Purpose

This document summarizes and provides context to the emissions monitoring report developed by EPA Environmental Response Team (ERT), Big Ox Energy H2S – WA SERAS-360 – Trip Report (ERT Report).

Source Description

Big Ox Energy, LLC (BOE) owns and operates a waste-to energy facility in South Sioux City, NE. The facility is designed to process waste from various industries around the region including slaughter and meatpacking, food, and other high strength, industrial organic waste. The waste received onsite is digested in anaerobic digesters where biogas comprised of methane, carbon dioxide, and other trace gases (e.g., N2, H2S, etc.) is produced. The biogas produced at the facility is either flared or converted (CO2 and trace gases removed) to pipeline quality methane.

Facility Conditions

The majority of the hydrogen sulfide (H2S) released from the facility originates in the digesters; however, a significant portion may also be present in the waste material received by trucks from BOE's customers. Biogas is normally routed to a biogas clean up system to remove trace gases before pumping it to the natural gas pipeline. When the clean-up system is not operational, the biogas is flared.

Odor Complaints

Residents and businesses located near the site have filed multiple complaints to the Nebraska Environmental Quality Department (NDEQ) and the Environmental Protection Agency (EPA) regarding odors that are possibly originating from BOE. Odors from the facility are likely attributed to H2S trace gases formed during the anaerobic process and present in the biogas as well as incoming waste shipments. Release points for the biogas include, but are not limited to, fugitives, pressure release valves, receiving building exhaust and biogas scrubber skid.

H2S Characteristics and Regulatory Framework

Hydrogen Sulfide is produced by the breakdown of organic materials under anaerobic (absence of oxygen) conditions. It is a colorless, flammable and extremely hazardous gas. Humans can detect (smell) traces of the gas at very low concentrations, but continuous exposure or at higher concentrations, olfactory desensitization or immediate loss of smell may occur. The H2S olfactory detection threshold for H2S can range from 0.0005 to 0.3 ppm (ATSDR ToxGuide, CAS#7783-06-4). At this time, H2S is not regulated by any federal statutes or regulations addressing emissions. However, a few states regulate H2S, which is the case of the State of Nebraska's Total Reduced Sulfur (TRS) Standard. Federal regulations designed to protect worker's safety include those published by NIOSH and OSHA and regulate permissible levels of worker exposure to H2S. A summary of regulatory requirements, recommend exposure limits and guidelines is presented below:

Limits	**Concentration, ppm**	**Concentration, ppb**
Nebraska TRS Standard (30-min/1-min)[1]	0.1/10	100/10,000
NIOSH IDLH[2]	100	100,000
NIOSH Recommended Exposure Limit (REL)[3]	10	10,000
OSHA Permissible Exposure Limit for GI/C[4]	20/10	20,000/10,000
ACGIH TLV/STEL[5]	1/5	1,000/5,000
AEGL 1 (10-min/30-min/1-hr/4-hr/8-hr)[6] AEGL 2 AEGL 3	0.75/0.60/0.51/0.36/0.33 41/32/27/20/17 76/59/50/37/31	750/600/510/360/330 41,000/32,000/27,000/20,000/17,000 76,000/59,000/50,000/37,000/31,000
Sensory Detection (smell)	**Concentration, ppm**	**Concentration, ppb**
H2S Olfactory Detection Threshold[7]	0.0005 to 0.3	0.5 to 300 ppb

Notes:

1. Based on 30-min average or 1-min average.
2. National Institute for Occupational Safety and Health Immediately Dangerous to Life or Health.
3. Based on 10-min exposure ceiling.
4. General Industry (GI), Construction (C).
5. American Conference of Governmental Industrial Hygienists threshold limit value (TLV) as an 8-hour time weighted average and a short-term exposure limit (STEL).
6. Acute Exposure Guideline Levels, AEGL-1: Reversible health effects; -2: irreversible or serious; -3: life-threatening.
7. Range may vary based on individual's sense of smell. ATSDR ToxGuide, CAS#7783-06-4.

ATSDR has published Minimal Risk Levels (MRLs) for inhalation exposure to H2S, which are not regulatory limits and intended as screening levels. The MRL of 0.07 ppm (70 ppb) has been derived for acute-duration (≤ 14 days) while 0.02 ppm (20 ppb) has been derived for intermediate-duration. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure.

In reference to community studies[1], long-term or repeated exposures to malodorous sulfur-based emissions have been associated with quality of life issues (e.g., changes in mood, including increased anxiety, tension, anger, confusion, and depression). In addition, long term exposures are associated with increased risk of

[1] Health Consultation, Bridgeton Evaluation of Exposure to Landfill Gases in Ambient Air. Missouri Department of Health and Senior Services (MDHSS), 2018.

acute respiratory infection such as common cold and/or Bronchitis. It is important to note that up to date, ambient monitoring concentrations around the BOE facility (beyond fence line) were measured well below the H2S concentration (2,000 ppb) shown in a critical clinical study[2] to cause adverse respiratory effects in people with asthma.

Monitoring and Test Results

Description

In response to the community's odor complaints, EPA ERT deployed ambient monitoring equipment to detect H2S concentrations at targeted locations around the facility from November 12 to 19, 2018.

Monitoring Equipment

Ambient monitoring for H2S was performed using Honeywell's SPM Flex Single Point Monitor. The SPM Flex monitor is an extractive gas monitoring system equipped with a Chemcassette Hydride tape-based (Flex CC XP) optical gas detector and configured to monitor H2S. The monitor range is 0.001 to 9.999 ppm (1 to 9,999 ppb), which matches expected and previously detected ambient H2S concentrations around the site.

Location of Monitors

The siting of monitors was based on the climatological winds from the nearby, approximately 5 km (3 miles), Sioux City, IA Airport and in areas of expected maximum pollutant concentrations downwind of the facilities emissions. Monitors were placed to the south and north of the facility based on the predominant north-south winds in the area. The expected maximum concentrations are likely to occur within 1 km (0.62 miles) of facility given the known emission points, building structures of the facility and nearby land-use. A summary of monitor locations and distance from the facility is presented below:

Monitor	Description	Approx. Distance, km (mi)	Relation to site
1	Frame Aligners, Inc.	0.9 (0.6)	NW
2	The Dakota Thurston county fair building	0.7 (0.4)	NW
3	Private residence	0.5 (0.3)	NW
4	Private residence	0.5 (0.3)	NNE
5A	Electrical substation	0.5 (0.3)	SSE
5B	Electrical substation	0.5 (0.3)	SSE
6	BPI - North side of Dakota Cold Storage[1]	0.5 (0.3)	SSW
7	BPI facility[1]	0.7 (0.4)	ESE
8	NW corner of Siouxland Estates office building	1.6 (1.0)	NW

Notes:
1. Data collection for monitor locations 6 and 7 did not begin until 11:34 am November 13, 2018 because monitor site access was not granted until such time.
2. A map showing monitor locations can be found in Figure 1 of the ERT Report.

Limitations of Monitoring Event

- Monitoring results only represent a limited "snapshot" in time (7 days) of the conditions related to H2S-odor concentrations near the facility. It does not represent long-term conditions and emissions from H2S in and around the site. Sampling was performed continuously and real-time 30-min time weighted-average calculated (see Appendix D of ERT report for instantaneous and TWA data).
- The correlation of monitored concentrations and wind conditions (i.e., speed and direction) is limited in that wind conditions are based on the National Oceanic and Atmospheric Administration (NOAA) weather station located at the Sioux Gateway Airport approximately 5 km (3 miles) from the facility. Local wind conditions near monitor locations may differ because of elevation and topography associated with sited monitors.
- Meteorological data acquired from the NOAA station is available based on hourly intervals in contrast to 1-min data collected by the ERT SPM Flex monitors. Meteorological conditions leading to and during H2S detection events may be different than those reported by the NOAA station making it difficult to attribute specific elevated H2S concentrations to a particular source.
- Facility waste throughput was curtailed during weeks prior to and during the monitoring event to minimize exposure to site contractors performing repairs to digester equipment. As such, system operations were not at full load/normal conditions during the monitoring event reducing potential H2S emissions from the facility.

Monitoring Results

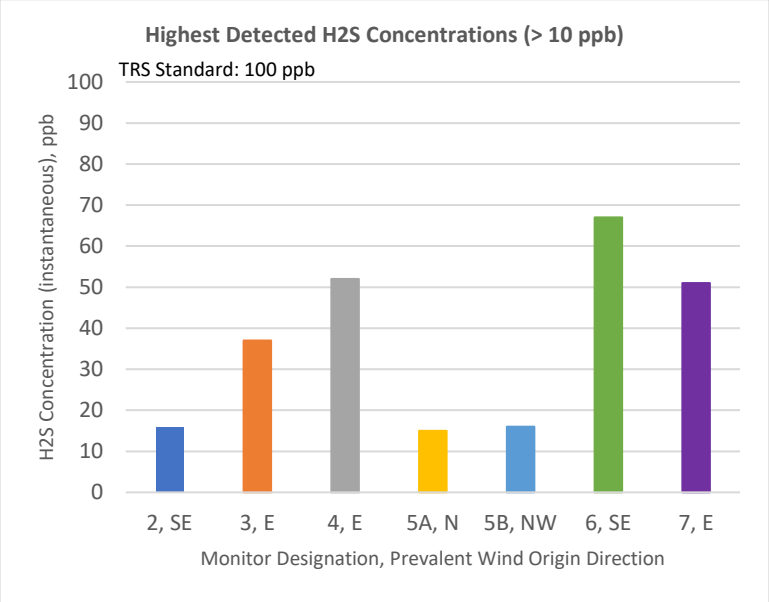
The data gathered during the monitoring event was quality controlled by ERT staff prior to development of the final ERT Report. For the duration of the monitoring event, no monitors reported H2S ambient concentrations above Nebraska's TRS standard. Although no H2S concentrations were detected above the

[2] Draft toxicological profile for hydrogen sulfide and carbonyl sulfide. Atlanta, GA: USDHHS, Public Health Services. ATSDR, 2014.

TRS standard, it is important to recognize that all monitors detected H2S concentrations above olfactory threshold.

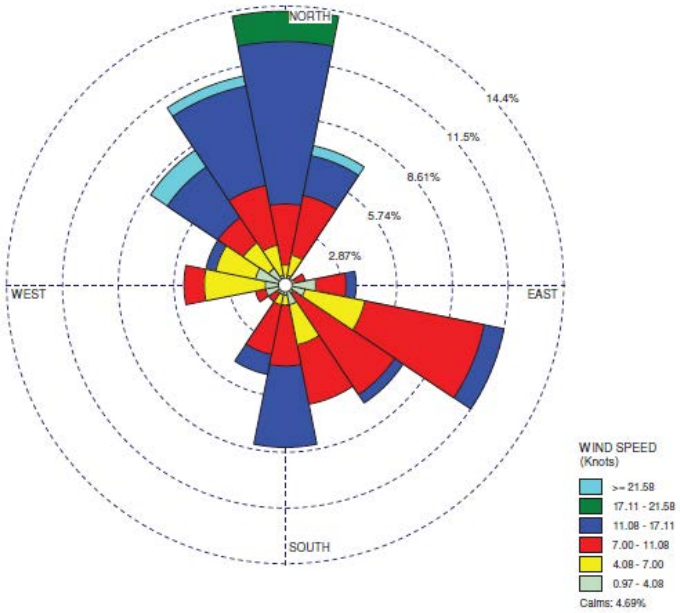
Notes:

1. The chart summarizes highest detected instantaneous H2S concentrations for each monitor reporting values above 0.01 ppm (10 ppb).
2. Monitors 1 and 8 did not detect H2S concentration values above 10 ppb and are not shown.
3. Monitors detected 28 instances when H2S concentrations were > 10 ppb.
4. Approximately 54% of the detected H2S concentrations above 10 ppb correlated with prevalent wind direction where origin of emission could be attributed to the facility.
5. Although detected H2S concentrations validate odor complaints from local population, exact origin of H2S emissions remain inconclusive since wind data may not necessarily represent local monitor conditions.
6. Wind rose diagram represents entire monitoring period and show prevalent wind from N, NNW, S and SE directions. Appendix C of the ERT Report include daily wind rose charts for the sampling period.



Number of instances H2S concentrations were detected above 10 ppb:

Monitor	2	3	4	5A	5B	6	7
Instances	3	2	8	2	2	7	4



Current Monitoring and Next Steps

EPA continues to review BOE operations and steps being taken to reduce H2S emissions and odors from the facility. As part of an administrative consent order (ACO) issued by EPA R7 in November 2018, the facility has installed three-band electrochemical fence line H2S monitors (SulfNose by Odotech, Inc.) with range of 0-300 ppb, 0-20 ppm and 0-100 ppm. The SulfNose monitors have an accuracy of +/- 10% and are located NW and SE to the facility. The monitors are equipped with GPS and capable of measuring wind speed and direction in 1-min intervals. EPA reviews this monitoring data on a weekly basis and discusses elevated levels with BOE. As required by the ACO, EPA R7 anticipates future additional testing and monitoring of H2S emissions from the facility.