Aria Environmental, Inc.
INDUSTRIAL HYGIENE & SAFETY CONSULTANTS

November 2, 2017

Mr. Jeff Klenk
Howard County Public School System (HCPSS)
10910 Route 108
Ellicott City, MD 21043

RE: Indoor Air Quality Assessments during Renovations at Swansfield Elementary School
Project #J16-971 (October 5, 18, and 27 and November 1, 2017)

Dear Mr. Klenk,

Aria Environmental, Inc. (AE) is pleased to present this report of findings for indoor air quality assessments conducted at Swansfield Elementary School (Swansfield). Jeff Klenk of HCPSS requested AE start making frequent visits to Swansfield to monitor indoor air quality that may be affected by the current major renovation of the school. The visits discussed in this report were performed on October 5, 18 & 27 and November 1, 2017 and included work site observations, and real-time measurements for particles, indoor air quality parameters (temperature, humidity, carbon monoxide (CO) and carbon dioxide (CO_2)) and volatile organic compounds (VOCs). These assessments were performed by Julie Barth, CIH, CSP, LEED Green Associate of AE. Presented below are observations and recommendations made based upon conditions readily observed on the reported dates.

Particles

Particulate matter or PM is the term for a mixture of solid particles and liquid droplets found in the air. It does not distinguish between the types of particles in the air (e.g., pollen, skin cells, soil, etc.). Particulate matter includes "inhalable coarse particles," with diameters larger than 2.5 micrometers and smaller than 10 micrometers (PM10) and "fine particles," with diameters that are 2.5 micrometers and smaller (PM2.5). A micrometer is also called a micron and is one millionth of a meter. To put these particle diameters in perspective, the average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle. Particle loads expected to be a part of the school environment include carpet and clothing fiber, soil tracked in from outside, paper dust and dust and fibers from building materials.

ASHRAE Standard 62.1–2010 suggests target indoor concentrations for PM2.5 and PM10 of 15 $\mu g/m^3$ and 50 $\mu g/m^3$, respectively. These concentrations are taken from the EPA's National Ambient Air Quality Standards (NAAQS) based on annual arithmetic means deemed acceptable for outdoor air quality. Occupational standards and guidelines for particles are nearly an order of magnitude higher than concentrations typically found in non-occupational settings and are not appropriate for comparison. Particle measurements were taken with an Aerocet 531 particulate monitor. The particle monitor takes a two minute averaged sample of particle concentrations in 5 size fractions (PM1, PM 2.5, PM 7, PM10 and total suspended particles (TSP)). Results of particulate monitoring are presented in Tables 1, 2 and 3.

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Indoor Air Quality Assessments during Renovations at Swansfield Elementary School
October 5, 18 & 27 and November 1, 2017

Discussion of Particle Results for October 5, 2017

The PM2.5 particle concentrations ranged from 0 to 2 μg/m³ and PM10 particle concentrations ranged from 3 to 18 μg/m³ on October 5, 2017. Measurements were collected at the end of a normal school day. PM 2.5 and PM 10 concentrations were below the target concentrations in the areas monitored. Results of particulate monitoring are presented in Table 1.

Table 1 – Results of Particulate Monitoring Swansfield Elementary School on October 5, 2017

Location	Time	PM1 (μg/m³)	PM2.5 (μg/m³)	PM7 (μg/m³)	PM10 (μg/m³)	TSP (μg/m³)
Front Lobby at Containment	3:53 PM	0	2	13	18	33
Pod Center (159-163)	3:58 PM	0	0	2	3	6
Hallway near Gym	4:00 PM	0	0	2	3	6
Pod Center (140)	4:03 PM	0	1	2	3	6
Pod Center (130)	4:06 PM	0	0	2	4	5
Outside	4:10 PM	0	1	7	9	12

Bold-faced results indicate results above target concentrations.

Discussion of Particle Results for October 18, 2017

The PM2.5 particle concentrations ranged from 0 to 2 μg/m³ and PM10 particle concentrations ranged from 1 to 25 μg/m³ on October 18, 2017. PM 2.5 and PM 10 particle concentrations were below the target concentrations in all locations. The building was mostly occupied because it was a normal school day. Results of particulate monitoring are presented in Table 2.

Table 2 – Results of Particulate Monitoring Swansfield Elementary School on October 18, 2017

Location	Time	PM1 (μg/m³)	PM2.5 (μg/m³)	PM7 (μg/m³)	PM10 (μg/m³)	TSP (μg/m³)
Front Lobby at Containment	10:42 AM	0	2	21	25	52
Rm 113 (Guidance)	10:46 AM	0	0	1	1	4
Pod Center (159-163)	10:48 AM	0	0	1	2	9
Gym with full class	10:51 AM	0	0	3	3	41
Pod Center (140)	10: 56 AM	0	0	9	16	57
Pod Center (130)	10:59 AM	0	0	6	12	27
Outside	11:03 AM	0	0	3	4	5

Bold-faced results indicate results above target concentrations

Discussion of Particle Results for October 27, 2017

The PM2.5 particle concentrations ranged from 0 to 1 μg/m³ and PM10 particle concentrations ranged from 14 to 31 μg/m³ on October 27, 2017. PM 2.5 and PM 10 concentrations were below the target concentrations in all areas monitored. The building was occupied because it was a normal school day. Results of particulate monitoring are presented in Table 4.

Table 3 – Results of Particulate Monitoring Swansfield Elementary School on October 27, 2017

Location	Time	PM1 (μg/m³)	PM2.5 (μg/m³)	PM7 (μg/m³)	PM10 (μg/m³)	TSP (μg/m³)
Front Lobby at Containment	3:00 PM	0	0	10	14	31
Room 113 (Guidance)	3:03 PM	0	1	15	24	45

Location	Time	PM1 (µg/m³)	PM2.5 (µg/m³)	PM7 (µg/m³)	PM10 (µg/m³)	TSP (µg/m³)
Pod Center (159-163)	3:06 PM	0	1	19	29	72
Gym (5 students)	3:09 PM	0	0	11	16	44
Pod Center (140)	3:11 PM	0	1	13	26	77
Pod Center (130)	3:14 PM	0	1	19	31	73
Outside	3:17 PM	0	1	7	10	15

Bold-faced results indicate results above target concentrations

Discussion of Particle Results for November 1, 2017

The PM2.5 particle concentrations were consistently 0 µg/m³ and PM10 particle concentrations ranged from 2 to 20 µg/m³ in the areas monitored on November 1, 2016. PM 2.5 and PM 10 concentrations were below the target concentrations in all areas monitored. The results of particulate monitoring are presented in Table 4.

Table 4 – Results of Particulate Monitoring Swansfield Elementary School on November 1, 2017

Location	Time	PM1 (µg/m³)	PM2.5 (µg/m³)	PM7 (µg/m³)	PM10 (µg/m³)	TSP (µg/m³)
Front Lobby at Containment	12:04 PM	0	0	13	20	40
Room 113 (Guidance)	12:07 PM	0	0	2	2	27
Pod Center (159-163)	12:10 PM	0	0	4	7	17
Gym	12:13 PM	0	0	10	13	30
Pod Center (140)	12:16 PM	0	0	6	7	14
Pod Center (130)	12:19 PM	0	0	2	3	10
Outside	12:22 PM	0	1	6	9	12

Bold-faced indicates results outside of recommended comfort ranges or target concentrations.

Indoor Air Quality Measurements

Industry guidelines or standards for seasonal temperature and humidity ranges for thermal comfort are established by the American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) standard 55-2013. These ranges are presented in Table 5. The U.S. Environmental Protection Agency (EPA) recommends maintaining indoor relative humidity below 60% and ideally between 30 and 50%. Low humidity is expected in buildings that do not add humidity during the heating season. The comfort ranges are only set for the Summer and Winter seasons when temperatures are usually consistent. There are no Fall or Spring ranges because these seasons can include both heating and cooling modes of HVAC operation. Carbon dioxide and carbon monoxide measurements are used to assess ventilation system performance. The exhaled breath of building occupants is the main indoor source of carbon dioxide; therefore, the build-up of carbon dioxide indicates inadequate ventilation. Results of temperature, relative humidity, carbon dioxide and carbon monoxide monitoring are presented in Tables 6-9 below.

Table 5- Acceptable Ranges of Temperature and Relative Humidity in Summer and Winter[a]

Relative Humidity	Winter Temperature	Summer Temperature
30%	68.5°F – 76.0°F	74.0°F – 80.0°F
40%	68.5°F - 75.5°F	73.5°F – 79.5°F
50%	68.5°F - 74.5°F	73.0°F – 79.0°F
60%	68.0°F - 74.0°F	72.5°F – 78.0°F

[a]adapted from ASHRAE Standard 55-2013

Real Time Volatile Organic Compounds Measurements

Instantaneous measurements for volatile organic compounds (VOCs) were collected using a ppbRae 3000 monitor calibrated using isobutylene gas. This instrument is used as a screening tool for VOCs in general with a limit of detection of 1 ppb. VOCs include a variety of chemicals, some of which may cause adverse health effects. Concentrations of many VOCs are generally higher indoors than outdoors. VOCs are emitted by many common products including paints, paint strippers, cleaning supplies, building materials, furnishings, fuels, office equipment and supplies, glues, and permanent markers, as well as cosmetics, perfumes and other personal hygiene products. These products can release organic compounds while being used or stored. It is important to note that the measurements taken are instantaneous and are intended to aid the inspector in detecting potential sources of VOC contamination. A VOC source is suspected when the measured concentration is significantly higher than the outdoor concentration or if a spike in concentration is seen in one location compared to others. Results of VOC monitoring are also presented in Tables 6-9 below.

Discussion of IAQ and VOC Measurements for October 5, 2017

The indoor temperatures for October 5, 2017 ranged from 74.2°F to 78.4°F. Temperature measurements were within the recommended summer comfort ranges. Indoor relative humidity measurements ranged from 47.1 to 51.0% and were all within the recommended range of 30 to 60%.

Carbon dioxide concentrations ranged from 372 to 492 ppm. The concentration of concern for carbon dioxide is set by ASHRAE standard 62.1 as 700 ppm above outdoor air. On the day of monitoring, the outdoor air concentration of carbon dioxide was 262 ppm; therefore, concentrations were within the comfort parameters in all areas monitored. Measurements were made during a normal school day. Carbon monoxide is mainly attributed to incomplete combustion. Concentrations of CO were consistently 0.0 ppm for all indoor and outdoor locations monitored and were below the ASHRAE concentration of concern (9 ppm).

Indoor concentrations of VOCs measured on October 5, 2017 ranged from 0 to 110 ppb, and the outdoor measurement was 0 ppb. These measurements are considered low and do not indicate any obvious source of VOCs above a normal building background level. Results of IAQ and VOC monitoring on October 5, 2017 are presented in Table 6.

Table 6 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on October 5, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Front Lobby at Containment	3:53 PM	78.4	47.1	0.0	432	0

Table 6 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on October 5, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Pod Center (159-163)	3:58 PM	75.4	47.7	0.0	372	33
Hallway near Gym	4:00 PM	74.4	47.9	0.0	474	57
Pod Center (140)	4:03 PM	74.5	51.0	0.0	433	35
Pod Center (130)	4:06 PM	74.2	50.3	0.0	492	110
Outside	4:10 PM	79.1	52.6	0.0	262	0

Bold-faced indicates results outside of recommended comfort ranges or target concentrations.

Discussion of IAQ and VOC Measurements for October 18, 2017

The indoor temperatures for October 18, 2017 ranged from 71.2°F to 73.1°F. Temperature measurements in classrooms and occupied areas of the school were within the recommended summer comfort ranges. Indoor relative humidity measurements were between 38.5% and 41.9%, and below the recommended maximum of 60%.

Carbon dioxide concentrations ranged from 412 to 623 ppm within indoor occupied areas. The concentration of concern for carbon dioxide is set by ASHRAE standard 62.1 as 700 ppm above outdoor air. On the day of monitoring, the outdoor air concentration of carbon dioxide was 289 ppm; therefore, concentrations were within the comfort parameters in all areas monitored. Measurements were made on a normal school day. Carbon monoxide is mainly attributed to incomplete combustion. Concentrations of CO were consistently 0 ppm for all indoor and outdoor locations monitored and were below the ASHRAE concentration of concern (9 ppm).

Indoor concentrations of VOCs measured on October 18, 2017 ranged from 0 to 3 ppb, and the outdoor measurement was 0 ppb. The concentrations are considered low (<1,000 ppb). Air freshener odors were observed in the Classroom pod center near Room 139 on the day of monitoring. These odors may have been coming from the bathrooms nearby. Results of IAQ and VOC monitoring on October 18, 2017 are presented in Table 7.

Table 7 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on October 18, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Front Lobby at Containment	10:42 AM	72.0	38.5	0.0	528	0
Rm 113 (Guidance)	10:46 AM	71.6	39.3	0.0	489	0
Pod Center (159-163)	10:48 AM	72.1	38.5	0.0	439	0
Gym with full class	10:51 AM	69.3	42.0	0.0	412	0
Pod Center (140)	10: 56 AM	71.2	43.6	0.0	623	0
Pod Center (130)	10:59 AM	73.1	41.9	0.0	659	0-3
Outside	11:03 AM	68.5	35.5	0.0	289	0

Bold-faced indicates results outside of recommended comfort ranges or target concentrations.

Discussion of IAQ and VOC Measurements for October 27, 2017

The indoor temperatures for October 27, 2017 ranged from 71.9°F to 75.5°F. Temperature measurements in classrooms and occupied areas of the school were within the recommended comfort ranges. Indoor relative humidity measurements ranged from 39.4% to 47.0%, and were within the recommended comfort ranges of 30 to 60%.

Carbon dioxide concentrations ranged from 420 to 1,135 ppm within indoor occupied areas. The concentration of concern for carbon dioxide is set by ASHRAE standard 62.1 as 700 ppm above outdoor air. On the day of monitoring, the outdoor air concentration of carbon dioxide was 260 ppm; therefore, concentrations were within the comfort parameters in all areas monitored except the measurement collected in the center of the classroom pod near Room 139. Students were lining up to go to the buses in the center of the pod and about 50 students were nearby when the measurement was collected. Measurements were made during a normal school day. Carbon monoxide is mainly attributed to incomplete combustion. Concentrations of CO ranged from 0.0 ppm to 0.1 ppm for all indoor locations and the outdoor concentration was 0.2 ppm and below the ASHRAE concentration of concern (9 ppm).

Indoor concentrations of VOCs measured on October 27, 2017 were consistently 0 ppb, and the outdoor measurement was 0 ppb. The measurements are considered low (<1,000 ppb). Results of IAQ and VOC monitoring are presented in Table 8.

Table 8 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on October 27, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Front Lobby at Containment	3:00 PM	71.9	39.4	0.0	420	0
Room 113 (Guidance)	3:03 PM	72.5	41.2	0.0	618	0
Pod Center (159-163)	3:06 PM	73.3	41.9	0.0	35	0
Gym (5 students)	3:09 PM	74.0	42.2	0.0	788	0
Pod Center (140)	3:11 PM	74.6	40.7	0.0	673	0
Pod Center (130)	3:14 PM	75.5	47.0	0.1	**1,135**	0
Outside	3:17 PM	68.0	35.0	0.2	260	0

Bold-faced indicates results outside of recommended comfort ranges or target concentrations.

Discussion of IAQ and VOC Measurements for November 1, 2017

The indoor temperatures for November 1, 2017 ranged from 68.5°F to 73.0°F. Temperature measurements in classrooms and occupied areas of the school were all within the recommended comfort ranges. Indoor relative humidity measurements were between 35.5% and 40.0% and were all below the recommended maximum of 60%. Outdoor temperature and relative humidity were 59.5° F and 43.1%.

Carbon dioxide concentrations ranged from 513 to 909 ppm within indoor occupied areas. The concentration of concern for carbon dioxide is set by ASHRAE standard 62.1 as 700 ppm above

outdoor air. On the day of monitoring, the outdoor air concentration of carbon dioxide was 291 ppm; therefore, concentrations were within the comfort parameters in all areas monitored. Measurements were made during a normal school day. Carbon monoxide is mainly attributed to incomplete combustion. Concentrations of CO were consistently 0.0 ppm for all indoor locations and the outdoor concentration was 0.1 ppm. All concentrations measured were below the ASHRAE concentration of concern (9 ppm).

Indoor concentrations of VOCs measured on November 1, 2017 were consistently 0 ppb, and the outdoor measurement was 0 ppb. The measurements are considered low (<1,000 ppb). Results of IAQ and VOC monitoring are presented in Table 9.

Table 9 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on November 1, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Front Lobby at Containment	12:04 PM	68.5	40.0	0.0	534	0
Room 113 (Guidance)	12:07 PM	70.9	38.8	0.0	584	0
Pod Center (159-163)	12:10 PM	71.5	36.1	0.0	627	0
Gym	12:13 PM	72.0	39.8	0.0	909	0
Pod Center (140)	12:16 PM	72.7	35.5	0.0	513	0
Pod Center (130)	12:19 PM	73.0	36.4	0.0	597	0
Outside	12:22 PM	59.5	43.1	0.1	291	0

Bold-faced indicates results outside of recommended comfort ranges or target concentrations.

Conclusions and Recommendations

Based upon our observations and sampling results on October 5, 18 & 27 and November 1, 2017 at Swansfield Elementary School, attention is being given to prevent construction dust and odors from entering the occupied areas of the school. All measurements collected during these four visits were below target concentrations or within guidelines for comfort with the exception of one carbon dioxide measurement collected in a hallway with over 50 students. There is currently only one construction containment wall. This wall is completely sealed and is not used as a door for construction workers.

AE will continue to make weekly visits to Swansfield Elementary School as requested. Thank you for choosing Aria Environmental, Inc. for your industrial hygiene consulting needs. Should you have any questions about the information contained herein, please do not hesitate to contact us at 410-549-5774.

Sincerely,
Aria Environmental, Inc.

Julie Barth

Julie Barth, CIH, CSP, LEED Green Associate