INDOOR AIR QUALITY
POST-OCCUPANCY ASSESSMENT

1000 Washington Street
Boston, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
August 2010

Background/Introduction

In response to a request from Martha Goldsmith, Director of Leasing, Division of Capital Asset Management (DCAM), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH), conducted post-occupancy air testing at various state offices located at 1000 Washington Street, Boston, Massachusetts. This air sampling was done as part of a new effort to assess indoor air quality of office space leased by Massachusetts state agencies shortly after taking occupancy. On April 16, 2010, a visit to conduct an indoor air quality assessment was made by Michael Feeney, Director, of BEH's Indoor Air Quality (IAQ) Program. Mr. Feeney was accompanied by Gilles Quintal, Project Manager, DCAM.

Floors 8, 9 and 10 and a portion of the 6^{th} floor are occupied by the following Massachusetts state agencies: Office of Consumer Affairs, Department of Telecommunications and Cable, the Division of Banks, the Division of Insurance, and the Division of Professional Licensure. The center section of the first floor contains various hearing and interview rooms that are utilized by various agencies. The building has no openable windows.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). BEH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The state offices collectively have an employee population of approximately 160. The tests were taken during normal operations. Test results appear in Table 1 and are numbered to correspond with locations listed on Maps 1-5.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas, indicating optimal air exchange at the time of the assessment. Each floor has separate air-handling unit (AHUs). Fresh air is drawn into the AHU through a vent located on the south exterior wall of the building (Picture 1). It is then heated or cooled and delivered to occupied areas via ductwork. Air is directed into the office space by ceiling-mounted supply diffusers. Return air is drawn into ducts that are connected to the AHUs, where it is exhausted through a vent on the south exterior wall (Picture 1)

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; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

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

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

Temperature readings ranged from 69^{o} F to 74^{o} F during the assessment, which were within or very close to the lower end of the MDPH recommended comfort guidelines. 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 measured during the assessment ranged from 22 to 30 percent, which was below the MDPH recommended comfort range in all areas surveyed the day of the assessment. 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. Relative humidity levels in the building would be expected to drop during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

No water damage and/or microbial growth was noted during this assessment.

Other Indoor Air 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.

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. Outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No measureable levels of carbon monoxide were detected in the building (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 ($\mu g/m^3$) 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 concentration was measured at 9 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 2 to 15 $\mu g/m^3$ (Table 1), which were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. It is important to note that the 1st floor had higher particulate measurements than the other floors, which may be attributed to motor vehicles in the loading dock. Vehicle exhaust contains particulate and may enter the occupied areas of the building though loading dock access doors. A number of other 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.

Volatile Organic Compounds

Indoor air concentrations can be greatly impacted by the use of products containing volatile organic compounds (VOCs) within the building. VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total volatile organic compounds (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 determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). No measureable levels of TVOCs were detected in the building (Tables 1).

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Consider installing weather-stripping around hallway doors leading to the loading dock.
2. Operate the loading dock ventilation exhaust system at least 10 minutes before and after as well as during deliveries to capture vehicle exhaust.

References

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL.

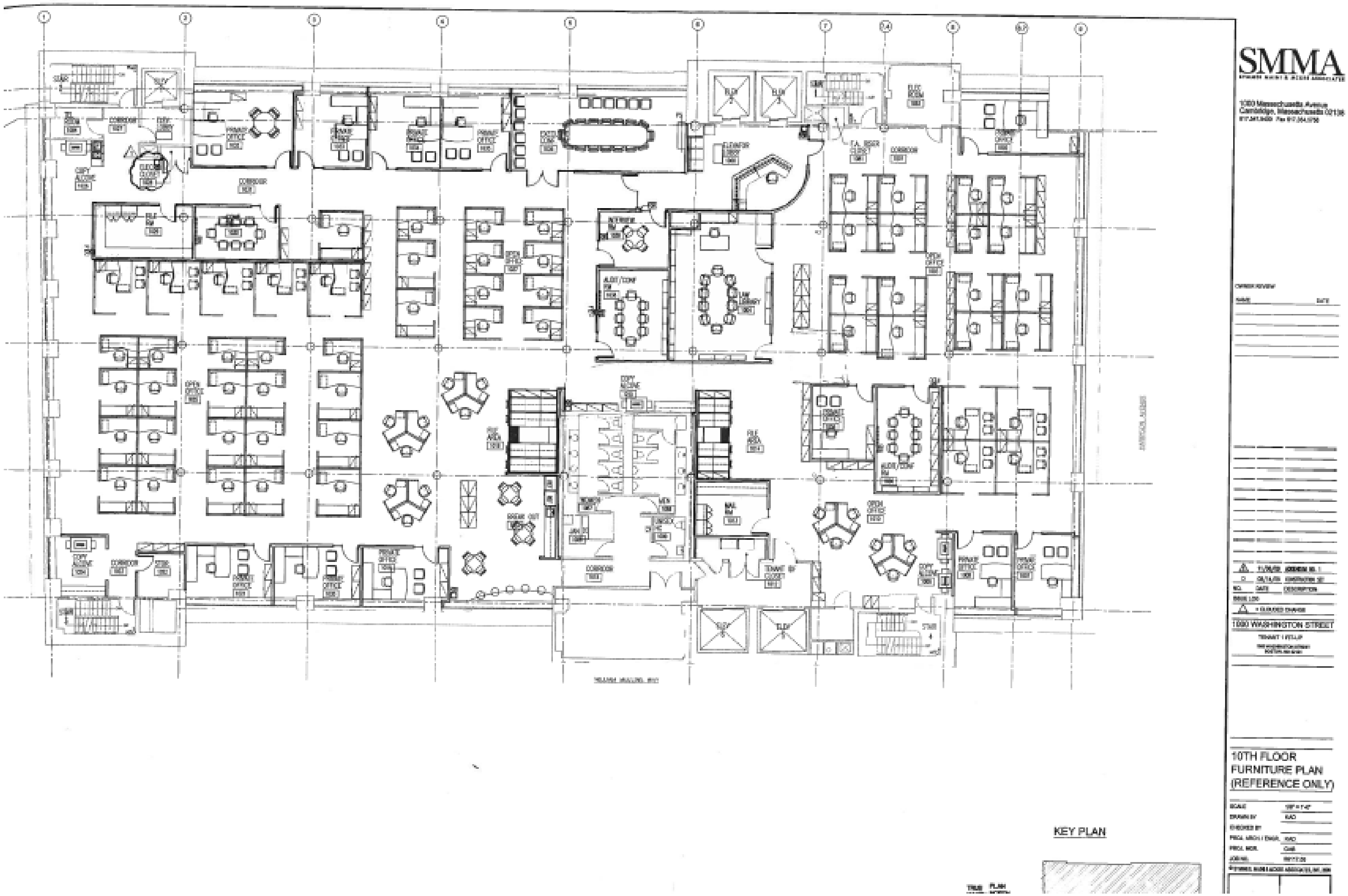
MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

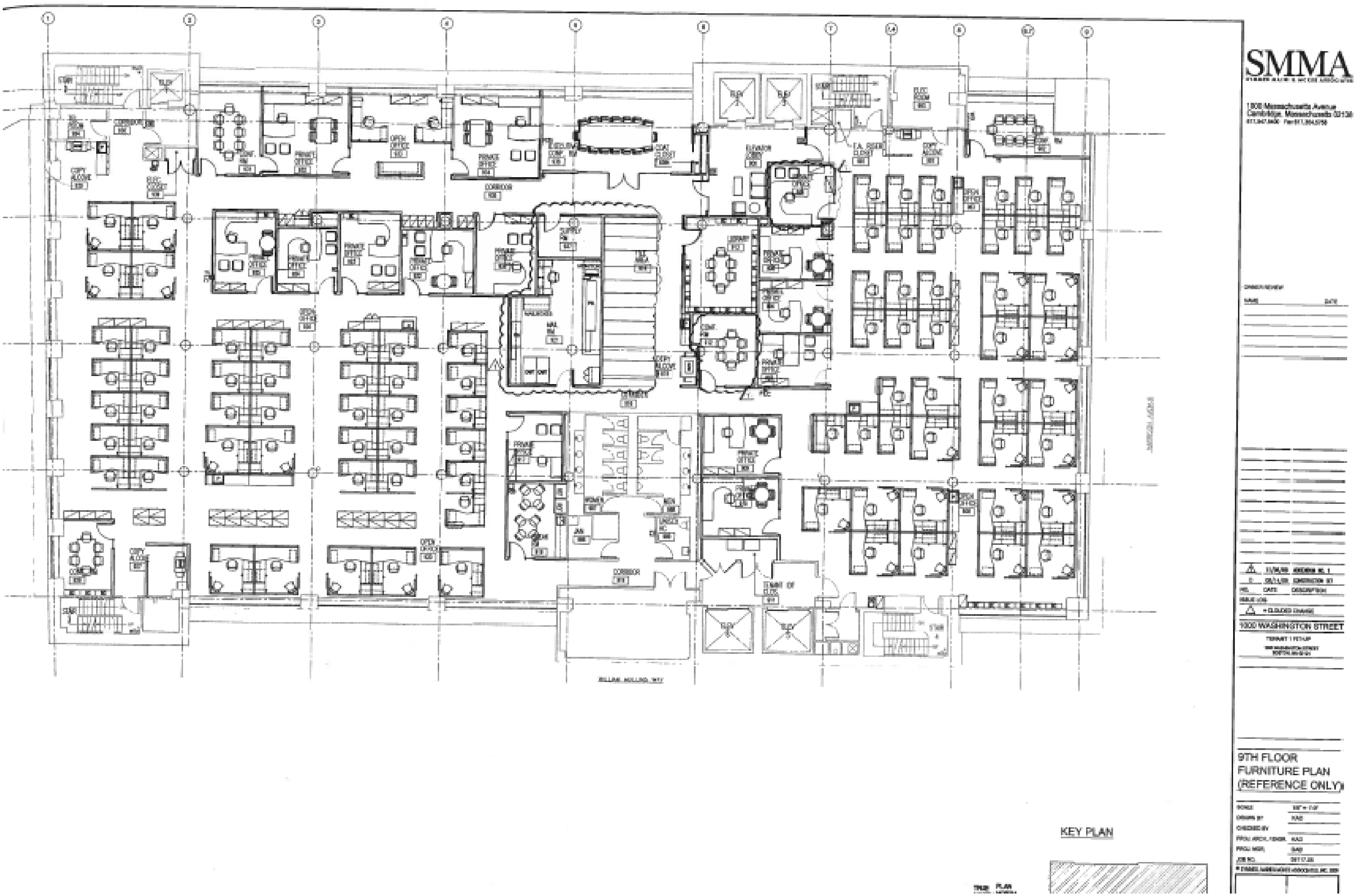
SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

US EPA. 2006. National Ambient Air Quality Standards (NAAQS). US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

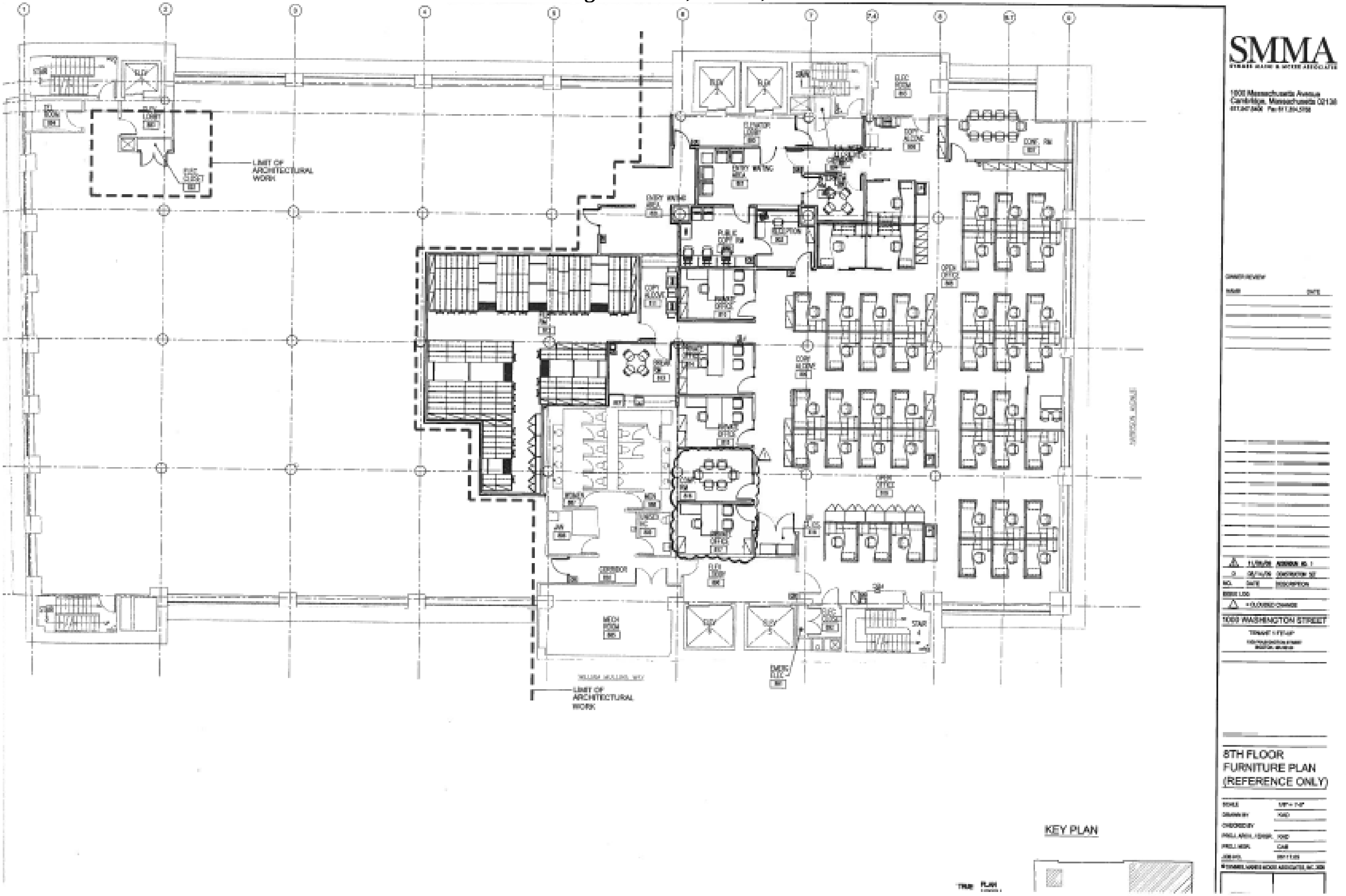
Map 1
1000 Washington Street, Boston, MA 10th Floor



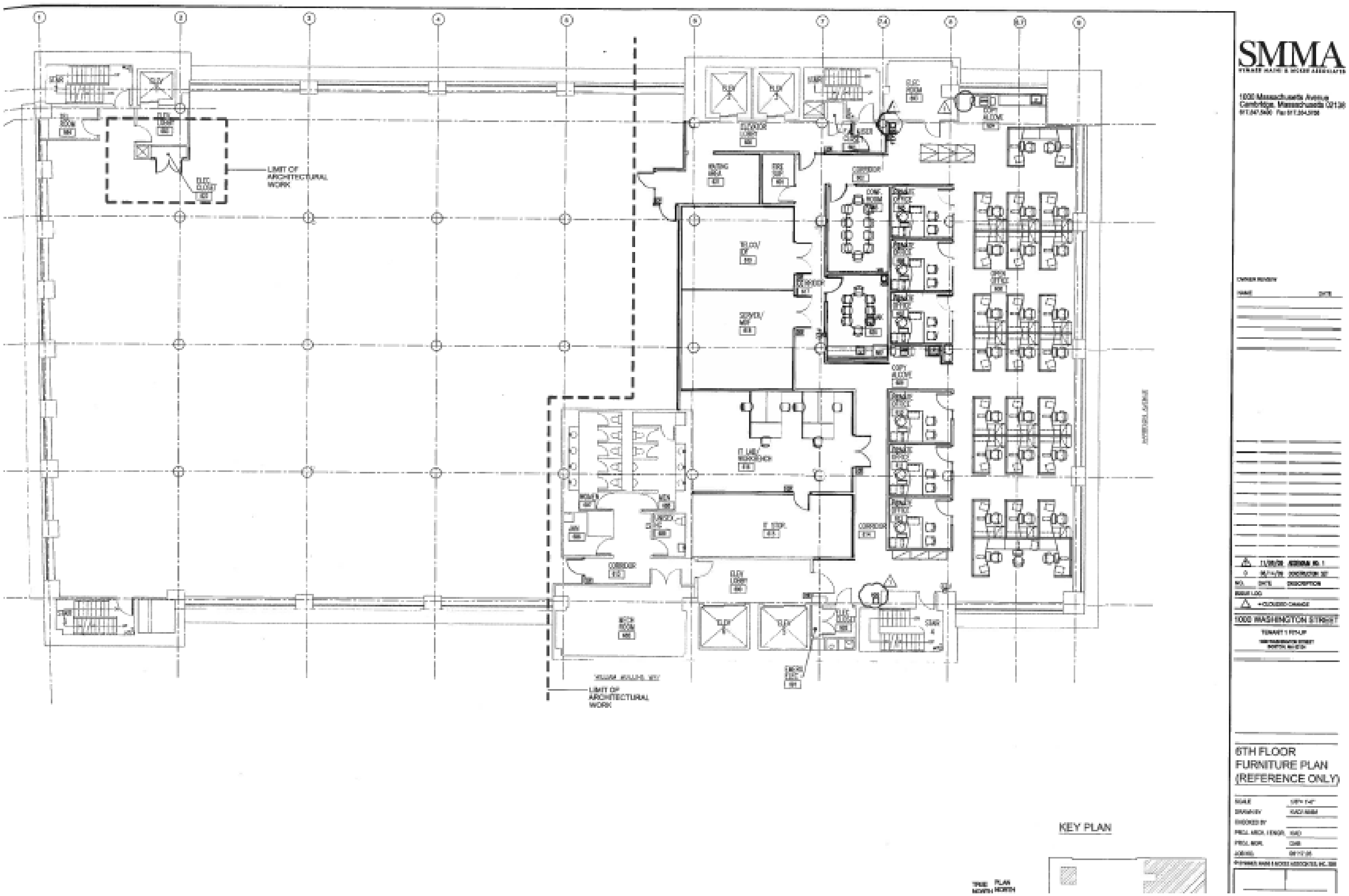
Map 2
1000 Washington Street, Boston, MA 9th Floor



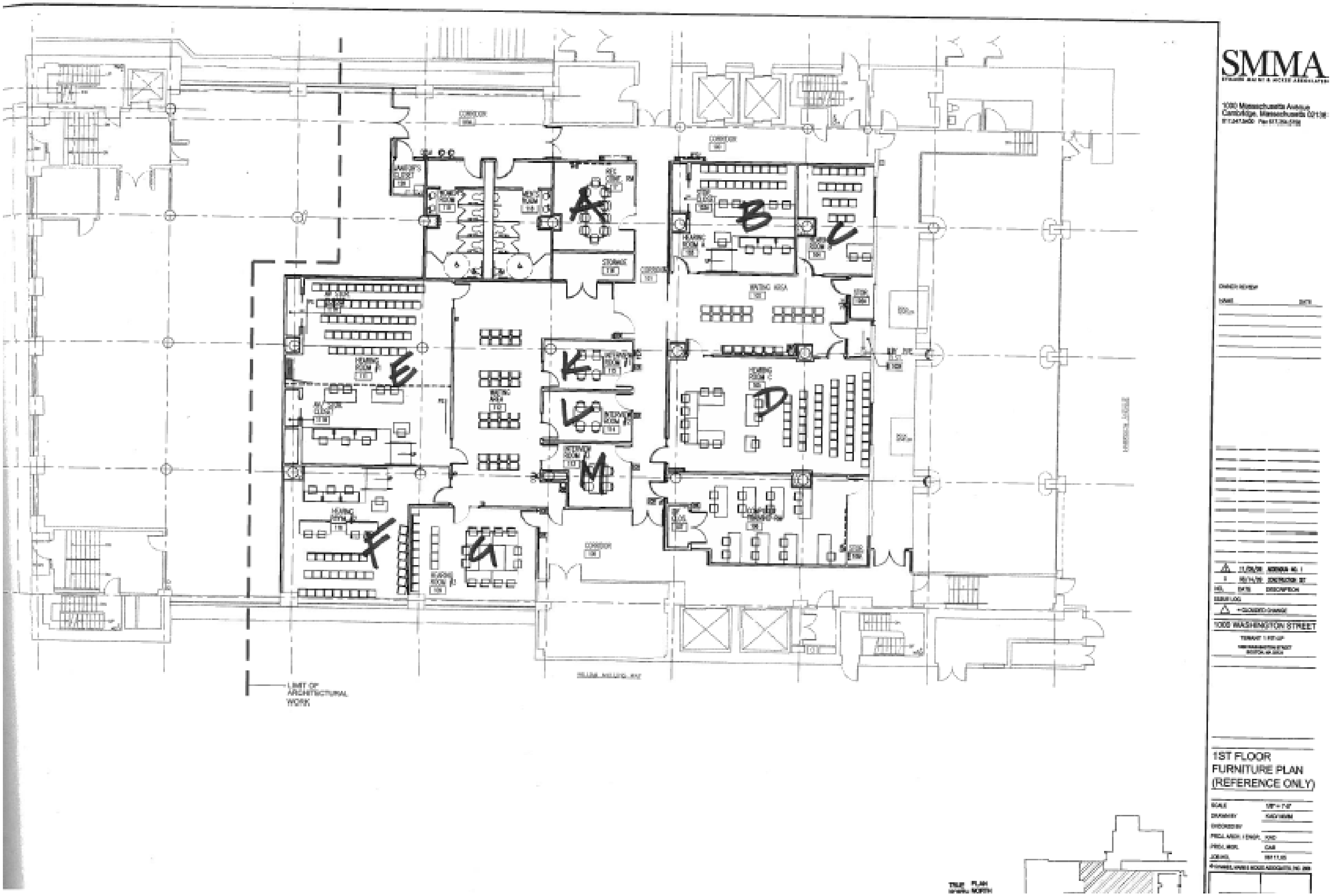
Map 3
1000 Washington Street, Boston, MA 8th Floor



Map 4
1000 Washington Street, Boston, MA 6th Floor



Map 5
1000 Washington Street, Boston, MA 1st Floor



Picture 1

Fresh Air Supply and Exhaust Vents

Location: 1000 Washington Street, Floors 1, 6, 9, 10

Address: 1000 Washington Street, Boston, MA

Indoor Air Results

Date: 4/16/10

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (μg/m³)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	-	47	50	314	ND	ND	9	N	Y	Y	Cool, clear, wind calm
1024	0	69	25	570	ND	ND	3	N	Y	Y	
1017	0	69	26	541	ND	ND	3	N	Y	Y	
Men RR	0	70	26	541	ND	ND	3	N	Y	Y	
1012	0	70	26	562	ND	ND	7	N	Y	Y	
1013	0	71	25	556	ND	ND	4	N	Y	Y	
1010	5	71	25	573	ND	ND	3	N	Y	Y	
1008	1	71	25	568	ND	ND	3	N	Y	Y	
1003A	4	70	25	545	ND	ND	3	N	Y	Y	
1003	4	70	25	662	ND	ND	3	N	Y	Y	
1002	1	71	25	580	ND	ND	3	N	Y	Y	

ppm = parts per million   ND = non detect   μg/m³ = micrograms per cubic meter   TVOC = total volatile organic compounds

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: 1000 Washington Street, Floors 1, 6, 9, 10 **Indoor Air Results**

Address: 1000 Washington Street, Boston, MA **Table 1** **Date: 4/16/10**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
1004	0	71	25	547	ND	ND	4	N	Y	Y	
1005	1	71	24	567	ND	ND	3	N	Y	Y	
1006	0	71	25	605	ND	ND	4	N	Y	Y	
1014	0	71	24	573	ND	ND	3	N	Y	Y	
1015	1	71	24	566	ND	ND	3	N	Y	Y	
1000	2	71	25	607	ND	ND	3	N	Y	Y	
1038	0	69	30	639	ND	ND	3	N	Y	Y	
1036	0	70	27	579	ND	ND	3	N	Y	Y	
1035	4	70	26	609	ND	ND	3	N	Y	Y	
1034	0	70	26	629	ND	ND	3	N	Y	Y	
1033	1	70	26	599	ND	ND	3	N	Y	Y	

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									Supply	Exhaust	
1032	1	70	26	603	ND	ND	2	N	Y	Y	
1029	0	71	25	537	ND	ND	3	N	Y	Y	
1026	2	70	25	630	ND	ND	3	N	Y	Y	
1025	3	70	25	579	ND	ND	3	N	Y	Y	
1025A	4	70	26	603	ND	ND	3	N	Y	Y	
1025B	1	71	25	556	ND	ND	3	N	Y	Y	
1020	0	71	25	556	ND	ND	2	N	Y	Y	
1021	0	71	25	571	ND	ND	3	N	Y	Y	
900	0	72	24	522	ND	ND	4	N	Y	Y	
938	0	72	24	549	ND	ND	3	N	Y	Y	
935	0	72	24	540	ND	ND	4	N	Y	Y	

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									Supply	Exhaust	
936	1	72	25	674	ND	ND	4	N	Y	Y	
933	1	72	25	606	ND	ND	3	N	Y	Y	
932	1	72	24	594	ND	ND	3	N	Y	Y	
931	0	72	24	577	ND	ND	3	N	Y	Y	
929	0	73	24	599	ND	ND	3	N	Y	Y	
926A	5	72	24	574	ND	ND	3	N	Y	Y	
922	0	71	24	531	ND	ND	3	N	Y	Y	
926B	1	71	24	545	ND	ND	4	N	Y	Y	
920	1	71	24	538	ND	ND	3	N	Y	Y	
928	0	71	24	577	ND	ND	3	N	Y	Y	
927	1	71	27	618	ND	ND	4	N	Y	Y	

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									Supply	Exhaust	
918	0	71	25	544	ND	ND	3	N	Y	Y	
989	0	71	26	535	ND	ND	4	N	Y	Y	
911	0	72	25	564	ND	ND	4	N	Y	Y	
910	1	72	24	557	ND	ND	3	N	Y	Y	
908	2	73	24	572	ND	ND	4	N	Y	Y	
908A	2	73	25	561	ND	ND	4	N	Y	Y	
903A	2	73	25	561	ND	ND	4	N	Y	Y	
903	3	73	24	615	ND	ND	3	N	Y	Y	
901	3	73	24	606	ND	ND	3	N	Y	Y	
904	1	73	24	582	ND	ND	3	N	Y	Y	
905	1	73	24	603	ND	ND	3	N	Y	Y	

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									Supply	Exhaust	
906	1	73	24	618	ND	ND	3	N	Y	Y	
907	1	73	24	544	ND	ND	3	N	Y	Y	
912	0	72	24	551	ND	ND	3	N	Y	Y	
916	0	72	24	587	ND	ND	3	N	Y	Y	
921	2	72	24	589	ND	ND	4	N	Y	Y	
917	0	72	24	541	ND	ND	3	N	Y	Y	
801	2	72	25	560	ND	ND	3	N	Y	Y	
802	0	71	25	548	ND	ND	3	N	Y	Y	
805	0	71	25	556	ND	ND	3	N	Y	Y	
806	0	71	25	555	ND	ND	3	N	Y	Y	
807	0	71	25	551	ND	ND	3	N	Y	Y	

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									Supply	Exhaust	
808A	3	71	25	588	ND	ND	4	N	Y	Y	
808	2	71	25	575	ND	ND	4	N	Y	Y	
808B	3	71	25	619	ND	ND	4	N	Y	Y	
819A	2	71	26	615	ND	ND	3	N	Y	Y	
819B	2	71	25	587	ND	ND	3	N	Y	Y	
817	0	71	25	580	ND	ND	5	N	Y	Y	
816	0	71	24	553	ND	ND	4	N	Y	Y	
814	1	71	25	578	ND	ND	4	N	Y	Y	
810	0	71	25	577	ND	ND	4	N	Y	Y	
811	0	71	24	561	ND	ND	4	N	Y	Y	
813	0	71	25	554	ND	ND	4	N	Y	Y	

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									Supply	Exhaust	
812	1	71	25	580	ND	ND	4	N	Y	Y	
812A	0	71	25	627	ND	ND	5	N	Y	Y	
603	0	72	24	491	ND	ND	4	N	Y	Y	
602	0	72	23	468	ND	ND	4	N	Y	Y	
604	0	72	23	431	ND	ND	4	N	Y	Y	
608A	2	73	23	430	ND	ND	4	N	Y	Y	
608	0	73	23	46	ND	ND	4	N	Y	Y	
608B	0	73	23	448	ND	ND	4	N	Y	Y	
608C	2	74	22	455	ND	ND	4	N	Y	Y	
612	0	73	22	443	ND	ND	4	N	Y	Y	
606	0	74	22	457	ND	ND	4	N	Y	Y	

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									Supply	Exhaust	
605	1	74	22	466	ND	ND	4	N	Y	Y	
620	0	73	22	443	ND	ND	5	N	Y	Y	
617	0	73	24	442	ND	ND	4	N	Y	Y	
609	0	73	22	444	ND	ND	4	N	Y	Y	
614	0	73	22	463	ND	ND	4	N	Y	Y	
600	0	71	24	421	ND	ND	4	N	Y	Y	
101	0	71	26	456	ND	ND	8	N	Y	Y	
112	3	72	26	514	ND	ND	10	N	Y	Y	
111	0	72	24	455	ND	ND	8	N	Y	Y	
110	0	72	24	471	ND	ND	6	N	Y	Y	
109	0	72	24	458	ND	ND	6	N	Y	Y	

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									Supply	Exhaust	
114	0	72	24	467	ND	ND	11	N	Y	Y	
115	0	73	23	436	ND	ND	13	N	Y	Y	
106	0	73	24	444	ND	ND	8	N	Y	Y	
Loading dock 1		51	60	407	ND	ND	10	N	Y	Y	Trucks delivering goods
Loading dock 2		62	42	406	ND	ND	10	N	Y	Y	
Loading dock hallway door 3		57	52	490	ND	ND	15	N	Y	Y	
Loading dock hallway 4		63	54	410	ND	ND	9	N	Y	Y	

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