Health Consultation

LEBANON ROAD LANDFILL

NASHVILLE, DAVIDSON COUNTY, TENNESSEE

EPA FACILITY ID: TND980848204

JUNE 10, 2008

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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

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

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HEALTH CONSULTATION

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Prepared By:

Tennessee Department of Health
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Foreword

This document summarizes an environmental public health investigation performed by Environmental Epidemiology of the State of Tennessee Department of Health. 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 actions 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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Or call us at: 615-741-7247 or toll-free 1-800-404-3006 during normal business hours

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Introduction

The Tennessee Department of Environment and Conservation (TDEC), Division of Remediation (DoR), contacted the Tennessee Department of Health (TDH), Environmental Epidemiology Program (EEP), about landfill gas vapor intrusion concerns in buildings near the old Lebanon Road Landfill (LRL). In the past, indoor methane vapor levels were measured above the lower explosive limit (LEL). This explosion hazard led to the installation of a passive vapor extraction system. TDEC DoR continues to provide oversight for the site, and they remain concerned about the danger of methane gas. This public Health Consultation will assist TDEC DoR in their role to ensure site safety now and in the future.

Background

The Lebanon Road Landfill (LRL) is located in urban Nashville, Davidson County, Tennessee, a few miles east of downtown. The site located at 1450 Lebanon Pike, Zip Code 37210. The wedge-shaped site is 30 acres in size (Figure 1). It operated from 1971 to 1974. Over those years, an unknown amount of unknown wastes were buried in the LRL.

Ownership and leasing of the site has changed over the years. Some of the stakeholders involved include: the former waste operator the Metropolitan Nashville and Davidson County Government Department of Public Works (Metro), the property owner TN Services Corporation, and the current site user Manheim's Tennessee Auto Auction (AA). Many Site actions are directed by the TDEC Commissioners' Report Case No. 96-0109 which states, "Metro shall perform any remedial activities required by the Record of Decision, except that as long as the Site is in active use by a company affiliated with AA, AA shall maintain any asphalt pavement installed at the Site in a manner consistent with the Site's commercial use. If AA's obligation under this subparagraph expires, responsibility is no longer obligated to maintain asphalt under this subparagraph, AA shall give notice to Metro…"

There are several buildings on the site (Figure 1). The main office and sales space is located near Lebanon Road, uphill from the known landfilled areas. A small rock house, which is seldom used, is located in the southeastern corner of the site. Offices A and B, which include the maintenance garage, are on the west side of the site. Another office, called the Graveyard Building in site files, is located at a lower elevation on the far north side of the site. The site is mostly an asphalt parking lot. After years of waste decomposition, the asphalt has sunk. The parking lot has a rolling, hilly appearance (Figure 2).

Two on-site ponds, which are a backwater of the Cumberland River, were filled with waste when the landfill was in use. A natural groundwater spring flows through the site. Several environmental inspections were performed, between 1972 and 1980, to characterize the site. The site was promulgated as state Superfund site #19-524 in 1985. The landfill was capped by the asphalt parking lot to prevent rain or surface water from infiltrating the waste and creating additional leachate.

Although the leachate was mainly an off-site concern, there is an on-site hazard. Methane gas is a common byproduct of landfill waste decomposition. Over the years, methane measurements

gradually increased. At times during 2002 to 2003, the methane measurements exceeded the lower explosive limit within the Graveyard Building. A passive gas removal system was put into the building in December 2003. After the installation, the methane levels in the building quickly decreased. Over time, the methane levels crept back up. Maintenance, including sealing cracks to prevent vapor intrusion, was performed in June 2005. Since that time, methane gas monitoring has recorded only low levels of the potentially explosive gas. This health consultation will discuss the potential for methane gas to be a health hazard now or in the future.

Discussion

Traditional chemical exposure pathways may be present at the LRL. However, for the old landfill site, any risks from chemicals that might be toxic are perceived to be low. At this site, the chemical property that is most important is flammability. Methane gas is the main concern for physical hazards due to fire or explosion.

Methane

Methane is a colorless, odorless gas. It is readily flammable. Methane is a simple asphyxiant when inhaled. It displaces air, which lowers the partial pressure of oxygen, causing hypoxia (HSDB 2007a).

Methane is not considered a toxin. Rather, its combustibility and flammability make it an explosion and fire hazard. The amount of methane needed to be explosive in air, or methane's lower explosive limit (LEL), is 5% or 50,000 parts per million (ppm). At this level there is the proper ratio of methane to oxygen in air to allow for combustion if an ignition source is present. For the workplace, 10% of the LEL, or 5,000 ppm is often considered a warning level. In many LRL site reports, 25% of the LEL for methane or 12,500 ppm, was used as a level for corrective action.

Environmental Sampling for Methane

Several reports in the TDEC DoR site file for 19-524 (2007) contain the environmental sampling data. Gresham, Smith, and Partners, a Nashville-based Consultant performed the most recent methane gas monitoring.

Background Ambient Air Sampling

Between March 16, 2001, and March 5, 2007, a total of 34 background air measurements were collected. The values ranged from 0.40 to 20.00 ppm methane. The average methane background level over the six years was 5.49 ppm.

Indoor Air

Indoor air samples were collected within several buildings, including the offices, rock house, and Graveyard Building. Typically, the methane levels measured were low. See Table 1 for the methane levels measured quarterly from 2001 to 2007.

The Graveyard Building, however, seemed to accumulate more methane over time. In 2001, methane gas measurements were fairly low. In 2002, the level began to rise. By October 2002, the methane level had risen above the 25% LEL action level, and monitoring became more frequent. Figure 3 shows the methane gas concentration trend over time. Figure 3 has two horizontal lines to help illustrate the LEL and the 25% of the LEL action level. The methane level in the Graveyard Building stayed above the action level and sometimes even exceeded the lower explosive limit. Corrective action became necessary. In late 2003, a passive vapor removal system was installed. This system worked to remove methane vapors from under the building before they might otherwise enter the building. The system seemed to work well as methane levels dropped dramatically. After a while, methane levels crept up again, and maintenance was performed in June 2005. Cracks in the floor were caulked to minimize the opportunity for landfill gas to flow into the building. The maintenance seemed to have worked, as the quarterly indoor air sampling from March 2006 through July 2007 showed no problem due to methane.

Other Landfill Gases

There are other gases that are common byproducts of landfill waste decomposition. Carbon dioxide is as common as methane. Carbon dioxide is colorless and odorless. As of this report, Environmental Epidemiology was not aware of any concerns due to elevated levels of carbon dioxide within buildings at the LRL.

Another group of landfill gases is the sulfides. Gases, such as hydrogen sulfide, are produced in small amounts when waste decomposes (ATSDR 2006). As of this report, Environmental Epidemiology was not aware of any measurements of sulfide vapors collected at the LRL. Some sulfides are likely to be present on-site, as unpleasant odors were reported some mornings within the Graveyard Building. Landfill materials generate many times more methane vapors than sulfide vapors.

A detailed discussion of landfill gases (ATSDR 2003a) is provided in Appendix A for readers wanting to know more about the chemicals produced when organic landfill materials decompose.

Child Health Considerations

The current use of this site is as an automotive auction business. Children are not likely visitors to this commercial/industrial site. Methane can be an explosive hazard dangerous to all persons. Children would be at greater risk as they will be unable to make intelligent decisions regarding this silent, colorless, and odorless gas.

Site Visit

On Wednesday morning, July 11, 2007, a site visit was conducted. Pamela Franklin, DoR, escorted Michelle Weiss, Metro Nashville Public Health Department, and David Borowski, TDH, around the site. The buildings in which methane monitoring had been conducted were visited. The passive vapor removal systems for the Rock House and Graveyard Building were

both seen. (Note the automobile auction workers do not use the name "Graveyard Building" though it will continue to be used for continuity in presenting the site data.)

The large size of the site and unevenness of the asphalt pavement were noted. Recent rain helped to show the surface drainage pattern as well as the low areas of the asphalt parking lot. As shown in Figure 4, a portion of asphalt that was sunken and severely cracked was noted as a possible compromise in the landfill cap.

As the Graveyard Building had the highest past methane levels, extra time was spent observing the building, talking with those who worked in it, and viewing its vapor removal system (Figure 5). An impromptu employee interview provided several important points to note. The building is used infrequently as an office space for about three workers who work in the car lot far from the main office. The building has heating and cooling that worked well for indoor climate control and ventilation.

The workers knew about the methane concerns related to the site. They knew about the two vent pipes designed to keep the methane out of the Graveyard Building (Figure 5). We were shown an area of tile floor that had been repaired and was again separating (Figure 6). They said they did not know how to tell if the passive vapor removal system was working. Also, they did not think the building had a methane monitoring alarm system. They reported an early morning "methane odor." Oftentimes when arriving to work in the morning, they would prop the door open to ventilate the Graveyard Building. This is interesting in that methane itself has no odor but other landfill products such sulfides do have unpleasant smells. It would be safe to assume that if sulfides are present in the building, then methane would be present, too.

Future Safety

The most recent methane monitoring data does not suggest an explosion hazard. What future monitoring data will show is obviously unknown. To ensure the safety of workers or visitors to the automobile auction, a/k/a Lebanon Road Landfill, safety precautions are encouraged.

Methane gas in the Graveyard Building has been an on-going site concern. There are several precautions that can minimize any hazard due to methane for workers. First, on-going preventative maintenance should be performed. At least annually, the passive vapor removal system should be inspected. Also, any building foundation, floor, or plumbing cracks that could allow vapor intrusion should be sealed. As part of the normal routine at the start of a workday, the building door can be opened and left open to ventilate it. A few minutes of air mixing between the indoor air and the outdoor ambient air should allow any methane that may have accumulated to disperse. Continual use of the building's ventilation system or another vent fan is encouraged. Continual use means twenty-four hours per day and seven days per week. Non-sparking fans should be used where flammable vapors may be present. Maintaining an inflow of outdoor air into the Graveyard Building will create a positive pressure situation which will discourage vapors from rising into the building from below. It is suggested that when a new HVAC system is required for this building, a new make-up air HVAC system would be selected to increase the ventilation in the building. Next, an explosive gas monitor with alarm should be installed. Employees should be trained to understand the explosive gas monitor in case an alarm

should sound. A safety plan for action or evacuation is needed. In case of a small fire, a fire extinguisher should be kept handy.

As the current site user, the auto auction business is well aware of ventilation and fire issues from automobiles on their lot and in their buildings. Still, having a well-developed safety plan that includes the risks posed by landfill gas is encouraged. As methane can be emitted from simple pavement cracks, a good safety plan will include a minimization of ignition sources. Convenient, safe containers for cigarette butts, matches, and other flammables are encouraged. There have been accidents at other landfills, such as methane flares due to improper cigarette disposal at recreational facilities built on top of landfills. Simple static electricity can be enough of a spark to ignite methane gas. With hundreds of automobiles in the parking lot over the landfill, even a small fuel leak near a crack could lead to a flare or fire. The use of non-sparking tools would be preferred. Having fire extinguishers in useful places is a good idea. As a measure of preparedness, employees and the local fire department should be notified about the methane gas considerations at this property. Emergency response and an evacuation route should also be part of the site safety plan.

The site safety plan should include appropriate employee training that teaches about the unique site conditions, the use of safety equipment, and the understanding of monitoring devices. Records of the monitoring data should be maintained. Elevated methane levels should be noted and reported.

Methane can readily escape from cracks in the landfill's asphalt cover. Given elevated levels of methane and an ignition source, methane flares or fires are possible. Therefore, as part of annual preventative maintenance, checking asphalt cracks for methane venting is strongly encouraged. This can be performed by sweeping the area using a field instrument such as an explosive gas detector. Any cracks or areas that show methane release can then be sealed. This type of sampling is best performed in the winter on a cool, clear morning. The methane vapor, a bit warmer underground, should more readily escape through the cold, contracted pavement and thus be more easily detected by the explosive gas detector.

The LRL Site would benefit from institutional control including placing future developmental activities into the Metro permit tracking system. This will enable MPHD to review and sign off on future projects to ensure that there will be no significant health risk to the public. Since there is both landfill material and landfill gas at the property, a land use restriction is in order. If the property should be sold or leased, future users of the property need to be aware of the special circumstances of the site by the land use restrictions associated with the deed and the permit tracking system If any type of construction work permit is requested on this site then the permit requestor will be notified of the restrictions and the requirements under which the permit was being issued if at all. Obviously, extensive digging into the landfill is problematic. New building construction over the landfill should be engineered to prevent landfill gases from entering the buildings. Workers at the site need to be trained about fire prevention and safety.

Conclusions

1. A current and future public health hazard exists in the Graveyard Building, at the Lebanon Road Landfill site in Davidson County, Tennessee, due to the unpredictable nature of methane vapor intrusion which can lead to fire or explosion.

2. If appropriate actions are not taken, a future public health hazard due to the flammable property of methane is possible as the asphalt landfill cap cracks or becomes otherwise compromised over time.

Recommendations

1. Immediately, install a methane alarm in the Graveyard Building where methane levels have been elevated in the past because monitoring is the only way to know the amount of methane present in the air.

2. Continual operation, that is twenty-four hours per day, of the passive vapor mitigation systems installed on site buildings should be required.

3. Preventive maintenance needs to be a requirement if this site is actively used. This would include inspection of passive vapor mitigation systems, sealing cracks in the Graveyard Building, and routine checks of the integrity of the entire asphalt landfill cap.

4. A site safety plan that includes fire prevention and emergency evacuation due to the potential methane hazard should be required for users of this old waste site.

5. Employees must be trained to understand safety equipment and procedures such as the methane monitor and the site safety plan.

6. An institutional control to limit future use of this waste site should be implemented.

Public Health Action Plan

1. EEP will provide this public health consultation to the government agencies responsible for oversight of the LRL and indicate the need to complete proposed recommendations.

2. EEP, working with TDEC, will provide this report and any needed health education to the property owner or site users.

3. EEP is available to review additional data for the LRL Site as needed.

References

[ATSDR] Agency for Toxic Substances and Disease Registry. 2006. Toxicological profile for hydrogen sulfide. Atlanta, GA: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2003a. Landfill gas primer. Available from: http://www.atsdr.cdc.gov/HAC/landfill/html/preface.html. Last accessed July 18, 2007.

[EPA IRIS] United States Environmental Protection Agency Integrated Risk Information System. 2007a. Available from: *http://www.epa.gov/iris*. Last accessed, June 7, 2007.

[HSDB] Hazardous Substances Data Bank. 2007a. Available from: *http://toxnet.nlm.nih.gov*. Last accessed, September 13, 2007.

[TDEC DoR] Tennessee Department of Environment and Conservation Division of Remediation. 2007. Project file TDOR 19-524. Last viewed, September 13, 2007.

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Table and Figures

TABLE 1. Methane gas levels, shown in parts per million (ppm) measured at several different locations at the Lebanon Road Landfill, Nashville, Davidson County, TN, between March 16, 2001 – July 13, 2007. *(Values from site files may not be significant digits.)* (TDEC DoR 2007)

Date	3/16/01	06/29/01	10/19/01	10/26/01	3/1/02	3/4/02	6/6/02	8/27/02	8/28/02
Background	20.00	15.51	3.01	250.00	6.52	<500.00	1.05	2.33	NA
Graveyard – Inside	<10.0	321.00	1,691.00	NA	6.52	<500.00	606.00	2,436.00	3,600.00
Graveyard – Outside	<10.1	15.51	513.00	NA	6.52	<500.00	30.63	515.00	NA
Office A	<10.2	1.68	31.59	NA	5.43	<500.00	1.03	5.63	NA
Office B	<10.3	1.44	3.28	NA	5.31	<500.00	0.63	4.20	NA
Canopied Building	<10.4	1.92	2.59	NA	3.78	<500.00	1.64	2.92	NA
Rock House	<10.5	64.58	1,920.00	112.00	4.32	<500.00	204.00	2,478.00	3,038.00
Front Office Building	NA	NA	NA	NA	NA	NA	NA	49.65	NA

Date	10/11/02	10/14/02	12/17/02	1/31/03	2/19/03	3/4/03	4/4/03	5/22/03	6/12/03
Background	3.22	4.08	3.90	1.06	1.66	NA	4.51	1.07	0.96
Graveyard – Inside	3,330.00	14,100.00	18,700.00	18,000.00	250.00	NA	663.00	50,600.00	47,600.00
Graveyard – Outside	84.00	65.56	433.00	1,188.00	50,000.00	NA	15.93	1,350.00	5,200.00
Office A	31.77	NA	4.32	0.33	NA	NA	27.80	2.54	35.96
Office B	9.52	NA	39.86	1.50	NA	NA	128.00	4.17	19.81
Canopied Building	3.12	NA	4.33	0.06	NA	NA	0.53	0.94	1.82
Rock House	2,245.00	83.64	35.54	493.00	NA	NA	1,033.00	850.00	143.00
Front Office Building	91.05	NA	3.90	77.18	NA	NA	58.80	132.00	58.92

Date	7/2/03	8/28/03	9/11/03	10/29/03	12/13/03	12/15/03	12/17/03*	12/21/03*	12/29/03*
Background	1.06	0.96	1.06	7.50	2.01	NA	NA	NA	0.40
Graveyard – Inside	81,000.00	3,300.00	40,000.00	5,542.00	33,300.00	29,000.00	246.00	17,000.00	26.88
Graveyard – Outside	23,800.00	7,500.00	470.00	10.22	17,000.00		27.28	143.00	4.60
Office A	31.24	27.05	14.03	13.67	7.20	NA	NA	NA	NA
Office B	2.11	27.75	7.83	15.01	4.44	NA	NA	NA	NA
Canopied Building	3.45	3.20	5.74	14.01	9.92	NA	NA	NA	NA
Rock House	132.00	50.04	63.01	120.00	86.00	NA	NA	NA	NA
Front Office Building	152.00	110.00	135.00	103.00	164.00	NA	NA	NA	NA
* = time period when the passive vapor mitigation system was installed in the Graveyard Building									

Date	1/30/04	6/18/04	7/14/04	9/29/04	10/25/04	12/20/04	1/3/05	2/4/05	3/2/05
Background	3.09	-5.67	NA	0.82	7.08	3.86	2.90	4.31	NA
Graveyard – Inside	1,012.00	702.00	205.00	2,800.00	21,000.00	15,000.00	19,000.00	38,900.00	41,800.00
Graveyard – Outside	5.21	1,305.00	NA	110.00	522.00	982.00	NA	5.31	1,600.00
Office A	NA	20.67	141.00	0.32	1.34	-0.98	205.00	7.30	NA
Office B	NA	0.46	115.00	0.66	0.32	-1.60	54.30	6.58	NA
Canopied Building	NA	-5.53	120.00	1.27	0.47	2.89	6.30	71.00	NA
Rock House	NA	24.50	31.25	8.13	0.30	598.00	130.00	101.00	NA
Front Office Building	NA	981.00	3,440.00	121.00	54.59	526.00	805.00	105.00	NA

Date	6/20/05†	7/13/05	8/26/05	10/31/05	12/1/05	1/25/06	6/16/06	7/6/06	12/6/06
Background	NA	NA	NA	4.38	4.97	13.78	19.43	2.33	2.31
Graveyard – Inside	760	513	5.98	84.50	103.00	203.00	3,470	985	871
Graveyard – Outside	NA	NA	NA	11,000.00‡	14,000.00‡	184.00	4,001	41,800	51,800
Office A	NA	31.08	NA	18.19	4.95	7.84	73.08	296	11.6
Office B	NA	29.52	NA	69.05	13.98	6.78	41.9	23.64	18.79
Canopied Building	NA	3.17	NA	4.67	63.00	9.11	31.94	156	13.15
Rock House	NA	782	NA	391.00	511.00	336.00	302	43.12	98.17
Front Office Building	NA	104	NA	89.00	71.00	184.00	151	1,203	101

† = time period when the maintenance including sealing floor cracks was performed to the Graveyard Building
‡ = sampling directly over a crack in the concrete

Date	3/5/07	4/20/07	07/13/07
Background	2.81	2.45	4.2
Graveyard – Inside	85.30	1,745	250
Graveyard – Outside	80.70	40.83	2,900
Office A	6.75	3.45	3.45
Office B	8.23	3.43	3.43
Canopied Building	2.81	2.47	1.27
Rock House	80.26	35.67	404
Front Office Building	53.24	NA	45.08

FIGURE 1. Aerial image showing the current Tennessee Auto Auction land use over the former Lebanon Road Landfill. The locations where methane gas levels have been measured in site reports have been noted. (Image credit: Google 2007)

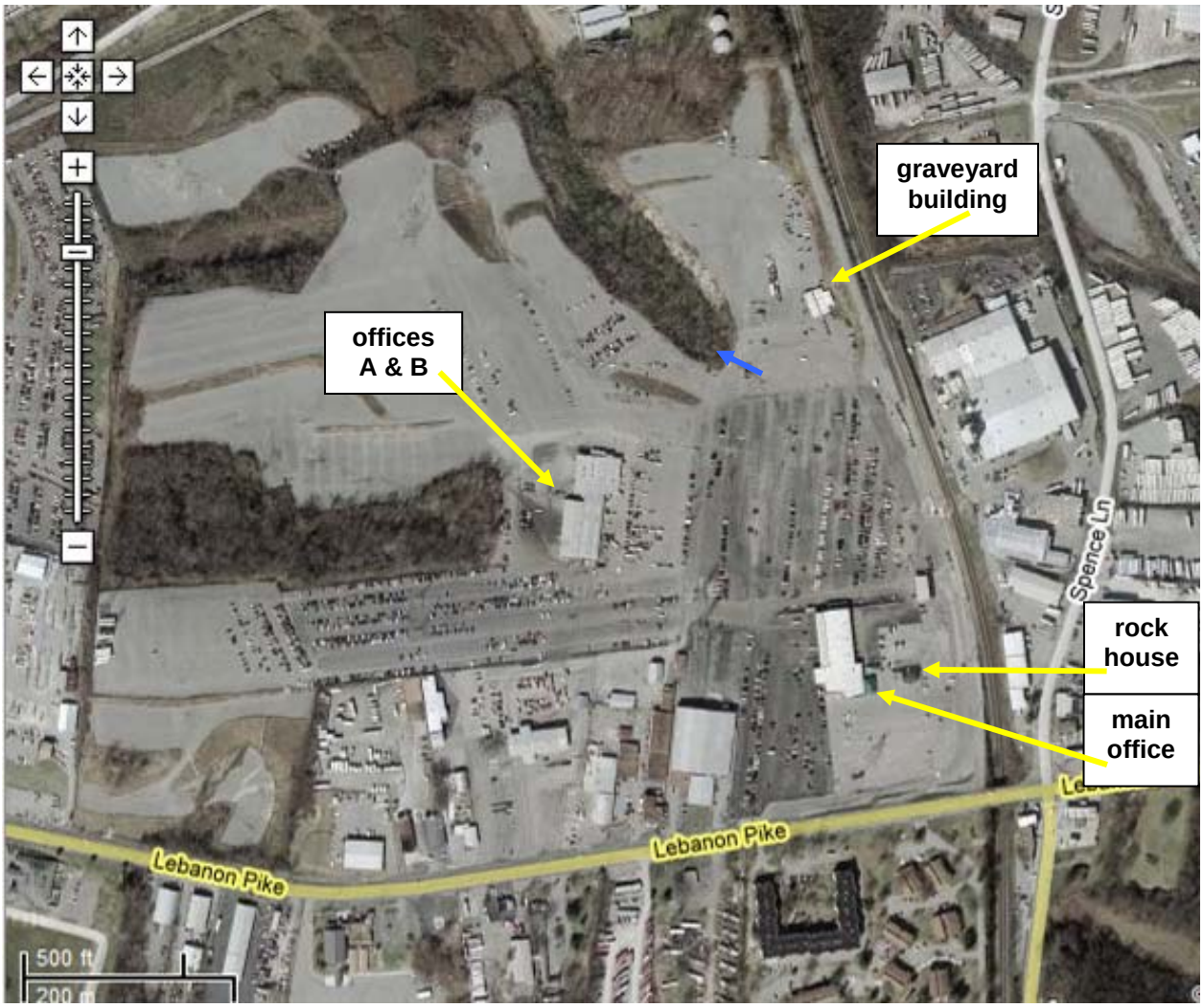


FIGURE 2. A photo facing northward taken from near the main office of the auto auction at the Lebanon Road Landfill. Note the approximate half mile the site extends and the "rolling hill" aspect of the pavement as it has sunken with the landfill over time. (TDH photo 07/11/07)

FIGURE 3. Methane gas levels, shown in parts per million (ppm) measured in and near the Graveyard Building at the Lebanon Road Landfill, Nashville, Davidson County, TN, between June 6, 2002 – July 13, 2007 (TDEC DoR 2007).

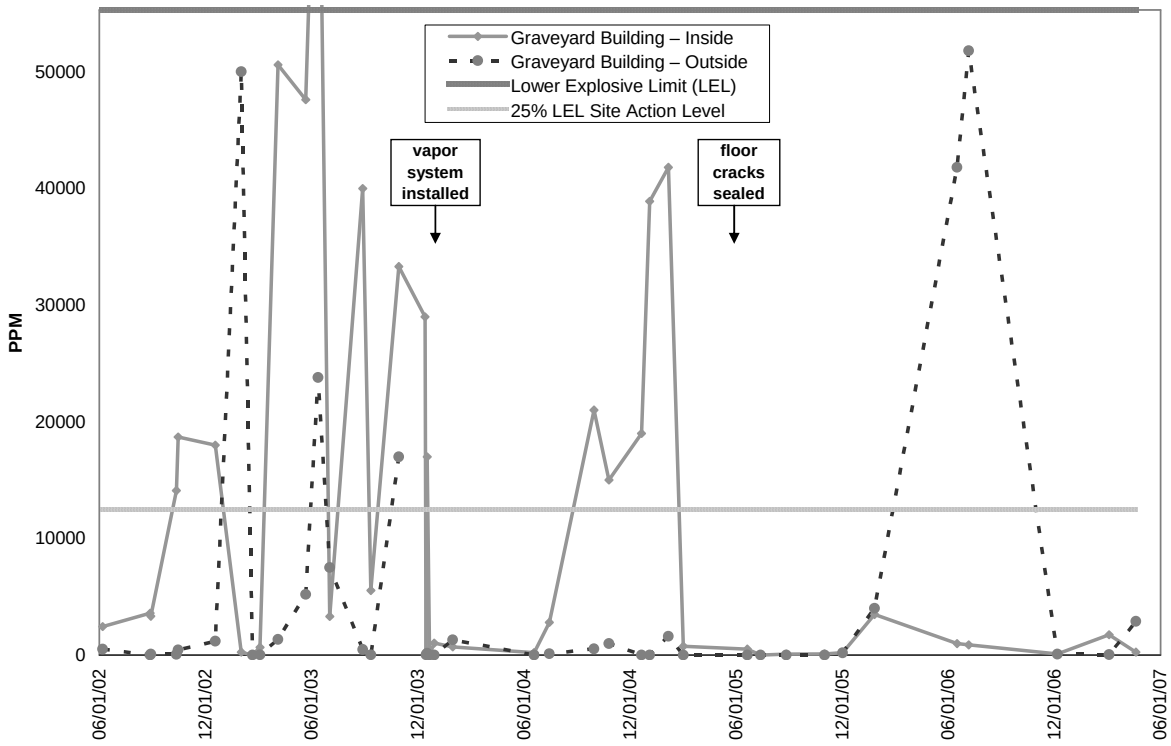


FIGURE 4. A portion of the large asphalt parking lot. The parking lot is used daily by the auto auction. The parking lot also acts as a cap over the old landfill to prevent water infiltration. The pavement has sunk over time, likely due to the landfill materials degrading. Areas, such as this one, with lots of cracks in the asphalt, suggest that landfill gases are being produced underneath and may be able to escape through the cracks.

(TDH photo 07/11/07)

FIGURE 5. The southern side of the small graveyard building. One of two vapor vents is marked. This small building contained offices for about three employees. In the past, methane gas levels were highest within this building. A passive exhaust system was installed in December 2003 to prevent landfill gas from building up within the confined space. In December 2005, additional maintenance including caulking the floor cracks was performed to limit vapor intrusion into the building. Even with the vapor mitigation system in place, workers mentioned that unpleasant odors were often present in mornings. The building has both heating and cooling systems for indoor air climate control and ventilation.

(TDH photo 07/11/07)

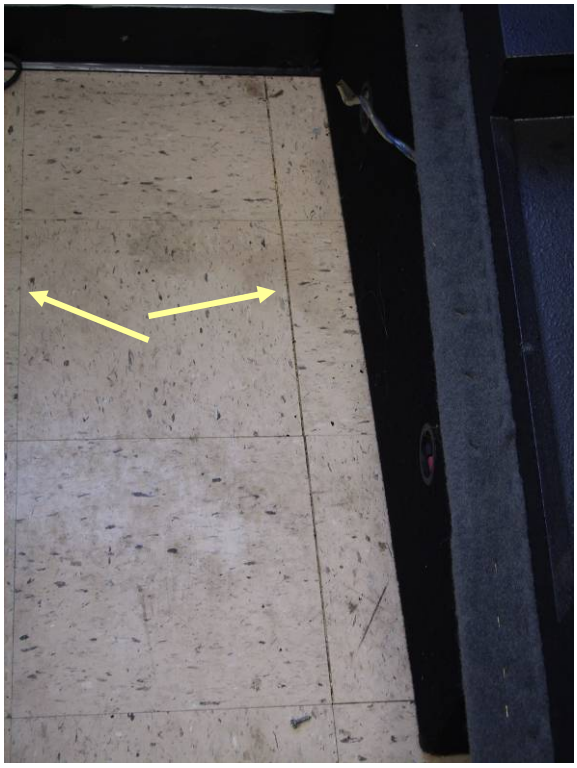


FIGURE 6. Floor tiles near the northeastern corner of the graveyard building. A previous floor crack in this area had been described as having a noticeable movement of “air” coming up through the crack. The floor had been reported to have been redone in the past few years. Even with the passive vapor mitigation system operating, widening of the floor tiles has been noticed where a past floor crack had been located. Compare the tight seem of the tiles on the left to the small gap between the tiles on the right.

(TDH photo 07/11/07)

Certification

This Public Health Consultation: *Lebanon Road Landfill, Nashville, Davidson County, Tennessee*, was prepared by the Tennessee Department of Health Environmental Epidemiology under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was prepared in accordance with the approved methodology and procedures that existed at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement Partner.

Technical Project Officer, CAT, SPAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment and concurs with the findings.

Team Leader, CAT, SPAB, DHAC, ATSDR

Appendix

Landfill Gases (ATSDR 2003a)

Typical Landfill Gas Components		
Component	**Percent by Volume**	**Characteristics**
methane	45–60	Methane is a naturally occurring gas. It is colorless and odorless. Landfills are the single largest source of U.S. man-made methane emissions
carbon dioxide	40–60	Carbon dioxide is naturally found at small concentrations in the atmosphere (0.03%). It is colorless, odorless, and slightly acidic.
nitrogen	2–5	Nitrogen comprises approximately 79% of the atmosphere. It is odorless, tasteless, and colorless.
oxygen	0.1–1	Oxygen comprises approximately 21% of the atmosphere. It is odorless, tasteless, and colorless.
ammonia	0.1–1	Ammonia is a colorless gas with a pungent odor.
NMOCs (non-methane organic compounds)	0.01–0.6	NMOCs are organic compounds (i.e., compounds that contain carbon). (Methane is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes. NMOCs most commonly found in landfills include acrylonitrile, benzene, 1,1-dichloroethane, 1,2-cis dichloroethylene, dichloromethane, carbonyl sulfide, ethyl-benzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, and xylenes.
sulfides	0–1	Sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans) are naturally occurring gases that give the landfill gas mixture its rotten-egg smell. Sulfides can cause unpleasant odors even at very low concentrations.
hydrogen	0–0.2	Hydrogen is an odorless, colorless gas.
carbon monoxide	0–0.2	Carbon monoxide is an odorless, colorless gas.
Source: Tchobanoglous, Theisen, and Vigil 1993; EPA 1995		

Methane CH_4

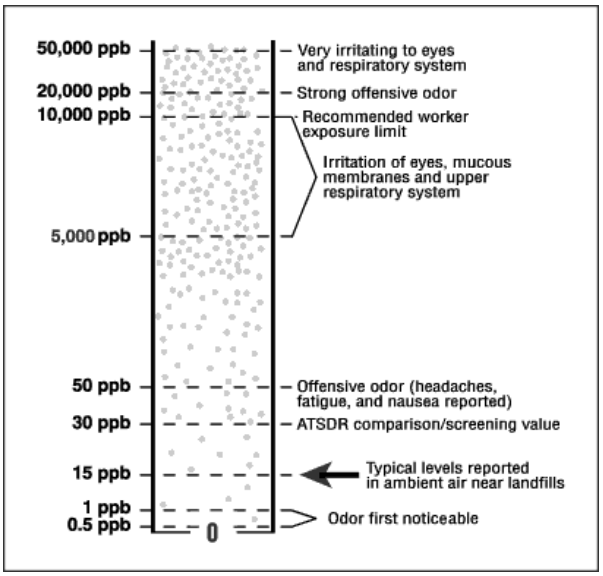
Methane is a colorless, odourless gas. It is the simplest carbon-based organic molecule, having one carbon atom surrounded by four hydrogen atoms. Occurring naturally through decomposition of organics, methane gas is highly flammable.

In landfills, methane is often found to comprise 50% of the gases by volume. At that level, methane dominants the atmosphere and cannot combust. If, however, the methane migrates away from the landfill and mixes with oxygen in ambient air to 5%–15% of the atmosphere by volume, an explosion potential arises, which needs only an ignition source.

Sulfides S-R

Sulfides, including hydrogen sulfide, dimethyl sulfide, and mercaptans, are common odorous gases associated with landfills. These gases produce a strong rotten-egg smell—even at very low concentrations. Hydrogen sulfide is the most common of the three. Humans are extremely sensitive to hydrogen sulfide odor and can detect ½ to 1 part per billion (ppb). The following diagram details the effects of sulfides with increasing air concentration. Notice that a level of only 50 ppb is described as an offensive odor capable of causing headaches, fatigue, and nausea.

Sulfide Level–Human Discomfort Comparison



Sulfides can cause eye irritation and can lead to headaches, fatigue, and nausea. That said, no known adverse health effects have been associated with prolonged exposure to low levels of sulfides. Studies of workers in animal processing and sewage treatment plants found that eye irritations due to hydrogen sulfide often occurred between 5,000 ppb and 10,000 ppb.

Ammonia NH_3

Ammonia is another odorous gas produced by the decomposition of organic matter in landfills. Ammonia is common in the environment and is required by plant and animal life. Ammonia has a familiar smell, stemming from its use as a common household cleaner. Humans are much less sensitive to the odor of ammonia than they are to sulfide odors. The odor threshold for ammonia is between 28 and 50 parts per million (ppm).

Non-Methane Organic Compounds

Non-methane organic compounds (NMOCs) associated with landfill gases is a generic grouping for compounds other than methane. NMOCs such as vinyl chloride and hydrocarbons can also cause odors. In general, however, NMOCs are emitted at very low (trace) concentrations and are unlikely to pose severe odor problems.

Carbon Dioxide CO_2

Carbon dioxide is a by-product of natural decomposition and is associated with landfills. A simple molecule, carbon dioxide is common in the atmosphere and formed by cellular processes. Accumulation of CO_2 in air results in a reduction in the percentage of oxygen present in that air. Any level of oxygen below 21% can lead to impaired night vision, increased breathing volume, accelerated heart beat, poor muscle coordination, and fatigue. Carbon dioxide is denser than air and can accumulate at ground level in confined spaces. Extremely high levels CO_2, resulting in oxygen levels below 10%, will lead to unconsciousness and eventually death via suffocation.

Carbon monoxide CO

Carbon monoxide is produced in landfills below 1% of the total gas products. Carbon monoxide has similar suffocation risks as carbon dioxide.

Hydrogen H_2

Hydrogen gas is the simplest molecule consisting of two hydrogen atoms bonded together. Hydrogen is produced in trace amounts in landfills. The gas is colorless and odorless. Hydrogen is extremely light and highly flammable.