Aria Environmental, Inc.
INDUSTRIAL HYGIENE & SAFETY CONSULTANTS

November 14, 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 (August 29 and September 15, 22, and 28, 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 August 29, and September 15, 22 & 28, 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.

Discussion of Particle Results for August 29, 2017

The PM2.5 particle concentrations were consistently 0 µg/m³ and PM10 particle concentrations ranged from 0 to 3 µg/m³ in the newly completed construction phase on August 29, 2017. The school was occupied by custodians and a few construction workers on this day. PM 2.5 and PM 10 concentrations were below the target concentrations in the areas monitored. Results of particulate monitoring on August 29, 2017 are presented in Table 1.

Table 1 – Results of Particulate Monitoring Swansfield Elementary School on August 29, 2017

Location	Time	PM1 (µg/m³)	PM2.5 (µg/m³)	PM7 (µg/m³)	PM10 (µg/m³)	TSP (µg/m³)
Pod Center (159-163)	6:35 PM	0	0	0	0	1
Classroom 159	6:38 PM	0	0	0	0	0
Classroom 162	6:41 PM	0	0	0	0	0
Room 171	6:44 PM	0	0	0	0	1
Rm 157	6:48 PM	0	0	2	3	3
Gym	6:50 PM	0	0	1	1	2
Hall near 155	6:53 PM	0	0	2	2	4
Café	6:58 PM	0	0	0	0	0
Outside	7:03 PM	0	0	3	3	4

Bold-faced results indicate results above target concentrations.

Discussion of Particle Results for September 15, 2017

The PM2.5 particle concentrations ranged from 0 to 17 µg/m³ and PM10 particle concentrations ranged from 7 to 170 µg/m³ on September 15, 2017. PM 2.5 and PM 10 particle concentrations were all below the target concentrations in all locations except the front lobby where a new containment wall had been installed. The building was mostly occupied because it was a normal school day. Results of particulate monitoring on September 2, 2017 are presented in Table 2.

Table 2 – Results of Particulate Monitoring Swansfield Elementary School on September 15, 2017

Location	Time	PM1 (µg/m³)	PM2.5 (µg/m³)	PM7 (µg/m³)	PM10 (µg/m³)	TSP (µg/m³)
Outside	2:15 PM	0	0	2	2	3
Front Lobby	2:22 PM	1	**17**	131	**170**	204
Hall near Art Room 167	2:25 PM	0	0	7	11	22
Pod Center (159-163)	2:29 PM	0	0	4	7	22
Gym	2:32 PM	0	4	29	38	53
Hall near Gym	2:34 PM	0	5	36	47	70
Pod Center near Rm 144	2:39 PM	0	3	29	36	51

Bold-faced results indicate results above target concentrations

Discussion of Particle Results for September 22, 2017

The PM2.5 particle concentrations ranged from 0 to 36 µg/m³ and PM10 particle concentrations ranged from 2 to 499 µg/m³ on September 22, 2017. PM 2.5 concentrations were all below the target concentration except for the measurement in the front lobby (36 µg/m³). PM 10 particle concentrations were below the target concentrations in all locations except for the measurement in the front lobby (499 µg/m³). Custodians reported sweeping in the front lobby on this day. The

building was occupied with teachers, staff and construction workers and students had the day off. Results of particulate monitoring on September 22, 2017 are presented in Table 4.

Table 3 – Results of Particulate Monitoring Swansfield Elementary School on September 22, 2017

Location	Time	PM1 (µg/m³)	PM2.5 (µg/m³)	PM7 (µg/m³)	PM10 (µg/m³)	TSP (µg/m³)
Front Lobby	1:46 PM	4	**36**	319	**499**	838
Pod Center (159-163)	1:50 PM	0	0	2	2	3
Rm 157	1:53 PM	0	1	9	14	17
Gym	1:55 PM	0	1	3	4	9
4th Grade Pod Center	2:10 PM	0	2	12	18	29
Pod Center near 139	2:13 PM	0	0	1	2	4
Outside	2:16 PM	0	1	4	6	9

Bold-faced results indicate results above target concentrations

Discussion of Particle Results for September 28, 2017

The PM2.5 particle concentrations ranged from 0 to 46 µg/m³ and PM10 particle concentrations ranged from 4 to 397 µg/m³ in the areas monitored on September 28, 2016. Some areas had PM 2.5 and PM 10 particle concentrations above the target concentrations. The drywall containment in the front lobby had been deconstructed and reinstalled approximately 4 hours prior to the monitoring. This explains the higher particle measurements in the areas near the front lobby. The higher particle concentrations in the Gym and in the center of the 4th Grade Pod may have been related to this drywall work. No other explanation for the higher particle concentrations was observed. The Results of particulate monitoring on September 28, 2017 are presented in Table 4.

Table 4 – Results of Particulate Monitoring Swansfield Elementary School on September 28, 2017

Location	Time	PM1 (µg/m³)	PM2.5 (µg/m³)	PM7 (µg/m³)	PM10 (µg/m³)	TSP (µg/m³)
Front Lobby @ Containment	12:57 PM	4	**31**	187	**259**	345
Front Lobby @ Bench	1:00 PM	4	**46**	298	**397**	503
Main Office	1:03 PM	3	**20**	86	**106**	126
Face	1:07 PM	0	4	25	33	61
Rm 113 (Guidance)	1:10 PM	2	**17**	66	**84**	104
Pod Center (159-163)	1:18 PM	0	1	5	6	10
Gym Entrance	1:20 PM	1	10	58	**77**	97
Pod Center (140s)	1:24 PM	1	**15**	108	**129**	157
Pod Center (130s)	1:27 PM	0	0	3	4	8
Outside	1:30 PM	0	0	5	9	14

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 August 29, 2017

The indoor temperatures for August 29, 2017 ranged from 68.5°F to 72.1°F. Most temperature measurements were below the recommended summer comfort ranges. Indoor relative humidity measurements ranged from 52.6 to 75.5% and were mostly within the recommended range of 30 to 60%.

Carbon dioxide concentrations ranged from 269 to 380 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 260 ppm; therefore, concentrations were within the comfort parameters in all areas monitored. Measurements were made during a day when the building was occupied with teachers, staff and construction workers only prior to the start of the school year. Carbon monoxide is mainly attributed to incomplete combustion. Concentrations of CO ranged from 0.0 ppm to 0.1 ppm for all indoor and outdoor locations monitored and were below the ASHRAE concentration of concern (9 ppm).

Indoor concentrations of VOCs measured on August 29, 2017 ranged from 0 to 50 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 August 29, 2017 are presented in Table 6.

Table 6 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on August 29, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Pod Center (159-163)	6:35 PM	**70.4**	53.6	0.0	346	0
Classroom 159	6:38 PM	**69.8**	52.6	0.0	272	0
Classroom 162	6:41 PM	**68.5**	54.3	0.0	320	0
Room 171	6:44 PM	**70.3**	58.0	0.0	269	0
Rm 157	6:48 PM	**72.1**	57.6	0.0	304	39
Gym	6:50 PM	**70.9**	**67.9**	0.0	283	28
Hall near 155	6:53 PM	**71.1**	59.3	0.0	380	50
Café	6:58 PM	**69.8**	**75.5**	0.1	296	0
Outside	7:03 PM	68.0	79.3	0.0	260	0

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

Discussion of IAQ and VOC Measurements for September 15, 2017

The indoor temperatures for September 15, 2017 ranged from 75.2°F to 78.8°F. Temperature measurements in classrooms and occupied areas of the school were within the recommended summer comfort ranges. Indoor relative humidity measurements were all between 53% and 60%, with one measurement at the recommended maximum of 60%.

Carbon dioxide concentrations ranged from 442 to 584 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 337 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 ranged from 0.1 ppm to 0.6 ppm for all indoor and outdoor locations monitored and were below the ASHRAE concentration of concern (9 ppm).

Indoor concentrations of VOCs measured on September 15, 2017 ranged from 100 to 321 ppb, and the outdoor measurement was 0 ppb. The concentrations are considered low (<1,000 ppb) but variations in concentrations indicate sources of VOCs that are most likely related to new building materials, new furniture and school supplies. One employee reported that she noticed fuel odors after school in the past week and she said that there had been sewage leaks on September 14. No fuel odors or sewage types odors were observed on the day of monitoring and no sign of water damage was observed. Results of IAQ and VOC monitoring on September 22, 2017 are presented in Table 7.

Table 7 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on September 15, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Outside	2:15 PM	82.5	54.6	0.0	337	0
Front Lobby	2:22 PM	78.8	55.3	0.6	442	100
Hall near Art Room 167	2:25 PM	75.8	53.0	0.1	499	189
Pod Center (159-163)	2:29 PM	75.4	54.1	0.1	522	204
Gym	2:32 PM	75.2	**60.0**	0.2	493	310
Hall near Gym	2:34 PM	75.5	59.9	0.2	558	254
Pod Center near Rm 144	2:39 PM	75.4	57.5	0.1	584	321

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

Discussion of IAQ and VOC Measurements for September 22, 2017

The indoor temperatures for September 22, 2017 ranged from 75.1°F to 80.1°F. Temperature measurements in classrooms and occupied areas of the school were mostly within the recommended summer comfort ranges. Indoor relative humidity measurements ranged from 49.8% to 63.8%, and were mostly below 60%.

Carbon dioxide concentrations ranged from 288 to 357 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 249 ppm; therefore, concentrations were within the comfort parameters in all areas monitored. Measurements were made during a day when the building was occupied with teachers, staff and construction workers. Students had the day off. Carbon monoxide is mainly attributed to incomplete combustion. Concentrations of CO ranged from 0.0 ppm to 0.8 ppm for all indoor and outdoor locations monitored and were below the ASHRAE concentration of concern (9 ppm).

Indoor concentrations of VOCs measured on September 22, 2017 ranged from 0 to 546 ppb, and the outdoor measurement was 0 ppb. The measurements are considered low (<1,000 ppb) but variations in concentrations indicate sources of VOCs that are most likely related to new building materials, new furniture and school supplies. A paint or glue-type of odor was observed in the gym that reportedly was due to new paint and window caulk in the gym storage room. These activities could have contributed to the higher concentration of VOCs in the Gym (546 ppb). Results of IAQ and VOC monitoring on September 15, 2017 are presented in Table 8.

Table 8 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on September 22, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Front Lobby	1:46 PM	80.1	54.8	0.8	357	353
Pod Center (159-163)	1:50 PM	76.1	49.8	0.0	300	0
Rm 157	1:53 PM	75.5	58.3	0.0	446	435
Gym	1:55 PM	76.1	**63.8**	0.0	288	546

Table 8 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on September 22, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
4th Grade Pod Center	2:10 PM	75.1	55.8	0.1	305	224
Pod Center near 139	2:13 PM	75.0	56.0	0.0	345	292
Outside	2:16 PM	79.3	63.2	0.0	249	0

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

Discussion of IAQ and VOC Measurements for September 28, 2017

The indoor temperatures for September 28, 2017 ranged from 73.8°F to 79.4°F. Temperature measurements in classrooms and occupied areas of the school were all within the recommended summer comfort ranges. Indoor relative humidity measurements were between 44.2% and 59.9% and were all below the recommended maximum of 60%. Outdoor temperature and relative humidity were 76.4° F and 39.4%.

Carbon dioxide concentrations ranged from 477 to 725 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 252 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 ranged from 0.0 ppm to 0.5 ppm for all indoor and outdoor locations monitored and were below the ASHRAE concentration of concern (9 ppm).

Indoor concentrations of VOCs measured on September 28, 2017 ranged from 0 to 337 ppb, and the outdoor measurement was 0 ppb. The measurements are considered low (<1,000 ppb) but variations in concentrations indicate sources of VOCs that are most likely related to new building materials, new furniture and school supplies. An odor was reported in Guidance Room 113. The odor observed by the industrial hygienist was a slight plastic or putty-type odor, and the VOC concentration was only 87 ppb in this room. Results of IAQ and VOC monitoring on September 28, 2017 are presented in Table 9.

Table 9 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on September 28, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Front Lobby @ Containment	12:57 PM	79.4	44.2	0.4	568	14
Front Lobby @ Bench	01:00 PM	78.6	45.9	0.4	569	15
Main Office	01:03 PM	76.1	45.3	0.5	492	18
Face	01:07 PM	73.8	47.0	0.1	519	0
Rm 113 (Guidance)	01:10 PM	74.6	59.9	0.1	725	87
Pod Center (159-163)	01:18 PM	75.7	51.1	0.2	503	144
Gym Entrance	01:20 PM	75.6	51.0	0.0	477	160

Table 9 – Results of Indoor Air Quality (IAQ) Measurements at Swansfield Elementary School on September 28, 2017

Location	Time	Temperature (°F)	Relative Humidity (Rh%)	Carbon Monoxide (CO)	Carbon Dioxide (CO_2)	Volatile Organic Compounds (VOCs)
Pod Center (140s)	01:24 PM	75.7	52.5	0.1	525	156
Pod Center (130s)	01:27 PM	74.8	53.8	0.0	568	337
Outside	01:30 PM	76.4	39.4	0.0	252	0

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

Conclusions and Recommendations

Based upon our observations and sampling results on August 29, 2017, September 15, 2017, September 22, 2017 and September 28, 2017 at Swansfield Elementary School, attention is being given to prevent construction dust and odors from entering the occupied areas of the school. Although the particle measurements were above the recommended concentrations in some areas, these were temporary conditions (drywall installation or sweeping) and the school is fully occupied. Elevated concentrations are expected in a fully occupied building and are not entirely due to construction activities. The tiled floors were being kept clean of visible dust. 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