April 27th, 2017

RSU #38
C/o Curt Morse
2250 Millard Harrison Drive
Readfield, Maine 04355

Re: Limited Indoor Carbon Dioxide (CO_2) Assessment at Manchester Elementary School on 17 School Street in Manchester, Maine.

AQM Project #: 17-200

Air Quality Management Services, Inc. (AQM) conducted a limited Carbon Dioxide (CO_2) assessment at your request on April 24th, 2017 in locations throughout the School at the above location.

I. Background

AQM's services were retained on March 30th, 2017 (AQM Project # 17-164) due to a reported concern for air quality in the McNaughton Classroom (reportedly due to odors detected upon entering the Classroom and reported headaches). AQM was originally asked only to perform mold testing, but given the complaint (headaches), AQM also performed measurement of Carbon Dioxide (CO_2) levels. AQM found CO_2 levels to be below regulatory levels, but exceeding comfort guidelines.

Client requested CO_2 testing in other areas of the building due to levels that were identified in the previous sampling event (See Above). Sampling was performed from 10:00 to 12:45 (when children were in their Classrooms – as applicable).

II. Actions to Date

Occupants of the McNaughton Classroom have reportedly been moved to another Classroom in the Building.

III. Testing

Carbon dioxide (CO_2) was measured with a TSI IAQ-Calc 7545 meter.

IV. Observations

Classrooms were occupied at the time of the sampling event, unless as noted in the Table on Page 2.

V. Results

Table 1. Carbon Dioxide (CO_2) Levels

Site	CO_2 (ppm)	Occupied	Comments
Outdoors	520	N/A	
Main Hallway	679	N/A	
McNaughton (Empty –Windows Closed)	760	N/A	
McNaughton (Empty – Windows Open)	605	N/A	
Henry Classroom	1830	Yes	
Galletta Classroom	1790	Yes	
Art Room / Science	2395	Yes	
Ballard Classroom	2170	Yes	
Mitchell Classroom	1650	Yes	
Collins Classroom	2316	Yes	
Pierce Classroom	1609	Yes	
Computer Lab	1267	Yes	
Tarr Classroom	1947	Yes	
Special Ed (McMullen)	952	Yes	
Gurney Classroom	1450	Yes	
Johnson Classroom	992	Yes	
Dwyer Classroom	997	1 Student	
Teacher's Room	865	Yes – Lunch Time	
Library	597	2 Adults – 1 Student	
Speech (Cole Classroom)	1388	Teacher – 2 Students	
GT Room	985	Teacher – 2 Children	
Office	768	Yes	
Boudreau Classroom	774	Yes	
Kindergarten Hallway	895	N/A	
Holman Classroom (shortly after occupancy)	1502	No	
Gym (During Lunch)	680	Yes	
Doherty Classroom (Pre-K)	966	Yes	
Vining Classroom	660	Yes	
Reading Room 1	922	Yes	
Criteria	1000 (1) / 5000 (2)	----	----

Key: ppm = parts per million; CO_2 = Carbon dioxide
(1) ASHRAE (Prior) Limit Guideline (Maximum)
(2) OSHA PEL (Permissible Exposure Limit)
N/A = Not Applicable

V. Results (Continued)

Carbon dioxide (CO_2) was well below the OSHA regulatory limit in each location tested; however it was elevated relative to the former ASHRAE Limit (1000 ppm) for some locations tested (See Gray Shaded Cells in the Chart on Page 2). Note that ASHRAE no longer specifies a specific numerical guideline for CO_2. Past ASHRAE guideline documents specified an upper limit of 1000 ppm for carbon dioxide, but this is not stated in current guidelines. The 1000 ppm limit has never been considered a requirement and is neither a ceiling nor a time weighted average value. Rather, it has been considered a target concentration level based on adequate removal of human bioeffluents / odors. Since comfort (odor) criteria are likely to be satisfied when the CO_2 does not exceed 1000 ppm the converse is also likely to be true, i.e., when the CO_2 level exceeds 1000 ppm, the comfort (odor) criteria may not be satisfied.

In addition to the above odor / comfort based criteria, there is recent evidence that moderate amounts of Carbon Dioxide can lead to measurable cognitive effects among occupants (Satish U, Mendell MJ, Shekhar K, Hotchi T, Sullivan D, Streufert S, Fisk WJ. 2012. Is CO_2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO_2 Concentrations on Human Decision-Making Performance. Environ Health Perspect 120:1671–1677; http://dx.doi.org/10.1289/ehp.1104789). This study found that moderately high indoor concentrations of carbon dioxide (CO_2) can significantly impair people's decision-making performance. On nine scales of decision-making performance, test subjects showed significant reductions on six of the scales at CO_2 levels of 1,000 parts per million (ppm) and large reductions on seven of the scales at 2,500 ppm. Refer to the above citation for additional details. The lower level (1000 ppm) used in the recent study noted here is not a calculated threshold level, but simply the lowest level in the study that produced a measurable effect in individuals (2500, 1000 and 600 ppm levels were used in the study, with no effects noted at 600 ppm). Therefore it is possible for effects to occur below 1000 ppm (but above 600 ppm), based on this study. For Locations with Gray Shaded Cells in the Chart on Page 2, CO_2 levels were elevated beyond the mid-level used in the study (1000 ppm) but below the maximum level (2500 ppm). Based on this study, some effects on decision-making performance are possible. Some effects may also be possible in those areas with CO_2 between 600 and 1000 ppm; however, note that 600 ppm is not a threshold level, but is merely the highest level with no effects in the quoted study. Achieving 600 ppm CO_2 in a building may not be economically feasible nor is it known to be necessary.

To AQM's knowledge, the levels of CO_2 in Locations with Gray Shaded Cells are below the level where the CO_2 itself would produce any direct health effects (the 5000 ppm level is generally used as this threshold). However, as an indicator of ventilation, with higher CO_2 levels it is likely that ventilation in the area is not optimal. When this is the case, volatile chemicals from common indoor materials and products (e.g. cleaning solutions, markers, perfumes and fragrances, etc.) and even common particulates may accumulate and potentially affect sensitive individuals. Improving ventilation (outdoor air exchange) should alleviate these issues.

VI. Discussion and Recommendations

- Improve ventilation with the outdoors in the Building to reduce CO_2 levels. Ideally, this is best achieved with a building mechanical system, which draws in variable amounts of outdoor air depending on occupancy and/or other conditions. Control of outdoor air exchange may be coupled to CO_2 levels using local sensors and automated (computer) control.
- Other solutions to ventilation may be effective. This might be achieved by opening windows (interim control). A local air-exchange unit may also be installed to address ventilation in specific Classrooms (monitoring areas of concern with CO_2 meters may be beneficial and assist in operating local air-exchange units).
- Also consider better ventilation in Classrooms / Areas where CO_2 levels are close to 1000 (approximately 800 and above). These levels can escalate with increased occupancy, and as noted previously there is some possibility of cognitive effects on occupants in this CO_2 range.

AQM appreciates this opportunity to have aided in this project. In the event you have questions or require further assistance, please do not hesitate to contact us.

Sincerely,

Randy Geoffroy, CMI
Industrial Hygienist