DEPARTMENT OF HEALTH & HUMAN SERVICES
Agency for Toxic Substances and Disease Registry

Public Health Service
Region 8
1595 Wynkoop St.
Denver, CO 80202-2466

September 1, 2016

Dr. Kelly Weidenbach
Executive Director
Casper-Natrona County Health Department
475 South Spruce Street
Casper, Wyoming 82601

Dear Dr. Weidenbach:

On June 27, 2016, the Agency for Toxic Substances and Disease Registry (ATSDR) received an email from you regarding results of indoor air sampling at the Midwest School in Natrona, Wyoming. You requested that ATSDR review results provided by CS Consulting on behalf of Fleur de Lis Energy (FDL), and provide an analysis of the potential public health implications of exposure to gases intruding into the school from the Salt Creek oil well field. We understand that carbon dioxide (CO_2) is used to pressurize the surrounding wells and on May 24, 2016, the school was evacuated because of elevated air levels of CO_2. On May 26, the air levels in the building measured by FDL exceeded ATSDR short-term (acute) health guidelines for benzene and the CO_2 levels exceeded recommended indoor CO_2 levels of 1,000 parts per million for a healthy school environment (EPA 2009). The data demonstrated a positive correlation between interior VOC concentrations and CO_2 levels.

ATSDR received air sampling data from the Casper-Natrona County Health Department that documented air sampling on June 16-17, 2016. This sampling estimated average indoor air concentrations of volatile organic chemicals (VOC) and other gases in the school over an 8-hour period. Based on an evaluation of the data from the June sampling event, ATSDR determined that there were no exceedances of health-based air concentration guidelines at that time. However, it should be noted that CO_2 levels were low during the June sampling period, demonstrating that the indoor air environment was different from those of the May sampling event and might not be representative of conditions when oil field operations adversely impacted building indoor air.

Conditions of operation vary and air data are not available for all circumstances when well field operations may be impacting the school. Consequently, ATSDR cannot conclude that the occupants of the school will be safe under all conditions of well field operation. It is possible that another event similar to the May 24th incident could occur in the future. ATSDR concluded that the events in May posed an urgent health hazard. ATSDR recommends that interim and more permanent mitigation be instituted before deciding to reoccupy the building in order to protect the students and staff of

Midwest School. We understand that FDL is in the process of taking corrective action to mitigate impacts to the school from oil well field operations. These actions include sealing any abandoned wells near to the school, installing soil vapor extraction under the school foundation, and conducting a comprehensive evaluation of well bores drilled within a half-mile of the school. Additionally, FDL is working with county and town officials to provide additional gas monitoring in the community adjacent to the school and oil field.

It is unclear to ATSDR whether actions taken by FDL will adequately mitigate vapor intrusion into the school building. ATSDR recommends that multiple lines of evidence be considered by the school district before reoccupying the school. This may include multiple rounds of indoor air samples and soil gas measurements under the building foundation. Additionally, ATSDR recommends that if the school is reoccupied, ongoing monitoring for volatile organic compounds and CO_2 occur to ensure the continued safety of the students and staff. A safety plan should be developed in case of malfunction of the mitigation systems.

Sampling during May 26, 2016, also revealed that the air in the crawlspace under the swimming pool had elevated CO_2 and VOC concentrations. It is possible that this crawlspace could present a confined space hazard to someone entering the area without adequate ventilation or protective equipment if the air in the crawlspace is oxygen deficient or VOC concentrations are acutely toxic and immediately dangerous to life and health. ATSDR recommends that access to the crawlspace should be restricted and warnings placed on the crawlspace access until the situation is corrected and monitoring demonstrates that the area can be entered safely.

ATSDR understands that there are areas where gas is seeping out of the ground near the track. We understand that school district officials have notified school staff that those areas should be avoided. ATSDR recommends that access to those areas be restricted and signs be posted to avoid access to those areas until the seeps are mitigated.

A description of the evaluation of the air data is provided as an attachment to this letter, along with more detailed conclusions and recommendations. ATSDR remains available to assist with health and safety concerns. Please contact the ATSDR Denver regional office at 303-312-7012 if you have any questions regarding this letter or need further assistance.

Sincerely,

Scott Sudweeks
Regional Toxicologist
Agency for Toxic Substances and Disease Registry
Centers for Disease Control and Prevention, Denver, CO

cc: Natrona County School district, WY DEQ, WY DOH

Site Assessment for Midwest School

Site description and condition

Midwest School is a public school in the Natrona County School District in Midwest, Wyoming. It is the only school in the district that serves students in preschool through 12th grade. The Natrona County School District reports 211 students and 23 staff at Midwest School. The school was constructed in the 1950s within the boundary of the existing Salt Creek Oil Field.

The Salt Creek Oil Field has been operational since the 1890s. Many early wells were abandoned without being properly sealed. According to state records, 120 permanently abandoned wells sit in the 640-acre area surrounding the school. The school is adjacent to active oil wells. Abandoned and active oil wells are located on school property (Figure 1).

Fleur de Lis Energy (FDL) injects carbon dioxide (CO_2) gas underground to improve oil well production. As a result, CO_2 and volatile organic compounds like benzene can migrate underground, escape improperly sealed wells, and adversely impact school indoor air. There are reports of areas where gases are seeping out of the ground on school property. Sampling data from these seeps are not available but as a precaution, school district officials have notified school staff that the sloped area by the track should be avoided. However, no restricted access or warning signage is currently in place to communicate this.

On May 24, 2016, CO_2 alarms outside the school went off, prompting an evacuation of students and staff. Air monitoring and investigation began two days later on May 26. As of July 30, the school will not open to students for the 2016-2017 school year until county health and school district officials determine that the building is safe to reoccupy.

School Indoor Air Sampling

During the period May 26 - June 17, 2016, several sampling events were undertaken to assess indoor air concentrations of hydrogen sulfide, benzene, and other chemical compounds in the Midwest School.

FDL and their consultants conducted sampling using MultiRAE and MSA Altair 5x gas monitors on May 26. Real-time air monitoring in the school reported benzene concentrations exceeding the ATSDR acute minimal risk level (MRL) of 29 micrograms per cubic meter ($\mu g/m^3$) or 0.009 parts per million (ppm) (Table 1). There appeared to be an acute (short-term) hazard from benzene at the reported levels. At those concentrations, immediate evacuation of the building was warranted. The building has not been reoccupied since the evacuation. ATSDR recommends that the building not be reoccupied until thorough investigation and sampling demonstrate no potential health hazards from building indoor air.

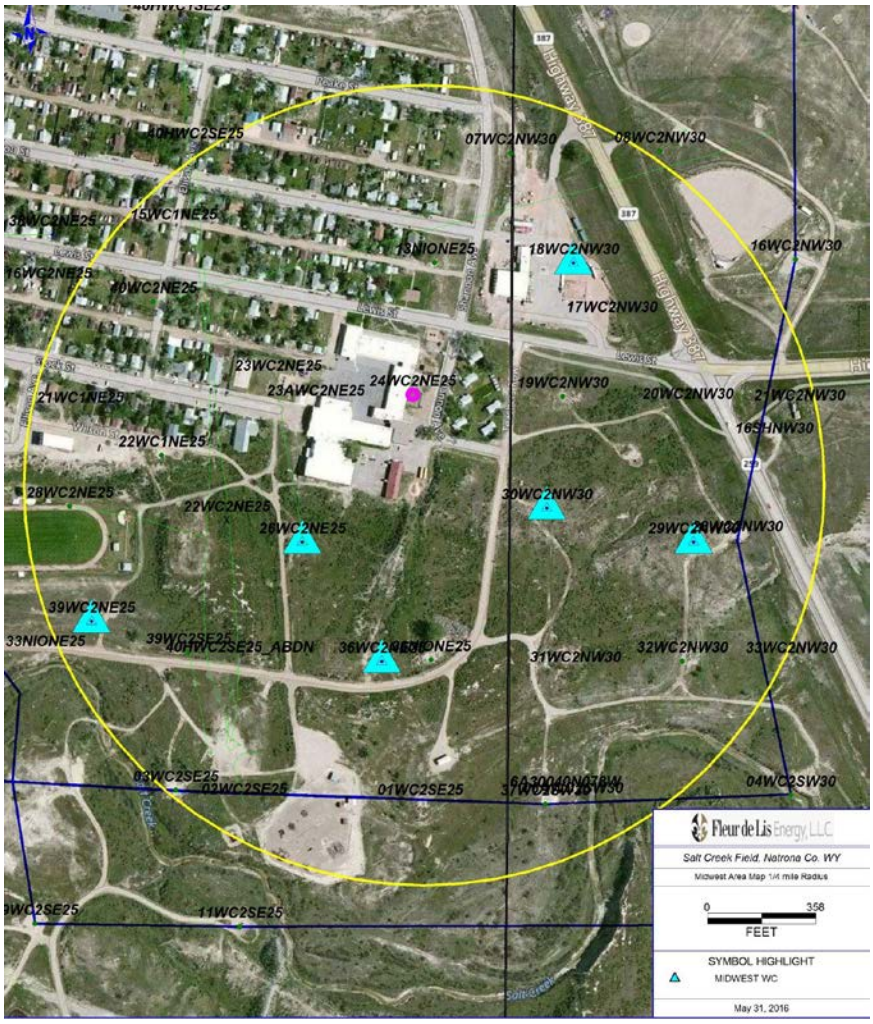
Most areas of the school sampled in May showed CO_2 levels exceeding the ACGIH occupational health guideline of 5,000 ppm. At 9:30 am on May 26, FDL detected levels of CO_2 as high as 26,000 ppm. Oxygen levels in some areas were below 19.5%, which is considered oxygen-deficient and an

immediate health hazard. Elevated levels of CO_2 can result in an oxygen-deficient atmosphere, and if high enough can affect mental acuity and cause asphyxia. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the United States Environmental Protection Agency (EPA) recommend that CO_2 levels not exceed 1,000 ppm indoors for a healthy school environment (EPA 2009).

On May 30, the Wyoming Department of Environmental Quality (WDEQ) sampled interior air using the same type of real-time monitoring equipment. Monitoring results show that CO_2 and VOC concentrations remained elevated, and that oxygen levels were below normal in several areas of the school (Table 2).

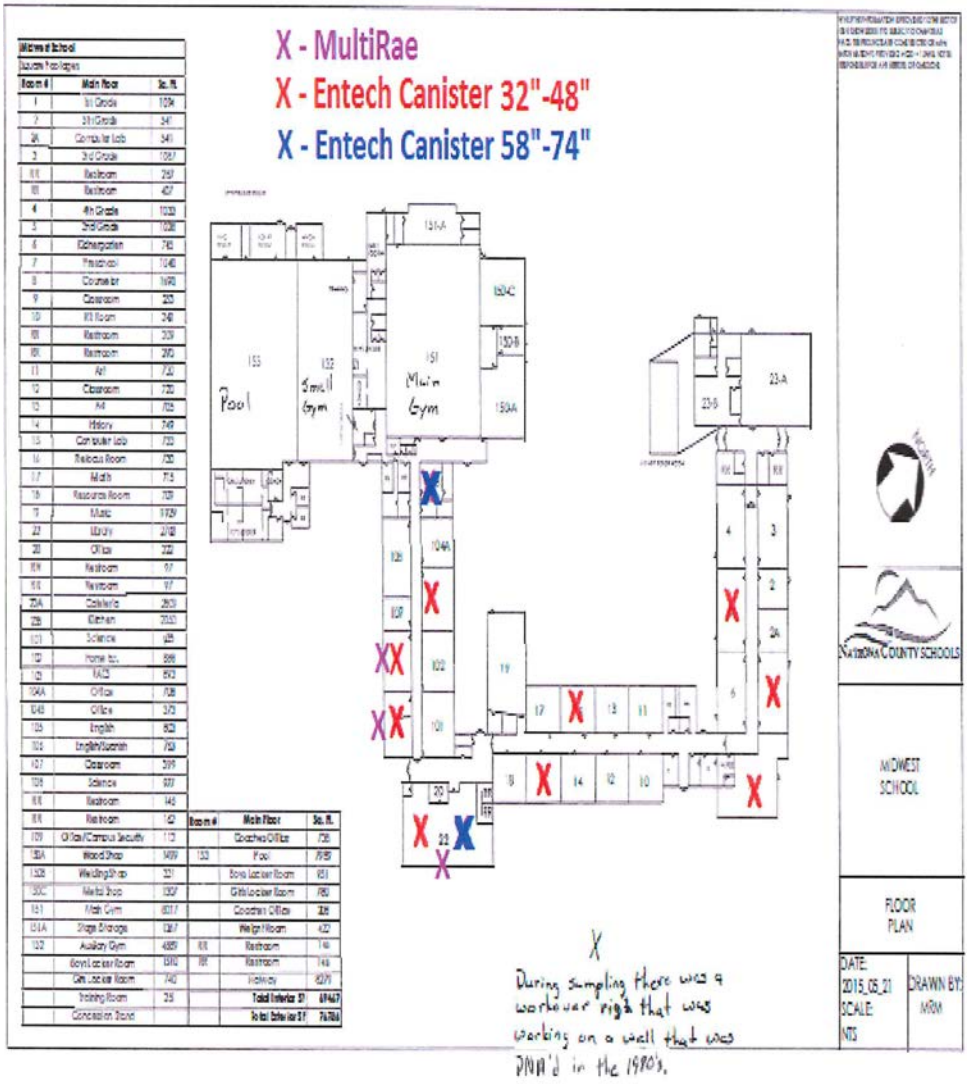
On June 16-17, FDL arranged for indoor air sampling using SUMMA canisters at several locations in the school (Figure 2). Sampling was designed to collect air over an 8-hour period to define what concentrations might be present during a school/work day. Samples were analyzed by a commercial lab using EPA method TO-15 to identify concentrations of volatile organic chemicals. ATSDR provided technical assistance and input into the sampling plan (FDL 2016) at the request of Casper-Natrona Health Department. Analytical results are presented in Table 3.

Figure 1. Aerial photo showing school and surrounding well field. Large white building in center of yellow circle is the Midwest School. Active oil wells are indicated by blue triangles. Abandoned well #24 is indicated by magenta circle. Residential areas to west and northwest of school.



Source: FDL

Figure 2. Sampling locations inside Midwest School, June 16 and 17 2016.



Source: FDL

Table 1. Midwest school indoor air quality sampling, May 26, 2016.

Time	Room	Oxygen (% vol)	% of Lower Explosive Limit	Carbon Monoxide (ppm)	Hydrogen Sulfide (ppm)	Volatile Organic Compounds (ppm)	Benzene (ppm)	Carbon Dioxide (ppm)
Casper Safety Consultants sampling using MultiRAE and UltraRAE 3000								
1400	Women's Library Bathroom	20.4	0	0	0	25	**0.35**	NA
1403	Men's Library Bathroom	20.4	0	0	0	25	**0.55**	NA
1405	Library Office	20.4	2	0	0	NA	NA	NA
1407	First Hallway South Side Room 105	20.9	5	0	0	37	**0.85**	NA
1409	Classroom 107	20.9	2	0	0	9	**1.30**	NA
1410	Classroom 106	19.9	6	0	0	50	**1.85**	NA
1417	Classroom 106	20.4	8	0	0	77	**0.40**	NA
1419	Classroom 108	20.9	0	0	0	17	**0.40**	NA
1423	Principal's Office	20.9	0	0	0	26	**0.40**	NA
Pullen Services sampling with MSA Altair 5x Gas Monitor								
	S/SE Entry	NA	NA	NA	NA	NA	NA	1,400
	Library	NA	NA	NA	NA	NA	NA	3,300
	Library Office	NA	6	NA	NA	NA	NA	16,000
	Room 105	NA	5	NA	NA	NA	NA	13,700
	Hall between 105 and 106	NA	NA	NA	NA	NA	NA	7,000
	Room 106	NA	NA	NA	NA	NA	NA	10,600
	Room 107	NA	4	NA	NA	NA	NA	7,700
	Room 108	NA	NA	NA	NA	NA	NA	5,100
	North Gym	NA	NA	NA	NA	NA	NA	6,200
	Southwest Girls Restroom	NA	5	NA	NA	NA	NA	5,400
	Southwest Boys Restroom	NA	NA	NA	NA	NA	NA	6,600

Source: Casper Safety Consultants and Pullen Services, LLC.

Note: NA – no data available, or data not collected. Benzene concentrations in **bold** text exceed ATSDR acute health comparison value of 29 micrograms per cubic meter (µg/m3) or 0.009 parts per million (ppm).

Table 2. Midwest school indoor air quality sampling, May 30, 2016.

Time	*Room*	*CO2 (ppm)*	*LEL (%)*	*O2 (%)*	*H2S (ppm)*	*VOC's (ppm)*
10:05	Background	300	0	20.9	0	0
10:08	Main Office	6050	0	20.7	0	12.0
10:10	105A	8450	0	20.9	0	14.9
10:11	105B	7510	0	20.9	0	13.3
10:13	106	9990	0	20.7	0	19.3
10:14	107	6130	0	20.7	0	12.1
10:16	103	3900	0	20.9	0	8.7
10:18	104 A&B	3850	0	20.9	0	9.5
10:20	108	4230	0	20.9	0	8.3
10:21	104B	3140	0	20.9	0	6.5
10:24	Small Gym	3710	0	20.9	0	6.5
10:25	Main Gym	4470	0	20.9	0	8.8
10:28	Pool	2890	0	20.9	0	2.3
10:31	109	2690	0	20.9	0	4.7
10:34	101	7180	0	20.8	0	12.4
10:37	Library	9180	0	20.7	0	13.7
10:38	Bathroom in Library	12,300	0	20.5	0	19.8
10:40	Library Hallway	7430	0	20.9	0	14.3
10:41	18	1610	0	20.9	0	1.3
10:43	19	1200	0	20.9	0	0.9
10:44	16	7670	0	20.9	0	17.5
10:47	15	5240	0	20.9	0	11.4
10:54	14	1200	0	20.9	0	0.9
10:56	Computer Lab	750	0	20.9	0	0.1
10:58	12	880	0	20.9	0	0.8
11:00	13	760	0	20.9	0	0.4
11:02	10	670	0	20.9	0	0.2
11:03	9	4190	0	20.9	0	8.1
11:04	Custodial Closet	1940	0	20.9	0	2.3
11:05	8	3330	0	20.9	0	5.7
11:07	7	3420	0	20.9	0	5.5
11:09	6	3610	0	20.9	0	6.3
11:10	1	1440	0	20.9	0	1.4
11:12	5	3230	0	20.9	0	4.4
11:13	2	1060	0	20.9	0	0.9
11:14	4	2790	0	20.9	0	4.3

Table 2. (continued)

Time	*Room*	*CO2 (ppm)*	*LEL (%)*	*O2 (%)*	*H2S (ppm)*	*VOC's (ppm)*
11:16	3	1980	0	20.9	0	2.2
11:18	Custodial Closet	2450	0	20.9	0	3.7
11:20	Cafeteria	1740	0	20.9	0	2.1
11:22	Kitchen	2080	0	20.9	0	2.8
11:30	Playground Background	440	0	20.9	0	0.0

*The sampling was performed with a MultiRAE IR programmable multi-gas monitor designed to provide continuous exposure monitoring of Carbon Dioxide, H2S, VOC's, Oxygen and Combustible Gasses for workers in potentially hazardous environments.

*Red colored numbers in the above chart represent concentrations of CO2 that are above the National Institute for Occupational Safety and Health (NIOSH) 8 hour time weighted average limits of 5000 ppm. It should be noted that this sampling event was conducted using a real time monitor and is not based on a time weighted average.

*Blue colored numbers in the above chart show an oxygen percentage that is below the 20.9% that is found in normal breathing air.

*The global average concentration of CO_2 in Earth's atmosphere is currently about 0.0400%, or 400 parts per million by volume (ppm).

Source: Wyoming Department of Environmental Quality
Note: CO2 - carbon dioxide, LEL% - percent of the lower explosive limit, O2 - oxygen, H2S - hydrogen sulfide, VOCs - volatile organic compounds, ppm - parts per million

Public health implications of indoor air sampling at Midwest School

Air sampling data prior to June 16, 2016 demonstrated elevated CO_2 and the presence of VOCs, including benzene. The concentrations of benzene detected on May 26 posed an acute health hazard, warranting immediate evacuation of the building.

During the June 16-17 sampling event, the highest detected concentrations of VOCs in the school were found in samples from room #105. The highest detected concentrations were compared to ATSDR and EPA health comparison values in Table 3 (column CV_{air}). Comparison values represent concentrations of substances in water, soil, and air to which humans might be exposed during a specified period of time without experiencing adverse health effects. These comparison values are protective for both adults

and children. It is important to note that comparison values are data screening tools and not thresholds for adverse health effects.

No detected concentrations of VOCs during the June sampling event exceeded these comparison values. However, real-time monitoring at the school showed maximum benzene concentrations from May 26 showed a 200-fold exceedance of the ATSDR acute air comparison value.

Table 3. Air sampling results from room #105. June 17, 2016.

Chemical	Concentration (µg/m^3)	CV_{air} (µg/m^3)
Acetone	49	31,000
Acetonitrile	2.3	60*
Benzene	7.7	9.6
Chloromethane	1.1	100
Cyclohexane	200	6,000*
Ethanol	16	-
Heptane	130	-
Hexane	490	2100
Methanol	12	20,000*
Methyl ethyl ketone	505	5*
2-propanol	12	7*
Toluene	7.1	300

Note: µg/m^3 – microgram per cubic meter, CV_{air} –air health comparison value. Assumes daily 24 exposure over a year or more duration. ATSDR comparison value unless noted. * EPA reference concentration.

Because benzene is carcinogenic (cancer-causing) in people, concentrations were compared to ATSDR cancer risk evaluation guidelines (CREG) to determine whether there may be an elevated risk of cancer over a lifetime from exposure to benzene at detected levels in school indoor air over many years. The ATSDR CREG for benzene is 0.13 µg/m^3. Because the benzene concentrations exceeded the CREG, they were evaluated further (Table 4).

ATSDR calculated lifetime excess cancer estimates (i.e., cancers over population background rate) from exposure to benzene at the detected concentrations for both staff and students (Table 5). The risk estimate is calculated by multiplying the air concentration by the EPA inhalation unit risk value for benzene of 7.8 E-06 per µg/m^3 (EPA 2000). Risk estimates were then adjusted to account for the relevant frequency and duration of exposure. For example, scenario 2 represents a student, and assumes exposure 8 hours/day, 5 days/week, 9 months/year over 12 years. Scenario 1 represents school staff and assumes exposures 8 hours/day, 5 days/week, 350 days/year for 30 years.

Cancer risk estimates are statistical probabilities and intentionally conservative (i.e., health-protective). These estimates are used to determine whether a significantly elevated cancer risk is present under a specific exposure situation. Estimates of excess cancer risk were on the order of one additional cancer per 100,000 people to three additional cancers per 1,000,000 people (1E-05 to 3E-06) for adult workers. Excess lifetime cancer risk for children was calculated to be even lower (4E-06 to 7E-07). These values are considered to be a very low increased cancer risk. These calculated risk estimates are also within or below the EPA target risk range. Typically, regulatory agencies use cancer risk estimates in the range of 1E-04 to 1E-06 to support decisions about the need for corrective action. The concentrations of VOCs including benzene detected during the June 16-17 sampling event did not exceed health comparison values. However, because benzene is a known human carcinogen, any exposure to benzene poses some risk and should be avoided when possible.

Table 4. June 17 benzene data above ATSDR Cancer Risk Evaluation Guidelines (CREG)

Sample No.	Date	Benzene concentration (µg/m3)
5	6/17	**1.7**
6	6/17	**3.4**
7	6/17	**3.6**
8	6/16	**8.3**
	6/17	**7.7**
9	6/16	**6.4**
	6/17	**6.9**
10	6/16	**3.2**
	6/17	**1.6**
11	6/16	**3.2**

Note: µg/m^3- microgram chemical per cubic meter air. Concentrations in **bold** text exceed the ATSDR benzene chronic cancer risk evaluation guideline (CREG) of 0.13 µg/m^3.

Table 5. Lifetime excess cancer risk estimates from benzene exposure based on measured levels.

Sample No.	Sampling Date	Scenario 1: Staff	Scenario 2: Student
5	6/17/2016	3E-06	7×10^{-7}
6	6/17/2016	6E-06	1×10^{-6}
7	6/17/2016	7E-06	2×10^{-6}
8	6/16/2016	2E-05	4×10^{-6}
	6/17/2016	1E-05	3×10^{-6}
9	6/16/2016	1E-05	3×10^{-6}
	6/17/2016	1E-05	3×10^{-6}
10	6/16/2016	6E-06	1×10^{-6}
	6/17/2016	3E-06	7×10^{-7}
11	6/16/2016	6E-06	1×10^{-6}

Note: Scenario 1 represents potential risk to year-round staff member. Scenario 2 represents potential risk to a student enrolled K-12.

Health effects of benzene exposure

Breathing high levels of benzene over a short time can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. The major effect of benzene from long-term exposure is on the blood. Benzene causes harmful effects to bone marrow and can cause a decrease in red blood cells leading to anemia. Long-term exposure can also cause excessive bleeding and can affect the immune system, increasing the chance for infection. Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries, but it is not known for certain that benzene caused the effects. It is not known whether benzene affects fertility in men (ATSDR 2007).

Long-term exposure to high levels of benzene in the air can cause leukemia, particularly acute myelogenous leukemia. This is a cancer of the blood forming tissues in the body. The Department of Health and Human Services has determined that benzene is a known carcinogen. The International

Agency for Research on Cancer and the EPA have both determined that benzene is carcinogenic to humans (ATSDR 2007).

Indoor air quality guidelines for carbon dioxide

Exhaled air is usually the largest source of CO_2 in classrooms. However, in the case of Midwest School CO_2 concentrations are significantly elevated due to oil field operations. CO_2 is an asphyxiant that displaces oxygen in high enough concentrations. This is especially hazardous in an enclosed space such as a closet or crawlspace where there may be inadequate ventilation. At concentrations above 1.5 percent (15,000 ppm) some loss of mental acuity has been noted (EPA 2009). CO_2 concentrations were reported as high as 26,000 ppm May 26, 2016.

ASHRAE Standard 62-2001 recommends 700 ppm above the outdoor concentration as the upper limit for occupied classrooms (usually around 1,000 ppm). CO_2 alarms are located outside the school, but no continuous monitoring is conducted in the school interior. Installing CO_2 monitors inside the school would be an important step to protect staff and students, and help maintain healthy indoor air quality.

Resources

The EPA has a web page dedicated to creating healthy indoor air quality in schools at http://www.epa.gov/iaq-schools. Additionally, the State of Texas Department of Health Services Indoor Air Quality Guidelines for Public Buildings provides recommended concentration limits for indoor air contaminants (including VOCs), and resources for improving indoor air quality. https://www.dshs.texas.gov/iaq/SchoolsGuide.shtm#Minimum_r .

Conclusions

After a review of the indoor air sampling data from Midwest School, ATSDR concludes:

1. The air concentrations of benzene, oxygen, and carbon dioxide in the school building on May 26, 2016 indicated an urgent public health hazard existed at the school.
2. Air sampling on May 26, 2016, revealed that the air in the crawlspace under the swimming pool had elevated CO_2 and VOC concentrations. It is possible that this crawlspace could present a confined space hazard to someone entering the area without adequate ventilation or protective equipment.
3. Sampling data from June 16-17, 2016, were below health-based comparison values. Estimated increased lifetime cancer risk to staff and students from benzene exposure at the concentrations found on those sampling dates was very low.
4. The air samples from June 16-17, 2016, were a snapshot in time and were not taken concurrently with CO_2 concentrations that triggered alarm levels in May. Given oil well pressurization and school proximity to active and abandoned wells, future CO_2 and VOC levels in the school could be a health hazard.
5. Currently, the situation at the Midwest school is an urgent public health hazard to students and staff occupying the building. The building currently remains unoccupied, and should not be

reopened until necessary corrective actions are instituted and there is adequate assurance that the indoor air quality does not pose a current and future health hazard to students and staff.

Recommendations

1. ATSDR recommends that the school building not be reoccupied until appropriate corrective action is taken to prevent future intrusion of CO_2 and VOCs into the school, and the indoor environment is demonstrated safe for building occupants.
2. ATSDR recommends if the school is reoccupied after corrective measures are complete, routine indoor air and soil gas sampling be conducted. It is recommended that the concentrations of VOCs be quantified in the samples using EPA method TO-15; that concurrent oxygen and CO_2 levels be collected; that the timing of the sampling coincide with normal oil well field operations and well pressurization; and that indoor air, soil vapor extraction, and building HVAC systems operate within designed parameters during these sampling events.
3. ATSDR recommends that a safety plan be developed for any failures of the mitigation systems, with audible and visual warning to school occupants.
4. ATSDR recommends installing carbon dioxide detectors in the school building to provide notification if concentrations exceed 1000 ppm CO_2
5. ATSDR recommends that access to the pool crawlspace be restricted, and warnings be placed on the crawlspace access until the situation is corrected and monitoring demonstrates the area can be entered safely.
6. ATSDR recommends the school district post warning signs and restrict areas where underground gas releases occur on school property. ATSDR recommends that FDL investigate and mitigate these releases.

References

ATSDR 2007. Toxicological Profile for Benzene. U.S. Department of Health and Human Services, Public Health Service. Agency for Toxic Substances and Disease Registry. Atlanta, GA. 2007.

EPA 2000. Carcinogenicity Assessment for Lifetime Exposure to Benzene. Integrated Risk Information System, U.S. Environmental Protection Agency. January 2000. https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0276_summary.pdf#nameddest=cancerinhal

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