INDOOR AIR QUALITY ASSESSMENT

Suffolk County Sheriff's Department
151 Merrimac Street
Boston, Massachusetts

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

August 2010

Background/Introduction

At the request of Lawrence McGrath, Chief Deputy Sheriff, Suffolk County Sheriff's Department (SCSD), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality at the SCSD, Civil Process Division, 151 Merrimac Street, Boston, Massachusetts. Reports of water leaks, flooding and various building conditions that staff suspect may be related to health issues prompted the assessment.

On June 29, 2010, a visit was made to this building by Michael Feeney, Director, Indoor Air Quality (IAQ) Program, BEH. The SCSD office is located on the first floor and basement of a 6-story brick building located at the corner of Causeway and Merrimac Streets in Boston. A parking lot exists to the south, which was likely the site of a building that formerly adjoined the south wall (Map 1) of 151 Merrimac Street. The offices do not have openable windows, therefore the SCSD space is entirely reliant on the heating, ventilation and air-conditioning (HVAC) system for air exchange.

The SCSD offices were previously evaluated by Envirotest Lab, Inc. on two separate occasions. In December 2009, Envirotest conducted mold testing in "the main work area, the two corridor spaces, the pump room, the telephone room and the common storage space" (Envirotest, 2009). Based on the their description, the areas noted as Areas I, J, K, L in the Envirotest report match the description of "the two corridor spaces" which were used by SCSD staff to store records (Map 2). The pump room, the telephone room and the common storage space are locations outside of the SCSD work area that are accessible through a basement door. In their initial assessment, the following recommendations were made by Envirotest:

- Purchase HEPA-filtered air purifiers;

- Use dehumidifiers in sub-grade areas;
- Do not have humidity level exceed 40%;
- Install condensate drain pump;
- Hire mold removal firm to remove all the sheetrock walls and insulation from floor to ceiling;
- Replace flexible ductwork;
- Replace duct insulation;
- Remove 3-feet of sheetrock walls and sheetrock ceiling from the common storage space, telephone room and pump room;
- Apply a fungicide to structural wall supports and base plates;
- Install a mold inhibitor on all surfaces exposed to the mold removal process; and
- Clean ductwork (Envirotest Lab, 2009).

As part of this remediation, Envirotest made the following suggestions:

- Seal all foundation pin holes and cracks;
- Replace damaged structural material with pressure treated lumber or metal supports;
- Use only closed cell polyurethane foam to insulate walls;
- Replace sheetrock with cementboard or Hardiboard material; and
- Run dehumidification at "all times" to maintain humidity below 40% (Envirotest, 2009).

At the time of the BEH assessment, IAQ staff could not identify any dehumidifiers in use to control relative humidity in sub-grade areas. In addition, it does not appear that any of the recommendations made by Envirotest were acted upon in any substantive manner. Gypsum wallboard (GW, sheetrock) remained in place in Areas I, J, K, and L (Picture 1).

Envirotest returned to the building in May 2010, and conducted air testing in the main working area *only*. In this report, Envirotest again recommended: the purchase of HEPA-filtered air purifiers and the use of dehumidifiers in sub-grade areas to ensure that humidity levels do not exceed 40% (Envirotest, 2010). This seems to imply that building management did not act on these initial recommendations. In addition, a finding that "[t]he storage space side walk (*sic*) ceilings are still not functioning correctly and must be repaired to prevent mold problems from re-occurring" was made (Envirotest, 2010).

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

These offices have an employee population of approximately 10 with varying numbers of visitors on a daily basis. The tests were taken under normal operating conditions in locations notated on Maps 2 and 3. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 ppm in all but two of nineteen areas surveyed, indicating adequate air exchange in the majority of areas at the time of the assessment. Fresh air is distributed by three air handling units (AHUs); one for the first floor, two for the basement floor (north AHU and Area L AHU). A thermostat controls the operation of the AHUs. Each AHU has its own ductwork that distributes fresh air through ceiling-mounted air diffusers. As stated, there are no openable windows; therefore the sole source of fresh air is via the ventilation system.

Return ventilation is provided by ceiling and/or wall-mounted return vents that are ducted back to AHUs (Pictures 2 and 3). This design uses the entire office space as a return air plenum. Private offices do not have return air vents, but appear to rely on return air being drawn through spaces beneath office doors. It appears that the AHUs do not have the capacity to exhaust air from the office. Without a means of exhaust ventilation, stale air and associated interior pollutants can accumulate inside the building and be continuously re-circulated, which can lead to air quality/comfort complaints.

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 HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last servicing and balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997). 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, consult Appendix A.

Temperature measurements ranged from 72^{o} F to 77^{o} F, which were within the MDPH recommended comfort range during the assessment. The MDPH recommends that indoor air temperatures be maintained in a range between 70° F to 78° F in order to provide 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 in the building ranged from 43 to 58 percent, which was also within 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. It is important to note however, that relative humidity measured indoors exceeded outdoor measurements (range +19 to 34 percent). This increase in relative humidity can indicate that a source of uncontrolled moisture exists in the building and/or the exhaust system alone is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). A number of moisture sources were identified. Immediately adjacent to the SCSD offices are three sewage receptacles with pumps (Pictures 4, 5 and 6) and an open pit with a sump pump (Picture 7). Another source of moisture is water penetration through the ceiling and exterior walls of the storage rooms (areas I, J, K, L on Map 2). These areas of the basement are not equipped with functioning exhaust ventilation. Moisture from these areas is likely drawn through the SCSD basement door when the AHUs are operating, since the office space becomes depressurized. With no operating exhaust components in the HVAC system, water vapor will tend to accumulate, which in turn can moisten building and office materials leading to musty odors and/or mold growth.

Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. 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 Growth/Moisture Concern

The basement offices had a distinct musty odor, which can be attributed to chronic water damage in Areas I, J, K, L (Map 2) that are used for records storage. These areas are below sidewalks that leak into the basement and had numerous signs of water penetration through ceilings and exterior walls (Pictures 8 through 11). The exterior wall behind gypsum wallboard (GW) appears to be flagstone (Picture 12), which is not watertight.

These areas are also unconditioned space that has GW and polyethylene plastic installed over the flagstone foundation wall[1] (Pictures 1 and 12). As moisture passes through the flagstone wall, GW absorbs water to become routinely moistened, particularly after rainstorms. As a result Areas I, J, K, L are routinely subjected to uncontrolled moisture exposure, making it unsuitable for storage of paper records. Any porous materials (paper documents and cardboard boxes) stored in this area would be susceptible to mold growth. 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.

Building occupants reported that drainpipes leaked into office space and saturated building materials (Picture 13 and 14). It was also reported that wall-to-wall carpeting was replaced in this area; however wall coving and GW were not remediated. Since this drain system likely contained sewage, methods for cleaning heavy microbial contamination should have been employed (IICRC, 1999). In general, it is recommended that absorbent materials (GW, insulation, carpeting, fabrics, books, cardboard, etc.) be discarded once in contact with sewage (IICRC, 1999). Flooring and sub-flooring (such as wood and tile) should be evaluated, cleaned, disinfected, dried and sealed when appropriate (IICRC, 1999). The GW and plastic coving should have been removed and replaced.

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 indoor environment, BEH staff obtained measurements for carbon monoxide and PM2.5.

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[1] Flagstone foundation consists of piled stone to form a foundation wall. This type of construction frequently lacks concrete between stone and is highly water vapor permeable.

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. Outdoor carbon monoxide concentrations were non-detect (ND) the day of the assessment (Table 1). No measureable levels of carbon monoxide were detected in 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/m3) 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/m3 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 9 μg/m3. PM2.5 levels measured indoors ranged from 3 to 8 μg/m3 (Table 1), which were below the NAAQS PM2.5 level of 35 μg/m3. 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

The AHUs had filters missing (Picture 15) or filters installed in a manner that allow air to bypass the filter (Picture 16). The AHU must have the appropriate equipment to make each filter fit flush in the rack. Without filters properly in place, spaces around filters can allow for unfiltered air to bypass the filters and be distributed by the AHUs.

Finally, of note was the use of rodent bait traps inside office space. The location of the bait traps draws pests *into* the work space. 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 nasal and skin irritation/rashes. Pest attractants should be reduced/eliminated.

Conclusions/Recommendations

The office space occupied by the SCSD has a number of conditions that can adversely affect indoor air quality. The conditions noted in Areas I, J, K, L present conditions that led to chronically damp conditions which affected the ground level office area. In view of the findings at the time of the assessment, the following recommendations are made:

1. Due to the configuration of the foundation wall, Areas I, J, K, L should not be used for document storage due to its lack of ventilation and chronic dampness. At minimum, all recommendations made in the 2009 Envirotest report should be implemented.
2. It is not recommended that any material be put in place of GW unless measures to prevent water infiltration are implemented.
3. In order to prevent further water penetration into Areas I, J, K, L a building engineer should be consulted. Repairs most likely to prevent water penetration may include:
    a. Waterproofing the exterior side of the foundation;
    b. Sealing interior ceilings with an appropriate material; and
    c. Sealing all spaces in the topside of the sidewalk, parking lot/building junction along the south exterior wall and the sidewalk/building junction.
4. All doors to Areas I, J, K, and L should be rendered airtight using weather-stripping and door sweeps.
5. Completely seal all seams to the AHU located in Area L to prevent dust/debris/odors from being entrained into the HVAC system.
6. All GW in areas where sewage contamination occurred should be removed to a height of 1-foot above the flood-line.
7. Doors leading to unoccupied basement areas should be rendered airtight using weather-stripping and door sweeps.
8. Consideration should be given to installing mechanical exhaust ventilation in the pump room area to draw odors and moisture away from the SCSD office space.
9. Consideration should be given to reconfiguring the HVAC system to relocate the Area L AHU to a dry location.

10. Consideration should be given to installing an exhaust ventilation component to the HVAC system if one does not exist.

11. Ensure filters are properly installed in all AHUs. Change as per the manufacturer's instructions or more frequently if needed.

12. 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. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

13. Place rodent bait traps in locations outside the office space.

14. 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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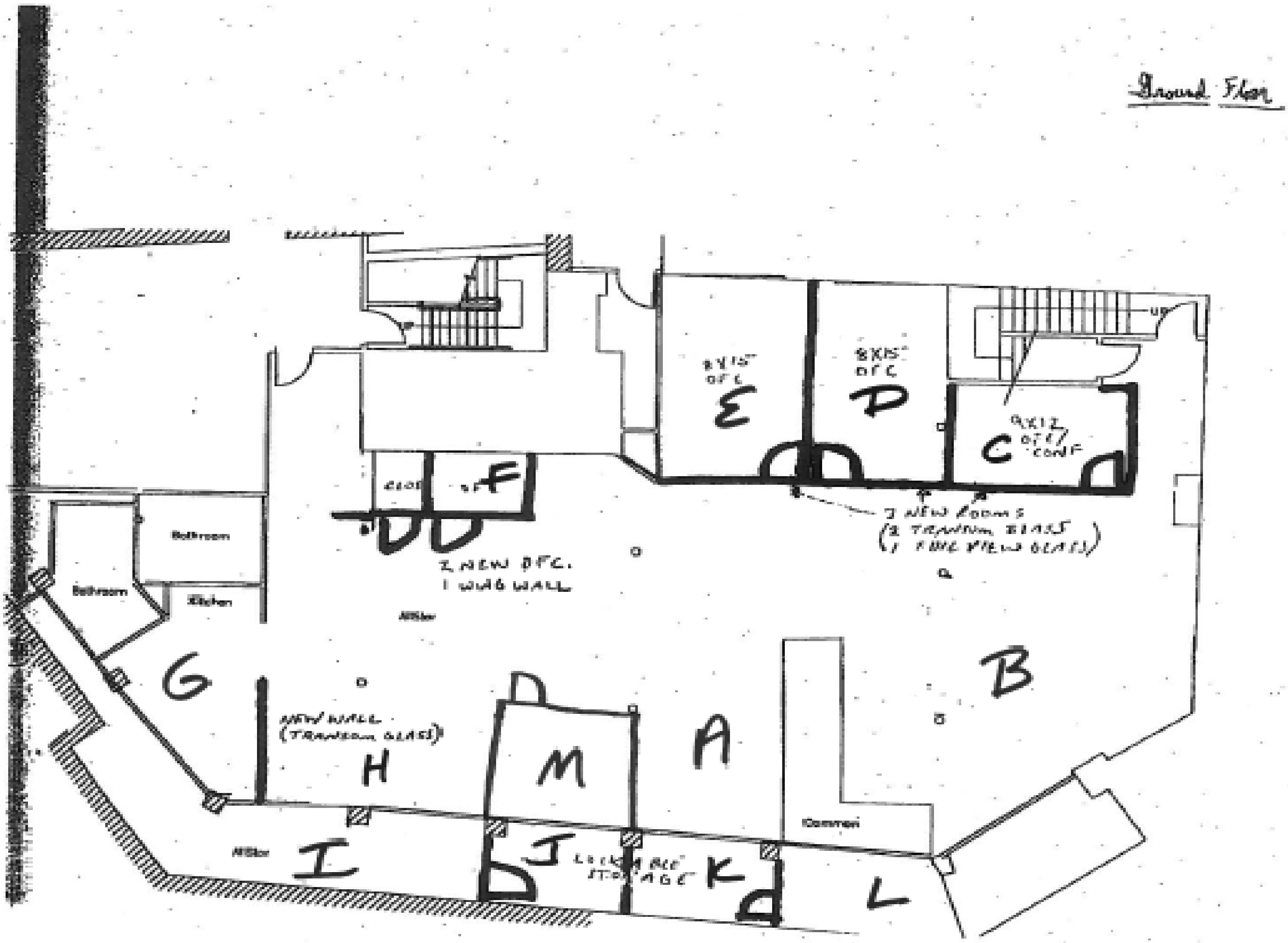
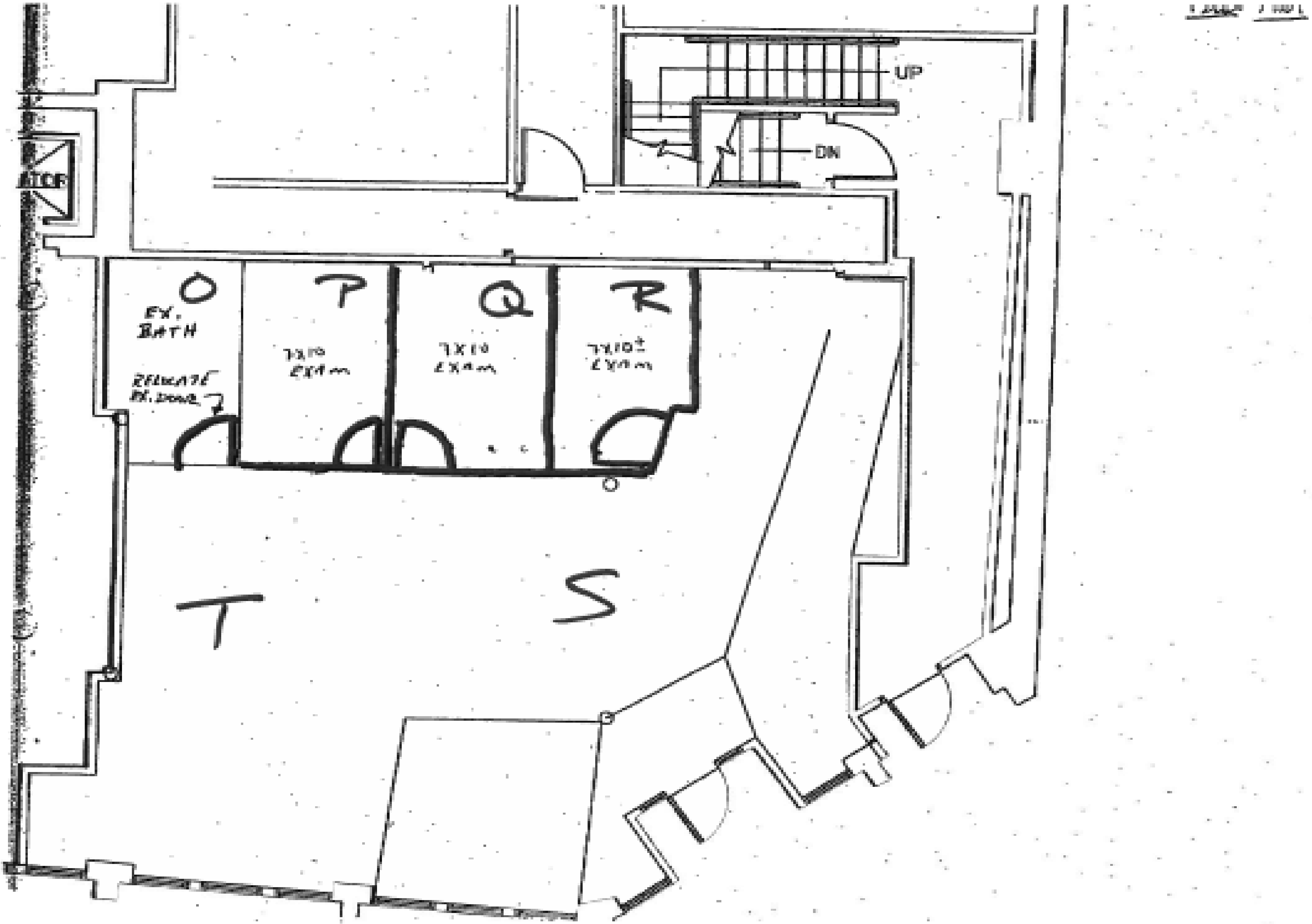
Map 1
151 Merrimac Street (Arrow)

Map 2
SCSD Civil Process Division, 151 Merrimac Street, Boston, Massachusetts
Ground Floor/Basement Level



Map 3
SCSD Civil Process Division, 151 Merrimac Street, Boston, Massachusetts
First Floor



Picture 1

GW and Polyethylene Plastic Installed over Flagstone Foundation

Picture 2

North AHU Return Air Intake

Picture 3

Area L AHU Return

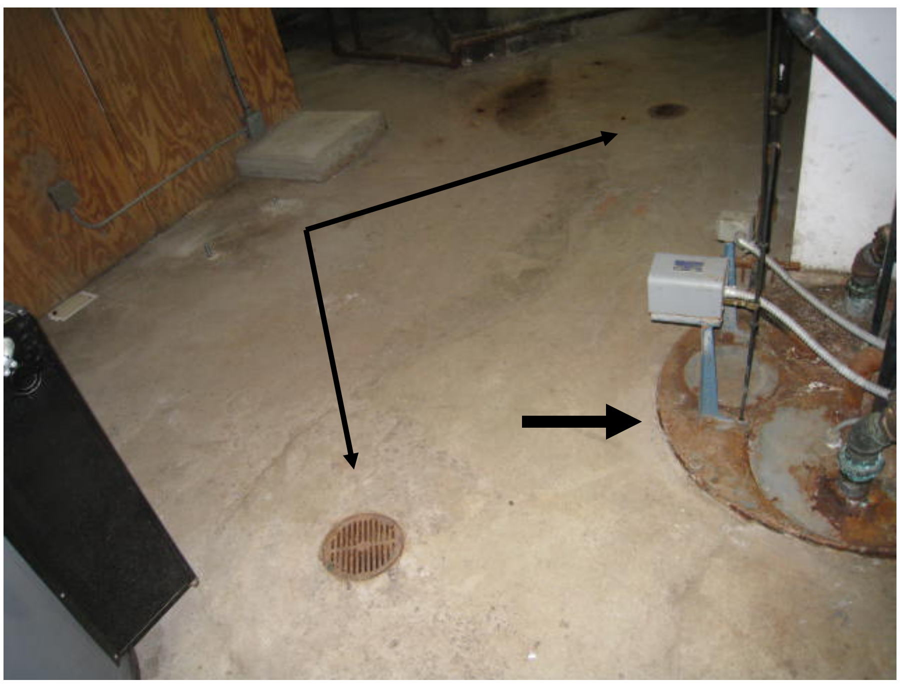
Picture 4

Pump in Pump Room

Picture 5

Pump outside Pump Room

Picture 6



Pump outside Pump Room (Large Arrow) and Two Floor Drains

Picture 7

Open Pit with Sump Pump

Picture 8

Water-Damaged Ceiling and Wall in Area I

Picture 9

Water-Damaged Ceiling and Wall in Area I

Picture 10

Water-Damaged Ceiling and GW in Area L

Picture 11

Water-Damaged Ceiling and GW in Area L

Picture 12

Flagstone Foundation with Minimal Concrete in Joints

Picture 13

Pipes (along ceiling) in Office Reported to Have Leaked Sewer Water

Picture 14

Wet Floor from Reported Sewer Leak

(Picture Provided by SCSD Staff)

Picture 15

North AHU Fresh Air Intake Missing Filter

Picture 16

Hole in Tape Allowing AHU to Draw Air from Area L

Location: Suffolk County Sheriff's Department **Indoor Air Results**

Address: 151 Merrimac St., Boston, MA **Table 1** **Date: 6/29/2010**

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (μg/m³)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Outside (Background)		90	24	382	ND	9				
A	1	73	49	745	ND	4	N	Y	N	
B	1	73	49	688	ND	4	N	Y	N	
C	1	73	49	844	ND	3	N	Y	N	
D	1	73	48	805	ND	4	N	Y	N	
E	1	73	48	719	ND	4	N	Y	N	
F	1	72	48	662	ND	4	N	Y	N	
G	0	73	50	644	ND	5	N	Y	N	Deodorizer
H	1	73	49	679	ND	3	N	Y	N	
I	0	74	58	661	ND	7	N	N	N	Water damaged gypsum wallboard
J	0	74	58	582	ND	5	N	N	N	Water damaged gypsum wallboard
K	0	74	58	607	ND	5	N	N	N	Water damaged gypsum wallboard

ppm = parts per million μg/m³= micrograms per cubic meter ND = non-detect

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: **Suffolk County Sheriff's Department** **Indoor Air Results**

Address: **151 Merrimac St., Boston, MA** **Date:** **6/29/2010**

Table 1 (continued)

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
L	0	74	57	636	ND	6	N	N	N	Water damaged gypsum wallboard
M	1	73	48	689	ND	4	N	Y	N	
O	0	76	46	658	ND	7	N	Y	N	Fresh air supply off
P	0	75	48	684	ND	7	N	Y	N	Fresh air supply off
Q	0	74	47	686	ND	8	N	Y	N	Fresh air supply off
R	0	76	49	665	ND	7	N	Y	Y	Fresh air supply off Restroom exhaust off
S	3	77	44	684	ND	8	N	Y	N	Fresh air supply off
T	0	77	43	675	ND	7	N	Y	Y	Fresh air supply off

ppm = parts per million $\mu g/m^3$= micrograms per cubic meter ND = non-detect

Comfort Guidelines

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