In an attempt to reduce the dust accumulation inside the buildings, ceiling mounted air filtration equipment has been installed (figures 158, 159). These are electronic filters that use a corona wire to provide a positive charge to the dust particles. Metal plates, which are negatively charged, attract the positively charged dust. In theory it should be about 80% efficient in reducing airborne particulates. However, these electronic air filters lose efficiency quickly when a thin coating of dust accumulates on the plates rendering them ineffective in a very short time (figure 160). It was reported that there is a weekly cleaning schedule for these plates (figure 161). Considering the amount of dust that accumulates particularly during dry seasons, these plates should be cleaned daily.

Figs. 158 and 159: Ceiling mounted air filtration unit.

Fig. 160: Ceiling mounted air filtration unit with dust-plugged filter.
Fig. 161: Electronic air filter plates are removed and cleaned by rinsing with water.

4.4.6 Portable Air Filters

Several portable air filters were operating in the common public corridors in an attempt to reduce the amount of dust in the building. They are made by Abatement Technologies. Most of them are model H1990L. These portable machines contain three separate filters, which are configured in series. A black sponge-like first stage pre-filter captures coarse particles in the air (figure 162). Then, behind the first stage pre-filter is a second stage pre-filter, a pleated medium efficiency air filter, which is about 20-30% efficient to capture slightly finer material (figure 163). Some of these were discovered to be very dirty (figure 164). According to the H1990L machine specifications, the third filter should be a 99.97% efficient HEPA filter, but we could not confirm this because we were not allowed to remove it for inspection (figure 165). In fact, we were told that only the manufacturer could change the HEPA filter. If this is actually a HEPA filter, then it would clog up quickly due to the considerable dust that is prevalent during dry seasons. Frequent changes would be necessary. According to the maintenance technician's information, they change the first filter once a week, the pleated filter every three weeks and they don't change the HEPA filter at all. Maintenance records were not available for us to examine. It is likely that filter changes vary as indicated by the condition of the units at Conklin Lodge where the first stage pre-filters were totally absent (figure 166). The build-up of dust around the exhausts of the portable air units may indicate that the HEPA filter is over saturated and no longer functioning (figure 167).

There were no portable air filters in the corridors of the residential modules (wings). These are the areas in which the housekeeping staff and the contract workers are sleeping. It would make sense to maintain some type of air filtration in the residential wings as well.

Fig. 162: A medium-efficiency second stage pleated filter is located behind the first stage pre-filter.
Fig. 163: Dust on the black of the first stage pre-filter.


Fig. 164: Very dirty second stage pleated filter found on this air scrubber.
Fig. 165: This HEPA filter can only be serviced by the manufacturer. Its replacement schedule is unknown.


Fig. 166: A first stage prefilter was not present in the portable air filters at Conklin Lodge.
Fig. 167: Dust accumulating around exhaust grille of portable air filter.

4.5 Environmental Monitoring

The measurements and test results are merely snapshots of conditions obtained during a limited time frame. It is expected that the measurements and test results will fluctuate over time.

4.5.1 Airborne Particulates

4.5.1.1 Gravimetric Measurement

All airborne particulate concentrations PM2.5 were well under the guideline of being less than outdoor levels, which is recommended to be less than 30µm/m^3. The highest level measured was in the bag-up room where concentrations rose to 0.16µm/m^3 for a short period of time. The lobby also experienced a spike in PM2.5 concentrations at the same time.

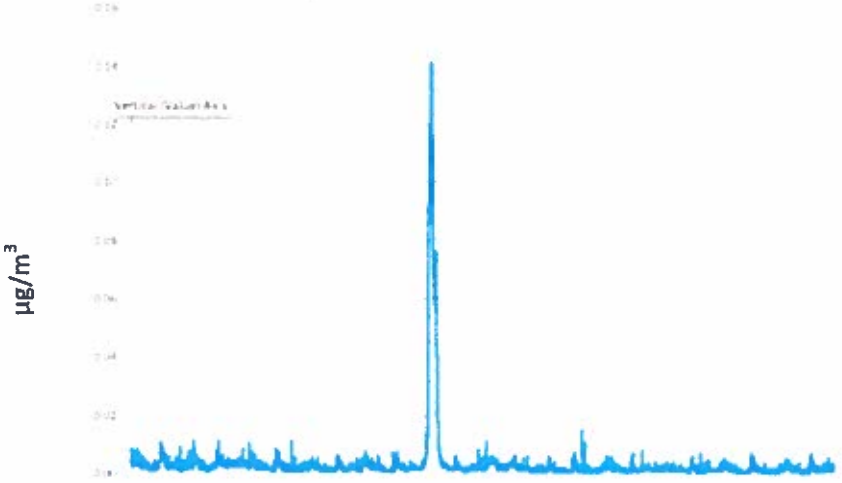

Fig. 168: Airborne Particulates in Lobby Reception

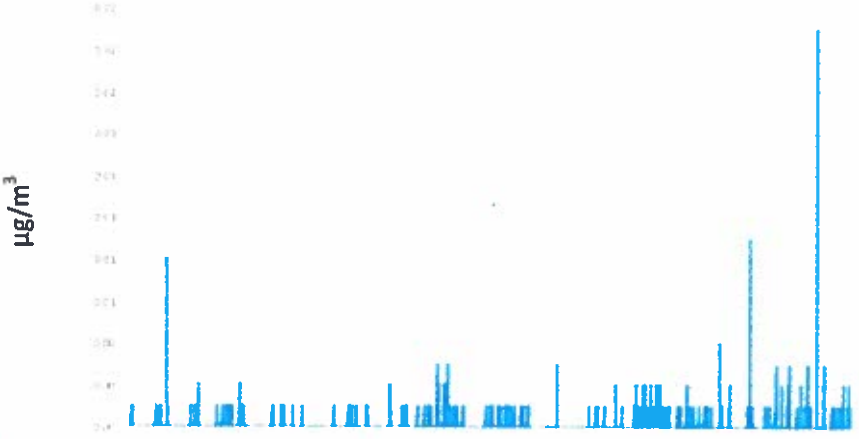

Fig. 169: Airborne Particulates in Kitchen

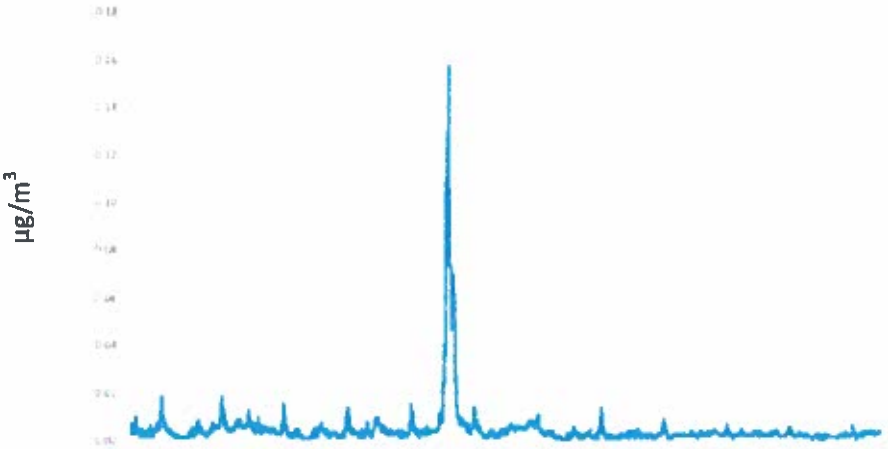

Fig. 170: Airborne Particulates in Bag-up Room

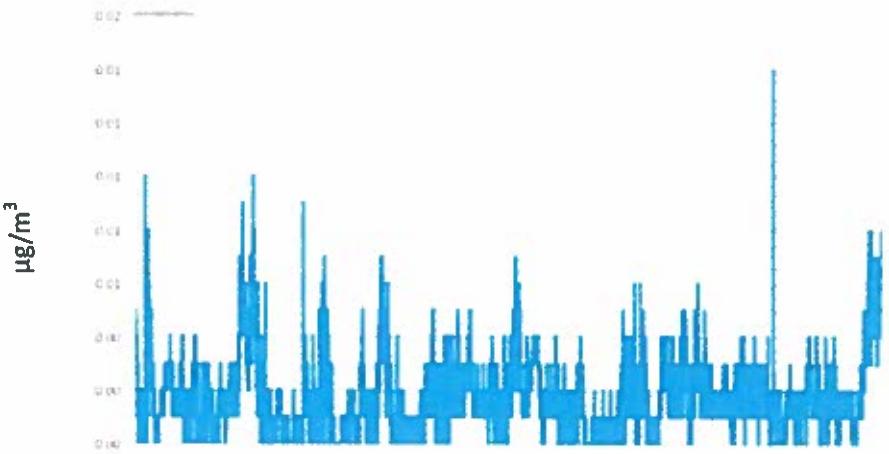

Fig. 171: Airborne Particulates in Housekeeping

4.5.1.2 Airborne Particle Counts

Spot measurements with an airborne particle counter were taken at various locations in Wapasu Creek West. In most cases three samples were taken at each location and then averaged.

The indoor concentrations should not exceed the outdoor concentrations, but in most cases they did. The outdoor concentrations were averaged to be 10,930 and 10,188 at two locations. The games room and one location in the kitchen were less than outdoor concentrations, but all other areas were higher than outside. The lounge had considerably more particulates than any other area (Table 6).

Measurements taken at the exhaust of the portable air scrubbers had reduced particle counts compared to measurements taken in front of the machines suggesting a 51.7% filtration efficiency for particles 0.3 microns in size. This suggests that the filters inside the machine are filtering out particles, but the efficiency is much less than the 99.97% efficiency rating promised by the manufacturer.

Table 6: Total Particulate Counts at Various Locations in Wapasu West

	Sample 1	Sample 2	Sample 3	Average
Sample Location	Total Particulate Counts/m^3 (0.3 – 10.0µm)			
Outside front doors, on porch	12,240	7,134	13,415	10,930
Outside on driveway	11,870	8516	-	10,188
Front lobby area, inside front doors	11,590	16,280	10,230	12,700
Front reception in lobby	16,810	16,392	15,951	16,384
Full valet in lobby	19,810	22,616	14,622	19,016
Union office	10,340	16,546	-	13,443
Games room	7,660	6,004	7,936	7,200
Lounge	74,790	76,100	68,203	73,034
Housekeeping office	13,620	7,752	24,944	15,439
Housekeeping sorting area	8,650	-	18,953	13,801
Kitchen - food storage below vents	12,730	11,287	6,262	10,093
Kitchen - next to loading area	25,340	51,476	17,195	31,337
Air scrubber intake	4,680	6,630	20,498	10,603
Air scrubber exhaust	1,600	4,410	8,951	4,987

Measurements highlighted in red are higher than outdoor levels.

4.5.2 Diesel

4.5.2.1 NIOSH 5040

The guideline for non-carcinogenic health effects is 5µg/m^3 or 0.005mg/m^3. All samples were under this guideline (Table 7). In fact this method of sampling did not detect any elemental carbon in the indoor or outdoor air.

Table 7: Diesel Particulates

Location	Date / Time	Organic Carbon (mg/m^3)	Elemental Carbon (mg/m^3)	Total Carbon (mg/m^3)	Volume (m^3)
Lobby	03/07 PM	0.037	<0.004	0.037	0.512
Kitchen	03/07 PM	0.010	<0.004	0.010	0.500
Housekeeping	03/07 PM	0.034	<0.004	0.034	0.494
Outside	03/07 PM	0.010	<0.004	0.010	0.500
Lobby	03/08 AM	0.050	<0.004	0.050	0.500
Kitchen	03/08 AM	0.012	<0.004	0.012	0.502
Housekeeping	03/08 AM	0.074	<0.004	0.074	0.502
Outside	03/08 AM	0.039	<0.004	0.039	0.512

4.5.2.2 Long–term Monitoring

Diesel particulate was measured over a period of 24 hours from 12:21pm on March 18, 2015 to 1:47pm on March 19. The instrument did not detect any diesel particulate matter (DPM) in the kitchen and the 24-hour TWA was zero.

The 24-hour TWA for outdoor concentration of DPM was 0.05µg/m^3. There were two peaks that went up to 0.55µg/m^3 on March 18 and up to 0.51µg/m^3 on March 19 (figure 172). Roughly at the same time each day, these two peaks may indicate a truck idling at a loading dock.

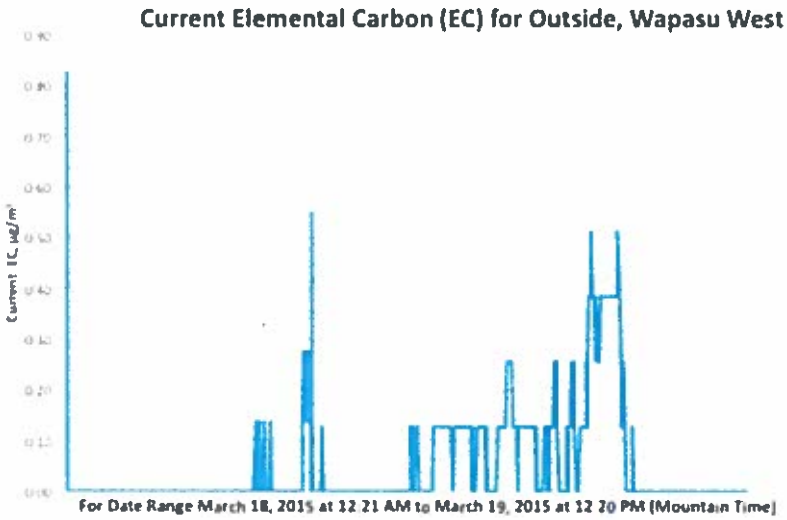

Fig. 172: Diesel Particulate Outside

4.5.3 Fungi

An indoor amplification source of fungi is suspected if fungi concentrations are higher indoors than outdoors or if a genus/species of fungi shows up indoors, but is not similarly represented outside.

4.5.3.1 Airborne Spore Count (Spore Trap Method): Wapasu Creek West

No fungi spores were identified in the outdoor samples. This suggests that all indoor fungi spores originate from an indoor amplification source.

The crawl space has a significantly high amount of fungi. *Basidiospores* and *Cladosporium* are very common types of fungi. The lobby ceiling where there was an active water leak was supporting some *Basidiospores* and some non-specified spores were identified in housekeeping. These were not similarly represented outside and therefore indicate an indoor amplification source.

Table 8: Spore Trap - Wapasu Creek West

	Sample Location									
	Housekeeping	Lobby Ceiling	Lobby	Kitchen (back corner)	Kitchen	Furnace Room (Women's Gym)	Crawlspace	Outside 1	Outside 2	Outside 3
Fungi Genus	**Spore Counts/m^3**									
Basidiospores		100					60			
Cladosporium							710			
Non-specified spore	60						200			
TOTAL SPORES	60	100	<60	<60	<60	<60	970	<60	<60	<60

Measurements highlighted in red indicate an indoor amplification source.

4.5.3.2 Viable Fungi Testing (RCS Method): Wapasu Creek West

Allergenic and toxigenic fungi were identified in the lobby and furnace room of the women's gym. The lobby ceiling where there was an active water leak was supporting moderately high amounts of *Penicillium chrysogenum*, which are capable of producing mycotoxins. These were not similarly represented outside indicating an indoor amplification source.

The crawl space supports high concentrations of several species of allergenic and toxigenic fungi and consequently is a particularly toxic environment.

Table 9: RCS - Wapasu Creek West

		Sample Location									
		Housekeeping	Lobby Ceiling	Lobby	Kitchen (back corner)	Kitchen	Furnace Room (Gym – Women)	Crawlspace	Outside 1	Outside 2	Outside 3
Fungi Genus	**Health Effects**	**Colony forming Units/m^3**									
Acremonium sp.				3							
Acremonium strictum								560			
Aspergillus versicolor	A T		18	3			8				
Cladosporium cladosproioides	A T		12			6		980	5		6
Cladosporium herbarum	A T				10			170	5		12
Erotium amstelodami	A T								5		
Lecanicillium muscarium	A							13			
Penicillium brevicompactum	A T							170			
Penicillium chrysogenum	A T		220	3				180			
Penicillium echinulatum	A T							51			
Phialophora repens								13			
Rhizomucor variabilis		10	6								
Yeast (total)	A							230			
Non-sporulating (total)		10	30				23	51	5	40	
TOTAL (CFU/m^3)		20	290	10	10	6	30	2400	20	40	30

A: Allergenic T: Toxigenic
Measurements highlighted in red indicate an indoor amplification source.

4.5.3.3 Airborne Spore Count (Spore Trap Method): Wapasu Creek Main and East

Small amounts of *Basidiospores* and *Cladosporium* were identified in Wapasu Creek East lobby and kitchen. These were not similarly represented outside and therefore may indicate an indoor amplification source.

Table 10: Spore Trap - Wapasu Creek Main and East

Fungi Genus	Wapasu Main Lobby	Wapasu Main Kitchen	Wapasu East Lobby	Wapasu East Kitchen	Outside 4	Outside 5
	Spore Counts/m^3					
Basidiospores				60		
Cladosporium			60			
Penicillium / Aspergillus		60			100	
TOTAL SPORES	<60	60	60	60	100	<60

Measurements highlighted in red indicate an indoor amplification source.

4.5.3.4 *Viable Fungi Testing (RCS Method): Wapasu Creek Main and East*

Small amounts of allergenic and toxigenic fungi were found in Wapasu Creek Main kitchen and Wapasu Creek East kitchen and lobby.

Table 11: RCS - Wapasu Creek Main and East

Fungi Genus	Health Effects	W. Main Lobby	W. Main Kitchen	W. East Lobby	W. East Kitchen	Outside 1	Outside 2
		Sample Location					
		Colony forming Units/m^3					
Aspergillus versicolor	A T				5		
Beauveria bassiana				5			
Cladosporium cladosproioides	A T		6	5		4	
Cldosporium herbarum	A T				5	12	
Erotium amstelodami	A T						10
Black Yeast						4	
TOTAL (CFU/m^3)		<6	6	10	10	20	10

A: Allergenic T: Toxigenic

Measurements highlighted in red indicate an indoor amplification source.

4.5.3.4 *Bulk Sample*

Most of the fungi found on the drywall were *Phialophora repens*, which has no known health effects. However, *Penicillium chrysogenum* and *Stachybotrys chartarum* are both known to be toxigenic (table 12).

Table 12: Fungi Species Identified in the Bulk Sample

Fungi Species	Species Distribution (%)	Health Effects
Penicillium chrysogenum	8.6	A T
Phialophora repens	77	
Phoma sp.	5.7	
Stachybotrys chartarum	2.9	T
Yeast	5.7	A
TOTAL	100%	

A: Allergenic T: Toxigenic

4.5.4 Volatile Organic Compounds

Many of the VOCs identified in the test results did not have any corresponding guidelines in Schedule 1 of the Alberta Occupational Health and Safety Code. Only one VOC went over the recommended guideline level (40 times higher): carbon disulphide, which was identified in housekeeping.

Table 13: VOCs

	Lobby	Kitchen	Housekeeping	Outside	Guideline[1]
Volatile Organic Compound	$\mu g/m^3$				
Propane	260			22	-
Isobutane	240		27		-
Ethanol	700		64		1880
Acetone	130		150	51	1200
Isopropanol	100				492
Methylene chloride*	16	52	270	20	174
Hexamethyltrisiloxane*	27				-
Limonene	110				-
Hexamethyltrisiloxane*	560				-
Carbon dioxide		14			-
Ethylcyclopropane		190	74	240	-
Carbon disulfide			130		3.1
TOTAL VOCs	3000	660	880	640	

*Probable laboratory or instrument contaminant

[1] Guideline from Alberta Occupational Health and Safety Code Schedule 1: Occupational Exposure Limits for Chemical Substances divided by 100 to obtain residential exposure limits.

Measurements highlighted in red indicate concentrations above the guideline level.

4.5.4.1 *VOCs Identified in this Report*

Propane

Propane is a colourless odourless gas, but under pressure it can be a liquid. It is a by-product of natural gas processing and petroleum refining and is used as a fuel for engines. When propane is burned, it produces primarily carbon dioxide and water, but may also emit carbon monoxide (CO), nitrogen oxide (NO) and particulates. Propane combustion is cleaner than gas combustion but not as clean as natural gas. The burning of propane emits greenhouse gases. Low concentrations are not harmful. High concentrations can displace oxygen, which causes headache, nausea, dizziness, drowsiness and confusion.

Isobutane

Isobutane is a colourless, odourless gas. It is used as a feedstock in the petrochemical industry, as a gas for refrigeration systems and as a propellant for aerosol cans. It degrades rapidly in air and water. Inhalation in high concentrations can irritate the respiratory system and can displace oxygen, which causes headache, nausea, dizziness, drowsiness and confusion.

Ethanol

Ethanol, also known as ethyl alcohol, drinking alcohol or grain alcohol, is a flammable, colourless chemical compound, and is best known as the alcohol found in thermometers and alcoholic beverages. In common usage, it is often referred to simply as alcohol. Ethanol has widespread use as a solvent for substances intended for human contact or consumption, including scents, flavourings, colourings, and medicines. Ethanol has a long history as a fuel for internal combustion engines. Ethanol is produced both as a petrochemical, through the hydration of ethylene, and biologically, by fermenting sugars with yeast. The intoxicating effects of consuming ethanol have been well-documented. Some changes to lung function have resulted from inhalation.

Acetone

Acetone is a clear, colourless, volatile and flammable liquid with a characteristic odour described as pungent or fruity. It is primarily used as an industrial solvent and is found in paints, varnishes, lacquers, cement, leather, and rubber. Acetone is a natural metabolism product of both plants and animals, including humans. Those who consume either a high fat, low carbohydrate diet, are fasting, exercise strenuously, or have uncontrolled diabetes are likely to produce higher than usual levels. Acetone is quickly absorbed by ingestion, inhalation, and dermal exposure. Mild nervous system effects that abated soon after exposure ceased were seen in humans exposed to concentrations of acetone of 500 ppm in air and greater. Symptoms also included irritation of the eyes and respiratory system, mood swings, nausea. Levels of exposure below 500 ppm did not cause any adverse health effects.

Isopropanol

Isopropanol or isopropyl alcohol is a colourless liquid with a strong odour. Acetone is a metabolite of isopropanol. It is used as a solvent, as a fuel additive and in personal care products. Disinfecting pads typically contain a 60-70% solution of isopropyl alcohol. Isopropanol is a skin irritant and in higher concentrations can be a nervous system depressant causing headache, dizziness, nausea and vomiting.

Methylene Chloride

Also called dichloromethane, methylene chloride is a colourless liquid with a sweet odour. It is used as a solvent and to decaffeinate tea and coffee. Its presence in the environment is usually due to industrial emissions. Acute overexposure causes difficulty concentrating, dizziness, fatigue, headaches, numbness, weakness, and irritation of the upper respiratory tract and eyes.

Limonene

Limonene (1-methyl-4-isopropenyl-1-cyclohexene) is a liquid with a lemon like odour. It is a major constituent in several citrus oils (orange, lemon, mandarin, lime, and grapefruit) and is present in a number of other essential oils, as well. Limonene is used primarily as a flavour and fragrance ingredient. It is also used in making paint solids and in cleaning products. Limonene is irritating to the skin. When Limonene is oxidized (Limonene is exposed to the air for prolonged periods), isomers of Limonene are produced. These isomers are potential allergens. Limonene is very toxic to insects and aquatic organisms, and should not be disposed of in waterways. No information is available on the health effects of inhalation exposure to Limonene in humans and no long-term inhalation studies have been conducted in laboratory animals.

Hexamethyltrisiloxane

Hexamethyltrisiloxane is a colourless, odourless liquid that is used in the manufacture of many other compounds. Overexposure by inhalation may cause dizziness and it can be irritating to the respiratory system, but little is known about its toxicological effects.

Ethylcyclopropane

Overexposure may cause anaesthetic effects as well as dizziness, drowsiness and headache. It can cause skin and eye irritation.

Carbon disulfide

Carbon disulphide is a colourless liquid with an 'ether-like' odour. Ambient sources are from industrial processes. It is used as an insecticide, soil fumigant, fungicide and a solvent. At high concentrations it can cause nausea, vomiting, dizziness, fatigue, headaches and affect the nervous system. Repeated long-term inhalation of vapours can lead to chronic respiratory irritation. Chronic health effects include toxicity to kidney, nervous system and liver, and risk of spontaneous abortion, sperm abnormalities, and menstrual disorders.

4.5.5 BTEX

Concentrations of benzene, ethylbenzene, toluene and xylene (BTEX) were all well under the guideline level. Indoor concentrations were higher than outdoor concentrations suggesting that the building's mechanical system brings in the contaminant at a higher rate than it can exhaust the contaminant resulting in indoor accumulation.

Table 14: BTEX

	Lobby	Kitchen	Housekeeping	Outside	Guideline
Benzene	1.43 µg/m^3 0.447 ppb	1.33 µg/m^3 0.418 ppb	1.25 µg/m^3 0.392 ppb	1.12 µg/m^3 0.352 ppb	16 µg/m^3 5 ppb
Ethylbenzene	0.408 µg/m^3 0.094 ppb	0.251 µg/m^3 0.058 ppb	0.338 µg/m^3 0.078 ppb	0.191 µg/m^3 0.044 ppb	2300 µg/m^3 600 ppb
Toluene	4.76 µg/m^3 1.27 ppb	3.49 µg/m^3 0.927 ppb	2.77 µg/m^3 0.737 ppb	1.20 µg/m^3 0.320 ppb	4340 µg/m^3 1000 ppb
Xylene (total)	1.14 µg/m^3 0.262 ppb	0.80 µg/m^3 0.185 ppb	1.14 µg/m^3 0.263 ppb	0.50 µg/m^3 0.116 ppb	4340 µg/m^3 1000 ppb

4.5.6 Acoustics

Workers are exposed to high levels of ambient noise in most of the tested spaces. The kitchen is especially noisy, as are the corridors due to the noise emitted by the portable air filtration devices. A 10-hour workday under these noisy conditions could cause stress, fatigue, decreased job performance, and psychological effects. Noise levels in the staff sleeping quarters are acceptable if the fan in their room is not operating, but when the fan is operating, the noise exceeds the noise criterion. This noise level will affect restful sleep.

The following table shows the measured noise level (low and high) in decibels (dBA) for various spaces at Wapasu Creek West. Measurements that exceed the guideline level are highlighted in red.

Table 15: Sound levels in dBA for various spaces in Wapasu Creek West

LOCATION	LOW	HIGH	Guideline NC (dBA)
Reception office	44.7	55.1	40-45
Air scrubber in corridor (@ 1 metre)	54.0	62.1	40-45
Air scrubber in corridor (@ 3 metre)	53.5	58.0	40-45
Corridor (between 2 scrubbers 40 feet apart)	47.0	47.7	40-45
Games Room	57.0	58.0	40-45
Lounge	40.0	43.3	40-45
Men's washroom in Lounge (fan on)	65.1	65.9	40-45
Snack machine	49.8	50.5	40-45

LOCATION	LOW	HIGH	Guideline NC (dBA)
Cardio Exercise Room	61.4	62.0	40-45
Gymnasium furnace room	55.3	56.1	40-45
Gymnasium (2 metres from fan)	57.6	58.5	40-45
Women's fitness room (TV and furnace off)	44.1	44.3	40-45
LUNCH ROOM AND KITCHEN			
Lunch room middle (no occupants)	49.3	50.3	40-45
Kitchen serving counter Phase 1 (no occupants)	64.1	65.0	40-45
Pastry preparation area	57.3	59.4	40-45
Dishwasher on	67.2	70.5	40-45
Dishwasher off	65.1	65.4	40-45
Storage	51.6	53.4	40-45
Executive chef office	47.8	48.3	40-45
Shipping near overhead door	49.9	54.3	40-45
Kitchen serving counter Phase 2 (no occupants)	64.8	65.1	40-45
Dining Room middle Phase 2 (no occupants)	48.4	50.3	40-45
Bag Room Phase 2	52.5	53.2	40-45
SHOWER ROOM (no occupants)			
Locker area	50.8	51.6	40-45
Shower area	45.2	46.3	40-45
Toilets (with exhaust fan on)	56.1	56.4	40-45
RESIDENTIAL			
Wing 45	45.0	45.3	40-45
Between air scrubbers 60 feet away	46.7	47.3	35-40
Executive suite (fan off)	32.1	33.0	35-40
Executive suite (fan on at grille)	59.0	59.5	35-40
Executive suite (fan on at middle of room)	45.4	46.0	35-40

Noise levels that exceed the noise criterion guideline are highlighted in red.

4.5.7 Temperature

Workers reported having to work in hot temperatures particularly in the summer months. The stairwells in the wings have no fresh air supply and can become very hot especially as heat rises to the third floor due to stack effect. Some of the wings have no fresh air supply and housekeeping staff bring in portable fans in order to provide some air movement while they carry on with their work (figure 173). They also prop open doors at the end of hallways in order to keep the air moving despite the fact that there are signs on the doors to keep them closed for fire reasons (figure 174).

Fig. 173: Portable fan in Wing.
Fig. 174: Door closure notice.

Workers also reported temperature issues in the bag up room on summer mornings when the oil field employees are filing through before they go to work.

Fig. 175: Bag-up room becomes hot and stuffy on crowded summer mornings.

Temperature measurements at four indoor locations were generally 20-24°C. The bag-up room tended to be a little warmer for the first ten days and then dropped (figure 175). Two major fluctuations happened in the kitchen about the same time. Housekeeping also experienced a fluctuation.

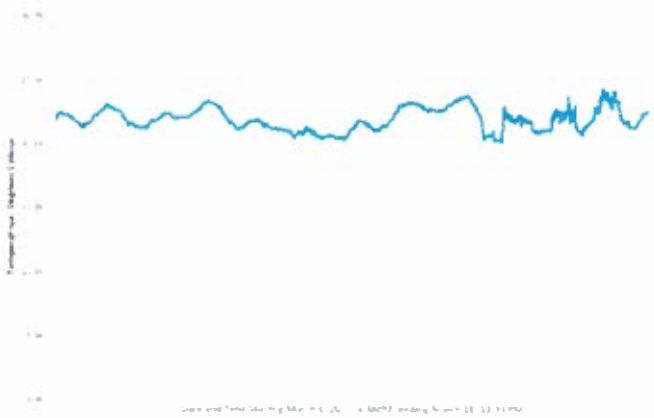

Fig. 176: Lobby Reception Temperature

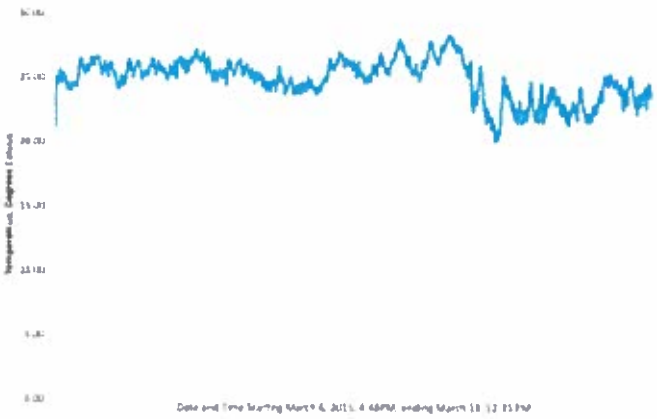

Fig. 177: Bag-up Room Temperature

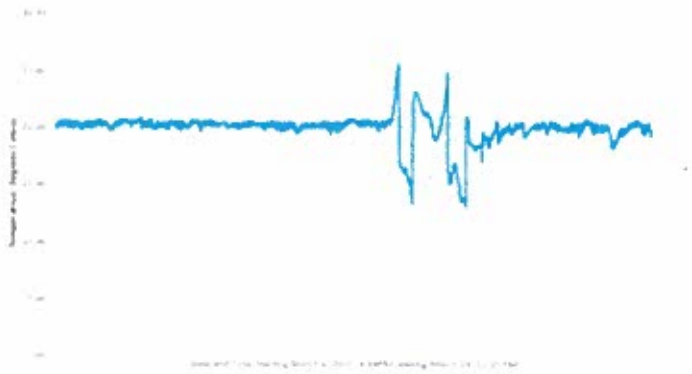

Fig. 178: Kitchen Temperature

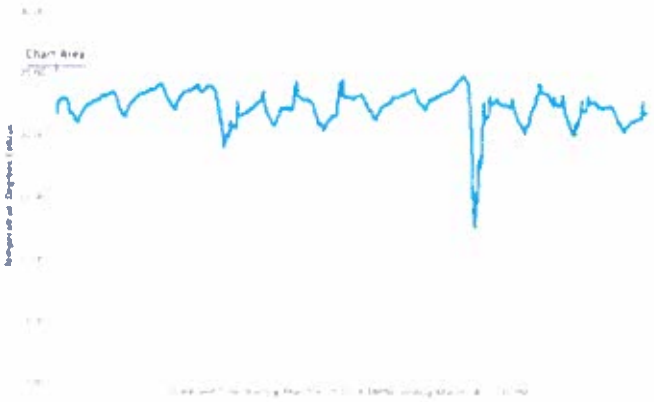

Fig. 179: Housekeeping Temperature

During the monitoring period, outdoor temperatures experienced major fluctuations ten days into the monitoring period, with a low and high temperature range of up to 24.1°C (Table 16). The mechanical system would have difficulty dealing with these high temperature fluctuations.

Table 16: Outdoor Temperatures During the Sampling Period

	Temperature (°C)			
Date (March 2015)	**Low**	**Mean**	**High**	**Range**
6	-10.1	-2.7	3.2	13.3
7	-4.4	0.4	5.3	9.7
8	-6.4	1.1	6.6	13.0
9	2.5	3.7	5.3	2.8
10	-10.0	-2.7	5.4	15.4
11	-10.0	-5.0	1.7	11.7
12	-7.7	-4.2	3.2	10.9
13	-1.6	4.6	11.9	13.5
14	0.5	5.9	13.7	13.2
15	-8.4	-0.9	15.7	24.1
16	-13.2	-8.9	6.6	19.8
17	-16.8	-7.5	7.0	23.8
18	-9.8	-1.4	8.0	17.8

4.5.8 Relative Humidity

The relative humidity varied between 22-40%RH in the lobby reception; 20-50%RH in the bag-up room; 12-35%RH in the kitchen; and 10-25%RH in housekeeping.

The 10%RH in housekeeping is somewhat low, but the other areas are within the guidelines of 20-30%RH in winter in Alberta.

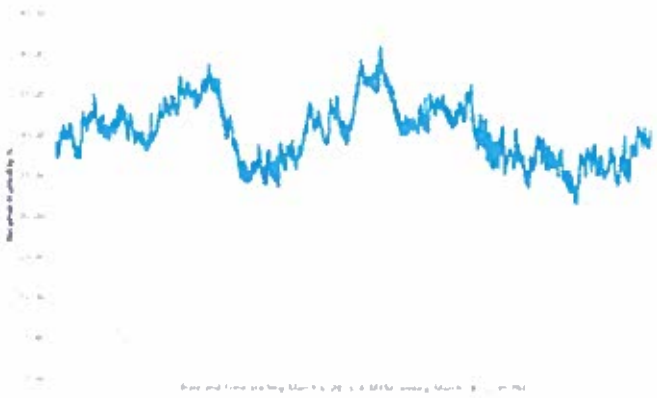

Fig. 180: Relative Humidity Lobby Reception

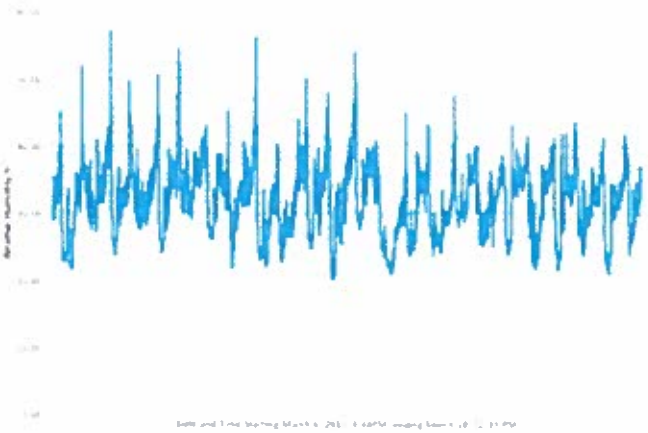

Fig. 181: Relative Humidity Bag-up Room

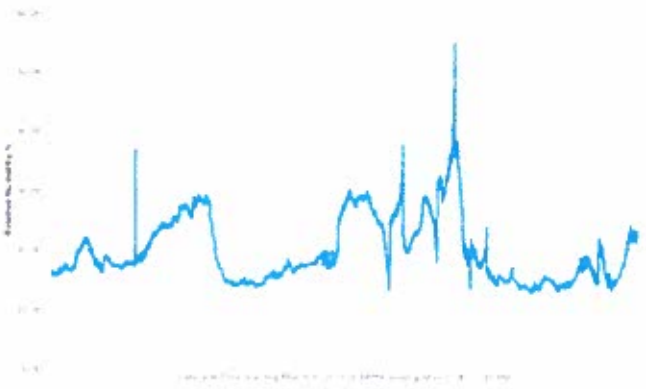

Fig. 182: Relative Humidity Kitchen

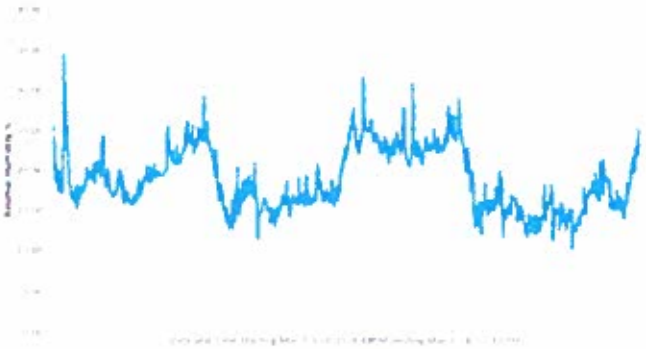

Fig. 183: Relative Humidity Housekeeping

5.0 Summary and Conclusions

5.1 Building-related Health Issues

The most likely causes for health complaints at Wapasu Creek West include diesel, vehicle exhaust and fungi. Noise, airborne particulates and carbon disulphide may also be responsible for some of the health effects.

The relationship between the health symptoms reported at Wapasu Creek West and indoor environmental contaminants is described in Table 17. There are definite correlations between the reported health symptoms and the indoor contaminants present in this building.

Table 17: Reported Health Symptoms and Possible Causes from Indoor Air Contaminants

		Airborne Particulates	High Carbon Dioxide	Low Relative Humidity	High Temperature	Diesel	Carbon Monoxide	Nitrogen Oxides	Fungi	VOCs	BTEX	Acoustic
1	Cough	•				•	•	•	•	•	•	
2	Sleep disturbance					•	•	•	•	•	•	•
3	Cold symptoms					•	•	•	•	•		
4	Headache	•	•		•	•	•	•	•	•	•	•
5	Fatigue		•		•	•	•	•	•	•	•	•
6	Runny nose	•				•	•	•	•	•	•	
7	Stiff joints					•	•	•	•	•	•	
8	Eye irritation	•		•		•	•	•	•	•	•	
9	Allergies	•				•			•	•		
10	Drowsiness		•		•	•	•	•	•	•	•	
11	Sore throat	•		•		•	•	•	•	•	•	
12	Dizziness		•		•	•	•	•	•	•	•	
13	Sinus Pressure / pain	•				•	•	•	•	•	•	
14	Difficulty concentrating		•		•	•	•	•	•	•	•	•
15	Light-headedness		•			•	•	•	•	•	•	
16	Chest Pain	•				•	•	•	•	•	•	
17	Nose bleeds	•		•		•	•	•	•	•	•	
18	Nausea					•	•	•		•	•	
19	Blurred vision					•	•	•	•	•	•	
20	Ringing of the ears					•		•	•	•	•	•
21	Shortness of breath	•	•			•	•	•	•	•	•	
22	Flu-like symptoms					•	•	•	•	•	•	
23	Loss of voice			•		•	•	•	•	•	•	
24	Migraines					•	•	•	•	•	•	
25	Wheezing	•				•	•	•	•	•	•	
26	Skin rashes			•		•	•	•	•	•	•	•
27	Heart palpitations					•	•	•	•	•	•	
28	Asthma	•				•	•	•	•	•	•	
29	Numbness of extremities					•	•	•	•	•	•	
30	Earaches					•	•	•	•	•	•	•
31	Bronchial spasms	•				•	•	•	•	•	•	

5.2 Building Code Violations

We identified a number of Building Code violations. Factory-built assemblies must comply with the Canadian Standards Association (CSA) Article 2.4.5.1. of the Alberta Building Code, entitled Factory-Built Assemblies, which states the following:

1) Where a *building* or component of a *building* is assembled off the *building* site in such a manner that it cannot be reviewed on site, off-site reviews shall be carried out to determine compliance with this Code.
2) Every *manufactured home* and off-site manufactured house that is constructed after 02 September 2007 shall be certified by the Canadian Standards Association or an organization approved for this purpose by the *Chief Building Administrator*, to confirm that the unit complies with the objectives and functional statements of this Code.
3) Every re-locatable industrial camp *building* that is constructed after 02 September 2007 shall be certified by an organization approved for this purpose by the *Chief Building Administrator*, to confirm that the *building* complies with the objectives and functional statements of this Code.

Table 17: Summary of Building Code Violations

Article	Title	Description
4.2.3.2	Preservation Treatment of Wood	Wood exposed to soil or air must be preservative-treated
5.6.2.1.(1)	Sealing and Drainage	Joints in materials, assemblies and components need to be sealed
5.6.2.2	Accumulation and Disposal	Safety issues with water, snow and ice accumulating around the building
5.6.2.2	Accumulation and Disposal	Specifies roof drainage to minimize hazardous conditions
5.6.2.2.4)	Accumulation and Disposal	Surface water should drain away from the building
5.7.1.1	Prevention of Accumulation and Ingress	Surface water should not accumulate against a building
5.7.1.1	Prevention of Accumulation and Ingress	There should be provisions for grading or catch basins so water does not enter the building
A-6.2.2.7.(1)	Ventilation and Venting of Crawl Spaces	Vented crawl space requires a ground cover as well as insulation, air barrier and vapour barrier between the crawl space and the building High moisture in a crawl space may cause mould and structural damage Ventilation alone cannot correct moisture-related problems caused by inadequate drainage Negative pressure in a crawl space should be maintained to prevent migration of moisture to occupied areas
9.3.2.9	Termite and Decay Protection	Wood needs to be preservative treated to resist decay
9.18.3.1	Ventilation of Unheated Crawl Spaces	Vents must prevent entry of snow, rain and insects
9.18.5.1	Crawl Spaces	Water is to be controlled by grading or drainage
9.18.6.1	Crawl Spaces	Ground cover is required in unheated crawl spaces

Article	Title	Description
9.20.13.7.1)	Flashing Joints	Flashing should be water tight
9.26.3.1	Roofing Types and Slope Limits	Minimum slope for flat roofs
9.26.4.9	Roof Penetrations	Flashing is required at joints where a pipe or duct penetrates a roof
9.21.4.10.1)	Flashing	Flashing is required at material junctions
9.27.2.4.1)	Protection of Cladding from Moisture	There should be 200mm minimum between finished ground and building cladding that might be adversely affected by water
9.27.3.8	Flashing Installation	Specifies locations where flashing is required
9.27.3.8.4)	Flashing Installation	Specifies how flashing must extend, terminate and slope
9.32.3.13.7)	Outdoor Intake and Exhaust Openings	Screens required on air intakes to prevent insects from entering
9.32.3.13.1)	Outdoor Intake and Exhaust Openings	Location of air intakes away from local sources such as vehicle exhaust
9.33.4.1	Design of Heating and Air-conditioning Systems	Specifies requirements for support of ducts and electrical conduits
10.5.1.8.1)	Screens	Requirements for screens on openings to rooms where food is prepared to prevent entrance of flies and other insects

5.3 Crawl Space Issues

The crawls spaces are deficient in many ways:

- drainage is poor around the buildings causing water to accumulate in and around the crawl spaces, which will support fungi, other microorganisms and insects
- condensate from furnaces drain into the crawlspace adding moisture
- the floor of the crawl space is exposed soil and gravel (a ground cover is required by code)
- fungi-contaminated debris was observed in the crawl spaces
- crawl space vents are blocked by snow
- gaps around the floor penetrations allow contaminated crawl space air to migrate up into the conditioned building through stack effect
- insulation along the skirting is not required

5.4 Building Envelope Issues

The building envelope was deficient in many locations:

- unprotected wood for exterior cladding
- flashing was poorly designed, improperly installed, or nonexistent

5.5 Roof Issues

Standing water was observed on the roof indicating insufficient drainage. Multiple roof leaks were evident due to poorly installed roofing membrane or building movement that has torn the roof membrane. Water intrusion may damage building materials, support fungi growth and cause a fire if in close proximity to electrical wiring. Evidence included:

- water staining on ceilings, walls, floors
- buckets set out to catch leaks
- multiple cold signatures, which may indicate moisture
- positive results with the moisture meter
- observed mould
- positive mould air test results

5.6 Mechanical Equipment Deficiencies

Issues with the mechanical equipment include:

- location of MUA near loading docks will bring vehicle exhaust into the building
- inadequate filtration system to filter out PM2.5 and DPM
- dust and flies getting in through the MUA: there must be gaps in the ductwork that bypass the filters or the filters do not have a tight fit
- direct fire units will burn dust particles and whatever is attached to them bringing additional contaminants into the building
- inability to keep bag-up room cool in summer, stairwells cool, and hallways in the wings ventilated
- inability to flush out contaminants brought in by the air intakes
- mechanical equipment has difficulty keeping indoor temperature constant during times of high fluctuations in outdoor temperature
- the mechanical equipment is too noisy

5.7 Airborne Particulates and Nuisance Dust

As measured by the airborne particle counter, particulates in the 0.3 – 10µm size range were generally higher indoors than outdoors. This indicates an indoor source.

Dust is brought into the building on people's boots. The 'boots-off' policy is not 100% followed and additional methods to control dust need to be considered.

5.8 Fungi

The crawl space is a toxic environment, one of the worst areas IAQm has ever tested. The Alberta Building Code recognises that contaminants from the crawl space will migrate up into the occupied spaces of the building through floor penetrations.

Toxigenic fungi were also present in the ceiling space near the lobby where there was an active water leak and in the bulk sample of drywall from the women's gym furnace room. Roof leaks are common and toxigenic fungi may also exist in multiple other areas. Although the wetted and stained ceiling tiles are replaced by maintenance, the structure above is not. Repeated wetting events increase the likelihood that mycotoxins are being produced.[6] If allowed to continue, health effects from fungi will worsen.

5.9 VOCs

Carbon disulfide was identified in housekeeping at concentrations 40 times above the guideline level. We suspect carbon disulphide was used prior to our visit as a fungicide in the crawl space, however this needs to be confirmed. Yet, if this assumption is correct we can conclude that the fungicidal treatment was ineffective (because measured concentrations of mould in the crawl space and elsewhere were still high) and was unsafely applied resulting in worker exposure to an additional contaminant.

We wonder if carbon disulfide is used routinely as a fungicide. Carbon disulfide can cause nausea, vomiting, dizziness, fatigue, headaches and can affect the nervous system: a definite correlation with many of the reported health symptoms. In high concentrations carbon disulphide can cause toxicity to kidney and liver, spontaneous abortion, sperm abnormalities, and menstrual disorders.

5.10 Acoustics

This building has considerable amount of loud noise, primarily attributable to the portable air filters and other mechanical equipment throughout the building. Measures to reduce the noise level are warranted to maintain the health and safety of the occupants.

6.0 Recommendations

1. Additional testing

The testing we conducted provides information about indoor contaminants concentrations that were measurable during the test period, but it only represents a snapshot of conditions at that time.

Due to the time of year, lower traffic volume and snow cover we were not able to measure some of the contaminants when they might be at their peak. Testing at different times of the year is needed to obtain a more thorough and accurate account, for instance:

- in summer when dust and airborne particulates are highest
- in summer when temperatures are high in stairwells and bag-up room
- in winter when diesel and other contaminants from vehicle exhaust may be greater due to idling of buses and other vehicles

[6] Repeated wetting events increase the likelihood that fungi colonies will grow bigger. When different species detect each other, they will start producing toxins in an effort to compete for the same food source.

Diesel testing should take place when the lodges are busier and there is more vehicle traffic in order to capture the worst case scenario with the greatest impact on human health. We noticed a substantial reduction in the amount of bus traffic between August 2014 and March 2015.

We would also like to see additional testing at Wapasu Creek East where there are more health complaints.

In addition, we also had difficulty with one of the instruments that we rented: the VRAE, which measures carbon monoxide, nitrogen dioxide and sulphur dioxide. All data had been erased or no data was recorded over the ten days it was set up onsite. This test must be repeated.

2. Crawl Space Improvements

Conditions in the crawl space represent a health hazard and its design violates the Alberta Building Code. Improvements involve:

- grading
- ground cover
- debris removal
- sealing around floor penetrations
- securing electrical conduits and mechanical ductwork
- keeping vent openings clear of snow
- creating negative pressure with mechanical fans

Workers will need to protect themselves from microorganisms present in the crawl space as well as be cognizant of electrical hazards. Recommendations to remediate the fungi in the crawl space include:

a. Planning

The contaminated area is over 100ft^2 (10m^2) indicating that a contractor certified in mould remediation should carry out the work.

The crawlspace should be isolated from the rest of the building and the immediate outdoor area by using ventilation (negative air unit with a HEPA filter) to keep the work area under negative pressure.

Ensure workers who enter the crawlspace wear protective gear including a full-face mask with P100 and organic vapour filter, disposable clothing, gloves, and rubber boots.

b. Scope of work

Improve grading around to buildings to ensure snowmelt and rainwater drains away and does not accumulate under or around the buildings. Drywells may be needed in some locations.

Seal all penetrations between the crawl space and the occupied areas of the building.

Remove all contaminated debris. Place contaminated materials in double plastic bags before carrying them outside.

Clean all wood surfaces in the crawlspace including studs and overhead floor joists or plywood by sanding down or use the ice blasting method. Replace extensively contaminated wood.

The use of anti-microbial disinfectants, biocides, or bleach for the purpose of killing mould is not recommended. Mould remediation consisting of treatment only with a biocide or disinfectant has not been proven to be effective, necessary or beneficial because dead and dormant mould spores and mould fragments still have toxigenic and allergenic health effects and therefore still present a health hazard. Encapsulation of mouldy areas is also not a recommended procedure because mould left in place will begin to grow if water is reintroduced in the future. Removal of all mouldy materials is the only effective mould remediation strategy.

The soil/gravel floor is contaminated and cleaning is impossible.

Option 1: Cover the entire crawlspace with a water proof ground cover and overlap about 12 inches at the seams and up the sides of the foundation walls.

Option 2: The best and most permanent solution is to pour a concrete floor in the crawlspace. Some excavation may be necessary.

Install mechanical ventilation to keep the crawlspace under negative pressure.

Ensure that none of the crawl space vents are blocked by snow or debris.

c. Surveillance and clearance testing

Carry out surveillance during the remediation process to verify that the remediation activities are being conducted in a manner consistent with typical or prescribed remediation practices and job-specific specifications. In most cases a visual inspection will be adequate, but in some cases sampling outside the containment is carried out to ensure that containment structures are properly erected and that mould spores are not migrating to unaffected areas.

Once remediation activities are completed a final clearance test should be undertaken by a third party to ensure the effectiveness of the remediation process. The final clearance test will consist of a visual inspection and air testing for fungi and may include surface sampling.

3. Repair Building Envelope

All exterior cladding and flashing should conform to the Alberta Building Code. Exposed OSB should be replaced with metal siding and installed in a manner that will shed water and keep building materials inside the roof, wall and floor assemblies dry. Specific items include:

- replace sheets of OSB on the exterior walls
- replace OSB skirting with metal skirting
- replace existing glued on flashing with proper flashing that conforms to the Alberta Building Code
- reconstruct the roof so that there is a slope and water does not pool
- ensure the roof membrane is continuous and waterproof and includes provisions for expansion & contraction and building movement

An architect with specialisation in building envelope is needed to prepare the required remediation to the building envelope and compliance to the Alberta Building Code and other regulations. The architect is needed during the remediation and to sign off on the work undertaken.

4. Fungi Related to Roof Leaks

Many roof leaks throughout the buildings were identified, but this study is only a sampling of some areas that the team had access. A building envelope specialist is required to identify all areas that require remediation, developed the scope of work, and to be the professional of record during the remediation process.

Replacing damaged ceiling tiles is only a cosmetic remedy. The roof assembly above the ceiling tiles also needs to be addressed. Once the roof has been repaired, all water-damaged building materials require remediation. This will involve the following steps:

a. Isolate the affected area from the rest of the building by using a containment with a polyethylene barrier and using ventilation to keep the work area under negative pressure. Place a drop sheet below the work area. Turn off HVAC system and seal over all system openings. Keep occupants well away from the remediation containment area.

b. Workers should protect themselves from the potential allergenic, pathogenic and toxic health effects of fungi present in the contaminated building materials by wearing respirators equipped with P100 filters, protective clothing and gloves.

c. Ensure roof joists and roof sheathing are in good condition. Extensively damaged wood joists should be replaced. Lightly damaged wood joists can be sanded down or wire brushed to remove water staining and associated mould growth. Discard stained ceiling tiles and stained, wet or discoloured insulation.

d. Place contaminated materials in double plastic bags before carrying them outside the containment.

e. The use of anti-microbial disinfectants, biocides, or bleach at any stage in the remediation is not recommended. Mould remediation consisting of treatment only with a biocide or disinfectant has not been proven to be effective and thus is not recommended. Dead mould spores and fragments still present a health hazard because their toxigenic and allergenic properties remain. In addition, the application of a biocide, anti-microbial disinfectant, or bleach following the completion of mould remediation, with the intent of inhibiting possible future fungal growth, is not considered effective, necessary or beneficial. Encapsulation of a mouldy area is also not a recommended procedure. Removal of mouldy materials is the only effective mould remediation strategy.

f. Once the renovations and remediation are completed, the property should undergo a comprehensive cleaning of the adjacent occupied space. This cleaning will remove any dust and debris left by the renovation activities and any microbial contaminants that may be on various surfaces and materials. Specific tasks include the cleaning of all exposed surfaces such as floors, walls, ceilings, doors, light fixtures, bookshelves, countertops, and windowsills.

g. Mechanical duct cleaning should be undertaken by an experienced duct-cleaner who will cut access holes into the ducts and scrub them spotless. Vacuuming the ducts without physically scrubbing

them is not acceptable after mould remediation. All air cleaning filters need to be replaced, all vents and grills removed and cleaned, and all ductwork thoroughly cleaned. It is recommended that the furnace cleaning company be a member in good standing with the Better Business Bureau (BBB) and/or the National Air Duct Cleaners Association or an equivalent professional body.

5. Mechanical Equipment

The mechanical equipment requires an effective filtration system that will at least filter out flies and visible dust.

Measures to deal with poor outdoor air quality that contains vehicle exhaust may include:

- installing a more sophisticated building mechanical filtration system with VOC absorption
- moving the air intakes away from loading docks, roads and pick up locations
- ensuring buses and other vehicles are equipped with cleaner burning diesel engines[7] or replacing bus fuel with compressed natural gas
- enforcement of 'no-idling' policy

The direct fired roof top units should be replaced with conventional heaters due to absence of a chimney to exhaust flue gasses as well as burnt dust that is drawn into the kitchen.

Low noise fans should be installed to replace the existing noisy fans. Sleeping areas are a priority. Kitchens also require quieter fans.

The ductwork needs cleaning, especially around floor-mounted grille openings.

The system requires some redesign to improve ventilation in summer in the bag-up room and stairwells and be adequate enough to deal with temperature fluctuations throughout the year.

6. Airborne Particulates and Nuisance Dust

Attempts to reduce airborne dust brought indoors by boots with the 'boots-off' policy and the portable air scrubbers is not reliable or effective. The 'boots-off' policy does not have sufficient compliance and is not enforced. The portable and ceiling mounted air scrubbers are not working as efficiently as expected. In addition they are very noisy and expensive to maintain.

A better solution involves control at the source. There should be a porch for oil field workers where they can remove their boots before entering the building. In addition, Tim Horton's customers and their boots should be in a separate location or at least isolated from the lobby.

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7 Available retrofits aimed at reducing emissions from older diesel engines include: diesel oxidation catalyst, diesel particulate filters, and diesel multi-stage filters. In response to diesel being reclassified as a carcinogen in 2012, the European Union is developing additional strategies.

7. Acoustics

Remediation action to control noise levels in the building include:

- remove the portable air scrubbers from the corridors or replace with quieter units
- build a porch where workers can remove their boots before entering the building so that portable air scrubbers are not necessary
- replace all fans in the kitchen and sleeping areas with low noise fans (Section 9.32.3.10. of the Alberta Building Code recommends fans with sound ratings in accordance with
  a) CAN/CSA-C260-M, "Rating the Performance of Residential Mechanical Ventilating Equipment," or
  b) HVI915, "Procedure for Loudness Rating of Residential Fan Products.")

8. Communication

Devise a communication strategy to notify the building occupants of activities relating to the recommendations in this report so that an understanding of the problem and how it will be solved is understood. Provide a means by which questions can be asked and answered. Provide assurances that the recommendation in this report and subsequent studies will be implemented and with a reasonable schedule.

9. IAQ Management Plan

Civeo's existing IAQ Management Plan requires improvement. Even though their plan includes a statement of commitment, there is little evidence that health complaints by workers are taken seriously. Human rights laws stipulate that even the most sensitive people must be accommodated (environmental hypersensitivity is considered a disability).

Civeo's lack of cooperation with IAQm's team (denied access to areas of the building, equipment, and other buildings; lack of knowledgeable building mechanical and maintenance people made available to interview; inability to produce construction documents) does not support their statement of commitment to indoor air quality.

Civeo needs to have plans in place outlining who takes the responsibility, what actions will be taken and how the remediation will be done to correct indoor air quality problems caused by numerous types of contaminants. They also need to have a budget in place so that funds are available to carry out the work.

The presence of carbon disulfide (a fungicide) suggests to us that Civeo may have attempted to minimise microorganism levels prior to our visit in order to skew our test results. Their credibility as building managers has been affected.

Specifications for the design of new buildings should be part of an IAQ Management Plan. There are many lessons to be learned from this report regarding the design and management of prefabricated structures destined for remote sites. We identified many building code violations and deficiencies

inherent in the building envelope, architectural detailing and mechanical equipment. We hope that the next generation of prefabricated structures will be improved.

10. Miscellaneous

Photocopier manufacturers specify that photocopiers need to be placed in a well-ventilated area. Photocopiers in the office areas at Wapasu Creek West require a local exhaust vent above.

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