INDOOR AIR QUALITY REASSESSMENT

Abbot Public Library
235 Pleasant Street
Marblehead, Massachusetts

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

October 2011

Background/Introduction

At the request of Mr. Phil Sweeney, Chairman of the Board of Library Trustees, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) conducted a follow up Indoor Air Quality (IAQ) assessment at the Abbot Public Library (APL), located at 235 Pleasant Street, Marblehead, Massachusetts. On September 23, 2011, Cory Holmes and Kathleen Gilmore, Environmental Analysts/Regional Inspectors for BEH's IAQ Program made a visit to the APL to conduct the reassessment. The building was previously visited by BEH staff in August 2006.

Actions on MDPH Recommendations

As mentioned, MDPH staff had previously visited the building in 2006 and issued a report detailing conditions observed at the time and provided recommendations to improve IAQ (MDPH, 2006). A summary of actions taken on previous recommendations is included as Appendix A.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 7565. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. BEH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The APL has approximately 20 employees and can have several hundred members of the public visiting on a daily basis. Tests were taken during normal operations and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate air exchange. Mechanical ventilation is provided by a heating, ventilation and air-conditioning (HVAC) system. Air handling units (AHUs) are located in a mechanical room on the third floor (Picture 1). Fresh air is drawn from an outside air intake on the exterior of the building and ducted into an "air mixing" room (Pictures 1 and 2). Air is then drawn through pleated filters into the AHUs (Picture 1) where it is heated or cooled and delivered to occupied areas by ceiling-mounted air diffusers (Picture 3). Return air is draws air through ceiling-mounted exhaust grilles (Picture 4) and ducted back into the air mixing room (Picture 5).

The return duct appeared to be lined with a fibrous material that is conducive to collecting dust and debris (Picture 5). It is unclear what the purpose of this material is. At the time of the assessment this material was completely occluded. In its current condition it can serve as a reservoir of airborne particulates in the air mixing room. BEH staff recommended that library officials contact their HVAC vendor to determine if the duct-lining material can be cleaned, or if deemed not necessary, removed.

HVAC systems are typically controlled by wall-mounted thermostats that have fan settings of *on* and *auto*. When the fan is set to *on,* the system provides a continuous source of air circulation and filtration. The *automatic* setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. The thermostats at the APL are reportedly set to the *auto* position. The MDPH recommends that thermostats be set to the fan *on* setting during occupied hours to provide continuous air circulation.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of 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 HVAC system was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 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 B.

Temperatures in occupied areas ranged from 71° F to 80° F. In the 3rd floor Technical Services area temperatures were above the MDPH recommended comfort guidelines. This area reportedly is an area of chronic heat complaints. BEH staff noted that the area also contains several supply vents but no return/exhaust vents to remove excess heat. 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.

The relative humidity measured indoors ranged from 62 to 76 percent, which was above the MDPH recommended comfort range in all areas surveyed during the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Elevated indoor relative humidity conditions were reflective of outdoor conditions (90 to 100%), due to opened windows and deactivation of the air conditioning (AC) system. It was reported that the AC system had been deactivated several weeks prior to the BEH visit, due to decreasing outdoor temperatures.

The relationship between temperature and relative humidity is known as the heat index. As indoor temperature rises, the addition of humid air increases occupant discomfort and generate heat complaints. If moisture levels are decreased, the comfort of the individuals increases. It is important to note that the operation of AC systems removes moisture from the air and also provides cooling. While temperature is mainly a comfort issue, relative humidity in excess of 70 percent for extended periods of time can provide an environment for mold and fungal growth (ASHRAE, 1989). 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.

In addition, one area of the APL (the Marblehead Room), is a climate-controlled room specifically designed to preserve and protect important historical volumes and documents. It was reported that the HVAC systems in this room were not operating at the time of the assessment. Due to the nature of materials stored in this area, APL officials should contact an HVAC engineering firm to evaluate and make repairs as needed in this area to avoid damage/destruction of records.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of water exposure is necessary. As detailed in Appendix A, many actions have been taken to prevent/reduce sources of water infiltration and conditions that have resulted in water damage and microbial growth.

Water-damaged/mold-colonized ceiling tiles were seen, such as the 644-657 non fiction area on the main floor (Picture 6/Table 1). Water-damaged ceiling tiles indicate leaks from either the roof or plumbing system and can provide a source for mold growth. These tiles should be replaced after a water leak is discovered and repaired.

Water-damaged drywall, pipe insulation and efflorescence were observed in the 3rd floor mechanical room (Pictures 7 through 9). The mechanical room shares a common wall with the unconditioned attic space (Picture 10). The source of moisture causing this water damage appears to be condensation due to unconditioned air penetrating above the ceiling of the mechanical room, where the warm moist air comes in contact with a surface with a temperature below the dew point. In this case, chilled water pipes to the HVAC system (Picture 11).

In subsequent correspondence with Mr. Sweeney, he reported that the carpet was moistened during a sustained heavy rainfall that resulted in widespread flooding across northeastern New England. Mr. Sweeney reported that the building was dried out and cleaned by a flooding restoration firm (Service Master). Mr. Sweeney also reported that the carpet was evaluated by a local flooring company and remains in-place. Since this carpeting has been repeatedly subjected to moisture/flooding and condensation, BEH staff recommends that the carpeting be replaced with a non-porous material to prevent future mold growth. Until the carpeting is replaced, BEH staff recommends regular vacuuming with a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner, which filters out 99.97% of fine particles 0.3 micrometers (µm) in diameter that can exacerbate asthma and allergy symptoms (US EPA, 2001). It is also important to note that wall to wall carpeting in below grade space is generally not recommended if that space is subject to chronic dampness due to water leaks or condensation accumulation (US EPA, 2001).

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials (e.g., ceiling tiles, carpeting) 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.

Although a number of improvements to the gutter/downspout system were made (Appendix A), a downspout at the front of the building appeared to be clogged with debris and plant growth (Picture 12). This equipment should be monitored on a regular basis to ensure proper drainage.

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 can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the building environment, BEH staff obtained measurements for carbon monoxide.

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, Refrigerating 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 the assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No measureable levels of carbon monoxide were detected inside the building during the assessment (Table 1).

Particulate Matter

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 micrograms per cubic meter (μg/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 μg/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 was measured at 46 to 52 μg/m^3 (Table 1), which were above the NAAQS PM2.5 level of 35 μg/m^3. The most likely sources of elevated particulates in the area were ragweed/pollen and idling cars/traffic. Indoor PM2.5 levels ranged from 8 to 14 μg/m^3 (Table 1), which 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 indoors 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, use of stoves and/or microwave ovens in kitchen areas; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Other Conditions

Several other conditions that can potentially affect indoor air quality were identified during the assessment. Libraries in general have a large number of flat and irregular surfaces (e.g., book shelves, books) that provide locations for dust to accumulate. The number of flat surfaces in combination with the heavy foot traffic over carpeting can reaerosolize settled dust. Accumulated dust was also observed collecting on air diffusers and return grills. If return/exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Supply vents can aerosolize accumulated dust once activated. Dust can be irritating to the eyes, nose and respiratory tract.

Lastly, a number of items were stored in the HVAC mechanical room, including a water-damaged/moldy cardboard box (Pictures 13 and 14). The air mixing room should be routinely cleaned and not used for storage.

Conclusions/Recommendations

As detailed in Appendix A, many actions have been taken to prevent/reduce sources of water infiltration and conditions that previously resulted in water damage and microbial growth. In view of the findings at the time of the visit, the following additional recommendations are made to further improve indoor air quality:

1. Work with HVAC vendor to determine best methods to set thermostats to operate the HVAC system continuously in the fan "on" mode during periods of occupancy to maximize air circulation and filtration.
2. Have HVAC vendor evaluate the system for proper temperature control on the third floor. Methods to improve temperature control may include the installation of return/exhaust vent(s) in the third floor "Technical Services" work area.
3. Develop a written protocol to ensure proper maintenance/changing of HVAC filters. Change filters for air handling equipment as per the manufacturers' instructions or more frequently if needed.

4. Have HVAC vendor determine the function of duct shown in Picture 5 and whether the fibrous liner can be cleaned or removed if deemed not necessary. For additional information regarding duct cleaning, please consult the National Air Duct Cleaners Association guidance at https://www.nadca.com/download/NADCA%20GENERAL%20SPECIFICATIONS%202006.pdf
5. Remove stored items from HVAC mechanical room.
6. Remove carpeting in below grade areas (e.g., young adult library), replace with non-porous floor covering.
7. Monitor conditions as needed to adjust the HVAC system to avoid elevated relative humidity (>70%) conditions that would be prone to condensation and/or mold growth.
8. Ensure climate control system is repaired/restored in the Marblehead Room to preserve and protect important historical documents.
9. 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. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
10. Clean carpeting annually or semi-annually in soiled high traffic areas as per the recommendations of the Institute of Inspection, Cleaning and Restoration Certification (IICRC). Copies of the IICRC fact sheet can be downloaded at: http://www.cleancareseminars.com/carpet_cleaning_faq4.htm (IICRC, 2005).

11. Seal above ceiling space between HVAC mechanical room and unconditioned attic (Pictures 10 and 11) to reduce/prevent condensation and further water damage.
12. Replace or make repairs to water-damaged materials in HVAC mechanical room.
13. Remove plant growth in downspout gutter system shown in Picture 12.
14. Remove/replace water-damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
15. Ensure paper/cardboard materials are not stored directly on floors in unconditioned areas. Discard any water-damaged/mold colonized porous materials.
16. Consider extending HVAC system ductwork into unconditioned book storage area. At the least dehumidifiers should be used in this area to reduce relative humidity as needed.
17. Ensure dehumidifiers are cleaned and maintained as per the manufacturer's instructions to prevent microbial growth.
18. Clean library books, shelving, flat surfaces as well as HVAC supply, exhaust and return vents periodically of accumulated dust.
19. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://mass.gov/dph/iaq.

References

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Picture 1

Air Handling Units with Pleated Filters in HVAC Mechanical/Air Mixing Room

Picture 2

Ductwork Connected to Outdoor Air Intake on Exterior of Building

Picture 3

Ceiling-Mounted Supply Diffuser

Picture 4

Ceiling-Mounted Return Vent

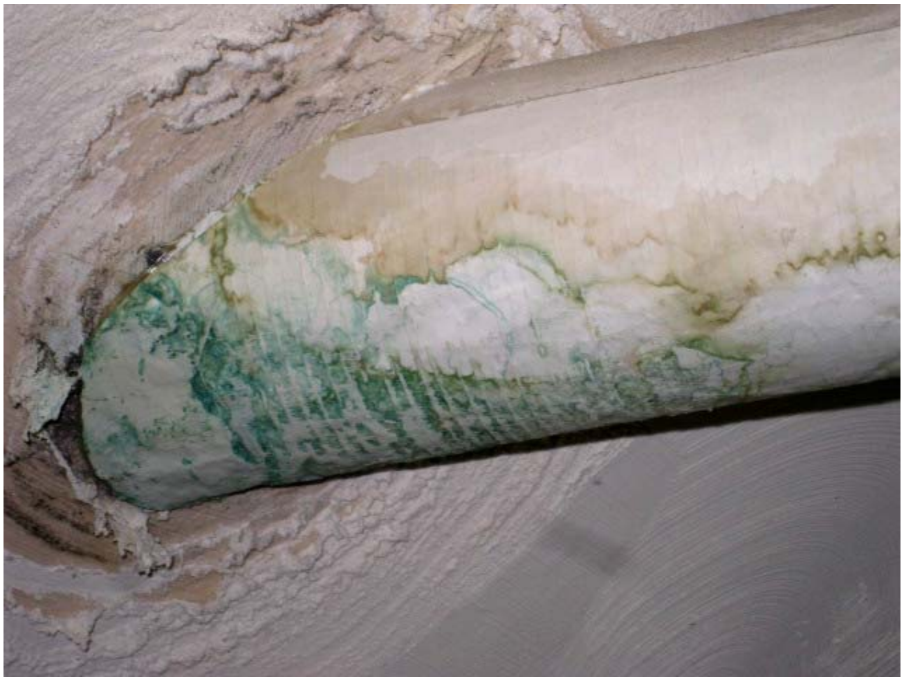
Picture 5

Fibrous Mesh-Lined Return Duct in HVAC Mechanical/Air Mixing Room Covered with Dust/Debris

Picture 6

Mold-Colonized Ceiling Tile in the 644-657 Non-Fiction Area on Main Floor

Picture 7



Water-Damaged Ceiling and Pipe Insulation in HVAC Mechanical/Air Mixing Room

Picture 8

Efflorescence and Water Damaged Ceiling and Pipe Insulation in HVAC Mechanical/Air Mixing Room

Picture 9

Efflorescence and Water-Damaged Ceiling and Pipe Insulation in HVAC Mechanical/Air Mixing Room

Picture 10

Unconditioned Attic

Picture 11

Air Space Where Unconditioned Attic Air Flows into Ceiling Plenum of HVAC Mechanical Room causing Condensation and Water Damage to Building Materials

Picture 12

Debris/Plant Growth in Downspout at Front of Building

Picture 13

Items Stored in HVAC Mechanical/Air Mixing Room

Picture 14

Water-Damaged/Mold-Colonized Box in HVAC Mechanical/Air Mixing Room

Location: Abbot Public Library | **Indoor Air Results**

Address: 235 Pleasant Street, Marblehead, MA | **Date: 9/23/2011**

Table 1

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (ug/m^3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
Background	520	ND	81	90-100	46-52					Cloudy, rainy, humid, idling cars, moderate traffic in area
HVAC Mechanical Room	489	ND	76	62	12	0	N	Y	Y	Storage boxes and supplies on floor
Basement Book Storage Room	448	ND	78	63	11	0	N	Y	Y	WD boxes, MT, boxes on plastic bins
Children's Library	438	ND	75	62	12	3	Y	Y	Y	Area carpets dirty
Children's Office room	430	ND	74	63	11	0	Y	Y	Y	
Children's Storage Room	462	ND	75	63	11	0	N	Y	Y	
Main Circulation Desk	455	ND	74	65	12	4	Y	Y	Y	
Young Adult	471	ND	73	73	9	0	Y	Y	Y	Carpet old/soiled
Meeting Room	473	ND	71	76	14	0	Y	Y	Y	Standing water in exterior stairwell, efflorescence on doorframes, sump pump in corner

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
HVAC = heating, ventilation and air conditioning

ND = non-detect
DO = door open

MT = missing tile
WD = water-damaged

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems		

Location: Abbot Public Library **Indoor Air Results**

Address: 235 Pleasant Street, Marblehead, MA **Date: 9/23/2011**

Table 1 (continued)

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (ug/m^3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
Reference	444	ND	75	70	11	3	Y	Y	Y	
Adult Non-Fiction	439	ND	76	68	10	0	Y	Y	Y	
Non-Fiction 644-657	462	ND	78	63	8	0	Y	Y	Y	
Reading Room	433	ND	77	64	13	4	Y open	Y	Y	Dirt/dust accumulation on vents
Fiction	425	ND	77	66	12	0	Y	Y	Y	Plant-water stained carpet
Marblehead Room	494	ND	76	66	12	0	Y	Y	Y	Dehumidifier, DO, HVAC system reportedly not operating
Staff Room	411	ND	76	67	13	0	Y open	Y	Y	
Tech Service	422	ND	80	63	12	1	Y	Y	N	Chronic heat complaints, no return/exhaust vent in this area
Admin	443	ND	80	63	12	0	Y	Y	Y	

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

Location: Abbot Public Library **Indoor Air Results**

Address: 235 Pleasant Street, Marblehead, MA **Date: 9/23/2011**

Table 1 (continued)

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (ug/m^3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Intake	Exhaust	
Director	461	ND	80	63	12	0	Y	Y	Y	
Assistant Director	448	ND	80	62	11	0	Y	Y	Y	

ppm = parts per million

$\mu g/m^3$ = micrograms per cubic meter

HVAC = heating, ventilation and air conditioning

ND = non-detect

DO = door open

MT = missing tile

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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
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Temperature: 70 - 78 °F
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Appendix A

Actions on MDPH Recommendations, Abbot Public Library, Marblehead, MA

The following is a status report of action(s) taken on MDPH recommendations (**in bold**) based on reports from library officials, photographs and MDPH staff observations.

- **Consult with an architect and/or general contractor regarding the integrity of the building envelope, primarily concerning water penetration through walls and the foundation. Examine the feasibility of re-pointing brickwork.**
- **Action:** A masonry contractor was hired to remove/repair exterior brick walls to eliminate water penetration.
  - **Make repairs to gutter system. Consider installing elbow extensions on downspouts to direct rainwater away from the building. Have a professional drainage/gutter installation contractor evaluate the design/condition of the current system for improvement/replacement to direct water away from the building and prevent further water damage.**
- **Action:** Gutters were repaired and elbow extensions were added. In addition, drainage around the perimeter of the building was improved by installing a French drain, clearing out drain pipes and improving existing drainage.

Repair/replace loose/broken windowpanes and missing or damaged window caulking to prevent water penetration through window frames.

- **Action:** Windows were repaired and resealed.
- **Refrain from storing porous materials directly on cement floor in the book storage room. Inspect and discard any water-damaged/mold colonized materials. Disinfect any**

Appendix A

areas of microbial growth with a one in ten bleach in water solution; wipe clean surfaces with soap and water after disinfection.

Action: The majority of stored materials were elevated off the floor (e.g., stored on pallets), more work is needed in this area.

- **Consider discarding area rugs in children's library or have professionally cleaned on a regular basis. Replace with foam, rubber, or other non-porous material.**

  Action: Rugs are reportedly cleaned on a regular schedule. Rugs appeared to be in need of cleaning at the time of the reassessment.