Health Consultation

INDOOR AIR INVESTIGATION

IGI ADHESIVES, INC. AND VICINITY

NASHVILLE, DAVIDSON COUNTY, TENNESSEE

SEPTEMBER 16, 2011

Disclaimer: This report was supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act through a cooperative agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. It was completed in accordance with approved methodologies and procedures existing at the time the Health Consultation was initiated. Editorial review was completed by the cooperative agreement partner.

Foreword

This document summarizes an environmental public health investigation performed by the State of Tennessee Department of Health's Environmental Epidemiology Program. Our work is conducted under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry. In order for the Health Department to answer an environmental public health question, several actions are performed:

Evaluate Exposure: Tennessee health assessors begin by reviewing available information about environmental conditions at a site. We interpret environmental data, review site reports, and talk with environmental officials. Usually, we do not collect our own environmental sampling data. We rely on information provided by the Tennessee Department of Environment and Conservation, U.S. Environmental Protection Agency, and other government agencies, businesses, or the general public. We work to understand how much contamination may be present, where it is located on a site, and how people might be exposed to it. We look for evidence that people may have been exposed to, are being exposed to, or in the future could be exposed to harmful substances.

Evaluate Health Effects: If people could be exposed to contamination, then health assessors take steps to determine if it could be harmful to human health. We base our health conclusions on exposure pathways, risk assessment, toxicology, cleanup actions, and the scientific literature.

Make Recommendations: Based on our conclusions, we will recommend that any potential health hazard posed by a site be reduced or eliminated. These actions will prevent possible harmful health effects. The role of Environmental Epidemiology in dealing with hazardous waste sites is to be an advisor. Often, our recommendations will be action items for other agencies. However, if there is an urgent public health hazard, the Tennessee Department of Health can issue a public health advisory warning people of the danger, and will work with other agencies to resolve the problem.

If you have questions or comments about this report, we encourage you to contact us.

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Glossary of Terms and Acronyms

additive effect: A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together.

adverse health effect: A change in body function or cell structure that might lead to disease or health problems

ambient: Surrounding (for example, *ambient* air).

ATSDR: Agency for Toxic Substances and Disease Registry.

background level: An average or expected amount of a substance in a specific environment, or typical amounts of substances that occur naturally in an environment.

cancer: Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

cancer risk: The theoretical excess risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower. The excess cancer risk is often expressed as $1x10^{-6}$ for one excess cancer in 1 million people.

chronic exposure: Contact with a substance that occurs over a long time (more than 1 year).

comparison value (CV): Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

concentration: The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

contaminant: A substance that is either present in an environment where it does not belong.

detection limit: The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

EPA: United States Environmental Protection Agency.

Epidemiology: The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

exposure: Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).

exposure pathway: The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: 1) a source of contamination (such as an abandoned business), 2) an environmental media and transport mechanism (such as movement through ground water), 3) a point of exposure (such as a private well), 4) a route of exposure (eating, drinking, breathing, or touching), and 5) a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

groundwater: Water beneath the Earth's surface in the spaces between soil particles and between rock surfaces.

health consultation: A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical.

inhalation: The act of breathing. A hazardous substance can enter the body this way.

intermediate duration exposure: Contact with a substance that occurs for more than 14 days and less than a year.

migration: Chemical movement from one location to another.

minimal risk level (MRL): An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.

plume: A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with ground water.

ppb: parts per billion.

remediation: 1. Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a site; 2. for the Asbestos Hazard Emergency Response program, abatement methods including evaluation, repair, enclosure, encapsulation, or removal of greater than 3 linear feet or square feet of asbestos-containing materials from a building.

remedial Investigation (RI): The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process of determining the type and extent of hazardous material contamination at a site.

risk: The probability that something will cause injury or harm.

route of exposure: The way people come into contact with a hazardous substance. Three routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact).

sample: A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population. An environmental sample, such as a small amount of soil or water, might be collected to measure contamination in the environment at a specific location.

soil-gas: Gaseous elements and compounds in the small spaces between particles of earth and soil. Such gases can be moved or driven out under pressure.

solvent: A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

source area: The location of or the zone of highest soil or ground water concentrations, or both, of the chemical of concern. The source of contamination is the first part of an exposure pathway.

toxicological profile: An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology: The study of the harmful effects of substances on humans or animals.

volatile organic compounds (VOCs): Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, dichloroethylene, toluene, trichloroethylene, methylene chloride, methyl chloroform, and vinyl chloride.

SUMMARY

INTRODUCTION

Ensuring the wellbeing of those living in, working in, or visiting Tennessee is a priority of the Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP).

EEP wrote this health consultation at the request of the Tennessee Department of Environment and Conservation (TDEC) State Remediation Program (SRP). It documents TDH EEP's collection of indoor air samples and review of indoor and outdoor air sampling data. The air sampling was done on April 18 and 19, 2011 at and near the former IGI Adhesives Site. The former IGI Adhesives Site is located at 6100 Centennial Boulevard in Nashville, Tennessee. The site consists of a former manufacturing building, portions of which are now rented to different companies who use various parts of the building.

Chemicals were released to site soils from spills and leaks from underground storage tanks used by IGI in their manufacturing process. These chemicals migrated through the soil and reached shallow groundwater. The groundwater travels away from the site to the southwest, under at least one business and several homes. TDEC SRP was concerned about vapors from the chemicals in the groundwater migrating up into and mixing with the indoor air in the businesses and homes sampled. Therefore, TDEC asked EEP to test indoor air to determine if workers in the businesses or residents in the selected homes were being exposed to site-related chemicals.

All data supplied for this health consultation were compared to Agency for Toxic Substances and Disease Registry (ATSDR) and U.S. Environmental Protection Agency (EPA) residential indoor air comparison values. Comparison values are chemical concentrations or doses based on toxicology below which no adverse health effects are predicted to occur. When a comparison value is exceeded, it does not immediately indicate that people would be expected to develop adverse health effects. Instead, it means further evaluation is needed.

CONCLUSIONS

EEP reached three conclusions in this health consultation:

Conclusion 1

Very small amounts of the site-related chemicals, trichloroethylene, 1,1,1-trichloroethane, 1,1-dichloroethylene and 1,1-dichloroethane were measured in the indoor air of Home A. The very small amounts of the chemicals measured inside Home A were greater than the outdoor background air sample collected in the front yard of the home. EEP concludes that the levels measured are not expected to harm the health of adults or children living in or visiting the home.

Basis for Conclusion	The very small amounts of trichloroethylene, 1,1,1-trichloroethane, 1,1-dichloroethylene and 1,1-dichloroethane measured in the indoor air of Home A were well below health comparison values established by both the Agency for Toxic Substances and Disease Registry (ATSDR) and the U.S. Environmental Protection Agency (EPA) to protect the health of adults and children who would breathe the indoor air.
Next Steps	TDEC communicated all results to the homeowners. There is not a problem with the indoor air of Home A. TDEC is continuing to work with IGI to clean up the site.
Conclusion 2	EEP concludes that the since no chemicals were measured above laboratory reporting limits in Home B and Home C, no adverse health effects are predicted to occur in adults or children living in the homes.
Basis for Conclusion	No chemicals were found in indoor air in Homes B and C.
Next Steps	TDEC communicated all results to the homeowners. No further actions regarding indoor air are recommended for the two homes.
Conclusion 3	EEP concludes that the levels of chemicals found in the indoor air of the two businesses are not expected to harm the health of adults who work in those businesses.
Basis for Conclusion	Amounts of chemicals found in the indoor air of the two businesses were low. Amounts of chemicals found were below the levels established by both ATSDR and EPA expected to protect the health of adults who would breathe the indoor air of these businesses.
Next Steps	TDEC communicated all results to the business owners. No further actions regarding indoor air are recommended for the two businesses. TDEC continues to work with IGI to clean up the site.
FOR MORE INFORMATION	If you have any questions or concerns about your health, you should contact your healthcare provider. For more information on this environmental site call TDEC toll free at 1-888-891-8332. For more information on this health report, please call TDH EEP at 615-741-7247 or 1-800-404-3006 during normal business hours. You can also email TDH EEP at eep.health@tn.gov.

Introduction

It has been many years since chemicals were first discovered leaking from the IGI Adhesives (IGI) Site (Site No. SRS-0061). The Tennessee Department of Environment and Conservation (TDEC) has been overseeing numerous environmental investigations to understand the area affected by releases from the IGI Site. As another step in the investigation of the site, TDEC's, Division of Solid and Hazardous Waste Management (DSWM), State Remediation Program (SRP), requested that the Tennessee Department of Health's (TDH), Environmental Epidemiology Program (EEP), help plan and conduct indoor air sampling. Samples of indoor air were collected in selected homes and businesses above a defined area of groundwater that was affected by chemicals in the vicinity of the site. These indoor air samples were the main part of a vapor intrusion investigation of potentially affected homes downgradient from the site and the site itself.

Environmental investigations and remedial actions to eliminate further chemical releases have been carried out since 1990. The groundwater has been found to migrate away from the site in a south or southwesterly direction. Chemicals found in the groundwater that migrates from the IGI Site included trichloroethylene (TCE), and the TCE breakdown product chemicals cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and vinyl chloride. Other similar chemicals found were 1,1-dichloroethane (1,1-DCA) and 1,1,1-trichloroethne (1,1,1-TCA). These chemicals are in a group of chemicals called chlorinated solvents. Chlorinated solvents were made for a variety of uses including being used as degreasers and cleaners. These chemicals are volatile and their vapors can come from the groundwater, migrate up through the soil cover, and come into the indoor air of buildings above the contaminated groundwater. TDEC SRP was concerned about the potential intrusion of these chemical vapors into nearby homes and businesses.

The State of Tennessee does not have promulgated environmental regulatory guidance for conducting indoor vapor intrusion investigations at these types of sites. Therefore, the investigation was conducted using various procedures that are generally accepted by other State and Federal regulatory agencies and outlined in various indoor air sampling guidance documents. This health consultation will present what was done as part of the indoor vapor intrusion sampling and will evaluate the results.

In April 2011, the indoor air in three homes and two businesses was sampled. The single family homes were of brick or wood frame construction and had either a basement or a crawlspace. The businesses were of brick or concrete and steel construction and had concrete floors at ground level. All of the homes and businesses were in the path of the underground chemical migration from the IGI Site. An outdoor, or "background", air sample was also collected in the front yard of one of the homes.

Background

The IGI Site was operated as an adhesives manufacturing facility for many years before it was closed in 2001. The site property was sold at auction to a local Nashville businessman who has leased portions of the site to different commercial businesses that were not related to the prior adhesives manufacturing activities. The parent company of IGI retained the responsibility for investigating and mitigating the impact that site activities have had on the environment.

Soil contamination and groundwater contamination were discovered at the site in 1990 when IGI Adhesives replaced its underground chemical storage tanks with a new above-ground tank system. The contamination apparently resulted from leaks and spills related to the operation of the old above-ground and underground tank systems used to store chemicals needed for plant operations. Upon discovery of the contamination, the old tanks and piping were removed, along with contaminated soil and tank pit backfill material. Once these remedial activities were done, TDEC SRP agreed the soils at the site were adequately clean and that no chemical contaminant source areas remained at the site. However, the leaks and spills of stored chemicals allowed some of the chemicals to migrate through the soil and reach the underlying groundwater. Groundwater containing these chemicals has migrated from the site to the south and southwest. Overall, based on EEP's previous experience, levels of these chemicals in the groundwater at the IGI Site are similar to those found near other former manufacturing sites in Tennessee. IGI remains responsible for addressing the groundwater contamination even though IGI no longer owns the site.

IGI's environmental consultant continues to investigate the site. TDEC SRP provides oversight for the investigations conducted. TDEC SRP asked IGI to evaluate the potential for vapor intrusion to occur at the site. IGI, through their environmental consultant TriAD, performed a *Tier 1 and 2 Screening for Subsurface Vapor Intrusion* at the site (TriAD 2009). The evaluation showed that vapor intrusion could potentially occur in buildings above the groundwater contaminant plume that migrates from the IGI site. IGI chose not to implement a proposed vapor intrusion investigation work plan that was prepared based on their Tier 1 and 2 evaluations. Therefore, TDEC SRP asked TDH EEP to prepare a work plan and to investigate the vapor intrusion potential at the site by sampling indoor air.

TDEC SRP and TDH EEP personnel secured access from the owners of the homes and businesses that were tested. The indoor air investigation was conducted jointly by personnel from TDEC SRP and TDH EEP.

Discussion

Introduction to Chemical Exposure

To determine whether persons have been or are likely to be exposed to chemicals, TDH EEP evaluates ways that could lead to human exposure. Chemicals released into the environment have the potential to cause harmful health effects. Nevertheless, a release does not always result in exposure. People can only be exposed to a contaminant if they come into contact with it. If no one comes into contact with a contaminant, then no exposure occurs, and thus, no health effects could occur. An exposure pathway contains five parts:

- a source of contamination
- contaminant transport through an environmental medium
- a point of exposure
- a route of human exposure, and
- a receptor population.

An exposure pathway is considered complete if there is evidence that all five of these elements have been, are, or will be present at the site. An exposure pathway is considered incomplete if one of the five elements is missing.

The source of contamination is the place where the chemical was released. For this site, the source was spills and leaks from chemical storage tanks at the IGI Site. The environmental media transports the contaminants. Environmental media are groundwater, soils, surface water, or air. For this site, the chemicals are transported through the groundwater and indoor air. The point of exposure is the place where people come into contact with the contaminated media. Indoor air is the point of exposure for this site. The route of exposure is the way the contaminant enters the body. Ways a contaminant can enter the body are through ingestion, inhalation, or dermal contact. For this site, the route of exposure is inhalation or breathing of indoor air.

Physical contact alone with a potentially harmful chemical in the environment by itself does not necessarily mean that a person will develop adverse health effects. A chemical's ability to affect health is controlled by a number of other factors, including:

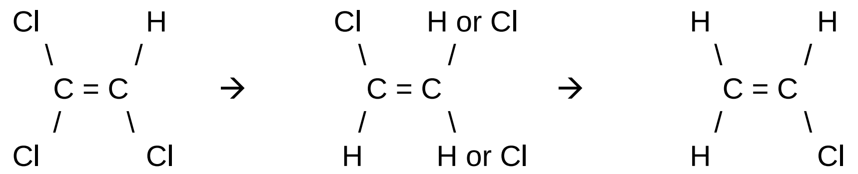
- the amount of the chemical that a person is exposed to (dose)
- the length of time that a person is exposed to the chemical (duration)
- the number of times a person is exposed to the chemical (frequency)
- the person's age and health status, and
- the person's diet and nutritional habits.

For this project, a potentially exposed population includes the residents who live above the groundwater chemical contamination that migrates from the IGI Site. The homes selected for sampling represented the population that live near the site. The three homes were selected to be sampled because they were in a worst-case location. The homes appeared to be located in the direct path of the underground chemical contamination. One of these homes has a basement that would allow people who use it to be potentially closer to the groundwater contamination beneath the home. The people living in the three homes represent a cross section of potentially exposed populations. Young adults, an older adult, and a family with a young child live in the homes. The businesses selected to be sampled were also selected because they were in the path of the underground chemical contamination and represent another potentially exposed population.

Solvent Explanation

It is not known what the chlorinated solvent chemicals were used for at the IGI Site. This evaluation will focus on the chlorinated solvent chemicals found in groundwater away from the site. The main chemicals found included TCE and its chemical breakdown products cis- and trans-1,2-DCE and vinyl chloride. In addition, 1,1-DCA and 1,1,1-TCA will be evaluated.

TCE is a volatile organic compound. It can quickly evaporate into a gas at room temperature. As its name implies, trichloroethylene has three chlorine anions on a two-carbon molecule. The molecule breaks down into other chlorinated volatile organics. Each of these breakdown chemicals has slightly different chemical properties and toxicities. The following diagram is an example of how TCE can break down to form another chemical.



trichloroethylene | dichloroethylene cis & trans isomers | vinyl chloride

In this example, TCE can break down to DCE, and then to VC. The only way to truly know the ratio of these breakdown chemicals is to collect environmental samples. TCE and its breakdown products cis-1,2-DCE, trans-1,2-DCE, 1,1-dichlororethylene (1,1-DCE), and vinyl chloride (VC) have been noted in groundwater samples collected at the site. The solvents, TCE, cis-1,2-DCE, and VC, as well as 1,1-DCA and 1,1,1-TCA, were carefully considered in developing this report.

Comparison Values

To evaluate exposure to a hazardous substance, health assessors often use health comparison values. If the chemical concentrations are below the comparison value, then health assessors can be reasonably certain that no adverse health effects will occur in people who are exposed. If concentrations are above the comparison values (ATSDR 2011a, 2011b, EPA 2011) for a particular chemical, then further evaluation is needed.

The Agency for Toxic Substances and Disease Registry (ATSDR) develops Minimal Risk Levels (MRLs) using conservative or "worst case" assumptions. MRLs are an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a set time of exposure. ATSDR uses the term 'conservative' to refer to values that are protective of public health in essentially all situations. Environmental Media Evaluation Guidelines (EMEGs) are calculated by ATSDR from their MRLs. EMEGs represent concentrations of substances in water, soil, and air to which humans may be exposed during a specified period of time (acute, intermediate or chronic) without experiencing adverse health effects. EMEGs only consider non-cancer adverse health effects. These exposure durations are defined as acute (14 days or less), intermediate (15–365 days), or chronic (365 days or more). Chronic EMEGs are generally the more conservative and assume exposure for 24 hours per day, 7 days per week, 52 weeks each year, 365 days per year, for 1 year or longer. Exposure to a level above the EMEG for a chemical does not necessarily mean that adverse health effects will occur (ATSDR 2007).

To understand the degree that TCE or TCE's breakdown chemicals cis-1,2-DCE, trans-1,2-DCE, or vinyl chloride, could lead to excess cancers from breathing indoor air containing these chemicals, the measured indoor air levels of these chemicals were also compared to ATSDR Cancer Risk Evaluation Guides (CREGs). Environmental media concentrations are compared to CREGs to understand the risk of cancer from exposure to the chemical (ATSDR 2011a, 2011b). Lifetime exposure to a chemical at a concentration equal to its CREG comparison value could theoretically result in a one in a million risk of developing cancer in addition to the background risk of developing cancer. Both ATSDR and EPA prefer to base health comparison values on 1 excess cancer in 1,000,000 people or $1x10^{-6}$. Residential comparison values were used for evaluation of exposure for those living in homes and businesses above the groundwater contamination that has migrated downgradient from the site (ATSDR 2006a). When making remedial action decisions, EPA uses an acceptable cumulative carcinogenic site risk "target range" of 1 in 10,000 to 1 in 1,000,000, or 10^{-4} to 10^{-6} (EPA 1991).

EPA's residential indoor air inhalation Regional Screening Levels (RSLs) were also used in evaluating the results of the indoor air testing (EPA 2011). Exposure to workers in the businesses would be involuntary. Since the original operations are no longer conducted at the site and the site is being reused, current site workers may not know that there are potential exposure issues in the site building. Federal Occupational Safety and Health Administration (OSHA) work place standards were not used in the businesses because employees of the business within the former IGI building no longer use solvents and are not covered under a workplace safety plan outlining the hazards associated with these chemicals. Industrial health comparison values were not used for comparison of the indoor air values measured in the building because of the involuntary exposure that would be experienced by those workers (ATSDR 2006a).

TCE is thought to be *"reasonably anticipated to be a human carcinogen"* (IARC 1995, NTP 2001). For this site, we were concerned with the inhalation of TCE from vapor intrusion into indoor air. Compared to pulmonary exposure, uptake of TCE vapor by the skin is minimal (ATSDR 1997).

The carcinogenic and non-carcinogenic toxicity of TCE has been under review for a number of years by a variety of State, Federal, and other human health and environmental organizations. ATSDR recently adapted California EPA's oral cancer slope factors to generate interim CREGs for TCE (ATSDR 2011b). The interim TCE CREG is 0.09 ppb. EPA has a residential setting TCE inhalation RSL for one excess cancer in 1,000,000 people of 0.22 ppb. EPA has set a non-cancer RSL of 7.4 ppb for indoor air for TCE (EPA 2001a).

Cis-1,2-DCE is not classified regarding carcinogenicity. Vinyl chloride has been determined to be a *"known human carcinogen"* (NTP 2005). Again, like TCE, we were concerned about the potential for someone to inhale indoor air containing vinyl chloride vapors. ATSDR has a published CREG of 0.04 ppb for vinyl chloride (ATSDR 2011a). ATSDR does not have a chronic EMEG for vinyl chloride, but has an intermediate EMEG of 30 ppb (ATSDR 2006b). EPA has both a non-cancer and cancer RSL for vinyl chloride. EPA's non-cancer RSL is 39 ppb. EPA's RSL for one excess cancer in 1,000,000 people for vinyl chloride is 0.06 ppb.

1,1-DCA has been determined to be a *"possible human carcinogen"* (EPA 1986), although its classification is based on limited animal studies and not human evidence. There is no ATSDR CREG for this chemical, however there is an EPA RSL for cancer health effects of 0.37 ppb for a risk of 10^{-6}. There is not an EPA RSL for non-cancer health effects nor is there an ATSDR EMEG for 1,1-DCA.

According to EPA (2005) there is inadequate information to assess carcinogenic potential for 1,1,1-TCA. Neither EPA nor ATSDR have a cancer health comparison value for 1,1,1-TCA. There is an ATSDR EMEG for non-cancer health effects for intermediate exposures from 15 days to 364 days of 700 ppb (ATSDR 2006c).

Introduction to Vapor Intrusion

Volatile and semi-volatile chemicals evaporate from impacted subsurface soil and/or groundwater beneath a building and move toward areas of lower chemical levels such as the atmosphere, utility conduits, or basements. Subsurface vapors can enter a building due to two main factors: 1) environmental effects, and 2) building effects. Some examples of these factors are barometric pressure changes, wind load, temperature currents, or depressurization from building exhaust fans. Chemicals can migrate up and enter indoor air through foundation slabs, crawl spaces, or basements. The chemical migration depends on the construction of the building, if there are any unsealed joints or cracks in the foundation, the buildings heating and ventilation characteristics, and other factors. The rate of movement of the vapors into the building is difficult to measure and depends on soil type, chemical properties, building design and condition, and the pressure differences (ITRC 2007). Upon entry into a structure, chemical vapors mix with the existing air through the natural or mechanical ventilation of the building.

Commonly found concentrations of chemicals in indoor and outdoor air are referred to as "background levels." These levels are generally determined from the results of samples collected in homes, offices, and outdoor areas not known to be affected by “outside” sources of volatile chemicals. For example, a home not known to be near a chemical spill, a hazardous waste site, a drycleaner, or a factory. Background levels of volatile chemicals are considered when conducting an investigation of the vapor intrusion pathway (NYSDOH 2006).

Environmental Sampling

The indoor air testing was conducted in 3 homes on a residential street called New York Avenue by TDEC and TDH (Figure 1) in the vicinity of the IGI Site. The homes are located southwest of and downgradient from IGI in the direction of groundwater flow. The homes were selected because of 1) their location over the underground groundwater chemical plume, 2) residents granting access, and 3) the varying ages of potentially exposed populations in these homes. These 3 homes were thought to be representative of the various construction types of homes on New York Avenue. All three of the homes were considered by TDEC to be in the pathway of the perceived underground chemical migration from IGI. An age range of residents were present in the homes, including a child, adults, and an older adult. These people were thought to be representative of the other households on New York Avenue.

Two businesses were also sampled. There are several independent businesses located inside the former IGI building. Indoor air in the business closest to the location of the release(s) was sampled to determine if vapors originating from the site groundwater were migrating upwards into the building. Indoor air in another business southwest of the IGI Site was also sampled. The business was located downgradient from the IGI Site in the direction of groundwater flow. The groundwater from the IGI Site travels beneath this business. There are both offices and a warehouse area in this business.

TDEC and TDH secured access and discussed the sampling procedures with the homeowners, occupants of the homes, and business representatives. TDH EEP developed an information sheet explaining why the testing was being done and what specifically would be done in the home. The information sheet was given to each homeowner and business representative during the initial discussion upon entering their home and before beginning the indoor air testing. The information sheet is presented in Appendix A.

Indoor air was sampled in the main living area in each of the three homes. In addition, one indoor air sample from the basement of Home A was collected. An outdoor, “background” air

Figure 1. Indoor air sampling locations in the vicinity of the IGI Site. Indoor air sampling was conducted in these buildings on April 18 and 19, 2011. Business A and Homes A, B, and C are located over the contaminated groundwater plume migrating away from the IGI Site. Samples were collected in both the basement and main living area in Home A because the basement allows residents to be potentially closer to contaminated groundwater. Home B and Home C were sampled because they were located on either side of Home A. (Reference: Google Earth 2010).

sample was also collected from the front yard of Home A. The outdoor air sample was used to measure levels of chemicals in the outdoor air that would be considered ambient levels.

Indoor air samples were collected from areas on the ground floor of the two businesses. At one business, 2 indoor air samples were collected. One was in a large room used for storage of supplies. This sample was placed in a location away from open overhead doors. The second sample was located in an administrative area near overhead doors that were open during the work day. The doors could not be closed as there was no forced air ventilation system in place in the building.

As mentioned previously, the work plan had a provision for sampling water in a sump reported to be located in the basement of Home A. Home A actually has two sumps to collect water that seeps through the concrete block walls of the basement. There are trenches in the floor of the basement where the floor and the walls meet, to channel collected water to the sumps. At the time of the indoor air sampling, the sumps and collection trenches around the basement walls were dry. TDH EEP contacted the homeowner after each of 3 rainfall events that happened after the indoor air sampling. According to the homeowner, water did not accumulate in the sumps after these events. Therefore, sump water sampling did not take place.

Home and Business Characteristics

The three homes on New York Avenue were of similar wood frame construction. Home A was sheathed in brick. Home B and Home C had vinyl siding. Home A was constructed around 1950. Home B was built about 1930. Home C was built about 1900 (according to the owner). Home A had a basement while Home B and Home C had limited crawl spaces. Business A was constructed about 1998. It was constructed of concrete block and metal panels. Its foundation is concrete slab-on-grade. The former IGI building was constructed about 1964 and is made of concrete block and brick. Its foundation is also concrete slab-on-grade.

Home A

Home A was a brick, ranch-style home. It had a full basement that was used for a work shop, minor storage, and a laundry area. The family lived on the main floor of the home. The basement was not finished, and no one used this space as a living area. The basement had a trough around the inside concrete block walls to channel water that seeps into the basement to 2 sumps. The sumps were located in the northwest and southwest corners of the basement and have sump pumps in them to pump the water out of the basement to the municipal storm sewer. Paint and other household chemical and cleaning supplies were stored in the basement. Laundry soaps, spot removers, and bleach items were stored in the laundry area in the northern portion of the basement. Personal vehicles were parked outside of the home and in the garage. The vehicles in the garage could potentially contribute petroleum-related chemicals to the indoor air of the home.

Home B

Home B was vinyl sided cottage-style single story home. The home reportedly had a very low crawl space. TDEC and TDH did not inspect the crawl space. There is no garage for the home and personal vehicles were parked outside. Parking vehicles outside likely eliminates petroleum chemical vapors from the indoor air of the home.

Home C

Home C was a single story cottage-style home with an attic. The living area was on the main or first floor. The home was sheathed with vinyl siding and wood trim. Home C had a limited crawl space, the condition of which was unknown, but it was described by the occupant of the home as not being very tall. TDEC and TDH did not inspect the crawl space. There was a detached garage. Personal vehicles were parked outside.

Business A

Business A was a seed company. The business was housed in an approximate 14,100 square foot metal and concrete block building. The building had a concrete slab floor and was built in approximately 1998. The building had a small office area and large receiving/shipping and warehouse areas. Propane-powered fork-lifts were used inside the warehouse portion of the building.

Former IGI Building

There was an electrical supply business in a portion or the former IGI building. The electrical supply business leased approximately 20,000 square feet of an approximate 63,000 square feet building. Various businesses leased other portions of the larger building. Indoor air was sampled only in the rear, approximate 20,000 square foot portion of the main building. Two samples were collected from this large area; one in the western portion and one in the extreme eastern portion. One propane-powered fork-lift and one gasoline-powered fork lift were used in the business. It was unknown if either of the fork lift's were operated during the indoor air testing.

General Sampling Protocol

A general indoor air sampling protocol was developed for the New York Avenue homes and the two businesses. This general indoor air sampling protocol is in Appendix B. The protocol outlines general steps that should be considered when conducting an indoor air sampling investigation and what regulatory or health values the results should be compared to in order to interpret them.

Building Inventory and Pre-Screening

Prior to vapor sampling, an indoor air quality questionnaire and building inventory form was completed for each home and business. The forms used were developed by the New York State Department of Health (NYSDOH) and are readily available online (NYSDOH 2006). The completed forms for each home and business were retained in TDH EEP files. Photographs in Appendix C show details of the various sampling locations.

Conducting a building inventory allows common household sources of chemicals to be evaluated prior to sampling. It allows interaction between the sampler and resident and what chemicals may be used inside the building during the course of a normal day. Additionally, it allows the sampler to observe the structural condition, building floor plan, and details prior to sampling. In general, the building inventory sheets contained information on the following:

- historic and current storage and uses of volatile chemicals,

- sources of volatile chemicals present in the building,
- use of heating or air-conditioning systems during sampling,
- floor plan sketches,
- significant activities in the vicinity of the sampling locations,
- weather conditions and ventilation conditions,
- pertinent observations, such as spills, floor stains, odors, and readings from field instrumentation,
- overhead doors or entrance door status,
- uses of volatile organic compounds (VOCs) during normal living in the home, and
- any pertinent observations, such as odors and readings from field instrumentation.

At each of the three homes and the two businesses, the occupants were advised not to smoke during the test. They were also advised to limit the number of times that any door to the outside was opened. Additionally, they were advised not to use any gasoline powered machines or have candles burning during the test.

A photoionization detector (PID) was used during the building survey. The PID was used to measure background volatile organic compound (VOC) vapors and vapors from specific chemicals or containers at all the homes and businesses tested. The PID used was able to measure vapors in parts per billion (ppb). Thus, the PID was able to detect vapors in the indoor air at very low levels. The PID can also detect vapors from many more chemicals other than the chemicals of interest that have been found migrating from the IGI Site. The PID came pre-calibrated from the rental company.

Home A
Before the indoor air sampling, a photoionization detector (PID), able to read in parts per billion, was used to determine if the indoor air in Home A had any volatile organic compounds (VOCs). Background indoor air vapor readings were measured to be 0 ppb in the front living and dining area on the main floor where the Summa canister was placed for the test.

Home A had a full unfinished basement. Home A contained various cleaning products stored beneath the kitchen sink and in the basement. There were also insecticides, automotive products, and PVC pipe solvent and cleaner stored in the basement (Appendix C). Photographs of these products are in Appendix C. PID vapor readings were 0 ppb for cleaning products or other products stored on the main level and in the basement of Home A. These readings indicate there were no vapors emanating from the products.

Home B
Vapor readings of 0 ppb were measured in the kitchen area where the Summa canister was placed. Home B contained cans of lighter fluid, furniture stain, lighters, and cleaning products (Appendices C). The PID was used to detect any off-gassing of chemicals from the products

noted. Using the PID to screen the product containers for volatile chemicals, readings were 0 ppb.

Home C

Vapor readings were 0 ppb in the front living area where the Summa canister was placed (Appendices C). In closets, in the kitchen, and on bookshelves, various oils, lighter fluid, and furniture stain were noted as were various cleaning products. The PID did not show any readings of VOCs from product containers stored within Home C.

Business A

The indoor air sample location in Business A was inside a break room removed from the front reception area. The reception area was the main entrance to the building for customers and visitors. No chemicals were noted in the office area during the building survey which was done before the testing. All PID readings were 0 ppb.

Business A was typically cleaned every weekend. However, no cleaning was done the weekend prior to indoor air testing. Pesticides were also applied inside the building on a schedule. The weekend prior to indoor air testing, Phostoxin® was applied. Phostoxin® is a burrowing rodent pesticide composed of aluminum phosphide that is dangerous when wet and is a poison. The company manager reported that the Phostoxin® treatment "failed." TDH EEP felt that the indoor air sample would not be influenced by the "failed" pesticide treatment. PID readings were 0 ppb in the office area.

Former IGI Building

Two indoor air samples were collected inside the electrical supply warehouse. Sample 1 was located in the western warehouse and supply storage area of the business. Sample 2 was located near the overhead and entrance doors to the business. There was a large overhead door that was reportedly open from 6:30 am to 4:30 pm. Sample 1 was collected at least 100 feet from the door. There were no stored chemicals noted during the building survey near the location of indoor air Sample 1. PID readings were 0 ppb.

In the vicinity of the location of Sample 2, there were 1-gallon containers of concrete and masonry bonding and primer. There was also an automobile battery. PID readings were 0 ppb. Sample 2 was located near a large overhead door and a smaller entrance door that were open from 6:30 am until 4:30 pm. Workers were not willing to close the doors as open doors were the only means of ventilation for their work environment. There was no forced air ventilation or air conditioning.

Air Sampling Methods

Sampling was conducted using generally accepted procedures (NYSDOH 2006, ITRC 2007, EPA 2011) over an approximate 24-hour time period from April 18 to 19, 2011. Indoor and outdoor background air samples were collected using certified clean, 6-liter Summa canisters with 24-hour calibrated individual flow controllers. This certification process is how the subcontract laboratory, TestAmerica, Inc., in Knoxville, Tennessee, ensured the cleanliness of the canisters when dealing with low reporting limits. The air samples collected were analyzed for the chlorinated solvent chemicals PCE, TCE, cis- and trans-1,2-DCE, 1,1-DCE, vinyl chloride, 1,1-DCA and 1,1,1-TCA using the U.S. Environmental Protection Agency (EPA) Method TO-15 for VOCs.

The Summa canisters were positioned in a heavy traffic area on the lowest floor used as the living area of each home. The Summa canisters were set at a height of approximately 3 to 5 feet. The canisters were positioned at this height so that they would mimic the seated, breathing height of an individual in the home. For Home A, one of the Summa canisters was positioned in the basement on a counter near the laundry area. The second Summa canister set in Home A was positioned on a small table in the area between the front living room and dining room. The outdoor air background sample was positioned approximately 3 feet above the ground surface in the front yard of Home A. For Home B, the canister was positioned on a kitchen counter in the main living area of the home. In Home C, the Summa canister was positioned on a table in the dining room of the home. The Summa canister was placed on a counter in the Business A break room. For the former IGI building, Summa 1 was placed on cart in the western warehouse area while Summa 2 was placed on a desk in the eastern administrative area of the electrical supply business. The beginning sample time, sample identification, and initial canister pressure were recorded on the sample label of each canister.

A weather summary for the testing period is in Appendix D. April 18, 2011, began with temperatures in the high 50's warming into the low 70s during the day and settling into the high 60s at night. The day was mostly cloudy with winds from the south at 5 to 15 miles per hour (mph). The barometric pressure dropped approximately one inch of mercury before rising again in the early morning of April 19 (Wunderground 2011a). For April 19, 2011, the temperature rose from the high 60s into the mid 80s. The day was mostly sunny. Winds were from 10 to approximately 25 mph and were from the south. The barometric pressure stayed relatively constant throughout the day before dropping in the late afternoon (Wunderground 2011a). Studies (e.g. McHugh and McAlary, 2009) have shown that pressure changes may influence advective soil-gas flow if there is a laterally continuous fine grained layer in the unsaturated soil zone.

Limitations and Uncertainties

There are several characteristics of the homes and businesses that may influence indoor air testing. Limitations and uncertainties can sometimes influence the results of the investigation.

Some examples of limitations and uncertainties include the detail of the design of each of the homes and businesses not being readily available. The number of cracks in floor slabs or utility perforations entering the buildings are also variables that can influence the test. Also, the amount of the chemicals in the groundwater beneath the buildings is unknown, and, hence, the amount and frequency of vapor off-gassing from the groundwater is likely not constant and not measured. The presence of background chemicals in the indoor air of the homes and businesses tested could also be a limitation. The use of cleaning products that sometimes contain many chemicals can influence the results of the testing. This can be the case especially if cleaning products were recently used in the home or business.

The routines of the individuals living in the homes and working in the businesses were another uncertainty. Sometimes, people will smoke or open doors and windows during tests.

What has happened in the past at the sampling locations is another uncertainty. Any or all spills that may have occurred are likely to remain undocumented, especially at a residence.
Having and following an accepted protocol for conducting indoor air investigations is important. A general protocol was developed for this investigation. The protocol was discussed in the previous section and outlined in Appendix B.

Indoor and Outdoor Air Sampling Results

Results of the 7 indoor air and 1 outdoor background air tests are shown in Table 1. The chemicals of concern were found at very low levels only in Home A and in the two businesses.

Chemicals are a part of our everyday life. They are found in common household and cleaning products we use and in such things as drycleaned clothing. As such, chemicals are found in indoor air of homes and businesses not affected by the migration of vapors into a home or business. Chemicals can also be in the outdoor air that enters a home or place of business. Also, gasoline stations, drycleaners, and vehicle exhaust can increase general background levels in outdoor air (NYSDOH 2006).

Background or Outdoor Air Sample
The background air sample collected on New York Avenue did not have measureable levels of site-related chemicals (Table 1). All results were below the laboratory reporting limit, or detection limit, of 0.08 ppb for each of the chemicals. This is a very low detection limit.

Several studies (ATSDR 1997, ATSDR 2001b) show typical background outdoor air levels for TCE are 0.03 ppb in rural/remote areas and 0.46 ppb in suburban/urban areas. For 1,1,1-TCA, typical background outdoor air levels are 0.1 to 0.9 ppb (ATSDR 2006). For 1,1-DCE, the mean range of outdoor air levels is from 0.005 to 0.39 ppb (ATSDR 1994). For 1,1-DCA, there is a mean U.S. outside air concentration of 0.055 ppb with urban concentrations ranging from 0.1 to 1.5 ppb (ATSDR 1990). EPA reports that typical outdoor levels of vinyl chloride are below 1 ppb (1999)

Home A
The main living level indoor air sample of Home A had minimal levels of solvent chemicals (Table 1). The basement sample had somewhat higher levels of solvent chemicals, but the levels were still low. All levels of chemicals detected in Home A were equal to or above the outdoor air sample reporting limit values. TCE was found at 0.08 ppb in the main living level of the home. TCE was found at 0.09 ppb in the basement. Even though TCE was detected in the indoor air, the levels found were very low and below typical indoor air background levels (EPA 2011). 1,1,1-TCA was detected at 0.83 ppb in the main living area while it was found at 3.8 ppb in the basement. The levels found are also below typical indoor air background levels (EPA 2011). 1,1,-DCE was found at 0.13 ppb on the main level and at 0.32 ppb in the basement. These levels are below typical indoor air background levels (EPA 2011). 1,1-DCA was found at 0.34 ppb on the main level and 1.4 ppb in the basement. These levels are slightly higher than

Table 1. Indoor air sampling results for 3 homes and 2 businesses near the former IGI Adhesives Site, Nashville, TN. Homes and businesses sampled were thought to overlie the groundwater contamination. Samples were collected April 18 - 19, 2011, over 24 hours with Summa canisters. Values reported in parts per billion (ppb). Where the chemical was not detected, the result is reported as being less than (<) the reporting limit of the analysis. Health comparison values used are non-cancer chronic Environmental Media Evaluation Guides (ATSDR 2011), ATSDR interim cancer risk and cancer risk evaluation guides (ATSDR 2011), and EPA residential indoor air Regional Screening Levels (EPA 2010).

Chemical / Sampling Data and Location Name	Acronym	Home A Outside	Home A Indoor	Home A Basement	Home B	Home C	Business A	Former IGI Building Location 1	Former IGI Building Location 2	ATSDR EMEG (non-cancer) (ppb)	ATSDR CREG (10^{-6} excess cancer risk) (ppb)	EPA RSL	
												(10^{-6} excess cancer risk) (ppb)	(10^{-4} excess cancer risk) (ppb)
trichloroethylene	TCE	<0.04	0.08	0.09	<0.04	<0.04	0.60	<0.04	0.48	7.4[EPA]	0.09[1]	0.22	22
1,1,1-trichloroethane	1,1,1-TCA	<0.08	0.83	3.8	<0.08	<0.08	4.9	0.17	2.8	700[i]	in	ngv	ngv
1,1-dichloroethylene	1,1-DCE	<0.08	0.13	0.32	<0.08	<0.08	0.17	<0.08	0.16	20[i]	ns	ngv	ngv
1,1-dichloroethane	1,1-DCA	<0.08	0.34	1.4	<0.08	<0.08	0.74	0.097	3.1	ngv	c	0.37	37
cis-1,2-dichloroethylene	cis-1,2-DCE	<0.08	<0.08	<0.08	<0.08	<0.08	0.23	<0.08	1.3	ngv	nc	nc	nc
trans-1,2-dichloroethylene	trans-1,2-DCE	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	200[i]	nc	nc	nc
chloroethane		<0.08	<0.08	<0.08	<0.08	<0.08	0.12	<0.08	0.38	20,000[a]	nc	nc	nc
vinyl chloride	VC	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.16	30[i]	0.04[2]	0.06	6

Notes:

ATSDR EMEG	= Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2010). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.
ATSDR CREG[1]	= Agency for Toxic Substances and Disease Registry Interim Cancer-Based Comparison Value Risk Evaluation Guide, ATSDR Interim Guidance, April 26, 2011. Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.
ATSDR CREG[2]	= Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide (ATSDR 2011). Cancer risk comparison values for cancer risk of 1 excess cancer in 1,000,000 people.
EPA RSL	= Environmental Protection Agency Regional Screening Level (EPA 2010). The screening levels were developed using risk assessment guidance from the EPA Superfund Program. RSLs are considered by EPA to be protective for humans, including sensitive groups, over a 70-year lifetime.
a	= ATSDR comparison value for acute exposures of 1 to 14 days.
i	= ATSDR comparison value for intermediate exposures of 15-365 days.
EPA	= There is not a published EMEG for TCE. The results were compared to the EPA's most current evaluation of the potential health risks from exposure to TCE at 7.4 ppb (EPA 2001) for non-cancer health effects.
in	= Inadequate information to assess carcinogenic potential.
ns	= Suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential.
c	= Possible human carcinogen with no human evidence and limited animal studies.
nc	= Not classified as to carcinogenicity and no guidance value is available.
ngv	= No guidance value available.

typical indoor air background levels (EPA 2011). All other compounds tested were below laboratory reporting limits.

Indoor air chemical concentrations detected in the main living area of the home and in the home's basement were below non-cancer environmental media evaluation guide (EMEG) concentrations for non-cancer health effects. Levels of detected chemicals in the indoor air of the living space and basement of Home A are within the range of health comparison values (ATSDR 2011a and 2011b and EPA 2011) and the corresponding excess cancer risk is considered very minimal and acceptable by EPA (EPA 1991). There likely will not be harmful health effects due to vapor intrusion to those breathing indoor air in this home. Future vapor intrusion into this home is likely to be less than what it is today given that the source of the groundwater contamination has been removed and the chemicals are degrading naturally in the environment.

Home B

Solvent chemicals were not found in the indoor air of Home B (Table 1). The reporting limit values for the tests were compared to the ATSDR and EPA comparison values for indoor air (ATSDR 2011a and 2011b, EPA 2011). There likely will not be harmful health effects from vapor intrusion to people who live in the home and breathe indoor air.

Home C

Solvent chemicals were not found in the indoor air of Home C (Table 1). The reporting limit values for the tests were compared to the ATSDR and EPA comparison values for indoor air (ATSDR 2011a and 2011b, EPA 2011). There should not be harmful health effects from vapor intrusion to people who live in this home and breathe the indoor air.

Business A

Indoor air in Business A contained TCE, 1,1,1-TCA, 1,1-DCE, 1,1-DCA, cis-1,2-DCE, and chloroethane. Although measurable levels of these chemicals were found in the indoor air sample collected, their levels were low and lower than the health comparison values typically applied to commercial business settings. The measured levels are below EMEG comparison values for non-cancer health effects. The levels were within the range of excess cancer risk that is typically used by EPA for commercial settings (EPA 1991). Allowable levels of chemicals in indoor air in these settings are generally higher than in homes as the workers are not breathing indoor air up to 24 hours per day for a 70-year lifetime as a person would be who stays home,

Former IGI Building

Two indoor air samples were collected in different areas of the former IGI building. One sample was collected in a warehouse area. The other was collected in an employee administrative area. The indoor air sample collected in the warehouse area and away from the administrative area had fewer chemicals detected and lower levels of those chemicals than the sample collected in the administrative area. Chemicals found in the warehouse sample included 1,1,1-TCA and 1,1-DCA. Chemicals found in the administrative area sample include TCE, 1,1,1-TCA, 1,1-DCE, 1,1-DCA, cis-1,2-DCE, chloroethane, and vinyl chloride. The levels of chemical measured were below EMEG comparison values for non-cancer health effects. Levels of these chemicals were within the range typically applied to industrial settings and were within the excess cancer risk considered acceptable by EPA for industrial settings (EPA 1991).

Chemical Mixture

When more than one chemical is identified at a sampling location, there can be 4 potential health effects from the chemical mixture to an exposed population (ATSDR 2004). The four types include: additive, antagonistic, synergistic, and other interactive health effects. There is no health or chemical-specific evidence to indicate that greater-than-additive interactions among TCE, cis-1,2-DCE, and 1,1,1-TCE occur. TCE and minor amounts of other chemicals were measured in indoor air samples collected from 3 locations tested.

Assuming additive effects, adding together the approximate site-specific theoretical risks, the actual risk, would be within EPA's acceptable range of risk (EPA 1991). Therefore, there is little if any increased risk from breathing indoor air containing a mixture of these chemicals.

Other Considerations

The 3 homes and 2 businesses tested were thought to be representative of the building construction types present in the area near the IGI Site. One of the households tested has a basement that can possibly put the homeowner closer to potentially contaminated groundwater. The vapors from the contaminated groundwater would have less distance to travel and therefore, if there were high levels of chemicals in the vapor that is moving, there could be a higher risk of vapor intrusion at this home.

The source of the chemicals at the IGI Site was eliminated long ago. The deteriorated piping, impacted soil, and the above ground and underground storage tanks have been removed. The health risk from the site is less than it would have been in the past. This is because the source has been removed, the chemicals in the groundwater are degrading, and the site will continue to be monitored by the responsible party and TDEC SRP. In the future, any health risk should be similar to, or likely less, than it is now. This is because the chemicals are expected to degrade in the soil (and bedrock) over time. There does not appear to be a vapor intrusion problem occurring at the site now and therefore it is unlikely to occur in the future.

Children's Health Considerations

Children could be at greater risk than adults from certain kinds of exposure to hazardous substances (ATSDR 1997, 1998). Children have lower body weights than adults. Although children's lungs are usually smaller than adults, children breathe a greater relative volume of air compared to adults. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health.

In preparation of this health document, the health of children was thoughtfully considered. Children breathe a higher volume of air than adults. The following discussion presents our consideration of how the levels of chemicals measured might affect children.

The former tanks, piping, and contaminated soil have been removed from the IGI Site. The sources for the chemicals are now gone. Only very minor amounts of chemicals found in the groundwater at the IGI Site were found in the indoor air of Home A and in the two businesses. No chemicals were found in the indoor air of Home B and Home C. There is at least one child that lives in one home tested and typically visits another home that was also tested. Based on the results of the indoor air testing, there should not be any harm to this child from breathing the indoor air in the homes. Children would not typically visit the businesses tested. If they did, they would not physically be at the businesses for any significant length of time. Any exposure would be expected to be minimal if they did.

Conclusions

EEP reached three conclusions in this health consultation:

Conclusion 1
EEP concludes that very small amounts of the site-related chemicals, trichloroethylene, 1,1,1-trichloroethane, 1,1-dichloroethylene and 1,1-dichloroethane were measured in the indoor air of Home A. The very small amounts of the chemicals measured inside Home A were greater than the outdoor background air sample collected in the front yard of the home. EEP concludes that the levels measured are not expected to harm the health of adults or children living in or visiting the home.

The very small amounts of trichloroethylene, 1,1,1-trichloroethane, 1,1-dichloroethylene and 1,1-dichloroethane measured in the indoor air of Home A were well below health comparison values established by both the Agency for Toxic Substances and Disease Registry (ATSDR) and the U.S. Environmental Protection Agency (EPA) to protect the health of adults and children who would breathe the indoor air.

Conclusion 2
EEP concludes that the since no chemicals were measured above laboratory reporting limits in Home B and Home C, no adverse health effects are predicted to occur to the health of adults or children living in the homes.

No chemicals were found in indoor air in Homes B and C.

Conclusion 3
EEP concludes that the levels of chemicals found in the indoor air of the two businesses are not expected to harm the health of adults who work in those businesses.

Amounts of chemicals found in the indoor air of the two businesses were low. Amounts of chemicals found were below the levels established by both ATSDR and EPA expected to harm the health of adults who would breathe the indoor air of these businesses.

Recommendations

The focus of this health consultation was to evaluate the results of the indoor air sampling event conducted in April 2011 in homes and businesses downgradient from the IGI Site. The evaluation was done to determine if groundwater beneath the homes and businesses was emitting volatile organic chemical vapors into the indoor air breathed by adults and/or children who may live in the homes tested, and adults who work in the businesses. With that in mind, the following recommendations are believed to be appropriate based on EEP's review of the indoor air sampling data.

- It is recommended that the TDEC, the TDH, and other appropriate parties continue to work together to see that public health continues to be protected during clean up of the IGI Site.

Public Health Action Plan

The public health action plan for the IGI Site contains a list of actions that have been or will be taken by EEP and other agencies. The purpose of the public health action plan is to ensure that this health consultation identifies public health hazards and offers a plan of action designed to mitigate and prevent harmful health effects that result from breathing hazardous substances in the environment. Included is a commitment on the part of EEP to follow up on this plan to ensure that it is implemented.

Public health actions that TDH EEP has taken included:

- Speaking with homeowners and business representatives regarding general environmental conditions of the area.

- Preparation of a fact sheet explaining the indoor air testing and distribution to homeowners and business representatives who allowed access for the indoor air testing.

- Preparation of this health consultation.

Public health actions that will be taken include:

- TDH EEP and TDEC will provide copies of this health consultation to the residents of the 3 homes

- TDH EEP and TDEC will provide copies of this health consultation to representatives of the 2 businesses tested as part of this investigation.

- TDH EEP will provide copies, if asked, of this health consultation to state, federal, and local government, other community members, and community group members.

- TDH EEP will maintain dialogue with TDEC, ATSDR, other government agencies and interested stakeholders to safeguard public health.

- TDH EEP will be available to review additional environmental data, and provide interpretation of the data, as requested.

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Certification

This Public Health Consultation: *Indoor Air Investigation, IGI Adhesives Inc. and Vicinity, Nashville, Davidson County, Tennessee*, was prepared by the Tennessee Department of Health's Environmental Epidemiology Program. It was prepared in accordance with the approved methodology and procedures that existed at the time the health consultation was begun.

Bonnie S. Bashor

Director of EEP, CEDS, TDH

Appendix A

Homeowner Information Sheet

What is soil vapor intrusion?

The phrase "soil vapor intrusion" refers to the process by which volatile chemicals move from a below ground source into the indoor air of overlying buildings.

Soil vapor, or soil gas, is the air found in pore spaces between soil particles. Because of a difference in pressure, soil vapor enters buildings through cracks in slabs or basement floors and walls, and through openings around sump pumps or where pipes and electrical wires go through the foundation. Heating, ventilation or air-conditioning systems may create a negative pressure that can draw soil vapor into a building.

Why is the sampling being done?

Chemicals that readily evaporate are called "volatile chemicals." Volatile chemicals include volatile organic compounds (VOCs). Subsurface sources of volatile chemicals may include contaminated soil and groundwater, or buried wastes. If soil vapor is contaminated, and enters a building as described above, indoor air quality may be affected. Indoor air sampling being done in your home is to identify if this has happened.

What should I expect if indoor air samples are collected in my home?

Indoor air samples are generally collected from the lowest-level living space in a building, typically a finished basement, during the heating season. Indoor air samples may also be collected from the first floor living space. The greatest exposure potential with respect to soil vapor intrusion is from indoor air.

The person doing the indoor air sampling will complete an indoor air quality questionnaire and building inventory. The questionnaire includes a summary of the building's construction characteristics; the building's heating, ventilation and air-conditioning system operations; and potential indoor and outdoor sources of volatile chemicals. The building inventory helps to identify products present in the building that might contain volatile chemicals. In addition, we take real time readings from an organic vapor meter (also known as a photoionization detector or PID). The PID is an instrument that detects many different VOCs in the air. When indoor air samples are collected, the PID will be used to help determine whether products containing VOCs might be adding to levels that are detected in the indoor air.

We will be doing the sampling using clean Summa canisters. These stainless steel sample collection “cans” are under a vacuum. They collect air that is in your home over a set sampling period. The sampling will be done over a 24-hour time period. A flow controller, placed on top of the Summa canister, controls the flow of air into the canister. It is important that opening doors and windows is kept to a minimum during the sampling. You should also not smoke inside, use craft supplies such as hobby paints or glues, use cleaning products, or vacuum. It is fine to keep your air conditioning or heat on during the testing.

Once the 24-hour sampling period has ended, the person who set up the sampling will retrieve the Summa canister and ship it to an environmental laboratory for testing. The VOCs we are looking for in this testing are related to manufacturing plants in the area. If you have any other questions please contact Ashley Holt at (615) 532-0853. Thank you for your cooperation.

Appendix B

General Sampling Protocol

General Protocol for Monitoring of Air with Summa Canisters

Sampling Equipment

The most common sampling device used to collect indoor vapor samples is a 6-liter Summa canister. The Summa canister is under vacuum and needs an accompanying flow controller calibrated to the amount of time the test is to be performed (e.g. 8 hour or 12 hours or longer flow controller calibration). The Summa canisters and each individual flow controller should be certified to the reporting limits is suggested. This certification process is how the laboratory ensures cleanliness of the media when dealing with low reporting limits. It is recommended that the Summa canisters be of stainless steel construction.

Preferred Sampling Equipment Location

Two schools of thought are expressed here. One is that sampling equipment (Summa canisters) should be placed on the lowest occupied space of the dwelling of interest, at a height of approximately 3 feet above the floor to represent the breathing height at which occupants are normally seated. Another is that the height of the breathing zone of occupants should be sampled. This height can vary from approximately 3 feet to 5 feet, representing a normal standing breathing zone.

Ideally, the sampling location should also be centrally located in a high-use area. For a conservative approach to the sampling, if the dwelling is slab on grade, collect the sample from the lowest occupied space at a height of 3 to 5 feet. If the dwelling has a basement, samples should be collected from the basement and lowest main floor, as a conservative approach, at a 3 to 5 foot height. For large surveys (multiple locations on the same property) and also for use as a background sample, an ambient air sample should also be collected outside, upwind, and in a relatively protected area from the location(s) of interest.

Summa Canister / Flow Controller General Sampling Procedures

The procedures below are recommended to be followed when conducting the sampling.

1. The flow controller will be calibrated at the laboratory to the sampler's specifications prior to shipping. This calibration valve is sealed with a protective locked cap and should not be altered in the field.

2. If sampling outside, keep in mind that precipitation may clog the flow controller filter and could cause a reduction or stoppage of flow. "Candy cane" inlet extensions can be used. Sampling in this type of weather should be avoided, if possible, or some type of temporary shelter provided. Usually, problems do not crop up during precipitation events.

3. First remove the brass cap on the Summa canister (typically 9/16-inch size) and the quarter-inch plug (if included) on the flow controller. Do not open the Summa canister.

4. Connect the flow controller to the canister.

5. Record starting date and time on the sampling label and chain of custody.

6. Open sampling valve by turning knob counter clockwise. Turn until knob moves easily, usually 1 and one-half turns. The vacuum gauge should read near 30" of mercury (Hg - vacuum) when opened. Record the initial pressure on the sampling label and chain of custody. If the initial pressure reading is less than 25" of mercury,

close and set aside the initial Summa canister and use another Summa canister for the sampling (indoor air and ambient air sample flow rates should be less than 0.2 liters per minute).

7. When sampling period has ended to designated specification, close the knob tightly. It is not necessary to “crank down” on the valve knob-this can cause permanent damage.

8. Remove the flow controller and replace the brass cap on sampling port.

9. Record sampling stop date, time, and final pressure on label and chain of custody. The final pressure should be near 5” Hg at the end of the sampling period. I f it less the sample will be biased to earlier in the sampling time period. If the reading is close to 0” Hg at the end of the test period, there is not sufficient pressure to “drive” the flow controller. The sampler can’t be sure the desired sampling interval was achieved before the canister arrived at ambient conditions. The actual sampling interval is uncertain but the canister still contains a sample from the site.

10. Place flow controller in the protective packing it was shipped in to provide maximum protection during shipment to lab.

General Notes:

• Summa canisters should be checked regularly during the sample collection period to make sure a substantial drop in pressure does not occur. If a pressure drop occurred, then there was a leak in the sampling system and another canister must be deployed at the location to obtain an accurate sample.

• Observations related to weather conditions, work activities by others, location of other chemicals or cleaning solutions, etc. in the vicinity of the monitoring, and other relevant items should be documented as they are helpful in the overall analysis of the data. A photoionization detector (PID) capable of reading in parts per billion (ppb) should be used to evaluate the chemicals or cleaning solutions. A chemical inventory should be conducted using visual observations and the PID prior to sampling.

• Photographs of sampling locations and any items, chemicals, or activities that could have influenced the sampling event should also be taken.

• Samples must be submitted with chain-of-custody documentation to a Tennessee accredited analytical laboratory for analysis.

Sample Collection Duration

Depending on the proposed use of the former drycleaner, sample collection during can be either an 8-hour duration to simulate a normal workday exposure, or a 24-hour duration to simulate a residential exposure. Samples should be collected anytime during the standard workday period of approximately 7 a.m. to 6 p.m. for the 8-hour sampling period. The 24-hour sample collection duration is recommended for residences to obtain normal living exposure concentrations for the inhabitants. Other time spans can be accommodated for certain exposures such as in for retail or commercial setting (e.g. 12 hours).

Sample Collection Characteristics

A pre-sampling inspection should be performed in all spaces in which a sample is scheduled to be collected. Try to identify and minimize conditions that may interfere with the proposed testing. The inspection should evaluate the type of structure, floor layout, air flows, and physical conditions of the building(s) being sampled. This information along with information on sources of potential indoor air contamination from other substances should be compiled. Items to be noted include the following:

• construction characteristics of the building including foundation cracks and utility penetrations,

• presence of attached garage or work area,

• recent renovations or maintenance to the building (e.g., fresh paint, new carpet, etc.),

• mechanical equipment that can effect pressure gradients (e.g., heating systems, exhaust fans, air conditioners, etc.),

• use or storage of petroleum products (fuel containers, gasoline-operated equipment),

• recent use of cleaners or products containing volatile chemicals, and

• drop off or pickup for drycleaned clothing.

Building construction characteristics of the spaces indoor air is to be sampled should be noted. In addition to cracks in the foundation or floor and utility penetrations, locations of drains or storm sewers (if beneath the floor) should also be noted.

Any buildings attached, or in very close proximity, to the location of the building in which indoor air sampling is scheduled should be noted. This includes enclosed attached storage areas or shed-like structures.

When collecting an indoor air sample within a residence, items used by residents include various hair care products, bathroom and other cleaning products, and vapors from stored items, new furniture items, or refinished furniture contain compounds whose vapors can be detected. Because of this, an inventory of items stored or used in the general location of the sample collection area should be taken. Ingredients of the products should also be recorded. The specific ingredients or compounds making up each product can be typically found on the product's label. Photographs of items are extremely helpful. If compounds contained in the products in the area of sampling are indentified in the indoor air analysis, and you have performed a product inventory or taken a sufficient number of photographs, you likely have a starting point to investigate the occurrence of the compounds detected. To minimize or prevent detection of some vapors, the resident can be contacted in advance and asked not to use these products or remove them from the area near the sampling location.

The ventilation system for the spaces sampled should be in normal operating capacity and condition during the sampling period. It is the goal of the sampling to simulate normal representative conditions and not to induce any additional variations into the sampling environment. Any heating or air conditioning system operation should be noted. Sometimes there is no control of systems if the system is shared with another tenant.

Sample Holding Time

It is advisable to ship your summa canisters back to the laboratory shortly after sampling. There is no need to "preserve" the sample containers other than making sure the brass cap is sealing the inlet. They are shipped back to the laboratory in the boxes they arrived in, and the flow controllers are returned. Analytical laboratories typically report that a hold time to analysis is up to 30 days. Typical chlorinated solvent compounds are stable over this holding time period. It is advisable to contact the analytical laboratory before sampling begins to confirm the holding time. Some compounds degrade more quickly than others and the laboratory can inform you which ones they are.

Detection Limits

Ideally, one should obtain the lowest possible detection limit for each compound when analyzed by the contract laboratory. The first sampling event will identify if the lowest detection limits can be achieved. Typically there can be interferences from degassing of infrastructure (plywood, carpets, newly painted walls, household cleaner storage, flooring) or storage of chemicals in or near the spaces tested. Currently, the State of Tennessee does not have established indoor air concentration regulations for any compound. The State typically defaults to comparison values established by the Federal Agency for Toxic Substances and Disease Registry (ATSDR). In addition, indoor air comparison values established by EPA (Regional Screening Levels for indoor air) are also reviewed. For some compounds, these established concentration values are low. A detection limit of a fraction of a part per billion (ppb) or less than 1 microgram per cubic meter (µg/m3) is usually sufficient for nearly all compounds. Some analytical laboratories do not have this capability so the analytical laboratory should be consulted before contracting with them.

Appendix C

Photographs

Photo 1 - Photo of the household products stored beneath the kitchen sink in Home A. These products were screened to see if they were off-gassing chemicals. None of the products had detectable readings of organic vapors when screened using the Photoionization detector (PID). (Photo credit: TDH, 04/18/11).

Photo 2 - View of household products stored in another area of Home A. No PID readings from these products were noted. (Photo credit: TDH, 04/18/11).

Photo 3 - Various household products stored in the basement of Home A. PID readings were 0 parts per billion for these products. (Photo credit: TDH, 04/18/11).

Photo 4 - View of trench that drains water from the basement walls to the corner sumps in Home A. Water from the outside soils or from a high water table could contain chemicals which could lead to vapor intrusion in the home (Photo credit: TDH, 04/18/11).

Photo 5 - View of sump in the northwest corner of the basement of Home A. There is an identical sump pump in the southwest corner of the basement. (Photo credit: TDH, 04/18/11).

Photo 6 - Location of indoor air sampling canister on main living level of Home A. (Photo credit: TDH, 04/18/11).

Photo 7 - The kitchen area of Home B. The PID had readings of 0 ppb throughout the portion of the home surveyed. (Photo credit: TDH, 04/18/11).

Photo 8 - Location of indoor air sampling canister on main living level of Home B. (Photo credit: TDH, 04/18/11).

Photo 9 - Storage area within closet of Home C. Household cleaning products and oils were noted. No vapors from these products were detected with the PID. (Photo credit: TDH, 04/18/11).

Photo 10 - View of household cleaning products in closet within Home C. No vapors were detected from these products using the PID. (Photo credit: TDH, 04/18/11).

Photo 11 - View of sample location in the main living level of Home C. (Photo credit: TDH, 04/18/11).

Photo 12 - View of office area of Business A. The PID indicated there were no vapors in the office area. (Photo credit: TDH, 04/18/11).

Photo 13 - Indoor air sampling canister location in the break room of Business A. (Photo credit: TDH, 04/18/11).

Photo 14 - Former IGI building portion that was sampled. Note open overhead door (right center of photo) and access door (in front of red pickup). Both Doors were open during a portion of the indoor air sampling. (Photo credit: TDH, 04/18/11).

Photo 15 - Warehouse area of the electrical supply company. Sampling location 1 is to the right. PID readings were 0 ppb here. (Photo credit: TDH, 04/18/11).

Photo 16 - Sample 1 location in the warehouse area of the electrical supply company. PID vapor readings were 0 ppb here. (Photo credit: TDH, 04/18/11).

Photo 17 - Sample location 2 in the electrical supply company. PID readings were 0 ppb for the cans of concrete and masonry bonding and primer and the battery. (Photo credit: TDH, 04/18/11).

Appendix D

Weather Information for Sampling Dates

History for Nashville, TN

Monday, April 18, 2011 — View Current Conditions

Monday, April 18, 2011

« Previous Day April 18 2011 View Next Day »

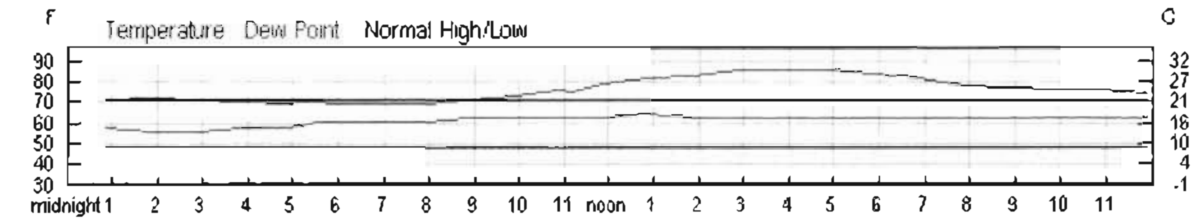
Daily Weekly Monthly Custom

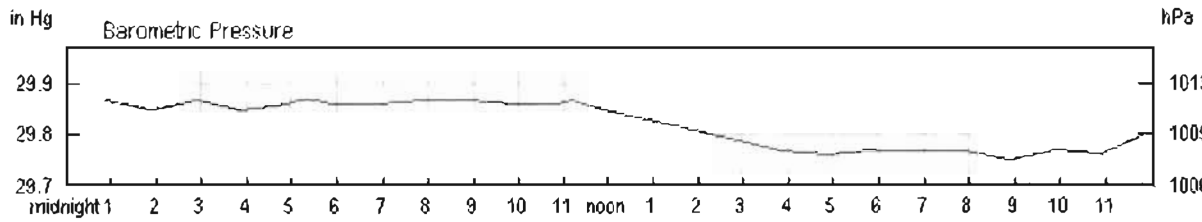
	Actual	Average	Record
Temperature			
Mean Temperature	**65** °F	**59** °F	
Max Temperature	**77** °F	**71** °F	**88** °F (1955)
Min Temperature	**52** °F	**48** °F	**28** °F (1875)
Degree Days			
Heating Degree Days	0	7	
Month to date heating degree days	115	154	
Since 1 July heating degree days	3576	3556	
Cooling Degree Days	0	1	
Month to date cooling degree days	32	17	
Year to date cooling degree days	46	26	
Growing Degree Days	14 (Base 50)		
Moisture			
Dew Point	**48** °F		
Average Humidity	53		
Maximum Humidity	70		
Minimum Humidity	36		
Precipitation			
Precipitation	**0.00** in	**0.13** in	**2.00** in (1940)
Month to date precipitation	4.30	2.32	
Year to date precipitation	16.74	14.85	
Snow			
Snow	**0.00** in	**0.00** in	**0.00** in (2002)
Month to date snowfall	0.0	0.1	
Since 1 July snowfall	12.5	9.1	
Snow Depth	**0.00** in		
Sea Level Pressure			
Sea Level Pressure	**29.91** in		
Wind			
Wind Speed	**9** mph (South)		
Max Wind Speed	**20** mph		
Max Gust Speed	**25** mph		
Visibility	**10** miles		

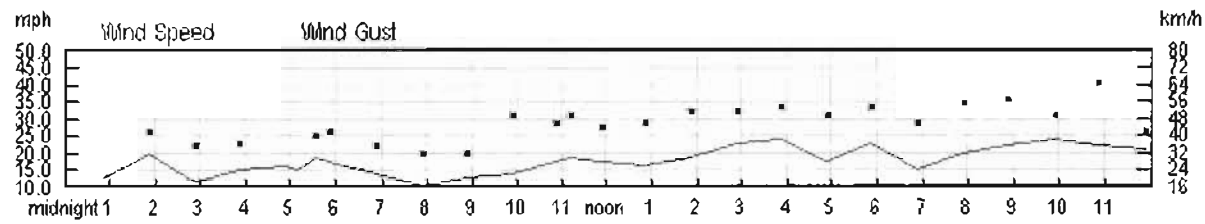
	Actual	Average	Record
Events			

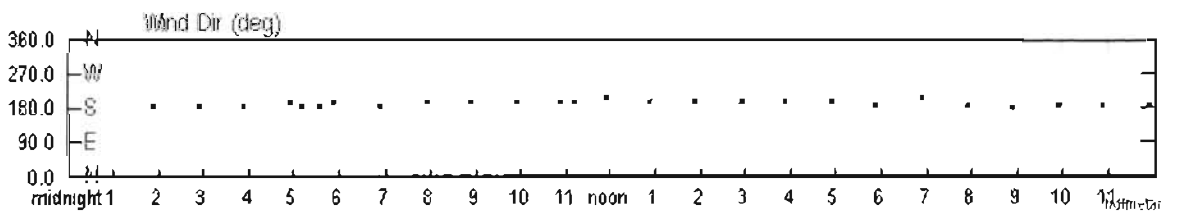
T = Trace of Precipitation, **MM** = Missing Value

Source: NWS Daily Summary









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Hourly Observations

Time (CDT)	Temp.	Dew Point	Humidity	Sea Level Pressure	Visibility	Wind Dir	Wind Speed	Gust Sp
12:53 AM	71.1 °F	57.9 °F	63%	29.87 in	10.0 miles	South	12.7 mph	20.7 mp
1:53 AM	72.0 °F	55.9 °F	57%	29.85 in	10.0 miles	South	19.6 mph	26.5 mp
2:53 AM	71.6 °F	55.4 °F	57%	29.87 in	10.0 miles	South	11.5 mph	21.9 mp
3:53 AM	70.0 °F	57.9 °F	65%	29.85 in	10.0 miles	South	15.0 mph	23.0 mp
4:53 AM	69.1 °F	57.9 °F	68%	29.86 in	10.0 miles	SSW	16.1 mph	-
5:10 AM	69.8 °F	59.0 °F	68%	29.87 in	10.0 miles	South	15.0 mph	20.7 mp

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Time (CDT)	Temp.	Dew Point	Humidity	Sea Level Pressure	Visibility	Wind Dir	Wind Speed	Gust Sp
5:34 AM	69.8 °F	60.8 °F	73%	29.87 in	10.0 miles	South	18.4 mph	25.3 mp
5:53 AM	69.1 °F	60.1 °F	73%	29.86 in	10.0 miles	SSW	17.3 mph	26.5 mp
6:53 AM	69.1 °F	61.0 °F	75%	29.86 in	10.0 miles	South	13.8 mph	21.9 mp
7:53 AM	69.1 °F	61.0 °F	75%	29.87 in	10.0 miles	SSW	10.4 mph	19.6 mp
8:53 AM	71.1 °F	62.1 °F	73%	29.87 in	10.0 miles	SSW	12.7 mph	19.6 mp
9:53 AM	73.0 °F	63.0 °F	71%	29.86 in	10.0 miles	SSW	13.8 mph	31.1 mp
10:53 AM	75.9 °F	63.0 °F	64%	29.86 in	10.0 miles	SSW	17.3 mph	28.8 mp
11:12 AM	75.2 °F	62.6 °F	65%	29.87 in	10.0 miles	SSW	18.4 mph	31.1 mp
11:53 AM	79.0 °F	63.0 °F	58%	29.85 in	10.0 miles	SSW	17.3 mph	27.6 mp
12:53 PM	82.0 °F	64.0 °F	54%	29.83 in	10.0 miles	SSW	16.1 mph	28.8 mp
1:53 PM	82.9 °F	63.0 °F	51%	29.81 in	10.0 miles	SSW	18.4 mph	32.2 mp
2:53 PM	86.0 °F	62.1 °F	44%	29.79 in	10.0 miles	SSW	23.0 mph	32.2 mp
3:53 PM	86.0 °F	62.1 °F	44%	29.77 in	10.0 miles	SSW	24.2 mph	33.4 mp
4:53 PM	86.0 °F	62.1 °F	44%	29.76 in	10.0 miles	SSW	17.3 mph	31.1 mp
5:53 PM	84.0 °F	63.0 °F	49%	29.77 in	10.0 miles	South	23.0 mph	33.4 mp
6:53 PM	82.0 °F	62.1 °F	51%	29.77 in	10.0 miles	SSW	15.0 mph	28.8 mp
7:53 PM	78.1 °F	63.0 °F	60%	29.77 in	10.0 miles	South	19.6 mph	34.5 mp
8:53 PM	77.0 °F	63.0 °F	62%	29.75 in	10.0 miles	South	21.9 mph	35.7 mp
9:53 PM	75.9 °F	62.1 °F	62%	29.77 in	10.0 miles	South	24.2 mph	31.1 mp
10:53 PM	75.9 °F	62.1 °F	62%	29.76 in	10.0 miles	South	21.9 mph	40.3 mp
11:53 PM	73.9 °F	63.0 °F	68%	29.80 in	10.0 miles	South	20.7 mph	26.5 mp

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History for Nashville, TN

Tuesday, April 19, 2011 — View Current Conditions

Tuesday, April 19, 2011

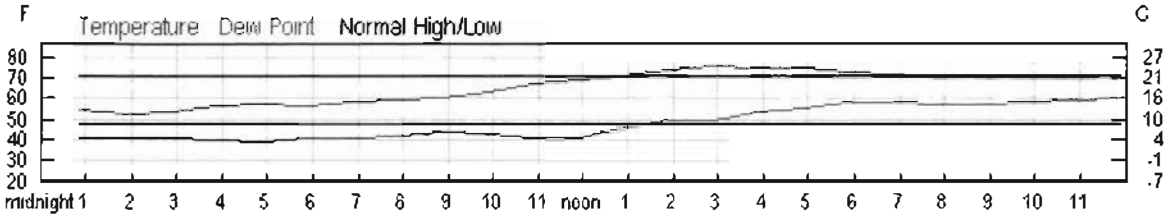
« Previous Day April 19 2011 View Next Day »

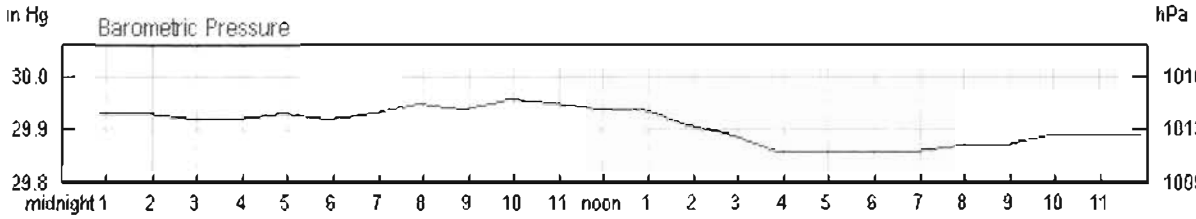
Daily Weekly Monthly Custom

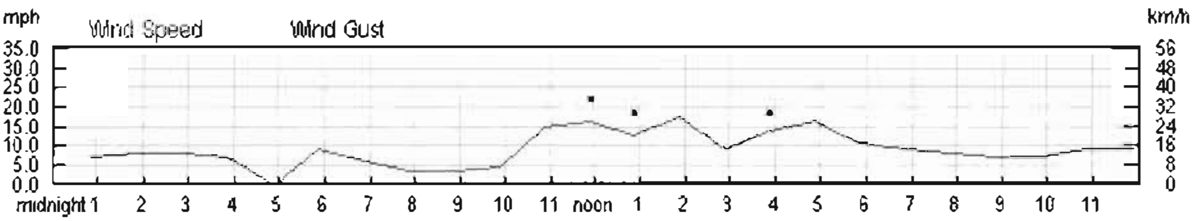
	Actual	Average	Record
Temperature			
Mean Temperature	**78** °F	**59** °F	
Max Temperature	**86** °F	**71** °F	**88** °F (2006)
Min Temperature	**69** °F	**48** °F	**27** °F (1983)
Degree Days			
Heating Degree Days	0	6	
Month to date heating degree days	115	160	
Since 1 July heating degree days	3576	3562	
Cooling Degree Days	13	1	
Month to date cooling degree days	45	18	
Year to date cooling degree days	59	27	
Growing Degree Days	28 (Base 50)		
Moisture			
Dew Point	**61** °F		
Average Humidity	59		
Maximum Humidity	73		
Minimum Humidity	45		
Precipitation			
Precipitation	**0.00** in	**0.13** in	**1.80** in (1981)
Month to date precipitation	4.30	2.45	
Year to date precipitation	16.74	14.98	
Snow			
Snow	**0.00** in	**0.00** in	**0.00** in (2002)
Month to date snowfall	0.0	0.1	
Since 1 July snowfall	12.5	9.1	
Snow Depth	**0.00** in		
Sea Level Pressure			
Sea Level Pressure	**29.83** in		
Wind			
Wind Speed	**18** mph (SSW)		
Max Wind Speed	**31** mph		
Max Gust Speed	**43** mph		
Visibility	**10** miles		

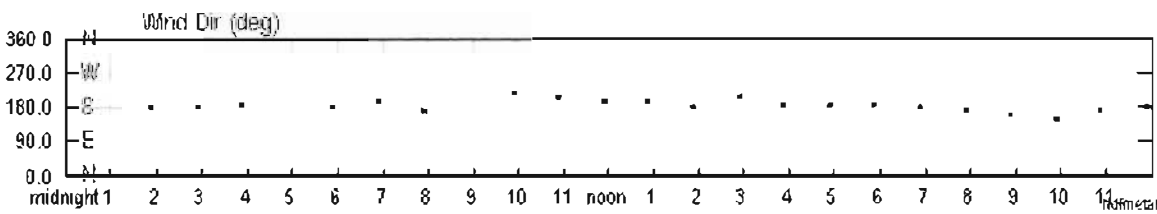
	Actual	Average	Record
Events			

T = Trace of Precipitation, **MM** = Missing Value **Source:** NWS Daily Summary









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Hourly Observations

Time (CDT)	Temp.	Dew Point	Humidity	Sea Level Pressure	Visibility	Wind Dir	Wind Speed	Gust Sp
12:53 AM	**54.0** °F	**41.0** °F	62%	**29.93** in	**10.0** miles	South	**6.9** mph	-
1:53 AM	**52.0** °F	**41.0** °F	66%	**29.93** in	**10.0** miles	South	**8.1** mph	-
2:53 AM	**53.1** °F	**41.0** °F	64%	**29.92** in	**10.0** miles	South	**8.1** mph	-
3:53 AM	**55.9** °F	**39.9** °F	55%	**29.92** in	**10.0** miles	South	**6.9** mph	-

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Time (CDT)	Temp.	Dew Point	Humidity	Sea Level Pressure	Visibility	Wind Dir	Wind Speed	Gust Sp
4 53 AM	57.0 °F	39.0 °F	51%	29.93 in	10.0 miles	Calm	Calm	-
5:53 AM	55.9 °F	41.0 °F	57%	29.92 in	10.0 miles	South	9.2 mph	-
6:53 AM	57.9 °F	41.0 °F	53%	29.93 in	10.0 miles	SSW	5.8 mph	-
7:53 AM	59.0 °F	42.1 °F	53%	29.95 in	10.0 miles	South	3.5 mph	-
8:53 AM	60.1 °F	44.1 °F	55%	29.94 in	10.0 miles	Variable	3.5 mph	-
9.53 AM	63.0 °F	43.0 °F	48%	29.96 in	10.0 miles	SW	4.6 mph	-
10:53 AM	66.9 °F	41.0 °F	39%	29.95 in	10.0 miles	SSW	15.0 mph	25.3 mp
11:53 AM	69.1 °F	41.0 °F	36%	29.94 in	10.0 miles	SSW	16.1 mph	21.9 mp
12:53 PM	71.1 °F	46.0 °F	41%	29.94 in	10.0 miles	SSW	12.7 mph	18.4 mp
1.53 PM	73.9 °F	50.0 °F	43%	29.91 in	10.0 miles	South	17.3 mph	-
2:53 PM	75.9 °F	50.0 °F	40%	29.89 in	10.0 miles	SSW	9.2 mph	20.7 mp
3 53 PM	75.0 °F	53.1 °F	46%	29.86 in	10.0 miles	South	13.8 mph	18.4 mp
4 53 PM	75.2 °F	55.4 °F	50%	29.86 in	10.0 miles	South	16.1 mph	-
5 53 PM	73.0 °F	57.9 °F	59%	29.86 in	10.0 miles	South	10.4 mph	-
6:53 PM	72.0 °F	57.9 °F	61%	29.86 in	10.0 miles	South	9.2 mph	-
7.53 PM	69.8 °F	57.2 °F	64%	29.87 in	10.0 miles	South	8.1 mph	-
8:53 PM	70.0 °F	57.0 °F	63%	29.87 in	10.0 miles	SSE	6.9 mph	-
9:53 PM	70.0 °F	57.9 °F	65%	29.89 in	10.0 miles	SSE	6.9 mph	-
10:53 PM	70.0 °F	59.0 °F	68%	29.89 in	10.0 miles	South	9.2 mph	-
11:53 PM	71.1 °F	60.1 °F	68%	29.89 in	10.0 miles	South	9.2 mph	-

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