INDOOR AIR QUALITY ASSESSMENT

South Street Elementary School
376 South Street
Fitchburg, MA 01420

Winter 2008/2009

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
July 2009

Background/Introduction

At the request of the Fitchburg Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality (IAQ) at South Street Elementary School (SSES), 376 South Street, Fitchburg, Massachusetts. The IAQ Program conducted an assessment of the SSES on June 13, 2008, as detailed in a report released in July 2008 (MDPH, 2008) and discussed at a presentation to the school committee on September 15, 2008.

Since the initial assessment of SSES was conducted during warm weather, BEH's IAQ Program agreed to return and assess the building during the heating season when the heating, ventilating and air conditioning (HVAC) system was operating. Under Massachusetts General Law c. 149, sec. 113, workplaces "shall be properly heated during the period from October fifteenth to May fifteenth", which essentially correspond to late fall to early spring each year.

Ms. Lisa Hébert, Regional IAQ Inspector within BEH's IAQ Program, visited the SSES on November 6, 2008. The HVAC system and furnace system were operating at the time of the visit. Due to objections by several building staff about conducting an indoor air quality assessment on a temperate fall day [outdoor temperature 59° F (Weather Underground, 2009)], IAQ staff agreed to conduct further indoor air-sampling later during the winter of 2008-2009. Michael Feeney, Director of BEH's IAQ Program, and Ms. Hébert returned to the building on February 6, 2009 to conduct additional air-sampling. This report details indoor air quality testing results based upon the November 6, 2008 and February 6, 2009 visits. Details concerning repairs conducted as a result of the DPH IAQ Program July 2008 report (MDPH, 2008) are also provided in this report.

The SSES is a building complex that consists of four wings that were constructed at various times during the 1940s, 50s and 60s (Map 1). The original three, free-standing buildings were the campus of Holy Family High School, which closed prior to the acquisition of the buildings and grounds by the Fitchburg School Department in the 1990s. The sections of the complex are as follows:

- The West Building was constructed as a free standing, four-story convent with basement in 1940. This building was converted into the Fitchburg School Department headquarters. The wing currently contains a medical office, several kindergarten classes and a former chapel converted into a music room.
- The North Building was constructed in the 1950s as a free standing structure that served as a parochial elementary school. This building contains classrooms and gymnasium/cafeteria. A copier resides in what was formerly a kitchen.
- The South Building was constructed in the 1960s as a free standing building that served as a parochial high school. The building was constructed as a two-story structure, with two occupied classrooms on the basement level. This wing currently contains classrooms and a gymnasium.
- The East Building was constructed in the 1990s and joins the three, free-standing buildings into a single building complex. It is a single-story structure that contains a library, cafeteria, art room and several classrooms.

It is important to note that each wing contains a separate, independently operating boiler room. The North and South Buildings contain crawlspace for pipes and electrical conduit. The East and West Buildings do not have crawlspace.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak,™ IAQ Monitor, Model 8551. Air tests for airborne particulate matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. BEH staff performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school has a student population of approximately 1,300 and a staff of approximately 80. Tests were taken during normal operations at the school and results appear in Tables 1 and 2.

Discussion

Ventilation

It can be seen from that carbon dioxide levels were above 800 parts per million (ppm) in 40 of 65 areas on November 6, 2008 (Table 1) and in 31 of 73 areas on February 6, 2009 (Table 2), indicating inadequate air exchange in a number of areas surveyed during the assessment dates. It is important to note that a number of classrooms were empty/sparsely populated, which can result in reduced carbon dioxide levels. Carbon dioxide levels would be expected to increase with greater occupancy. Each building has a different configuration and manufacturer of HVAC equipment components. The buildings are discussed in order of construction (i.e., oldest to newest).

West Building

As reported by Fitchburg school officials, the West Building was converted from church living quarters to classrooms and office space about the same time the East Building was constructed. Fresh air in classrooms is supplied by unit ventilator (univent) systems (Figure 1). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Adjustable louvers control the ratio of outside to recirculated air. With univents in their current condition, the sole source of fresh air is open windows. Univents were also found obstructed by materials stored on top of air diffusers and/or in front of return vents. In order for univents to operate as designed, units must be activated while rooms are occupied and air diffusers should remain free of obstructions. Classrooms do not appear to have exhaust vents. Without sufficient exhaust ventilation, environmental pollutants can build up, leading to indoor air quality/comfort complaints.

Office space contains both fresh air supply and return vents that are connected to an air-handling unit (AHU) via ductwork. Cooling in some offices is provided by window-mounted air conditioners.

The former chapel/music room is serviced by a second AHU. Ductwork connects the fresh air supply and return vents to an AHU. It could not be determined if this equipment was functional at the time of the assessment.

North Building

Fresh air is supplied to classrooms by univents. These univents were manufactured by John J. Nesbitt, Inc. and were likely installed when the building was constructed (1950s). No information for John J. Nesbitt, Inc. could be identified by BEH staff, suggesting that this company no longer exist. Thus, obtaining replacement parts for these univents is extremely difficult at best. Two univent fresh air supply vents are located below grade, which would render these univents vulnerable to drawing moisture, pollen and other debris into the univents.

Exhaust ventilation is provided by vents located in storage closets. Air is drawn into the closets via undercut doors. Air then exhausts through vents at the top of the closets, which are ducted to a series of rooftop motors. According to SSES facilities staff, teachers in this building requested that the exhaust vents be turned off due to excessive noise. SSES facilities staff also reported that the original motors for the rooftop exhaust were replaced with those that are a ½ horse power rating higher, which would increase noise associated with their operation.

As mentioned in the previous report, a copier is located in an abandoned kitchen. A local exhaust fan was off in the copy room at the time of Febraury 2009 assessment.

South Building

Fresh air is supplied to classrooms by univents. These univents were manufactured by AAF-Herman Nelson and were likely installed when the building was constructed (1960s). Due to the age and condition of these univents, maintenance of these units would be difficult. BEH staff found many univents deactivated at the time of assessment.

The mechanical exhaust ventilation system in classrooms consists of unit exhaust ventilators. A unit exhaust ventilator appears similar to a univent, but removes air from the

classroom and exhausts it out of the building. As with the univents, BEH staff found a majority of the unit exhaust vents deactivated at the time of the assessment. Without sufficient supply and exhaust ventilation, environmental pollutants can build up, leading to indoor air quality/comfort complaints.

Mechanical ventilation in the gymnasium is provided by AHUs located in mechanical rooms. Fresh air is supplied by vents located on the ceiling; air is returned to the AHUs by wall-mounted exhaust vents.

East Building

Fresh air is supplied to classrooms by univents. Exhaust ventilation is provided by ceiling mount vents connected to the roof exhaust via ductwork. Mechanical ventilation in large areas (e.g., library, cafeteria, and kitchen) is provided by air handling units (AHUs) located in mechanical rooms.

As discussed, mechanical ventilation must be free of obstructions and allowed to operate while rooms are occupied. Without sufficient supply and exhaust ventilation, environmental pollutants can build up, leading to indoor air quality/comfort complaints.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of the system was not available at the time of the assessment.

The Massachusetts Building Code requires that each area have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature measurements ranged from 68° F to 72° F on November 6, 2008 (Table 1) and 65° F to 89° F on February 6, 2009 (Table 2), which were above the MDPH recommended comfort guidelines in a number of classrooms. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of

building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Of note are classrooms in the east wing, where temperatures ranged from 81°F to 89°F during the February 6, 2009 assessment. Thermostats that should control temperature in these classrooms were installed using a pneumatic system which has failed. In essence, no temperature control exists to activate louvers that would draw fresh air to temper the heated air provided by the univents, which leads to uncontrolled heating of air. Teachers frequently will open windows to attempt to temper air in classrooms, but windows were intentionally closed on the day of the February 2009 assessment, as reported by a teacher in this wing. In the July 2008 assessment, BEH staff recommended opening windows to help temper air in these classrooms. If temperature in any room is above 78° F, windows should be opened to increase comfort in these classrooms.

The relative humidity ranged from 51 to 64 percent on November 6, 2009 (Table 1), within the MDPH recommended comfort range. Relative humidity ranged from 7 to 26 percent on February 6, 2009 (Table 2), below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. "Extremely low (below 20%) relative humidity may be associated with eye irritation [and]…may affect the mucous membranes of individuals with bronchial constriction, rhinitis, or cold and influenza related symptoms" (Arundel et al., 1986). The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States. In addition to "dry and sore nose and throat, inability to wear contact lenses, and dry, itchy, flaky

skin" [low relative humidity] can "contribute to an increase in respiratory illness by weakening the defense provided by the mucous membranes" (Bayer et al., 1999). As discussed, for buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations) (MDPH, 2008). These recommendations should be adopted if SSES has not already done so, since the relative humidity measurements were below 20% in a number of classrooms when the heating system is activated.

Microbial/Moisture Concerns

North Building

As indicated in the previous report, a crawlspace exists beneath the first floor of this building that is accessible from the boiler room. Spaces and holes in walls and floors around pipes and within the air-handling cabinet were sealed as recommended.

East Building

Concerns have been raised regarding the presence of a storm drain located within several feet of a univent's fresh air intake. While storm drains can be a source of microbial growth, there are several factors that may limit the effect of pollutants from this drain, particularly in cold weather.

- With snow cover, a barrier exists between the univent fresh air intake and the storm drain (Picture 1).
- Cold air will tend to sink into the storm drain, creating a downward air movement.
- The draining of water from the bottom of the drain will create suction, which will draw air from the outdoors into the drain pit.
- Water draining from the storm drain will prevent standing water, which may be a source of microbial growth.
- Microbial growth is inhibited at temperatures below 45° F.
- Due to the lack thermostat control, it is highly likely that the fresh air intake control damper is closed, preventing the draw of air from the vicinity of the storm drain.

Under these conditions, it is unlikely that the storm drain has any effect on the univent fresh air intake during cold weather. These conditions may change during warm weather if the drain is not functioning properly and standing water exists in the storm drain.

The purpose of the drain is to remove water that runs off the bus shelter, which was not equipped with gutters or downspout. An alternative would be to install a gutter or downspout on the bus shelter, which can be connected to the storm drain via an underground pipe. Connecting a downspout directly to the storm drain would allow for a water permeable covering (e.g. stone) to limit possible airflow from the storm drain to the univent fresh air intake.

It is not appropriate to shut off the univent fresh air intake as has been suggested to BEH staff. If this were done, this action would then eliminate the ability of the univent to introduce fresh air into the classroom, which would then cause normally occurring pollutants in the classroom to build which could possibly adversely affect all of the occupants in the classroom.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon Monoxide

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health effects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public

health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2006). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2006).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Tables 1 and 2). Carbon monoxide levels measured in the school were also ND.

Particulate Matter (PM2.5)

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2006). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA established a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 $\mu g/m^3$ over a 24-hour average (US EPA, 2006). Although both the ASHRAE standard and BOCA Code adopted the

PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations the day of the assessment were measured at 12 $\mu g/m^3$. PM2.5 levels measured inside the school ranged from 1 to 11 $\mu g/m^3$ on November 6, 2008 (Table 1) and 5 to 27 $\mu g/m^3$ on February 6, 2009 (Table 2). Indoor PM 2.5 levels for both days of assessment were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Conclusions/Recommendations

As indicated in the previous BEH IAQ assessment report, the conditions found at the SSES present issues that require a variety of remedial steps. The SSES has an HVAC system that is not unified, with each wing functioning as a separate building with its own furnace. The combination of age and lack of maintenance of HVAC equipment in the north and south wings limit the ability of these systems to both dilute and remove air from SSES classrooms. The HVAC system components installed in the west wing lack exhaust ventilation, and in the east wing, do not have a control system that is readily repairable. The combination of the design of the building, capital maintenance issues and occupant activities present conditions that can adversely influence indoor air quality. For these reasons a two-phase approach is required,

consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns.

In view of the findings at the time of the visits, the following **short-term** recommendations are made:

1. Continue to implement recommendations made in the July 2008 MDPH IAQ Program assessment.
2. Use openable windows in conjunction with classroom univents and unit exhaust vents to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
3. Assess whether unit ventilator exhaust vents in the South Building are operational and repairable.
4. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
5. Consult a ventilation engineer to ascertain the best method for increasing fresh air supply and controlling temperature in classrooms. Operate all ventilation systems throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange. To increase airflow in classrooms, set univent controls to “high”.

The following **long-term** measures should be considered:

1. Based on the age, physical deterioration and availability of parts for ventilation components, the BEH strongly recommends that an HVAC engineering firm fully evaluate the ventilation system. It is possible that restoration of the current univents in this building is not feasible from a technical standpoint or may be cost prohibitive since

the manufacturer appears to be out of business. If repair is technically not feasible or is cost prohibitive, consideration should be give to replacing the ventilation system.

2. Consider equipping the bus shelter with a gutter downspout, which can then connect to the storm drain via an underground pipe. Then consider covering the storm drain with an appropriate water permeable covering (e.g. stone) to limit possible airflow from the storm drain to the univent fresh air intake.

3. Examine the feasibility of providing exhaust ventilation for the classrooms in the West Building.

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Picture 1

Storm Drain outside Room 105

Location: South Street Elementary School **Indoor Air Results**

Address: 376 South St. Fitchburg **Table 1** **Date: 11/6/08**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
background			87							
North 326	8	69	58	1344	ND	11	Y	Y	Y	DC, Univent not on
327	58 8	69	56	ND 1043	ND	10	Y	N	Y	DC
329	1	69	56	989	ND	11	N	N	N	DC
330	6	69	55	1177	ND	9	Y	N	N	DC, WDCT
340	0	69	53	948	ND	10	Y	N	N	DO
Gym	2	67	52	643	ND	7	N	Y	Y	DO
Copy room	0	64	69	436	ND	3	Y	N	Y Fan on wall	DC

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
DO = door open
FC = food container
GW = gypsum wallboard
MT = missing ceiling tile
NC = non-carpeted

ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals

TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WD = water-damaged
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location: South Street Elementary School **Indoor Air Results**

Address: 376 South Street Fitchburg **Date: 11/6/08**

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
346	0	67	62	1045	ND	10	Y	Y	Y	DO, exhaust still blocked
345	3	67	61	979	ND	11	Y	Y	Y	DO, clutter on univent
344	0	66	62	538	ND	4	Y	Y	Y	
343	7	67	64	862	ND	7	Y	Y	Y	DO, exhaust blocked by boxes
342	1	67	63	785	ND	6	Y	Y	Y	DO
3-5	0	67	63	744	ND	5	Y	Y		DO
3-7	0	68	62	836	ND	8	Y	Y	Y	
3-15	1	67	58	781	ND	6	Y	Y	Y	DC

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Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
3-14	2	68	60	807	ND	5	Y	Y	Y	DO Univent blocked
3-13	32	69	51	916	ND	11	Y	Y	Y	DO
3-12	13	69	61	881	ND	9	Y	Y	Y	DO
3-11	15	69	60	896	ND	8	Y	Y	Y	DO
East Building 105	1	69	60	878	ND	10	Y	Y	Y	DO, Carpet gone, new tile floor
106	0	69	60	925	ND	8	Y	Y	Y	DC, Univent blocked
107	23	70	59	1052	ND	8	Y	Y	Y	DC
108	0	70	58	1027	ND	5	Y	Y	Y	DO

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Table 1 (continued)

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								Supply	Exhaust	
112	18	69	60	1090	ND	5	Y	Y	Y	DO
113	2	69	58	790	ND	6	Y	Y	Y	DC
114	2	69	59	663	ND	6	Y	Y	Y	DO
115	19	70	61	1083	ND	5	Y	Y	Y	DO, CT in tact, no leaks evident
116 Library	3	69	57	630	ND	4	Y	Y	Y	DC
138 Art	10	69	58	1264	ND	15	Y	Y	Y	DO, Univents blocked, Lots of paper
Cafeteria	96	68	62	623	ND	6	Y	Y	Y	
South Bldg 2-7	0	67	58	631	ND	4	Y	Y	Y	

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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location: South Street Elementary School **Indoor Air Results**

Address: 376 South Street Fitchburg **Date: 11/6/08**

Table 1 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2-5	3	67	60	644	ND	5	Y	Y	Y	
2-31	0	67	57	482	ND	4	Y	Y	Y	
2-32	0	68	59	927	ND	8	Y	Y	Y	DC
2-36	2	68	59	928	ND	6	Y	Y	Y	Exhaust blocked
2-28 Gym	20	69	60	1028	ND	15	Y	Y	Y	DC
223A	0	68	57	836	ND	6	Y	N	N	
223B	2	68	58	1110	ND	12	Y	N	N	DC
220	0	68	58	1151	ND	10	Y	N	Y	DC

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								Supply	Exhaust	
Reading Recovery	0	68	57	1041	ND	11	Y	Y	N	DO
2-15	6	68	59	1022	ND	9	Y	Y	Y	DC
2-42	2	68	59	1252	ND	6	Y	Y	Y	DO
2-46	21	70	63	1324	ND	10	Y	Y	Y	DO
2-48	26	70	64	1944	ND	14	Y	Y	Y	DO, WDCTs
2-44	0	70	58	584	ND	10	Y	Y	Y	DO
2-43	20	70	59	1214	ND	10	Y	Y	Y	DO
2-52	24	70	62	1424	ND	8	Y	Y	Y	Many WDCTs

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								Supply	Exhaust	
2-53	2	70	58	713	ND	4	Y	Y	Y	DO
2-58	7	70	59	1451	ND	4	Y	Y	Y	WDCTs
2-57	10	70	61	754	ND	5	Y	Y	Y	WDCTs
2-56	10	71	60	922	ND	7	Y	Y	Y	DC, WDCTs
2-55	23	72	60	1860	ND	9	Y	Y	Y	Many WDCTs
Nurse's Rm	1	70	54	599	ND	5	Y	Y	Y	Sump open
2	1	70	54	599	ND	5	Y	N	N	WDC
West Bldg 21-39	22	71	59	1276	ND	14	Y	Y	N	DO

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								Supply	Exhaust	
29-30	13	72	58	967	ND	8	Y	Y	N	
Mrs. Young Preschool	16	72	59	978	ND	6	Y	Y	N	WDCTs
Music	17	70	55	665	ND	4	Y	Y	Y	DO
Mrs. Wiljanen	1	71	54	693	ND	2	Y	Y	N	Clutter
KFMO	22	72	59	740	ND	2	Y Windows open	Y	N	DO
Mrs. Nadeau	24	73	58	921	ND	5	Y Windows open	Y	N	DO
OT/PT	1	71	54	476	ND	1	Y	Y	N	DC, Water damage above windows
Mrs. Hoeske	1	72	56	741	ND	2	Y	Y	N	

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								Supply	Exhaust	
Speech Pathology	1	70	56	475	ND	1	Y	N	N	DO
Mrs. Crotty	18	71	62	1185	ND	10	Y	Y Off	N	DO

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Location: South Street Elementary School **Indoor Air Results**

Address: 376 South Street Fitchburg **Table 2** **Date: 2/6/09**

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								Supply	Exhaust	
background					ND					
Mrs. W	1	70	16	669	ND	7	Y	Y	N	DO, Clutter
Ms. McCann	0	71	15	546	ND	9	Y	Y	N	
Psych	0	70	26	723	ND	10	Y	N	N	Holes in ceiling
Mrs. Morrison	21	72	20	1029	ND	7	Y	Y	N	Carpet under univent
Mrs. Nadeau	26	73	19	1074	ND	7	Y	Y	N	
PT & OT	5	72	18	827	ND	10	Y 2/4 open	Y Off	N	
Mrs. Clark	0	69	10	507	ND	9	Y	Y Off	N	
Mrs. Hoeske	1	70	14	734	ND	7	Y	Y	N	DEM

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								Supply	Exhaust	
Speech	0	70	21	701	ND	8	Y	N	N	
Ms. Crotty	17	71	15	725	ND	8	Y 3/7 open	Y Off	N	
Mr. Casey	18	72	17	859	ND	9	Y	Y Off	N	
29-30	3	73	15	607	ND	9	Y	Y Off	N	
Mrs. Young	0	74	14	601	ND	8	1/7 open	Y	Y	N
Guidance	4	75	11	579	ND	8	Y	N	N	
Nurse's	2	78	11	567	ND	10	Y 1/4 open	N	N	Musty smell in sump room
2	3	78	11	786	ND	8	Y	N	N	

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								Supply	Exhaust	
Music Room	20	74	12	647	ND	8	Y	Y	Y	Window open Supply off Exhaust off
Music storage left side	0	73	9	447	ND	7	Y	N	N	
Music storage right side	0	73	8	401	ND	8	Y	N	N	
Principal's office	2	73	12	752	ND	10	N	Y	Y	
Photocopy room	0	65	8	395	ND	7	Y	N	Y	Exhaust off
North gym	0	71	11	412	ND	6	N	Y	Y	
North gym office	0	73	13	677	ND	21	Y	N	N	
346	22	75	14	944	ND	11	Y	Y	Y	Supply off

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								Supply	Exhaust	
345	5	83	12	791	ND	9	Y	Y	Y	Supply off Exhaust off
344	0	81	8	632	ND	8	Y	Y	Y	Supply off Exhaust off
330	5	80	12	828	ND	10	Y	N	N	
343	0	80	10	761	ND	10	Y	Y	Y	Supply off Exhaust off
327	10	79	12	909	ND	13	Y	N	Y	
342	16	78	10	686	ND	12	Y	Y	Y	
326	7	79	10	764	ND	9	Y	Y	N	
328	3	79	12	1211	ND	12	Y	N	N	

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								Supply	Exhaust	
329	0	80	12	947	ND	11	N	N	N	
315	3	74	13	569	ND	11	Y	Y	Y	
314	28	75	15	892	ND	22	Y	Y	Y	Exhaust off
313	7	74	12	728	ND	10	Y	Y	Y	
312	12	75	14	763	ND	11	Y	Y	Y	DO
3-7	15	75	14	910	ND	11	Y	Y	Y	
3-6	13	73	12	874	ND	11	Y	Y	Y	Supply off Exhaust off
3-11	20	73	16	979	ND	11	Y	Y	Y	Supply off Exhaust off

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								Supply	Exhaust	
108	0	84	13	1111	ND	5	Y	Y	Y	
107	24	82	10	1014	ND	11	Y	Y	Y	
112	19	86	14	1111	ND	18	Y	Y	Y	
113	0	89	7	556	ND	8	Y	Y	Y	
106	1	87	5	470	ND	9	Y	Y	Y	
105	21	81	13	732	ND	10	Y	Y	Y	
114	0	83	7	379	ND	9	Y	Y	Y	
115	19	86	11	858	ND	13	Y	Y	Y	

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								Supply	Exhaust	
Library	30+	82	10	792	ND	11	Y	Y	Y	
Art Room	0	71	11	744	ND	12	Y	Y	Y	
Cafeteria	100+	73	15	799	ND	16	Y	Y	Y	
236	20	76	14	856	ND	13	Y	Y	Y	DO
South Gym	0	70	13	853	ND	27	Y	Y	Y	Supply off
232	23	71	16	950	ND	18	Y	Y	Y	Supply off Exhaust off
231	4	68	13	533	ND	11	Y	Y	Y	Exhaust off
2-6	21	68	13	533	ND	11	Y	Y	Y	Exhaust off

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								Supply	Exhaust	
2-58	6	71	14	652	ND	11	Y	Y	Y	Exhaust off
2-57	0	67	15	816	ND	11	Y	Y	Y	Exhaust off
2-56	10	72	17	961	ND	18	Y	Y	Y	Window open
2-53	0	71	13	852	ND	10	Y	Y	Y	
2-55	21	74	19	1456	ND	12	Y	Y	Y	Exhaust off
2-52	21	73	19	1722	ND	17	Y	Y	Y	Supply off Exhaust off
2-42	10	71	17	1003	ND	13	Y	Y	Y	Supply off Exhaust off
2-43	17	72	17	1108	ND	15	Y	Y	Y	Supply off Exhaust off

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								Supply	Exhaust	
2-46	15	72	18	1311	ND	18	Y	Y	Y	Supply off Exhaust off
2-44	0	72	14	1078	ND	13	Y	Y	Y	Supply off Exhaust off
2-47	13	70	19	1172	ND	12	Y	Y	Y	
2-48	19	73	18	1272	ND	15	Y	Y	Y	Supply off Exhaust off
2-23	3	71	15	740	ND	9	N	N	N	
2-21	1	70	15	756	ND	11	Y	N	N	
2-19	0	67	15	689	ND	10	N	N	N	
2-15	2	70	18	635	ND	9	Y	Y	Y	Supply off Exhaust off

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
DO = door open
FC = food container
GW = gypsum wallboard
MT = missing ceiling tile
NC = non-carpeted

ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals

TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WD = water-damaged
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location: South Street Elementary School **Indoor Air Results**

Address: 376 South Street Fitchburg **Date: 2/6/09**

Table 2 (continued)

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2-16	0	71	14	680	ND	13	Y	Y	Y	

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