Health Consultation

PUBLIC COMMENT VERSION

Evaluation of Reported Animal Health Issues

as part of the

MIDLOTHIAN AREA AIR QUALITY PETITION RESPONSE

MIDLOTHIAN, ELLIS COUNTY, TEXAS

AUGUST 26, 2015

COMMENT PERIOD ENDS: NOVEMBER 23, 2015

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 health consultation is one of a series of six health consultations being prepared by ATSDR for this site. Completion of all six health consultations concludes the health consultation process for this site and 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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Public Comments:
ATSDR will accept public comments on this health consultation until November 23, 2015. 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 Petition Response—*Evaluation of Reported Animal Health Issues*
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.

HEALTH CONSULTATION

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

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Acronyms and Abbreviations

APHIS	(USDA) Animal and Plant Health Inspection Service
ATSDR	Agency for Toxic Substances and Disease Registry
BRFSS	Behavior Risk Factor and Surveillance Survey
CDC	Centers for Disease Control and Prevention
CEDM	Corporation for the Economic Development of Midlothian
CO	carbon monoxide
COPD	chronic obstructive pulmonary disease
DHHS	(U.S.) Department of Health and Human Services
DSHS	(Texas) Department of State Health Services
EPA	(U.S.) Environmental Protection Agency
ERM	Environmental Resources Management
GFAAS	graphite furnace atomic absorption spectrometry
H_2S	hydrogen sulfide
ICP-MS	inductively coupled plasma mass spectrometry
µg/dL	micrograms/deciliter
mg/kg	milligrams/kilogram
MRL	minimum risk level
MSU	Michigan State University (Diagnostic Center for Population and Animal Health)
MTL	maximum tolerable level
NAAQS	National Ambient Air Quality Standards
NAHMS	National Animal Health Monitoring System
NOx	nitrogen oxides
NRC	National Research Council
PCB	polychlorinated biphenyls
$PM_{2.5}$	particulate matter up to 2.5 microns in size
PM_{10}	particulate matter up to 10 microns in size
ppb	parts per billion
ppm	parts per million
RR	relative risk
SO_2	sulfur dioxide
TAMU	Texas A&M University (College of Veterinary Medicine)
TCEQ	Texas Commission on Environmental Quality
TDSHS	Texas Department of State Health Services
TNRCC	Texas Natural Resource Conservation Commission
TPWD	Texas Parks and Wildlife Department
TVMDL	Texas Veterinary Medical Diagnostic Laboratory
TXI	Texas Industries, Inc.
USDA	United States Department of Agriculture
VMDB	Veterinary Medical Databases
VOC	volatile organic compounds
ZIP	zone improvement plan (code)

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 the community members in Midlothian, Texas. This health consultation, which examines animal health issues reported for the Midlothian area, is one of a series of six health consultations being prepared by ATSDR for this site.

The goal of this Health Consultation is to evaluate the animal health issues reported by residents living in the Midlothian area which they attribute to exposures from several facilities surrounding the community. While ATSDR does not traditionally address animal health issues, the agency decided to address this issue after recognizing that community members had concerns that the illnesses seen in their animals could indicate possible health problems for people.

The animal health concerns are summarized and an evaluation is made to put a perspective on the animal disease burden in the area. Since there are only limited animal disease registries and surveys and the rates of various animal health effects in Midlothian could not be determined, epidemiologic and statistical methods could not be used. Instead, the veterinary literature was reviewed for the known causes of these diseases and these diseases are discussed with respect to what is known about the chemicals of concern related to the cement kiln and steel facilities in the Midlothian area.

This Health Consultation provides the results from the exposure investigation conducted by ATSDR that looked at chromium and other metal concentrations in the blood and serum from dogs living in Midlothian and outside the Midlothian area. Community concerns on the comparison of animal and human health issues and the use of animals as sentinels are discussed.

CONCLUSIONS

ATSDR reached three main conclusions in this health consultation:

CONCLUSION 1
Animal health concerns

This animal health consultation does not and cannot determine cause and effect relationships between the reported animal health issues and the chemicals of concern identified at the site.

BASIS FOR DECISION

This health consultation summarized community concerns about animal health and provided information from the veterinary literature

	on the diseases. There are insufficient data to draw any conclusions about the cause of the reported animal health issues in Midlothian. ATSDR received reports of illness in dogs, horses, cattle, and other animals from residents of Midlothian. The rates of such animal health issues in Midlothian could not be determined from these reports. Additionally, there are only limited animal disease registries and surveys to serve as comparisons, so epidemiologic and statistical methods could not be used. In this health outcome data evaluation, geographical groupings serve as a surrogate for exposure data. All members in a group are treated as if they had the same exposure. This assumption cannot be verified and is typically untrue. Thus, this evaluation can suggest research questions to pursue, but cannot show cause and effect.
CONCLUSION 2 Exposure pathway analysis	There are several potentially completed exposure pathways for Midlothian area animals that could have pose a past, present, and future health concern. Irritant air pollutants such as sulfur dioxide, sulfuric acid aerosols, and cement kiln dust are a potential health concern to animals from inhalation or direct contact with chemicals deposited in the soil.
BASIS FOR DECISION	An evaluation of potential exposure pathways for animals in the Midlothian area was made by reviewing material included in the Midlothian Health Consultations that address environmental sampling of various media. Air emissions and deposition from air emissions may result in animals being exposed to contaminants via inhalation or ingestion and direct contact with soils. While concentrations of most of the chemicals analyzed were too low to anticipate a health effect, the irritant nature of sulfur dioxide, sulfuric acid aerosols, and cement kiln dust could present as mucus membrane and skin irritation to exposed animals.
CONCLUSION 3 Exposure Investigation	ATSDR's exposure investigation found that blood and serum concentrations of chromium and 16 other metals found in dogs from the Midlothian area were similar to the levels found in dogs residing beyond the Midlothian area.
BASIS FOR DECISION	ATSDR conducted an exposure investigation that compared blood and serum concentrations of chromium and 16 other metals in 10 dogs from the Midlothian area to the levels in 10 dogs residing beyond the Midlothian area. The results for both groups were similar for all metals. Statistical testing that looked specifically at chromium in blood found no significant difference between the two groups of dogs.

NEXT STEPS (All Conclusions)	ATSDR and TDSHS will present the findings of this health consultation to the community. As the remaining Midlothian health consultations that address environmental data are completed, ATSDR will discuss findings with respect to animal health issues, if they have not been addressed in this health consultation.
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.

1.0 Purpose and Statement of Issues

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 many concerns outlined in the original petition. Many comments were received on the draft Health Consultation.

During the process of evaluating these comments, the ATSDR and National Center for Environmental Health Director requested that the ATSDR and TDSHS team take a more comprehensive look at the site. As outlined in its Midlothian Public Health Response Plan [ATSDR 2012a], ATSDR independently, but in coordination with TDSHS, will complete this reevaluation in a series of projects.

Purpose of this Document
ATSDR prepared this Health Consultation to review the animal health concerns reported by residents in the Midlothian area. Since, there are no standardized animal disease registries or surveillance systems, animal health reports and veterinary literature were reviewed to look for patterns of disease that fell outside the normal range. While this review cannot provide a cause and effect evaluation for the chemicals of concern at the site, this document discusses completed exposure pathways, possible chemicals of concern, and potential associations with animal health findings. Additionally, this document provides the results from ATSDR's exposure investigation involving blood and serum samples from dogs in the Midlothian area.

This document should be used in conjunction with the companion health consultations prepared or in preparation for the site in order to have a more thorough appreciation for the issues addressed.

This ATSDR Health Consultation on reported animal health issues is part of the series of ATSDR Health Consultations prepared or in preparation related to the Midlothian, Texas area air quality issues. As a public health agency, ATSDR does not traditionally address animal health issues, except as they relate to animals that may be consumed by humans. However, ATSDR decided to address this issue after recognizing that community members have many concerns about the health of their animals and concerns that these same illnesses seen in their animals could indicate possible health problems for people.

The goal of this Health Consultation is to address the animal health issues reported by residents living in the Midlothian area which they attribute to exposures from several facilities surrounding the community. To accomplish this, we reviewed information provided about the health problems seen in Midlothian animals and we searched current veterinary literature for evidence that these problems could be linked to industrial chemical exposure. Since the animal disease burden in the community could not be quantified, no standardized epidemiologic and statistical methods could be used.

2.0 Background

This section presents background information that ATSDR considered when evaluating the relationship between animal health concerns and industrial releases in the Midlothian area.

2.1 Location and Site Description

Midlothian is located in Ellis County, Texas, approximately 30 miles south of the Dallas/Fort Worth metropolitan area (Appendix, Figure A.2.1). The town consists of commercial/retail buildings and residential properties. With regard to air quality, the facilities of interest for this site are Gerdau Ameristeel, Ashgrove Cement, Holcim Texas, and Texas Industries[1] (TXI). These facilities are all located in Midlothian and its Extra-territorial jurisdiction (Appendix, Figure A.2.2).

Much of the surrounding area is agricultural (Appendix, Figure A.2.3). Approximately 50% of the land within one mile of the facilities of interest is considered vacant or agricultural and available for development. There are many animals in the Midlothian area, including dog breeding operations; small horse, goat and cattle herds; wildlife; and many pet animals. The area in the southern section of Midlothian, south of US 67 and US 287, has a lower population density than the northern sections and is characterized by undeveloped property, family farms and ranches [Midlothian 2007]. In 2012, there were 613 agricultural facilities employing 3,719 workers in Midlothian and the extraterritorial jurisdiction [CEDM 2012].

2.2 History of Addressing Animal Health Concerns

Animal health issues have been a concern in Midlothian, Texas for over 20 years. Documents provided by community members show that citizens and some state agencies had reservations about the impact on public health, animal health, and agriculture of burning hazardous waste as fuel for cement kilns.

In 1994, in response to a rancher's inquiry about the potential for adverse health effects related to the agricultural field directly south of Chaparral Steel (now Gerdau Ameristeel) (Appendix, Figure A.2.1), the Texas Natural Resource Conservation Commission (TNRCC) (now known as the Texas Commission on Environmental Quality (TCEQ)) sampled pond water, forage vegetation, hay-bale, wheat, and soil for up to eighteen different metals [TNRCC 1994]. TNRCC's preliminary opinion was that grazing in the south hay field should be avoided due to the potential of impaired animal performance or in unsafe metal concentrations in food (e.g. milk or meat) for human consumption. TNRCC stated that metal concentrations in wheat from adjacent fields would be safe for human and animal consumption.

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1 Texas Industries, Inc. (TXI) merged with Martin Marietta Materials, Inc. in January 2014. This document refers to this facility as TXI.

The results from the TNRCC environmental analyses described above were incorporated into a summary report on the "Critical Evaluation of the Potential Impact of Emissions from Midlothian Industries" prepared by TNRCC in October 1995. The report discussed the environmental monitoring in the Midlothian area that began in January 1991. At the time of the report, the south hay field had recently been purchased by TXI and was being used for industrial purposes, so the area was no longer considered a concern for cattle [TNRCC 1995].
As a response to residents' concerns about impacts on animal health from hazardous waste burning facilities in Midlothian, the United States Environmental Protection Agency (EPA) conducted an animal health survey. A work plan was prepared in January 1995, the voluntary survey was conducted in September 1995, and the final report was issued in January 1996 [EPA 1996]. This voluntary survey included the study area (Midlothian) and two comparison areas. Only 31 of 335 potential participants completed the animal health questionnaire. Response was so low, that it precluded EPA from making any statistical comparisons or conclusions [EPA 1996]. Due to confidentiality concerns of local veterinarians, no attempt was made to review veterinary records.

In July 2005, ATSDR was petitioned by Midlothian residents to evaluate health concerns that residents believed were caused by poor air quality due to industrial emissions. These concerns included the issue of area animals acting as sentinels (indicators or early warning system) of human exposure. In October 2005, the ATSDR and TDSHS met with several residents to listen to their concerns and discuss a plan of action.

The Texas Department of State Health Services prepared a letter health consult in January 2009 that evaluated contaminant results for five surface soil samples collected by TCEQ from a residential property near the Midlothian facilities [TDSHS 2009]. The soil data evaluated did not provide any insight into why the property owner or her animals were experiencing health effects.

In 2009, ATSDR conducted a formal community survey. During this survey, more residents expressed concern about their animals. These concerns were reported in the Public Health Response Plan prepared for the site [ATSDR 2012a]. Follow-up occurred with these specific residents in December 2009 when ATSDR veterinarians visited Midlothian animal owners, Midlothian area veterinarians, the Texas state veterinarian and various professors at the Texas A&M University (TAMU) College of Veterinary Medicine. Further follow-up took place in September 2010 when ATSDR veterinarians returned to Midlothian to meet with animal owners and the Texas Parks and Wildlife Department (TPWD) to gather additional information.

2.3 Chemicals of Concern

As mentioned in the introduction, this health consultation, examines reported animal health issues in the Midlothian area. It is one of a series of six health consultations being prepared by ATSDR to address health concerns related to the air quality in Midlothian. The four facilities of interest in Midlothian emit several pollutants at rates that have consistently ranked among the highest for Ellis Count industrial facilities that submit data to TCEQ's Point Source Emissions Inventory. Aggregate air emissions include particulate matter (PM_{10} and $PM_{2.5}$), volatile organic compounds (VOC), nitrogen oxides (NOx), sulfur dioxide (SO_2), carbon monoxide (CO) and combustion products from tires and hazardous waste used as fuel. Air sampling data evaluated in the Midlothian Health Consultation on National Ambient Air Quality Standards (NAAQS) criteria air pollutants and hydrogen sulfide (H_2S) [ATSDR 2012c] and on VOC and metal air emissions [ATSDR 2015b] identified several air pollutants of concern for sensitive individuals. The Midlothian Health Consultation on VOCs and metals in soil, water, and other media evaluated contaminants that may be of concern for humans and animals [ATSDR 2015c].

Air sampling data and from 1997 through late 2008 show sulfur dioxide (SO_2) at concentrations that could have harmed sensitive individuals [ATSDR 2012c]. In areas primarily around the Gerdau Ameristeel plant and east, south, and southeast of the TXI fence line, data since 2008 show SO_2 at levels below those of health concern. Sulfur dioxide can combine with water vapors to form sulfuric acid aerosols that can acutely irritate the eyes, nose, and skin. Mucous membrane irritation would be anticipated in the animal population as well.

In a localized area north of Gerdau Ameristeel, breathing air contaminated with fine particulate matter ($PM_{2.5}$) for a year or more was determined to be a public health concern during the time period 1996 through 1998 [ATSDR 2012c]. There have also been some infrequent but potentially harmful short term levels of $PM_{2.5}$ measured in Midlothian between 2001 and 2011; these levels could have resulted in harmful cardiopulmonary effects. Several studies have shown radiographic changes in the lungs of dogs that were exposed to particulates and ozone in urban environments [Reif 2011].

Ozone was identified as a public health concern in the Midlothian Health Consultation on criteria (NAAQS) air pollutants and hydrogen sulfide [ATSDR 2012c]. Ellis County is part of the Dallas-Fort Worth ozone non-attainment area. Midlothian is crisscrossed by several major highways (Appendix, Figure A.2.2) and traffic is a major contributor to ozone levels. Since air monitoring began in 1997, ozone levels have occasionally been detected that would increase the likelihood of adverse respiratory effects for sensitive individuals. There were some rare occasions when ozone concentrations were above 100 parts per billion (ppb), a level that would be harmful to the general public, and most likely to animals, as well.

During the period 1993 to 1998, in a localized area north of the Gerdau Ameristeel fence line, airborne lead exposures could have harmed area children [ATSDR 2012c]. Since 1998, air levels of lead in this area have decreased. In animals, cattle are more commonly affected by lead poisoning than other species [Hoff 1998]; indiscriminate feeding habits might explain this finding. Lead poisoning is more common in cattle younger than 4 years of age and the peak occurrence of lead poisoning in cattle is in the late spring and summer [Mavangira 2008].

Exposure routes that are more relevant for animals than people in the Midlothian area include direct soil contact and ingestion of vegetation. The Midlothian Health Consultation on volatile organic compounds and metals in media other than air reviewed the data available on soil and vegetation [ATSDR 2015c]. Iron, an essential mineral for animals, was found in hay bale and vegetation samples taken from fields surrounding the Chaparral Steel (now Gerdau Ameristeel) facility at concentrations above the National Resource Council's (NRC) maximum tolerable level (MTL) in cattle feed [TNRCC 1994]. Iron toxicity is not common in most domestic animals; uptake is limited when levels are high and iron from natural feed is more tolerable than soluble iron compounds [NRC 2005]. In 2004, vegetation sampling by Chaparral Steel in fields south of the facility found some samples with aluminum and iron concentrations above the MTL for cattle feed. Samples from hay bales from the fields were not above the MTL in cattle feed [ERM 2004]. Aluminum is not an essential mineral for animals; however, livestock occasionally exposed to high levels usually do not show signs of toxicity if their gut and kidney functions are normal [NRC 2005].

3.0 Approach to Reported Animal Health Issues Review

ATSDR is a public health agency. As noted previously in Section 1, ATSDR has not traditionally addressed animal health issues. Animal exposures to contaminants and body burden have typically been addressed only as they relate to the human diet, such as fish, game, and cow's milk.

3.1 Data Sources

The goal of this review is to determine whether chemical releases from local industrial facilities could have affected the health of animals in the Midlothian area. We did this by reviewing provided information about the health problems seen in Midlothian animals and reviewing current literature for evidence that these problems could be linked to industrial chemical exposure. We looked for abnormal patterns of disease in the animal population.

Unfortunately, there are limitations to using animal data:

- Animal data tends to be anecdotal, often without confirmatory veterinary records. Lay terminology used in these reports may not adequately describe the medical condition.
- Breeding and herd records are useful in some situations, but records often are not thorough or accurate and may depend on recall.
- Most people do not consult veterinarians about their animal's health issues as often as they consult medical doctors about their own health problems. This makes it difficult to track trends in animal health or compare animal and human health trends.
- Many breeding operations do much of their own veterinary care and rarely consult a veterinarian for a birth defect or a death.
- Most animal studies are done on small sample populations because of the difficulty of obtaining data from larger populations.
- There are few databases available for animal health problems to determine background rates, and they are limited in scope and coverage.

To get background rates on animal health issues for this health consultation, journal articles especially those citing the Veterinary Medical Databases (VMDB) as a source of their animal epidemiological data were reviewed to determine if relevant prevalence and incidence data were available for the animal health issues of concern. The VMDB was originally an initiative of the National Cancer Institute for the purpose of studying cancer in animals. The database has been collecting animal visits of any kind from over 26 university veterinary teaching hospitals in the North America since 1964. There are over 7 million abstracted animal medical records available as a resource for researching animal diseases and treatments. The Texas A & M University Veterinary Medical Teaching Hospital contributed over 325,000 records between 1976 and 2001. Currently, there are 9 active institutions and 5 additional institutions working with VMDB to send their data.

Data on livestock mortality, some birth outcomes, and some disease rates were obtained from reports prepared by United States Department of Agriculture (USDA) Animal Plant Health Inspection Service (APHIS). Under USDA's National Animal Health Monitoring System

(NAHMS), APHIS conducts national studies on the health, health management, and productivity of United States domestic livestock and poultry populations. The monitoring program, initiated in 1983, is designed to include States that represent 70% of the targeted animal commodity. Commodities are studied at intervals of 5 years or more. Data from cattle, horse, sheep, and goats were used in this Health Consultation. Livestock operations in Texas were included in each of these reports. Additionally, USDA APHIS performs animal disease surveillance as part of the National Animal Health Surveillance System. This surveillance system focuses on communicable diseases to protect animal health, human health, and the agricultural industry from foreign and epidemic diseases.

In order to truly attribute an illness to an environmental point source, it is necessary to do a thorough evaluation of the animal and the animal husbandry to rule out other underlying causes [Poppenga 2000]. Having records of disease in herds in conjunction with veterinary records and environmental data analysis can sometimes be informative [Lloyd 1991], but we have limited data of this type for Midlothian.

The data we do have for this health consultation review include: anecdotal information from Midlothian animal owners, some veterinary records, some breeding records, environmental media testing (air, soil, water, and vegetation), biological testing results, laboratory cancer diagnoses from the Texas Veterinary Medical Diagnostic Laboratory (TVMDL), and scientific literature.

Even though the information is too limited to quantify animal health problems in the Midlothian area, we will attempt a review based on the current information and determine what data gaps exist that prevent a more thorough analysis. Human and some animal health effects of the chemicals of concern will be reviewed in more depth in the Midlothian Health Consultations that address environmental sampling of other media [ATSDR 2012c; 2015a,b,c].

3.2 Exposure Pathway Evaluation

When performing public health assessments, ATSDR uses an exposure pathway analysis and media-specific health based comparison values to determine if a public health hazard exists at a site [ATSDR 2005]. For this health consultation, the exposure pathway analysis was adapted for use in evaluating animal health concerns.

An animal must be exposed to chemical contaminants in the environment before an adverse health effect is possible. An exposure pathway consists of five parts that must be present to be considered a completed exposure pathway. If one or more of the parts are unknown, it may be considered a potentially completed exposure pathway. The five parts of the exposure pathway include:

- Source of the hazardous chemicals.
- Fate and transport— the method that allows the chemicals to move from the source and contact the animals (surface water, groundwater, soil, dust, vapors, soil gas);
- Point of exposure—the point where the animal comes in contact with the chemical.
- Route of exposure—the route through which the chemical enters the animal (drinking, eating, breathing, touching).

• Exposed population—the animals who come in contact with chemicals released from the site.

An evaluation of potential and completed exposure pathways for animals in the Midlothian area was accomplished by reviewing material included in the Midlothian Health Consultations that address environmental sampling of various media [ATSDR 2015b,c]. Exposure pathways are further characterized by the exposure's timing as past, present, or future. All three time frames are relevant for Midlothian area animals. An analysis of potentially completed exposure pathways for animals in the Midlothian area in the past, present or future is described below (Table 3.1).

Table 3.1 Potential and completed exposure pathways for Midlothian area animals

Pathway	Source	Fate and Transport	Point of Exposure	Route of Exposure	Exposed animal population
Inhaling air	Stack and fugitive emissions from factories	Winds carry emissions downwind	Locations downwind from factories	Inhalation	Pets, livestock, horses and wildlife
Contacting cement kiln dust	Emissions from bag house, especially when ruptured	Winds carry dust downwind	Locations immediately downwind from factories	Inhalation and dermal contact	Pets, livestock, horses and wildlife
Contacting contaminated soil off-site	Air emissions deposited in soil	Winds carry emissions which deposit in the soil	Locations immediately downwind from factories	Dermal contact, incidental ingestion	Pets, livestock, horses and wildlife
Contacting water in creeks and ponds downstream from factories	Contaminant from the quarries where waste water, incinerator ash and bag house contents are dumped	Rain overflows the quarries and washes contaminants downstream, leaching from quarries into groundwater.	Locations downstream from factories	Ingestion, dermal, consumption of biota from the stream	Pets, livestock, horses and wildlife with access to ponds and streams
Contacting sediment in creeks downstream from factories	Contaminant from the quarries where waste water and bag house contents are dumped	Rain overflows the quarries and washes contaminants downstream, contaminants settle in sediment.	Locations downstream from factories	Incidental ingestion, dermal	Pets, livestock, horses and wildlife with access to ponds and streams

Contact with a chemical contaminant in and by itself does not necessarily result in adverse health effects. A chemical's ability to affect the animal's health is affected by a number of other factors, including:

- How much of the chemical an animal comes into contact with (the dose);
- How long an animal is exposed to the chemical (duration of exposure);
- How often an animal is exposed to the chemical (acute versus chronic);
- The chemical's toxicity and how it impacts the body.

Other factors include the animal's history of past exposure to chemicals, current health status, age and sex, or genetic predisposition.

After determining the existence or potential for a completed exposure pathway, evaluation is made by comparing the dose an individual may receive to a health screening value. For human exposures, ATSDR has derived media-specific comparison values from minimal risk levels (MRLs). These comparison values were not designed for animal health screening values and ATSDR does not have any MRLs or other health-based screening values for animals. As explained in Section 3.1, for this health consultation, ATSDR used a variety of data sources to address animal health issues; however, the comparisons made were primarily on incidence of disease and not on toxicity doses.

As described previously (Section 2.2), TNRCC has used the National Academies National Research Council's (NRC) Committee on Minerals and Toxic Substances in Diets and Water for Animals, maximum tolerable level (MTL) for a screening value for vegetation and hay. The MTL of a mineral is "the dietary level that, when fed for a defined period of time, will not impair animal health and performance." The toxicity threshold is dependent on the animal species and tolerance usually increases with age. The MTL is based solely on animal health and productivity and does not take into consideration the possible human toxicity from consuming food products of animal tissues where minerals might have accumulated [NRC 2005]. Since this document does not review environmental sampling data, MTLs are not used as ingestion comparison values, but are used to compare differences in mineral tolerance between species.

3.3 Exposure Investigation

For some sites, where critical data is missing or not available that preclude reaching a health conclusion, ATSDR may conduct an exposure investigation. Typically, this investigation may include environmental and/or biological testing with the goal of determining whether people have been exposed to hazardous substances. For the Midlothian site, ATSDR took the opportunity following the demise of a litter of puppies in 2011 to perform some blood analyses on some dogs related to the litter. ATSDR conducted an exposure investigation as a follow-up to these preliminary clinical findings. The exposure investigation is presented in Section 5.0 Biological Testing.

4.0 Animal Health Issues

The animal health concerns reported by the community encompass many organ systems. The majority of the issues in horses and livestock were reported in the early 1990s, and we do not have recent data regarding the horse and cattle populations. Reports of problems in dogs are heavily centered around 2005, but date back to the 1990s and continue to the present. Some residents have commented on decreased numbers of wildlife and expressed concerns about fish kills. We categorized the problems reported by the community according to body system or health concern (Table 4.1).

Table 4.1 Health problems in Midlothian area animals as reported by community members.

Health Problem	Dog	Horse	Goat/sheep	Cattle	Other*
Birth Defects					
Limb Deformities	X	X	X	X	O
Ocular Deformities	X	X		X	
Facial deformities	X	X	X	X	
Reproductive tract deformities	X	X		X	O
Fetus & Newborn mortality					
Spontaneous abortion/Stillborn	X	X	X	X	O
Decreased newborn survival	X	X			
Infertility & Reproduction problems					
Twinning		X	X	X	
Cystic ovaries		X			
Other reproduction problems	X	X		X	Hh
Other Health Issues					
Dermatologic Illness	X		X		
Immune System Disorders	X	X	X		
Neurologic Illness				X	
Respiratory Problems	X	X	X		C,Hh
Thyroid Problems		X			
Cancer/tumor formation	X	X			R
Sudden Death	X	X	X	X	C,Ch,F

* Other animals include: cat (C), chicken (Ch), fish (F), hedgehog (Hh), ostrich (O), and rabbit (R).

BIRTH DEFECTS

Birth defects are structural or functional abnormalities that are present in the newborn animal at birth. Community members have reported the following birth defects in Midlothian-area animals:

Birth defect	Species
Limb deformities	Dogs, horses, ostrich
Coloboma (one eye not developed)	Dogs, horses
Neural tube defects	Dogs
Incomplete body wall closure	Dogs
Craniofacial deformities	Dogs, goats, cattle, horses, donkeys, sheep
Schistosomus reflexus	Cattle
Hydrocephalus	Dogs
Cryptorchid (undescended testicles)	Dogs, cattle, horses
External reproductive organs at birth	Horse

For humans, TDSHS maintains the Texas Birth Defects Registry and has conducted surveillance for human birth defects in Midlothian and Ellis County since 1997. However, there are no birth defect registries for animals. Most animals born with a birth defect do not survive or are promptly euthanized and necropsies are rarely performed; hence there are often no veterinary records for cases of birth defects in animals. The majority of the reports of birth defects in animals in Midlothian are personal recollections. We are unable to quantify the number of defects that have occurred to determine if there is a higher incidence in the area. In the United States, the USDA reports that for foals born alive that died within the first 30 days of life, birth defects were the cause of death in about 9 percent of the cases [USDA 2006].

Birth defects occur due to a variety of reasons, many of which are poorly understood. The majority of birth defects occur during the earliest stages of pregnancy when organs and other body structures are being formed. Common causes that are known to cause birth defects include genetic problems, fever, infection, certain medications, and exposure to toxins.

Cryptorchidism, failure of the testicles to descend normally, is an inherited congenital defect in dogs. A study by Yates [2003] found that the overall prevalence of cryptorchidism at a Royal Society Prevention of Cruelty to Animals veterinary clinic was 6.8% and was significantly higher in pedigree dogs as compared to crossbreed dogs. An analysis of horse veterinary records from the Veterinary Medical Databases revealed that cryptorchidism was one of the ten most common diagnoses reported for horses with a rate of 20.7 per 1,000 patients [Priester 1970]. The USDA reported a lower rate: for foals born alive, 0.3 percent of the foals had reproductive tract problems such as cryptorchidism or hermaphrodism (having both male and female sex organs) [USDA 2006].

Fetal exposure to some chemicals, especially during the first trimester, has been associated with abnormal development. There are no confirmed reports in the literature of birth defects in mammals exposed to industrial toxins in the wild, but it is theorized that exposure to environmental toxins could be influencing an increased rate of birth defects in wildlife, birds and aquatic species [Vos 2000]. Laboratory animal studies have been used as a model for human birth defect risks for certain chemicals, although doses and delivery route are often not comparable to environmental exposures. While it is plausible that exposure to toxins in the environment contributed to the birth defects in Midlothian animals, more information on the specific exposures and the nature and quantity of defects from breeding or veterinary records is needed to test this link.

FETUS AND NEWBORN MORTALITY

Spontaneous abortion was reported in Midlothian area dogs, goats, horses, cattle and sheep. A perceived increased newborn mortality rate was reported in dogs, horses and cattle. We do not have numbers to evaluate the rate of abortion and loss in many of these species; however, we do have breeding records from a dog breeding facility.

A dog breeding facility adjacent to two of the Midlothian industrial facilities appears to have had a higher than normal rate of puppy loss since the late 1990s. The facility breeds both Miniature Pinschers and Doberman Pinschers. Spontaneous abortion and puppy mortality were not differentiated in the records; however, the owner reports that the majority of the losses were live puppies who died within two months of birth and that there were very few cases of spontaneous abortion and stillborn puppies. Not all losses were recorded in these records; some entire litters were lost and not recorded. The exclusion of this data will cause the calculated mortality rate to differ from the actual rate. There is a marked discrepancy between the mortality rates of the two breeds. These rates from records provided from the owner for 1993 through 2010 are defined in the following chart:

	Doberman Pinschers	Miniature Pinschers
Total puppies born	703	378
Average litter size	6.2	2.8
Puppies lost before two months of age	321	62
Mortality rate before two months of age	47.5%	17.7%
Puppies lost between two and four months of age	27	28
Mortality rate before four months of age	49.5%	23.8%

While residing on the same property, the two breeds in effect have different living environments. The Miniature Pinschers are confined to kennels with attached runs. These runs are covered with purchased sod each year so the dogs have very little contact with the soil. The Doberman Pinschers are allowed to roam the property; they have access to most of the yard and the property's pond. Due to the karst (landscape formed from soluble rocks) geology in the area, it is hard to predict patterns of ground water flow; however, the stream running on the backside of the property is downstream from the TXI and Gerdau steel facilities. When they are due to whelp, the Doberman Pinschers are moved to an environment similar to the Miniature Pinschers, which are kennels with attached sodded runs. The dogs remain there until the puppies are over two months of age. While veterinary records have not been examined, the breeder's veterinarian does not think that animal husbandry contributes to puppy losses. His opinion is that the dogs are well cared for, including appropriate nutrition and a good preventive care program.

Average puppy mortality rates could not be found specifically for Doberman Pinschers, however, the mortality rates found in the literature for other breeds (including large and small breeds) range from 12% to 33% [Potkay 1997; Nielen 1998]. The Doberman Pinscher average mortality rate seen at this facility between 1993 and 2010 is above that range. Puppy loss can occur from a wide range of problems including: difficult labor or birth, lactation or nursing problems, accidental suffocation by the mother or other puppies, trauma, inadequate nutrition, extreme temperatures, poor sanitation, overcrowding, stress, birth defects and (most commonly) by infection with a variety of viral, bacterial or parasitic agents [Mandigers 2006; Van der Beek 1999].

There were no journal articles found showing an association between industrial exposure and increased neonatal mortality relating to dogs. These differing death rates given similar care and different living environments could suggest an association between maternal environmental exposures and mortality. There are insufficient environmental data to confirm or refute this potential association.

No rates could be determined from the neonatal mortality reports for livestock in the Midlothian area. To provide some context for the reader, information from the USDA National Animal Health Monitoring System (NAHMS) on neonatal mortality of domestic livestock is provided in the chart below:

	Percent (%) Born alive	Percent (%) Born dead or aborted	Reference
Foals	93.5	6.5	USDA 2006
Calves*	89.2	9.4	USDA 2010b
Lambs	96.0	4.0	USDA 2012
Kids	94.6	5.4	USDA 2010c

* Other (1.4%)—includes cow died, sold, or lost before calving.

Similarly, there was not enough data to evaluate death of young livestock in the Midlothian area. Nationally, in their national surveys, USDA found that 3.6% of calves born alive in 2007 died or were lost prior to weaning [USDA 2010a]. Calf deaths were higher in smaller herds. About one third died in each time category: within 24 hours, between 24 hours and 3 weeks, and between 3 weeks or more before weaning. About half of the calves that died that were less than 3 weeks old died of either birth-related or weather-related causes. Digestive or respiratory problems were the leading causes of death in calves older than 3 weeks.

In the NAHMS 2005 Equine study, 2.6% of the foals born alive died within the first two days and 2.3% died within the subsequent 28 days [USDA 2006]. The leading causes of foal deaths during these first 30 days were injury/wounds/trauma unrelated to birth (18.6%), unknown causes (17.9%), and failure to get colostrum or milk from mare (14.9%). As stated previously, 8.9% of the foal deaths were from birth defects and 10.7% of foal deaths were related to difficult delivery, trauma, or complications at birth [USDA 2006].

INFERTILITY AND OTHER REPRODUCTION PROBLEMS

The following problems have been reported by Midlothian community members about area animals: infertility in dogs, goats and horses; cystic ovaries in horses; and twinning in horses and cattle.

Infertility has many causes, including genetics, injury, infection, systemic or endocrine disorders and exposure to drugs or chemicals. It is suspected that endocrine disrupting chemicals released by incineration and other industrial processes can lead to fertility problems in animals and humans [Hutz 2006]. Numerous studies have demonstrated the effect of various industrial toxicants on fertility (male and female) in laboratory animals. One study of a sick cattle herd in Chile found decreased fertility with increased exposure to heavy metals from a copper smelting factory [Parada 1987]. No other reports of industrial exposures and infertility among domestic animals could be found in the literature.

Twinning was reported in cattle and horses in the area. Twinning rates vary widely by species, breed and herd. The twinning rate for beef cattle is 0.5% and 2% for dairy cattle and the rate increases with age [cited in Lloyd 1988]. Multiple ovulations that produce twinning are more common in Thoroughbred and Draft mares and in barren or maiden mares [Miller 1988]. Twinning in both species has a strong genetic influence, but can also be affected by medications and chemical exposures. Two studies were found that linked increased rates of twinning in cattle to industrial activities [Buckley 2007; Lloyd 1988]; no such reports could be found for horses.

We have been unable to examine veterinary or breeding records to determine fertility or twinning rates in Midlothian animals. Without knowledge of these rates and a thorough examination of the animal's health, husbandry and breeding conditions, we are unable to attribute these reported cases to possible chemical exposures.

DERMATOLGIC ILLNESS

Community members reported the following dermatologic conditions in Midlothian area animals: severe generalized demodex mite infection (demodicosis) in dogs; severe bacterial skin infection (pyoderma) in dogs; dermatitis of the paws (pododermatitis) in dogs; conjunctivitis in dogs and horses; and hair loss (alopecia) in dogs, squirrels, goats, and sheep.

With the exception of demodex, which is discussed below, all of the dermatologic symptoms are non-specific and can be caused by a variety of conditions. Allergies commonly cause pododermatitis, conjunctivitis, pyoderma and alopecia. Many of these conditions can also develop due to external or internal parasites, endocrine disease, hereditary disorders or other factors which cause immunosuppression, including exposure to toxins in the environment. Exposure to chromium has been shown to cause hypersensitivity reactions in many species, including dogs. Most of these studies have been done in a laboratory setting, but one dog study reported sensitivity of hairless dogs to chromium in metal cages [Kimura 2007]. It is possible that chromium on the soil or water could cause a similar hypersensitivity reaction in dogs.

Dermatologic conditions are common in animals. Analysis by Priester [1970] of one year of veterinary records from the Veterinary Medical Databases found that the rate of skin-related diagnoses in horses was 140.5/1,000 patients. The USDA reported that 5.4% (54/1,000) of horse operations reported at least one horse affected with skin problems [USDA 2006]. Skin related diagnoses made up 11% (110/1,000 patients) of the total number of diagnoses for Swedish horses insured for veterinary care [Penell 2005]. Dermatitis due to infection (47.5/1,000 patients), allergic dermatitis (34.4/1,000 patients), and conjunctivitis (23.2/1,000 patients) were all among the ten most common diagnoses reported for dogs at 12 veterinary hospitals [Priester 1970].

Demodectic mange is a common skin disease in the southeastern United States [Sischo 1989]. It is caused by a mite, which resides in the hair follicles of all dogs. In some dogs, overgrowth of mites can cause localized or generalized demodicosis. Generalized demodicosis causes scaling and hair loss and can lead to a secondary bacterial infection and pododermatitis. The secondary infection can present with pustules, hair loss, and a severe pyoderma which needs to be treated with antibiotics. Dogs often recover from this condition with aggressive treatment, but in severe cases it can lead to infection of the connective tissue of the skin (cellulitis), lethargy, decreased appetite, swollen lymph nodes, sepsis and even death [Lemarie 1996]. Demodicosis is not a well understood disease. It is unclear why some dogs are able to fight the infection and others develop severe disease. It is theorized that a hereditary immunodeficiency, a T-cell defect, can lead to generalized demodicosis, however not all animals with this condition develop disease and it is thought that other immune suppressive factors contribute to its development [It 2010]. These factors can include concurrent disease, immunosuppressive medications, stress, poor husbandry, exposure to immunosuppressive chemicals, or other unknown factors.

There was no literature found that estimated the rate of disease in specific dog breeds or litters; however, the veterinarian of the Doberman Pinscher breeding facility in Midlothian believes that they have a high rate of demodicosis. In particular, there were two litters in early 2005 in which all of the puppies (same sire and different dams) developed severe generalized demodicosis at six or seven months of age. The puppies became severely ill within a few weeks. Several of the puppies died, the ones that survived had permanent follicular damage and never regrew their coats. Consultation with two board certified veterinary dermatologists and the regular veterinarian revealed that this rate of severe generalized demodicosis is very uncommon and that there is likely another factor causing immunosuppression in the dogs. The regular veterinarian indicated that the dogs are very well cared for and that animal husbandry did not contribute to the problem. It is plausible that an environmental exposure to toxins which suppress the immune system (see immune disorders discussion below) could cause enough immunosuppression to allow this severe form of the disease to develop in puppies with a predisposition to demodicosis. However, we are unable to establish a link between the exposure and disease. In part, this is because of inadequate environmental and biological sampling and information regarding underlying conditions in these dogs.

IMMUNE SYSTEM DISORDERS

Community members have reported the following immune disorders in animals in the Midlothian area: demodicosis in dogs; allergies in dogs and horses; swollen lymph nodes in dogs, horses and goats.

Immune disorders in animals have many causes. It is often possible to determine that an animal has an immune disorder with biological testing, but the cause and mechanism cannot always be determined. There are many known hereditary immunodeficiencies in various species and breeds [DeBay 2010]. Allergies usually have a hereditary component but primarily develop due to sensitization to allergens in the animal's diet or environment. Allergies have increased in humans and animals in recent years and it is hypothesized that air pollution may contribute to this increase. Swollen lymph nodes can develop in response to infectious agents, allergens, or cancer. Demodicosis is discussed above under dermatologic illness.

Studies in laboratory animals have shown that many industrial chemicals and byproducts, such as dioxins and heavy metals, can alter the immune system. These studies are the basis for several ATSDR minimal risk levels (MRLs) for chemicals. There is little data concerning industrial and environmental exposures and immune modulation in animals. However, a study of beef cattle residing near oil and gas production and processing facilities demonstrated decreased T-cell production with increased exposure to toluene; this finding was not observed with sulfur dioxide or hydrogen sulfide [Betchel 2009]. Clinical symptoms were not seen in the animals in this study.

There is currently a wide range of understanding of the effects of individual chemicals on the immune system, and rudimentary knowledge of the combined effect of multiple exposures. The immune disorders have not been quantified in the Midlothian area animals, and there are no biological testing data and limited environmental testing. Therefore, we are unable to draw any conclusions about the possible role of exposure to environmental contaminants in the immunosuppression reported for the area animals.

NEUROLOGIC ILLNESS

A farmer reported death of his cattle that grazed on a 1,000 acre-property leased from TXI. Approximately 400 head of cattle began grazing on the land in 1998. Cattle started dying over a period of time and two cows reportedly had neurologic symptoms and "yellow livers". Dr. Murl Bailey Jr., DVM, PhD reviewed the laboratory analysis of hay, vegetation, water and soil taken from the area. He reported that all but two chemicals were "considerably lower than the safe levels as described in various reports." He identified the maximum level of sulfate in hay and selenium in the sediment as being slightly elevated but well below the levels known to cause symptoms in cattle. His analysis concluded that the most likely cause of the deaths, liver disease and neurologic symptoms (hepatic encephalopathy, secondary to liver failure) was a highly toxic plant, *Senecio ampullaceus*, otherwise known as Texas ragwort, Texas groundsel, or Texas squaw-weed [Bailey 2004]. This plant was identified in the hay samples by TVMDL.

Ingestion of several different species of this plant is known to cause liver failure and cattle will eat it when it is mixed with hay [Lloyd 1991]. Most livestock losses are from chronic exposures with cattle and horses consuming as little as 0.25 percent of their body weight (http://essmextension.tamu.edu/plants/). Using epidemiological methods, Lloyd [1991] determined that cattle deaths initially attributed to ragwort at two dairy operations in Scotland were more likely due to exposure to industrial waste. At one operation, runoff from a waste dump containing PCB (polychlorinated biphenyls), dioxin, chromium and selenium was the likely explanation. At the second facility, PCB deposition in the soil was the proposed explanation for toxicity.

In this case, Dr. Bailey's interpretation of the environmental media data and his conclusions about the cause of the illness appear sound. However, given the lack of veterinary records or necropsy reports and limited information about the herd we are unable to confirm or refute his conclusions.

RESPIRATORY PROBLEMS

Midlothian community members have reported the following respiratory conditions in area animals: respiratory distress of unknown origin in dogs, horses, donkeys, goats and cattle; heaves in horses; chronic cough in dogs and horses.

Heaves, a respiratory condition in horses, is otherwise known as chronic obstructive pulmonary disease. It is often identified by a distinct muscular line across the abdomen caused by chronic labored breathing and is an inflammatory lung disease often caused by allergens in the animal's living environment. Allergies are a leading cause of asthma in animals and can be caused by many different environmental allergens, such as dust, mold, pollen and other particulate matter.

Acute respiratory symptoms can be caused by many factors, including reversible airway obstruction, infectious disease, exacerbation of underlying cardio-pulmonary disease and exposure to respiratory irritants. The incidence of acute respiratory disease in area animals has not been quantified and, so we do not know the rate or whether the rate is increased in the Midlothian area.

Air pollution, particularly high levels of particulate matter, sulfur dioxide and sulfuric acid can cause an increase in airway inflammation and can exacerbate the symptoms of chronic and allergic airway disease in both animals and humans [D'Amato 2010; ATSDR 1998a,b]. A review of canine studies with long-term exposure to air pollutants identified sulfur dioxide as a causative agent in bronchitic lesions and ozone as an agent in fibrotic lung lesions [Heyder 1996]. No studies were found in the literature related to industrial pollution and respiratory effects on horses. A Canadian study of calves exposed to emissions from the oil and gas industry indicated an increased risk of respiratory problems with increasing exposure to benzene and toluene; data on sulfur dioxide was suggestive of an association with respiratory lesions [Waldner 2009].

USDA NAHMS [2006] reported that 1.9% of horses experienced respiratory problems in 2005, although most likely many cases were infectious in origin such as strangles or pneumonia. One year of veterinary records from the Veterinary Medical Databases found that the rate of respiratory diagnoses in cows, horses, and dogs was 123.9, 46.0, and 72.0 per 1,000 patients, respectively [Priester 1970]. The cause of the respiratory diagnosis was not listed. In the Swedish dog population, dogs display a pattern of respiratory illness that is similar to that seen in humans; more risk is seen at younger and older ages [Bonnett 2010]. During the four year period evaluated, 5% of all diagnoses in Swedish horses insured for veterinary care were related to the respiratory system [Penell 2005].

The Dallas-Fort Worth area has a high level of airborne allergens and air pollution, some of which comes from the industries in the Midlothian area. It is plausible that animals directly downwind from the facilities emitting particulate matter or sulfur dioxide could experience an increased incidence of respiratory conditions due to the exposure, but we are unable to evaluate this link based on the information available.

THYROID PROBLEMS

Cases of hypothyroidism, a condition in which the thyroid gland does not produce enough thyroid hormone, have been reported in horses in the Midlothian area. While hypothyroidism is the most common type of thyroid gland problem reported in horses, the condition is sometimes incorrectly diagnosed [Frank 2002]. Priester [1970] reported a rate of 2.7 cases/1000 patients for endocrine-related diagnoses in horses seen at 12 veterinary teaching hospitals. The rate of hypothyroidism among horses in the Midlothian area has not been quantified, and no conclusions can be made about a potential relationship between hypothyroidism and exposure.

CANCER and TUMOR FORMATION

Various types of cancer have been reported in all species. In particular, the community reported cancers of the bone, sinuses, mammary glands, thyroid, skin (mast cell tumors) and white blood cells (lymphoma) in animals.

A query of laboratory confirmed animal cancer cases proved inconclusive. We ran a query of the incidence of animal cancer cases in the Midlothian area from 2000 to 2010, including all species and neoplastic diagnoses. There are three primary veterinary diagnostic laboratories to which Midlothian veterinarians can submit biopsies for histopathology. The two private laboratories, Antech Diagnostics and Idexx Laboratories, would not agree to give us the data, but the Texas Veterinary Medical Diagnostic Laboratory (TVMDL) ran the query on the Midlothian ZIP code and a comparable ZIP code outside of the possible exposure area. The data only returned three cases from Midlothian for the ten year period. This is clearly not an accurate representation of the incidence of cancer in the area. Veterinarians tend to favor using one laboratory for biopsies. There are few veterinarians in Midlothian; therefore, the discrepancy is most likely related in part to the local veterinarians using predominantly the private laboratories from which we could not get data. Another reason for the discrepancy is that laboratories do not always have data on the animal owner's address; therefore, the query was run on the veterinarian's ZIP code, not the animal's physical address. Many citizens of Midlothian use veterinarians in neighboring towns, such as Cedar Hill and Waxahachie. These cases would not have been reported in our query.

Human cancer rates can often be quantified by cancer registries. Every state and some cancer organizations have a cancer registry, most of which have mandatory reporting of cancer cases. No mandatory reporting for animal cancers exists, however, the Veterinary Medical Databases (VMDB), an initiative of the National Cancer Institute, was established in 1964 for the purpose of studying cancer in animals. Currently, 9 veterinary teaching hospitals voluntarily contribute records to the database. Research articles that used VMDB records were reviewed to find rates of cancer in animals seen at participating veterinary hospitals. As stated previously, the Texas A & M University Veterinary Medical Teaching Hospital contributed records between 1976 and 2001.

VMDB records from 1964 to 1969 showed that 5.5% of the total dog patients had tumors, with the leading four tumors were skin, mammary glands, digestive system and hemic/ lymphatic system [Priester 1971]. Doberman Pinschers had a slightly elevated relative risk of getting tumors (RR: 1.4) compared to all dogs [Priester 1971]. Data from VMDB found that thyroid cancers made up 1.1% of all cancers diagnosed in dogs [Wucherer 2010] and the incidence of cardiac tumors was 0.1% in all dogs seen at VMDB participating hospitals between 1982-1995 [Ware 1999]. These studies found that older dogs were more likely than younger dogs to have cardiac tumors or thyroid cancer. Data on insured Swedish dogs found that the risk of tumors increased with age [Bonnett 2010].

Data from the VMDB on cutaneous tumors in dog patients seen between 1964 and 2002 found that lipoma, adenoma, and mast cell tumors were the top three skin tumor types [Villamil 2011]. Dogs older than 7 years of age had significantly higher odds of having cutaneous tumors than dogs younger than 7 years of age. Doberman Pinschers had higher odds of having melanoma and lower odds of having mast cell tumors as compared with all other dogs.

The VMDB records from 1964 to 1969 for bovine and equine patients found 4.0% and 2.5% of the patients had tumors, respectively [Priester 1971]. The leading two tumor sites for bovines were the eyes and the hemic and lymphatic systems, and these tumors were predominantly malignant. Tumors of the skin and genital system were the next most frequent tumors, but only about 10% of these tumors were malignant. For horses, tumors of the skin, eye and genital system were the most frequently diagnosed tumors. USDA NAHMS Equine 2005 survey [2006] found that 1.1% of the horse operations reported a horse with cancer; 0.1% of all horses were affected.

While it is known that some industrial emissions contain toxins which can cause cancer at high doses and frequent exposure, it is very difficult to prove an association between an exposure and cancer, particularly without more data about the cancer rates in the area.

SUDDEN DEATH

Community members have reported sudden death in dogs, cats, cattle and goats. There are many causes for sudden death, including trauma, infection and various causes of organ failure. However, without a necropsy there is no way to determine the exact cause of death, and many necropsies are inconclusive.

There were some reports of livestock dying after drinking from a stream near the cement factories; however, no environmental data for this stream were identified. It is possible that extremely alkaline water, high sulfate levels, caustic chemicals, heavy metals, other chemical contaminants or even bacteria (such as Leptospirosis) at very high levels could have caused the death. Poor water quality due to high sulfate levels and salinity has been blamed for an outbreak of sudden deaths and diarrhea in a herd of horses [Burgess 2010]. Some deaths in a herd of dairy cattle in Scotland were likely due to exposure to runoff from a neighboring waste dump [Lloyd 1991]. Since we do not have details about the livestock deaths in Midlothian, veterinary records, necropsy data, or water testing data from the stream, we are unable to confirm an association between the exposure and the deaths.

USDA NHAMES studies provide some information on livestock mortality rates at facilities surveyed, but not on sudden death. In 2005, 1.8% of the horses from operations surveyed had horses die, lost, or euthanized [USDA 2006]. Old age, the leading cause of death, was the cause of death in 28.9% of the cases. The next four leading causes of horse death or loss were injury/wounds/trauma (16.3%); colic (14.6%); lameness, leg, or hoof problems (7.7%); and unknown causes (6.6%).

For cattle, 1.5% of the cattle were reported to have died or been lost or euthanized in 2007 [USDA 2010a]. The top 4 reported causes of death in cattle were unknown causes (23.4%), other known causes (such as old age) (22.2%), calving-related (17.3%), and weather-related (16.2%). Non-predator sheep deaths or losses reported in operations surveyed in 2009 were 4.4% [USDA 2010d]. The top 5 non-predator causes of death in sheep were old age (24.7%), weather-related (15.7%), unknown causes (13.9%), digestive problems (13.2%), and lambing problems (12.5%).

Fish kills were reported in a pond near the industrial facilities in Midlothian. Fish kills can occur due to many human-related or natural factors including toxic spills (industrial or agricultural), climatic factors, infectious disease, and pond mismanagement. While low dissolved oxygen in ponds is the most common cause of fish kills, they can occur due to many other natural and human-related factors [TPWD 2003].

According to the Texas Parks and Wildlife Department, almost any industrial chemical or pesticide can cause a fish kill at high enough levels. The pond in question is downstream from the TXI and Gerdau steel facilities and it is possible that runoff from the quarry used as a waste site could have contaminated the pond. Review of sampling data obtained on two occasions found that concentrations of metals were not high enough to cause a fish kill [ATSDR 2015c]. Without an investigation of the fish kills including details of the management and condition of the pond and climatic conditions, there is no way to determine if these fish kills were brought about by contamination from the nearby industrial facilities or by other causes.

5.0 Biological Testing

As discussed in Section 3.3, ATSDR conducts exposure investigations at some sites to obtain biological or environmental sampling data that is not available.

In 2011, after the demise of a litter of puppies within three days of birth on a property adjacent to the TXI cement facility and the Gerdau Ameristeel facility, ATSDR took the opportunity to perform biological testing on three dogs related to that litter and property. A complete necropsy (similar to an autopsy in people) was performed on one deceased puppy from the litter by the Texas Veterinary Medical Diagnostic Laboratory (TVMDL). There were no abnormal findings and the cause of death could not be determined. The puppy was tested by TVMDL for the following chemicals in the liver: dioxins (17 types including furans), arsenic, chromium, lead, cadmium, mercury, iron, zinc, selenium, and molybdenum. All values fell within the normal reference ranges; however, there are no normal reference ranges for chromium levels in canine liver, and no studies that reported canine chromium liver values were found. We therefore had to use other species as a reference. Reference ranges were obtained from the Wisconsin Veterinary Diagnostic Laboratory: the puppy's liver chromium level of 0.06 parts per million (ppm) fell below or in the low end of the comparison reference ranges, and therefore it is unlikely that this chromium liver level was significant. Reference ranges for liver chromium: bovine 0.04-3.8 parts per million (ppm), rabbit 0.3-1.0 ppm, and bear 0.01-0.53 ppm.

Blood samples were taken from the four year old dam that lost the puppies and a seven year old dog with a chronic skin condition (demodex) that had been living on the property its entire life. The serum samples were tested by TVMDL for arsenic, chromium, lead, mercury, iron, zinc, selenium, magnesium, and molybdenum. These chemicals were targeted because they were deemed to be possible chemicals of concerns from the industrial nearby facilities and because it was feasible to perform this testing in the animals. All values were within normal reference ranges with the exception of iron and chromium discussed below.

The four year old dam's iron level was elevated at 438.6 micrograms per deciliter (µg/dL) (TVMDL reference range: 30-180 µg/dL). The post partum status of the dog can cause elevated iron levels. The serum sample was hemolyzed, which can falsely elevate the iron level. Therefore this result does not appear to be significant.

The whole blood chromium levels reported were 68.9 parts per billion (ppb) in the four year old dam and 73.4 ppb in the seven year old dog. Chromium is an essential mineral for animals and must be in the diet for optimum health [NRC 2005]. High concentrations of chromium can cause irritation, hypersensitivity reactions, anemia, and decreased fertility in animals [ATSDR 2012b]. One dog study reported a sensitivity of hairless dogs to chromium in metal cages [Kimura 2007]. The NRC maximum tolerable level in feed for horses, cattle and sheep is 3,000 milligrams per kilogram (mg/kg) for chromium oxide and 100 mg/kg for soluble trivalent chromium [NRC 2005]. Soil samples taken at the property where the dogs resided ranged from 6.2 to 48 ppm (ppm is equivalent to mg/kg for soil), which falls within the range of Texas background soil chromium concentrations [TCEQ 2006].

There are numerous issues and considerations in collecting and analyzing chromium in human biological samples and the quantification of chromium is difficult and not well standardized [ATSDR 2012b]. The TVMDL blood samples were analyzed by graphite furnace atomic absorption spectrometry **(**GFAAS**)**. There are no normal reference ranges available for canine whole blood chromium levels, but a reference was found which tested the serum level of 152 dogs with no known chromium exposure. The highest chromium levels were in the healthy dog population, with a mean of 4.7 +/- 2.8 ppb, and dogs with cancer had a slightly lower level [Kazmierski 2001]. Serum levels tend to be lower than whole blood levels because chromium accumulates in the red blood cells; however, the ratio of chromium levels in serum to blood for canines could not be found in the literature. All of the blood available was used during the original analysis, making retesting impossible.

Because of the uncertainty in the interpretation of the chromium blood testing from the two dogs, ATSDR conducted a more formal exposure investigation in April 2011. The protocol was submitted to CDC Animal Care and Use Program Office for review and approval. The investigation was performed on the two adult dogs initially tested as well as six other randomly chosen Dobermans and two randomly chosen Miniature Pinschers from the same breeding facility. Ten comparison adult dogs of various breeds were selected from surrounding towns outside the possible exposure area. Consent for the blood draw was obtained from the dogs' owners.

Whole blood and serum samples were taken from the dogs and submitted to two laboratories for chromium analysis: the TVMDL and the Michigan State University (MSU) Diagnostic Center for Population and Animal Health. The two laboratories reported very different whole blood chromium concentration ranges, most likely due to following different protocols and the challenges inherent in analyzing for chromium. For instance, TVMDL uses GFAAS for analyses while the MSU laboratory uses inductively coupled plasma mass spectrometry (ICP-MS). The conclusions drawn from the results from the two laboratories were similar: there was no statistically significant difference between the exposed and unexposed dogs whole blood chromium levels (Mann-Whitney U test on TVDML data: p=0.53). Table 5.1 presents the results from the TVDML analyses.

Table 5.1 Whole blood chromium levels* (ppb) in the blood of dogs from Midlothian and outside Midlothian, May 2011.

	Whole Blood Chromium Levels (ppb)	
	Range	**Mean**
Midlothian area	17.3-126.0	41.23
Outside Midlothian	18.8-91.8	44.99

*Results from samples analyzed by TVMDL using GFAAS.

Very little is known about chromium levels in dogs due to the limited testing that has been done previously. Typically, for animal blood chemistries, laboratories determine their own reference ranges based on their own methodologies and animal population. Further study would be necessary to determine normal ranges in dogs and the most appropriate technique for determining chromium levels in dogs.

In addition to the laboratory analysis for chromium, whole blood and serum samples in the twenty dogs were analyzed by the MSU laboratory by ICP-MS for 16 additional analytes. Results on the range of values and mean value for cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, and zinc for the samples from dogs in the Midlothian area and the dogs from outside of the potential exposure area are provided in Table 5.2. For the most part, results for both groups of dogs showed a similar range and mean. All these minerals except nickel and lead are considered essential to the diet and have well defined biochemical roles in animals [NRC 2005]. Nickel is often found to be beneficial when supplemented to the diet, but specific functions have not been identified.

Table 5.2 Whole blood and serum concentrations* of various analytes in dogs from Midlothian and outside Midlothian, May 2011.

Analyte	Specimen type	Midlothian Area		Outside Midlothian	
		Range	Mean†	Range	Mean
Cobalt (ppb)	Blood	0.16 - 0.76	0.32	0.26 - 0.77	0.42
	Serum	0.13- 0.84	0.33	0.22 - 0.59	0.38
Copper (ppm)	Blood	0.53 - 0.71	0.64	0.45 - 0.68	0.57
	Serum	0.30 - 0.62	0.47	0.37 - 0.55	0.44
Iron‡ (ppm)	Blood	315.5 - 429.7	386.00	410.3 - 584.0	474.67
	Serum	1.25 - 20.99	6.67	1.67 - 24.20	8.92
Lead (ppb)	Blood	1.6 - 73.6	11.30	2.9 - 51.0	20.53
	Serum¶	<1		<1	
Manganese (ppb)	Blood	13.89 - 33.30	23.32	27.21 - 76.54	44.73
	Serum	2.59 - 5.53	3.54	2.28 - 5.58	3.55
Molybdenum (ppb)	Blood	3.51 - 6.42	4.89	5.43 - 59.79	18.68
	Serum	3.39 - 6.67	5.04	3.69 - 22.8	11.60
Nickel (ppb)	Blood	1.69 - 3.05	2.29	1.43 - 16.61	4.98
	Serum	1.83 - 2.78	2.24	1.66 - 2.83	2.18
Selenium (ppb)	Blood	308.5 - 366.7	326.99	341.9 - 379.1	360.41
	Serum	205.3 - 328.6	252.76	232.2 - 312.5	277.38
Zinc (ppm)	Blood	4.20 - 5.36	4.78	3.97 - 5.41	4.86
	Serum	1.89 - 3.72	2.70	2.35 - 3.93	3.04

*Samples analyzed by MSU laboratories using ICP-MS.
†For dogs in Midlothian, 2 of the 10 blood samples could not be analyzed, so the mean is based on 8 samples.
‡ Iron blood samples are for total iron in a hemolyzed sample. ICP-MS methodology, which was used in this special study, is not the standard method for blood and serum iron determination.
¶ All serum lead concentrations were below the detection limit of 1.0 ppb.

In all samples, results in both whole blood and serum for antimony, arsenic, beryllium, cadmium, mercury, thallium, and vanadium were all below the MSU laboratory detection limits of 1.00 ppb for these chemicals. Serum lead was below the MSU laboratory detection limit of 1.0 ppb in all samples. While arsenic and vanadium are not essential minerals, some studies indicate beneficial effects of these minerals when supplemented to the diet [NRC 2005]. Antimony, cadmium, lead, and mercury have no known benefit in animals; however, there are maximum tolerable levels of these minerals that can be present in the diet before animal health is impaired [NRC 2005].

Animal hair metal analyses were provided to ATSDR by residents for analyses performed in 1993 (3 samples), 2006 (1 sample), and 2007 (5 samples) on six dogs, a chicken, a horse, and a cow. ATSDR chose not to evaluate these results. No sample collection or laboratory procedures were provided, and two laboratory reports stated that readings were inaccurate due to extremely dirty samples. ATSDR finds only a limited usefulness of human hair analyses for evaluating potential environmental exposures. Many scientific issues need to be resolved before hair samples can be used confidently to assess exposure [ATSDR 2001]. In addition to the lack of standardized methods, interpretation of animal and human hair analyses have similar limitations, including the lack of reference ranges to frame results, difficulty in distinguishing internal and external contamination, lack of correlation between levels in hair and blood or other target tissues, and lack of epidemiologic data linking hair levels with adverse health effects.

6.0 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 held 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.

The following are responses to community concerns related to animal health that were evaluated in this document.

1. **Do the animal health issues parallel human health issues in the community?**

Response: There were insufficient animal epidemiological data available and limited animal survey data to determine any rates of occurrence for health outcomes in animals from the Midlothian area. Thus, while the concerns people raised about animal and human health might be similar, it is not possible to compare them quantitatively.

There were three major categories of human health concerns by residents of Midlothian that overlap somewhat with their concerns about area animals: birth defects, cancer, and respiratory complaints. The Midlothian Health Consultation on the Evaluation of Health Outcome Data [ATSDR 2015a] used the Texas Birth Defects Registry, Texas Cancer Registry and other validated databases to explore the rates of occurrence of these health outcomes in the Midlothian area. A summary of the human health outcome data on these health concerns follows and a discussion about the use of animals as sentinels is covered in response to the next question of this section.

With a few exceptions, human birth defect rates in the Midlothian area are comparable to the rates in Ellis County and Texas. TDSHS provided data from the Texas Birth Defects Registry for 185 birth defects and any monitored birth defect for 1999-2008. The vast majority of the 185 human birth defects examined had either zero cases reported or had prevalence rates that were not statistically significantly different from background rates. Reproductive tract birth defects in animals were a general category of concern. In people, hypospadias (a birth defect in which the urinary outlet is on the underside of the penis) was a specific reproductive anomaly of concern. Registry data found that after adjusting for maternal age and race, hypospadias rates in male children in the Midlothian area were not significantly different from rates in the state of Texas.

Based on Texas Cancer Registry data from 1999-2008, the occurrence of new human cancer cases and the death rates from cancer in the Midlothian ZIP code 76065 were similar to the corresponding rates for the state of Texas. Cancers evaluated included all cancer sites combined, total childhood cancers (age 0-19), total childhood leukemia, 5 leukemia sub-types, and 25 additional cancers grouped by site. The additional cancers evaluated in humans included the cancer sites of concern raised about animals in Midlothian (bone, sinus, breast, thyroid, melanoma, and lymphoma). No statistically significant differences were found for rates of these cancers in people in Midlothian as compared to rates for people in the state of Texas. Mast cell skin tumors, a common tumor in dogs and cats, are a rare cancer in people and was not evaluated.

Asthma and chronic obstructive pulmonary disease (COPD) were the primary respiratory diseases addressed in the Midlothian Health Consultation that evaluated human health outcome data. Based on data from the Behavior Risk Factor and Surveillance Survey (BRFSS) provided by TDSHS for the years 2001 to 2010, the occurrence of human adult and childhood asthma and other chronic respiratory diseases is comparable in Midlothian ZIP code 76065, Ellis County, and Texas. Human mortality data from TDSHS Center for Health Statistics for 1999-2010 showed that the death rates due to COPD and asthma and to other respiratory diseases were not significantly different in the Midlothian ZIP code than in Ellis County and Texas. It is difficult to ascribe these chronic respiratory conditions to animals. As discussed in Section 2.0, periodic acute respiratory symptoms in both humans and animals can result from exposure to high concentrations of irritants such as sulfur oxides, ozone, and particulates.

2. Can animals act as sentinels to human health?

Response: Animals have long been recognized as sentinels or as a sensitive indicator or early warning system, for human exposure and disease. Under appropriate conditions, the use of domestic and wild animals can help identify environmental chemical exposures before the exposures may become harmful to humans [NRC 1991]. One iconic example is the canary in the coal mine to detect dangerous carbon monoxide levels. Unfortunately, research in this area is limited.

Animals can make good sentinels for human exposures for the following reasons:

- animals often share the same environment as people, drinking the same water, breathing the same air and are exposed to the same soil;
- animals respond to most toxic chemicals in ways similar to humans; and
- animals often respond more quickly due to in part to their shorter life spans and lower body weight [NRC 1991].

Other advantages of animals as sentinels include restricted mobility and lower frequency of migration over the animal's shorter lifespan [Reif 2011]. Animal studies are not as strongly influenced by life-style exposure hazards such as smoking or occupational exposures. Animals often have higher exposure rates than human adults because they spend more time outside, are closer to the ground, and have higher rates of soil contact and incidental ingestion. This relative overexposure may be valuable when serving as an early warning signal.

Animal sentinels have been successful in detecting environmental hazards in several circumstances, for example:

- A CDC investigation found that birds and horses could function as sentinels of dioxin exposure in a horse arena sprayed with waste oil, even before severe human health effects occurred [Carter 1975; EPA 1975].
- Pet dogs have been shown to serve as good predictors of blood lead levels in children [Ostrowski 1990].
- Geographical mapping has shown a similar distribution of canine and human bladder

cancer in industrial areas [Hayes 1981].

Conversely, animals and humans have anatomical, physiological and behavior differences that make some health effects from animal species not directly comparable to humans. No animal species used for risk assessment can respond in exactly the same way as humans [NRC 1991]. Animal laboratory studies usually include a ten-fold or more safety factor when extrapolating data for human health based values. Most pet owners are familiar with the advice to not feed chocolate, onions, or garlic to their dog or cat. The active chemicals in chocolate are slowly metabolized in dogs making them susceptible to prolonged abnormal heart rhythms. The sulfur compounds in raw and cooked onions and garlic can result in hemolytic anemia (ruptured red blood cells) in dogs and cats, which might not be apparent until days afterward when the pet appears tired and weak [Kovalkovičová 2009].

For some chemicals, humans have a lower tolerance for a chemical than animals. While methanol poisoning causes drunkenness in dogs and cats that is similar to ethanol (alcohol) poisoning, blindness is typically only seen in humans and other primates. The NRC maximum tolerable level (MTL) for dietary iron for animals could result in excessive, harmful intake for humans if protein-rich foods such as livestock liver or kidneys are eaten regularly [NRC 2005].

Additionally, there is variation of tolerance among animals. Ruminants (cattle, sheep, goats, deer) are sometimes more tolerant of high levels of dietary minerals than animals with one-compartment stomachs. This has been attributed to ruminant microflora and the relatively low food intake of ruminants [NRC 2005]. Sometimes the reverse is true, for example, the NRC MTL for copper is 250 mg/kg feed for horses and 40 mg/kg feed for cattle [NRC 2005].

In their evaluation of the use of animals as sentinels of environmental health hazards, the National Research Council found that factors that contributed to the under use of animal sentinel systems included the lack of coordinated and standardized data collection systems and that the predictive value of animal data for human health has not been evaluated sufficiently [NRC 1991]. As mentioned throughout this document, there are only limited databases to examine the rates of health concerns in animals and the underlying rates for animal illnesses in Midlothian were not known. Thus, we were unable to relate information on animal health concerns in Midlothian to possible human health concerns.

7.0 Conclusions

ATSDR reached three main conclusions in this health consultation related to community concerns about animal health issues, the exposure pathway analysis, and the exposure investigation.

There was insufficient data to draw any conclusions about the cause of the reported animal issues in Midlothian. Residents have reported numerous health related issues in animals living around the Midlothian area. Comprehensive breeding records and veterinary records would be necessary to determine the exact extent and nature of the problems. We have been unable to obtain this kind of information in most cases. These data gaps prevent us from making an association between the possible exposure to environmental contaminants and the reported health problems. Additionally, lack of information on exposure doses and biological mechanisms of disease by many of these chemicals prevents conclusions about the animal health problems. Thus, this animal health consultation does not and cannot provide a cause and effect evaluation related to the chemicals of concern identified at the site. Animal owners are encouraged to keep thorough veterinary, animal husbandry and breeding records and to perform appropriate biologic testing and necropsies as problems arise to rule out other possible causes of observed health effects.

There are several completed potential exposure pathways that may have in the past and could present a possible current and future threat to area animals. However, there was insufficient environmental data and dose-response information in animals to confirm or reject many of the animal health concerns related to these exposures. The irritant nature of sulfur dioxide, sulfurous acid, and cement kiln dust could cause mucus membrane and skin irritation to exposed animals, and these air pollutants are potential health concerns for animals through inhalation of airborne contaminants or ingestion or direct contact of airborne contaminants deposited in the soil.

ATSDR's exposure investigation found that blood and serum concentrations for chromium and the other 16 metals analyzed were similar in the 10 dogs from the Midlothian as compared to 10 dogs residing beyond the Midlothian potential area of exposure. Statistical testing that looked specifically at chromium in blood found no significant difference between the two groups of dogs.

8.0 Recommendations

Based on the conclusions in this health consultation, ATSDR recommends that:

1) Animal owners keep thorough veterinary, animal husbandry and breeding records and request appropriate biologic testing and necropsies of their animals as problems arise to rule out other possible causes of observed health effects.
2) As explained in the Midlothian Health Consultation on criteria (NAAQS) air pollutants and hydrogen sulfide [ATSDR 2012c], ATSDR and TDSHS work with TCEQ to insure that levels of air pollutants remain below health levels of concern.
3) At this time, no additional animal blood and serum be collected and analyzed.

9.0 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:

- ATSDR and TDSHS will present the findings of this health consultation to the community.
- As the remaining Midlothian health consultations that address environmental data are completed, ATSDR will discuss any findings related to animal health issues that have not been addressed in this health consultation.

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References

[ATSDR] Agency for Toxic Substances and Disease Registry. 1998a. Toxicological Profile for Sulfur Dioxide. http://www.atsdr.cdc.gov/toxprofiles/tp116.pdf . Atlanta, Georgia: U.S. Department of Health and Human Services; December 1998.

[ATSDR] Agency for Toxic Substances and Disease Registry. 1998b. Toxicological Profile for Sulfur Trioxide and Sulfuric Acid. http://www.atsdr.cdc.gov/toxprofiles/tp117.pdf . Atlanta, Georgia: U.S. Department of Health and Human Services; December 1998.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2001. Summary Report. Hair Analysis Panel Discussion: Exploring the State of the Science, June 12-13, 2001. http://www.atsdr.cdc.gov/hac/hair_analysis/hairanalysis.pdf. Atlanta, Georgia: U.S. Department of Health and Human Services, Public Health Service; December 2001.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2005. Public Health Assessment Guidance Manual (Update). http://www.atsdr.cdc.gov/hac/PHAManual/PDFs/PHAGM_final1-27-05.pdf. Atlanta, Georgia: U.S. Department of Health and Human Services, Public Health Service; January 2005.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2012a. Public Health Response Plan: Midlothian, Texas. Atlanta, GA: US Department of Health and Human Services; May 2012. Available from: [http://www.atsdr.cdc.gov/sites/midlothian/docs/midlothian---updated-phrp-may-2012.pdf].

[ATSDR] Agency for Toxic Substances and Disease Registry. 2012b. Toxicological Profile for Chromium. http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=62&tid=17. Atlanta, GA: U.S. Department of Health and Human Services; September 2012.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2012c. Health Consultation. Assessing the Public Health Implications of the Criteria (NAAQS) Air Pollutants and Hydrogen Sulfide as part of the Midlothian Area Air Quality Petition Response, Midlothian, Ellis County, Texas. Public Comment version. Atlanta, GA: US Department of Health and Human Services; November 2012. Available from: [http://www.atsdr.cdc.gov/hac/pha/MidlothianAreaAirQuality/MidlothianAreaAirQuality(NAAQS)HCPC11162012.pdf].

[ATSDR] Agency for Toxic Substances and Disease Registry. 2015a. Health Consultation. Evaluation of Health Outcome Data as part of the Midlothian Area Air Quality Petition Response, Midlothian, Ellis County, Texas. Public Comment version. Atlanta, GA: U.S. Department of Health and Human Services; July 2015.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2015b. Health Consultation. Review and Analysis of Volatile Organic Compounds (VOC) and Metal Exposures in Air as part of the Midlothian Area Air Quality Petition Response, Midlothian, Ellis County, Texas. Public Comment version. Atlanta, GA: US Department of Health and Human Services; August 2015.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2015c. Health Consultation. Review and Analysis of Volatile Organic Compounds (VOC) and Metal Exposures from Air Emissions in Media Other than Air as part of the Midlothian Area Air Quality Petition Response, Midlothian, Ellis County, Texas. Public Comment version. Atlanta, GA: US Department of Health and Human Services; Anticipated Winter 2015.

Bailey Jr. M. 2004. Report for Chaparral Steel Midlothian L.P. and Texas Industries, Inc. ("TXI"), regarding ERM findings and microscopic analysis of hay samples, prepared by Murl Bailey, Jr., D.V.M., PhD. Diplomate, American Board of Veterinary Toxicology. Garland, Bailey & Associates, College Station, Texas, April 1, 2004.

Bechtel D, C Waldner, and M Wickstrom. 2009. Association between immune function in yearling beef cattle and airborne emissions of sulfur dioxide, hydrogen sulfide, and VOCs from oil and natural gas facilities. *Archives of Environmental and Occupational Health* 64(1):73-86.

Bonnett BN and A Egenvall. 2010. Age patterns of disease and death in insured Swedish dogs, cats and horses. *Journal of Comparative Pathology* 142:S33-S38.

Buckley J, J O'Donovan, D Berry, P O'Mahony, and K O'Farrell. 2007. Comparison of production and calving data for 10 Irish dairy herds in the vicinity of an industrial chemical complex and 10 herds in rural, non-industrialised areas. *Veterinary Record* 161: 841-845.

Burgess BA, KL Lohmann, and BR Blakley. 2010. Excessive sulfate and poor water quality as a cause of sudden deaths and an outbreak of diarrhea in horses. *Canadian Veterinary Journal* 51(3):277-82.

Carter, CD, RD Kimbrough, JA Liddle, RE Cline, MM Zack, Jr., WF Barthel, RE Koehler, and PE Phillips. 1975. Tetrachlorodibenzodioxin: An accidental poisoning episode in horse arenas. *Science* 188(4189):738-40.

[CEDM] Corporation for the Economic Development of Midlothian. 2012. 2012 Midlothian Texas Community Profile. http://www.midlothian.tx.us/DocumentCenter/Home/View/580

D'Amato G, L Cecchi, M D'Amato, and G Liccardi. 2010. Urban air pollution and climate change as environmental risk factors of respiratory allergy: An update. *Journal of Investigational Allergology and Clinical Immunology* 20(2): 95-102.

DeBay M. 2010. Primary immunodeficiencies of dogs and cats. *Veterinary Clinics of North America: Small Animal Practice* 40:425-438.

[EPA] U.S. Environmental Protection Agency. 1975. Dioxin poisoning caused by improper waste disposal in Missouri. Hazardous Waste Disposal Damage Reports EPA/530/SW-151.2. December 1975.

[EPA] U.S. Environmental Protection Agency. 1996. Animal Health Survey: Midlothian, Texas. U.S. EPA Region 6, Dallas, Texas. January 31, 1996.

[ERM] Environmental Resources Management. 2004. Summary of surface water, sediment, surface soil, vegetation, hay, and ground water analytical results, southern area investigation, Midlothian, Texas, prepared by GT Donnan, Senior Associate. Environmental Resources Management, Houston, Texas, March 9, 2004.

Frank N, J Sojka, and NT Messer IV. 2002. Equine thyroid dysfunction. *Veterinary Clinics of North America: Equine Practice* 18(2):305-19.

Hayes HM, R Hoover, and RE Tarone. 1981. Bladder cancer in pet dogs: a sentinel for environmental cancer? *American Journal of Epidemiol*ogy 114(2):229-233.

Heyder J and S Takenaka. 1996. Long-term canine exposure studies with ambient air pollutants. *European Respiratory Journal* 9:571-584.

Hoff B, J Herman, J Boermans, and JD Baird. 1998. Retrospective study of toxic metal analyses requested at a veterinary diagnostic toxicology laboratory in Ontario (1990-1995). *Canadian Veterinary Journal* 39:39-43.

Hutz R, M Carvan III, M Baldridge, L Conley, and T King Heiden. 2006. Environmental toxicants and effects on female reproductive function. *Trends in Reproductive Biology* 2:1–11.

It V, L Barrientos, J López Gappa, D Posik, S Díaz, C Golijow, and G Giovambattista. 2010. Association of canine juvenile generalized demodicosis with the dog leukocyte antigen system. *Tissue Antigens* 76:67–70.

Kazmierski K, G Ogilvie, M Fettman, S Lana, J Walton, R Hansen, K Richardson, D Hamar, C Bedwell, G Andrews and S Chavey. 2001. Serum zinc, chromium, and iron concentrations in dogs with lymphoma and osteosarcoma. *Journal of Veterinary Internal Medicine* 15:585–588.

Kimura T. 2007. Contact hypersensitivity to stainless steel cages (chromium metal) in hairless descendants of Mexican hairless dogs. *Environmental Toxicology* 22(2):176-84.

Kovalkovičová N, I Šutiaková, J Pistl and V Šutiak. 2009. Some food toxic for pets. *Interdisciplinary Toxicology* 2(3):169-176.

Lemarie L, G Hosgood, and CS Foil. 1996. A retrospective study of juvenile and adult-onset generalized demodicosis in dogs (1986-91). *Veterinary Dermatology* 7:3-10.

Lloyd OL, MM Lloyd, FL Williams, and A Lawson. 1988. Twinning in human populations and in cattle exposed to air pollution from incinerators. *British Journal of Industrial Medicine* 45(8):556-60.

Lloyd O, M Lloyd, FL Williams, A McKenzie, and A Hay. 1991. Toxicity from ragwort and fat cow syndrome, or from industrial chemicals: the value of epidemiological analysis for interpreting clinic-pathological findings. *Science of the Total Environment* 106:83-96.

Mandiger PJ, T Senders, and J Rothuizen. 2006. Morbidity and mortality in 928 Dobermanns born in the Netherlands between 1993 and 1999. *Veterinary Record* 158(7):226-9.

Mavangira V, TJ Evans, JA Villamil, AW Hahn, M Chigerwe, and JW Tyler. 2008. Relationships between demographic variables and lead toxicosis in cattle evaluated at North American veterinary teaching hospitals. *Journal of the American Veterinary Medical Association* 233(6):955-959.

[Midlothian] City of Midlothian. 2007. EnVision Midlothian 2025 Comprehensive Plan. February 2007. http://www.midlothian.tx.us/DocumentCenter/View/1179

Miller A and GL Woods. 1988. Diagnosis and correction of twin pregnancy in the mare. *Veterinary Clinics of North America: Equine Practice* 4(2):215-20.

Nielen AL, I van der Gaag, BW Knol, and YH Schukken. 1998. Investigation of mortality and pathological changes in a 14-month birth cohort of boxer puppies. *Veterinary Record* 142(22):602-6.

[NRC] National Research Council, Committee on Animals as Monitors of Environmental Health Hazards. 1991. *Animals as sentinels of environmental health hazards*. Washington, DC: National Academy Press.

[NRC] National Research Council, Committee on Minerals and Toxic Substances in Diets and Water for Animals. 2005. *Mineral tolerance of animals: Second revised edition.* Washington, DC: National Academy Press.

Ostrowski SR.1990. Sentinel animals (dogs) as predictors of childhood exposure to environmental lead contamination. In: Sandhu SS *et al*., editor. *In situ Evaluations of Biological Hazards of Environmental Pollutants.* Plenum Press, pages145-150.

Parada R, S Gonzales, and E Bergqvist. 1987. Industrial pollution with copper and other heavy metals in a beef cattle ranch. *Veterinary and Human Toxicology* 29(2):122-126.

Penell JC, A Egenvall, BN Bonnett, P Olson, and J Pringle. 2005. Specific causes of morbidity among Swedish horses insured for veterinary care between 1997 and 2000. *Veterinary Record* 157:470-77.

Poppenga R. 2000. Current environmental threats to animal health and productivity. *Veterinary Clinics of North America: Food Animal Practice* 16(3):545-558.

Potkay S and JD Bacher. 1977. Morbidity and mortality in a closed foxhound breeding colony. *Laboratory Animal Science* 27(1):78-84.

Priester, WA. 1970. A summary of diagnoses in the ox, horse, dog and cat from 12 veterinary school clinics in the U.S. and Canada. *Veterinary Record* 86:654-658.

Priester, WA and N Mantel. 1971. Occurrence of tumors in domestic animals. Data from 12 United States and Canadian Colleges of Veterinary Medicine. *Journal of the National Cancer Institute* 47:1333-1344.

Reif, JS. 2011. Animal sentinels for environmental and public health. *Public Health Reports* Supplement 1, 126:50-57.

Sischo, WM. 1989. Regional distribution of ten common skin diseases in dogs. *Journal of the American Veterinary Medical Association* 195:752-756.

[TCEQ] Texas Commission on Environmental Quality. 2006. Interoffice memorandum. Toxicology Section Contact Recreation Evaluation of the Sediment and Surface Water Data Collected from the Ellison Creek Reservoir, Loan Star, Morris County, Texas. November 29, 2006. Available at: http://www.netmwd.com/reports/Ellison%20Creek%20Reservoir%20Memo-Final.pdf.

[TDSHS] Texas Department of State Health Services. 2009. Letter health consultation. Review of 2005 Soil Analysis, Venus, Ellis County, Texas. January 23, 2009. Austin, Texas.

[TNRCC] Texas Natural Resource Conservation Commission. 1994. Interoffice memorandum. Office of Air Quality. Preliminary Review of Analyses of Wheat, Hay, Vegetation, Soil, and Water Samples Taken Near Chaparral Steel/International Mill Service, Midlothian, Texas, 2/3/94 through 5/20/94. June 9, 1994.

[TNRCC] Texas Natural Resource Conservation Commission. 1995. Critical evaluation of the Potential Impact of Emissions From Midlothian Industries: A Summary Report. Office of Air Quality. Austin, Texas. October 25, 1995.

[TPWD] Texas Parks and Wildlife Department. 2003. Thirty Years of Investigating Fish and Wildlife Kills and Pollution in Texas. Cindy Contreras, Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas. WRTS-2003-001. June 2003.

[USDA] United States Department of Agriculture. 2006. Equine 2005, Part I: Baseline Reference of Equine Health and Management, 2005. USDA:APHIS:VS, CEAH. Fort Collins, CO. #N451-1006.

[USDA] United States Department of Agriculture. 2010a. Beef 2007-08, Part IV: Reference of Beef Cow-calf Management Practices in the United States, 2007-08. USDA:APHIS:VS, CEAH. Fort Collins, CO. #523.0210.

[USDA] United States Department of Agriculture. 2010b. Beef 2007-08, Part V: Reference of Beef Cow-calf Management Practices in the United States, 2007-08. USDA:APHIS:VS, CEAH. Fort Collins, CO. #523.0410.

[USDA] United States Department of Agriculture. 2010c. Goat 2009, Part I: Reference of Goat Management Practices in the United States, 2009. USDA:APHIS:VS, CEAH. Fort Collins, CO. #574.1210.

[USDA] United States Department of Agriculture. 2010d. Sheep and Lamb Nonpredator Death Loss in the United States, 2009. USDA:APHIS:VS, CEAH. Fort Collins, CO. #591.0511.

[USDA] United States Department of Agriculture. 2012. Sheep 2011, Part I: Reference of Sheep Management Practices in the United States, 2011. USDA:APHIS:VS, CEAH. Fort Collins, CO. #601.0512.

Van der Beek S, AL Nielen, YH Schukken, and EW Brascamp. 1999. Evaluation of genetic, common-litter, and within-litter effects on preweaning mortality in a birth cohort of puppies. *American Journal of Veterinary Research.* 60(9):1106-10.

Villamil JA, CJ Henry, JN Bryan, M Ellersieck, L Schultz, JW Tyler, and AW Hahn. 2011. Identification of the most common cutaneous neoplasms in dogs and evaluation of breed and age distributions for selected neoplasms. *Journal of the American Veterinary Association* 239:960-965.

Vos JG, E Dybing, HA Greim, O Ladefoged, C Lambré, JV Tarzona, I Brandt, and AD Vethaak. 2000. Health effects of endocrine-disrupting chemicals on wildlife, with special reference to the European situation. *Critical Reviews in Toxicology* 30(1):71-133.

Waldner CL and EG Clark. 2009. Association between exposure to emissions from the oil and gas industry and pathology of the immune, nervous, and respiratory systems, and skeletal and cardiac muscle in beef calves. *Archives of Environmental and Occupational Health* 64(1):6-27.

Ware WA and DL Hopper. 1999. Cardiac tumors in dogs: 1982-1995. *Journal of Veterinary Internal Medicine* 13(2):95-103.

Wucherer KL and V Wilke. 2010. Thyroid cancer in dogs: an update based on 638 cases (1995-2005). *Journal of the American Animal Hospital Association* 46(4):249-54.

Yates, D, G Hayes, M Heffernan, and R Beynon. 2003. Incidence of cryptorchidism in dogs and cats. *Veterinary Record* 152:502-504.

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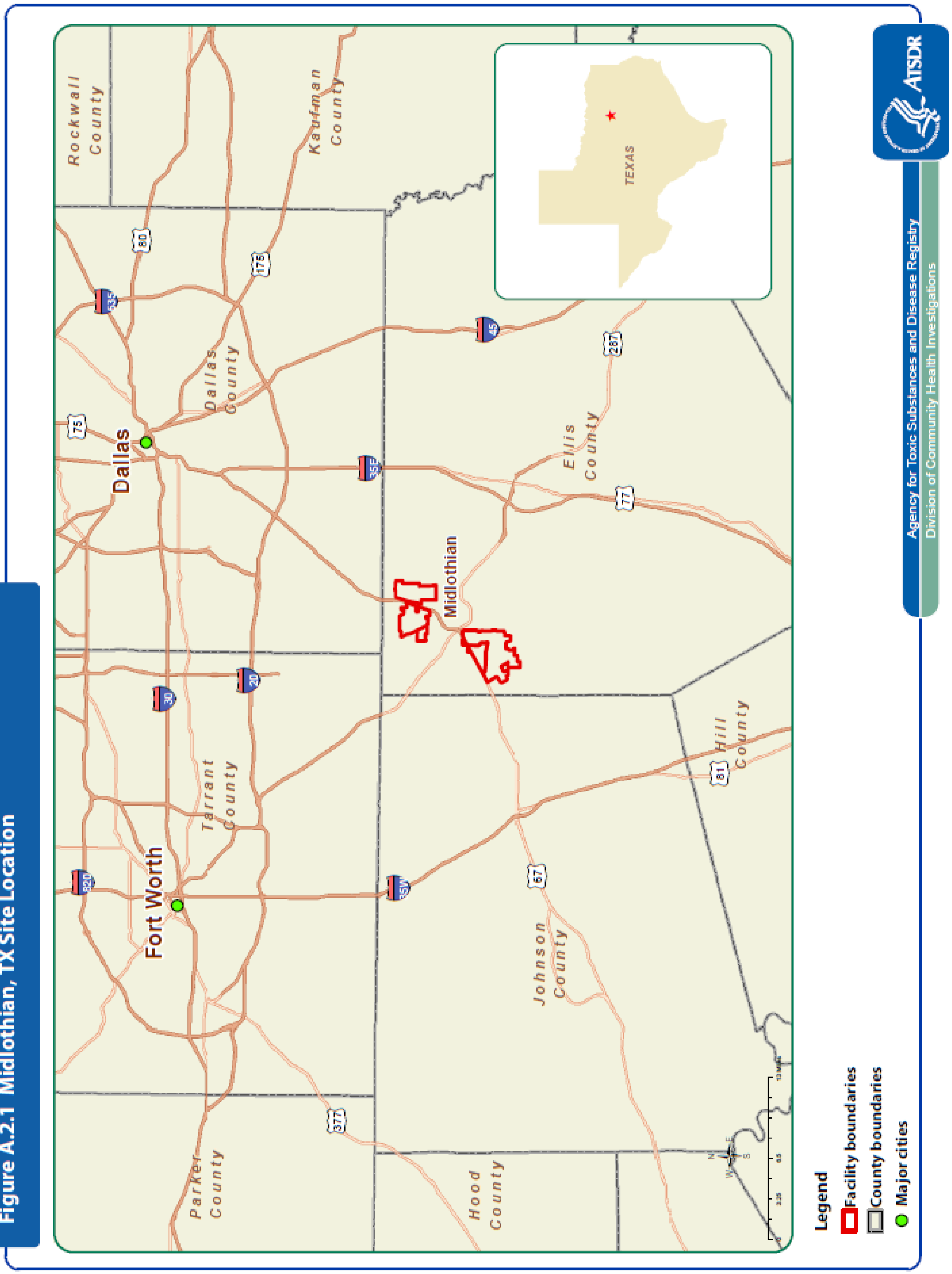


Figure A.2.1 Midlothian, TX Site Location

Figure A.2.2 Facilities of Interest in Midlothian, TX and Extraterritorial Jurisdiction

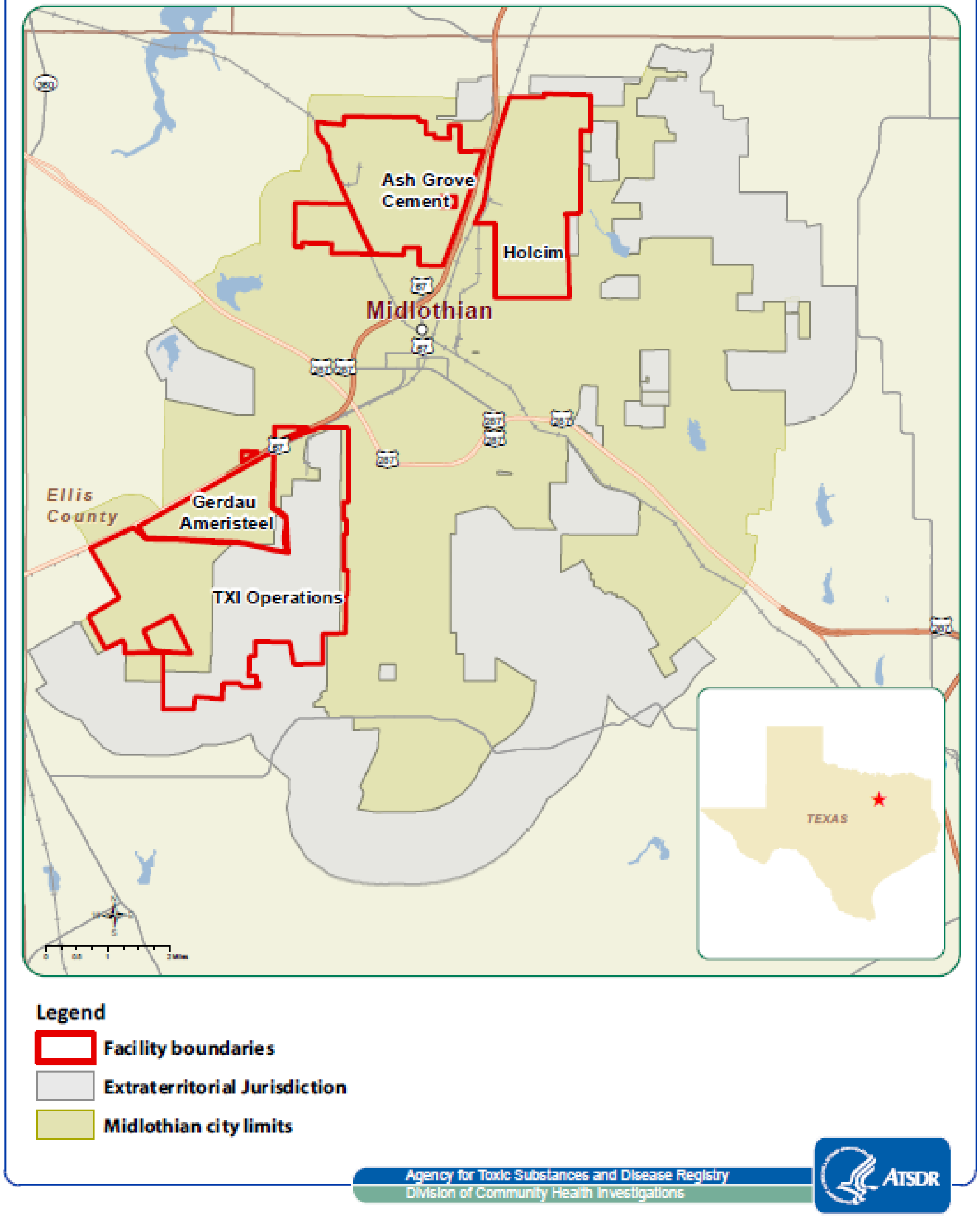
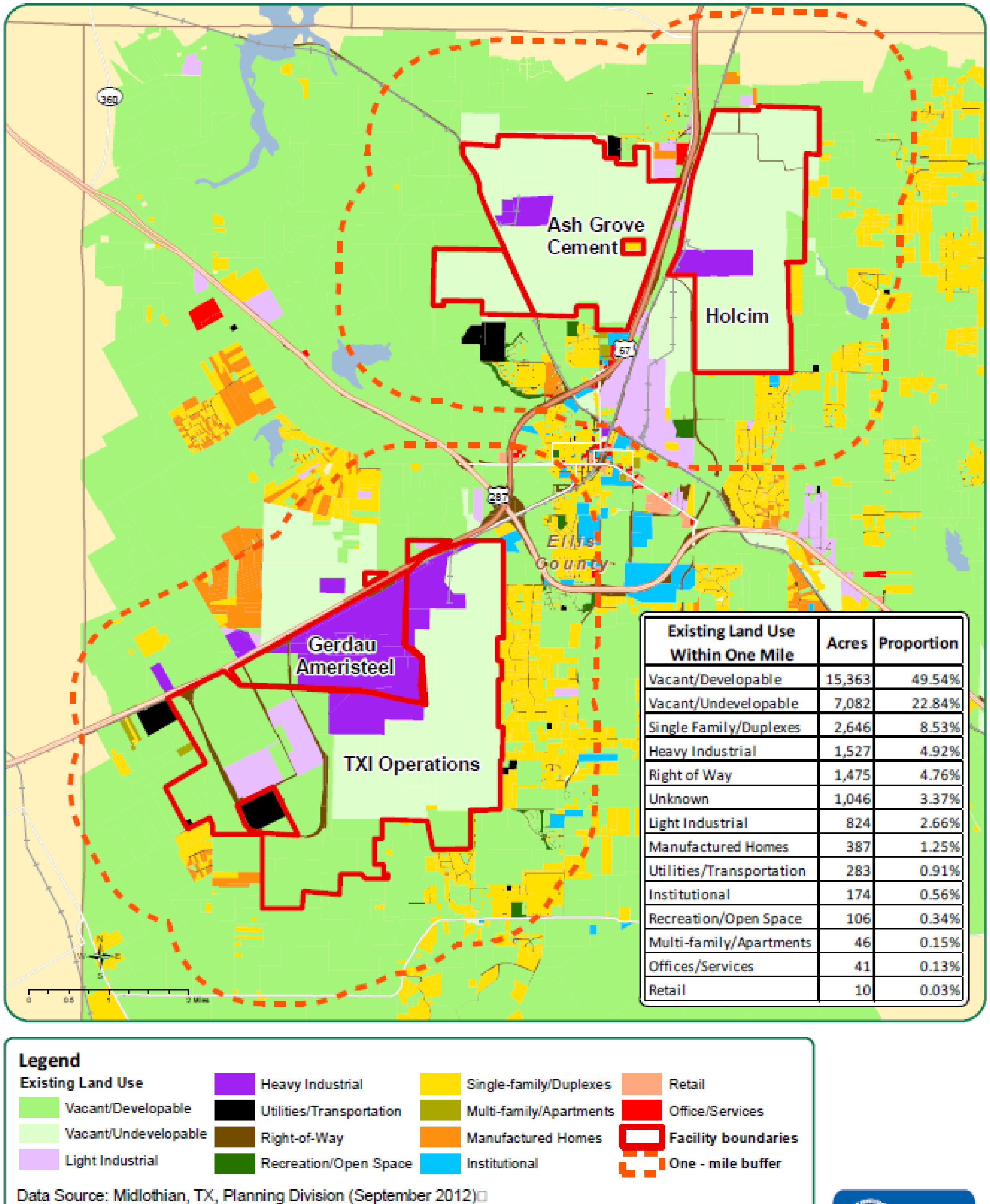


Figure A.2.3 Existing Land Use, Midlothian, TX



Existing Land Use Within One Mile	Acres	Proportion
Vacant/Developable	15,363	49.54%
Vacant/Undevelopable	7,082	22.84%
Single Family/Duplexes	2,646	8.53%
Heavy Industrial	1,527	4.92%
Right of Way	1,475	4.76%
Unknown	1,046	3.37%
Light Industrial	824	2.66%
Manufactured Homes	387	1.25%
Utilities/Transportation	283	0.91%
Institutional	174	0.56%
Recreation/Open Space	106	0.34%
Multi-family/Apartments	46	0.15%
Offices/Services	41	0.13%
Retail	10	0.03%

Data Source: Midlothian, TX, Planning Division (September 2012)

Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations