April 23, 2018

To: Waverly Elementary School

From: Christopher Madden, CIH
Indoor Environmental Quality Manager

Re: Indoor Air Quality Testing During Renovations - March

As Waverly Elementary School is currently undergoing renovations, the Howard County Public School System's Office of the Environment is conducting weekly Indoor Air Quality (IAQ) Testing to determine if renovation activities are adversely impacting the IAQ in areas located in close proximity to the renovation. The Office of the Environment visited Waverly Elementary on March 9, 14, 22 and 29, 2018. The Office of the Environment observed if engineering controls were in place to limit construction related constituents from migrating into occupied areas of the school and collected measurements of temperature, relative humidity, carbon dioxide (CO_2), carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter.

General Observations

March 9, 2018

Construction activities varied during the assessment but appeared to be primarily electrical work. Other trades were also performing various tasks. The Office of the Environment did not observe a negative air machine in the construction containment. The construction superintendent was contacted to install a negative air machine in close proximity to the construction barrier.

Visible emissions were not observed in the school in the vicinity of the construction containment.

March 14, 2018

Construction activities varied but primarily appeared drywall work and ductwork installation. Minor demolition (chipping of CMU block) was also occurring. The negative air machine was operational but the intake was facing the wall. The machine was turned so that the inlet faced the individual chipping CMU block. Smoke testing was performed within the containment and indicated general air flow was not migrating to occupied areas of the school during the testing. It was also noted that a door on the roof (connected to the construction area) was open. Given the proximity to the school's roof top ventilation units' intake, the door was closed to prevent construction dusts from moving into the ventilation system.

Visible emissions were not observed in the school in the vicinity of the construction containment.

March 22, 2018

Various general construction activities were being performed during the IAQ assessment. Additionally, snow removal operations (tractor and snow blower) were also being performed. It would be anticipated that exhaust from the snow removal would increase concentrations of CO and VOCs.

Visible emissions were not observed in the school in the vicinity of the construction containment.

It appeared that the primary activity being conducted within the construction area was electrical work. No odors or visible dust emissions were observed. The construction containment was in place and the negative air machine was operational.

Visible emissions were not observed on the school side of the construction containment.

General Indoor Air Quality Measurements

Temperature, Relative Humidity, CO_2, CO, and (VOC) readings were collected as part of the IAQ assessment.

The American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) recommends a temperature range of 68.5 to 75 degrees Fahrenheit (F) in the winter and 75 to 80.5 degrees F in the summer (assuming 50% relative humidity) (Indoor Environmental Quality 2015). The recommended temperature ranges vary slightly depending on relative humidity. There are no recommendations for the spring and fall due to the variabilities in outdoor temperatures.

To prevent mold growth, The Environmental Protection Agency (EPA) recommends relative humidity should be maintained below 60%, ideally between 30-50%. Humidity readings below 30% are often encountered in buildings where humidity is not introduced through the Heating Ventilation and Air Conditioning (HVAC) system.

Carbon Dioxide measurements can provide a general sense of the adequacy of the ventilation system. It is recommended that CO_2 readings be less than 700 parts per million (ppm) plus the outside concentration of CO_2.

Carbon Monoxide can be introduced through incomplete combustion (car exhaust, improperly ventilated boilers, etc.) and should not exceed 9 ppm.

"Low levels of VOCs are ubiquitous in indoor and outdoor air from both natural and man-made sources (The IAQ 2016). VOCs can be introduced by a variety of indoor (paints, perfumes, art products, building materials, carpet, furnisher, etc.) and outdoor sources (vehicles, manufacturing emissions, etc.). A "spike" is identified when indoor readings are significantly higher than the outdoor readings.

Temperature, Relative Humidity, CO_2, and CO data was collected using a TSI IAQ Calc (Model #7545). VOC data was collected using a Rae ToxiRae Pro Photoionization Detector (PID) (Model #PGM-1800). Below are the results of the temperature, relative humidity, CO_2, and CO measurements collected.

Table I - General IAQ Measurements – March 9, 2018

Location	Temperature (F)	Relative Humidity (%)	CO_2 (ppm)	CO (ppm)	Total VOCs (ppm)
Outside	35.0	34.9	366	0.0	0.1
Construction Containment	46.1	31.4	519	0.0	0.0
Lobby	**59.7**	30.9	766	0.0	0.0
Hallway Outside of Health Suite	**62.0**	26.6	695	0.1	0.0

Table I - General IAQ Measurements – March 9, 2018 (Continued)

Location	Temperature (F)	Relative Humidity (%)	CO_2 (ppm)	CO (ppm)	Total VOCs (ppm)
A124	**68.0**	22.9	590	0.1	0.0
A125	**67.6**	21.3	563	0.1	0.0
1st Floor Addition	69.0	16.8	561	0.0	0.0
Health Suite	69.9	18.6	610	0.1	0.0
Gymnasium Hallway	69.1	19.2	635	0.2	0.0
Outside	41.0	24.2	379	0.7	0.0

Note: Bolded values were not within recommended limits.

Table II - General IAQ Measurements – March 14, 2018

Location	Temperature (F)	Relative Humidity (%)	CO_2 (ppm)	CO (ppm)	Total VOCs (ppm)
Outside	43.9	17.4	379	2.6	0.2
Construction Containment	42.2	32.5	398	0.0	0.8
Lobby	**59.6**	28.7	630	0.0	0.3
Hallway Outside of Health Suite	64.7	24.2	690	0.1	0.1
A125	**65.6**	22.6	519	0.0	0.2
Hallway Outside of A123	**67.1**	23.6	703	0.0	0.0
Gymnasium Hallway	70.0	20.0	742	0.0	0.0
Health Suite	69.5	20.0	733	0.1	0.2
Media	69.4	18.0	643	0.0	0.0
1st Floor Addition	70.1	13.7	633	0.0	0.0
Outside	40.1	22.3	330	0.0	0.0

Table III - General IAQ Measurements – March 22, 2018

Location	Temperature (F)	Relative Humidity (%)	CO_2 (ppm)	CO (ppm)	Total VOCs (ppm)
Outside	36.8	37.0	381	1.8	0.1
Construction Containment	49.4	43.9	551	0.0	2.1
Lobby	51.7	42.6	409	0.0	0.1
Hallway Outside of Health Suite	61.5	28.1	458	0.1	0.1
A125	65.3	28.8	402	0.2	0.1
A123	69.9	25.1	501	0.0	0.6
Gymnasium Hallway	70.5	19.3	473	0.0	0.1

Table III - General IAQ Measurements – March 22, 2018 (Continued)

Location	Temperature (F)	Relative Humidity (%)	CO_2 (ppm)	CO (ppm)	Total VOCs (ppm)
Health Suite	68.0	22.8	608	0.1	0.2
Media	70.2	21.2	400	0.2	0.0
1st Floor Addition	69.4	15.1	412	0.2	0.0
Outside	37.7	39.1	389	0.0	0.0

Table IV - General IAQ Measurements – March 29, 2018

Location	Temperature (F)	Relative Humidity (%)	CO_2 (ppm)	CO (ppm)	Total VOCs (ppm)
Outside	66.3	50.0	406	0.0	0.0
Construction Containment	68.2	44.5	662	0.0	0.2
Lobby	68.5	49.1	658	0.0	0.0
Hallway Outside of Health Suite	69.5	47.7	786	0.0	0.1
A124	69.5	47.7	786	0.0	0.1
A125	70.2	42.8	743	0.0	0.1
Gymnasium Hallway	70.1	45.7	701	0.0	0.0
Health Suite	70.5	44.5	789	0.0	0.0
Media	69.8	45.5	676	0.0	0.0
1st Floor Addition	68.8	47.8	719	0.0	0.0
Outside	65.3	47.6	429	0.0	0.0

Particulate Matter Measurements

Particulate matter "is a complex mixture of extremely small particles and liquid droplets that get into the air (Particulate 2017). The data collected does not distinguish between types of particles in the air which can include pollen, skin cells, soil, human/animal airs, etc. Particles designated as "respirable" are less than 10 micrometers (µm) in diameter and typically fall into two categories, coarse and fine particles. Coarse particles are those that are less than 10 um (PM_{10}) and fine particles are those less than 2.5 µm ($PM_{2.5}$). ANSI/ASHRAE standard 62.1-2016 suggests target indoor concentration for $PM_{2.5}$ and PM_{10} of 12 and 50 µg/m3 respectively.

Particulate matter data was collected with a TSI AeroTrak Particle Counter (Model #9306-V2). Note that the particle counter is not capable of collecting PM2.5 data. Due to this limitation, PM3.0 data is used. This would provide a more conservative, overestimate of PM2.5.

Table V - Particulate Matter Measurements – March 9, 2018

Location	$PM_{0.5}$ (μ/m^3)	$PM_{1.0}$ (μ/m^3)	$PM_{3.0}$ (μ/m^3)	$PM_{5.0}$ (μ/m^3)	$PM_{10.0}$ (μ/m^3)
Outside	1	1	3	7	21
Construction Containment	3	15	**191**	819	**3,610**
Lobby	3	13	**97**	282	**819**
Hallway Outside of Health Suite	1	6	**57**	68	**436**
A124	1	4	**24**	37	110
A125	1	4	**18**	45	124
1st Floor Addition	0	0	3	11	67
Health Suite	2	10	**92**	265	**671**
Gymnasium Hallway	1	4	**29**	77	**220**
Outside	1	1	2	4	9

Table VI - Particulate Matter Measurements – March 14, 2018

Location	$PM_{0.5}$ (μ/m^3)	$PM_{1.0}$ (μ/m^3)	$PM_{3.0}$ (μ/m^3)	$PM_{5.0}$ (μ/m^3)	$PM_{10.0}$ (μ/m^3)
Outside	1	1	1	2	6
Construction Containment	1	7	**114**	563	**2,392**
Lobby	0	1	**25**	98	**320**
Hallway Outside of Health Suite	0	0	6	18	94
A125	0	1	10	31	74
A123	0	1	7	28	107
Gymnasium Hallway	0	0	2	7	44
Health Suite	1	4	**43**	129	**365**
Media	0	0	2	11	31
1st Floor Addition	0	0	1	4	22
Outside	1	1	3	10	33

Table VII - Particulate Matter Measurements – March 22, 2018

Location	$PM_{0.5}$ (μ/m^3)	$PM_{1.0}$ (μ/m^3)	$PM_{3.0}$ (μ/m^3)	$PM_{5.0}$ (μ/m^3)	$PM_{10.0}$ (μ/m^3)
Outside	0	0	1	3	6
Construction Containment	1	4	**53**	240	**1,047**
Lobby	0	1	**17**	51	146
Hallway Outside of Health Suite	0	1	11	26	67
A125	0	1	4	10	26
A123	0	1	6	15	29
Gymnasium Hallway	0	1	10	28	103
Health Suite	0	1	**54**	128	**272**
Media	0	1	7	24	69
1st Floor Addition	0	0	2	10	40
Outside	0	0	1	2	4

Table VIII - Particulate Matter Measurements – March 29, 2018

Location	$PM_{0.5}$ (μ/m^3)	$PM_{1.0}$ (μ/m^3)	$PM_{3.0}$ (μ/m^3)	$PM_{5.0}$ (μ/m^3)	$PM_{10.0}$ (μ/m^3)
Outside	10	20	49	2	6
Construction Containment	4	11	**103**	441	**1,705**
Lobby	3	5	12	27	75
Hallway Outside of Health Suite	3	5	12	30	109
A124	2	3	6	13	33
A125	1	2	3	4	14
Gymnasium Hallway	3	5	8	14	39
Health Suite	2	4	6	11	23
1st Floor Addition	3	5	7	10	20
Media	2	3	5	8	23
Outside	9	17	39	57	71

Discussion

March 9 and 14, 2018

Temperatures were slightly lower then than recommended levels in several areas. This would be expected so close to spring, as outdoor temperatures ranges can vary widely.

Particulate levels were elevated. Although this may not be entirely associated with construction activities, the general contractor was contacted so that a negative air machine could be re-installed on March 9. The negative air machine was repositioned on March 14.

March 22 and 29, 2018

Particulate matter levels were slightly elevated on March 22 in the lobby and the health suite. A direct link between construction activities could not be identified. Particulate levels are expected to vary depending on in-school student/staff activities.

Conclusion

Based on the assessment conducted on March 9 and 14, 2018 dust control measures needed improvement. The Office of Construction was contacted to inform the general contractor of the importance of the poly-ethylene sheeting and the negative air machine. The remaining visits showed reduced dust levels within occupied areas of the school. Regarding dust, it should be noted that elevated concentrations are expected and would not necessarily be associated with construction activities. Dust levels are expected to vary overtime based on student and staff activities. Additionally, dust levels are far from the enforceable OSHA Occupational Exposure Limit for respirable nuisance dust of 5,000 $\mu g/m^3$.

Housekeeping practices are also pivotal for dust control. Increased frequency of vacuuming and cleaning could also help reduce dust levels in areas around the construction containment such as the lobby, hallway outside of health, and the health suite.

It should be noted that the sampling is not being conducted for Occupational Safety and Health Administration (OSHA) compliance, in association with the renovation/construction contractors.

References

Indoor Environmental Quality, the National Institute for Occupational Safety and Health/Centers for Disease Control and Prevention, September 1, 2015. Retrieved from: https://www.cdc.gov/niosh/topics/indoorenv/temperature.html

The IAQ Investigator's Guide, 3rd Edition, American Industrial Hygiene Association, Edited by Ellen C. Gunderson, CIH, CSP, 2016.

Particulate Matter (PM) Pollution, Environmental Protection Agency, Last Updated on August 21, 2017. Retrieved from: https://www.epa.gov/pm-pollution

Volatile Organic Compounds (VOC) Criteria for New Construction White Paper, American Industrial Hygiene Association, March 15, 2017.