INDOOR AIR QUALITY ASSESSMENT

South Street Elementary School
376 South Street
Fitchburg, MA 01420

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
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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 at South Street Elementary School, 376 South Street, Fitchburg, Massachusetts. On June 13, 2008, a visit to conduct an assessment at the South Street Elementary School (SSES) was made by Michael Feeney, Director, and Lisa Hébert, Regional Indoor Air Quality (IAQ) Inspector within BEH's IAQ Program. On June 20, 2008, Mr. Feeney returned to the SSES to perform a visual inspection of the building.

The SSES is a building complex that consists of four wings that were constructed at various times (Map 1). The original three-free standing buildings was 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 deconsecrated 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. It joins the three free standing buildings into a single building complex. The East building 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 a crawlspace for pipes and electrical conduit. The East and West Buildings do not have crawlspaces.

A number of different consultants have conducted mold related testing at the SSES. Air-sampling for mold was conducted at the SSES by an environmental consultant, AHI, on January 29, 2008 in five rooms (AHI, 2008; Appendix A). This AHI report found "trace quantities of biological matter" and made no recommendations concerning remediation (AHI, 2008). A second consultant returned to conduct air-sampling in the copier room on May 30, 2008. This consultant recommended that "fans and blower be utilized to dry…[ceiling plaster]…completely" (A1SS, 2008; Appendix B). A third consultant was contracted to conduct an indoor mold assessment of the copier room on May 28, 2008 (OHI, 2008). It was recommended that the entire ceiling of the copier room be replaced, with recommendations concerning renovation as well as methods to protect the copier equipment and adjoining areas during renovation.

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. Due to an equipment malfunction (Dust trak), PM2.5 readings are only available for 46 of 62 areas assessed at the SSES.

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 Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in of 6 of 62 areas, indicating adequate air exchange in the majority of areas surveyed during the assessment. It is important to note that several classrooms had open windows and/or were empty/sparsely populated; each of these factors can result in reduced carbon dioxide levels. Carbon dioxide levels would be expected to increase with full occupancy and with windows closed.

Each building has a different configuration and manufacturer of heating, ventilating and air-conditioning (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. Univents were found deactivated in all rooms (Table 1). 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 (Picture 1/Table 1). 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 listing for John J. Nesbitt, Inc. could by identified by BEH staff, suggesting that this company no longer exists. This would make obtaining replacement parts for these univents extremely difficult and, in turn, render maintenance a challenge. In addition, two univent fresh air supply vents are located in a below grade location, which would render these univents vulnerable to drawing moisture, pollen and other debris into the univents (Picture 2).

Exhaust ventilation is provided by vents located in storage closets (Picture 3). Air is drawn into the closets via undercut doors. Air is then exhausted 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 motors were replaced with ones that were a ½ horse power rating higher, which would increase noise associated with their operation. As mentioned, a copier is located in an abandoned kitchen. A local exhaust fan was operating in the copy room at the time of assessment (Picture 4).

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 (Picture 5). 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 C.

Temperature measurements ranged from 76^{o} F to 81^{o} F, which were on the high end of the MDPH recommended comfort guidelines (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} 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.

The relative humidity ranged from 24 to 35 percent during the assessment, which was below the MDPH recommended comfort range (Table 1). 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. 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.

Microbial/Moisture Concerns

BEH staff identified specific water damage issues in each of the buildings. Again for discussion purposes, each building is described in order of construction (i.e., oldest to newest).

West Building

A number of areas in this building had water damage to plaster, which appear to be related to window leaks (Picture 6) or water penetration through window-mounted air conditioning installations (Picture 7). The back "altar" area in the music room has substantial water damage and fallen plaster (Picture 8), likely due to roof leaks along the low roof in this section of the building. Plaster is a building material that is not likely to support mold colonization due to its alkalinity.[1] Water infiltration around and through plaster is denoted by the presence of efflorescence. Efflorescence is a characteristic sign of water damage to building materials, but it is not mold growth. As moisture penetrates and works its way through building materials (e.g., plaster), water-soluble compounds dissolve, creating a solution. As this solution moves to the surface, the water evaporates, leaving behind white, powdery mineral deposits.

A sump pump (Picture 9) is located within a closet in the nurse's office (Picture 10). Sump pumps can be a source for moistening porous materials, which can result in mold colonization. In addition, the cover for this sump pump was found propped against a wall of this closet.

[1] Gypsum plaster surfaces are alkaline with pH 7-13+ (USG, 2005)

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed/discarded.

Shrubbery was noted in direct contact with the exterior wall brick or was in close proximity to univent fresh air intakes in several areas around the building (Pictures 11 and 12). Shrubbery can serve as a possible source of water impingement on the exterior curtain wall. Plants were growing directly against the building. Plants retain water and in some cases can work their way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth.

Plants were located in a number of areas, particularly at the top of two staircases that do not have any mechanical ventilation (Picture 13). Plants, soil and drip pans can serve as sources of mold growth, thus should be properly maintained. Over watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants and related materials should also be located away porous materials (e.g., carpeting, paper products) to prevent damage and potential microbial growth in/on these materials.

Of note are the classroom univents on the second floor. It appears that carpeting was installed on the floor of these classrooms prior to the installation of univents. As a result, carpeting exists inside the univent air-handling and control compartments (Picture 14). This carpeting would be subject to moist air and leaks from heating pipes, which can then result in mold growth.

Lastly, a hole was observed in the downspout located on the northwest corner of the West Building (Picture 15). A hole of this nature can lead to excessive moistening of exterior wall brick.

North Building

Of note is the copier room. SSES staff had expressed concerns related to water damage on the ceiling (Picture 16) and wall of this room, as well as the skylight (Picture 17) outside the room. As discussed, the copier resides in the former kitchen. Eroded plaster and efflorescence was noted, but no mold colonization was visible. The room contained one capped drain (Picture 18), but also had a floor drain. This floor drain likely has a dry trap. The purpose of a drain trap is to prevent sewer system gases and odors from entering the occupied space. When water is poured into a trap, an air tight seal is created by the water in the U-bend section of the pipe. These drains must have water poured into the traps at least twice a week to maintain the integrity of the seal. Without water, the drain opens the room to the sewer system. If a mechanical device (e.g., the fan) depressurizes the room, air, gas and odors can be drawn from the sewer system into the room. The effect of this phenomenon can be increased if heavy rains cause an air backup in the sewer system.

A number of classrooms also had water-damaged ceiling tiles (Table 1). Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired. Also of note were the sinks in classrooms, which had water damage to the wooden cabinets (Picture 19). Sink basins also had heavy corrosion, indicating chronic faucet leakage. Breaches were observed between the countertop and sink backsplashes in some classrooms. If not watertight, water can penetrate through these seams. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage. As discussed, moistened materials that are not dried within 24 to 48 hours can become potential sources for mold growth.

A crawlspace exists beneath the first floor of this building that is accessible from the boiler room (Picture 20). The crawlspace provides a chase way for univent heating pipes. The interiors of univents were randomly examined. Spaces and holes in walls and floors around pipes and within the air handling cabinet were observed (Pictures 21). These breaches can serve as pathways to draw air, odors and particulates from the crawlspace into classrooms, particularly through poor filter media (see **Other IAQ Evaluations** section of this report). Crawlspaces frequently are wet and contain mold, spores and associated odors.

South Building

A number of classrooms in the South Building have water-damaged ceiling tiles, particularly on the top floor (Picture 22). Skylights in this building also have water-damaged plaster. A substantial number of these interlocking ceiling tiles have been replaced since the roof over this building was replaced.

Plants were observed growing directly against the building (Pictures 23A and 23B). In addition, the front courtyard of the school has a wall that has a substantial ivy growth (Picture 24). The interior wall of the ivy growth did not appear to have water penetration. Clinging plants can cause water damage to building windows systems and spandrels by inserting tendrils into window frame seams. Water can penetrate into the brick along the tendrils, which can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in damage to the wall. Clinging plants on brickwork is not recommended. Some classrooms have fresh air intakes occluded by ivy growth. Moisture, pollen and other debris associated with plants can be drawn into the univent and distributed to classrooms.

Shrubbery was also noted in direct contact with the exterior wall brick or was in close proximity to univent fresh air intakes in several areas around the building.

A crawlspace exists beneath the first floor and shares an adjoining wall with Rooms 26 and 27 that is accessible by a hatchway in the stairwell outside of Room 27. The purpose of the crawlspace under classrooms is to provide a chase way for univent heating pipes. The interiors of univents were randomly examined. Spaces and holes in walls and floors around pipes and within the air handling cabinet were observed (Picture 25). In addition, spaces around pipes that transverse the shared Room 27/crawlspace wall exist (Picture 26). Each of these breaches can serve as pathways to draw air, odors and particulates from the crawlspace into classrooms, particularly through poor filter media of space leading from Room 27 to the crawlspace. Crawlspaces frequently are wet and contain mold, spores and associated odors.

East Building

Of note were reports of water leaks from the roof above room 115, which had reportedly moistened gypsum wall board above the suspended ceiling, ceiling tiles and carpeting. BEH staff examined the roof above the water-damaged classroom, which appeared to have been repaired. The likely reason for this repeated water damage is related to the manner in which water drains from the area above the library. The library roof is raised above the level of the other East Building roofs to form a parapet (Picture 27). Water is drained from the library roof by five scuppers in the parapet. The north parapet wall has three scuppers (Picture 28), whereas the south wall has only two (Picture 29). In this configuration, all of the water from a third of the roof pours through the scupper above the water-damaged area of room 114 (Picture 30). This increased water exposure likely enhanced the degradation of the roof material by the water exposure and mechanical damage from freezing.

Water damage was seen in gypsum wall board beneath a cantilever roof over the library balcony (Pictures 31 and 32). The roof of the balcony appears to be pitched towards the building, and evidenced by the debris pattern on the roof membrane. As with the roof section above room 114, increased water exposure likely enhanced the degradation of the roof material by the water exposure and mechanical damage from freezing is likely responsible for producing this water damage.

Stained ceiling tiles were also noted in areas where the East Building joined to other buildings. The likely source of these leaks is the manner in which the roof membrane for the East Building was attached to each pre-existing building. In order to prevent water penetration, flashing is installed in the seam where a new building meets a pre-existing building. The flashing is installed by cutting though the brick of the pre-existing wall and installing flexible metal (usually copper) shaped in a manner to transfer rain water from the original brick surface onto the roofing system to drain. An example of this can be seen on the window systems on the rear of the West Building (Picture 33). No flashing of this type exists on the East Building roof. The membrane is held in place by metal strapping with mechanical fasteners (Picture 34). A sealant was applied to the top seam to provide water resistance. Over time, this sealant has degraded to allow for rain to penetrate behind the roof membrane, resulting in water-damaged ceiling tiles.

As indicated by school personnel, room 5 has had water damage to carpeting with no apparent water leakage, usually during summer months. Fitchburg School Department facilities staff plans to remove the carpet and install tile in the East Wing. SSES does not have an air conditioning ventilation system; therefore, the indoor relative humidity will be dictated by outdoor relative humidity concentrations. For example, during the spring and summer of 2002, New England experienced a stretch of excessively humid weather during three periods in May, July and August. Specifically, outdoor relative humidity at various times ranged from 73 percent to 100 percent without precipitation from July 4, 2002 through July 12, 2002 (The Weather Underground, 2003).

According to the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), if relative humidity exceeds 70 percent, mold growth may occur due to wetting of building materials (ASHRAE, 1989). High relative humidity can cause the accumulation of moisture on surfaces that have a temperature lower than the ambient air temperature (e.g., building surfaces in contact with soil such as foundation floor or cement slabs). If the floor of Room 105 is prone to moisture accumulation, carpeting should not be used as a floor covering. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended.

Exterior wall systems should be designed to prevent moisture penetration into the building interior. An exterior wall system should consist of an exterior curtain wall (Figure 2). Behind the curtain wall is an air space that allows for water to drain downward and for the exterior cladding system to dry. At the base of the curtain wall should be weep holes that allow for water drainage. Opposite the exterior wall and across the air space is a continuous, water-resistant material adhered to the back up wall that forms the drainage plane.

The purpose of the drainage plane is to prevent moisture that crosses the air space from penetrating into interior building systems. The plane also directs moisture downwards toward the weep holes. The drainage plane can consist of a number of water-resistant materials, such as tarpaper or, in newer buildings, plastic wraps. The drainage plane should be continuous. Where breaks exist in the drainage plane (e.g., window systems, door systems and univent fresh air intakes), additional materials (e.g. copper flashing) are installed as transitional surfaces to direct water to weep holes. If the drainage plane is discontinuous, missing flashing or lacking air space, rainwater may accumulate inside the wall cavity and lead to moisture penetration into the building.

To allow water to drain from the exterior brick wall system, a series of weep holes is customarily installed at or near the foundation slab/exterior wall system junction (Figure 2). Weep holes allow for accumulated water to drain from a wall system (Dalzell, 1955). Failure to install weep holes in brickwork or burial of weep holes below grade will allow water to accumulate in the base of walls, resulting in seepage and possible moistening of building components (Figure 3).

The exterior of the East Building consists of a traditional red brick exterior wall (Picture 35). An examination of the exterior brick walls of East Building was conducted to identify the location and condition of weep holes. The exterior wall of East Building did not have identifiable weep holes. It is possible that weep holes may be buried by accumulated loam, dirt or cedar flakes along the edge of these walls. It is advised that "[i]n no case should the holes be located below grade", since dirt can fill weep holes to prevent drainage (Dalzell, 1955).

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 affects. 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) (Table 1). Carbon monoxide levels measured in the school were also ND.

A parking lot is located behind the school between the North and East buildings (Map 1). Motor vehicles are parked against the windows where fresh air intakes are located. Exhaust from these vehicles could be captured by these fresh air intakes and introduced into classrooms, thereby providing a source of motor vehicle exhaust and carbon monoxide.

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 μg/m^3. PM2.5 levels measured inside the school ranged from 5 to 19 μg/m^3 (Table 1). Both indoor and outdoor PM 2.5 levels were below the NAAQS PM2.5 level of 35 μg/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.

Volatile Organic Compounds

Indoor air concentrations can be greatly impacted by the use of products containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to identify materials that can potentially increase indoor VOC concentrations, BEH staff examined classrooms for products containing these respiratory irritants.

Located in the copier room are a number of photocopying machines (Picture 36) and a laminator. Of note is that at least one printer (Risograph®) uses a liquid toner. This product contains petroleum distillate, which is a VOC which is an irritant to the eyes, nose and respiratory system. Photocopiers can also produce VOCs and ozone, particularly if the equipment is older and in frequent use. VOCs and ozone are respiratory irritants (Schmidt Etkin, 1992). It is recommended that local separate exhaust systems that do not recirculate into the general ventilation system be used (US DOE, unknown).

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs in some areas. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix D (NIOSH, 1998).

Several classrooms contained dry erase boards and related materials. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Cleaning products were observed in a number of classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals. These chemicals can be irritating to the eyes, nose and throat and should be kept out of reach of students. Products should be kept in their original containers, or should be clearly labeled as to their contents, for identification purposes in the event of an emergency. Further, material safety data sheets (MSDS) for all cleaning products must be available at a central location.

Air fresheners and deodorizing materials were observed in several areas. Air deodorizers contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Many air fresheners contain 1,4-dichlorobenzene, a VOC which may cause reductions in lung function (NIH, 2006). Furthermore, deodorizing agents do not remove materials causing odors, but rather mask odors that may be present in the area.

Other Conditions

A number of other conditions that can affect indoor air quality were noted during the assessment. A selected number of univents were opened in each building. Univents were equipped with metal racks, into which filter materials would be cut to fit univent racks (Picture 37). The material used for filter media in these metal racks provides minimal filtration of respirable particulates that can be distributed by univents. In addition, seams between pieces of filter media would allow for unfiltered air to bypass the filter and be distributed in the air by the univents. Univents should be equipped with filters that strain particulates from airflow. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in univents. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow as a result of increased resistance, a condition known as pressure drop. Prior to any increase of filtration, univents should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

In some classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Classroom 009 contained a cage with rodents. Debris from the interior of the cage was noted on a table and carpeting (Picture 38). Rodent waste can contain a number of materials that are allergens. Rabbit dander, fur and wastes may also be allergenic to hypersensitive individuals. If animals are to be kept in classrooms, it is good practice to remove animal waste from cages frequently. In addition, cages of animals should be kept away from the air stream created during the operation of univents to limit aerosolization.

The structure that forms the copier room and athletic equipment storage room (Picture 39) has a damaged soffit (Picture 40). Sparrows were observed entering the roof space through this damage. Bird wastes can be a source of dust that is irritating to the respiratory system. In addition, bird wastes contain bacteria and mold, which can be a source of disease, such as psittacosis and hypersensitivity pneumonitis.

Additionally, the copier room floor exhibited floor tiles that were in disrepair, as did room 330 (North Building). Please be advised that prior to removal and/or replacement of these tiles, it must first be determined whether or not the tiles contain asbestos.

The rear storage room in the Art classroom contained a kiln. It was reported by SSES staff that the kiln is not in use at this time. The kiln was surrounded by paper and cardboard debris and should not be utilized in its present condition.

Old food containers were seen in several classrooms. Exposed food products and reused food containers can attract a variety of pests. The presence of pests inside a building can produce conditions that can degrade indoor air quality. For example, rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine is known to contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms in exposed individuals, including nose irritations and skin rashes. Pest attractants should be reduced/eliminated. Proper food storage is an integral component in maintaining indoor air quality. Food should be properly stored and clearly labeled. Reuse of food containers (e.g., for art projects) is not recommended since food residue adhering to the container surface may serve to attract pests.

Conclusions/Recommendations

The conditions found at the SSES present issues that require a variety of remedial steps. 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 with plans to remove carpeting from the East Wing. Also remove carpeted risers under windows in the East Wing classrooms. Carpeting should be removed in a manner consistent with recommendations in “Mold Remediation in Schools and

Commercial Buildings" published by the US Environmental Protection Agency (US EPA, 2001). This document is available from the US EPA website: http://www.epa.gov/iaq/molds/mold_remediation.html. Replace with a non-porous material (e.g., non-slip tile).

2. Remove water damaged GW from library and above the ceiling in Room 114 in manner consistent with Recommendation #1.
3. Replace all remaining water-damaged ceiling tiles in a manner consistent with Recommendation #1.
4. Install a gutter downspout on the scupper above Room 114 to decrease water draining impact on the roof membrane in this location.
5. Seal all penetrations (e.g., holes and open conduit) in univents floors with an appropriate, fire rated expandable foam.
6. Consider increasing the dust-spot efficiency of HVAC filters. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
7. Seal all floor drains in the copier room.
8. Seal all pipe penetrations in the shared crawlspace wall of Rooms 26 and 27.
9. Prevent parking along the exterior walls of Rooms 26 and 27.
10. Replace all existing filter metal frames with precut, cardboard filters that fit flush in univent filter racks.
11. Assess whether unit ventilator exhaust vents in the South Building are operational and repairable.
12. Remove all blockages from univents and exhaust vents to ensure adequate airflow.

13. Determine if weep holes exist in the exterior walls of the East Building. Unearth all weep holes in exterior walls to maximize water drainage from exterior wall systems.
14. Consult a ventilation engineer to ascertain the best method for increasing fresh air supply 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”.
15. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
16. 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.
17. All plants in contact with the foundation or walls of the SSES should be removed. Cut shrubbery in a manner to maintain a space of 5 feet from the building. Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek & Brennan, 2001).
18. Refrain from storing porous items (boxes, papers, books, etc.) in areas prone to water leaks.
19. Remove plants from the stairwells of the West Building. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Remove plants from univents.
20. Repair hole in downspout of the West Building’s northwest corner.

21. Clean and repair sinks in the North Building. Examine sink countertop and backsplash areas for water damage and/or mold growth. Disinfect and replace as necessary. Seal breaches to prevent damage.

22. 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).

23. Remove carpeting from beneath univents in West Building.

24. Place cover for sump pump over grill in medical office closet. Refrain from using closet for storage.

25. Discontinue the use of tennis balls on chair and desk legs. Consider replacing tennis balls with alternative chair glides.

26. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled. All cleaning products used at the facility should be approved by the school department with MSDS' available at a central location.

27. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

28. Move animal cages away from univents. Clean cage materials from tables and disinfect tables with an appropriate antimicrobial agent daily. Clean nesting materials from the interior of cages frequently.

29. Remove birds from roof of copier room. Either repair soffit wood or install bird screens over holes to prevent future bird roosting.

30. Determine composition of damaged floor tiles. If tiles contain asbestos material, remove in accordance with applicable federal and state regulations.

31. Remove stored materials surrounding kiln in art room.

32. Consider adopting the US EPA (2000) document, "Tools for Schools", to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.

33. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/indoor_air.

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

1. A decision to repair or abandon the copier room needs to be made. Given the deterioration of the roof soffit and wooden exterior walls, consider consulting a building engineer as to whether the roof and the walls of the copier room are repairable.

2. 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.

3. Examine the feasibility of installing a flashing system to prevent water penetration along the roof joint between the East Building and other buildings in the complex.
4. Examine the feasibility of providing exhaust ventilation for the classrooms in the West Building.
5. Repair water leaks around all skylights. Once repaired, repair water-damaged ceiling tiles.
6. Examine the feasibility of raising the height of the univent fresh air intakes shown in Picture 2.

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