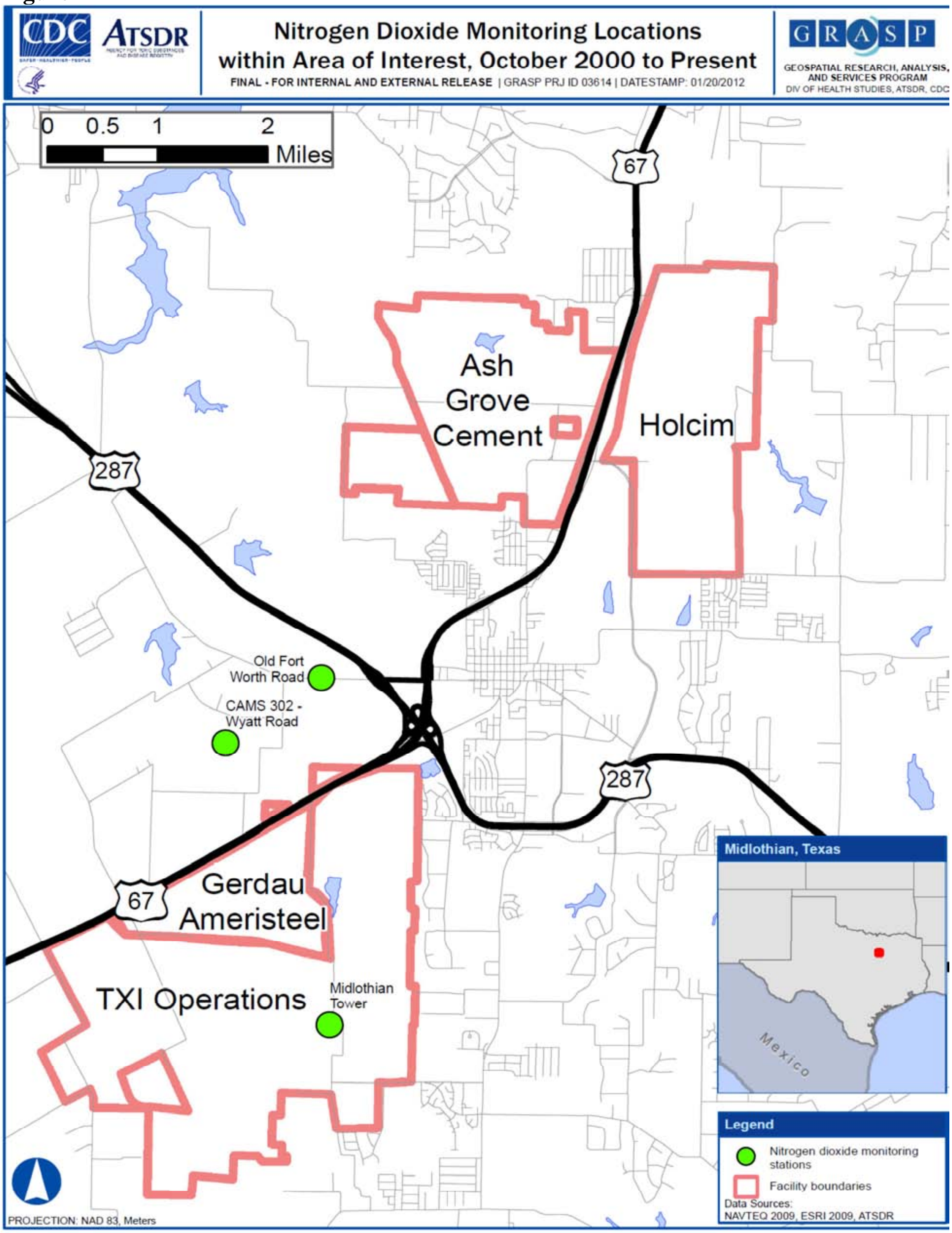

CDC
ATSDR
Lead Monitoring Locations within Area of Interest, January 1981 through July 2009
FINAL - FOR INTERNAL AND EXTERNAL RELEASE | GRASP PRJ ID 03614 | DATESTAMP: 01/20/2012
GRASP
GEOSPATIAL RESEARCH, ANALYSIS, AND SERVICES PROGRAM
DIV OF HEALTH STUDIES, ATSDR, CDC
0 0.5 1 2 Miles
67
287
Tayman Drive Water Treatment Plant
Ash Grove Cement
Holcim
Auger Road Water Treatment Plant
Jaycee Park
Auger Road
J.A. Vitovsky Elementary School
City Hall Roof
Triangle Park
Old Fort Worth Road
CAMS 302 - Wyatt Road
Cement Valley Road
Wyatt Road
Midlothian High School
Gerdau Ameristeel
Cedar Drive
Gerdau Ameristeel
TXI Operations
Midlothian Tower
Mountain Peak Elementary School
Midlothian, Texas
Mexico
Legend
Lead (PM_{10}) monitoring stations
Lead ($PM_{2.5}$) monitoring stations
Lead (TSP) monitoring stations
Facility boundaries
Data Sources: NAVTEQ 2009, ESRI 2009, ATSDR
PROJECTION: NAD 83, Meters
MAP AUTHOR: JR HENRY

Figure 2



MAP AUTHOR: JR HENRY

Figure 3

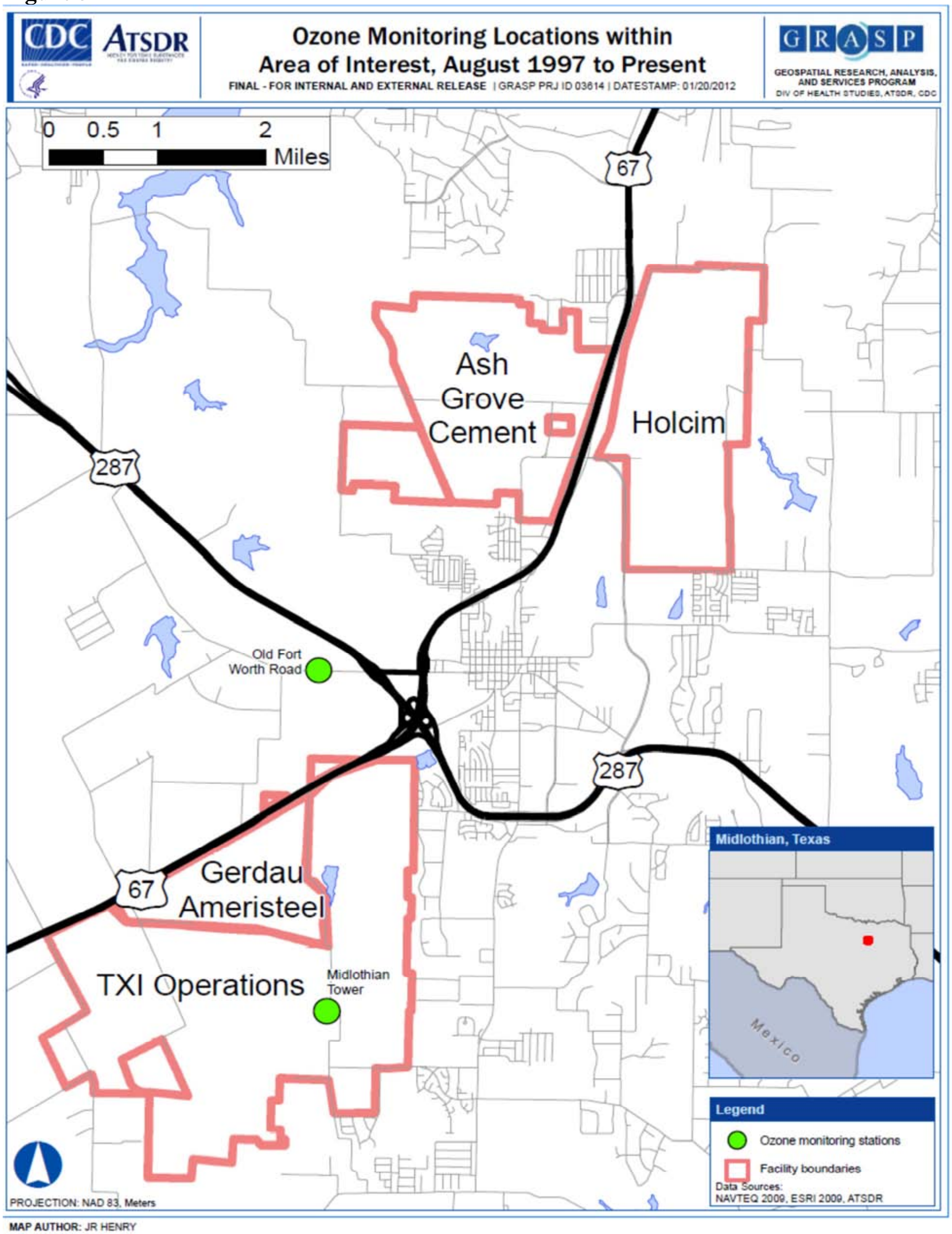

CDC
ATSDR
Ozone Monitoring Locations within
Area of Interest, August 1997 to Present
FINAL - FOR INTERNAL AND EXTERNAL RELEASE | GRASP PRJ ID 03614 | DATESTAMP: 01/20/2012
GRASP
GEOSPATIAL RESEARCH, ANALYSIS, AND SERVICES PROGRAM
DIV OF HEALTH STUDIES, ATSDR, CDC
0 0.5 1 2
Miles
67
287
Ash Grove Cement
Holcim
Old Fort Worth Road
Gerdau Ameristeel
TXI Operations
Midlothian Tower
Midlothian, Texas
Mexico
Legend
Ozone monitoring stations
Facility boundaries
Data Sources:
NAVTEQ 2009, ESRI 2009, ATSDR
PROJECTION: NAD 83, Meters
MAP AUTHOR: JR HENRY

Figure 4

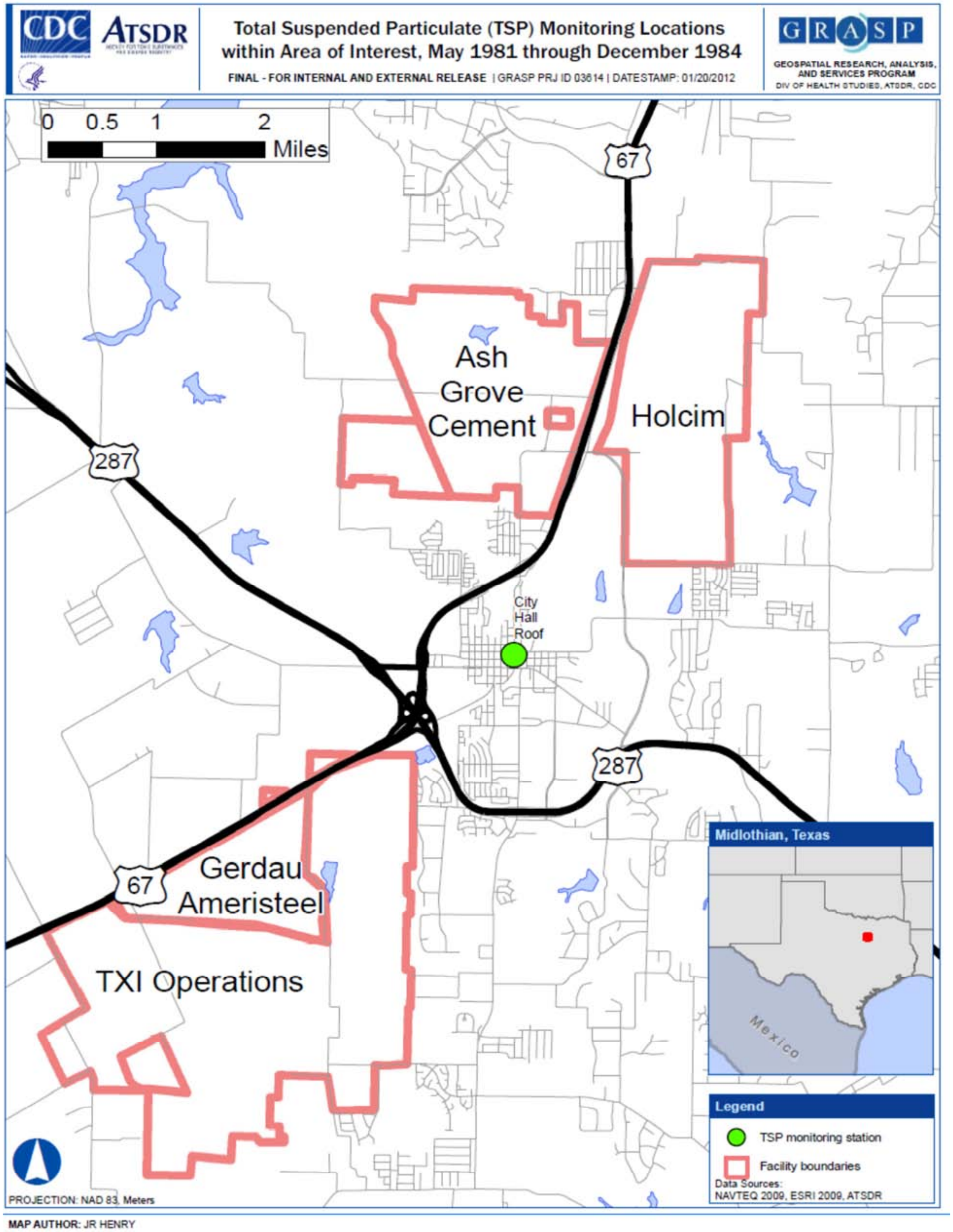

CDC
ATSDR
Total Suspended Particulate (TSP) Monitoring Locations within Area of Interest, May 1981 through December 1984
FINAL - FOR INTERNAL AND EXTERNAL RELEASE | GRASP PRJ ID 03614 | DATESTAMP: 01/20/2012
GRASP
GEOSPATIAL RESEARCH, ANALYSIS, AND SERVICES PROGRAM
DIV OF HEALTH STUDIES, ATSDR, CDC
0 0.5 1 2 Miles
67
287
Ash Grove Cement
Holcim
City Hall Roof
Gerdau Ameristeel
TXI Operations
Midlothian, Texas
Mexico
Legend
TSP monitoring station
Facility boundaries
Data Sources: NAVTEQ 2009, ESRI 2009, ATSDR
PROJECTION: NAD 83, Meters
MAP AUTHOR: JR HENRY

Figure 5

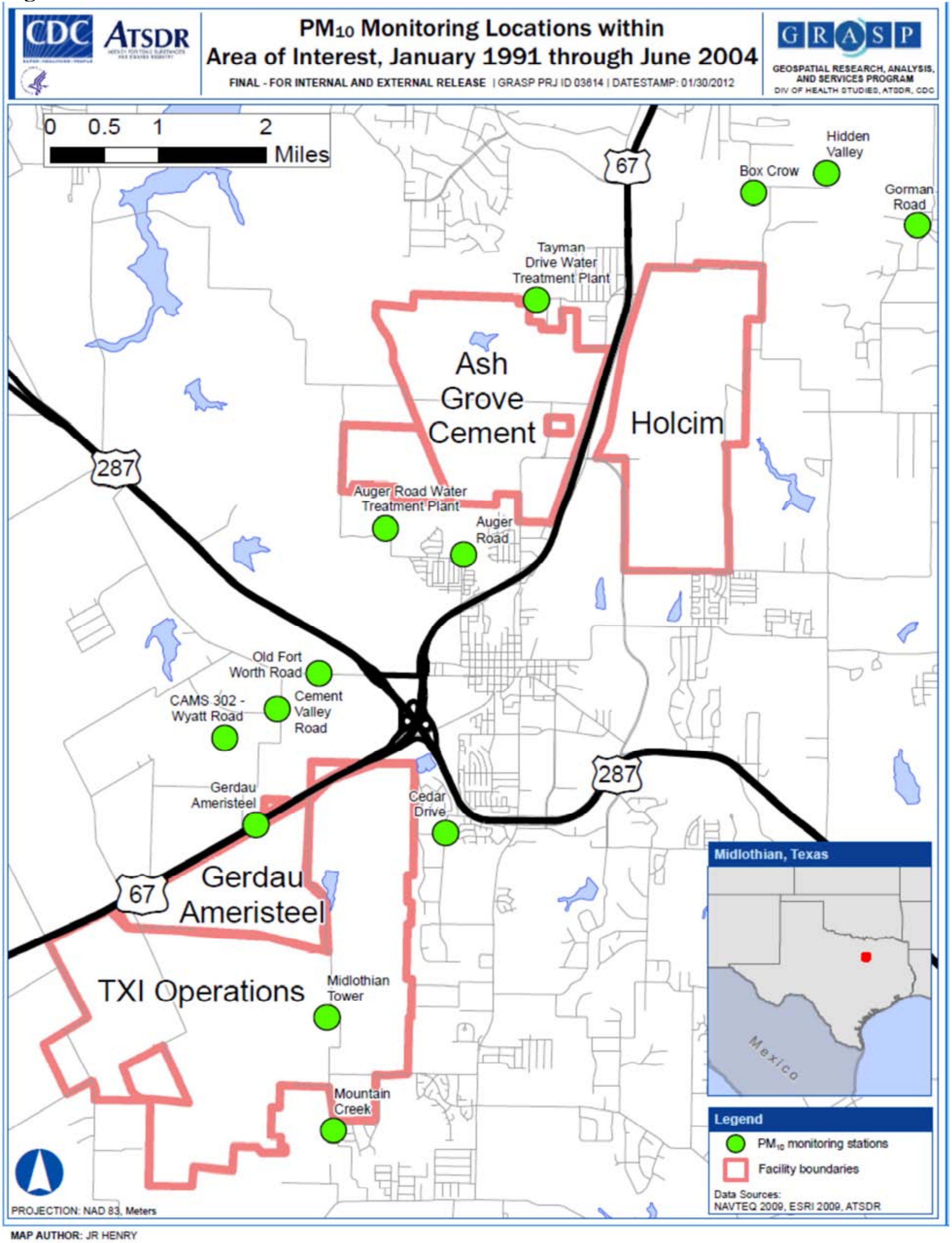
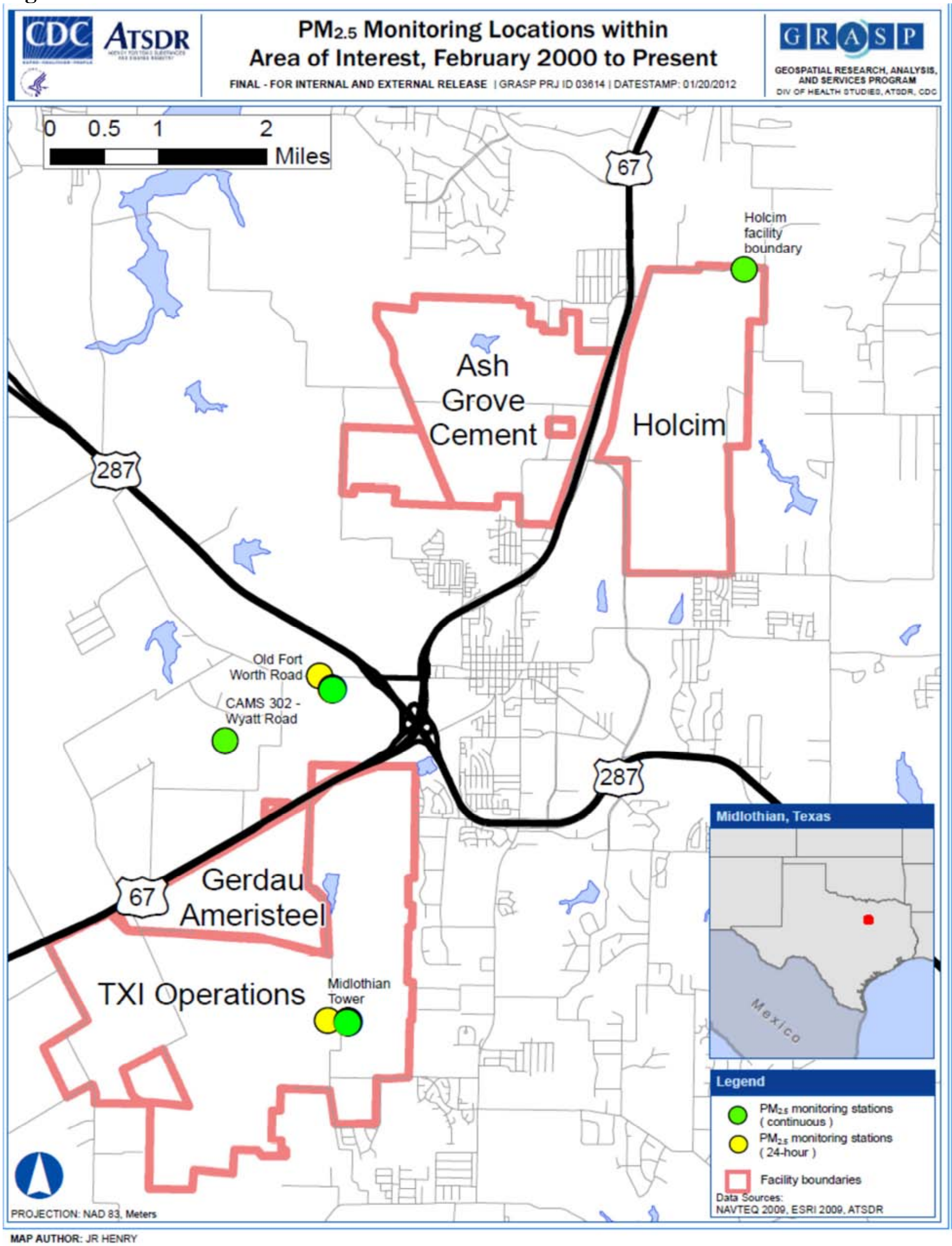
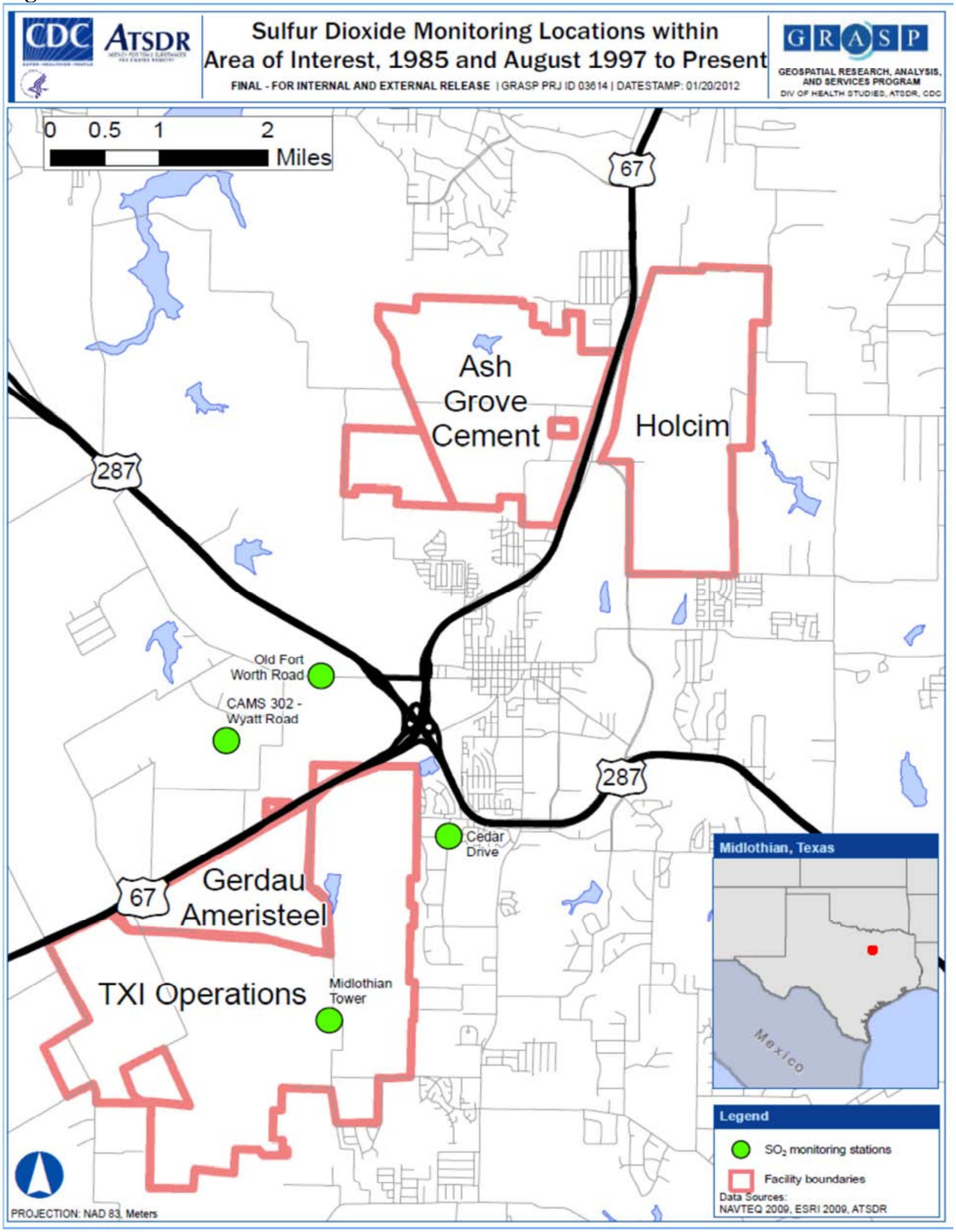

PM10 Monitoring Locations within Area of Interest, January 1991 through June 2004
FINAL - FOR INTERNAL AND EXTERNAL RELEASE | GRASP PRJ ID 03614 | DATESTAMP: 01/30/2012
GEOSPATIAL RESEARCH, ANALYSIS, AND SERVICES PROGRAM
DIV OF HEALTH STUDIES, ATSDR, CDC
0 0.5 1 2 Miles
Hidden Valley
Box Crow
Gorman Road
Tayman Drive Water Treatment Plant
Ash Grove Cement
Holcim
Auger Road Water Treatment Plant
Auger Road
Old Fort Worth Road
CAMS 302 - Wyatt Road
Cement Valley Road
Gerdau Ameristeel
Cedar Drive
Gerdau Ameristeel
TXI Operations
Midlothian Tower
Mountain Creek
67
287
287
67
Midlothian, Texas
Mexico
Legend
PM10 monitoring stations
Facility boundaries
Data Sources: NAVTEQ 2009, ESRI 2009, ATSDR
PROJECTION: NAD 83, Meters
MAP AUTHOR: JR HENRY

Figure 6



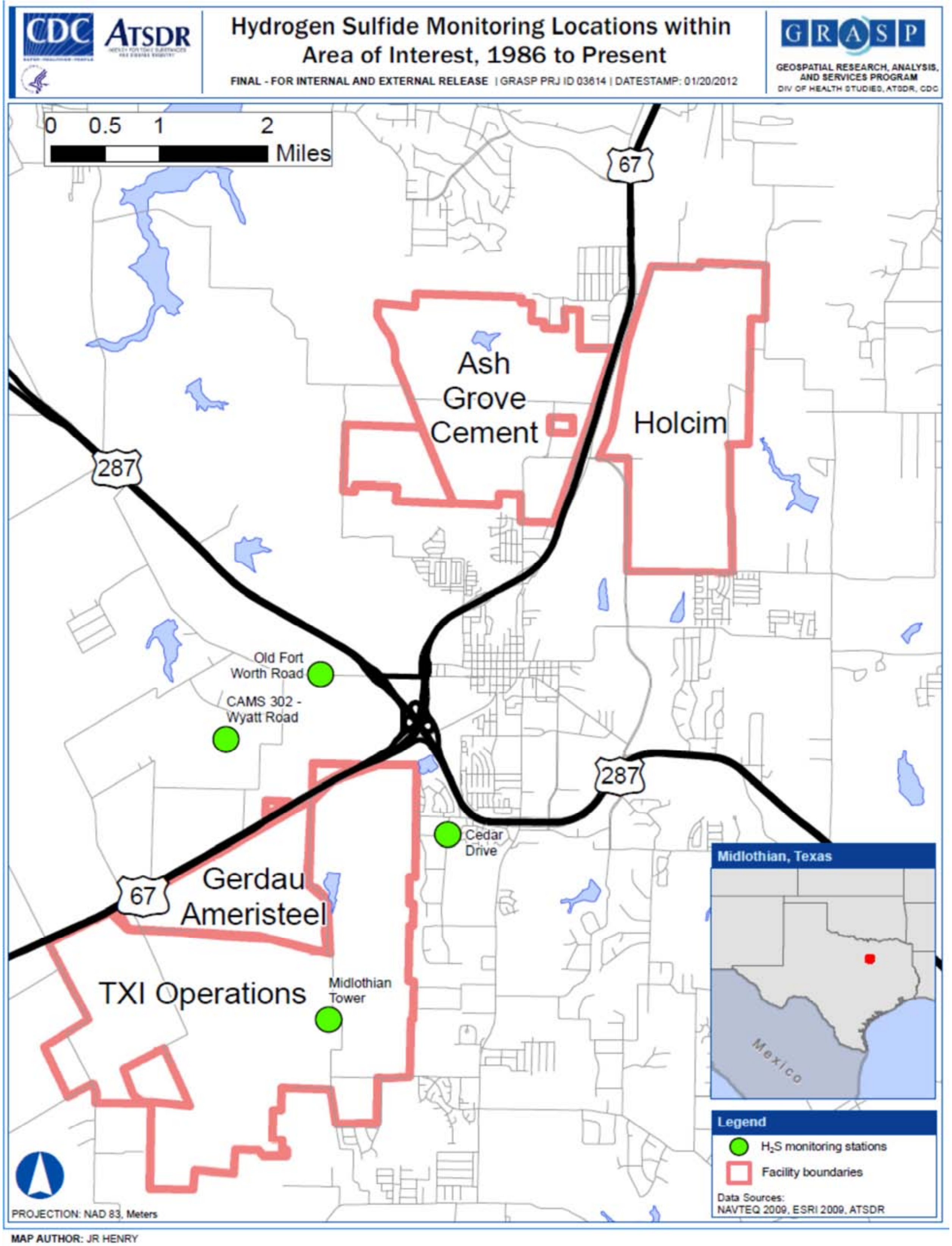
CDC
ATSDR
PM2.5 Monitoring Locations within
Area of Interest, February 2000 to Present
FINAL - FOR INTERNAL AND EXTERNAL RELEASE | GRASP PRJ ID 03614 | DATESTAMP: 01/20/2012
GRASP
GEOSPATIAL RESEARCH, ANALYSIS, AND SERVICES PROGRAM
DIV OF HEALTH STUDIES, ATSDR, CDC
0 0.5 1 2
Miles
67
Holcim facility boundary
Ash Grove Cement
Holcim
287
Old Fort Worth Road
CAMS 302 - Wyatt Road
287
67
Gerdau Ameristeel
TXI Operations
Midlothian Tower
Midlothian, Texas
Mexico
Legend
PM2.5 monitoring stations (continuous)
PM2.5 monitoring stations (24-hour)
Facility boundaries
Data Sources:
NAVTEQ 2009, ESRI 2009, ATSDR
PROJECTION: NAD 83, Meters
MAP AUTHOR: JR HENRY

Figure 7



MAP AUTHOR: JR HENRY

Figure 8



Hydrogen Sulfide Monitoring Locations within Area of Interest, 1986 to Present
FINAL - FOR INTERNAL AND EXTERNAL RELEASE | GRASP PRJ ID 03614 | DATESTAMP: 01/20/2012
GEOSPATIAL RESEARCH, ANALYSIS, AND SERVICES PROGRAM
DIV OF HEALTH STUDIES, ATSDR, CDC
0 0.5 1 2 Miles
67
287
Ash Grove Cement
Holcim
Old Fort Worth Road
CAMS 302 - Wyatt Road
Cedar Drive
Gerdau Ameristeel
TXI Operations
Midlothian Tower
Midlothian, Texas
Mexico
Legend
H2S monitoring stations
Facility boundaries
Data Sources: NAVTEQ 2009, ESRI 2009, ATSDR
PROJECTION: NAD 83, Meters
MAP AUTHOR: JR HENRY

Figure 9: Frequency of Sulfur Dioxide Exceedances by Wind Direction at the Old Fort Worth Road Monitor (September 1997- May 2009)

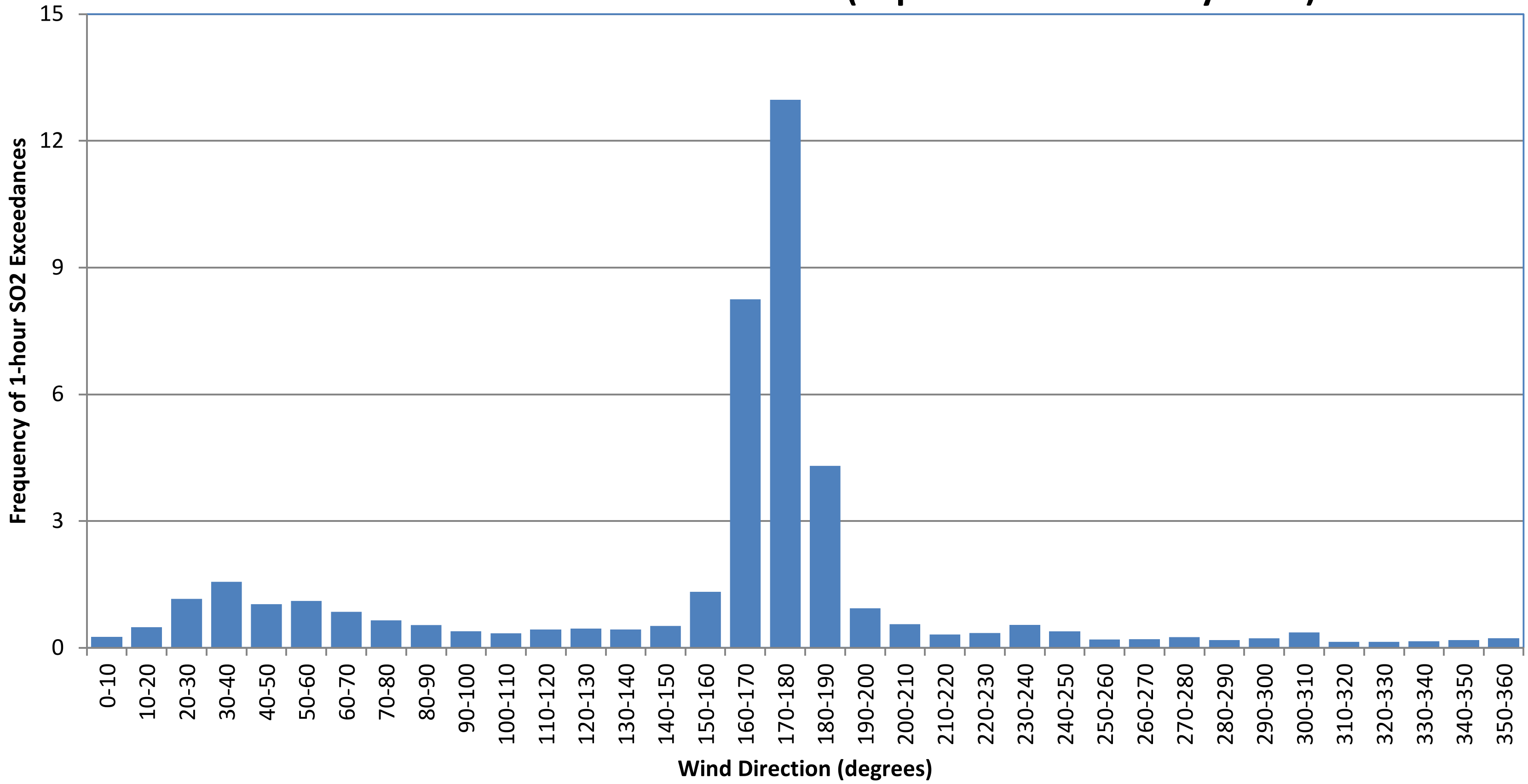
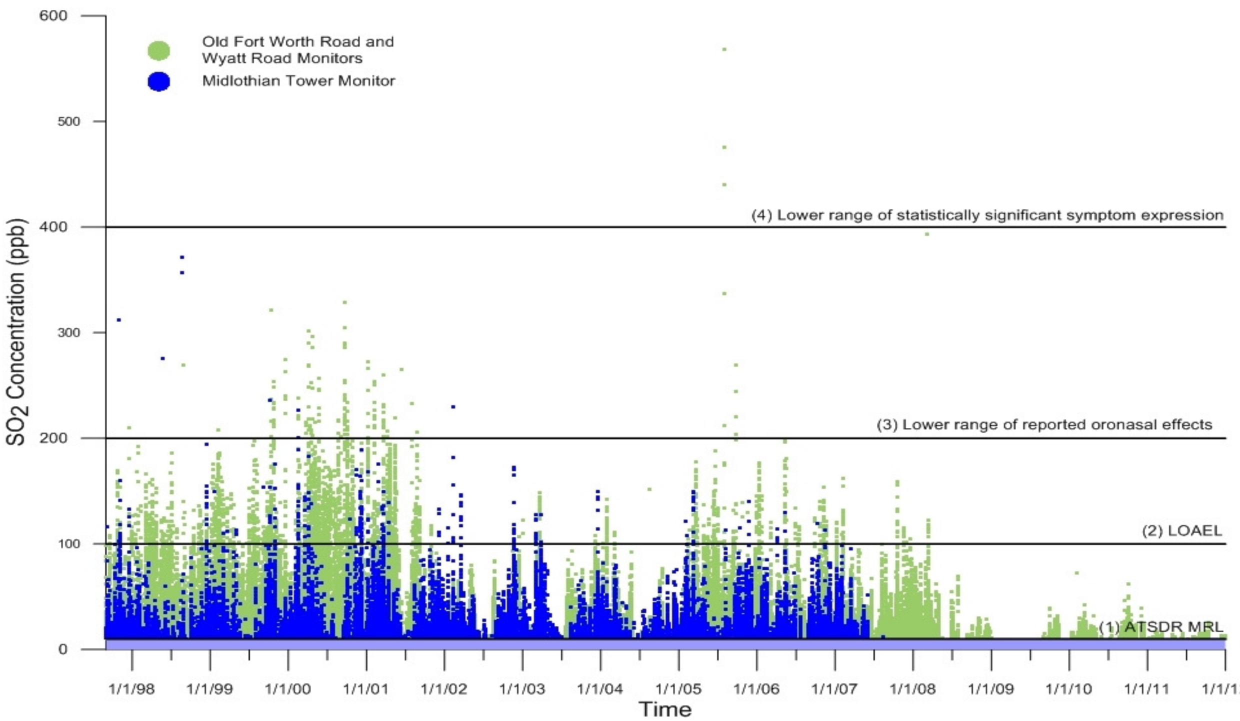


Figure 10: Peak 5-Minute Sulfur Dioxide Levels in Midlothian Area from 1997-2011



1. ATSDR MRL – ATSDR's acute Minimal Risk Level (10 ppb) for Sulfur Dioxide. ATSDR 1998: Toxicological profile for sulfur dioxide.
2. LOAEL – ATSDR acute Lowest Observed Adverse Effect Level (LOAEL)(100 ppb) using mouthpiece exposure in human clinical study. Shepard et al. 1981: Exercise increases sulfur dioxide-induced bronchoconstriction in asthmatic subjects. Am Rev Respir Dis 123:486-491.
3. Lower range of reported oronasal effects (200 ppb), based on several studies. USEPA 2008c: Integrated science assessment for sulfur oxides – health criteria. Office of Research and Development. EPA/600/R-08/047FA.
4. Lower range of statistically significant symptom expression (400 ppb), based on several studies. USEPA 2009c: Risk and exposure assessment to support the review of the SO_2 Primary National Ambient Air Quality Standards: second draft.

Appendices

Appendix A. ATSDR Carbon Monoxide Modeling

For most of the criteria pollutants considered in this Health Consultation, ATSDR based its conclusions on ambient air monitoring data, or direct measurements of levels of air pollution in the Midlothian area. This basis was not the case for carbon monoxide because no ambient air monitoring data are available for this pollutant. Therefore, ATSDR conducted air dispersion modeling analysis for carbon monoxide. Such models can be used to estimate air pollution levels based on facility configurations, emission rates, local meteorologic conditions, and other factors. This appendix describes the air dispersion modeling analysis that ATSDR conducted. All model input files used for this modeling are available in electronic format from ATSDR, upon request. The modeling described in this appendix was designed to characterize the combined air quality impacts from all four industrial facilities in the Midlothian areaand does not account for influences from any other sources.

Model selection. Modeling was performed using the AERMOD model, version number 11103. AERMOD was chosen because it is recommended in EPA's Guideline on Air Quality Models (EPA, 2005). AERMOD has been widely used for modeling how pollutants move from industrial facilities through the air to offsite locations. This model can be used for evaluating different types of emission sources, including point, area, and volume sources. AERMOD also can be used to assess air pollution levels in all types of terrain, including flat and complex.

Pollutants. This appendix reviews the modeling that ATSDR conducted for carbon monoxide. ATSDR also used this model to evaluate air-quality impacts for several other air pollutants. Those results will be presented in a separate Health Consultation.

Facilities and sources modeled. The modeling focused on emissions from Ash Grove Cement, Gerdau Ameristeel, Holcim, and TXI Operations. For carbon monoxide, the overwhelming majority of emissions that the facilities reported to the state emission inventory come from either kiln stacks (at the cement manufacturing facilities) or furnace stacks (at the steel mill). This reporting is consistent with the knowledge that industrial emission sources of carbon monoxide are dominated by fuel combustion sources and other high-temperature sources.

ATSDR's approach was to model carbon monoxide emissions from one stack per facility, and the stack selected was the one expected to have the least favorable dispersion (i.e., the shortest kiln or furnace stack and the lowest exit velocity). For each facility, ATSDR allocated 100 %of the facilitywide emissions to the one stack selected for modeling. In other words, 100 %of each facility's carbon monoxide emissions were considered in the model—they were just assumed to be emitted from the stack that would lead to the highest offsite air quality impacts. Although some facilities have ground-level emissions source of carbon monoxide (e.g., exhaust from trucks and small engines), these account for a small fraction of the facility's overall inventories. The tables at the end of this protocol list the stack parameters and emission rates for the facilities of interest. Building downwash was not considered, primarily because the stacks are higher than the nearby buildings and structures.

Meteorologic data. AERMOD, like most refined dispersion models, requires inputs that characterize local meteorologic conditions—typically hourly observations of wind speed, wind direction, temperature, and other parameters. For this modeling, ATSDR used the electronic meteorologic data sets that TCEQ had already processed for modeling applications in Ellis County, Texas. The data used were for medium surface roughness, which is appropriate for rural and suburban areas. The specific data set processed by TCEQ and used in modeling applications in this area includes surface meteorological data from the Dallas–Fort Worth Airport for calendar years 1985, 1987, 1988, 1989, and 1990; these data are processed with upper air data from Stephenville, Texas. The five individual year datasets were combined into a single file for input to the model.

Terrain data. Elevation data for the Midlothian area were obtained from the National Elevations Dataset available from the U.S. Geological Survey. These data were used to assign elevations to every location where air pollution was modeled and to make realistic assessments of how local terrain affects atmospheric dispersion.

Receptor grid. In the field of dispersion modeling, "receptors" refer to the locations where models estimate air pollution levels. Receptors can be assigned to any geographic area of interest. The proposed receptor grid for this modeling application was selected to help pinpoint locations with maximum impact from the primary stack at an individual facility. It is standard practice to have a high concentration of receptors in areas where one expects air pollution levels to be highest and fewer receptors in other areas. This approach helps ensure the highest air pollution levels are identified, while saving computational time. The receptor grid for this modeling is depicted in Figures C-1, C-2, and C-3, and included three tiers of receptors:

- *Fine grid for near-field receptors.* The most receptors were placed in the immediate vicinity of the four facilities. Specifically, receptors were placed at 100-meter intervals along the facility boundaries and at regular spacing to a distance 1 kilometer from the facility boundary. Concentrations were not modeled for locations within the facility boundaries. Figures C-1 and C-2 show the near-field receptor grid.

- *Intermediate grid receptors.* At distances between 1 and 5 kilometers from the facility boundaries, receptors were placed at 500-meter intervals. Figure C-3 shows these receptors.

- *Coarse grid for far-field receptors.* At locations between 5 and 10 kilometers from the facilities, receptors were placed at 1,000-meter intervals. Figure C-3 shows the locations of these receptors. Modeling was not conducted for locations more than 10 kilometers away from the facility boundaries. The outputs from the modeling confirmed that this modeling domain was adequate and that higher air quality impacts for carbon monoxide did not occur at locations further downwind.

Model inputs and emission rates. Table C-1 lists all of the model inputs for the individual facilities. For the stacks considered in the analysis, the table lists the geographic coordinates, the stack height and diameter, and the temperature and velocity of the emissions from the stack. These parameters are all taken from publicly available Emission Inventory Questionnaire data. Carbon monoxide emission rates used in the modeling (and shown in Table C-1) are the highest annual carbon monoxide emissions levels documented in the TCEQ Point Source Emission

Inventory for any year during the period 1990– 2010. These annual emissions are the total amounts of carbon monoxide released over the course of the year. For purposes of modeling, these values were used to calculate emission rates, which were assumed to remain constant throughout the year.

Model outputs and averaging times. The model was run with 5 years of meteorologic data, and carbon monoxide concentrations were calculated for each receptor. These concentrations represent the combined air quality impact from all four Midlothian facilities, not considering contributions from other sources. The highest air quality impacts were observed at locations immediately north of the Gerdau Ameristeel and TXI Operations facilities. Table C-2 lists the highest predicted carbon monoxide concentrations for several averaging periods.

Uncertainties and limitations. ATSDR considered the uncertainties and limitations of these modeling results. The model inputs for stack parameters are based on direct observations of facility conditions, and these are believed to be highly accurate. The meteorologic data used in the model are based on observations at the Dallas–Fort Worth Airport. Although this location is approximately 30 miles away from Midlothian, the prevailing wind directions in the data set are similar to those encountered in the Midlothian area.

The main source of uncertainty is likely associated with the emissions data. ATSDR took steps to ensure that the highest annual emissions were modeled. For example, for each facility, the highest annual carbon monoxide emissions were considered in the assessment. Further, even though the highest emissions occurred during different years across the four facilities, the model assumed the highest annual emissions from all four facilities occurred at the same time. ATSDR believes the emissions data to be accurate, given that reported emissions (at least in recent years) are largely based on continuous emissions monitoring data from the stacks; some of the facilities are required to directly measure the amounts of carbon monoxide that they are releasing. Despite these efforts to ensure that the modeling is based on health-protective assumptions, the main limitation in the emissions data is that the assessment is based on annual emissions, which were assumed to remain constant throughout the year. In reality, emissions vary from one hour to the next, and short-term fluctuations in emissions are not captured in the modeling analysis (but short-term fluctuations in the local meteorologicl conditions are addressed). Therefore, the possibility remains that some short-term carbon monoxide concentrations were higher than the worst-case levels predicted by the model, but they probably would have occurred only if elevated short-term emissions happened during times with unfavorable meteorologic conditions.

References

[EPA] US Environmental Protection Agency. 2005. Guideline on Air Quality Models. Code of Federal Regulations, Chapter 40, Part 51, Appendix W. November 9, 2005.

Table A-1. Model Input Parameters

Input Parameters	Facility			
	Ash Grove Cement	**Gerdau Ameristeel**	**Holcim**	**TXI Operations**
Stack modeled	"Kiln #1"	"Baghouse A"	"Kiln #1"	"Kiln #4"
UTM-North (zone 14)	3,599,875 meters	3,592,800 meters	3,599,176 meters	3,593,584.25 meters
UTM-East (zone 14)	687,419 meters	684,525 meters	690,633 meters	685,435.55 meters
Stack height	150 feet	80 feet	273 feet	200 feet
Stack diameter	10.5 feet	11.9 feet	13.5 feet	9 feet
Exit temperature	350 ^{o}F	150 ^{o}F	233 ^{o}F	383 ^{o}F
Exit velocity	31 feet/second	5.9 feet/second	56 feet/second	37.43 feet/second
CO annual emissions	1,254,600 lbs/year	4,278,660 lbs/year	12,175,846 lbs/year	2,104,000 lbs/year
Source of emissions data	1990 emission inventory	1994 emission inventory	2004 emission inventory	1990 emission inventory

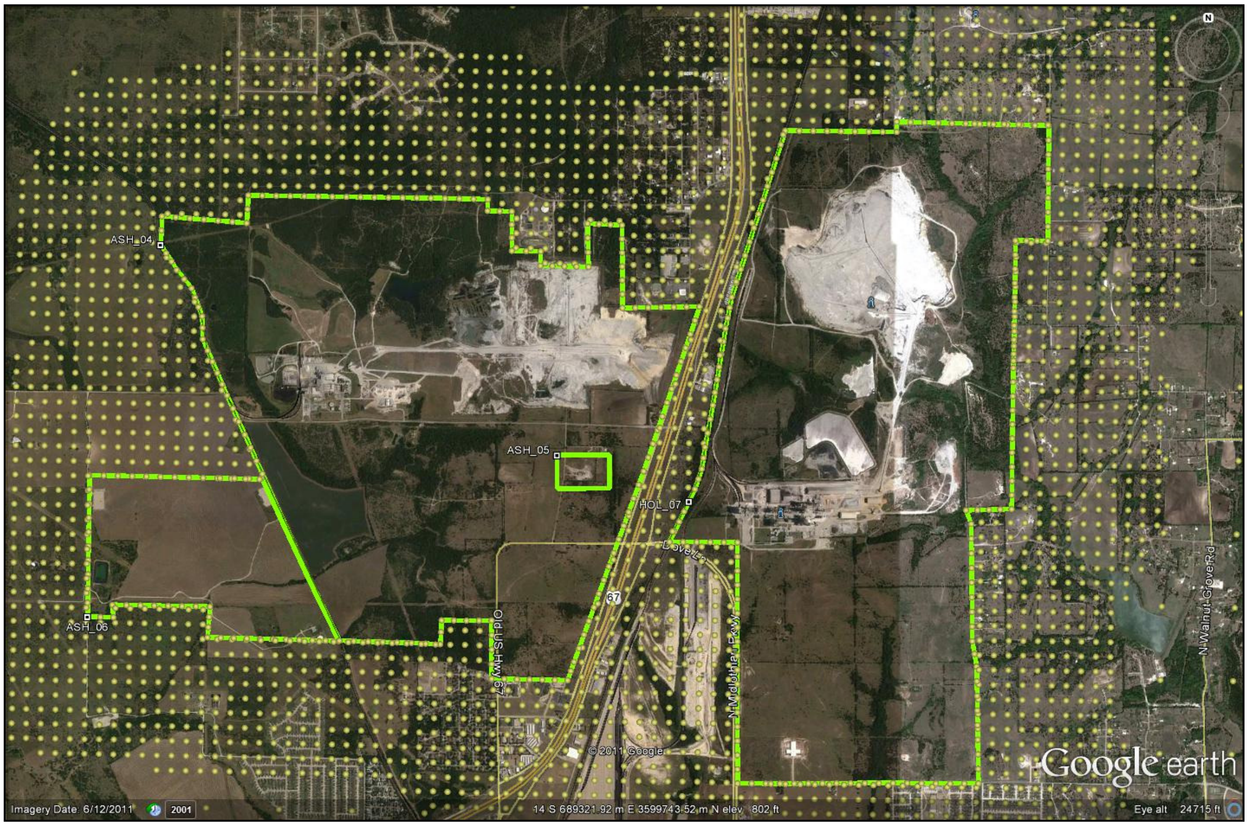
Notes: The stack parameters are all taken from data documented on the facility's Emission Inventory Questionnaires for years 2000, 2007, 2010. Stack parameters are not expected to change from one year to the next. In each case, the stack modeled is the kiln or furnace stack expected to have the highest air quality impacts. For purposes of the modeling, 100 % of the facility's carbon monoxide emissions were assumed to be emitted from these stacks.

The emissions data represent the highest annual carbon monoxide emission rates that were available from TCEQ's Point Source Emissions Inventory. ATSDR obtained all relevant records for the four industrial facilities, dating back to the first year of this emission inventory (1990). The entries shown above are the highest annual emissions over the entire period of record. ATSDR's modeling assumed that emissions occurred at these rates over the entire period considered in the modeling analysis.

Table A-2. Highest Estimated Carbon Monoxide Concentrations

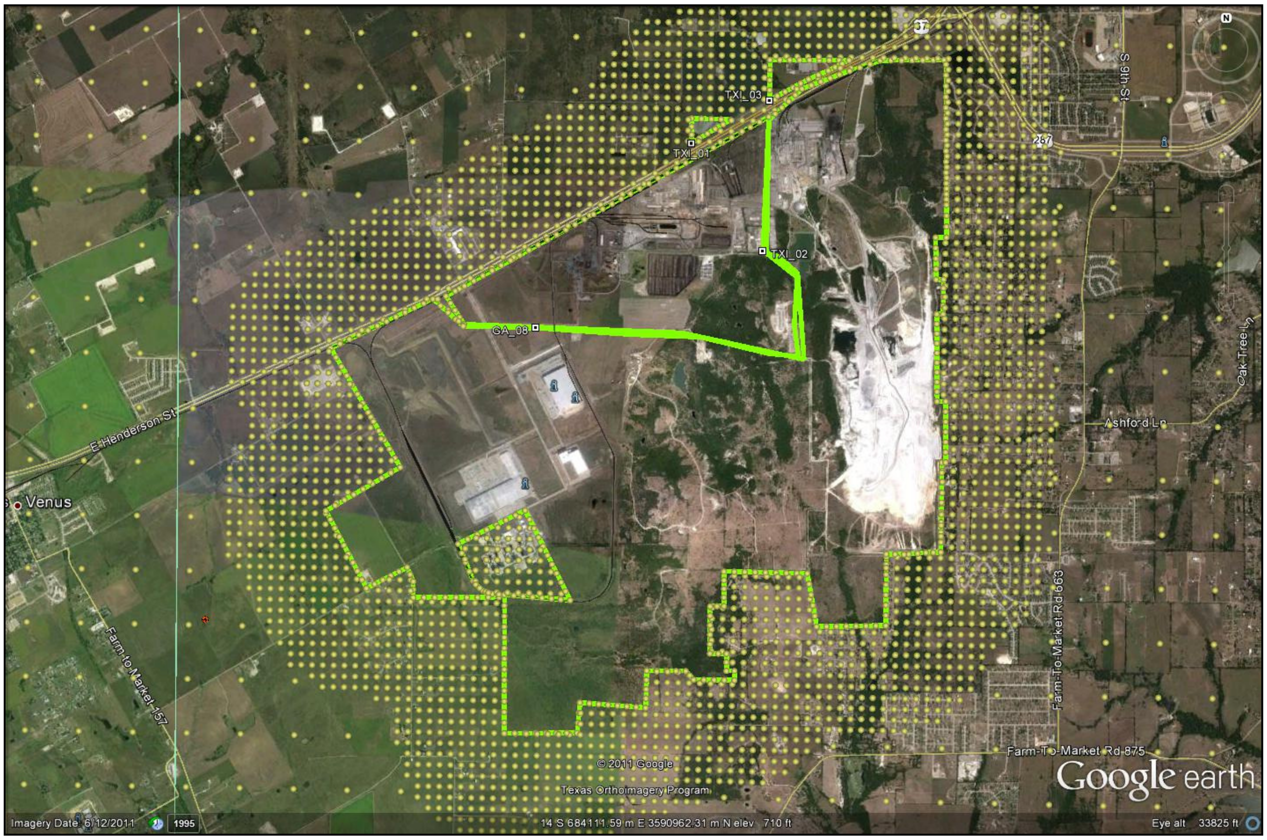
Averaging Time	Highest Estimated Carbon Monoxide Concentration	
	Parts per billion (ppb)	Micrograms per cubic meter ($\mu g/m^3$)
1-hour	848	971
8-hour	553	633
Annual average	103	118
5-year average	87	100

Figure A-1. Aerial Photograph Showing Near-Field Receptor Grid near Ash Grove Cement and Holcim



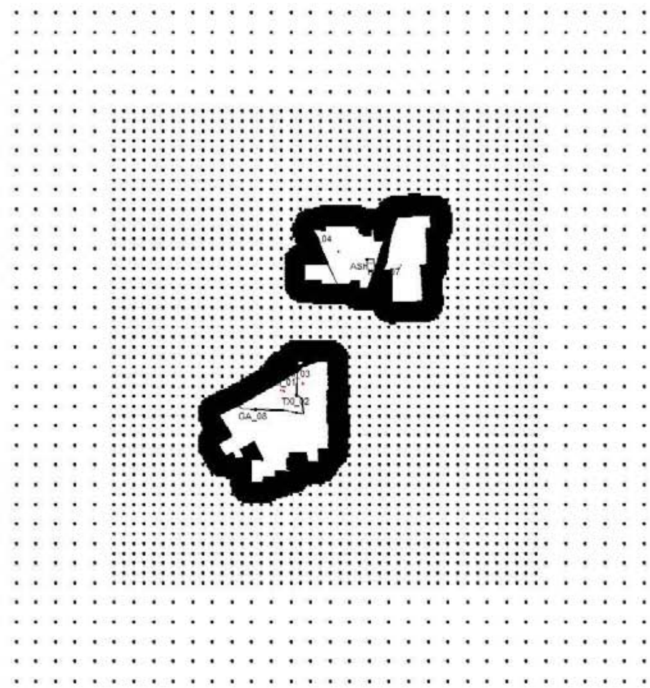
Note: Map shows placement of near-field receptors in the vicinity of the Ash Grove Cement and Holcim facilities. The near-field receptors are placed along the property lines and at 100-meter intervals and appear in the map as green dots. No receptors are placed within the facility boundaries.

Figure A-2. Aerial Photograph Showing Near-Field Receptor Grid near Gerdau Ameristeel and TXI Operations



Note: Map shows placement of near-field receptors in the vicinity of the Gerdau Ameristeel and TXI Operations facilities. The near-field receptors are placed along the property lines and at 100-meter intervals and appear in the map as green dots. No receptors are placed within the facility boundaries. Some intermediate-range receptors (placed at 500-meter intervals)also are displayed.

Figure A-3. Illustration Showing Entire Receptor Grid for Modeling Domain



Note: Map shows proposed placement of all receptors. The far-field receptors at 1,000-meter intervals appear around the exterior of the illustration. The intermediate range receptors at 500-meter intervals also are visible. The near-field receptors at 100-meter intervals also are displayed, but they appear as a shaded area rather than individual points because of their close proximity when displaying the entire modeling domain.

Appendix B. Sulfur Dioxide Health Evaluation

ATSDR addresses health concerns in public health assessments using both quantitative and qualitative methods. For SO_2, the qualitative strength of evidence approach will serve a primary role in deciding the public health significance of SO_2 levels. The strength of evidence approach requires (1) a thorough review of the scientific literature for health effects from acute and chronic exposures, (2) an evaluation of the potential for sensitive groups to be exposed, (3) the evaluation of site-specific exposure scenarios, and (4) the evaluation of co-exposures to other air pollutants.

Although health guidelines describe levels believed to be safe from exposure to a specific chemical on a population basis, they do not describe the likelihood of adverse health effects for exposures above that value. As part of ATSDR's strength of evidence evaluation, we evaluate the likelihood of harmful effects occurring should a health guideline be exceeded. The site-specific evaluation will consider sensitive populations, co-exposures to other contaminants, and the location, frequency, duration and time of day the exposures occur.

Health Effects Assessment

ATSDR evaluated potential health effects in the health consultation by considering the locations of concentrations of SO_2 of concern, the time of day, the frequency and duration of SO_2 peaks of concern, and co-exposure to other contaminants. The following identifies the SO_2 concentration ranges and associated ATSDR level of concern.

>10 – 400 ppb SO_2.
ATSDR recognizes the variability in asthmatic response and uncertainty associated with adopting any single SO_2 concentration as a level of concern.
Exposures to 10-400 ppb SO_2 appears to be the range of most uncertainty as to whether an effect will occur and whether that effect should be considered adverse. ATSDR will use the Midlothian 5-minute data to conduct a site-specific assessment to characterize the likelihood of health effects occurring in this range.

Exposures in this range might be considered a public health hazard depending on the frequency and duration of exposure, co-exposures to other contaminants, and exposure of potentially more sensitive populations, such as children and individuals with pre-existing respiratory disease. Exposures in this range will be evaluated using a site-specific strength of evidence approach.

Peak exposures (5 -minutes) above 10 ppb SO_2 to 400 ppb SO_2 are described as a dose-response continuum (Table B-1 below) where higher concentrations in this range are more likely to cause a response in a greater number of sensitive individuals than lower concentrations in this range. Clinical exposures in this range resulted in a response in healthy mild-to-moderate asthmatic adults and adolescents who were exercising (at an increased ventilation rate). Persons with severe asthma, unhealthy individuals, and children were not included in these studies. These populations might be more sensitive than the populations that were included in the clinical studies. The lowest effect level reported in human clinical studies was 100 ppb SO_2 via mouthpiece exposure (oral breathing) which bypasses the protective effect of the nasal mucosa [1, 2]. The lowest level reported for effects in free-breathing or oronasal breathing subjects occurred about 200-250 ppb SO_2 [3, 4]. An estimated 5 - 30 % of persons with asthma are believed to be sensitive to exposures between 200 and 300 ppb SO_2 and experience moderate or greater decrements in lung function (greater than or equal to a 100% increase in sRaw (airway resistance) and/or greater than or equal to a 15% decrease in Forced Expiratory Volume in 1 second, or FEV1) [7]. Further, an estimated 20% – 35 % of exercising persons with asthma experience moderate or greater lung function decrements at SO_2 concentrations 400 – 500 ppb [5].

Acute effects reported in exercising adult and adolescents with asthma exposed to <400 ppb SO_2 (5 minutes) are considered less serious than those exposed to > 400 ppb SO_2 (exposures <500 ppb do not usually require the individual to cease the activity, do not usually require medication, and do not usually require the individual to seek medical attention). Effects up to 250 ppb SO_2 are equivalent to reported effects of asthmatic responses to exercise alone [6]. Effects such as bronchoconstriction might not be perceived by the exposed individuals at the lower end of this range and symptoms (coughing, wheezing, dyspnea) begin to appear > 400 ppb SO_2.

Exposures of 10 ppb to 400 ppb SO_2 (5 minutes) might be considered of variable *public health concern*, depending on the intensity, frequency and duration of SO_2 exposure. Although about 200 ppb is the lower level of mild to moderate asthmatics experiencing effects while at increased ventilation rates in clinical studies, these studies did not include potentially more sensitive individuals. These studies were performed at laboratory conditions of controlled humidity and temperature, whereas actual exposures might occur at colder and dryer conditions that have been reported to result in an increased response [7, 8].

Current scientific literature links health effects with short-term exposure to SO2 ranging from 5-minutes to 24-hours. The Environmental Protection Agency (EPA) examined potential 5-minute health benchmark values in the 100 – 400 ppb range in the second draft of the Risk and Exposure Assessment to Support the Review of the SO_2 Primary National Ambient Air Quality Standards [9]. In addition, the frequency and duration of exposures might increase the risk for longer-term health effects leading to respiratory or cardiac disease. For example, increased frequency and duration of exposure to SO_2 leading to a 24-hour average concentration of 140 ppb SO_2, the former EPA National Ambient Air Quality Standard (NAAQS) may be considered a *public health hazard to all populations.* In epidemiologic studies, SO_2-related respiratory effects were consistently reported at lower concentrations than the clinical studies observed and in areas where the maximum ambient 24-hour average SO_2 concentration was below the former 24-hour average NAAQS level of 140 ppb.

A decrease in heart rate variability has been reported in adults with asthma exposed to 200 ppb SO_2 for 60 minutes [10]. The significance of these short-term effects to chronic cardiac endpoints is still being investigated but such exposures suggest the need for public health concern.

>400-1000 ppb SO_2

Exposures >600 ppb and less than 1000 ppb SO_2 (5 minutes) might cause adverse health effects in an estimated 35% - 60 % of exercising persons with asthma and an unknown portion of other sensitive populations [5]. Effects in exercising adult or adolescent persons with asthma exposed to this concentration range might include more serious health effects that necessitate (1) stopping the exercise, (2) taking medication, or (3) seeking medical attention. Exposures in this concentration range might be considered a *public health hazard to sensitive populations at elevated ventilation rates.*

>1000 ppb SO_2

Exposures to >1000 ppb SO_2 (5 minutes) are considered an *acute public health hazard to all populations.*

Sensitive populations

The following populations are considered sensitive or potentially sensitive to SO_2 exposures in that the response to SO_2 might be more severe or occur at a lower threshold than the general population.

Asthmatics

Many persons with asthma are sensitive to SO_2 exposure [11]. The referenced SO_2 exposure ranges above are based on exposure to exercising asthmatic adults and adolescents.

Children

Children might be at increased risk from exposure to ambient air contaminants with respect to both toxicology and exposure. That children are more toxicologically sensitive to SO_2 but might be more vulnerable because of increased exposure is not clear. Although physiologically based pharmacokinetic modeling has suggested that children might be more vulnerable in the pulmonary region to fine particulate matter, it also suggests that children's airways might not be more sensitive than adults to reactive gases such as SO_2 [12].

Factors that might contribute to enhanced lung deposition in children include higher ventilation rates, less contribution from nasal breathing, less efficient uptake of particles in the nasal airways, and greater deposition efficiency of particle and some vapor phase chemicals in the lower respiratory tract. A child breathes faster compared with an adult, which might result in increased uptake [13]. Children spend three times as much time outdoors as adults and engage in three times as much time playing sports and other vigorous activities [14]. Based on these parameters, children are more likely to be exposed to more outdoor air pollution than adults. Epidemiologic evidence suggests that air pollution effects (lung function decrements) in children might not be fully reversible, even if the exposure stops, although SO_2 was not a major contaminant in these studies [15].

Other SO_2 sensitive or vulnerable populations

Other sensitive populations might include obese individuals, individuals who have chronic pro-inflammatory state like diabetics, older adults (65+ years), and individuals with pre-existing respiratory and cardiopulmonary disease [16]. Vulnerable individuals are those who spend time outdoors at increased exertion levels and might include children, outdoor workers, and individuals who play sports or exercise outdoors.

Adverse health effects.

What constitutes an adverse health effect has long been debated [17]. Whether a less serious observed effect to SO_2 exposures in the 100 – 400 ppb range is considered an adverse health effect is still the subject of uncertainty. Some scientists consider a biological effect as an adverse effect only if the effect is medically significant in that the subject must take medication, seeks medical treatment (hospital or medical practitioner visit), or must stop the activity in which the subject was engaged. Other scientists consider a biological effect to be adverse if the exposure reduces the reserve function of the lung, reducing the subject's ability to withstand additional insults.

ATSDR recognizes the variability in asthmatic response and uncertainty associated with adopting any single health comparison value. ATSDR has described the reported range of health effects from the scientific literature in the range of most uncertainty, 10 – 400 ppb SO_2. ATSDR needs to make a site-specific assessment to characterize the likelihood of health effects occurring in this range. A site-specific evaluation would consider the location of SO_2 concentrations, the frequency, duration, time of day and day of week, and co-exposures to other contaminants.

Severity and incidence of respiratory symptoms has been shown to increase with increasing concentrations between 200 and 600 ppb SO_2 in free-breathing exercising adults with asthma following peak exposures (5-10 minutes). Statistically significant increases in symptoms (chest tightness, coughing, or wheezing) are observed at concentrations > or = 400 ppb SO_2.

Exposure to concentrations at or above 200 ppb SO_2 is considered by ATSDR to potentially result in a diminished capacity to respond to exposures to other agents in sensitive individuals at elevated ventilation rates. The diminished capacity results from a moderate or greater decrement in lung function (i.e. increases in sRaw > or = 100% or decrease in FEV1 > or = 15% in 5-30% of exercising asthmatics at 200-300 ppb SO_2 with 5-10 minute exposures). This diminished capacity from the decrement in lung function is considered an ***adverse health effect***. This adverse health effect might be considered a ***public health hazard to sensitive populations at elevated ventilation rates*** depending on the potential impact of site-specific frequency and duration of exposure and the temporal and spatial considerations and co-exposure potential. In addition, exposure must occur to a sensitive individual while at an elevated ventilation rate.

Exposure to concentrations at or above 400 ppb SO_2 might result in the increasing potential for the development of symptoms (chest tightness, coughing, and wheezing) in sensitive populations at elevated ventilation rates. SO_2 induces moderate or greater decrements in lung function (described above) in 20%-60 % of persons with asthma at 400 – 1000 ppb SO_2 with 5-10 minute exposures.

Exposure to concentrations at or above 600 ppb SO_2 is considered a ***public health hazard to sensitive populations at elevated ventilation rates*** because of the increasing potential that medical intervention may be appropriate.

These conclusions are based on clinical investigations reported in peer-reviewed scientific literature. These clinical investigations are based on responses in typically mild to moderate healthy adults with asthma at elevated ventilation rates in controlled temperature and humidity environments. Because of ethical considerations, investigations do not usually involve persons with severe asthma, children, or unhealthy individuals. These and other potentially sensitive or vulnerable individuals (obese individuals, individuals with pro-inflammatory state like diabetics, adults greater than 65 years, and individuals with pre-existing respiratory and cardiopulmonary disease) might be at risk for effects at lower SO_2 concentrations or more severe effects at equivalent concentrations. In addition, sensitive populations might experience an exacerbation of effects from exposure to dry, cold air or co-exposure to other agents such as particulate matter or ozone. Therefore, adverse health effects could occur to the more vulnerable or sensitive individuals at levels below 200 ppb SO_2. Although clinical investigations have not addressed free-breathing levels below 200 ppb, mouthpiece investigations have reports effects at 100 ppb.

Epidemiologic studies have provided consistent evidence of an association between ambient SO_2 exposures and increased respiratory symptoms in children, particularly those with asthma or chronic respiratory symptoms. Multicity studies have observed these associations at a median range of 17 to 37 ppb (75^{th} percentile: -25 to 50) across cities for 3-hr average SO_2 and 2.2 to 7.4 ppb (90^{th} percentile: 4.4 to 14.2) for 24-hr average SO_2 [18].

Table B-1. Sulfur Dioxide Concentrations of Interest
Peak exposures

Respiratory effects in clinical studies. Peak exposures < 15 minutes.

	Less serious effects in exercising asthmatics →			More serious effects in exercising asthmatics →	
10 ppb MRL	**100 ppb** Lowest oral exposure effects	**200-250 ppb** Lowest oronasal exposure effects	**400 ppb** Symptoms: cough wheeze dyspnea	**500-600 ppb** Take medication Seek medical attention Stop activity	**1000 ppb** Lowest Non-sensitive Populations
% asthmatics affected		5 - 30 % (200-300 ppb)	20 – 35 % (400 – 500 ppb)	35 - 60 % (600 – 1000 ppb)	

Short-term exposure
75ppb
1-hour (short-term)
NAAQS (99th percentile daily maximum concentration averaged over three consecutive years)

[1]EPA has revoked their previous short-term 24-hour standard and annual average standard.

Health Guideline Values

The following are health-based guidelines for sulfur dioxide.

Short-term health-based criteria (based on human clinical studies)		
ATSDR Acute MRL screening level (10 min)		10 ppb
UK/N Ireland	(15 minutes)	100 ppb
	(60 minutes)[1]	135 ppb
WHO 2005 Guidelines [2] (10 minutes)		190 ppb
CA EPA[1]	(60 minutes)	250 ppb
EPA[3]	(1-hour current standard)	75 ppb
Chronic health-based criteria (based on epidemiological studies)		
EPA[4] (24-hour NAAQS-Revoked in 2010)		140 ppb
Northern Ireland (24 hour)[5]		48 ppb
CA EPA[2] (24-hour)		40 ppb
WHO 2005 Guidelines (24-hour)		8 ppb
EPA (Annual Average NAAQS—Revoked in 2010)		30 ppb

1 not to be exceeded more than 24 times/calendar year
2 not to be exceeded value
3 not to exceed the 99th percentile of 1-hour daily maximum concentration averaged over three consecutive years
4 not to be exceeded more than once per year
5 not to be exceeded more than 3 times/calendar year

ATSDR's acute minimal risk level (MRL) [19]. Acute exposures <10 ppb SO_2 are not likely to cause adverse health effects. The MRL is a screening level below which exposure is believed to be without adverse (non-cancerous) health effects to all populations, including sensitive groups. The MRL is not a threshold for health effects, but exposures to concentrations above the MRL will be evaluated further using the strength of evidence approach and site-specific factors.

EPA acute exposure guideline levels (AEGLs) for sulfur dioxide. AEGLs are intended to apply to once-in-a-lifetime exposures to the general population including infants and children, and other individuals who might be sensitiveand susceptible.

AEGL1 (10 minutes – 4 hours)	200 ppb
AEGL2 (10 minutes – 4 hours)	750 ppb

AEGL 1 – general population and susceptible individuals could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. Effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL 2 – general population and susceptible individuals could experience irreversible or other serious, long-lasting adverse health effects or impaired ability to escape.

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