Health Consultation

ERSI LANDFILL

TAYLOR, LACKAWANNA COUNTY, PENNSYLVANIA

EPA FACILITY ID: PAD069601763

COST RECOVERY NO: A903

MARCH 22, 2010

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

Health Consultation: A Note of Explanation

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

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

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Prepared By:

U.S. Department of Health and Human Services
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Summary and Statement of Issues

In December 2003, a citizen petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) for assistance in evaluating the public impact of releases of airborne pollutants, most notably hydrogen sulfide, emanating from the Environmental and Recycling Services, Inc. (ERSI) Landfill in Taylor, PA. In response to the petition, ATSDR investigated exposures to substances accidentally released from the landfill in 2003 and assessed the potential public health implications associated with those releases. ATSDR conducted its investigation by reviewing ambient air monitoring data measured in 2003 and 2004.

Between September 2003 and December 2003, the Commonwealth of Pennsylvania, Department of Environmental Protection (PA DEP) responded to odor complaints and confirmed the ERSI Landfill as the source of sulfur-like odors. These odors migrated into residential neighborhoods and along public roadways adjacent to the landfill. Their strength varied from slight to very strong and lasted from several minutes to several hours. PA DEP determined that the odors were the result of uncontrolled gas releases from various portions of the ERSI Landfill and the nearby Amity Landfill. During that September–December period, PA DEP also confirmed off-site odors along a public roadway that emanated from a chemical neutralizer/masking agent used to diminish the smell of the landfill odors.

To conduct ambient air monitoring and individual location air sampling, during the weeks of November 17, 2003 and December 1, 2003, PA DEP used two mobile analytical laboratories, “MAU 1” and “MAU 2.” After a review of the PA DEP air data and other pertinent information, ATSDR concluded that residents living near the landfill may have experienced transient health effects (e.g., headaches, nausea, choking cough, tearing of eyes, aggravation of asthma); detectable peak levels of hydrogen sulfide measured in the air have been associated with such effects. ATSDR also concluded that these peak air exposures to hydrogen sulfide and sulfur dioxide during September–December 2003 posed a *Past Public Health Hazard*, but further concluded that any public health effect was reversible (i.e., the peak exposures did not cause significant harm then nor would they cause harm in the future to one’s health). Also, in its review of the air monitoring data, ATSDR concluded that the detectable levels of other landfill gases in the air posed *No Apparent Public Health Hazard* to area residents.

Primarily during 2004, PA DEP conducted post-ambient air monitoring to assess whether the ERSI remediation of the malodorous air releases significantly reduced hydrogen sulfide levels in the ambient air. ATSDR reviewed the 2004 post-ambient air monitoring data and concluded that post-air exposures to hydrogen sulfide emanating from the ERSI Landfill during 2004 posed *No Apparent Public Health Hazard*.

ATSDR remains concerned, however, about landfill gases accidentally migrating offsite since the emergency response/contingency plan on record may not have been activated for a severe malodorous incident that occurred on December 10, 2003 (Appendix D). After the malodorous air releases, landfill operators installed a gas collection system to control and prevent migration of landfill gases into nearby residential communities. PA DEP also revised the original landfill permit to include a Nuisance Minimization and Control Plan. The revised plan does require the landfill operators to control odors, to prevent offsite migration of landfill gases, and to manage and maintain the gas collection system. But the plan does not cover the possibility of a substantial failure to the gas collection system. For example, the plan does not list the emergency response, contingency, and community health actions necessary to mitigate or prevent likely exposures (e.g., residential/retail areas) to elevated levels of landfill gases.

Background

Site Description and History

The ERSI Landfill is in Taylor, Pennsylvania, close to the town of Old Forge. In or about October 1995, PA DEP issued to ERSI a Waste Disposal Operating Permit for a construction and demolition (C/D) waste landfill, where the landfill began operations in October/November 1996 (Tomayko 1995).

The landfill is within the permitted boundary of the former Amity Sanitary Landfill (Amity Landfill) (see Figure 1 in Appendix C). In fact, ERSI used a small portion of the Amity Landfill for minor dumping. The shared property of these landfills is directly across the street from Alliance Landfill, an active sanitary waste landfill owned and operated by Waste Management, Inc. (Figure 1). After approximately 10 years of operation, ERSI operators applied to PA DEP for a landfill expansion permit, proposing to add some 60 acres of new disposal area within the Amity/ERSI Landfill property. On February 1, 2006, PA DEP denied the expansion proposal, citing the lack of adequate safeguards against subsidence and groundwater pollution (PA DEP 2009a).

PA DEP did, however, renew ERSI’s existing Waste Disposal Operating Permit and set landfill closure for March 2007. ERSI began formal closure procedures as prescribed by the state’s Solid Waste Management Act. The procedure requires final cover of the landfill area, establishes final slopes and elevations according to regulation, and ensures post-closure monitoring for a specified period of years to be determined by PA DEP.

In 2008, PA DEP confirmed that the ERSI landfill was closed and final cover was applied (Tomayko 2008). Currently, ERSI operators have only one landfill gas control in place for the destruction of collected landfill gases, a flare. In the past, some of the collected landfill gases were diverted to electricity producing diesel turbines; however, these turbines have since been decommissioned and this activity no longer takes place. The landfill expansion application, however, remains pending. The Environmental Hearing Board reversed PA DEP’s denial of the original expansion request and remanded the application to PA DEP for further review. The review of the remanded application began in January 2008. As of the date of this health consultation, the application’s public comment period has commenced and it is believed that PA DEP is continuing with its review of the remanded expansion application.

Between the years of 1973 and 1990, Amity Landfill operated principally as a municipal waste landfill, but received other, mostly construction/demolition waste as well. In August 1987, PA DEP approved a closure plan submitted by the Amity operators. The plan obligated the operators to install and maintain a gas collection system for controlling landfill gas and to implement a gas monitoring plan for the release of any landfill gases. The collection, conveyance, and destruction system for Amity Landfill (Amity Gas System) was designed and installed, and operators began to collect methane gas from Amity and process it for sale. Methane gas was sold until 2006 when it was diverted to a flare and burned off. This operation was ongoing as of the date of this health consultation.

Current regulations require that landfill dumping areas must be at least 500 feet from the nearest residential property. Landfill operators stated that their dumping areas for the ERSI Landfill are approximately 700 to 800 feet from the nearest residential property, and the dumping areas for the Amity Landfill are at least 1,000 feet from the nearest residential property.

On July 22, 2004, an ATSDR Regional Representative met with the operators of the ERSI Landfill to discuss the September–December 2003 landfill releases. The operators readily admitted to the hydrogen sulfide releases but said that their full cooperation with PA DEP had the effect of mitigating those releases. In that regard, the operators noted that they had installed 24 gas collection wells throughout the landfill to collect gas and route it to an open flare where the collected gas was burned. Moreover, the operators stated that sometime in the then-near future the open flare would be replaced with an enclosed flare, and an enclosed flare was in fact installed on February 16, 2005 (Appendix D). With the installation of the gas collection system, hydrogen sulfide releases have greatly diminished. Operators said some evidence suggested that gypsum wallboard might have been the primary source of the problematic releases.

A chronological summary in Appendix D lists all actions performed by both PA DEP and ERSI Landfill operators during and after the September–December 2003 hydrogen sulfide releases.

Demographics/Land & Natural Resource Use

U.S. Census data for 2000 show a total of 9,468 people living within 1 mile of the site (see Figure 2). Whites comprised almost the entire population, with a census count of 9,347 or 98.7%. As a group, American Indians/Alaska Natives, Asians, and African Americans comprised 0.8% of the population, with a census count of 79, and 0.5% of the population was of Hispanic origin. Children 6 years and younger comprised 7.6% of the local population, with a census count of 719, and adults older than 64 years of age comprised 20.9%, with a census count of 1,982. Females considered to be of childbearing age—15 to 44 years—comprised 18.6% of the population, with a census count of 1,762. Most of the population occupied residential units adjacent to the property line of the ERSI Landfill toward the northeast, east, southeast, south and southwest. Alliance Landfill is toward the north, northwest, and west, adjacent to the ERSI Landfill property line.

The three landfills, Amity, ERSI, and Alliance, are in a mixed industrial and residential area of the Boroughs of Taylor and Old Forge, PA. The landfills are the dominant industrial facilities within the area; other industrial activity is considered light industry and includes such businesses as auto repair, auto salvage, dry cleaners, metal works, and printing shops. The area is served by public sewer and water, natural gas, and electricity.

Community Concerns and Odor Complaints

In a December 2003 email, a concerned citizen (petitioner) requested ATSDR's assistance regarding malodorous releases from the ERSI Landfill. In July 2004, a representative from ATSDR's Region 3 Office spoke with the petitioner by telephone to discuss community health concerns. The petitioner suggested, referencing conversations with the PA DEP, that the ERSI Landfill was a likely source of the odors, about which the petitioner had several health concerns:

- High cancer rate on streets next to the dump—7 persons in 29 years
- Multiple sclerosis (MS) diagnoses without the presence of any real clinical evidence of the disease (i.e., no indication of brain lesions as detected by conducting magnetic resonance imaging, MRI)
- Burning eyes, lips, and skin
- High prevalence of upper respiratory infection rates
- Headaches—some so severe they are considered migraines

The petitioner believed the September–December 2003 releases were a continuation of years of landfill exposures that residents had endured. The petitioner stated the earlier landfill (Amity Landfill) on the same property accepted all types of hazardous waste even though it was supposedly a household waste landfill permitted to accept only sanitation waste.

Other Community Concerns

In March 2002, another citizen had petitioned ATSDR to conduct a public health assessment for the Alliance Landfill. As stated, the Alliance Landfill is directly across the street from the ERSI Landfill. This petitioner also expressed concerns about “air and particulate emissions” and cancer incidence rates in the community. ATSDR released a health consultation in August 2003 for public comment (i.e., a comment period of approximately 30 days after document release) (ATSDR 2003). A final release version of the health consultation was completed in August 2004 (ATSDR 2004). Because the 2004 document recommended additional ambient air monitoring, PA DEP installed an ambient air monitoring station off Keyser Ave. in Taylor, PA (see Figure 1). After data collection was complete, PA DOH assessed the public health implications, and on February 28, 2008 ATSDR (per state cooperative agreement) released the findings of that public health evaluation (ATSDR 2008). As recommended in the public health evaluation, additional monitoring near the Alliance Landfill has been completed (Bellas 2008). ATSDR (per a state cooperative agreement) hopes to release the findings from these efforts in the near future, documented within another health consultation.

Odor Complaints

As stated, between the months of September and December 2003, area residents complained to the PA DEP that they had smelled foul odors, and PA DEP confirmed that the odors emanated from the ERSI Landfill. Appendix D lists a chronological summary of these malodorous releases that occurred between September 2003 and December 2003. Appendix D also lists the summarized descriptions of six malodorous releases, highlighted in yellow, as reported to the PA DEP.

Residents also stated in newspapers and in televised news segments that the odors were so bad they virtually became ill (Appendix D). Residents stated the odors were intermittent (i.e., a noticeable smell that dissipates after a few minutes to several hours), but that the strongest odors reportedly occurred mostly at night or in the early morning. On December 10, 2003, due to excessive hydrogen sulfide odors, school officials evacuated over 1,000 students from two schools, and Pennsylvania Turnpike toll collectors closed their booths. This particular malodorous release resulted in an Emergency Court Order issued by Lackawanna County Court

Judge Robert Mazzoni on that same day. PA DEP officials also reported that during the several malodorous releases between September and December 2003, residents complained of headaches, feelings of nausea, and eye, throat, and respiratory tract irritations.

As part of its investigation, ATSDR retrieved and reviewed compliance and inspection data from PA DEP's Environment Facility Application Compliance and Tracking System (eFACTS) for the ERSI Landfill (PA DEP 2008a). ATSDR used this data to create Figure 3, which shows the number of inspections conducted per quarter by PA DEP at the ERSI Landfill for calendar years 2003 and 2004. Most inspections and violations occurred in the 4th quarter of 2003 (time span of 91 days between 10/01/2003 to 12/31/2003). This corresponds with the period of malodorous releases for the ERSI Landfill that occurred between the months of September and December 2003. Figure 3 also shows that the 4th quarter of 2003 had the most complaint inspections (i.e., an inspection prompted by an odor complaint from a nearby resident).

Because of odor complaints that occurred during the 4th quarter of 2003, PA DEP conducted inspections at the ERSI Landfill about every 2 to 3 days and wrote odor complaint violations about every 5 days (i.e., approximately 1 complaint violation for every 2 complaint inspections). During the 1st quarter of 2004, corrective actions at the ERSI Landfill mitigated and eventually prevented malodorous releases. Complaint inspections and violations, together with public anxiety, also began to diminish. Eventually complaint inspections and violations diminished to a level considered a norm (i.e., no more than 1 to 2 complaint inspections per quarter). This is evident for the early quarters (1 and 2) of 2003 and the latter quarters (3 and 4) of 2004. The level of complaint inspections also holds true for other quarters not shown (before 2003 and after 2004) in Figure 3. Moreover, for the quarters considered a norm in which PA DEP actually conducted inspections for the one or two reported odor complaints, many instances PA DEP did not issue violations; when departmental inspectors arrived at the designated location, the odors had subsided.

Environmental Sampling and Chemical Analyses

2003 Ambient Air Investigations

In late 2003, to ascertain the substances present in the air and to identify those causing odor complaints, PA DEP dispatched two mobile analytical laboratories, 1 ("MAU 1") and 2 ("MAU 2"), on November 18–20, 2003 and December 1–4, 2003 (Conrad 2003). Mobile laboratory personnel also made ambient air measurements to detect substances in the atmosphere and to estimate the levels or concentrations of detected substances.

For the air analyses conducted during these investigations, the mobile laboratories used four instruments:

1. Multi-Polymer Array Response Network (Electronic Nose)
2. Gas Chromatograph/Mass Spectrometer (GC/MS)
3. TAGA IIE MS/MS spectrometer
4. Open Path Fourier Transform InfraRed spectrometer (OPFTIR)

The first three instruments provided qualitative results, meaning ambient air levels or concentrations of the substances could not be approximated. These three instruments employed methods of gathering data instantaneously, implying the spectral scans (measured data) are representative of the time a sample is collected, not a time-weighted average for a series of collected samples. The fourth instrument also gathers data instantaneously, but quantitative measures are approximated. ATSDR primarily used the results of the fourth instrument in its assessment of potential public health implications; the other three instruments did, however, provide supporting weight of evidence that odorous substances were present in the atmosphere and most were volatile in nature, similar to those detected by the fourth instrument.

The first instrument used in the investigations was the Multi-Polymer Array Response Network (Electronic Nose). This instrument uses an array of polymer sensors to mimic the human nose. The sensors change their electrical resistance in the presence of differing chemicals. Each sensor has a different characteristic response, which is logged and mapped to provide a visual/qualitative representation of a specific odor.

Results from the electronic nose are shown as a composite graph in Figure 4. Odor samples were collected for the 7 days of sampling that resulted in odor points residing in a common area within the neural-net (3-dimensional mapping space of odor points in Figure 4, defined by the intensity level of electrical signals from device sensors). The formation of the odor points in this specific arrangement formed a unique reference profile for the overall investigation.

Of the odor samples gathered, all were plotted within the neutral-net and displayed in Figure 4. In two distinct groups of odor samples, the instrument deemed to have similar odor characteristics; otherwise, the remaining odor points were distinct and dissimilar to each other and to the cluster groups. Each cluster group consisted of three odor points and was labeled as Cluster 1 and Cluster 2, consisting of the following sampling locations:

Cluster 1: Location #5, 508 Powell, and 752 Main
Cluster 2: Location #2, Location #3, Location #4

The next two instruments were a Gas Chromatograph/Mass Spectrometer (GC/MS) and a TAGA IIE MS/MS spectrometer. Both are ambient air measuring devices—a complex air sample is introduced into the instruments and an attempt is made to identify tentatively the sample's individual components. The GC/MS and the TAGA IIE are mass spectrometers used in tandem or conjunction with each other. The chemical constituents tentatively identified in the odor samples are listed in Tables 1 thru 4 (GC/MS) and Tables 5 thru 8 (TAGA IIE), all in Appendix B. As noted earlier, the results are qualitative and no exact concentrations were approximated or estimated.

The fourth instrument used in the investigations was the Open Path Fourier Transform InfraRed spectrometer (OPFTIR). The OPFTIR measures substances in the air by directing a beam of modulated infrared energy from the OPFTIR telescope. The beam contacts targets that can reflect (mirrored retro-reflector) the energy back along the same beam path into the OPFTIR. The approximate beam paths for the investigation are displayed in Figure 1. Molecules of each of the chemicals intercepted in this infrared beam path uniquely absorb energy. From the analysis of the resulting absorption spectrum, the OPFTIR identifies and quantifies the chemical compound molecules present. Together with their approximated air concentrations, the chemical substances identified are listed within Tables 9 thru 15. The data are summarized in Tables 16 and 17 together with health comparison values. The health comparison values selectively screen for substances that potentially pose a health concern to exposed populations and that therefore require further public health analysis.

2004 Post Ambient Air Monitoring of Hydrogen Sulfide

After ERSI Landfill operators installed gas collection wells and a John Zink Flare, PA DEP placed two continuous ambient air monitoring stations in close proximity to the landfill. The gas collection wells and flare collected and destroyed gases generated and created in the landfill, including those considered malodorous.

One of the ambient air monitoring stations was placed at the Taylor, Pennsylvania, Riverside Elementary School (Taylor H_2S Station in Figure 1). The other ambient air monitoring station was placed along the Pennsylvania Turnpike (Taylor Turnpike Station in Figure 1), adjacent to the ERSI Landfill. The stations only measured hydrogen sulfide levels within the air. Monitoring began at the Riverside station on February 1, 2004 and continued until June 14, 2004 (PA DEP 2008b). Monitoring began at the Turnpike station on March 29, 2004 and continued until September 23, 2004 (PA DEP 2008b). Between the months of February and September 2004 odor complaints by residents living adjacent to the ERSI Landfill substantially decreased, thus PA DEP ceased air monitoring at the two stations (see Figure 3). Moreover, most of the hydrogen sulfide levels recorded each month as time-weighted averages of 1 hour, 99.6%–100% for the Riverside Station and 83%–99% for the Turnpike station, were not detected (i.e., approaching a measured level of zero or below 1 part per billion (ppb)). The results of both monitoring stations are summarized in Table 18.

The detected hydrogen sulfide levels for a time-weighted average of 1 hour were below ATSDR's air comparison values (CVs) for acute exposures to hydrogen sulfide. ATSDR's air CVs are denoted as Environmental Media Evaluation Guides (EMEGs), air concentration levels in micrograms per cubic meter ($\mu g/m^3$) or ppb. ATSDR's air CVs are further discussed in Appendix A. Air concentration levels for hydrogen sulfide below their respective air CVs (e.g., EMEGs) present no appreciable risk of affecting public health (i.e., no adverse health effects are expected to occur in an exposed population). (See the "In-depth Public Health Analysis" below for discussion.)

Taylor Ambient Air Monitoring Station

Residents living in Taylor and in Old Forge, PA have also expressed concerns about the Alliance Landfill, directly across the street from the ERSI Landfill.

ATSDR recommended that the PA DEP conduct ambient air monitoring in Taylor Borough (ATSDR 2004). PA DEP installed an ambient monitoring station located off Keyser Ave. in Taylor (see Figure 1). The air monitoring station was centrally located, approximately between the Alliance Landfill, ERSI Landfill, the Pennsylvania Turnpike, and other commercial properties adjacent to Keyser Avenue and Union Street.

Air monitoring station equipment collected meteorological data and continuously monitored levels of hydrogen sulfide (H_2S) and sulfur dioxide (SO_2). The air monitoring station included a high-volume air sampling unit to detect total suspended particulates and various metals.

PA DEP staff installed, calibrated, and maintained the sampling equipment and meteorological equipment at the air monitoring station, and was also responsible for the compilation of the monitoring data. Data collection is completed for this station; PA DOH has reviewed the data and has made an assessment of the public health implications. Findings from this public health evaluation were released by ATSDR in a public health document on February 28, 2008, per its state cooperative agreement with PA DOH (ATSDR 2008).

Exposure Pathways

An exposure pathway is defined as the process by which people are exposed to or come into contact with chemical substances. An exposure pathway has five parts:

1. A source of contamination,
2. An environmental medium and transport mechanism,
3. A point of exposure,
4. A route of exposure, and
5. A receptor population.

When all five parts are present, the exposure pathway is a completed exposure pathway. But a completed exposure pathway does not necessarily mean the presence of a public health hazard. To determine the implications of any exposure, specific exposure conditions and exposure doses must be more closely evaluated. The only exposure pathway examined in this public health consultation is the inhalation of landfill gases from the ERSI Landfill—this pathway probably poses the most significant and greatest concern to public health.

Because community residents often complain about odors emanating from landfills, inhalation of landfill gases is usually the predominant landfill-related exposure pathway. Landfills odors are mainly due to landfill gases migrating either above or below ground. Such gases can move through the landfill surface to the ambient air. Once in the air, winds can carry landfill gases to the community. Landfill gases may also move underground through subsurface soils and enter homes or utility corridors on or adjacent to the landfill. Figure 5 illustrates the movement of landfill gases and potential locations for exposure. The levels of gases that migrate from a landfill and to which people can be exposed are dependent on many factors that can affect the direction, speed, and distance of landfill gas migration. Some of these factors include but are not limited to

- Landfill cover type,
- Natural and man-made pathways,
- Wind speed and direction,
- Moisture,
- Groundwater levels,
- Temperature, and
- Barometric and soil gas pressure.

Landfill gas collection and control systems probably have the greatest effect on gas migration and exposures. If a gas collection and control system is in place and operating properly, migration of and exposures to landfill gases should be minimal.

Public Health Analysis

Chemicals Selected for Further Public Health Analysis

Tables 16 and 17 summarize ATSDR's review of the ambient air monitoring data collected during the 2003 malodorous releases (Note: detection limits for all substances are displayed in Tables 9–15.) ATSDR environmental health scientists first applied a screening process to select specific substances detected in the air; these substances were then subjected to further analyses for peak inhalation exposures. Table 16 summarizes measurements for 29 substances. Of these substances, 18 had what are termed acute exposure guideline levels (e.g., Acute EMEGs or AEGLs) for making health screening comparisons. (Refer to Appendix A for further explanation of the acute exposure guidelines and the selective screening rationale used in this evaluation.) And of these 18 substances, three had detected peak air levels (i.e., air monitoring measurement of no more than a 2 minute duration, refer to Table 16) during the malodorous releases of 2003 that exceeded at least one of their respective acute exposure guidelines. The detected peak air levels of the other 15 substances never at any time exceeded their respective acute exposure guidelines and were therefore not selected for in-depth public health analysis.

Two of the substances selected for public health analysis were hydrogen sulfide (H_2S) and sulfur dioxide (SO_2). Benzene, the third substance, exceeded ATSDR's acute inhalation EMEG, an acute exposure guideline for daily exposure. Because, however, the detected air level for benzene is a measured peak air concentration, it is more appropriate to screen the detected level against U.S. EPA's AEGL for peak air exposures (10 minutes or less). Thus because benzene's detected peak air level was far below its AEGL for peak air exposures, it was not selected for in-depth public health analysis.

The remaining 11 substances summarized in Table 16 did not have Acute EMEGs or AEGLs. Two of the substances, ethylbenzene and triethylamine, had a threshold limit value (TLV) for peak exposures. TLVs are health-based guidelines set by the American Conference of Governmental Industrial Hygienists (ACGIH®) to promote workplace health and safety. The Occupational Safety and Health Administration (OSHA) have adopted many TLVs for use as permissible exposure limits (PELs). TLVs are normally designed to protect healthy adult workers and are usually much higher than the health-based values of ATSDR and U.S. EPA, which are designed to protect the health of the general population, including the very young and the elderly. Keeping this in mind and when making health screening comparisons, ATSDR focused on selecting health-based guidelines or standards that appropriately adjust the TLVs to be protective of the general population.

The American Industrial Hygiene Association (AIHA) is another scientific organization also concerned with environmental exposures to toxic airborne substances within the workplace. Accordingly, AIHA developed an emergency response exposure limit known as the Emergency Response Planning Guidelines (EPRG), which is similar to U.S. EPA's AEGLs. ERPG values are based on occupational exposure limits (OELs) (e.g., PELs, RELs, TLVs) rationally lowered to general exposure limits considered protective of nearly all persons within certain domestic settings subjected to a specific emergency response situation. Two states (Michigan and Wisconsin) also use OELs to establish their health-based air standards for peak air exposures. Michigan's health-based air standard is called the Initial Threshold Screening Level (ITSL) and Wisconsin's is called the Acceptable Ambient Concentration (AAC) (MI DEQ 2008, WI DNR 2000).

ATSDR made health screening comparisons using the guidelines in the above paragraph. If none of the above guidelines applied to a specific substance, a health screening comparison was made with a rationally reduced TLV (i.e., TLV value multiplied with a reduction factor of either 1/10 for peak inhalation exposures or 1/42 for short-term inhalation exposures, refer to Appendix A). The reduced TLV factor of 1/42 makes considerations for longer domestic exposures (80% of the time spent at home) and for human variability; however, the reduced TLV factor of 1/10 only makes the consideration for human variability (WI DNR 2000, Thrasher 2006). Applying the above screening rationale, ATSDR found that the peak air levels for ethylbenzene and triethylamine did not meet the criteria for in-depth analysis.

Four of the remaining 11 substances without Acute EMEGs or AEGLs (carbon monoxide, ethanol, methyl mercaptan, and n-octane) did not have a TLV for peak exposures but did have health-based exposure limits known as Immediately Dangerous to Life and Health (IDLH). An IDLH is an airborne concentration established by the National Institute for Occupational Safety and Health (NIOSH) from which a worker, in the event of respiratory protection equipment failure, could escape without injury or irreversible health effects. Again, applying the rationale wherein health screenings are compared to guidelines based on OELs (refer to Appendix A), ATSDR found that the peak air levels for the five substances also did not meet the criteria for in-depth analysis.

The last five substances of the 11 without Acute EMEGs or AEGLs (carbonyl sulfide, dimethyl sulfide, ethylene, methane, and 2-methyl butane) had neither listed appropriate comparison values nor Acute EMEGs, AEGLs or TLVs. ATSDR first reviewed additional sources (e.g., AIHA, NIOSH, MI ITSLs, WI AACs) to identify environmental guidelines for accessing any detected peak concentration levels. Michigan, for example, set an annual air standard for carbonyl sulfide at 9 $\mu g/m^3$ (3.7 ppb). During the peak air measurements, carbonyl sulfide was not detected; the detection limits (5 – 44 ppb), however, exceeded the Michigan air standard. Considering that this Michigan air standard is relevant to intermediate/chronic exposures and that potential detectable levels could be lower than this standard, ATSDR determined that any measurable peak air levels, if detected, were unlikely to cause any adverse effects. (Only transient health effects have been observed from continuous inhalation exposures to carbonyl sulfide ranging from 15,000 ppb to 30,000 ppb (BOC 1996). Thus, if detected at the detection limit of 44 ppb, it is still 340 times lower than levels associated with adverse health effects.)

2-Methyl Butane was also not detected during peak air measurements; detection limits range from 2 to 100 ppb. Yet even if 2-methyl butane were present at levels below detection limits, those levels would be far below the 8-hour Michigan air standard for 2-methyl butane, which is 17,700 $\mu g/m^3$ (6,000 ppb).

Only one peak concentration level (148 ppb) of dimethyl sulfide was detected, and it was below the ERPG-1 air standard for dimethyl sulfide (500 ppb) set by AIHA. ERPG-1 is a maximum airborne concentration from which persons may notice an odor or slight irritation, but that is still below any concentration that could cause adverse health effects.

Ethylene had measurable peak concentration levels ranging from 8 to 17 ppb. These levels are also far below a 24-hour Michigan air standard for ethylene, which is 6,240 µg/m^3 (5,440 ppb), implying that ill-health outcomes are unlikely. Methane also had measurable peak concentration levels ranging from 397 to 19,076 ppb (0.397–19.076 ppm), well below the ACGIH 8-hr TWA TLV of 1,000 ppm or 1,000,000 ppb, also implying unlikely ill-health outcomes (ACGIH 2008).

To select for further analysis specific substances detected in air, ATSDR also applied another screening rationale for short-term inhalation exposures. Table 17 summarizes the air level measurements for 29 substances (refer to Tables 9–15 for detection limits). These air level measurements represent averages for continuous time periods below 24 hours; thus any exposure at a detectable level would be considered short term. Of the 29 substances, only two (carbon monoxide and methane) had levels above measurable detection limits where averages could be calculated.

Using the screening rationale for short-term inhalation exposures, ATSDR found that the detectable levels of carbon monoxide, considered as short-term averages, (51–632 ppb) did not meet the selection criteria for in-depth analysis. ATSDR based this decision on detectable levels that were lower than three air standards: 1) ERPG-1 of 200,000 ppb; 2) MI ITSL of 8,730 ppb; and 3) VT HAAS of 8,730 ppb. ATSDR also found that the detectable levels for methane, considered as short-term averages (43–6,540 ppb) did not meet the selection criteria for in-depth analysis. ATSDR based this decision on the fact that detectable levels were far lower than the ACGIH 8-hr TWA TLV of 1,000 ppm or 1,000,000 ppb. None of the other remaining 27 substances were at levels substantially above their detection limits. Consequently, ATSDR could not derive representative short-term averages for these substances, and therefore did not apply the screening rationale for short-term exposures to them.

Public Health Implications

Public health analysis is an integrated process that studies site-specific exposures in conjunction with substance-specific toxicological, medical, and epidemiologic data (ATSDR 2005). As stated, hydrogen sulfide and sulfur dioxide were selected for further analysis because their detected levels in air exceeded the screening criteria applicable to peak exposures.

While none of the detection limits for H_2S and SO_2, listed in Tables 9–15 (Peak & Short-Term Concentrations, Nov 18 to Dec 4, 2003), exceeded occupational exposure limits (i.e., TLVs), they both exceeded—often by several orders of magnitude—ATSDR's screening values for daily acute (≤14 days) exposures. In addition, the detection limits varied markedly from place to place, probably reflective of several factors affecting the measurements of the OPFTIR instrument. Such factors may include but are not limited to

1. Instrument calibration,
2. Distance/angle the electromagnetic beam traverses (beam path),
3. Deployment of beam transmission and reception (mono-static, bi-static, or passive),
4. Ambient air temperature, and

5. Relative humidity of the air.

Peak Exposures to Hydrogen Sulfide

The available data suggest that the ERSI-related, intermittent, acute exposures to hydrogen sulfide that occurred in the final quarter of calendar year 2003, though unpleasant to most and uncomfortable to some, might have caused only temporary, non-serious effects, even in sensitive human subpopulations.

The detection limits reported for hydrogen sulfide in Tables 9–15 range from <1,897 ppb to <9,898 ppb. Assuming, as cited above, that the actual peak concentrations for non-detected measurements were essentially the same as the reported detection limits, and noting the two measured air levels of 6,355 and 8,906 ppb, the peak concentrations for hydrogen sulfide between November 8 thru December 4 of 2003 (i.e., during the "incident") may well have been high enough to cause temporary respiratory discomfort to those with asthma, and perhaps even in some without asthma who suffered from other preexisting respiratory conditions.

The actual air levels, however, may have been an annoyance for nearly all residents. The recognition threshold (i.e., the level at which 50% of people can recognize the chemical's characteristic odor) is only 5 ppb (0.005 ppm) for hydrogen sulfide's characteristic "rotten egg" odor.

ATSDR's 70-ppb acute Minimum Risk Level (MRL) for hydrogen sulfide is based on a 2000-ppb (2 ppm) human LOAEL for increased airway resistance and decreased specific airway conductance in 2 of 10 asthmatic subjects exposed for 30 minutes (Jappinen et al. 1990). In this study, no significant alterations in lung function (e.g., forced lung vital capacity, forced expiratory volume, bronchial responsiveness to a histamine challenge, airway resistance, and specific airway conductance) were observed in those with asthma exposed to 2 ppm for 30 minutes. But 2 of the 10 subjects had >30% changes in airway resistance and specific airway conductance, implying bronchial obstruction. Three of the subjects also reported headaches. Therefore, this LOAEL of 2000 ppb represents an approximate threshold for less serious effects in the most sensitive members of the most sensitive human subpopulation (i.e., those with asthma).

In another human study, no respiratory effects were experienced by men and women exposed to 10 ppm hydrogen sulfide for 15 minutes (Bhambhani et al. 1996). This human NOAEL is higher than any of the purported concentrations listed in Tables 16 and 17, and is based on exposures of comparable duration. The duration of the measured peak air concentrations listed in Table 16 was less than 2 minutes. The duration of the measured concentrations listed in Table 17 ranged from roughly one-third to one-half of a day (8–12 hours). ((Note: hydrogen sulfide levels could not be quantified as short-term averages (i.e., not detected at the detection limits used). In Table 17, therefore, the short-term air concentrations listed in the table represent upper limits (e.g., "<9,898" ppb) instead of actual concentrations.))

The current ACGIH 8-hr TWA TLV for hydrogen sulfide is also 10 ppm (ACGIH 2008). An ACGIH TLV represents a level to which nearly all workers (i.e., healthy adults) may be repeatedly exposed 8 hours a day, 40 hours a week, without adverse effects. Moreover, ACGIH TLVs are based solely on health factors and do not consider economic or technical feasibility.

That said, ACGIH TLVs are designed for application to healthy worker populations, which do not include children, the elderly, infirm, and other sensitive subpopulations.

Within the context of the human effect levels and assumptions described above, ATSDR's interpretation of the available monitoring data supports the conclusion that hydrogen sulfide exposures during the ERSI landfill malodorous incident of late 2003 may have constituted a *Past Public Health Hazard*. No serious or irreversible adverse effects are likely in either people with asthma or without asthma. But mild, reversible, respiratory effects would have been likely in some with asthma, and perhaps even in some without asthma who suffered from other preexisting respiratory conditions.

Post Exposures to Hydrogen Sulfide

The data summarized in Table 18 show that the levels of hydrogen sulfide (1-hr, 24-hr, and monthly averages), after the implementation of corrective actions at the ERSI Landfill in 2004. Levels ranged in the very low parts per billion (immeasurable or <1 ppb), that is, (mostly) immeasurable to 7 ppb at Riverside Elementary School, and (mostly) immeasurable to 3 ppb at the Pennsylvania Turnpike. As noted in the previous section, the lowest human LOAEL for less serious effects in more sensitive members of the most sensitive human subpopulation (i.e., persons with asthma) is 2000 ppb.

These post-incident air monitoring data are comparable to U.S. EPA's reference concentration (RfC) of 0.002 mg/m^3 or 1.4 ppb. The RfC is a level of a substance in air considered safe for continuous lifetime exposure. The RfC for hydrogen sulfide contains a 1000-fold safety factor (USEPA-IRIS, 2008). Therefore, post-incident hydrogen sulfide levels in areas near the ERSI Landfill were too low to produce adverse effects of any kind, even in the most sensitive persons.

Accordingly, after operators of the ERSI Landfill ensured that the landfill gas collection and capture system was fully functional and operational and would prevent further releases and migration of landfill gases, such exposures posed *No Apparent Public Health Hazard.*

Peak Exposures to Sulfur Dioxide

Measured peak concentrations (duration < 2 minutes) of sulfur dioxide (SO_2) were 436 ppb at Union St. (4:37 pm, December 2, 2003), and 93 ppb at the Pennsylvania Turnpike (6:57 pm, December 4, 2003). At all other locations monitored during November–December 2003, no measurable levels were reported (i.e., concentrations either below 136 ppb or less) and were, therefore, below U.S. EPA's 24-hr NAAQS (National Ambient Air Quality Standard) of 140 ppb.

About the only concentration that could have produced clinically significant symptoms in at least some persons with asthma was the 436-ppb measured peak concentration at Union St. Perhaps 20–35% of persons with asthma may be sensitive to exposures between 400 and 500 ppb (USEPA 2008). The resulting physiological effects are, however, usually not sufficiently serious to require persons either to cease activity, take medication, or seek medical attention.

The lowest human LOAEL for sulfur dioxide effects—which serves as the basis of ATSDR's 10 ppb acute MRL— is 100 ppb. And this is for a "slight" increase in specific airway resistance (SRAW) in "the two most sensitive" persons with asthma who were administered 100 ppb sulfur dioxide through a response-maximizing mouthpiece during 10 minutes of moderate exercise

(ATSDR 1998). But while statistically significant changes in specific airway resistance can be measured by special techniques in a laboratory or doctor's office, they do not necessarily correspond with clinically significant levels of broncho-constriction, which the exposed person with asthma will experience when having difficulty in breathing or dyspnea. Even in those with asthma, symptoms of coughing, wheezing, and dyspnea typically do not appear until levels of sulfur dioxide reach or exceed 400 ppb. In addition, during the same 24-hr period, those with asthma tend to respond less intensely to subsequent exposures than to the original exposure, which is to say that repeated exposure actually reduces sulfur dioxide sensitivity in those with asthma (ATSDR 1998).

Finally, in healthy persons without asthma, clinically significant lung changes are uncommon below 1,000 ppb. For example, ACGIH's recommended 8-hr TWA-TLV is 2000 ppb. Most epidemiologic evidence is mixed (i.e., limited to none) or insufficient, with respect to the assumption that children and elderly adults (65+ years) are more sensitive (i.e., susceptible) to the effects of sulfur dioxide exposure (USEPA 2008). However, evidence (mostly clinical chamber studies) does exist which suggests that pulmonary health status, rather than age, is the primary determinant of susceptibility to the effects of this gas (Rondinelli et al. 1987; Koenig et al. 1982).

The brief duration of the single measureable sulfur dioxide concentration of potential clinical significance, and the minimal severity of the reversible potential effects of that peak exposure, suggest that sulfur dioxide exposures during the malodorous air releases at the ERSI Landfill (final quarter of 2003) were not likely to have posed any serious public health concerns. Two facts, however, provide sufficient reason to err on the side of caution: 1) the exposures took place during November and December, and cold air exacerbates a person with asthma's response to sulfur dioxide, and 2) the available data cannot entirely exclude the possibility that during those 2 months equal or higher exposures may have occurred but were not measured.

Thus given the available data, ATSDR concludes that the highest peak sulfur dioxide exposures during November–December 2003 may have posed a *Past Public Health Hazard*, especially to more sensitive persons with asthma, and perhaps to some non-asthmatics who suffer from other preexisting respiratory conditions.

Community Health Concerns and Related Public Health Implications

ATSDR provides an initial response to three community health concerns posed by the petitioner and discusses any related public health implications that may exist in the paragraphs below. At least two of these concerns, cancer and odors, are similar to those posed by the community as a whole (ATSDR 2004).

Multiple Sclerosis

Multiple sclerosis (MS) is a slowly progressive central nervous system (CNS) disease characterized by demyelination of nerve fibers in the brain and spinal cord that results in a variety of neurological symptoms with spontaneous remissions and exacerbations (Merck Manual 1992). The cause of MS is unknown, but an immunological abnormality is suspected. Viral infection, genetic susceptibility, and environmental factors associated with the location of early residence (up to 15 years of age) may also be involved. Specific chemical exposures, however, have not been implicated (Williamson 2006). In particular, none of the VOCs associated with the malodorous air releases that occurred in the last quarter of 2003 have been associated with MS.

Cancer Rates

Because of the number of area landfills and Superfund sites located within the county, community residents petitioned ATSDR in 1992 to conduct a health assessment for Lackawanna County. The Pennsylvania Department of Health (PADOH), under a cooperative agreement with ATSDR, reviewed relevant health data for Taylor Borough. PA DOH reviewed cancer mortality data for the years of 1980–1991 and cancer incidence data for the years of 1985–1989. Statistics for total cancers and for eight cancer sites were analyzed. Taylor Borough showed a higher number of anus, rectum, and rectosigmoid cancers than were reflected in Pennsylvania statewide cancer numbers. The report suggested, however, that nonenvironmental factors such as heredity, occupation, and diet could increase a person's risk for such cancers. PADOH continues to monitor cancer mortality and incidence data for Lackawanna County (ATSDR 1993, PADOH 1999, PADOH 2000, PADOH 2001, PADOH 2002, PADOH 2003, PADOH 2004, PADOH 2005, PADOH 2006, PADOH 2007, PADOH 2008, PADOH 2009).

Only two of the VOCs, benzene and vinyl chloride (VC), detected during the ERSI Landfill incident during the last quarter of 2003 are known to be carcinogenic in humans, and such carcinogenicity requires exposures that are higher and of longer duration than those experienced at ERSI during the malodorous air releases in 2003 (Raabe & Wong 1996, Falk & Steenland 1998). The exposures assessed during the malodorous air releases were not of sufficient duration (<2 min) to pose any hypothetically increased cancer risk to exposed residents or workers. ATSDR’s inhalation CREGs are 0.04 ppb for both benzene and VC (ATSDR 2007; ATSDR 2006a). These concentrations are health guidelines that assume chronic life-long exposure. The CREGs are based on a risk of developing cancer within one's lifetime of 1 x 10e-6. Or in other words, a lifetime exposure of 1,000,000 people to 0.04 ppb benzene or VC would hypothetically result in 1 excess cancer.

Odors

Landfills emit gases comprised of a wide range of chemicals. Some of these chemicals are strong odorants. The VOCs and sulfur compounds measured near the ERSI, Amity, and Alliance Landfills may only constitute a portion of the chemicals responsible for landfill odor. Chemicals associated with landfill odors include trace quantities of 1) sulfur compounds, including hydrogen sulfide and organosulfurs, (e.g., mercaptans), 2) volatile acids, (e.g., butyric acid), 3) hydrocarbons, (e.g., limonene), 4) esters, (e.g., methyl butyrate), and 5) alcohols (e.g., 2-butanol) (Brosseau and Heitz 1994). Many of these compounds have odor thresholds well below levels measured by standard U.S. EPA analytic methods.

The relationship between odor and health is not fully understood because odors are complex, quantifying them is difficult, and the human response to odors is highly variable. Schiffman et. al. (2000) describe three paradigms for producing health symptoms. In the first paradigm, symptoms are induced by exposure to an odorant at levels that also cause irritation or other toxicological effects. Thus, the irritation rather than the odor causes symptoms, with the odor serving as an exposure marker. Indeed, for individual VOCs that occur in a mixture, laboratory evidence suggests that perceived sensory irritation may occur from exposure to levels below odor thresholds (Cometto Muñiz et. al. 1999).

In the second paradigm, exposure to odorous compounds produces health-related symptoms below irritant levels but at levels of odor thresholds. This typically occurs with exposure to certain types of sulfur-containing compounds or organic amines. These compounds also have odor thresholds well below levels that cause irritation. The mechanism by which health complaints result from these types of exposures is not understood, but it may include psychological and genetic factors. In the third paradigm, an odor is associated with a symptom when the odorant is part of a mixture containing a co-pollutant (e.g., dust or allergen) responsible for the health symptom. As in paradigm one, the odor acts as an exposure marker.

Exposure to landfill gas odor can cause transient effects such as headaches and nausea (ATSDR 2001). The effect of landfill gas odors on sensitive populations, such as persons with preexisting respiratory illnesses, is not well understood. A study conducted in Staten Island, New York showed on days of reported odors persons living near a landfill who had asthma also had an increase in self-reported wheezing (ATSDR 1999). Ambient air measurements, however, showed levels of hydrogen sulfide and other emissions much lower than levels known to be associated with adverse health effects. The study nonetheless suggested that odors may trigger respiratory effects among persons who have asthma. But this finding in persons with asthma living near a landfill may be confounded by other environmental triggers that can prompt a respiratory response, such as dust mites, animal dander, tobacco smoke, and other types of outdoor air pollution.

Child Health Considerations

ATSDR’s Child Health Initiative recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities concerned about air contamination. Children are at greater risk than are adults from certain kinds of exposures to hazardous substances released into their environment. Children play outdoors frequently and will more likely be exposed to outdoor air pollution. Because children are smaller than adults, exposure may result in higher doses per body weight. Also, children's developing body systems can sustain damage if toxic exposures occur during critical growth stages. Near the ERSI, Amity, and Alliance Landfills, children are potentially exposed to air contaminants due to the off-site migration of landfill gases via fugitive air emissions or from accidental releases due to a failure in the landfill gas collection system. ATSDR evaluated the limited offsite air-sampling data to assess the potential health effects on children in the community. One concern is the potential exacerbation of childhood asthma from landfill gases (IM 2000).

Limitations and Uncertainties

In preparing this health consultation, ATSDR relied on the information or data provided in referenced documents and in PA DEP’s web site (Conrad 2003). ATSDR did identify some concerns with this information and will discuss these concerns below. ATSDR assumed, however, that adequate quality assurance and quality control measures were followed with regard to chain-of-custody, laboratory procedures, and data reporting. The validity of the analyses and conclusions drawn in this health consultation is solely determined by the completeness and reliability of the referenced information.

As cited earlier, the environmental data presented in this health consultation are chiefly from site investigations conducted by PA DEP's Bureau of Laboratories, where ambient air monitoring near the ERSI Landfill occurred in November and December 2003. This includes continuous hydrogen sulfide monitoring at two air monitoring stations after the 2003 malodorous air releases. This post air monitoring occurred from February through September, 2004.

ATSDR initially recognized that some of the peak air measurements by the Bureau of Laboratories may have been questionable (refer to Table 16). Those that were considered questionable in Table 16 are highlighted or shaded in green; the measured or detected concentration either appeared at the end or outside of the monitoring period. Still, for the detected substances, some of the questionable measurements were within the range of measured peak air concentrations ATSDR considered valid (highlighted or shaded in yellow). ATSDR considered these questionable peak air measurements useable for this public health evaluation, though they were measured at the end or outside of the monitoring period.

The first concern ATSDR had with the referenced information was the methodology used to measure hydrogen sulfide levels. PA DEP's Bureau of Laboratories selected an analytical method in which the reporting limits were relatively fine for most of the targeted substances; that is, the reporting limits (limits of quantification) were either in line with or marginally above the substance's regulatory limits.

This was not, however, the case for hydrogen sulfide. For the air measurements made, the analytical method's reporting limit for hydrogen sulfide ranged from 1,897 ppb to 9,898 ppb. Moreover, PA DEP's regulatory limit for hydrogen sulfide is an average air concentration of 100 ppb over a period of 1 hour (peak or brief exposures) and an average air concentration of 5 ppb over a period of 24 hours (daily exposure), implying these are maximum values that may not be exceeded (PA DEP 2008c). Assuming a method detection limit (MDL) of 1,000 ppb, the reporting limits are more than one order of magnitude (10 times) higher than the 1-hour regulatory limit of 100 ppb and two orders (200 times) higher than the 24-hour regulatory limit of 5 ppb

As evidenced by the number of odor complaints, the public health effect of exposures at 100 ppb or more can be significant, especially if levels exceed 2,000 ppb (i.e., a level that could trigger transient health effects in those with asthma or in those with respiratory conditions). Peak levels of hyrdogen sulfide were detected twice (Table 16) at levels exceeding 2,000 ppb: 6, 355 ppb and 8,906 ppb. No hourly averages of hydrogen sulfide are reported in Table 17, given that for each individual air measurement, average reporting levels are below the reported detection limit. (Note: for hydrogen sulfide, the H_2S detection limits are greater than PA DEP's 1-hr regulatory limit of 100 ppb.) Whether the average H_2S concentration could have been lower than 100 ppb (PA DEP 1-hr regulatory limit for hydrogen sulfide) is unknown; however, if H_2S levels approach 100 ppb or lower, the levels probably would not cause any adverse health effects in ATSDR's judgment, other than an unbearable odor that most residents would complain about.

The latter sentences in the above paragraph are indicative of how governmental agencies may define the objective of an ambient air monitoring effort differently. A monitoring effort conducted by a regulatory government agency, such as PA DEP, usually place emphasis on identifying the odor source. This objective helps the regulatory agency to cite who may be responsible, if any violations were committed, and how to remedy the situation. PA DEP validated that the objective of the monitoring effort was limited to determining if the landfill was the source of the odors and to confirm that decomposition gasses from the landfill was also an additional source of odors (Tomayko 2009). Following such an objective would provide PA DEP and ERSI operators with the knowledge that implementing a gas management plan would achieve the goal of eliminating the source of the odors and properly managing landfill gases. ATSDR (a public health agency), on the other hand, is more concerned with health impacts and feels that the primary objective is to determine whether a toxic substance is released. Moreover, ATSDR is also concerned whether air levels may pose a fire or explosion hazard and whether the attained concentrations are of serious health concern. The latter is important because in its review of operational data for the newly installed and repaired gas collection system, ATSDR found out that hydrogen sulfide levels within the system (i.e., gas flow lines) ranged from 1,500 ppm (1,500,000 ppb) to 2,000 ppm (2,000,000 ppb). Scientific studies and observations have shown that H_2S exposures presumably at and above 500 ppm (500,000 ppb) can cause serious and irreversible health effects (ATSDR 2006b). No gas collection system was in place at the ERSI Landfill before December 2003, and portions of the original gas collection system at the Amity Landfill were in bad repair. Because of dilution with ambient air, whether unconfined levels of hydrogen sulfide reached or approached concentrations of serious health concern (i.e., the level of 500 ppm or greater) is unknown.

Another unknown was the selection of sampling locations. ATSDR feels that the selection should be based on fire/explosion hazard, toxicity, odor source, landfill history, landfill construction, location of receptor populations, and other area sources of contamination. (For more information pertaining to sampling strategy and locations, refer to Appendix E for ATSDR’s proposed guidelines on evaluating gases migrating from landfills.) Noting the above objective, PA DEP felt the sampling effort met the overall goal of identifying the problem, taking immediate steps to correct the problem, and providing post monitoring to confirm that the gas management controls were effective.

PA DEP felt the sampling strategy used to make air measurements during the malodorous air releases in 2003 provided information that allowed them to support enforcement and get a gas management system installed to correct the odor problem. ATSDR, however, felt the sampling effort provided limited information indicating that the highest or peak exposures probably approached levels near 9 ppm (9,000 ppb), where studies have shown transient/reversible health effects to occur.

Landfill Emergency Response/Contingency Plan

ATSDR believes that during the malodorous air releases of 2003, when ERSI landfill operators experienced problems with uncontrollable and unbearable odors, the necessary emergency response and contingency actions were not taken to alert and perhaps even evacuate the public. A landfill emergency response and contingency plan was not in place for the landfill. The belief was that the landfill would not generate a substantial amount of odors (i.e., only construction and demolition waste was collected). After the malodorous air releases, operators installed a gas collection system to control and prevent landfill gases from migrating into the outlying residential communities. PA DEP thus decided to revise the original landfill permit to include a

Nuisance Minimization and Control Plan. This plan was finalized via a permit modification in February 22, 2006 as imposed by PA DEP's Waste Management Program (Tomayko 2006). The plan requires the landfill operators to comply with the prime directive of controlling odors and preventing the off-site migration of landfill gases while managing and maintaining the gas collection system. The plan does not, however, list the emergency response, contingency, and community health actions—if a substantial failure to the gas collection system were to occur—to mitigate or prevent likely exposures (e.g., residential/retail areas) to elevated levels of landfill gases. The revised Nuisance Minimization and Control Plan may be adequate for odor control and minimizing minor odor effects, but it should in no way be considered a substitute for an Emergency Response/Contingency Plan. PA DEP regulations do require landfills to have emergency response/contingency plans and such a plan exists for the ERSI Landfill (PA DEP 2009b, Tomayko 1995). This plan is separate from the nuisance minimization plan referenced above (Tomayko 2009). Moreover, ERSI operators have also submitted such a plan as part of its expansion application, which is under review.

When developing an Emergency Response /Contingency Plan for a landfill, ATSDR feels the plan should at least consider and include the following:

- List of target compounds monitored and whether these compounds present a fire or explosion hazard, are toxic, or can attain concentrations of health concern.
- List of corrective, contingency, and safety/health actions taken in the event an emergency or accident occurs at the landfill (e.g., fire, explosion, or substantial failure of the gas collection system).
- Description of how first responders and other health/safety authorities (e.g., PA DEP, PA DOH, county health department, fire department, police department) are notified and their collaborative response to address an emergency or accident at the landfill.
- Description of the tiered procedure of alerting and perhaps evacuating residents who live near the landfill.

Conclusions

During the 2003 malodorous air releases spanning between September and December, ATSDR classified the releases of landfill gases from the ERSI Landfill as a *Past Public Health Hazard*. Peak exposures to hydrogen sulfide and sulfur dioxide could have made some residents of the surrounding community experience transient health effects (e.g., headaches, nausea, choking cough, tearing of eyes, aggravation of asthma). ATSDR considered, however, whether insofar as the public was concerned, these health effects were considered reversible (i.e., whether the peak exposures could cause significant harm to health then or possibly in the future). Moreover, post sampling after the malodorous air releases and upon completion of remediation efforts suggested that the exposures to landfill gases from the ERSI Landfill were significantly reduced and were considered *No Apparent Public Health Hazard*.

During the Malodorous Period of 2003 Spanning between September and December:

- The peak levels of hydrogen sulfide (H_2S) and sulfur dioxide (SO2) measured in the community adjacent to the ERSI Landfill presented a *Past Public Health Hazard* to exposed residents for short duration exposures.
- The levels of the remaining landfill gases, notably methane (CH_4), measured in the community adjacent to the ERSI Landfill were below levels expected to cause adverse health effects for short duration exposures. Therefore, ATSDR classified exposures to the remaining landfill gases from the ERSI Landfill as a *No Apparent Public Health Hazard*.

Post Sampling after the 2003 Malodorous Air Releases:

- The levels of hydrogen sulfide measured in the community adjacent to the ERSI Landfill facility were below levels expected to cause adverse health effects, thus ATSDR classified such exposures as *No Apparent Public Health Hazard for short or long duration exposures.*

Recommendations

Environmental and Recycling Services, Inc. (ERSI) should

- Initiate and implement a landfill emergency response/contingency plan, especially if granted a landfill expansion permit. The contingency/emergency response plan should be a collaborative effort with the Commonwealth of Pennsylvania, Department of Environmental Protection (PA DEP), the Pennsylvania Department of Health (PADOH), and other health/safety authorities within the county/city, while prompting community health actions to protect nearby residents from likely exposures (e.g., residential/retail areas) to elevated levels of landfill gases, notably hydrogen sulfide (H_2S) generated particularly from an uncontrolled or accidental release of gases at the landfill.
- Initiate and continue to maintain proper odor-management practices, particularly when excavating and when altering landfill cover.
- Notify the PA DEP before commencing any work that will uncover large volumes of materials used for landfill cover or immediately following any substantial failure of the landfill gas-collection system.

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APPENDIX A

Comparison Values

ATSDR comparison values (CVs) are media-specific concentrations considered safe under default conditions of exposure. They are used as screening values in selecting site-specific chemicals or substances for further evaluation of their public health implications. Generally, a substance is selected for further public health evaluation because its maximum concentration in air, water, or soil at the site exceeds at least one of ATSDR's CVs. This approach is conservative by design. ATSDR may also select detected chemicals or substances for further public health evaluation and discussion because ATSDR has no CVs or because the community has expressed special concern about the substance, whether it exceeds CVs or not.

CVs are not thresholds of toxicity. While concentrations at or below the relevant CV are generally considered to be safe, it does not automatically follow that any environmental concentration that exceeds a CV would be expected to produce adverse health effects. In fact, the whole purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems before they become actual health hazards. For that reason, ATSDR's CVs are typically designed to be 1 to 3 orders of magnitude lower (i.e., 10 to 1,000 times lower) than the corresponding no-observed-adverse-effect levels (NOAEL) or lowest-observed-adverse-effect levels (LOAEL) on which they are based. The probability that adverse health outcomes will actually occur depends not on environmental concentrations alone, but on several additional factors, including site-specific conditions of exposure, and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposures.

Listed below are the abbreviations for selected CVs and units of measure used within this public health document for peak and short-term exposures to substances in the air. Following this list of abbreviations are more complete descriptions of the various comparison values used within this public health document.

AAC = Acceptable Ambient Concentration
AAL = Ambient Air Limit
ASIL = Acceptable Source Impact Level
AEGL = Acute Exposure Guideline Level
EMEG = Environmental Media Evaluation Guide
EPRG = Emergency Response Planning Guideline
HAAS = Hazardous Ambient Air Standard
IDLH = Immediately Dangerous to Life and Health
ITSL = Initial Threshold Screening Level
LC_{50} = Lethal Concentration$_{(50)}$
LD_{50} = Lethal Dose$_{(50)}$
LOAEL = Lowest-Observed-Adverse-Effect Level
MRL = Minimal Risk Level
NOAEL = No-Observed-Adverse-Effect Level

OEL = Occupational Exposure Limit
PEL = Permissible Exposure Limit
REL = Recommended Exposure Limit
RfC = Reference Concentration
RfD = Reference Dose
TLV-C = Threshold Limit Value–Ceiling
TLV-STEL = Threshold Limit Value–Short-Term Exposure Limit
TLV-TWA = Threshold Limit Value–Time Weighted Average

Units of Measure:
ppm = parts per million [e.g., mg/L (water), mg/kg (soil)]
ppb = parts per billion [e.g., µg/L (water), µg/kg (soil)]
kg = kilogram (1,000 grams)
mg = milligram (0.001 gram)
µg = microgram (0.000001 gram)
L = liter (1000 mL or 1.057 quarts of liquid, or 0.001 m3 of air)
m^3 = cubic meter (a volume of air equal to 1,000 liters)

Two CVs or exposure limits commonly used by ATSDR for assessing the public health implications due to acute (short-term) domestic (residential) exposures from substances within the air are listed below:

Environmental Media Evaluation Guides (EMEGs) are media-specific concentrations that are calculated from ATSDR's Minimal Risk Levels by factoring in default body weights and ingestion rates. Different EMEGs are calculated for adults and children, as well as for acute (<14 days), intermediate (15-364 days), and chronic (> 365 days) exposures.

Minimal Risk Levels (MRLs) are ATSDR estimates of daily human exposures to a chemical that are unlikely to be associated with any appreciable risk of deleterious noncancer effects over a specified duration of exposure. MRLs are calculated using data from human and animal studies and are reported for acute (< 14 days), intermediate (15-364 days), and chronic (> 365 days) exposures. MRLs for oral exposure (i.e., ingestion) are doses and are typically expressed in mg/kg/day. Inhalation MRLs are concentrations and are typically expressed in either parts per billion (ppb) or µg/m3. The latter are identical to ATSDR’s EMEGs for airborne contaminants. ATSDR’s MRLs are published in ATSDR Toxicological Profiles for specific chemicals.

More and more governmental departments (local, state, and federal), businesses, corporations, health offices, hospitals, and professional/non-profit organizations are becoming involved with emergency preparedness and response activities. Thus, some of these entities started developing guidelines or exposure limits for responding to potential releases of airborne substances for use in emergency response planning. One such exposure limit has been developed by the Environmental Protection Agency (EPA) and is called the Acute Exposure Guideline Level (AEGL), which is described below. Another emergency response exposure limit is termed the Emergency Response Planning Guideline (ERPG). This emergency response exposure limit was developed by the American Industrial Hygiene Association (AIHA) and will be described later on within Appendix A.

Acute Exposure Guideline Level (AEGL) represents a threshold exposure limit for the general public and is applicable to emergency exposure periods ranging from 10 minutes to 8 hours (i.e., peak and short-term exposures). AEGL-1, AEGL-2, and AEGL-3 values will be developed for each of five exposure periods (10 and 30 min, 1 hr, 4 hr, and 8 hr) and will be distinguished by varying degrees of severity of toxic effects. It is believed that the recommended exposure levels are applicable to the general population including infants and children, and other individuals who may be susceptible. The three AEGL values are defined as follows:

AEGL-1 is the airborne concentration (expressed as parts per million or milligrams per cubic meter (ppm or mg/m3)) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Airborne concentrations below the AEGL-1 represent exposure levels that can produce mild and progressively increasing but transient and non-disabling odor, taste, and sensory irritation or certain asymptomatic, non-sensory effects. With increasing airborne concentrations above each AEGL, there is a progressive increase in the likelihood of occurrence and the severity of effects described for each corresponding AEGL. Although the AEGL values represent threshold levels for the general public, including susceptible subpopulations, such as infants, children, the elderly, persons with asthma, and those with other illnesses, it is recognized that individuals, subject to unique or idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL.

The following CVs or exposure limits are used at the workplace to protect workers from potential harmful exposures that may impair their health or functional capacity throughout their entire career or work life. In keeping a proper perspective, ambient air levels measured in domestic settings outside of the workplace are sometimes compared to these occupational exposure limits (OELs). If such domestic air levels exceed these OELs, this may require that appropriate health actions be implemented or taken.

Permissible Exposure Limit (PEL) is an 8-hour, time-weighted average concentration or occupational exposure limit (OEL) of a substance in workplace air designed by the Occupational Safety and Health Administration (OSHA) to assure, to the extent feasible, that chemical exposures in the workplace do not impair the health or functional capacity of workers throughout their working life. The PEL may be exceeded for brief periods, but the sum of the exposure levels averaged over 8 hours must not exceed the PEL.

Recommended Exposure Limit (REL) is similar to a PEL since it is developed for the workplace air exposures; however the REL is designed by the National Institute for Occupational Safety and Health (NIOSH) and based on a time-weighted average (TWA) for up to a 10 hour workday during a 40-hour work week. Moreover, a PEL is regulatory and legally enforceable, while a REL is not. RELs are also grouped into two subclasses similar to Threshold Limit Values (TLVs) as established by the American Conference of Governmental Industrial Hygienists (ACGIH®) to consider short-term and peak exposures. These REL subclasses are Short-Term Exposure Limit (STEL) and Ceiling (C).

Immediately Dangerous to Life and Health (IDLH) is an airborne concentration, as established by the National Institute for Occupational Safety and Health (NIOSH), from which a worker could escape without injury or irreversible health effects from an IDLH exposure in the event of the failure of respiratory protection equipment. The IDLH was considered a maximum concentration above which only a highly reliable breathing apparatus providing maximum worker protection should be permitted. In determining IDLH values, NIOSH considered the ability of a worker to escape without loss of life or irreversible health effects along with certain transient effects, such as severe eye or respiratory irritation, disorientation, and in-coordination, which could prevent escape. As a safety margin, IDLH values are based on effects that might occur as a consequence of a 30-minute exposure. However, the 30-minute period was not meant to imply that workers should stay in the work environment any longer than necessary; in fact, every effort should be made to exit immediately.

Threshold Limit Value–Time Weighted Average (TLV-TWA), according to the American Conference of Governmental Industrial Hygienists (ACGIH®), is "the time-weighted average (TWA) concentration or occupational exposure limit (OEL) of a substance for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect". Many of ACGIH's TLVs were adopted by OSHA for use as PELs.

Threshold Limit Value–Short-Term Exposure Limit (TLV-STEL), according to the American Conference of Governmental Industrial Hygienists (ACGIH®), is a 15-minute time weighted average (TWA) exposure limit of a substance that should not be exceeded at any time during a workday, even if the 8-hour TWA is within the Threshold Limit Value–Time-Weighted Average (TLV-TWA) Exposure Limit. The TLV-STEL is the concentration or occupational exposure limit (OEL) to which it is believed that workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, 3) dose-rate-dependent toxic effects, or 4) narcosis of sufficient degree to increase the likelihood of accidental injury, impaired self-rescue, or materially reduced work efficiency. The TLV-STEL will not necessarily protect against these effects if the daily TLV-TWA is exceeded. The TLV-STEL is not a separate, independent exposure guideline; rather, it supplements the TLV-TWA where there are recognized acute effects from a substance whose toxic effects are primarily of a chronic nature. Exposures above the TLV-TWA up to the TLV-STEL should be less than 15 minutes, should occur not more than four times per day, and there should be at least 60 minutes between successive exposures in this range. An averaging period other than 15 minutes may be recommended when this is warranted by observed biological effects.

Threshold Limit Value–Ceiling (TLV-C), according to the American Conference of Governmental Industrial Hygienists (ACGIH®), is the concentration or occupational exposure limit (OEL) of a substance that should not be exceeded during any part of the working exposure. If instantaneous measurements are not available, sampling should be conducted for the minimum period of time sufficient to detect exposures at or above the ceiling value. ACGIH® believes that TLVs® based on physical irritation should be considered no less binding than those based on physical impairment. There is increasing evidence that physical irritation may initiate, promote, or accelerate adverse health effects through interaction with other chemical or biologic agents or through other mechanisms.

TLVs and PELs, which were designed to protect healthy workers, are usually much higher than the health-based values of ATSDR and EPA, which were designed to protect the health of the general population, including the very young and the elderly. ATSDR does not base any of its community health decisions solely or primarily on TLVs or PELs, but these and other non-ATSDR values may be referred to in Public Health Assessments or consultations as a means of providing the reader with an expanded, and perhaps more meaningful, perspective on the concentrations of chemicals or substances detected at a site.

The American Industrial Hygiene Association (AIHA) is a scientific organization concerned with environmental exposures to toxic airborne substances within the workplace. AIHA also has developed an emergency response exposure limit, **Emergency Response Planning Guideline (EPRG)**, similar to the AEGL as derived by EPA. ERPG values are intended to provide estimates of concentration ranges in air where one reasonably might anticipate observing adverse effects as a consequence of exposure to a specific substance. ERPG values are based on OELs (e.g., PELs, RELs, TLVs, etc.) being rationally lowered, upon internal review of appropriate scientific studies, to exposure limits considered protective of nearly all individuals within certain domestic settings subjected to a specific emergency response situation. The AIHA has provided guidance on the utilization of three exposure limits, each defined and briefly discussed below:

ERPG-1: "*The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.*" The ERPG-1 identifies a level which does not pose a health risk to the community but which may be noticeable due to slight odor or mild irritation. In the event that a small non-threatening release has occurred, the community could be notified that they may notice an odor or slight irritation but that concentrations are below those which could cause unacceptable health effects.

ERPG-2: " *The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.*" Above the ERPG-2, there may be significant adverse health effects, signs, or symptoms for some members of the community which could impair an individual's ability to take protective action. These effects might include severe eye or respiratory irritation, muscular weakness, CNS impairments, or serious adverse health effects.

ERPG-3: "*The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.*" The ERPG-3 level is a worst-case planning level above which there is the possibility that some members of the community may develop life threatening health effects. This guidance level could be used to determine the airborne concentration of a chemical that could pose life threatening consequences should an accident occur. This concentration could be used in planning stages to project possible levels in the community. Once the distance from the release to the ERPG-3 level is known, the steps to mitigate the potential for such a release can be established.

AIHA recognizes (and should be remembered by all who make use of these values) that human responses do not occur at precise exposure levels but can extend over a wide range of concentrations. The values derived for ERPGs should not be expected to protect everyone but should be applicable to most individuals in the general population. In all populations there are hypersensitive individuals who will show adverse responses at exposure concentrations far below levels where most individuals normally would respond. Furthermore, since these values have been derived as planning and emergency response guidelines, not exposure guidelines, they do not contain the safety factors normally incorporated into exposure guidelines. Instead, they are estimates, by the AIHA, of the thresholds above which there would be an unacceptable likelihood of observing the defined effects. The estimates are based on the available data that are summarized in the documentation. In some cases where the data are limited, the uncertainty of these estimates is large. Users of the ERPG values are encouraged strongly to review carefully the documentation before applying these values.

In developing these ERPGs, human experience has been emphasized to the extent data are available. Because ,however, this type of information is rarely available, and when available is only for low level exposures, animal exposure data most frequently forms the basis for these values. The most pertinent information is derived from acute inhalation toxicity studies that have included clinical observations and histopathology. The focus is on the highest levels not showing the effects described by the definitions of the ERPG levels. Next, data from repeat inhalation exposure studies with clinical observations and histopathology are considered. Following these in importance are the basic, typically acute studies where mortality is the major focus. When inhalation toxicity data are either unavailable or limited, data from studies involving other routes of exposure will be considered. More value is given to the more rigorously conducted studies, and data from short-term studies are considered to be more useful in estimating possible effects from a single 1-hr exposure. Finally, if mechanistic or dose-response data are available, these are applied, on a case by case basis, as appears appropriate.

It is recognized that there is a range of times that one might consider these guidelines; however, it was AIHA's decision to focus its efforts on only one time period. This decision was based on the availability to toxicology information and a reasonable estimate for an exposure scenario. Users who may choose to extrapolate these values to other time periods are cautioned to review the documentation fully since such extrapolations tend to hold only over very limited time frames, it at all.

Environmental health departments of some state governments sometimes use OELs (e.g., PELs, RELs, TLVs, etc.) as a source for deriving peak and short-term ambient air standards by subjecting them to specified reduction factors. These reduction factors may account for several factors, including; 1) TLVs are premised on an 8-hour work-day and 5-day work week, while ambient standards are premised on continuous exposure for a lifetime, 2) TLVs are premised on a worker population that is relatively more healthy than the general population, and 3) generic application of "safety factors" are utilized in its formulation. Reduction factors for various states could possibly range from 1/10 to 1/4200. The various reduction factors employed by the states were all designed via a rational regulatory process integrated with health-based considerations in mind. A tabular listing below shows the peak and short-term ambient air standards for five different states used within this public health document. Each of these peak and short-term standards are defined and briefly discussed following the tabular listing.

Peak & Short-Term Air Standards of Five Different States

State	Reduction Factor (RF)	RF – Citation
Michigan, ITSL	1/100	R 336.1232 (c) http://www.michigan.gov/documents/deq-aqd-toxics-toxicsrules_117404_7.doc
New Hampshire, AAL	1/(24 to 420)	Env-A-1400 http://www.des.state.nh.us/rules/env-a1400.pdf
Vermont, HAAS (accumulation and uncertainty factors)	1/(42, 420, or 4200) or 1/(10, 100, or 1000)	section 5-261, appendix D http://www.anr.state.vt.us/air/docs/apcregs.pdf
Washington, ASIL	1/300	WAC 173-460 http://www.ecy.wa.gov/pubs/wac173460.pdf
Wisconsin, AAC (1-hr or 24-hr)	1/(10 to 42)	NR 445.04 & .05 http://www.legis.state.wi.us/rsb/code/nr/nr445.pdf

Initial Threshold Screening Level (ITSL), Michigan's Department of Environmental Quality health based screening level for non-carcinogenic effects of a toxic air contaminant. It is determined by a number of different formulas or equations, depending upon the available toxicological data (RfC, RfD, OEL, NOAEL, LOAEL, LC_{50}, and LD_{50}). Rule 232 specify a hierarchy of these formulas for determining the ITSL. The ITSL is set for three distinctive time-weighted averages (TWAs) of exposure that is dependent upon the available toxicological data: 1) 1 hour, 2) 8 hours, 3) 24 hours, or 4) 365 days (annual). In the interest of public health, the ITSL should not be exceeded for the designated TWA.

Ambient Air Limit (AAL) is a concentration limit of a toxic air pollutant not to be exceeded in the ambient air as set by the New Hampshire Department of Environmental Services. It is intended to provide public health protection over a time-weighted average (TWA) of exposure (i.e., for the designated TWA and the interest of public health, the AAL should not be exceeded). Depending upon the substance, available toxicological data, and the method used to calculate the AAL, the time-weighted average of exposure can be for a twenty-four (24) hour exposure or exposures up to 365 days in one year (annual).

Hazardous Ambient Air Standard (HAAS) means the highest acceptable concentration in the ambient air of a hazardous air contaminant as set by the Vermont Department of Environmental Conservation. The HAASs are designed to be protective of public health for an assumed time-weighted average (TWA) of exposure (i.e., for the designated TWA and the interest of public health, the HAAS should not be exceeded). Depending upon the substance, available toxicological data, and the method used to calculate the HAAS, the time-weighted average of exposure can be for a twenty-four (24) hour exposure or exposures up to 365 days in one year (annual).

Acceptable Source Impact Level (ASIL) means the highest acceptable concentration of a toxic air pollutant in the outdoor atmosphere in any area which does not have restricted or controlled public access that is used to evaluate the air quality impacts of a single source. There are three types of acceptable source impact levels: risk-based, threshold-based, and special. Concentrations for these three types of ASILs are determined by several methods as approved by the Washington Department of Ecology. The ASILs are designed to be protective of public health for an assumed time-weighted average (TWA) of exposure (i.e., for the designated TWA and the interest of public health, the ASIL should not be exceeded). Depending upon the substance, available toxicological data, and the method used to calculate the ASIL, the time-weighted average of exposure can be for a twenty-four (24) hour exposure or exposures up to 365 days in one year (annual).

Acceptable Ambient Concentration (AAC) means the highest acceptable concentration of a toxic air pollutant in the outdoor atmosphere that is used to evaluate the air quality impacts of an emission source(s). AACs are health-based air standards and are described in Chapter NR 445 of the Wisconsin’s Department of Natural Resources regulatory code. The AACs are set at levels designed to be protective of public health for an assumed time-weighted average (TWA) of exposure (i.e., for the designated TWA and the interest of public health, the AAC should not be exceeded). Depending upon the substance, available toxicological data, and the method used to calculate the AAC, the time-weighted average of exposure can be for a one (1) hour exposure, twenty-four (24) hour exposure, or exposures up to 365 days in one year (annual).

Listed below are some health-based guidelines commonly referenced in dose-response studies (e.g., toxicological, epidemiological, etc.) that were used in the derivation of some of the above health-based standards:

Lethal Concentration$_{(50)}$ (LC$_{50}$) is a calculated concentration of a chemical in air to which exposure for a specific length of time is expected to cause death in 50% of a defined experimental animal population.

Lethal Dose$_{(50)}$ (LD$_{50}$) is the dose (intake per body weight) of a chemical which has been calculated to cause death in 50% of a defined experimental animal population.

Lowest-Observed-Adverse-Effect Level (LOAEL) is the lowest exposure level of a chemical in a study, or group of studies, that produces statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control.

No-Observed-Adverse-Effect Level (NOAEL) is the dose of a chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be produced at this dose, but they are not considered to be adverse.

Reference Concentration (RfC) is an estimate (with uncertainty spanning perhaps an order of magnitude or more) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious non-cancer health effects during a lifetime. The inhalation reference concentration is for continuous inhalation exposures and is appropriately expressed in units of mg/m^3 or ppm.

Reference Dose (RfD) is an estimate (with uncertainty spanning perhaps an order of magnitude or more) of the daily exposure of the human population to a potential hazard that is likely to be without risk of deleterious non-cancer health effects during a lifetime. The RfD is operationally derived from the no-observed-adverse-effect level (NOAEL-from animal and human studies) by a consistent application of uncertainty factors that reflect various types of data used to estimate RfDs and an additional modifying factor, which is based on a professional judgment of the entire database on the chemical. The RfDs are for continuous daily exposures and are appropriately expressed in units of mg/kg/day.

Screening Rationale Used to Select Substances for Further Public Health Analysis

After potential exposure pathways are considered, the next step in any environmental health analysis or assessment process is the application of conservative screening values (i.e., comparison values) to the available sampling data (ATSDR 2005). This phase of the process helps to rule out any site-specific substances that would not pose a public health hazard under almost any plausible exposure scenario. The substances remaining after the preliminary screen would require in-depth public health analyses to evaluate their potential for causing adverse health effects under site-specific exposure conditions (ATSDR 2005). During this final phase or step (i.e., in-depth public health analysis) of the environmental health assessment process, potential public health implications are identified. Toxic exposures are not identified under the preliminary screening phase; it merely eliminates obviously nontoxic exposures. This allows environmental health scientists, when assessing public health implications, to focus on a reduced list of substances.

When selecting an environmental guideline for use in environmental health assessments, ATSDR environmental health scientists normally follow ATSDR's general hierarchy, as shown in Figure 6. Environmental guidelines listed under Hierarchy 1 are usually chosen first, given that the guidelines are based on ATSDR analyses of substance-specific toxicity data.

In the absence of these values, Hierarchy 2 environmental guidelines may be chosen. These are either based on ATSDR analyses of substance-specific toxicity data not used in Hierarchy 1 (e.g., intermediate exposures of 15–365 days) or on U.S. EPA analyses of the substance-specific toxicity data. If substance-specific guidelines are absent for Hierarchies 1 and 2, environmental guidelines in Hierarchy 3 may be chosen.

Finally, in some cases the environmental guidelines listed in the ATSDR hierarchy are simply unavailable. Other sources are then considered in choosing environmental guidelines to conduct the environmental health assessment. For example, other governmental agencies (federal, state, and tribal agencies) may require that their environment/health departments meet specified public health mandates by developing their own guidelines. These environmental guidelines may address hazardous substances in water, soil, air, fish, or other biota.

For screening purposes, typically the environmental guideline with the lowest concentration level and that is most consistent with conditions at or near the site is selected. ATSDR environmental health scientists must sometimes select the environmental guideline that best applies to site conditions in terms of time frames and potentially exposed populations. The following exposure elements may sometimes lead environmental health scientists to move away from the hierarchy listed in Figure 6; nevertheless, consideration of these exposure elements tends to help select the most appropriate CVs for screening:

- *Exposure duration*. When selecting the most appropriate environmental guideline, exposure duration is an essential consideration. A one-time exposure to a high contaminant concentration may result in different health effects than would a repeated exposure to a lower contaminant concentration. As noted, ATSDR has developed EMEGs that apply to acute (14 days or less), intermediate (15–365 days) and chronic (365 days or more) exposures. Comparison values developed by other organizations may apply to acute, intermediate, or chronic exposures, or to all three.
- *Site-specific exposure conditions*. In some instances, the most conservative environmental guideline may not be the most appropriate screening value. Of critical importance in conducting environmental health assessments is selecting environmental guidelines most appropriate and applicable to site-specific conditions. Exposures identified at the site should closely approximate the exposure assumptions used to derive the environmental guideline. For example, including a soil contaminant for further evaluation based on a comparison value for a child would be inappropriate if the contaminant is found in a restricted industrial site where children are prohibited. Also, past, current, and potential future exposure conditions must be borne in mind.

For this environmental health analysis or evaluation, a substance was initially selected for in-depth public health analysis if its maximum detected level in air exceeded its most relevant air comparison value (CV). (See Appendix A for a description of the air comparison values used in this environmental health analysis and their interpretation.) Using all of the CVs or environmental guidelines established for air exposures that ATSDR considers protective of public health, the most relevant air CV is chosen through a hierarchical or ranked arrangement, similar to that in Figure 6 (in Appendix C). ATSDR environmental health scientists then developed a hierarchical screening process for selecting—in terms of time frames and populations that might be exposed—the most appropriate environmental guideline that best applies to conditions at the ERSI Landfill (see Figures 7 and 8 in Appendix C). Even if through this screening process no relevant air CV exists for a particular substance, the substance is still selected for in-depth public health analysis.

Following the initial screening, the detected air concentration(s) is further utilized to interpret whether site-specific exposures to the selected substance(s) pose any potential concern to public health. Conducting an in-depth analysis of chemicals or substances selected for further public health analysis is the final step of the environmental health assessment process.

APPENDIX B. Tables

TABLE 1

GC/MS Sampling Results

Tuesday - November 18, 2003		
Sample	Time	Compounds Identified
LOC #2	12:55 PM	Dichlorofluoromethane, Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, Dimethyl Sulfide, Toluene, Ethylbenzene, one Xylene isomer, α-Pinene, Camphene, two C_4-Substituted benzenes, and eighteen Hydrocarbons in the range of C_5 to C_{10}.
LOC #1	2:00 PM	Dichlorofluoromethane, Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, α-pinene, one C_4-Substituted benzene, Limonene, and four Hydrocarbons in the range of C_5 to C_6.
LOC #4	2:45 PM	Five Hydrocarbons in the range of C_5 to C_9.
LOC #3	3:40 PM	*None*
LOC #1	4:37 PM	Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, α-Pinene, one C_4-Substituted benzene, and seven Hydrocarbons in the range of C_5 to C_6.
LOC #2	5:24 PM	Dichlorofluoromethane, Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, Toluene, one Xylene isomer, α-Pinene, Camphene, two C_4-Substituted benzenes, Limonene, and nine Hydrocarbons in the range of C_5 to C_7.
LOC #4	6:05 PM	Five Hydrocarbons in the range of C_5 to C_6, and one C_{10} Hydrocarbon.
LOC #3	7:40 PM	1,1-Dichloro-1-fluoroethane* and one Xylene isomer
LOC #1	8:50 PM	Dichlorofluoromethane, Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, α-Pinene, Camphene, and seven Hydrocarbons in the range of C_5 to C_6.
LOC #2	10:15 PM	Dichlorofluoromethane, Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, Toluene, α-Pinene, one C_4-Substituted benzene, and four Hydrocarbons in the range of C_5 to C_7.
LOC #3	11:20 PM	Three Hydrocarbons in the range of C_5 to C_7.
Landfill Ambient	5:11 PM	*None*
Landfill Ambient	6:34 PM	*None*
Landfill Ambient	9:20 PM	Trichloromonofluoromethane and Dipropyl 1,2-benzenedicarboxylate*.

*Tentative identification was made of the listed compound. As a result of the environmental interference surrounding the target compound peak, a true and accurate conclusion could not be ascertained, hence the compound is listed with a cautionary identification.

TABLE 2
GC/MS Sampling Results

Wednesday - November 19, 2003		
Sample	Time	Compounds Identified
LOC #1	12:58 PM	Dichlorofluoromethane, Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, α-pinene, and four Hydrocarbons in the range of C_5 to C_6.
LOC #2	2:10 PM	Dichlorofluoromethane, Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, Toluene, α-Pinene, Camphene, one C_4-Substituted benzene, Limonene, and thirteen Hydrocarbons in the range of C_5 to C_8.
LOC #3	5:10 PM	*None*
18 ROS	8:45 PM	*None*
Landfill Ambient	12:16 PM	*None*
Landfill Ambient	1:37 PM	*None*
Landfill Ambient	3:59 PM	*None*
Landfill Ambient	7:38 PM	*None*

Thursday - November 20, 2003		
Sample	Time	Compounds Identified
LOC #2	2:35 PM	Diphenylamine*
LOC #3	3:20 PM	Ethylbenzene, one Xylene isomer, and one C_7 Hydrocarbon.
LOC #4	4:30 PM	*None*
LOC #2	6:00 PM	*None*
LOC #3	8:10 PM	Ethylbenzene and one Xylene isomer
LOC #2	9:45 PM	Dichlorofluoromethane, one C_4-Substituted benzene, and Limonene.
Landfill Ambient	12:18 PM	*None*
Landfill Ambient	19:22 PM	*None*

*Tentative identification was made of the listed compound. As a result of the environmental interference surrounding the target compound peak, a true and accurate conclusion could not be ascertained, hence the compound is listed with a cautionary identification.

TABLE 3

GC/MS Sampling Results

Monday - December 1, 2003		
Sample	Time	Compounds Identified
LOC #5	1:00 PM	Trichloromonofluoromethane and one C_5 Hydrocarbon.
LOC #2	2:00 PM	*None*
426 Powell	2:35 PM	*None*
LOC #3	4:35 PM	One Xylene isomer
LOC #4	5:35 PM	One Xylene isomer and sixteen Hydrocarbons in the range of C_5 to C_{11}.
LOC #2	7:00 PM	Trichloromonofluoromethane, 1,1-Dichloro-1-fluoroethane*, Trichloroethylene, Toluene, two Xylene isomers, α-Pinene, one C_4-Substituted benzene, Limonene, and nine Hydrocarbons in the range of C_5 to C_7.
LOC #5	7:50 PM	*None*
Landfill Ambient	4:10 PM	*None*
Landfill Ambient	6:19 PM	*None*

Tuesday - December 2, 2003		
Sample	Time	Compounds Identified
LOC #5	10:55 AM	Two Hydrocarbons in the range of C_5 to C_6.
505 Powell	11:50 AM	One C_4-Substituted benzene, Limonene, and Diphenylamine*.
752 S. Main	1:05 PM	*None*
LOC #2	2:35 PM	*None*
508 Powell	4:00 PM	*None*
LOC #3	5:13 PM	*None*
508 Powell	6:30 PM	*None*
LOC #5	7:50 PM	*None*
Landfill Ambient	9:35 PM	*None*
Landfill Ambient	2:25 PM	Toluene
Landfill Ambient	7:04 PM	Trichloromonofluoromethane

*Tentative identification was made of the listed compound. As a result of the environmental interference surrounding the target compound peak, a true and accurate conclusion could not be ascertained, hence the compound is listed with a cautionary identification.

TABLE 4

GC/MS Sampling Results

Wednesday - December 3, 2003		
Sample	Time	Compounds Identified
LOC #2	10:25 PM	*None*
501 Powell	11:10 PM	*None*
LOC #5	12:10 PM	One C_5 Hydrocarbon* and one C_4-Substituted benzene.
LOC #4	1:00 PM	Three Hydrocarbons in the range of C_5 to C_7 and one C_{10} Hydrocarbon.
ELEMSCH	2:45 PM	*None*
752 Main	3:15 PM	*None*
505 Powell	4:30 PM	*None*
Turnpike	6:00 PM	*None*
LOC #3	7:20 PM	*None*
Turnpike	8:20 PM	*None*
Landfill Ambient	9:02 AM	*None*
Landfill Ambient	10:20 AM	*None*

Thursday - December 4, 2003		
Sample	Time	Compounds Identified
511 Hicko	9:45 AM	*None*
LOC #5	10:40 AM	Limonene
LOC #2	12:15 PM	Limonene
LOC #3	1:10 PM	*None*
Union	1:45 PM	*None*
LOC #5	3:15 PM	Trichloromonofluoromethane, Toluene, one C_4-Substituted benzene, Limonene, and three Hydrocarbons in the range of C_5 to C_7.
Union	3:53 PM	Limonene
LOC #4	4:55 PM	Ethylbenzene, one Xylene isomer, and ten Hydrocarbons in the range of C_5 to C_8 and one C_{11} Hydrocarbon.
#2 ROSEV	6:05 PM	Toluene and one Xylene isomer.
I 476	7:08 PM	*None*
Landfill Ambient	9:13 AM	*None*
Landfill Ambient	1:39 PM	*None*

*Tentative identification was made of the listed compound. As a result of the environmental interference surrounding the target compound peak, a true and accurate conclusion could not be ascertained, hence the compound is listed with a cautionary identification.

TABLE 5

TAGA IIE Sampling Results

Tuesday - November 18, 2003		
Sample	Time	Compounds Tentatively Identified
LOC#2	12:55pm	Butanol, Propyleneglycol, Pyrocatechol
LOC#1	2:00pm	Butanol, 1,5-Pentanediol
LOC#4	2:45pm	Propylene glycol, 2,3-Butanedione
LOC#3	3:40pm	2-Methyl-1-butanol
LOC#1	4:37pm	2-Methyl-3-butyne-2-ol, 1,5-Pentanediol
LOC#2	5:24pm	2-Methyl-3-butyne-2-ol, Pentanal
LOC#4	6:05pm	*None*
LOC#3	7:40pm	*None*
LOC#1	8:50pm	*None*
LOC#2	10:55pm	*None*
LOC#3	11:20pm	Acetol
Landfill Ambient	12:20pm	*None*
Landfill Ambient	2:30pm	*None*

Wind direction was from the South averaging 5 mph. At 4:20 pm the winds shifted to the east averaging 5 mph and then shifted back to the south at 9:00 pm, averaging 8 mph for the remainder of the sampling session.

No compounds could be identified from the spectra for the Landfill Ambient samples collected at 1:30 pm, 3:30 pm, 4:30 pm, 5:30 pm, 6:30 pm, 7:30 pm, 8:30 pm, 9:30 pm, 10:30 pm, and 11:30 pm.

Wednesday - November 19, 2003		
Sample	Time	Compounds Tentatively Identified
LOC#1	12:58pm	*None*
LOC#2	2:10pm	Acetol
LOC#3	5:10pm	*None*
18 ROS	8:45 PM	*None*
Landfill Ambient	12:00pm	*None*
Landfill Ambient	4:00pm	*None*
Landfill Ambient	8:00pm	*None*

Wind direction was from the South averaging 17 mph from 12:00 pm until 4:00 pm when the Met tower was put down due to bad weather.

No compounds could be identified from the spectra for the Landfill Ambient samples collected at 1:00pm, 2:00pm, 3:00pm, 5:00pm, 6:00pm, 7:00pm, 10:00pm, and 11:00pm.

TABLE 6
TAGA IIE Sampling Results

Thursday - November 20, 2003

Sample	Time	Compounds Tentatively Identified
LOC#2	2:35pm	*None*
LOC#3	3:20pm	2,3-Butanedione
LOC#4	4:30pm	*None*
LOC#2	6:00pm	*None*
LOC#3	8:10pm	*None*
LOC#2	9:45pm	*None*
Landfill Ambient	12:00pm	*None*
Landfill Ambient	2:00pm	*None*
Landfill Ambient	8:00pm	*None*
Landfill Ambient	10:00pm	*None*

Wind direction was from North from 12:00 pm until 3:00 pm when the direction changed to the West-Northwest and averaged 4 mph for the remainder of the sampling session.

No compounds could be identified from the spectra for the Landfill Ambient samples collected at 1:00pm, 3:00pm, 4:00pm, 5:00pm, 6:00pm, 7:00pm, and 9:00pm.

Monday - December 1, 2003

Sample	Time	Compounds Tentatively Identified
LOC#5	1:00pm	*None*
LOC#2	2:00pm	*None*
426 POWEL	2:35pm	*None*
LOC#3	4:35pm	*None*
LOC#4	5:35pm	Pentanal
LOC#2	7:00pm	*None*
LOC#5	7:50pm	*None*
LOC#3	8:50pm	*None*
Landfill Ambient	12:15pm	*None*

Winds were from the West-Northwest averaging 7 mph from 12:00 pm until 6:15 pm. The winds then shifted to the Southwest averaging 5 mph for the remainder of the sampling session.

No compounds could be identified from the spectra for the Landfill Ambient samples collected at 1:15 pm, 2:15 pm, 3:15 pm, 4:15 pm, 5:15 pm, 6:15 pm, 7:15 pm, and 8:15 pm.

TABLE 7

TAGA IIE Sampling Results

Tuesday - December 2, 2003		
Sample	Time	Compounds Tentatively Identified
LOC#5	10:55am	*None*
505 POWEL	11:50am	*None*
752 S MAIN	1:05pm	*None*
LOC#2	2:35pm	*None*
508 POWEL	4:00pm	*None*
LOC#3	5:13pm	*None*
508 POWEL	6:30PM	*None*
LOC#5	7:50pm	*None*

Winds were from the West-Northwest averaging 7 mph for the sampling session.

No compounds could be identified from the spectra for the Landfill Ambient samples collected at 1:15 pm, 2:15 pm, 3:15 pm, 4:15 pm, 5:15 pm, 6:15 pm, 7:15 pm, and 8:15 pm.

Wednesday - December 3, 2003		
Sample	Time	Compounds Tentatively Identified
LOC#2	10:25am	*None*
501 POW	11:10am	*None*
LOC#5	12:10pm	*None*
LOC#4	1:00pm	*None*
ELEMSCH	2:45pm	*None*
752 MAIN	3:15pm	*None*
505 POWEL	4:30pm	*None*
TURNPIKE	6:00pm	*None*
LOC#3	7:20pm	*None*
TURNPIKE	8:20 PM	*None*

Winds were from the North from 9:00 am averaging 1 mph until 10:40 am. The winds then shifted to the South and averaged 4 mph until 5:10 pm when the winds shifted to the Northwest at 1 mph for the remainder of the sampling session.

No compounds could be identified from the spectra for the Landfill Ambient samples collected at 9:00am, 10:00am, 11:00am, 12:00 pm, 1:00 pm, 2:00 pm, 3:00 pm, 4:00 pm, 5:00 pm, 6:00 pm, 7:00 pm, and 8:00 pm.

TABLE 8

TAGA IIE Sampling Results

Thursday - December 4, 2003		
Sample	Time	Compounds Tentatively Identified
511 HICKO	9:45am	*None*
LOC#5	10:40pm	*None*
LOC#2	12:15pm	*None*
LOC#3	1:10pm	*None*
UNION	1:45pm	*None*
LOC#5	3:15pm	*None*
UNION	3:53pm	*None*
LOC#4	4:55pm	*None*
#2 ROSEV	6:05pm	*None*
I 476	7:08pm	*None*

At 9:00 am the average wind direction was from the North at an average speed of 1 mph. The wind direction shifted from the South averaging 5 mph at 10:40 am. The direction of the wind remained from the South until 5:10pm when it shifted from out of the North at an average of 3 mph for the remainder of the sampling session.

No compounds could be identified from the spectra for the Landfill Ambient samples collected at 9:00am, 10:00am, 11:00am, 12:00 pm, 1:00 pm, 2:00 pm, 3:00 pm, 4:00 pm, 5:00 pm, 6:00 pm, and 7:00 pm.

TABLE 9

OPFTIR Analysis Results

Week 1: November 18-20, 2003

Day #1: Tuesday November 18, 2003 (1:00 pm to 12:00 am)

The OPFTIR was set-up with the beam path along the top plateau of the ERSI Landfill. The path length was 228 meters. Wind direction during the sampling was from the South, averaging 8 mph.

Compound	Detection Limit, ppb	Average Concentration, ppb	Highest Concentration, ppb (Time)*
Acetaldehyde	166	---	---
Ammonia	4	---	---
Benzene	88	---	---
Carbon Disulfide	127	---	---
Carbon Monoxide	39	---	265 (3:03 pm)
Carbonyl Sulfide	21	---	---
Chloroform	8	---	---
Dimethyl Sulfide	133	---	---
Ethanol	29	---	---
Ethylbenzene	262	---	---
Ethylene	9	---	---
Formaldehyde	40	---	---
Hydrogen Chloride	68	---	---
Hydrogen Sulfide	7081	---	8906 (1:34pm)
Methane	758	6540	18460 (6:41 pm)
Methanol	7	---	---
2-Methyl Butane	90	---	---
Methyl Mercaptan	415	---	---
Methylamine	88	---	195 (5:18 pm)
n-Octane	47	---	---
Sulfur Dioxide	136	---	---
TCE	8	---	35 (1:35 pm)
Toluene	120	---	---
Triethylamine	26	---	---
m-Xylene	103	---	---
o-Xylene	90	---	---
p-Xylene	264	---	---
Vinyl Chloride	14	---	---

"---" Compound Below Detection Limit

"*" Highest concentration existed for less than 2 min. unless otherwise noted.

TABLE 10

OPFTIR Analysis Results

Week 1: November 18-20, 2003

Day #2: Wednesday November 19, 2003 (11:30 am to 8:05 pm)

The OPFTIR was set-up with the beam path along the top plateau of the ERSI Landfill. The path length was 228 meters. Wind direction during the sampling was from the South, averaging 15 mph.

Compound	Detection Limit, ppb	Average Concentration, ppb	Highest Concentration, ppb (Time)*
2-Methyl Butane	86	---	---
Acetaldehyde	143	---	790 (8:06 pm)
Ammonia	4	---	6 (5:56 pm)
Benzene	86	---	---
Carbon Disulfide	151	---	---
Carbon Monoxide	46	---	122 (1:27 pm)
Carbonyl Sulfide	18	---	---
Chloroform	7	---	12 (7:58 pm)
Dimethyl Sulfide	133	---	---
Ethanol	36	---	---
Ethylbenzene	238	---	336 (11:58 am)
Ethylene	9	---	---
Formaldehyde	37	---	---
Hydrogen Chloride	62	---	---
Hydrogen Sulfide	6689	---	---
Methane	673	5727	14089 (8:06 pm)
Methanol	7	---	---
Methyl Mercaptan	500	---	---
Methylamine	92	---	178 (7:44 pm)
n-Octane	43	---	---
Sulfur Dioxide	131	---	---
TCE	16	---	31 (7:56 pm)
Toluene	125	---	---
Triethylamine	24	---	60 (6:07 pm)
Trimethylamine	12	---	---
Vinyl Chloride	14	---	---
m-Xylene	101	---	---
o-Xylene	107	---	---
p-Xylene	246	---	---

"---" Compound Below Detection Limit

"*" Highest concentration existed for less than 2 min. unless otherwise noted.

TABLE 11

OPFTIR Analysis Results

Week 1: November 18-20, 2003

Day #3: Thursday November 20, 2003 (2:15 pm to 10:00 pm)

The OPFTIR was set-up with the beam path parallel along Powell Street. The path length was 222 meters. Wind direction during sampling was from the North, averaging 3 mph.

Compound	Detection Limit, ppb	Average Concentration, ppb	Highest Concentration, ppb (Time)*
Acetaldehyde	121	---	---
Ammonia	5	---	12 (4:25 pm)
Benzene	123	---	---
Carbon Disulfide	209	---	---
Carbon Monoxide	59	---	1248 (4:24 pm)
Carbonyl Sulfide	44	---	---
Chloroform	11	---	---
Dimethyl Sulfide	137	---	---
Ethanol	38	---	---
Ethylbenzene	240	---	---
Ethylene	11	---	---
Formaldehyde	24	---	---
Hydrogen Chloride	29	---	---
Hydrogen Sulfide	9898	---	---
Methane	266	---	3077 (9:01 pm)
Methanol	7	---	---
2-Methyl Butane	53	---	---
Methyl Mercaptan	541	---	---
Methylamine	133	---	216 (8:56 pm)
n-Octane	20	---	---
Sulfur Dioxide	120	---	---
TCE	10	---	19 (2:20 pm)
Toluene	163	---	---
Triethylamine	15	---	---
Trimethylamine	39	---	---
m-Xylene	157	---	---
o-Xylene	147	---	---
p-Xylene	347	---	---
Vinyl Chloride	19	---	---

"---" Compound Below Detection Limit

"*" Highest concentration existed for less than 2 min. unless otherwise noted.

TABLE 12

OPFTIR Analysis Results

Week 2: December 1-4, 2003

Day #1: Monday December 1, 2003 (12:45 pm to 8:50 pm)

The OPFTIR was set-up with the beam path parallel along Powell Street. The path length was 218 meters. Wind direction during sampling was from the North, averaging 8 mph.

Compound	Detection Limit, ppb	Average Concentration, ppb	Highest Concentration, ppb (Time)*
Acetaldehyde	46	---	---
Ammonia	2	---	---
Benzene	40	---	---
Carbon Disulfide	51	---	---
Carbon Monoxide	16	76	2459 (8:29 pm)
Carbonyl Sulfide	7	---	---
Chloroform	3	---	---
Dimethyl Sulfide	40	---	---
Ethanol	9	---	---
Ethylbenzene	70	---	---
Ethylene	4	---	10 (8:31 pm)
Formaldehyde	14	---	---
Hydrogen Chloride	24	---	---
Hydrogen Sulfide	2886	---	---
Methane	225	2376	13157(1:25 pm)
Methanol	3	---	6 (5:42 pm)
Methylamine	32	---	60 (3:56 pm)
2-Methyl Butane	27	---	---
Methyl Mercaptan	113	---	130 (4:18 pm)
n-Octane	15	---	---
Sulfur Dioxide	60	---	---
Toluene	35	---	---
TCE	4	---	---
Triethylamine	8	---	---
Trimethylamine	5	---	8 (1:04 pm)
m-Xylene	29	---	---
o-Xylene	25	---	---
p-Xylene	66	---	---
Vinyl Chloride	8	---	---

"---" Compound Below Detection Limit

"*" Highest concentration existed for less than 2 min. unless otherwise noted.

TABLE 13

OPFTIR Analysis Results

Week 2: December 1-4, 2003

Day #2: Tuesday December 2, 2003 (9:00 am to 8:45 pm)

The OPFTIR was set-up with the beam path parallel along Union Street. The path length was 276 meters. Wind direction during the sampling was from the West, averaging 5 mph.

Compound	Detection Limit, ppb	Average Concentration, ppb	Highest Concentration, ppb (Time)*
Acetaldehyde	23	---	---
Ammonia	2	---	---
Benzene	36	---	44 (3:29 pm)
Carbon Disulfide	27	---	---
Carbon Monoxide	11	---	236 (5:24 pm)
Carbonyl Sulfide	5	---	---
Chloroform	2	---	---
Dimethyl Sulfide	24	---	---
Ethanol	8	---	84 (4:37 pm)
Ethylbenzene	28	---	---
Ethylene	5	---	8 (4:59 pm)
Formaldehyde	4	---	---
Hydrogen Chloride	6	---	---
Hydrogen Sulfide	1897	---	---
Methane	32	43	397 (10:55 am)
Methanol	4	---	---
2-Methyl Butane	2	---	---
Methyl Mercaptan	92	---	---
Methylamine	26	---	48 (5:00 pm)
n-Octane	4	---	---
Sulfur Dioxide	43	---	436 (4:37 pm)
TCE	4	---	7 (9:22 am)
Toluene	26	---	---
Triethylamine	4	---	---
Trimethylamine	3	---	5 (5:04 pm)
m-Xylene	23	---	46 (5:18 pm)
o-Xylene	17	---	---
p-Xylene	51	---	---
Vinyl Chloride	8	---	---

"---" Compound Below Detection Limit

"*" Highest concentration existed for less than 2 min. unless otherwise noted.

TABLE 14

OPFTIR Analysis Results

Week 2: December 1-4, 2003

Day #3: Wednesday December 3, 2003 (9:00 am to 8:45 pm)

The OPFTIR was set-up with the beam path parallel to the North side of the Riverside Elementary School. The Path length was 222 meters. Wind direction during the sampling was from the North, averaging 5 mph.

Compound	Detection Limit, ppb	Average Concentration, ppb	Highest Concentration, ppb (Time)*
Acetaldehyde	80	---	---
Ammonia	3	---	---
Benzene	69	---	---
Carbon Disulfide	123	---	---
Carbon Monoxide	36	51	384 (8:10 pm)
Carbonyl Sulfide	17	---	---
Chloroform	5	---	---
Dimethyl Sulfide	73	---	---
Ethanol	18	---	---
Ethylbenzene	135	---	261 (8:45 pm)
Ethylene	7	---	---
Formaldehyde	27	---	---
Hydrogen Chloride	43	---	---
Hydrogen Sulfide	5152	---	---
Methane	456	1684	12142 (8:25 pm)
Methanol	6	---	35 (11:25 am)
2-Methyl Butane	59	---	---
Methyl Mercaptan	246	---	---
Methylamine	68	---	274 (5:31 pm)
n-Octane	29	---	---
Sulfur Dioxide	105	---	---
TCE	7	---	15 (5:40 pm)
Toluene	67	---	---
Triethylamine	13	---	---
Trimethylamine	17	---	---
m-Xylene	63	---	---
o-Xylene	56	---	---
p-Xylene	136	---	---
Vinyl Chloride	12	---	16 (12:57 pm)

"---" Compound Below Detection Limit

"*" Highest concentration existed for less than 2 min. unless otherwise noted.

TABLE 15

OPFTIR Analysis Results

Week 2: December 1-4, 2003

Day #4: Thursday December 4, 2003 (9:00 am to 8:00 pm)

The OPFTIR was set up with the beam path parallel to the turnpike toll collection booths, along the exit ramp. The Path length was 350 meters. Wind speed and direction readings used were recorded by MAU-1 due to the ravine position of MAU-3. At 9:00 am the average wind direction was from the North at an average speed of 1 mph. The wind direction shifted from the South at an average of 5 mph at 10:40am. The direction of the wind remained from the South until 5:10pm when it shifted from out of the North at an average of 3 mph.

Compound	Detection Limit, ppb	Average Concentration, ppb	Highest Concentration, ppb (Time)*
Acetaldehyde	203	---	---
Ammonia	4	---	21 (4:18 pm)
Benzene	65	---	---
Carbon Disulfide	165	---	---
Carbon Monoxide	55	632	1579 (4:28 pm)
Carbonyl Sulfide	13	---	---
Chloroform	4	---	---
Dimethyl Sulfide	76	---	148 (5:38 pm)
Ethanol	15	---	29 (2:23 pm)
Ethylbenzene	123	---	226 (5:51 pm)
Ethylene	8	---	17 (9:31 am)
Formaldehyde	70	---	---
Hydrogen Chloride	126	---	---
Hydrogen Sulfide	4416	---	6355 (5:32 pm)
Methane	995	4961	19076 (7:16 pm)
Methanol	6	---	23 (9:46 pm)
Methylamine	62	---	145 (9:18 pm)
2-Methyl Butane	100	---	---
Methyl Mercaptan	206	---	---
n-Octane	69	---	---
Sulfur Dioxide	86	---	93 (6:57 pm)
Toluene	68	---	---
TCE	5	---	12 (9:22 am)
Triethylamine	13	---	41 (7:10 pm)
Trimethylamine	10	---	---

TABLE 15

OPFTIR Analysis Results

Week 2: December 1-4, 2003

Day #4: Thursday December 4, 2003 (9:00 am to 8:00 pm)

The OPFTIR was set up with the beam path parallel to the turnpike toll collection booths, along the exit ramp. The Path length was 350 meters. Wind speed and direction readings used were recorded by MAU-1 due to the ravine position of MAU-3. At 9:00 am the average wind direction was from the North at an average speed of 1 mph. The wind direction shifted from the South at an average of 5 mph at 10:40am. The direction of the wind remained from the South until 5:10pm when it shifted from out of the North at an average of 3 mph.

Compound	Detection Limit, ppb	Average Concentration, ppb	Highest Concentration, ppb (Time)*
m-Xylene	38	---	---
o-Xylene	35	---	---
p-Xylene	107	---	---
Vinyl Chloride	12	---	---

"---" Compound Below Detection Limit

"*" Highest concentration existed for less than 2 min. unless otherwise noted.

TABLE 16: Peak Sampling Concentrations as Measured between the Dates of November 18, 2003 to December 4, 2003

Compound	**Peak Air Concentrations (<2 min. duration)** Units ppb							**Peak Ambient Air Comparison Values** Units ppb					**In-Depth Analysis Required**
	11/18/2003 13:00 - 24:00 Landfill	**11/19/2003 11:30 - 20:05 Landfill**	**11/20/2003 14:15 - 22:00 Powell Street**	**12/1/2003 12:45 - 20:50 Powell Street**	**12/2/2003 9:00 - 20:45 Union Street**	**12/3/2003 9:00 - 20:45 Riverside Elem.**	**12/4/2003 9:00 - 20:00 Turnpike**	**ATSDR Acute EMEG**	**EPA AEGL (10 min)**	**Threshold Limit Value**			
										Ceiling	**STEL**	**IDLH**	
Acetaldehyde	<166	790 (20:06)	<121	<46	<23	<80	<203		45,000	25,000		2,000,000	No
Ammonia	<4	6 (17:56)	12 (16:25)	<2	<2	<3	21 (16:18)	2,000[s]	30,000		35,000	300,000	No
Benzene	<88	<86	<123	<40	44 (15:29)	<69	<65	9[d]	130,000		2,500	500,000	No
Carbon Disulfide	<127	<151	<209	<51	<27	<123	<165		17,000			500,000	No
Carbon Monoxide	265 (15:03)	122 (13:27)	1,248 (16:24)	2,459 (20:29)	236 (17:24)	384 (20:10)	1,579 (16:28)					1,200,000	No
Carbonyl Sulfide	<21	<18	<44	<7	<5	<17	<13	**None Available**					No
Chloroform	<8	12 (19:58)	<11	<3	<2	<5	<4	100[s]				500,000	No
Dimethyl Sulfide	<133	<133	<137	<40	<24	<73	148 (17:38)	**None Available**					No
Ethanol	<29	<36	<38	<9	84 (16:37)	<18	29 (14:23)					3,300,000[b]	No
Ethylbenzene	<262	336 (11:58)	<240	<70	<28	261 (20:45)	226 (17:51)				125,000	800,000[b]	No
Ethylene	<9	<9	<11	10 (20:31)	8 (16:59)	<7	17 (9:31)	**None Available**					No
Formaldehyde	<40	<37	<24	<14	<4	<27	<70	40[s]	900	300		20,000	No
Hydrogen Chloride	<68	<62	<29	<24	<6	<43	<126		1,800	2,000		50,000	No
Hydrogen Sulfide	8,906 (13:34)	<6,689	<9,898	<2,886	<1,897	<5,152	6,355 (17:32)	70[p]	750		15,000	100,000	Yes
Methane	18,460 (18:41)	14,089 (20:06)	3,077 (21:01)	13,157(13:25)	0,397 (10:55)	12,142 (20:25)	19,076 (19:16)	**None Available**					No
Methanol	<7	<7	<7	6 (17:42)	<4	35 (11:25)	23 (21:46)		670,000		250,000	6,000,000	No
2-Methyl Butane	<90	<86	<53	<27	<2	<59	<100	**None Available**					No
Methyl Mercaptan	<415	<500	<541	130 (16:18)	<92	<246	<206					150,000	No
Methylamine	195 (17:18)	178 (19:44)	216 (20:56)	60 (15:56)	48 (17:00)	274 (17:31)	145 (21:18)		15,000		15,000	100,000	No
n-Octane	<47	<43	<20	<15	<4	<29	<69					1,000,000[b]	No
Sulfur Dioxide	<136	<131	<120	<60	436 (16:37)	<105	93 (18:57)	10[p]	200		5,000	100,000	Yes
Trichloroethylene (TCE)	35 (13:35)	31 (19:56)	19 (14:20)	<4	7 (9:22)	15 (17:40)	12 (9:22)	2,000[d]	260,000		100,000	1,000,000	No
Toluene	<120	<125	<163	<35	<26	<67	<68	1,000[d]	200,000			500,000	No
Triethylamine	<26	60 (18:07)	<15	<8	<4	<13	41 (19:10)				3,000	200,000	No
Trimethylamine	Not Analyzed	<12	<39	8 (13:04)	5 (17:04)	<17	<10		8,000		15,000		No
m-Xylene	<103	<101	<157	<29	46 (17:18)	<63	<38	2,000[a,s]	130,000[a]		150,000[a]	900,000[a]	No
o-Xylene	<90	<107	<147	<25	<17	<56	<35	2,000[a,s]	130,000[a]		150,000[a]	900,000[a]	No
p-Xylene	<264	<246	<347	<66	<51	<136	<107	2,000[a,s]	130,000[a]		150,000[a]	900,000[a]	No
Vinyl Chloride	<14	<14	<19	<8	<8	16 (12:57)	<12		450,000				No

Notes: Further explanation of acronyms and definitions used for the comparison values in this table is shown in Appendix A.

Yellow shading in the table implies a valid measured air concentration within the period of evaluation. Green shading in the table is indicative where peak air measurements were considered questionable because they were measured directly at the end or outside the period of evaluation. Blue shading in the table indicate the substances selected for further public health analysis.

[a] Assume that the relative toxicity of exposure among the different isomers for xylenes or a mixture of varying xylene isomers is the same.

[b] Because the relevant acute toxicity data were either insufficient or unavailable, the IDLH occupational exposure limit for this substance is the air concentration considered 10% of its lower explosive limit (LEL).

Basis of exposure for setting ATSDR acute EMEG: 1) Peak Exposure (p), 2) Short-Term Exposure (s), and 3) Adjusted Daily Continuous Exposure (d).

TABLE 17: Short Term Sampling Concentrations as Measured between the Dates of November 18, 2003 to December 4, 2003

Compound	**Short Term Air Concentrations (time-weighted average of duration period)** Units ppb							**Short Term Ambient Air Comparison Values** Units ppb			**In-Depth Analysis Required**
	11/18/2003 13:00 - 24:00 (11 hr: 0 min) Landfill	**11/19/2003 11:30 - 20:05 (8 hr: 35 min) Landfill**	**11/20/2003 14:15 - 22:00 (7 hr: 45 min) Powell Street**	**12/1/2003 12:45 - 20:50 (8 hr: 5 min) Powell Street**	**12/2/2003 9:00 - 20:45 (11 hr: 45 min) Union Street**	**12/3/2003 9:00 - 20:45 (11 hr: 45 min) Riverside Elem.**	**12/4/2003 9:00 - 20:00 (11 hr: 0 min) Turnpike**	**ATSDR Acute EMEG**	**EPA AEGL (8 hr)**	**Threshold Limit Value (TWA)**	
Acetaldehyde	<166	<143	<121	<46	<23	<80	<203		45,000		No
Ammonia	<4	<4	<5	<2	<2	<3	<4	2,000[s]	30,000	25,000	No
Benzene	<88	<86	<123	<40	<36	<69	<65	9[d]	9,000	1,000	No
Carbon Disulfide	<127	<151	<209	<51	<27	<123	<165		6,700	1,000	No
Carbon Monoxide	<39	<46	<59	76	<11	51	632			25,000	No
Carbonyl Sulfide	<21	<18	<44	<7	<5	<17	<13	**None Available**			No
Chloroform	<8	<7	<11	<3	<2	<5	<4	100[s]		10,000	No
Dimethyl Sulfide	<133	<133	<137	<40	<24	<73	<76			10,000	No
Ethanol	<29	<36	<38	<9	<8	<18	<15			1,000,000	No
Ethylbenzene	<262	<238	<240	<70	<28	<135	<123			100,000	No
Ethylene	<9	<9	<11	<4	<5	<7	<8			200,000	No
Formaldehyde	<40	<37	<24	<14	<4	<27	<70	40[s]	900		No
Hydrogen Chloride	<68	<62	<29	<24	<6	<43	<126		1,800		No
Hydrogen Sulfide	<7,081	<6,689	<9,898	<2,886	<1,897	<5,152	<4,416	70[p]	330	10,000	Yes
Methane	6,540	5,727	<266	2,376	43	1,684	4,961			1,000,000	No
Methanol	<7	<7	<7	<3	<4	<6	<6		270,000	200,000	No
2-Methyl Butane	<90	<86	<53	<27	<2	<59	<100			600,000	No
Methyl Mercaptan	<415	<500	<541	<113	<92	<246	<206			500	No
Methylamine	<88	<92	<133	<32	<26	<68	<62		15,000	5,000	No
n-Octane	<47	<43	<20	<15	<4	<29	<69			300,000	No
Sulfur Dioxide	<136	<131	<120	<60	<43	<105	<86	10[p]	200	2,000	Yes
Trichloroethylene (TCE)	<8	<16	<10	<4	<4	<7	<5	2,000[d]	77,000	50,000	No
Toluene	<120	<125	<163	<35	<26	<67	<68	1,000[d]	200,000	50,000	No
Triethylamine	<26	<24	<15	<8	<4	<13	<13			1,000	No
Trimethylamine	Not Analyzed	<12	<39	<5	<3	<17	<10		8,000	5,000	No
m-Xylene	<103	<101	<157	<29	<23	<63	<38	2,000[a,s]	130,000[a]	100,000[a]	No
o-Xylene	<90	<107	<147	<25	<17	<56	<35	2,000[a,s]	130,000[a]	100,000[a]	No
p-Xylene	<264	<246	<347	<66	<51	<136	<107	2,000[a,s]	130,000[a]	100,000[a]	No
Vinyl Chloride	<14	<14	<19	<8	<8	<12	<12		70,000	1,000	No

Notes: Further explanation of acronyms and definitions used for the comparison values in this table is shown in Appendix A.

Yellow shading in the table implies a valid measured air concentration within the period of evaluation. Green shading in the table is indicative where peak air measurements were considered questionable because they were measured directly at the end or outside the period of evaluation. Blue shading in the table indicate the substances selected for further public health analysis. H_2S and SO_2 were selected based on peak air levels exceeding appropriate comparison values as denoted in the previous table (Table 16).

[a] Assume that the relative toxicity of exposure among the different isomers for xylenes or a mixture of varying xylene isomers is the same.

Basis of exposure for setting ATSDR acute EMEG: 1) Peak Exposure (p), 2) Short-Term Exposure (s), and 3) Adjusted Daily Continuous Exposure (d).

TABLE 18

ERSI LANDFILL POST AIR MONITORING: Monthly Data Summary

Monitoring Location: Riverside Elementary School
Parameter: Hydrogen Sulfide (units: ppb)

Month & Year	1-Hr Averages					24-Hr Averages		Monthly Average
	Total Samples	Total Detects	% Detection	Minimum Detection	Maximum Detection	Minimum Average	Maximum Average	
February 2004	694	3	0.43	1	7	0	1	0
March 2004	732	3	0.41	1	4	0	0	0
April 2004	718	0	0.00	0	0	0	0	0
May 2004	742	0	0.00	0	0	0	0	0
June 2004	321	0	0.00	0	0	0	0	0

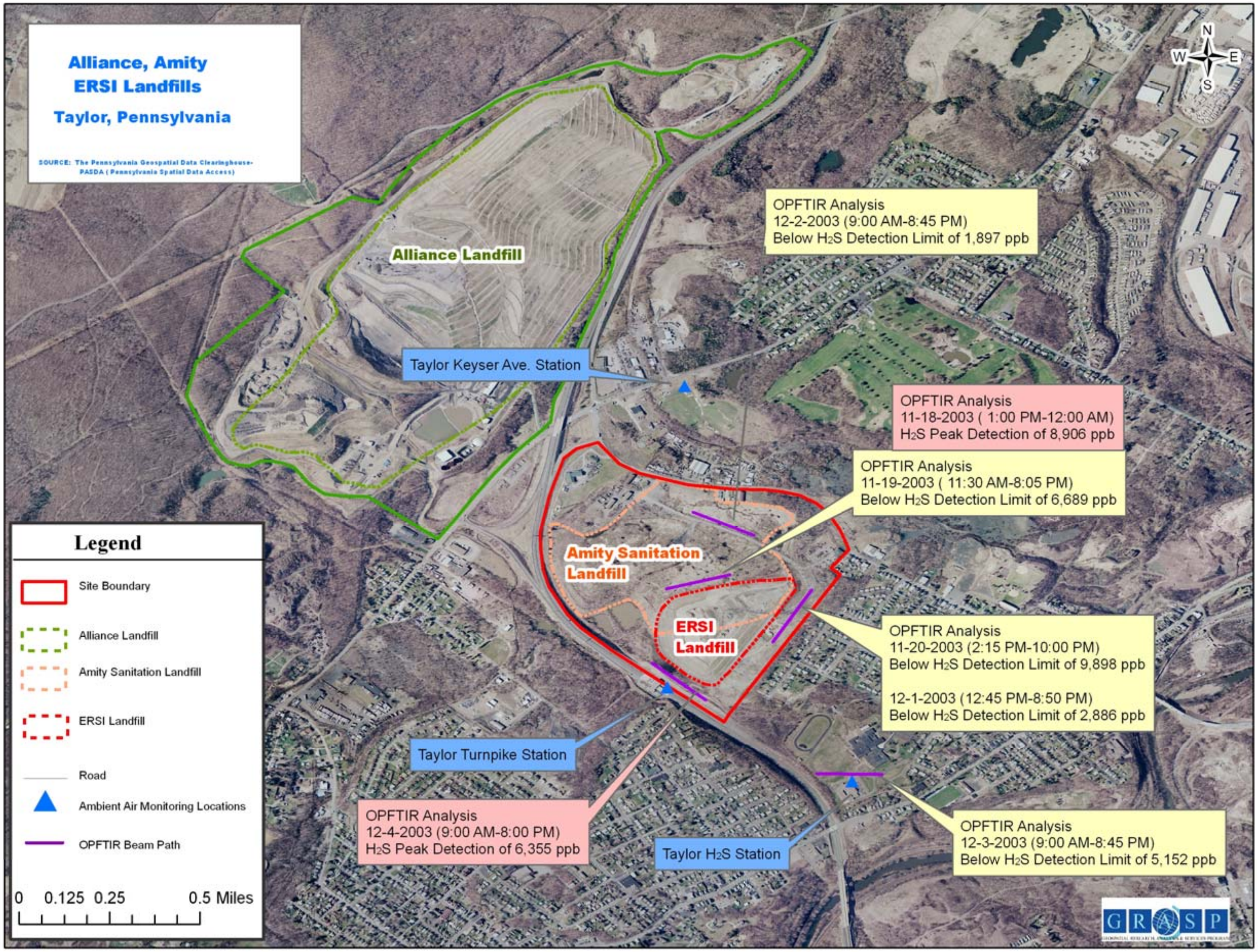
Monitoring Location: Pennsylvania Turnpike
Parameter: Hydrogen Sulfide (units: ppb)

Month & Year	1-Hr Averages					24-Hr Averages		Monthly Average
	Total Samples	Total Detects	% Detection	Minimum Detection	Maximum Detection	Minimum Average	Maximum Average	
March 2004	66	11	16.67	1	3	0	0	0
April 2004	718	85	11.84	1	3	0	0	0
May 2004	743	81	10.90	1	2	0	0	0
June 2004	720	7	0.97	1	1	0	0	0
July 2004	744	28	3.76	1	1	0	0	0
August 2004	743	32	4.31	1	3	0	0	0
September 2004	536	61	11.38	1	2	0	1	0

Values listed as zero in the above tables indicate that the level of hydrogen sulfide in the air was immeasurable or could not be detected, and was less than 1 ppb. All of the quantitative data was acquired from the following PA DEP website: **http://www.dep.state.pa.us/aq_apps/aadata/** [accessed 09/15/2008].

APPENDIX C. Figures

Figure 1
Site Map



SOURCE: The Pennsylvania Geospatial Data Clearinghouse-PASDA (Pennsylvania Spatial Data Access)

OPFTIR Analysis
12-2-2003 (9:00 AM-8:45 PM)
Below H_2S Detection Limit of 1,897 ppb

OPFTIR Analysis
11-18-2003 (1:00 PM-12:00 AM)
H_2S Peak Detection of 8,906 ppb

OPFTIR Analysis
11-19-2003 (11:30 AM-8:05 PM)
Below H_2S Detection Limit of 6,689 ppb

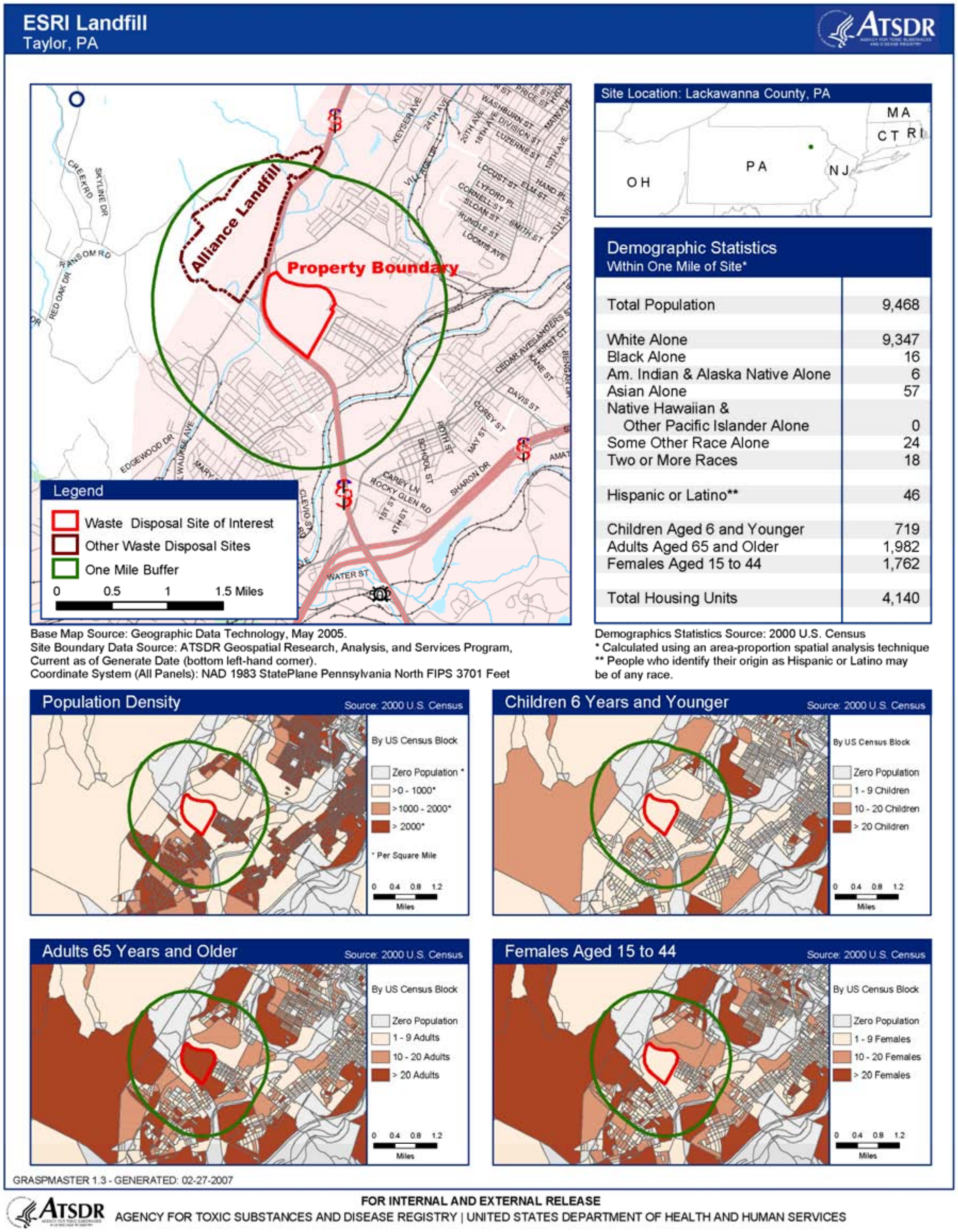
OPFTIR Analysis
11-20-2003 (2:15 PM-10:00 PM)
Below H_2S Detection Limit of 9,898 ppb

12-1-2003 (12:45 PM-8:50 PM)
Below H_2S Detection Limit of 2,886 ppb

OPFTIR Analysis
12-4-2003 (9:00 AM-8:00 PM)
H_2S Peak Detection of 6,355 ppb

OPFTIR Analysis
12-3-2003 (9:00 AM-8:45 PM)
Below H_2S Detection Limit of 5,152 ppb

Figure 2
Site Demographic Maps



Demographic Statistics
Within One Mile of Site*

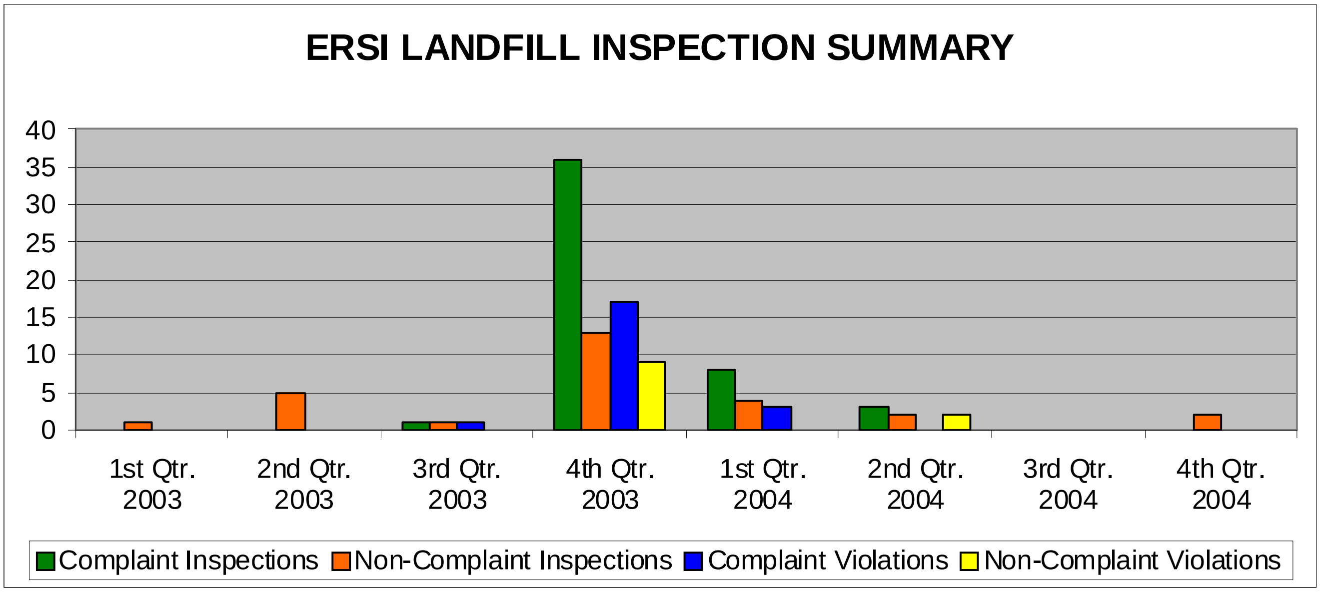
Total Population	9,468
White Alone	9,347
Black Alone	16
Am. Indian & Alaska Native Alone	6
Asian Alone	57
Native Hawaiian & Other Pacific Islander Alone	0
Some Other Race Alone	24
Two or More Races	18
Hispanic or Latino**	46
Children Aged 6 and Younger	719
Adults Aged 65 and Older	1,982
Females Aged 15 to 44	1,762
Total Housing Units	4,140

Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Geospatial Research, Analysis, and Services Program, Current as of Generate Date (bottom left-hand corner).
Coordinate System (All Panels): NAD 1983 StatePlane Pennsylvania North FIPS 3701 Feet

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

Figure 3

Total Count of Inspections Conducted at ERSI Landfill



TOTAL COUNT INFORMATION

	Complaint Inspections	Non-Complaint Inspections	Complaint Violations	Non-Complaint Violations
1st Qtr. 2003	0	1	0	0
2nd Qtr. 2003	0	5	0	0
3rd Qtr. 2003	1	1	1	0
4th Qtr. 2003	36	13	17	9
1st Qtr. 2004	8	4	3	0
2nd Qtr. 2004	3	2	0	2
3rd Qtr. 2004	0	0	0	0
4th Qtr. 2004	0	2	0	0

1st Qtr. 2003: 89 days (covers time span from January 1, 2003 to March 31, 2003)
2nd Qtr. 2003: 90 days (covers time span from April 1, 2003 to June 30, 2003)
3rd Qtr. 2003: 91 days (covers time span from July 1, 2003 to September 30, 2003)
4th Qtr. 2003: 91 days (covers time span from October 1, 2003 to December 31, 2003)
1st Qtr. 2004: 90 days (covers time span from Janaury 1, 2004 to March 31, 2004)
2nd Qtr. 2004: 90 days (covers time span from April 1, 2004 to June 30, 2004)
3rd Qtr. 2004: 91 days (covers time span from July 1, 2004 to September 30, 2004)
4th Qtr. 2004: 91 days (covers time span from October 1, 2004 to December 31, 2004)

Note: Other quarters before the 1st quarter in 2003 have similar inspection counts to the 1st and 2nd quarters in 2003 (i.e., low inspection counts approaching zero). Moreover, other quarters after 4th Otr. 2004 also have similar inspection counts.

Data Source: *PA Department of Environmental Protection (PADEP)*
eFACTS (Environmental Facility Application Compliance and Tracking System)
http://www.dep.state.pa.us/efacts/

Figure 4

Odor Points of Electronic Nose

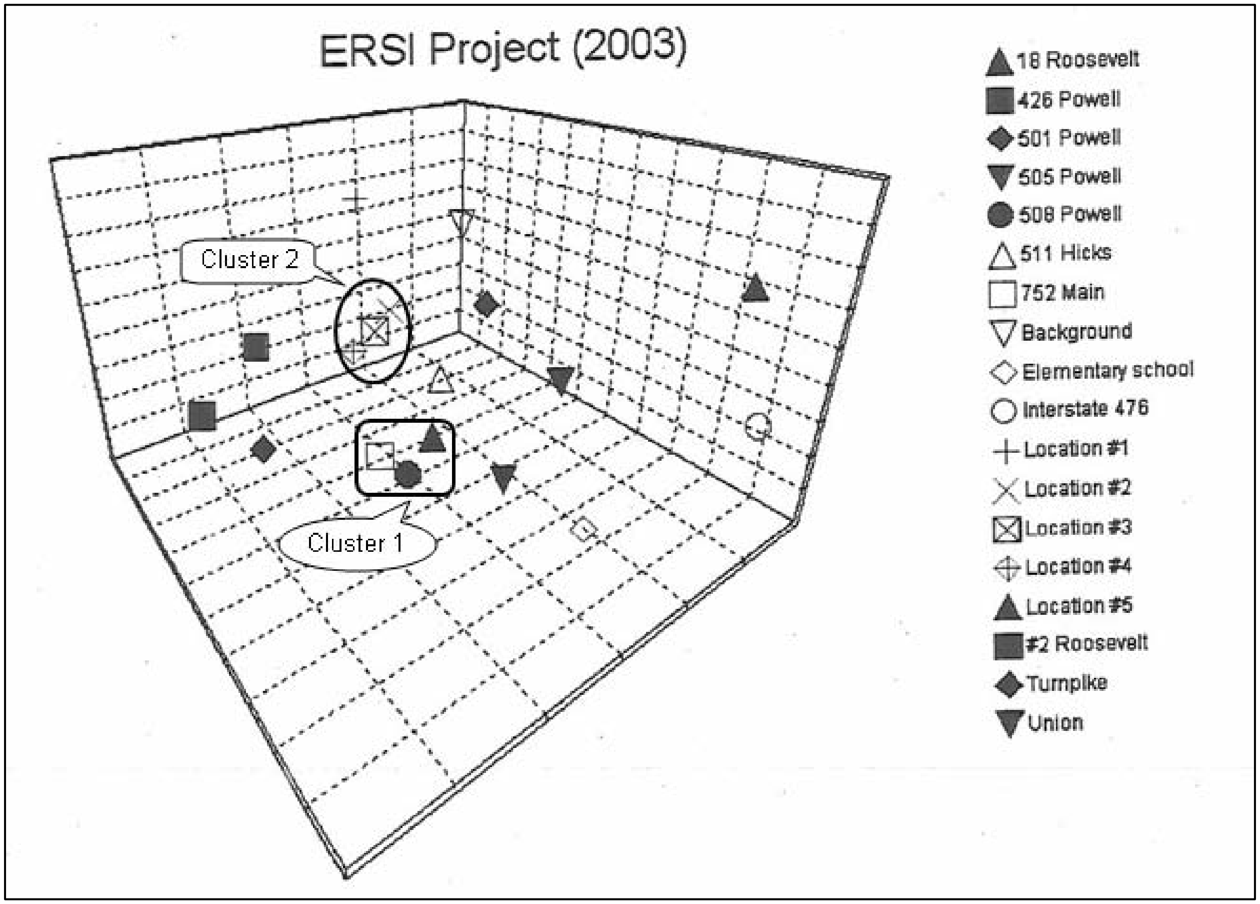


Figure 5

Potential Exposure Pathways to Landfill Gas

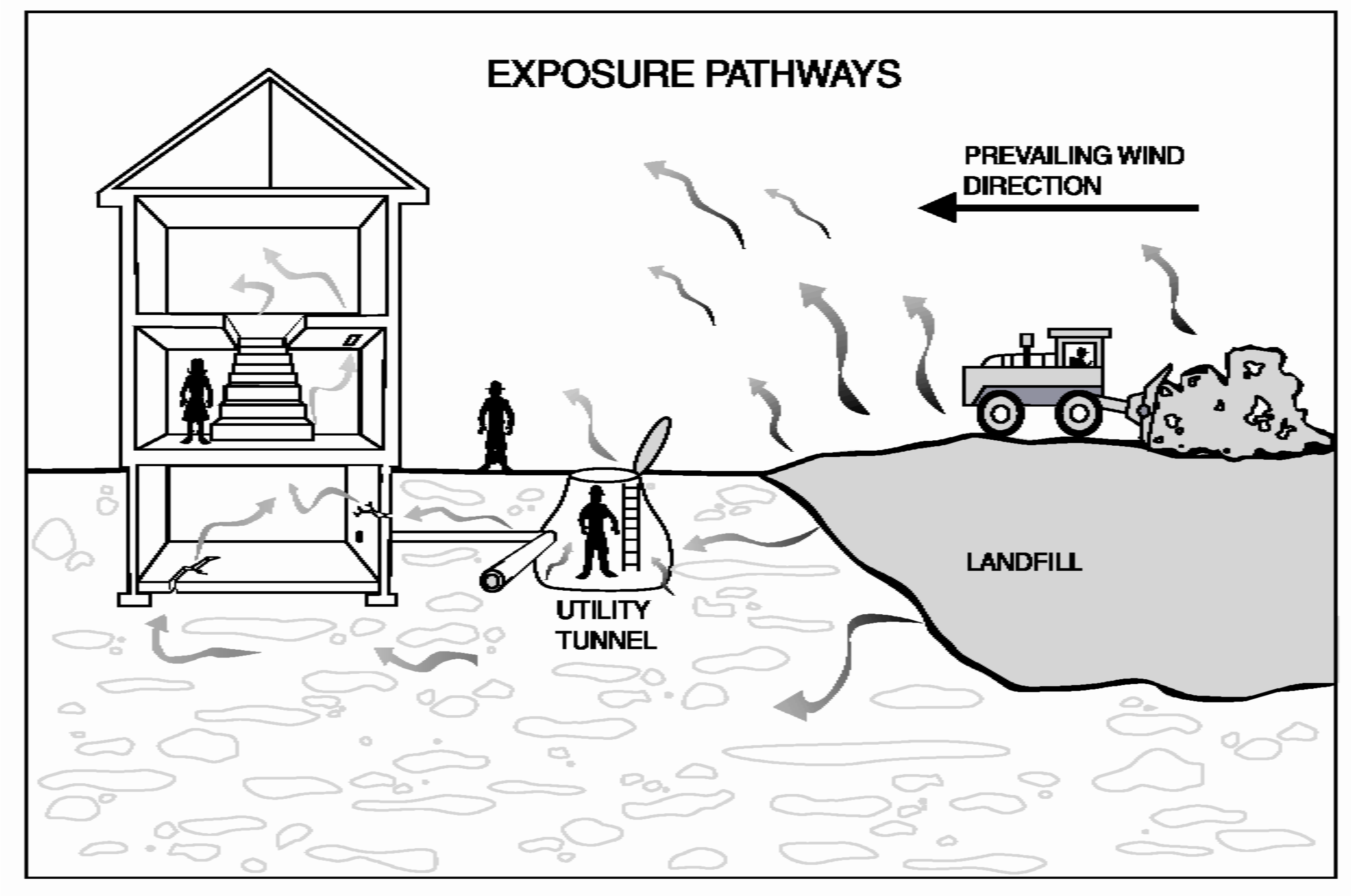


Figure 6
ATSDR Environmental Guideline Hierarchy

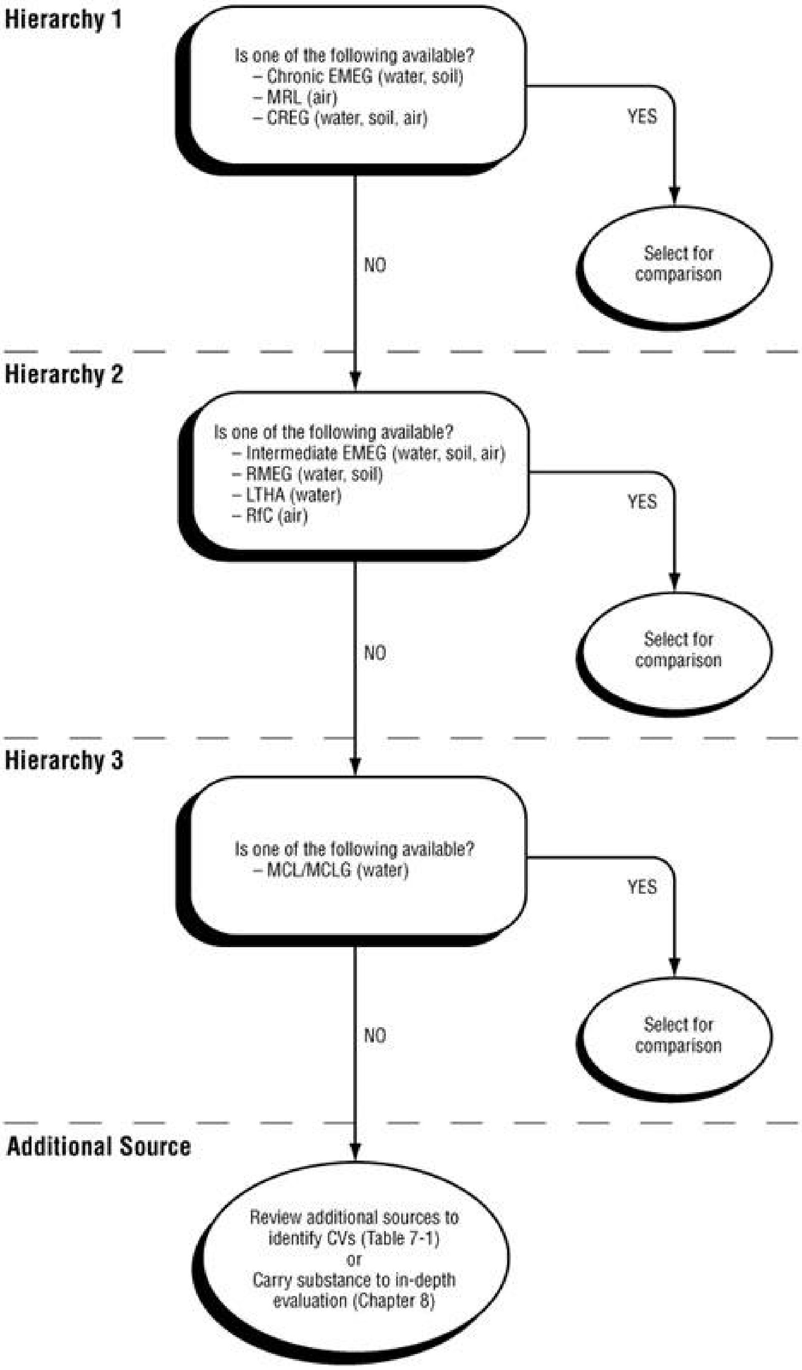


Figure 7

Environmental Guideline Hierarchy for Peak Inhalation Exposures

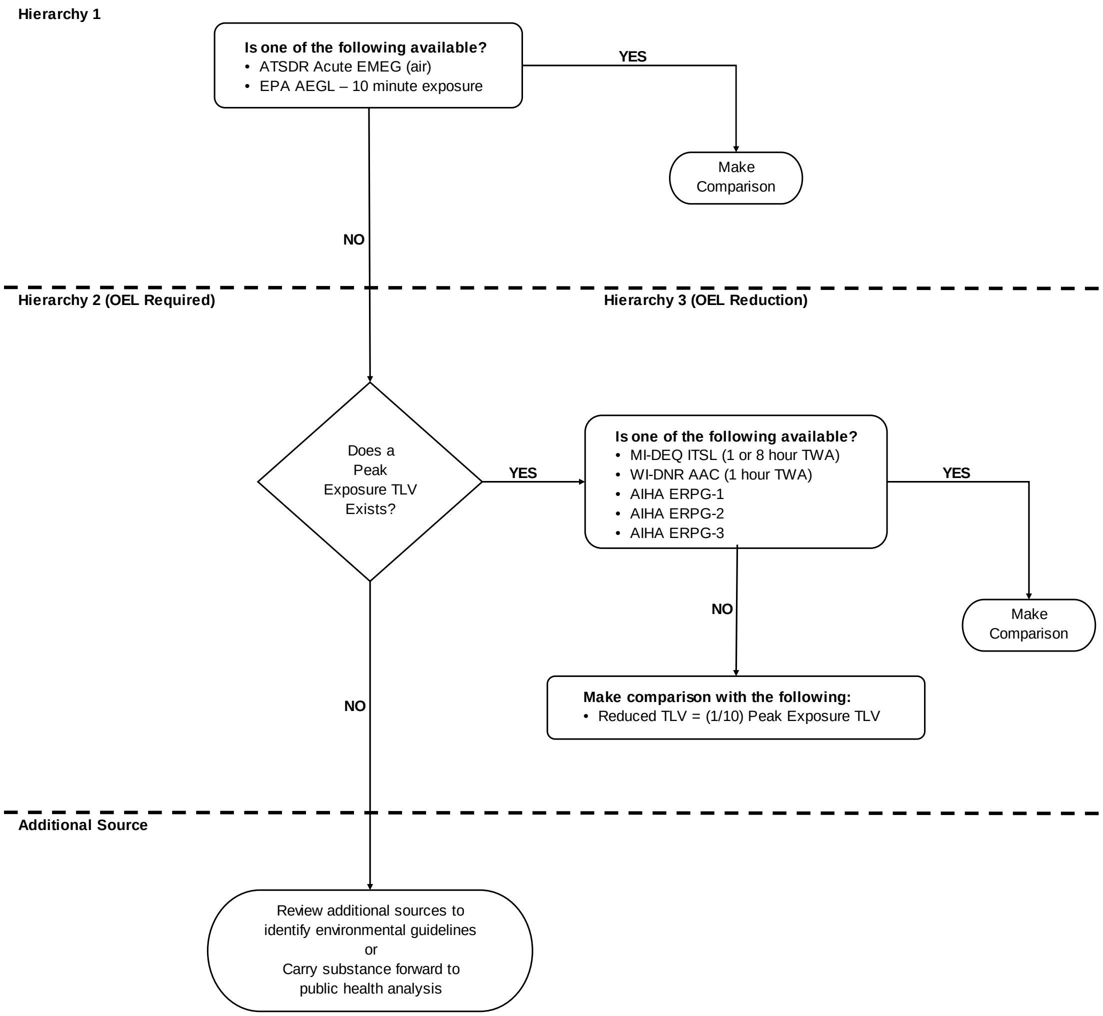
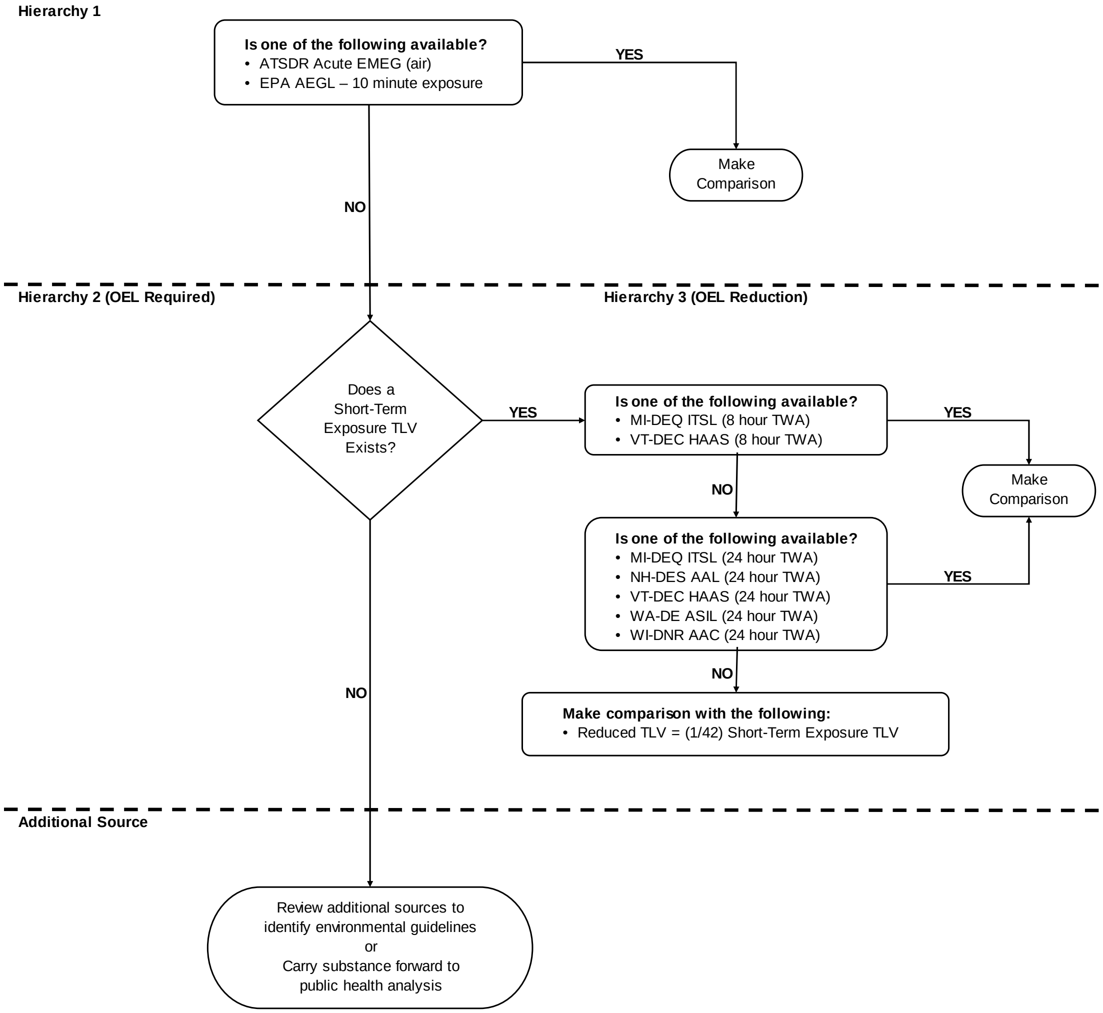


Figure 8
Environmental Guideline Hierarchy for Short-Term Inhalation Exposures



APPENDIX D. Chronological Summary of ERSI's Malodorous Period

Below are excerpts from a Consent Order and Agreement entered on the 29th day of August, 2005 by and between the Commonwealth of Pennsylvania, Department of Environmental Protection (PA DEP) and Environmental & Recycling Services, Inc. (ERSI). The listed information is only a portion of the findings founded by PA DEP related to malodorous releases (denoted or highlighted in yellow) from the ERSI Landfill occurring between September and December 2003:

Date	Event Summary
9/8/2003 – 11/11/2003	At various times during this period (including on at least 10 days), PA DEP responded to odor complaints and verified sulfur-like odors emanating from the ERSI Landfill and migrating into residential neighborhoods and public roadways adjacent to the landfill. The strength of the odors varied from slight to very strong over the course of this period, and the odors lasted from several minutes to several hours. PA DEP determined that the odors were the result of uncontrolled gas releases from various portions of the ERSI Landfill. During this period, PA DEP also verified off-site odors from a chemical neutralizer/masking agent along a public road emanating from the landfill.
9/23/2003	PA DEP issued to ERSI a Notice of Violation ("NOV") for the odors detected offsite on September 8, 2003. The NOV requested ERSI to submit a plan and schedule to correct the violation within 15 days.
10/10/2003	PA DEP received ERSI's response to the September 23, 2003 NOV. The response from ERSI indicated that bacterial degradation of gypsum (i.e. sheetrock, wallboard) within the landfill was the suspected source of the sulfur-like odors. The response indicated that ERSI planned to control odors through limitations on disposal of gypsum at the landfill, the addition of final cover soil to certain portions of the landfill, and the use of odor masking agents and odor neutralizers. The response indicated that the first phase of final cover installation would be completed by the end of October 2003, and the entire final cover project for those portions of the landfill where filling was finalized would be completed by the spring of 2004.
11/11/2003 – 11/12/2003	PA DEP representatives responded to a number of odor complaints and verified an off-site sulfur-like odor at some of the complainants' properties. PA DEP representatives conducted an on-site inspection and determined the source of the odor to be the ERSI Landfill. PA DEP representatives also determined that uncontrolled odors were present at and emanating off-site from multiple locations along the landfill. Moreover, PA DEP representatives documented that the Amity Gas System was in a state of disrepair at multiple locations and was causing uncontrolled releases of gas.
11/13/2003	PA DEP issued to ERSI an Administrative Order requiring certain corrective action at the ERSI Landfill and Amity Landfill. The Administrative Order required, among other things, that ERSI complete all capping activities started in October 2003, complete a landfill gas characterization and assessment, evaluate the need for a gas collection and control system, install twenty-four (24) landfill gas sample probes, conduct 24-hour odor monitoring, and submit a permit modification with changes to its nuisance minimization and control plan.

Date	Event Summary
11/13/2003 – 12/11/2003	At various times during this period (including on at least 9 days), PA DEP verified sulfur-like odors emanating from the ERSI Landfill and migrating into residential neighborhoods and public roads adjacent to the landfill. The strength of the odors varied from slight to very strong over the course of this period, and the odors lasted from several minutes to several hours. PA DEP determined that the odors were the result of uncontrolled gas releases from various portions of the ERSI Landfill.
11/17/2003	PA DEP's mobile analytical laboratory 1 ("MAU 1") and mobile analytical laboratory 2 ("MAU 2") arrived on site at the landfill to begin ambient air monitoring and individual location air sampling.
11/21/2003	At the request of ERSI, PA DEP conducted a meeting with them to discuss the Administrative Order and corrective action timetable. During the meeting, ERSI suggested and agreed to install twelve (12) gas collection wells into the active portion of the ERSI Landfill in lieu of the 24 test probes required by the Administrative Order. The gas collection wells would then be connected to a passive flare, the existing gas system at the Amity Landfill and/or a new landfill gas flare.
12/1/2003	PA DEP's mobile analytical laboratory 1 ("MAU 1") and mobile analytical laboratory 2 ("MAU 2") returned to begin ambient air monitoring and individual location air sampling.
12/2/2003	A PA DEP representative responded to a number of odor complaints and verified an off-site sulfur-like odor at most of the complainants' properties. The PA DEP representative conducted an onsite inspection and determined the source of the odor to be the ERSI Landfill. PA DEP was also informed by the Riverside Area School District that due to the landfill odor entering the building; four students became ill and were sent home.
12/3/2003	A PA DEP representative responded to a number of odor complaints and verified an off-site sulfur-like odor at most of the complainants' properties emanating from the ERSI Landfill. The PA DEP representative also confirmed moderate to strong sulfur-like odors at the Riverside Area School District.
12/1/2003 – 12/10/2003	Pursuant to the Administrative Order and the subsequent meeting with PA DEP representatives, ERSI installed twelve (12) gas collection wells into the active portion of the ERSI Landfill. ERSI gave advance notification of the dates of drilling and the likelihood of strong odors to PA DEP, Taylor Borough, Old Forge Borough, and Riverside School District.

Date	Event Summary
12/10/2003	PA DEP received upwards of thirty (30) complaints of strong sulfur-like odors from citizens who live and/or work in the area surrounding the ERSI Landfill. Complaints were received from the Riverside Elementary School, the Riverside High School, the Old Forge School District, the Taylor Nursing Home, the Pennsylvania Turnpike Commission, and residents living on Powell, Davis, Hospital, Main, Union, and Lincoln Streets. Some citizens alleged that the odors made them sick and/or forced them to leave their homes. Two schools in the area were evacuated as a result of the odors. PA DEP investigated these complaints and verified an offsite sulfur-like odor at many of the complainants' properties and along public roadways. The off-site odors entered the Riverside Area School District school buildings and prompted school officials to dismiss students. A PA DEP representative confirmed that hydrogen sulfide odors were present in the school buildings. The PA DEP representative also conducted an on-site inspection and determined the source of the odors to be the ERSI Landfill.
12/10/2003	PA DEP filed a Complaint in Equity and a Motion for Special Injunction against ERSI in the Court of Common Pleas for Lackawanna County relating to the December 10, 2003 odors. That case was docketed at Lackawanna County C.P. No. 2000-EQ-60080. The Complaint and Motion sought the imposition of deadlines for the implementation of certain corrective action, including completion and construction of the twelve wells, installation and operation of the 400 cfm flare, and connection of the wells to the flare. At the time that the Complaint and Motion were filed, ERSI was in the process of completing the work requested and ERSI voluntarily agreed to the court imposition of the deadlines by Court Order.
12/10/2003 – 12/11/2003	ERSI initially connected the twelve (12) installed gas collection wells to a temporary, passive flare, and then to the turbines operated by Taylor Energy and related to the Amity Gas System. ERSI ordered a temporary 400 cfm flare on December 10, 2003 to be delivered that day; however, it was not delivered until the early morning of the next day. ERSI installed and connected all twelve wells to the 400 cfm flare.
12/1/2003 – 12/10/2003	Within this timeframe, as required under the Administrative Order, ERSI commenced removal of all vegetation, with the exception of necessary ground cover, within 10 or more feet of all gas piping and gas wells as required by PA DEP over most of the site.
12/1/2003 – 12/10/2003	Within this timeframe, as required under the Administrative Order, ERSI commenced: (a) labeling of the wells on the Amity Gas System, (b) a detailed evaluation of the condition of the Amity Gas System, and (c) performing any necessary repairs on the system, including the repairs directed by PA DEP personnel during inspections. ERSI engaged Blazosky Associates to perform the evaluation of the Amity Gas System. In December 2003, Blazosky Associates submitted to PA DEP on behalf of ERSI a Landfill Gas Investigation Report, the receipt and adequacy of which are acknowledged by PA DEP. Certain repairs were made to the Amity Gas System. ERSI engaged Russ Mercer and SCS to perform additional repairs to the Amity Gas System. In addition, Mr. Mercer was hired to operate and monitor the ERSI gas system. As part of the work on the site, ERSI reconnected gas wells that had been disconnected. ERSI completed all of the repairs to the Amity Gas System recommended under the Blazosky Landfill Gas Investigation Report.

Date	Event Summary
12/1/2003 – 12/10/2003	Within this timeframe, as required under the Administrative Order, ERSI commenced hourly off-site and on-site perimeter odor monitoring, 24 hours a day, and such monitoring continues to the present. ERSI documented any odors confirmed as part of those inspections and kept the odor inspection logs as part of its daily operational record.
12/1/2003 – 12/10/2003	During the first occurrence of the gas odors around September 8, 2003, ERSI evaluated the use of chemical neutralizer/masking agents; however, within this timeframe, as required under the Administrative Order, ERSI has substantially reduced use of such agents as a result of the effectiveness of the gas collection and destruction system installed at the ERSI Landfill. ERSI has available for use chemical neutralizers as necessary.
12/1/2003 – 12/10/2003	Within this timeframe, as required under the Administrative Order, ERSI completed all scheduled final capping activities for the area of the landfill on which capping activities had begun in October 2003.
12/11/2003	ERSI informed PA DEP that all the work required by the Court Order (court case docketed at Lackawanna County C.P. No. 2000-EQ-60080) had been completed and that the flare was operational.
12/28/2003	ERSI engaged a cartographer to fly the site and prepare a map of the current contours. ERSI forwarded the drawn map and it was received by PA DEP in February 2004. Since that time, at the request of PA DEP, ERSI has developed and submitted to the PA DEP a phasing plan for filling of the landfill through closure, the receipt and adequacy of which is hereby acknowledged by PA DEP.
2/13/2004	ERSI installed a 450 cfm John Zink flare (the “John Zink Flare”) to replace the 400 cfin flare installed on December 10, 2003 as the primary means of gas destruction. PA DEP issued RFDs for the John Zink flare permitting its installation and temporary operation without the necessity for a plan approval or operating permit. ERSI maintained the 400 cfm flare installed on December 10, 2003 as a backup to the John Zink Flare.
2/14/2004 – 2/16/2004	With the approval of PA DEP, ERSI installed an additional nine (9) gas collection wells into the ERSI Landfill, and connected those nine wells and the original twelve wells to the John Zinc Flare. At the suggestion of PA DEP, the wells were installed utilizing a “box” over the drilling area to minimize the escape of odors, and each well was immediately attached to the ERSI Landfill gas system upon completion. ERSI gave advance notification of the dates of drilling and the likelihood of strong odors to PA DEP, Taylor Borough, Old Forge Borough, and the Riverside School District. PA DEP placed representatives on-site and in the surrounding community on the dates in question, and PA DEP collected air samples from neighborhoods, individual residences, schools, and various other locations.
3/4/2004	PA DEP moved to discontinue the matter of court case docketed at Lackawanna County C.P. No. 2000-EQ-60080 and that the past action has been closed.
12/14/2004	PA DEP issued ERSI an Air Quality Program Plan Approval Permit No. 35-322-008 (the “Air Quality Permit’). ERSI appealed certain provisions of the Air Quality Permit to the Pennsylvania Environmental Hearing Board.

Date	Event Summary
2/16/2005 – 2/18/2005	ERSI completed the installation of an enclosed flare for the destruction of landfill gases from the ERSI Landfill. The enclosed flare was tested on February 16, 17, and 18, 2005, and thereafter was placed into service.

APPENDIX E: ATSDR Guidelines for Evaluating Gases Migrating from Landfills

I. Background

Landfills, especially those that were operating before the stringent requirements of the Resource Conservation and Recovery Act (RCRA) became effective, may pose a health problem as they age. The problems center on the gases generated by the decomposition of the waste in the landfill. Most of the health concerns of landfill gases typically focus on the gases other than methane that may be part of the landfill gas “stream” and that can produce health effects at much lower concentrations than the fire and explosion hazard of methane.

This document is intended to provide guidance only; it should not be interpreted as mandatory. Deviation from the procedures by environmental health professionals is expected and desired when the situation does not conform to the constraints and assumptions made in this document.

II. Assumptions

Unless there is reasonable evidence otherwise, environmental health professionals should assume that hazardous substances were disposed of in any landfill that operated near an industrial area before the effective date of RCRA (~1977). If portable instruments indicate combustible gas readings, the combustible constituents of the landfill gas should be considered to be largely methane (~75%), with the remainder being other flammable or combustible vapors or gases such as benzene.

III. Migration Patterns

In general, there are two pathways by which landfill gases may migrate offsite. The first of these is vertically through the cover; the second is horizontally through the soil. The two pathways are not mutually exclusive; the landfill gases will follow the path of least resistance. Consequently, construction details of the landfill and the geology/hydrogeology of the site will have a bearing on this migration pattern.

Typically, vertical migration is not a concern unless structures have been built on the cover or public access is unrestricted. The gases tend to dissipate in the open environment. However, for people living or working on or adjacent to the landfill, the concentration of landfill gases in the ambient air may pose a concern and may contribute to local air quality problems, odor problems, greenhouse effects, and ozone depletion.. If the gases enter a structure built on the landfill cover, the contaminants can collect in the structure, and the resulting concentrations can reach a level of potential health concern. Depending on the size of the structure and the volume of confined space in relation to the volume of landfill gas entering the structure, a fire or explosion hazard could develop.

Horizontal migration is usually a concern, primarily for off-site structures. The landfill gases will follow the horizontal path of least resistance until they find an avenue to the surface. Because a major constituent of landfill gas is methane, that gas will usually be detected first. If the avenue to the surface accesses the open environment, the gases will dissipate, as they do in the vertical migration pathway. If the avenue intercepts a structure, the gases can build up in the structure as described. According to the data collected by EPA, this horizontal migration is usually limited to about 300 meters from the landfill boundary [1].

IV. Target Compounds

At any disposal site that accepted industrial waste in its lifetime, the list of analytes should be targeted at the industrial wastes and their environmental degradation products. If leachate or groundwater data are available, the results of this analysis should be considered in determining the target compounds of the landfill gas analysis. Whenever an environmental investigation of a landfill has been prompted by odorous compounds and/or explosive gases, the possible presence of toxic substances should be evaluated as well. With all landfills, alkyl benzenes, sulfur compounds (both organosulfides and acid gases), benzene, vinyl chloride, and methane should be included in an analysis. These are common gases that may be associated with industrial wastes, construction and debris waste, consumer products, normal organic wastes, and/or their degradation products.

V. Sampling Strategy and Locations

As with any form of sampling, the objectives of the sampling effort have to be understood prior to a determination of the sampling strategy. For landfill gases, common objectives may be to:

- determine if an fire or explosion hazard exists
- identify the source of odors
- determine if a toxic substance is being released
- determine if a toxic substance is attaining concentrations of health concern

Depending on the issues arising from any given landfill, other objectives not considered here could arise as well.

Sampling locations are selected based on these objectives and the history and construction of the landfill, the location of receptor populations, and other sources of contamination in the area (i.e., control samples or background concentrations). Fire and explosion hazards are usually a concern only when the gases collect in a confined space such as a building or a basement. Odor concerns arise most commonly in ambient outdoor air. Toxic substances may be a concern in both confined spaces and in ambient air, depending on the human exposure pathway and scenario.

Expected migration patterns are commonly used to determine the orientation of the sampling locations. For instance, “downgradient” locations are usually more numerous and the primary focus of the screening effort. However, “upgradient” samples should also be collected for use as a verification of the migration pattern; to determine if “upstream” diffusion is occurring; or for use as a control or background sample in the event that the migration pattern is well known.

Ambient air sampling locations should be designed through use of predicted prevailing weather conditions. However, the air sampling network should be flexible enough to allow sampling stations in any individual sampling effort to be established according to the actual weather conditions encountered on the day of sampling.

VI. Screening Sampling Techniques

A screening effort is usually the first step. Locations for sampling for a screening effort typically should include vents from the landfill, adjacent structures, and simplistic soil gas sampling between the landfill and the structures. Fourier-transformed infrared-red (FTIR) or Ultra-Violet (UVS) sampling (see below) along the boundary of the landfill should also be considered. In addition to monitoring wells and pre-existing source control (i.e., ventilation and/or “flare”) systems, landfill gases may be sampled from cracks in the landfill cover, from leachate “springs,” and from cracks in adjacent structures and paved parking areas.

Several broad spectrum real-time monitors are useful in landfill screening investigations. These monitors include combustible gas indicators (CGI), ionization detectors, and compound-specific monitors (e.g., hydrogen sulfide or sulfur dioxide meters, methane meters, carbon monoxide meters, etc.). These meters are important for detecting changes in the work environment of site investigators and for identifying sampling locations with good prospects of detecting landfill gases. However, the limitations of these monitors need to be clearly understood in any evaluation of the data obtained through their use. For instance, some ionization detectors suffer significant degradation under some conditions common in landfill gases. Methane can reduce the sensitivity of the photoionization detector (PID) by up to 90%[2]. The flame ionization detector (FID) requires enough oxygen in the sampled gas to maintain combustion (oxygen levels > ~ 12%by volume).

For screening efforts, sweep surveys of the landfill surface and adjacent areas by use of FIDs and CGIs to identify areas where fissures and cracks permit landfill gas to escape naturally may be advantageous for locating a well. During the survey, the team must give attention to identifying “flame out,” the emission of methane at such a rate that no oxygen gets to the flame to permit ionization of the methane.

Grab samples are also useful as indicators of potential trouble spots. Grab samples may be collected in Tedlar® bags or in SUMMA® or other evacuated canisters. Using real-time monitors to coordinate the timing, team members may find grab samples useful in evaluating peaks in the emissions. The results of the grab sampling can also be useful in modifying the target analytes of future sampling efforts.

Soil gas sampling, both on the landfill and off-site, can be extremely useful. In a screening effort, this type of sampling is normally accomplished with punchbars to varying depths, usually no more than 10 feet and often no more than 3–5 feet in depth. The punchbars should be deep enough to permit obtaining data below any cap on the landfill. After the sampling, the hole should be resealed to prevent inadvertent creation of a new vent for the landfill gases. Because pressure within the landfill is critical to predicting landfill gas migration, pressure measurements at these locations should also be considered.

FTIR and UVS sampling are spectroscopic sampling techniques that detect and identify contaminants in the air along a straight line (e.g., the boundary of a landfill). UVS is typically set up for specific compounds (usually inorganic gases), but FTIR can be used for multiple compounds (usually organic gases). The principle is that the infrared or UV light is generated and then passed to a receptor in a line-of-sight position along a boundary of concern. The receptor either analyzes the spectrography of the light or reflects it to another receptor, which then does the analysis. This second receptor may be part of the source instrument. The spectroanalysis can identify specific compounds and concentrations in the space between the source and the receptor. However, the units are usually given in a concentration of volume per unit distance (e.g., ppm-m) or mass per area of the beam (e.g., mg/m2). The identified constituents can be added to the list of target analytes [3].

VII. Landfill Gas Characterization

According to the results of the screening effort, a more comprehensive sampling effort can be planned. Sample locations in this expanded sampling would be designed to better characterize the gas streams at those locations identified in the screening effort, in similar locations, and near sensitive receptors (e.g., adjacent structures).

Any of the standard methods for ambient air, indoor air, and/or soil gas that attain the desired level of detection for the target analytes are appropriate for use in characterizing landfill gases over time. The detection limits should be lower than the concentration of health concern. Use of these limits makes protective allowance for the unavoidable errors of any chemical analysis.

Soil gas wells on the landfill, between the landfill and adjacent structures, and near the structures should be considered in any comprehensive sampling program. These wells should include pressure gauges to determine the gas pressure at their locations. This pressure may be used to predict the migration patterns of landfill gases.

VIII. Evaluation of Sampling Data

The health-based interpretation of any sampling data is dependent on the quality of the data obtained, the method of sample collection, the location of the sample, the media of the sample, and the demographics of the surrounding area. Many of the sampling methods, preferably used in conjunction with grab sampling at times most likely identify peak (or worst-case) emissions, will provide adequate data to characterize the health implications of landfill gases under the conditions of the sample.

As a landfill ages, the constituents and the relative concentration of the constituents in the gas stream will change over time. As environmental conditions change (e.g., the height of groundwater levels), the migration patterns and possibly the constituents of the gas stream may change. Any evaluation of environmental data is valid only for the information reviewed and the conditions during the sample collection. Therefore, once a potential threat is identified at a landfill, continued monitoring or additional sampling may be necessary. If the threat continues, source controls may be required.

Negative results during a screening effort may not mean the characterization effort can stop. More than one screening effort may be required to permit obtaining adequate data to indicate that the landfill does not pose a threat. Multiple screening efforts are particularly appropriate when a screening's results indicate variations in the gas stream so that certain constituents of the stream may pose a threat in the near future.

Conclusions based on sample results should be limited to the capabilities of the sample methodology and the knowledge available about the landfill; other possible impacts should be explored when they could be a concern. For instance, if explosive gases are the original concern prompting an environmental investigation, the bulk of the explosive gases from most landfills will be methane. If the choice is made to investigate combustible gases by use of a CGI only, any assumption as to the constituents of the gas stream and the relative hazard are not warranted. For example, if the explosive level measured by the CGI was 60% of the lower explosive limit (LEL) for methane (3% by volume), technically no fire or explosion hazard exists according to that data. However, there is also a need to consider the possible presence of other explosive gases; if only 1% of the combustible gas is a flammable vapor other than methane—for example, benzene—the landfill gas may contain approximately 300 ppm benzene (3% = 30,000 ppm X 1% = 300 ppm). This value for benzene is well above the OSHA PEL of 1 ppm (8-hour TWA) [4] and the ATSDR acute minimal risk level of 0.002 ppm [5].

Many of the typical landfill gases, notably the alkyl benzenes and the sulfur compounds (both organosulfides and acid gases), may present an odor problem that can cause health effects such as mucous membrane irritation, respiratory irritation, nausea, and stress. These health effects posed by an odor problem can be significant for individuals with pre-existing health conditions (e.g., allergies, respiratory illness).

Line-of-sight remote sensor sampling (i.e., FTIR/UVS) yields results that are given in units of volume per distance or mass per area of the beam. A value of 3 ppm-m may mean that the plume attained 3 ppm spread over 1 meter, 300 ppb over 10 meters, or 300 ppm over a centimeter. There are models that can predict, based on the reported values, the emission rate as well as the concentration that may impact downwind receptors.

Given some information in the form of environmental sample results, the environmental health professional should compare the concentrations in the samples to our current state of knowledge about those compounds detected while considering the plausible human exposure scenarios at the site. Whenever possible, the sample results should correspond to the media under consideration in the exposure scenario (e.g., air samples for inhalation exposures). Good quality empirical data should always supersede theoretical predictions (i.e., models), no matter how accurate the theory may be. The exception to that principle is a situation in which an interference or additional source of contamination exists and affects the empirical data. If the empirical data validates a model at a particular location, then that model can be used with confidence as long as the model’s conclusions are periodically verified with environmental data. If the model is valid at one site, it does not necessarily mean the model is valid at all sites.

Sampling of two different media at approximately the same time also has inaccuracies, unless the migration rate from the one media to the other is known to approximate the sample collection time. In the example of soil gas to indoor air, the migration rate would be dependent on such factors as the permeability of the gas through the soil and then through the structure, the pressure of the gas in the soil, possible variations in the migration patterns, and other factors unique to the specific type of soil and the environmental conditions at the time of the sampling (e.g., depth to water, ambient temperature, etc.).

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