Health Consultation

Orange County Solid Waste Management Facility
(Orange County Landfill)

Orlando, Orange County, Florida

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Prepared by:
Florida Department of Health
Division of Disease Control and Health Protection
Under Cooperative Agreement with
U. S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Foreword

The Florida Department of Health (Department) evaluates the public health risk of waste sites through a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ASTDR) in Atlanta, Georgia. The Department prepared this health consultation report using ATSDR guidelines. This report evaluates whether or not there are public health implications associated with hydrogen sulfide gas from the Orange County Landfill. The Department evaluates site-related public health issues through the following processes:

Evaluating exposure: Department scientists review available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is located, and how human exposures might occur. Orange County provided the data for this assessment.

Evaluating health effects: If the Department finds evidence that exposures to hazardous substances are occurring or might occur, its scientists next determine whether that exposure could be harmful to human health. Department scientists focus on potential health effects for the community as a whole. The Department bases its conclusions and recommendations on current scientific information.

Developing recommendations: The Department lists its conclusions regarding any potential health threats. The Department then offers recommendations for reducing or eliminating human exposure. The role of the Department in dealing with waste sites is primarily advisory. The Department's public health assessments may recommend actions for other agencies. If a health threat is actual or imminent, the Department will issue a public health advisory warning people of the danger and will work with the regulatory agencies to resolve the problem.

Soliciting community input: The evaluation process is interactive. The Department starts by soliciting and evaluating information from various government agencies, individuals, or organizations responsible for operating or cleaning up the site and those living in communities near the site. The Department shares its conclusions about the site with the groups and organizations providing the information and asks for feedback from the public.

If you have questions or comments about this report, please write:

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Summary

INTRODUCTION	At the Orange County Solid Waste Management Facility (Landfill), the Florida Department of Health's top priority is to ensure nearby residents have the best information to safeguard their health. The Orange County Landfill is at 5901 Young Pine Road, Orange County, Florida. In 2015, hydrogen sulfide odors from the landfill became strong when large amounts of construction and demolition debris began to decay. Although Orange County took steps to correct the odor problem, nearby residents were concerned about their health. For this report, the Department reviewed hydrogen sulfide levels from July 21 to October 19, 2016. The Department reached four conclusions.
CONCLUSION #1	The Department concludes that breathing hydrogen sulfide near the Orange County Landfill between July 21 and October 19, 2016 would not likely have caused illnesses, including headaches, throat irritation, breathing problems, weight gain, or dizziness/balance problems.
BASIS FOR DECISION #1	The highest hydrogen sulfide levels measured near the landfill were below those known to cause illness. The highest levels were between 71 and 240 parts per billion (ppb). These levels were well below those known to cause headaches and throat irritation (2,000 ppb). These levels were also unlikely to cause breathing problems, weight gain, or dizziness/balance problems.
CONCLUSION #2	The Department cannot conclude if breathing hydrogen sulfide near the Orange County Landfill between July 21 and October 19, 2016 would have caused nausea, eye irritation/infections, or an increase in allergies.
BASIS FOR DECISION #2	Associations between these symptoms and low levels of hydrogen sulfide exposure are not well-studied.
CONCLUSION #3	The Department concludes that between July 21 and October 19, 2016, residents near the Orange County Landfill have periodically been able to smell the unpleasant rotten egg odor of hydrogen sulfide from the Orange County Landfill.

BASIS FOR DECISION #3	Levels of hydrogen sulfide near the Orange County Landfill periodically exceeded the odor threshold (0.6 ppb).
CONCLUSION #4	The Department cannot assess public health impacts from hydrogen sulfide near the Orange County Landfill before July 2016.
BASIS FOR DECISION #4	Although odor complaints began in 2015, continuous air measurements for hydrogen sulfide did not begin until July 2016. Because hydrogen sulfide levels vary throughout the day and seasonally, the Department can only evaluate the potential health impacts for times with continuous measurements.
FOR MORE INFORMATION	If you have concerns about your health or the health of your children, you should contact your health care provider. You may also call the Department toll-free at 877-798-2772 and ask for information about the Orange County Landfill.

Background and Statement of Issues

The purpose of this health consultation report is to assess the public health threat from hydrogen sulfide gas from the Orange County Solid Waste Management Facility (Orange County Landfill). A community member requested this assessment.

Federal scientists set health guidelines for chemicals far below levels associated with illness. The Florida Department of Health uses these guidelines to protect the public, including sensitive populations such as children.

This assessment explores possible associations between health concerns of residents and hydrogen sulfide gas levels near the landfill. It requires the use of assumptions, judgments, and limited data. These factors contribute to uncertainty in evaluating the health threat. Assumptions and judgments in this assessment err on the side of protecting public health and may overestimate health risks.

This assessment estimates the health risk for individuals exposed to the highest measured levels of hydrogen sulfide near the Orange County Landfill. The level of hydrogen sulfide that people actually breathed may have been higher or lower. Those without exposure have no health risk from hydrogen sulfide.

The Department's role at waste sites is advisory. The Department of Environmental Protection (DEP) has regulatory authority at landfills. There are no federal or Florida regulatory standards for hydrogen sulfide in outdoor air.

Site Description

The Orange County Landfill is at 5901 Young Pine Road, Orlando, Orange County, Florida, 32829 (Figure 1). Orange County owns and operates the landfill, which is part of a 5,000-acre site [SCS Engineers/HSA Golden 2015].

In 2015, many nearby residents began to complain of a hydrogen sulfide (rotten egg) odor from the landfill. A consultant for the landfill determined that the primary cause of increased odor was the mixing of construction and demolition wastes with municipal solid waste. The landfill began this practice in 2013 within active Cells 9 and 10 (Figure 2) to improve efficiency and reduce tipping costs [SCS Engineers/HSA Golden 2015]. Construction and demolition debris contains gypsum drywall, which creates hydrogen sulfide gas when it decomposes. Organic material in municipal solid waste can increase gypsum drywall degradation and hydrogen sulfide production [EPA 2014a]. The consultant also concluded that disposal of sludge from wastewater facilities, as well as heavy rainfall, may have contributed to the production of hydrogen sulfide [SCS Engineers/HSA Golden 2015].

In February 2016, a nearby resident contacted the Department to share her concerns that the hydrogen sulfide could harm her health. Orlando TV and newspapers reported similar concerns from other residents. The Department reviewed existing hydrogen sulfide data

collected by Orange County and its consultants but found that there were not enough data to evaluate the health threat. The Department recommended the County measure hydrogen sulfide continuously (around-the-clock) for three months at three residential neighborhoods near the landfill active cell [DOH 2016]. The Department also recommended that the County monitor hydrogen sulfide during the summertime, when higher temperatures and rainfall can increase hydrogen sulfide production.

In July 2016, Orange County began around-the-clock monitoring of hydrogen sulfide every 30 minutes in three nearby neighborhoods. In late August, the County added an additional hydrogen sulfide meter in a neighborhood west-northwest of the landfill (Figure 3).

On August 31, 2016, Department staff visited the site (Photo 1) and viewed the hydrogen sulfide meter locations (Photo 2). They did not smell hydrogen sulfide at the time of the visit.

Orange County has taken steps to correct the odor problem. They separated the construction and demolition waste from the household garbage, installed additional gas collection wells, improved drainage, applied additional cover to the landfill, and neutralized odors [SCS Engineers/HSA Golden 2015].

Demographics

The Department examines demographic data to better characterize the populations near waste sites. The Department also considers factors like details on population mobility and residential history to gain insight into the duration of contaminant exposure for residents.

The American Census Bureau estimates, between 2010 and 2014, approximately 6,184 people lived within one mile of the Orange County Landfill. Forty percent were non-Hispanic white, 35 percent were Hispanic, 12 percent were African-American, 10 percent were Asian origin, and 3 percent were some other race. Twenty-five percent were less than 18 years old and 75 percent were older than 18. Twenty-eight percent of adults 25 years old or older had a high school diploma or less. Fifty-seven percent spoke only English at home, and 31 percent made less than $50,000 a year [EPA 2014b].

Land Use

The landfill is bordered by a mix of undeveloped land, residences, and businesses.

Hydrogen Sulfide Background

Occurrence

Hydrogen sulfide is a flammable, colorless gas with a characteristic rotten egg smell.

Hydrogen sulfide gas occurs naturally in areas with low oxygen: volcanoes, sulfur springs, swamps, and stagnant water bodies. Approximately 90% of the hydrogen sulfide in the atmosphere comes from these natural sources. Manmade sources of hydrogen sulfide include landfills, municipal sewers, sewage treatment plants, swine

containment/manure-handling operations, pulp/paper operations, petroleum refineries, natural gas plants, and tanneries. Cigarette smoke and car exhaust contain low levels of hydrogen sulfide as well [ATSDR 2014].

Hydrogen sulfide is commonly found in construction and demolition debris disposal areas. In low oxygen areas, common within landfills, sulfur-reducing bacteria convert sulfate present in drywall to hydrogen sulfide gas. Sulfur-reducing bacteria are most active in the presence of moisture and organic material [EPA 2014a].

Hydrogen sulfide gas is slightly heavier than air and may accumulate in low-lying areas outside landfill boundaries. Hydrogen sulfide odor problems near landfills occur most frequently in the early morning before sunrise, when there is less wind to mix the atmosphere and disperse the gas [Xu and Townsend 2014]. Landfill hydrogen sulfide levels can be highly variable, even when measured at the same time of day and in the same location [EPA 2014a]. Hydrogen sulfide levels tend to decrease with increasing distance from the landfill.

The same landfill conditions that produce hydrogen sulfide can also produce lesser amounts of other reduced sulfur compounds such as methyl mercaptan, carbon disulfide, dimethyl sulfide, and carbonyl sulfide. Hydrogen sulfide, however, is generally the dominant reduced sulfur compound [Lee et al. 2006]. Like hydrogen sulfide, people can smell other sulfur compounds at low levels. Health scientists, however, know less about the toxicity of these other reduced sulfur compounds than hydrogen sulfide.

Hydrogen Sulfide Exposure and Human Health

Hydrogen sulfide enters your body primarily through the air you breathe. When you breathe air with hydrogen sulfide, it is absorbed into the blood stream and distributed throughout the body. The body then rapidly converts hydrogen sulfide to sulfate and excretes it in the urine.

People can smell hydrogen sulfide at levels much lower than those that cause illness. There is, however, a wide range in the reported odor threshold for hydrogen sulfide. The odor threshold for hydrogen sulfide has been reported to be as low as 0.5 parts per billion (ppb) and as high as 300 ppb [ATSDR 2014]. One study that looked only at data collected with similar methodologies estimated the odor threshold to be 0.6 ppb [Ruijten et al. 2009].

No health effects have been found in humans exposed to hydrogen sulfide at background outdoor air levels (0.1 to 0.3 ppb). Exposure to levels of hydrogen sulfide well above background outdoor levels, however, may cause irritation of the eyes, nose, or throat. It may also cause difficulty in breathing for some asthmatics [ATSDR 2014].

At extremely high levels, hydrogen sulfide is poisonous. Brief exposures to extremely high levels (greater than 500,000 ppb) can cause rapid loss of consciousness and death [ATSDR 2014]. According to the U.S. Bureau of Labor Statistics, hydrogen sulfide caused 60 worker deaths between 2001 and 2010 [BLS 2016]. Very high levels of hydrogen sulfide (above 100,000 ppb) can also cause rapid/irregular heartbeat, difficult breathing, and fluid in the lungs. Very high levels usually occur only in enclosed spaces

such as sewers, animal processing plants, sludge plants, tanks, and cesspools. For individuals who recover, most regain consciousness without any lingering health effects. A few, however, may suffer permanent or long-term headaches, poor attention span, poor memory, and poor motor function. [ATSDR 2014; NRC 2010].

Scientists have not found that hydrogen sulfide causes cancer [ATSDR 2014]. EPA has not assessed hydrogen sulfide's ability to cause cancer because scientists have not studied it thoroughly [EPA 2003].

Because the body rapidly excretes hydrogen sulfide, medical monitoring is rarely useful. Scientists can measure hydrogen sulfide and its breakdown products in blood and urine, but they must take samples very soon after exposure. Furthermore, although these tests can tell whether you have been exposed to hydrogen sulfide, they cannot determine whether harmful effects will occur. [ATSDR 2014].

Little information exists about whether the elderly are more sensitive to the effects of hydrogen sulfide. The Department discusses children's sensitivity to hydrogen sulfide in the Child Health Considerations section.

Community Health Concerns

The Department reviewed a news report about health concerns [Jacim 2016], reviewed a complaint from a nearby resident, and spoke to staff at the Florida Department of Health in Orange County. The Department also sent out a survey to nearby residents and held a community meeting on November 15, 2016. Community health concerns include:

- odor
- respiratory problems, such as coughing
- throat irritation
- headaches
- weight gain
- increase in allergies
- nausea
- dizziness
- eye infections/irritation

Discussion

Environmental Data

Starting in fall of 2015, Orange County and its consultants measured hydrogen sulfide levels near the landfill using a handheld meter one or two times per week. Levels measured in neighborhoods surrounding the landfill were low [SCS Engineers/HSA

Golden 2015] (Orange County, unpublished data, 2016). The Department found that these discrete measurements were not adequate to assess the health risk. Because hydrogen sulfide levels change throughout the day and night, continuous (around-the-clock) monitoring is required to measure the highest levels of hydrogen sulfide.

In July 2016, Orange County installed Jerome 651 hydrogen sulfide meters in residential neighborhoods to the northeast, northwest and southwest of the landfill as recommended by the Department. They installed an additional meter in late August west of the northwest meter (Figure 3). The Jerome 651 contains a Jerome 631-X hydrogen sulfide analyzer, data storage, and a weather station.

The hydrogen sulfide meters took one 30-second air sample every 30 minutes. The Department analyzed the data starting 12 a.m. on July 21 through 11:30 p.m. on October 19, 2016 (Figures 4 to 7).

In general, hydrogen sulfide levels were highest at the meter northwest of the landfill. This meter was also the closest to the landfill.

The Department compared data to the Agency for Toxic Substances and Disease Registry (ATSDR) acute duration Minimal Risk Level (MRL) guideline of 70 ppb (Table 1/Figures 4-7). Hydrogen sulfide levels exceeded the MRL four times: three times at the northwest meter and once at the southwest meter. All exceedances lasted less than an hour. Peak levels at the northwest meter (71 to 150 ppb) occurred at night, when the wind was calm or from the landfill. The peak level at the southwest meter (240 ppb) occurred at 2:00 p.m. when the wind was from the southeast, not from the landfill. Hydrogen sulfide levels at the southwest meter were less than the detection limit (3 ppb) several days before and after the peak of 240 ppb. Both wind direction and short duration of the 240 ppb peak at the southwest meter suggest a transient source, possibly a vehicle on nearby State Road 417.

The Department compared two-week average hydrogen sulfide levels to the ATSDR intermediate duration MRL of 20 ppb (Table 2). The highest two-week average hydrogen sulfide level of 3.9 ppb did not exceed the ATSDR intermediate duration MRL of 20 ppb (Table 2)

The detection limit of the Jerome 631-X is 3 ppb. Therefore, it is not possible to assess the exact number of measurements between the odor detection threshold (0.6 ppb) and the meter detection limit (3 ppb).

Pathway Analyses

To assess any contaminant's public health importance, the Department estimates the frequency with which people could have contact with that contaminant. The method for assessing whether people face a health risk is to determine whether a completed exposure pathway connects them to a contaminant source, and whether exposures to that contaminant source are high enough to be of health concern.

Chemical contamination in the environment cannot harm a person's health unless that person is exposed to the contaminants. If exposure does occur, then risk of harm depends on quantity (level) of contaminants the person contacts, frequency of contact, duration of contact, and the danger (toxicity) of the contaminant.

For this report, the Department only investigated the air exposure pathway.

The Exposure Pathway

An exposure pathway is a series of steps starting with the release of a contaminant in environmental media and ending at contact with the human body. A completed exposure pathway consists of five elements:

1. Source of contamination (in this case, Orange County Landfill);
2. An environmental medium such as air that can hold or move the contamination;
3. A point where people come into contact with a contaminated medium, such as their house;
4. An exposure route, such as breathing contaminated air; and
5. A population, such as people who live near a waste site.

Generally, the ATSDR and the Department consider three exposure categories:

- Completed exposure pathways—all five elements of a pathway are present;
- Potential exposure pathways—one or more of the elements might not be present, but information is insufficient to eliminate or exclude the element; and
- Eliminated exposure pathways—at least one element is not present and will not likely be present.

Exposure pathways evaluate specific ways in which people were, are, or might be exposed to environmental contamination in the past, present, and future.

Completed Exposure Pathways

The Department considers exposure to hydrogen sulfide gas in air near the vicinity of the Orange County Landfill to be a past, current, and future completed exposure pathway (Table 3). Although other sources may exist, the primary source of the hydrogen sulfide is the Orange County Landfill [SCS Engineers/HSA Golden 2015]. Air is the environmental medium. Nearby residents are the exposed population. The exposure route is inhalation. The points of exposure are the neighborhoods near the landfill.

Public Health Risk

The Department provides site-specific public health recommendations based on toxicological literature, levels of environmental contaminants, evaluation of potential

exposure pathways, duration of exposure, and characteristics of the exposed population. Whether a person will be harmed depends on the type/amount of contaminant, how they are exposed, how long they are exposed, and how much contaminant is absorbed. Genetics and individual lifestyles also affect the risk of illness.

Identifying Contaminants of Concern

For the analysis of contaminants of concern in air, the Department compares contaminant levels directly to air comparison values. When determining which comparison value to use, the Department follows ATSDR's general hierarchy and uses professional judgment. The Department used ATSDR MRLs for comparison values in this assessment.

The Department selects contaminants with maximum levels above comparison values for further evaluation. Comparison values, however, are not thresholds of toxicity. The Department does not use them to predict health effects or to establish clean-up levels. A level above a comparison value does not necessarily mean harm will occur. It does indicate, however, the need for further evaluation.

Because the highest levels of hydrogen sulfide measured in the air near the Orange County Landfill exceeded the ATSDR acute duration MRLs, the Department selected hydrogen sulfide as the contaminant of concern.

Public Health Implications

ATSDR MRLs are estimates of human exposure to contaminants that are likely to be without risk of adverse non-cancer health effects. The Department uses these estimates to identify contaminants and potential health effects that may be of concern at contaminated sites. MRLs are substance-specific and for a specified duration of exposure. Because MRLs incorporate safety factors, contaminant levels slightly above MRLs do not necessarily cause illness. For this health consultation, the Department looked at a range of screening guidelines depending on the duration of exposure. Below are further discussions on each MRL.

ATSDR established an acute duration (short-term) MRL screening guideline of 70 ppb for hydrogen sulfide in air. ATSDR estimates that breathing 70 ppb or less of hydrogen sulfide is unlikely to cause illness. The basis for this guideline is a study of 10 people with mild to moderate asthma who breathed air with a level of 2,000 ppb hydrogen sulfide for 30 minutes under controlled laboratory conditions. After breathing hydrogen sulfide, subjects sensed nose and throat dryness, and 3 of the 10 people complained of headaches. There was no change in lung function but changes suggestive of bronchial obstruction were observed in two individuals [Jappinen et al. 1990]. ATSDR applied a safety factor of 27 to the 2,000 ppb level in this study to ensure the MRL of 70 ppb is protective of health. ATSDR derived the safety factor of 27 based on the product of a) 3 for use of a minimal lowest observed adverse effect level (LOAEL), b) 3 for human variability, and c) 3 for database deficiencies [ATSDR 2014].

ATSDR also established an intermediate duration MRL screening guideline of 20 ppb for hydrogen sulfide in air. ATSDR estimates that breathing 20 ppb or less of hydrogen sulfide between 15 and 365 days is unlikely to cause illness. The basis for this guideline is a study of rats exposed to 10,000, 30,000, or 80,000 ppb hydrogen sulfide 6 hours/day, 7 days/week for 10 weeks. Breathing 30,000 and 80,000 ppb damages the cells in the rat's nose that enable them to smell [Brenneman et al. 2000]. ATSDR applied a safety factor of 30 to the adjusted no observed adverse effect level (NOAEL) in this study (adjusted NOAEL = 10,000 ppb x 6 hours/24 hours x 7 days/7 days = 2,500 ppb). ATSDR derived the safety factor of 30 based on the product of a) 3 for extrapolation from animals to humans with dosimetric adjustment and b) 10 for human variability. ATSDR also used a factor of 0.184 to take into account the differences in surface area of the upper respiratory tract and inhalation rates between rats and humans. This ensures the intermediate duration MRL of 20 ppb (2,500 ppb/30 x 0.184, rounded to the nearest factor of 10) is protective of health [ATSDR 2014].

Several human epidemiology studies have examined the chronic toxicity of inhaled hydrogen sulfide. Most of these studies reported increases in the occurrence of subjective symptoms of respiratory irritation in workers or residents living near paper mills. Limitations, such as poor exposure characterization (including the lack of information on peak exposure levels) and co-exposure to other chemicals, limit the use of these field studies for establishing level-response relationships. Although case reports concerning temporary eye, nose, and throat irritation in humans are abundant, exposure parameters, level, and duration are often either unreported or only estimated [ATSDR 2014]. Although this report considers the results of field studies and case reports, it relies primarily on studies of human exposure to hydrogen sulfide under controlled laboratory conditions.

The following paragraphs describe the risk of illness from hydrogen sulfide measured near the Orange County Landfill.

Odor

People living near the Orange County Landfill may have periodically smelled the unpleasant odor of hydrogen sulfide. Many times since air monitoring began on July 21, 2016, the level of hydrogen sulfide near the landfill exceeded the odor threshold of 0.6 ppb. Levels of hydrogen sulfide greater than the odor threshold occurred most often at the northwest meter closest to the landfill. Because the meter detection limit is slightly greater than the odor detection limit, some sensitive residents may have smelled hydrogen sulfide even when the meters reported a level of zero. Although unpleasant, such low levels do not cause adverse health effects.

Headaches and Throat Irritation

The highest hydrogen sulfide levels measured in communities near the Orange County Landfill were unlikely to cause headaches or throat irritation.

The highest hydrogen sulfide level measured in communities near the landfill was 240 ppb. 240 ppb is almost ten times less than the 2,000 ppb levels that causes headaches and

throat irritation [Jappinen et al. 1990]. The 240 ppb level was also limited in duration, as levels were below the meter detection limit (3 ppb) for several days before and after the peak level.

The next highest hydrogen sulfide level near the landfill was 150 ppb. This level is more than ten times less than the 2,000 ppb level found to cause headache and throat irritation [Jappinen et al 1990]. Therefore, the highest hydrogen sulfide levels measured near the landfill were not likely to cause headaches or throat irritation.

Respiratory Problems

It is unlikely that the highest levels of hydrogen sulfide measured near the Orange County Landfill caused respiratory problems.

One controlled laboratory study of 10 adults with asthma exposed to 2,000 ppb hydrogen sulfide for 30 minutes found evidence suggesting bronchial obstruction but no statistically significant changes in lung function [Jappinen et al. 1990].

Therefore, since hydrogen sulfide levels near the Orange County Landfill were far below 2,000 ppb, it is unlikely they caused respiratory problems.

Dizziness/Balance Problems

The highest levels of hydrogen sulfide measured near the Orange County Landfill (240 ppb) are not likely to cause dizziness/balance problems.

Although cases of occupational-related hydrogen sulfide poisoning [Arnold et al. 1985] have been associated with dizziness and balance problems, levels of hydrogen sulfide during such occupational exposures are much higher than those measured near the landfill. A controlled study of healthy people exposed to 50 ppb, 500 ppb and 5,000 ppb hydrogen sulfide for two hours did not find balance impaired by hydrogen sulfide exposure [Fiedler et al. 2008]. Although community (epidemiological) studies of residents living near industrial sources of hydrogen sulfide [Kilburn et al. 2010; Kilburn 2012] have suggested increases of dizziness and/or balance problems with hydrogen sulfide exposures, levels of hydrogen sulfide and the presence of other contaminant exposures are not well understood in these studies.

Weight Gain

The highest levels of hydrogen sulfide measured near the Orange County Landfill (240 ppb) are not likely to cause weight gain.

Researchers have not studied the effect of hydrogen sulfide exposure on weight changes in humans [ATSDR 2014], but they have studied such effects in animals. Several studies [Saillenfait et al. 1989; Gagnaire et al. 1986; CIIT 1983b] did not find statistically significant changes in rats' weights after exposure to hydrogen sulfide levels between 10,000 ppb to 50,000 ppb for varying periods of time. Other animal studies have found associations between hydrogen sulfide exposure and weight loss. Pregnant Sprague-Dawley rats lost weight after exposure to concentrations greater than 150,000 ppb on

gestation days 6-20. Also, certain types of female rats [CIIT 1983c] and mice [CIIT 1983a] lost weight after exposure to time-weighted average levels of 80,000 ppb for 6 hours/day, 5 days/week for 90 days. Therefore, it is unlikely hydrogen sulfide caused community members to gain weight.

Nausea/Allergies

It is unclear if the highest concentrations of hydrogen sulfide measured near the Orange County Landfill (240 ppb) could cause nausea or allergies.

Nausea and vomiting have been noted in several cases of human inhalational hydrogen sulfide poisoning in occupational settings, but only at high concentrations. Significant increases in the incidence of reported nausea was found in community studies of lower level exposures of hydrogen sulfide and other reduced sulfur gases [Haahtela et al. 1992]. Exposures in these studies were not measured, however, and other reduced sulfur gases were present. The Department could not find any controlled studies of nausea and low levels of hydrogen sulfide exposure. Therefore, it is unclear whether hydrogen sulfide exposure near the Orange County Landfill caused nausea.

The Department did not find any studies examining the effect of hydrogen sulfide on existing allergies or developing allergies.

Eye Infections/Irritation

Hydrogen sulfide can cause conjunctivitis and eye irritation at high levels. Hydrogen sulfide levels of 6,000 ppb were shown to cause eye irritation in the presence of other reduced sulfur compounds [Vanhoorne et al. 1995].

In a less controlled field study of people living near a paper mill with estimated peak outdoor hydrogen sulfide concentrations of 70 ppb, residents self-reported eye irritation 12 times more often than people without exposure [Jaakkola et al. 1990]. Eye irritation in this study may have also have been due to methyl mercaptan as well as other air pollutants. The Department could not find controlled studies examining low concentrations of hydrogen sulfide and eye issues.

Therefore, although high concentrations of hydrogen sulfide cause eye infections/irritation, it is unclear if levels measured at the Orange County Landfill caused eye infections or irritation.

Child Health Considerations

In communities faced with air, water, soil, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk for certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter; this means they breathe dust, soil, and vapors closer to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical

growth stages, the developing body system of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health.

In a community setting, children are likely to be exposed to hydrogen sulfide in the same manner as adults. Very few data are available to assess if children are more sensitive to hydrogen sulfide; however, it is expected that hydrogen sulfide would have similar toxicological effects on children [ATSDR 2014]. Therefore, since levels near the Orange County Landfill were far below 2,000 ppb, the Department does not expect that hydrogen sulfide exposure would affect children differently than adults, although it is possible.

Limitations

Although the Department accurately assessed the potential public health hazards associated with the Orange County Landfill, there were limitations in the environmental data used to make this assessment. The Department based this assessment on continuous hydrogen sulfide monitoring around the landfill between July 21 and October 19, 2016. Because hydrogen sulfide levels may vary greatly throughout the day and night and spatially, sampling can only be used to verify the level of hydrogen sulfide at the sampling location at the time of the measurement. Results cannot be used to determine "worst case" or "typical" exposures, as hydrogen sulfide levels are likely to vary annually and seasonally. The Department cannot assess the potential health effects of hydrogen sulfide exposures before the monitoring period began or exposures in areas Orange County did not install hydrogen sulfide meters.

Conclusions

The Florida Department of Health reached four conclusions about the Orange County Landfill.

1. The Department concludes that breathing the highest levels of hydrogen sulfide measured near the Orange County Landfill between July 21 and October 19, 2016 were not likely to cause adverse health effects, including headaches, throat irritation, breathing problems, weight gain, and dizziness/balance problems.

2. Because of the lack of controlled studies, the Department cannot conclude if breathing the highest levels of hydrogen sulfide measured near the Orange County Landfill between July 21 and October 19, 2016 could cause eye irritation/infections, nausea, or allergies.

3. The Department concludes that since July 2016, residents near the Orange County Landfill have periodically been able to smell the unpleasant rotten egg odor of hydrogen sulfide from the Orange County Landfill. Although unpleasant, such low levels are not likely to cause illnesses.

4. A lack of data prevents the Department from determining the public health threat of hydrogen sulfide near the Orange County Landfill before July 2016.

The Department has no public health recommendations.

Public Health Action Plan

Previous actions

Between September 2015 and June 2016, Orange County Utilities held several meetings with community members about hydrogen sulfide levels and actions the County is taking to mitigate the odors.

On November 2, 2016, the Department released a draft of this health consultation report and solicited public comments. The Department also distributed fact sheets summarizing the report to approximately 1500 nearby residents.

On November 15, 2016, the Department, with the Department of Health-Orange County and Orange County Utilities, held an open house meeting to explain findings of this health consultation and to get information about residents' health concerns.

Planned actions

The Department will consider review of new data when requested.

Report Preparation

The Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services (DHHS) funded this report through a cooperative agreement with the Department. The findings and conclusions in these reports, however, are those of the Department and do not necessarily represent the views of ATSDR or DHHS. ATSDR did not revise or edit this document.

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Appendices

Appendix A: Tables

Table 1. Summary of Hydrogen Sulfide Levels near the Orange County Landfill: July 21, 2016 to October 19, 2016

Approximate Distance and Direction from the Landfill Active Cell	Total Number of Hydrogen Sulfide Measurements*	Average Level (ppb)**	Maximum Level (ppb)	Number of Measurements Exceeding the ATSDR Acute Duration MRL (70 ppb)
1 Mile Northwest	4214	3.1	150	3
4 Miles Northeast	4279	1.5	9	0
2 Miles Southwest	4152	1.7	240***	1
2 Miles West-Northwest	2416	1.6	24	0

ATSDR = Agency for Toxic Substances and Disease Registry
MRL = Minimal Risk Level
ppb = parts per billion

*Hydrogen sulfide meters took readings every 30 minutes; meter malfunctions on 8/23 and 8/24 and 9/19 to 9/22 resulted in fewer measurements at the Northwest and Southwest meters, respectively; monitoring at the West-Northwest meter began on 8/29/2016.

**The detection limit of the Jerome hydrogen sulfide meters is 3 ppb; to determine average levels, the Department assumed all reported values below 3 ppb were one-half the detection limit (1.5 ppb).

*** Wind direction and the short duration of this elevated level suggest a source other than the landfill.

Data source: [Orange County 2016]; (Orange County, unpublished data, 2016)

Shaded levels exceed the ATSDR Acute Duration MRL.

Table 2. Two-Week Average Hydrogen Sulfide Levels (ppb)*

Two Week Period	Northwest Meter	Northeast Meter	Southwest Meter	West-Northwest Meter**
July 21 - August 3	3.9	1.5	1.8	ND
August 4 - August 17	3.4	1.5	1.5	ND
August 18 - August 31	3.6	1.5	1.6	ND
September 1 - September 14	1.9	1.5	1.9	1.7
September 15 - October 5	2.6	1.5	1.6	1.6
October 6 - October 19	1.8	1.5	2.1	1.6
ATSDR Intermediate Duration MRL	20			

ATSDR = Agency for Toxic Substances and Disease Registry
MRL = Minimal Risk Level
ND = no data
ppb = parts per billion

* The detection limit of the hydrogen sulfide meters is 3 ppb; to determine average levels the Department assumed all reported values below 3 ppb were one-half the detection limit (1.5 ppb).
**Meter installed by the County on 8/30/2016

Data source: [Orange County Landfill 2016]; (Orange County, unpublished data, 2016)

Table 3. Complete Human Exposure Pathways at the Orange County Landfill Site

PATHWAY NAME	COMPLETE EXPOSURE PATHWAY ELEMENTS					TIME
	SOURCE	ENVIRONMENTAL MEDIA	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSED POPULATION	
Hydrogen Sulfide in Air	Orange County Landfill	Air	Neighborhoods near the landfill	Inhalation	Nearby residents	Past, present, and future

Appendix B: Figures

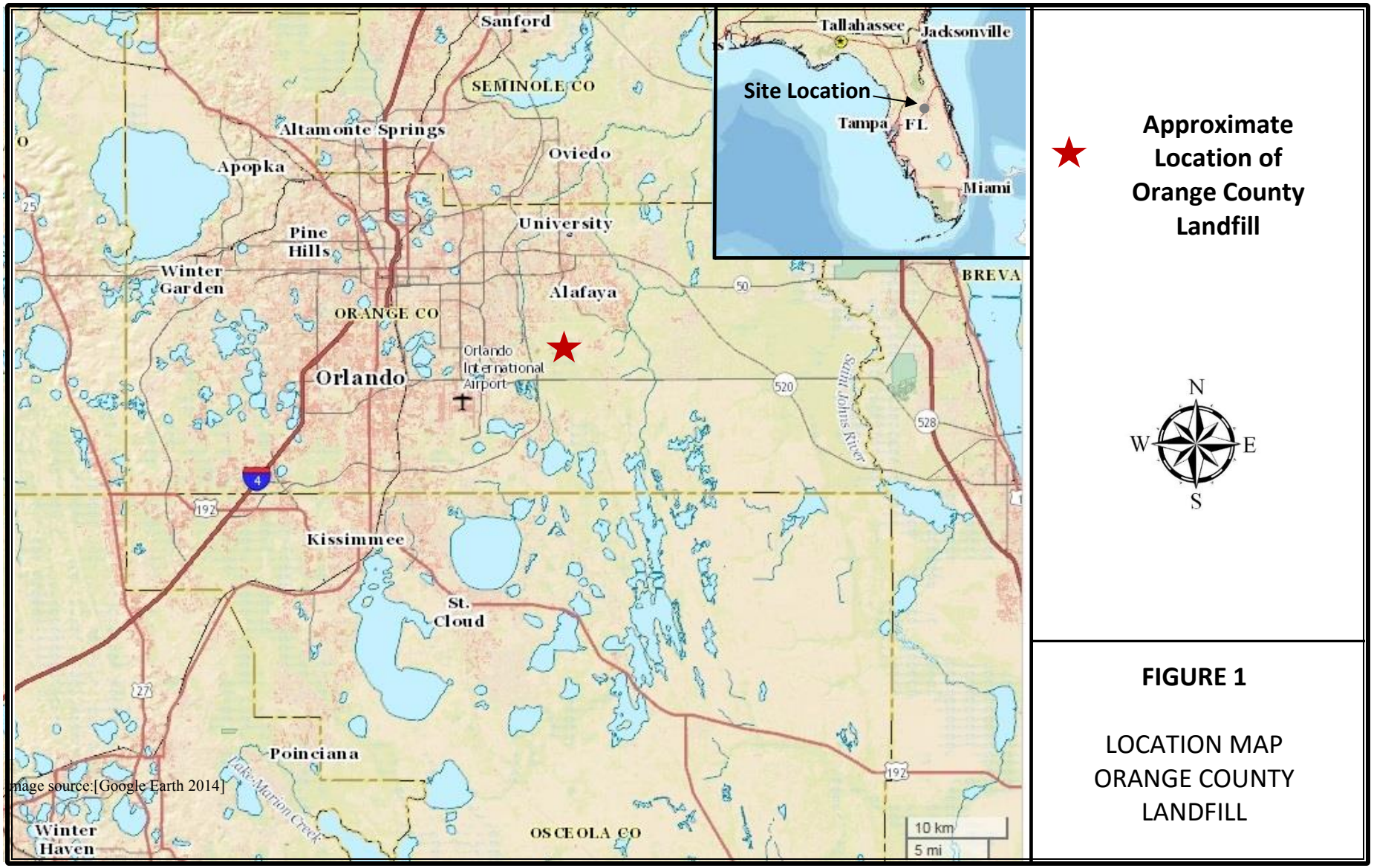
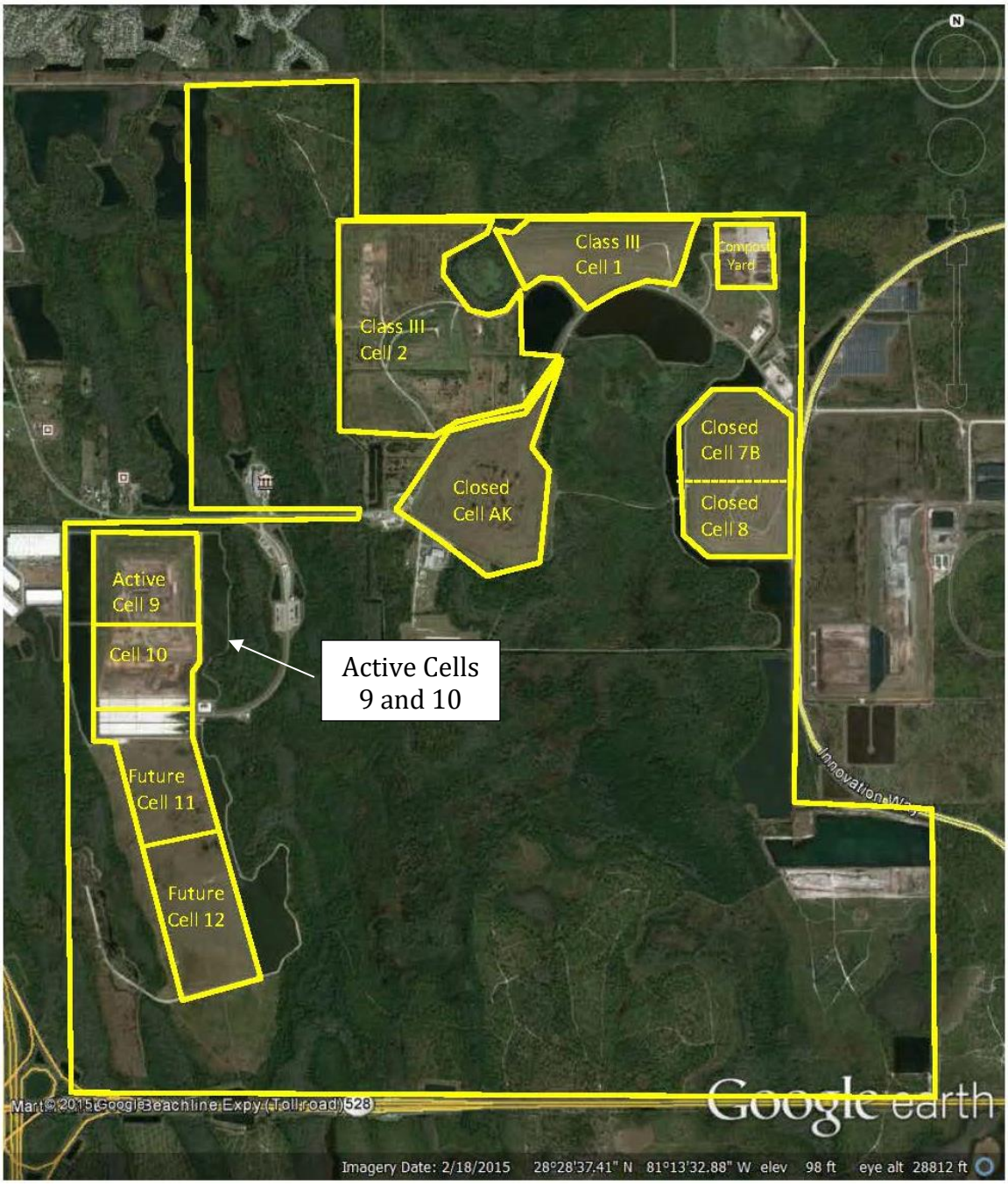


Image source:[Google Earth 2014]

FIGURE 1

LOCATION MAP
ORANGE COUNTY
LANDFILL

Image source: [USGS 2016]



N
W E
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FIGURE 2
SITE MAP
ORANGE COUNTY
LANDFILL

Source: [SCS Engineers/HSA Golden 2015]

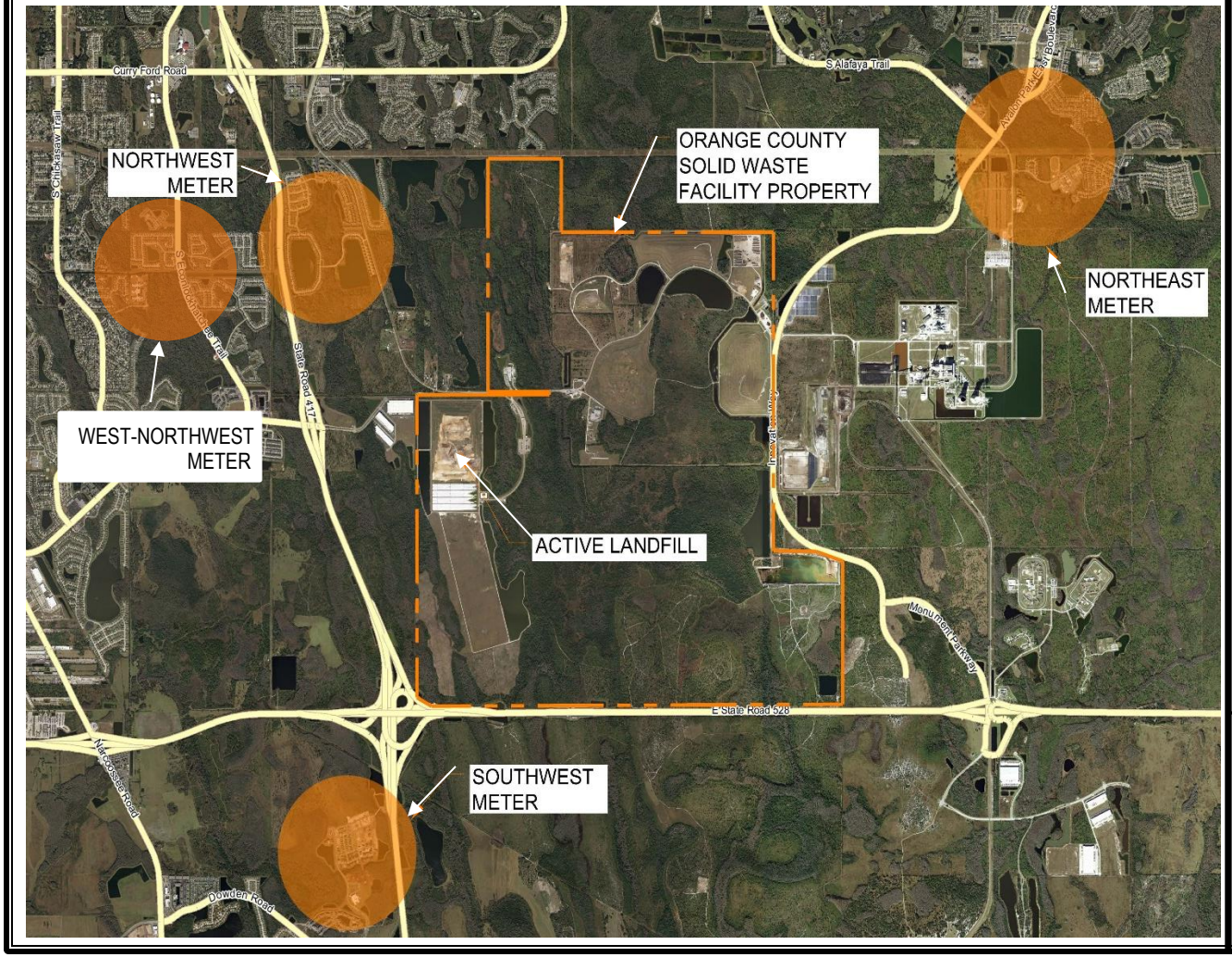


FIGURE 3
APPROXIMATE LOCATIONS OF HYDROGEN SULFIDE METERS

*Meters are within the orange circles.

Source: Orange County, unpublished data, 2016

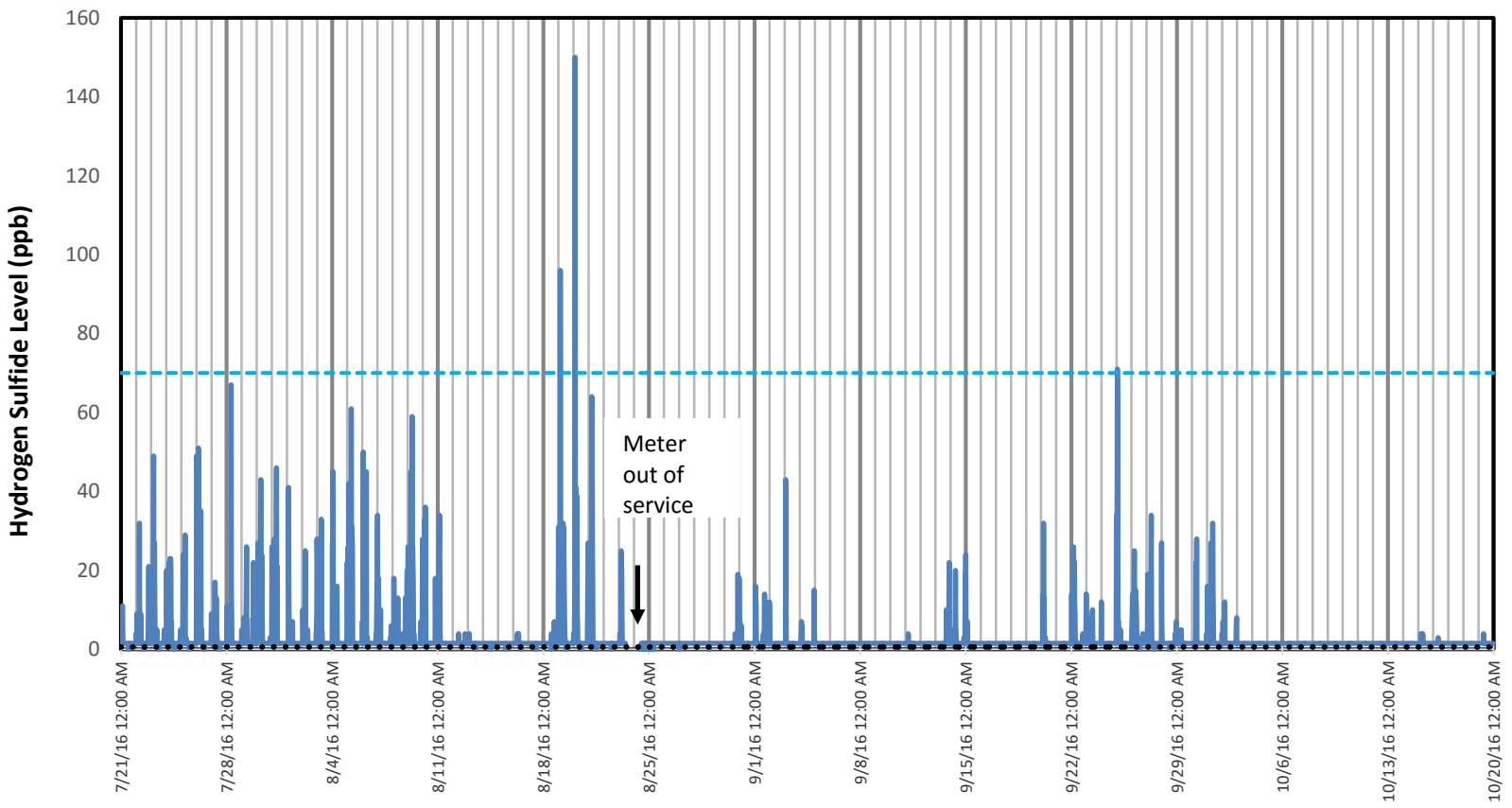
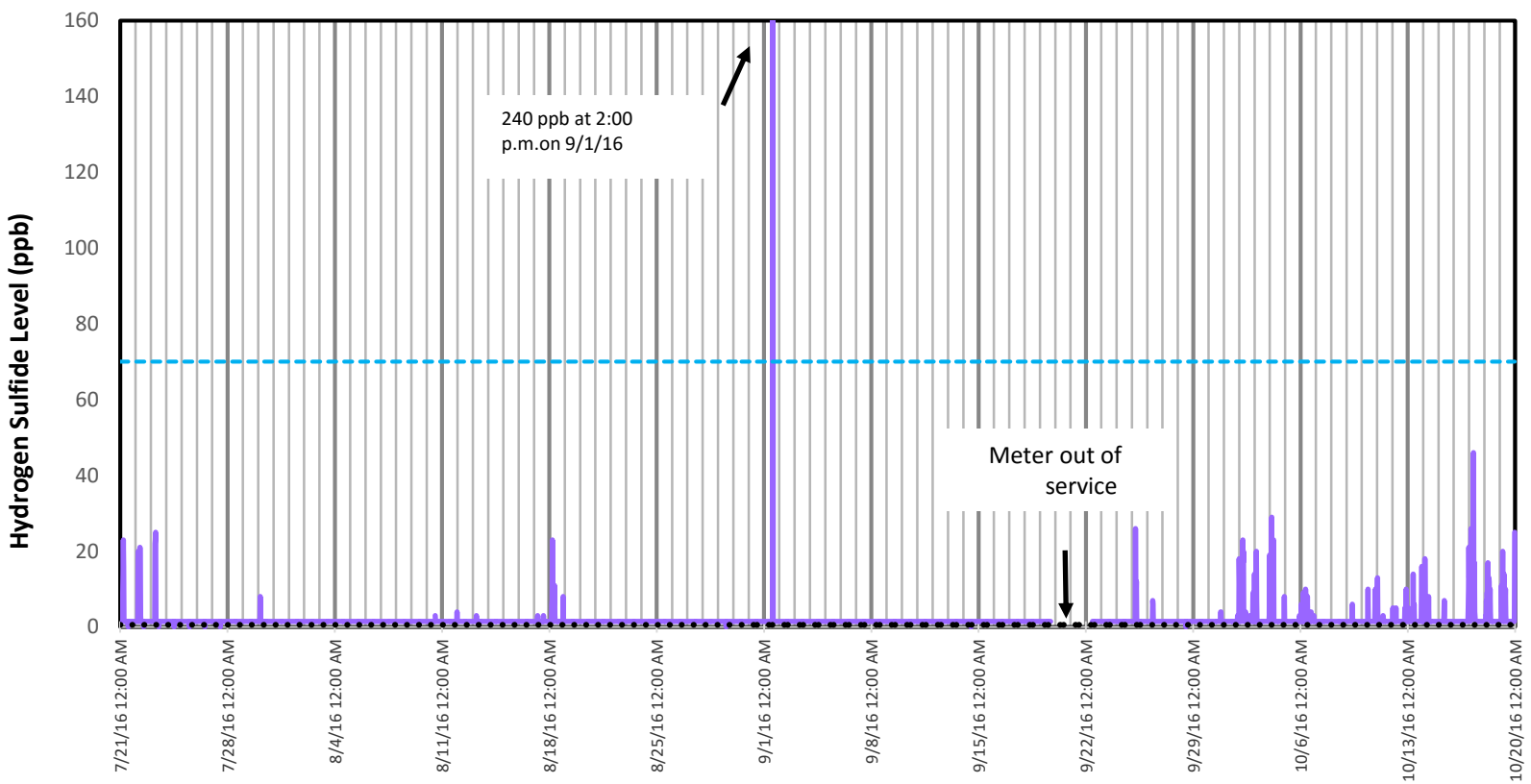


FIGURE 4

HYDROGEN SULFIDE LEVELS NEAR THE ORANGE COUNTY LANDFILL: NORTHWEST METER

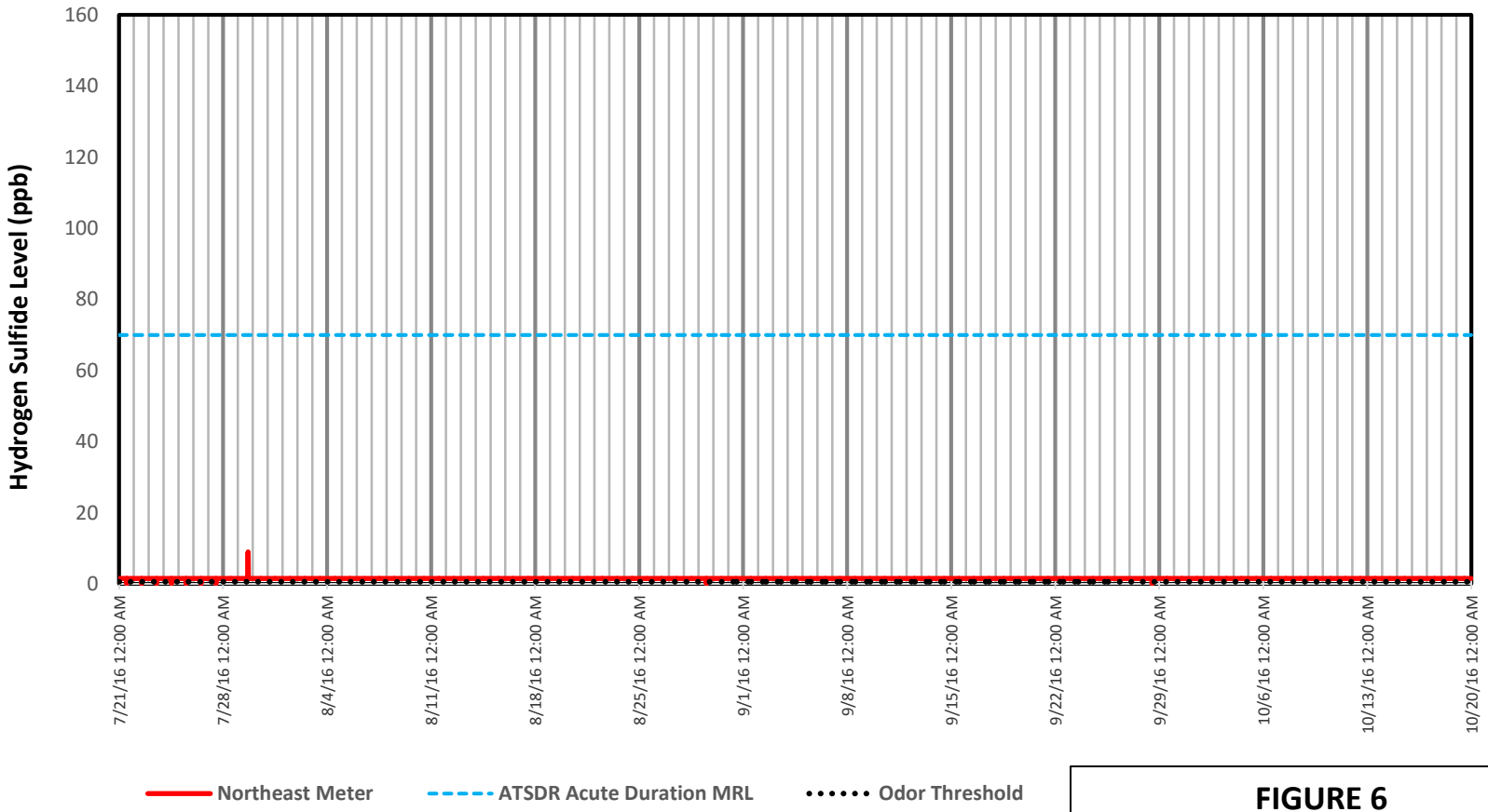
ATSDR = Agency for Toxic Substances Disease Registry; **MRL** = Minimal Risk Level; **ppb** = parts per billion
Data source: [Orange County 2016]



ATSDR = Agency for Toxic Substances Disease Registry; **MRL** = Minimal Risk Level; **ppb** = parts per billion
Data source: [Orange County 2016]

FIGURE 5

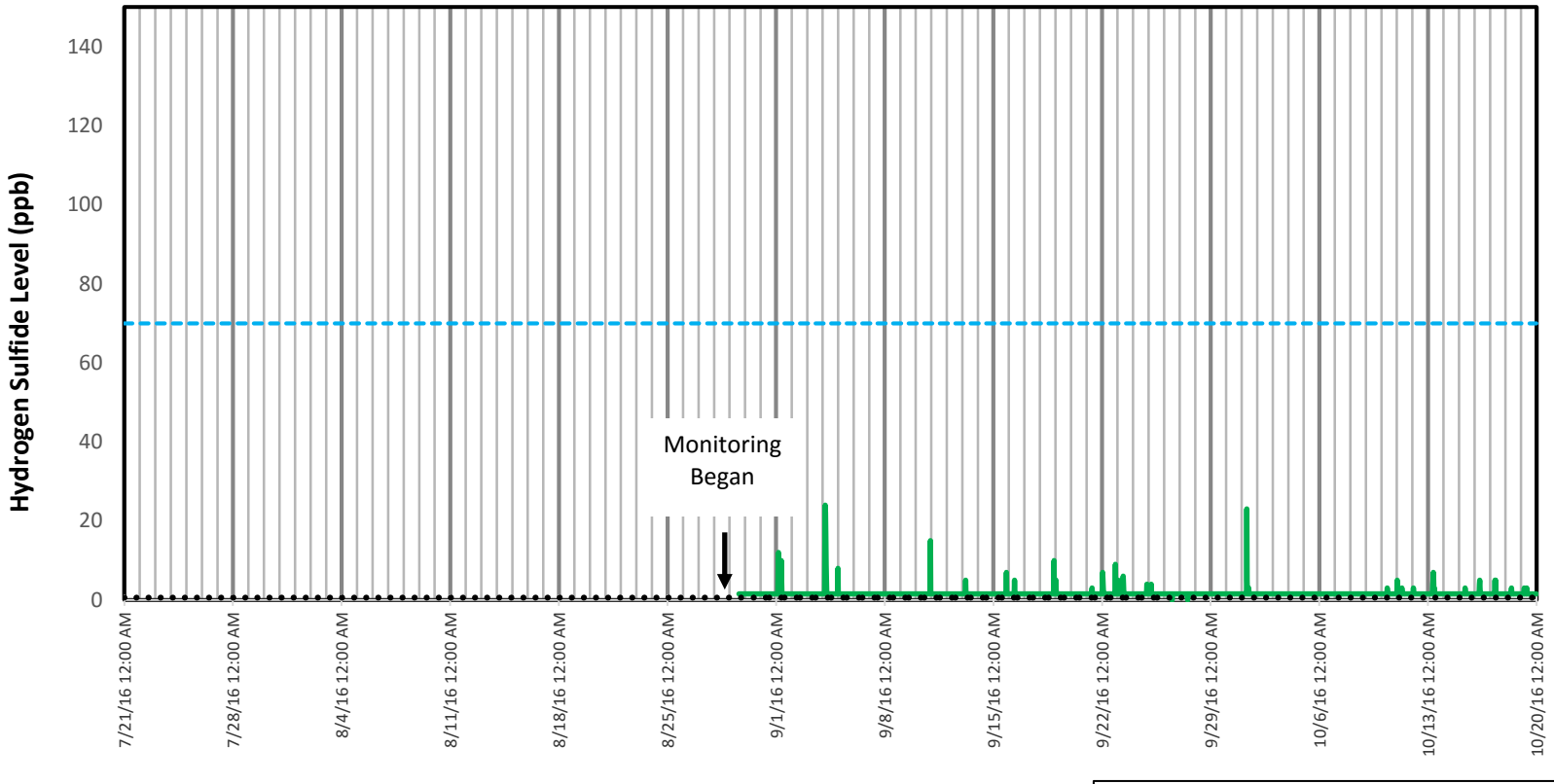
HYDROGEN SULFIDE LEVELS NEAR THE ORANGE COUNTY LANDFILL: SOUTHWEST METER



ATSDR = Agency for Toxic Substances Disease Registry; **MRL** = Minimal Risk Level; **ppb** = parts per billion
Data source: [Orange County 2016]

FIGURE 6

HYDROGEN SULFIDE LEVELS NEAR THE ORANGE COUNTY LANDFILL: NORTHEAST METER



ATSDR = Agency for Toxic Substances Disease Registry; **MRL** = Minimal Risk Level; **ppb** = parts per billion
Data source: (Orange County, unpublished data, 2016)
* The West-Northwest Meter began collecting data on August 29, 2016.

FIGURE 7

HYDROGEN SULFIDE LEVELS NEAR THE ORANGE COUNTY LANDFILL: WEST-NORTHWEST METER*

Appendix C: Photographs

Photo 1. Orange County Landfill

Photo 2. Hydrogen Sulfide Meter Northeast of Landfill

Appendix D: Response to Public Comments

Response to Public Comments

On November 2, 2016, the Florida Department of Health posted a public comment version of this report on its website. On November 4, 2016, the Department mailed a community update and survey to approximately 1500 addresses near the Orange County Landfill. This update summarized the draft report and solicited public comment through December 9, 2016. On November 15, 2016, the Department held an open house public meeting at the Orange County Landfill. The Department received eight surveys and two letters with comments.

During the public comment period, residents expressed health concerns including breathing problems, weight gain, eye infections and irritation, increases in allergies, nausea, headaches, dizziness/balance problems and memory problems. The Department addresses these health concerns in the Public Health Implications section of this report.

One respondent suggested they believed that there is a link between their family's depression and weight gain and inability to exercise outside as a result of hydrogen sulfide odors. Hydrogen sulfide gas has an extremely unpleasant smell, which can make it unpleasant to exercise outside. Some symptoms, such as weight gain and depression, can have many causes, but can be exacerbated by not exercising or going outdoors.

Glossary

Acute
Occurring over a short time [compare with **chronic**].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with **intermediate duration exposure** and **chronic exposure]**.

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

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

Chronic
Occurring over a long time (more than 1 year) [compare with **acute**].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with **acute exposure** and **intermediate duration exposure**].

Completed exposure pathway [see **exposure pathway**].

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

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

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

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and **biota** (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The **environmental media and transport mechanism** is the second part of an **exposure pathway**.

EPA
United States Environmental Protection Agency.

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

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

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

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

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with **acute exposure** and **chronic exposure**].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

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

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see **exposure pathway**].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

ppb
Parts per billion.

ppm
Parts per million.

Public health action
A list of steps to protect public health.

Public meeting
A public forum with community members for communication about a site.

Receptor population
People who could come into contact with hazardous substances [see **exposure pathway**].

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [**inhalation**], eating or drinking [**ingestion**], or contact with the skin [**dermal contact**].

Safety factor [see **uncertainty factor]**

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Substance
A chemical.

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

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a **safety factor**].