Worcester Public Schools

Ventilation Assessment
&
COVID-19
Mitigation Strategies

for

Francis J. McGrath Elementary School
Worcester, MA

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Worcester Public Schools

A. Preface:

Worcester Public School has as Nault Architects Inc. and their consultant Seaman Engineering Corporation (SEC) to review all of their occupied buildings and comment on existing natural and mechanical ventilation.

The first part of the report is SEC's evaluation of the existing mechanical systems.

The second part of the report is an evaluation of the natural ventilation. The Building Code requires ventilation of each occupied space and that can be achieved either through mechanical of natural ventilation methods. If the natural ventilation path is chosen, there must be a clear opening(s) in the space that meet or exceed the 4% of the total room square footage. After the field survey of each room / window type was complete, the ventilation information was added to a spread sheet for calculation of the 4% and color-coding. The calculations were also color-coded on a floor plans of the building for a better overall understanding of the existing conditions.

The natural ventilation color-coding (on the spreadsheet and plans) is as follows:

- **Green Spaces**: meets or exceed the code minimum natural ventilation.
- **Yellow Spaces**: does **not** meet the code minimum natural ventilation, but does have operable window to allow some natural ventilation.
- **Red Spaces**: does not meet the code minimum natural ventilation and does not have any operable windows.

It should be reiterated that the second part of this report is only measuring natural ventilation. Therefore, newer buildings or buildings with large amounts of fixed windows may have large amounts of red and/or yellow spaces, but that doesn't mean they are not code compliant, they may be relying on mechanical ventilation. However, for this part of the report, were asked to show a baseline for all schools without mechanical equipment.

B. Building Description:

Francis J. McGrath Elementary School:
Francis J. McGrath Elementary School is located in the Burncoat Quadrant of Worcester at 51 Chadwick Street. The School was built in 1977, houses grades K-06, has 15 classrooms and the building is 35,845 square feet. The original windows were replaced in 2016.

C. Table of Contents:

1) Mechanical Ventilation Report

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

This report briefly describes the existing ventilation systems at the Francis J. McGrath School in Worcester, MA as well as their capabilities to support current code required ventilation rates. In addition, we have evaluated the systems ability to support recommendations in accordance with the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020). Several of the ASHRAE recommendations as well as those from the Harvard T.H. Chan School of Public Health and other industry sources have been presented for consideration to assist in further mitigating virus transmission through the buildings heating, ventilation, and air conditioning (HVAC) systems.

Our inspection of the existing systems was limited to visual observations coupled with review of original design drawings, when available. The findings presented in this report presume the systems are operational and delivering air quantities indicated on the original design drawings. Proper operational testing of each piece of equipment and airflow measuring would be required to confirm such operation.

During, our visual inspection we also took several spot measurements of air quality in various locations throughout the school. Measurements taken were limited to Temperature (°F), Relative Humidity (% RH), CO_2 (carbon dioxide in ppm), CH_2O (formaldehyde in ppm) and Total Volatile Organic Compounds (TVOC in ppm).

The results of the readings taken during our inspection were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

COVID-19 Control Measures:

In line with the current American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) and those from the Harvard T.H. Chan School of Public Health - 5-Step Guide to Checking Ventilation Rates in Classrooms, as well as other industry recommendations the following HVAC COVID Control Measures (CCM's) are presented for consideration to assist in mitigating virus transmission thru the HVAC systems. The following descriptions are abbreviated with additional detail found later within the report.

As of the writing of this report, the city of Worcester Public Schools (WPS) has already begun implementation of several of the measures noted below where possible. For enhanced measures WPS has begun to incorporate Bipolar Ionization (see ECCM-#3) extensively throughout the Francis J. McGrath School to address the current pandemic condition.

<u>CCM #1 – Pre & Post Purge Ventilation</u> - Pre and post purge ventilation of occupiable spaces using outside air introduced thru the HVAC systems for an extended period of time prior to and after occupancy.

The building has a mix of HVAC system types, however those serving classrooms appear to be to be capable of implementing this measure.

CCM #2 – Increased Ventilation - Increase the quantity of outdoor air ventilation for improved space dilution where systems allow. Disable demand ventilation reset. The Harvard T.H. Chan School of Public Health identifies 3 outdoor air changes per hour (ACH) as the "bare minimum" during a pandemic condition.

The building has a mix of HVAC system types however, many appear to be to be capable of implementing this measure.

CCM #3 – Improved Filtration - Improve filtration to up to MERV-13 or higher on recirculating air handling systems which can support such filtration.

The unit ventilators in the school will not support increased filtration above MERV 8 either due to physical equipment limitations (i.e., unit ventilators limited to 1" filters) or due to fan capacity limitations. The air handling systems serving other areas are old and would not be expected to be capable of supporting increased filter efficiency. Increased filtration efficiency can lead to faster filter loading and a potential reduction in ventilation air for systems not designed to support this filtration level.

In addition to the above suggested measures, we have also presented Enhanced HVAC COVID-19 Control Measures (ECCM) which could be considered for implementation. Where the above CCM's cannot be employed, one or more of the ECCM measures outlined herein may be utilized to improve indoor air quality. The following descriptions are abbreviated with additional detail found later within the report:

ECCM #1: Portable Room Purifiers - Portable room air purifiers may be used in select areas and rooms to help clean the air within the room. These can be especially helpful where rooms have low outdoor air changes per hour and cannot be supplied with additional outdoor air or where existing systems cannot accommodate improved filtration.

ECCM #2: UV-C Light Sterilization - UV-C lights may be considered for insertion in equipment and ductwork to help neutralize viruses which becomes exposed to the light.

ECCM #3: Bipolar Ionization - Air ionizers may be installed in air handling systems or portable units installed in rooms to improve indoor air quality. These systems cause particles and airborne contaminants to bind together thereby increasing their size, so they tend to either drop out of the breathing zone or be better removed by air filtration. Recent studies have also shown Bipolar Ionization may inhibit the COVID-19 virus's ability to infect.

WPS has begun to incorporate Bipolar Ionization extensively throughout the Francis J. McGrath School to address the current pandemic condition.

Recommendations Summary:

Based on our site inspections, sample air quality readings and review of original drawings we found that a majority of the occupied areas of the Francis J. McGrath School have the ability to comply with current ventilation codes with few exceptions noted herein. There are no original HVAC design drawings to confirm outdoor air ventilation rates so verification would be required through airflow testing of the systems. In order to address the pandemic level conditions currently in place the following table summarizes our recommendations, several of which, align with the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) as well as those from the Harvard T.H. Chan School of Public Health.

WPS has already begun to incorporate Bipolar Ionization (ECCM-#3) extensively throughout the Francis J. McGrath School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
General Classrooms	Unit Ventilators	CCM - #1 & #2 ECCM - #1 or #3 (*see note below)
Cafeteria and Gymnasium	Air Handler HV Unit	CCM - #1 & #2 ECCM - #3
Offices and Interior Spaces	Air Handler HV Units	CCM - #1 & #2 ECCM - #1 or #3 (*see note below)

**Note*: *For individual classrooms and other areas noted, ECCM #1 – Portable Air Filtration and/or ECCM #3 – Ionization, are noted as possible options to improve air cleaning and changeover during pandemic conditions.*

Inevitably, during a pandemic, the best approach is a multi-faceted one which should include the above HVAC strategies as well as proper housekeeping (cleaning of spaces and surfaces), occupant actions (hand cleaning, wearing masks, social distancing, following recommended CDC guidelines) and other mitigation strategies.

II. HVAC VENTILATION ASSESSMENT

A. GENERAL

Over the last several weeks we performed site inspections of the existing school building to assess the ventilation systems in place. Manufacturer and model information was obtained from the existing ventilation equipment, when available/accessible, and visual conditions were noted.

For our review, original design drawings as well as drawings of various modifications over the years for the school were received from school facilities. In addition, we have also received and reviewed the available HVAC control drawings to ascertain current control configuration. We have used these documents to ascertain the original design ventilation rates so as to compare them to current ventilation codes and standards.

Our inspection was limited to visual assessment of systems and did not include operational testing of each piece of equipment or airflow measuring. We have however, taken some spot measurements of air quality in various locations throughout the school. Measurements taken were limited to:

- Temperature (°F)
- Relative Humidity (% RH)
- CO_2 (carbon dioxide in ppm)
- CH_2O (formaldehyde in ppm)
- Total Volatile Organic Compounds (TVOC in ppm)

These readings were taken at a specific moment in time and may vary during the day based on space occupancy, use and activities as well as the operational state of the HVAC systems. For example, most all spaces surveyed were unoccupied or very lightly occupied and as such most all CO_2 levels were low since space CO_2 is primarily generated by occupants.

TVOC's sources can vary widely and include but are not limited to paints, finishes, adhesives, cigarette smoke, pesticides, personal care products, car exhaust, new furnishings, wall coverings, cleansers, and cooking fuels. The meter used included the following chemicals in its TVOC analysis: Acetone, Ethylene Glycol, Formaldehyde, Xylene, 1,3-Butadiene, Tetrachloroethene, Hydrogen Sulfide, Ammonia, Toluene, Benzene, Methylene Chloride, Perchloroethylene, and MTBE. The meter cannot read every possible VOC nor quantify percentages of various VOC's. In addition, we did notice the TVOC readings tended to drift up during the study, possibly due to a calibration issue, as such, the readings in this report were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

The report ventilation calculations presume, the existing systems are operating to the levels reflected on the original design drawings. Testing and balancing by a certified balancer would be required to confirm actual airflows.

For ventilation calculations, data from current codes including the International Mechanical Code (IMC) 2015 and ASHRAE 62.1-Ventilation for Acceptable Indoor Air Quality were used. The outdoor airflow values have been corrected to adjust for the distribution systems ability to get the outdoor air to the space breathing zone with the breathing zone being within 6 feet of the occupied floor. This correction factor also known as the Zone Air Distribution Effectiveness (ZDE), varies based on how and where the air is introduced and removed from the room as well as the temperature of the air entering the room. Some examples of ZDE for various systems are as follows:

Distribution Configuration	ZDE
Ceiling supply of cool air (air below room temp.)	1.0
Ceiling supply of warm air & floor return	1.0
Clg. supply of warm Air >15F above space temp. & clg. return	0.8
Floor supply of warm air & floor return	1.0
Floor supply of warm air & ceiling return	0.7
Displacement cooling floor supply & ceiling return	1.2

For example, a displacement cooling system with a ZDE of 1.2 would require 17% (1.0 / 1.2) less outside air to properly ventilate a space than a system with warm air supplied at the ceiling level being that the displacement system is more effective in getting the outdoor air into the breathing zone. A room with a ZDE of 0.8 would require 25% (1.0 / 0.8) more outdoor air to comply with ventilation standards.

This report contains a brief description of the types of ventilation systems serving the building as well as makes recommendations, where applicable, to improve ventilation of area served by these systems. Our evaluation considered the recommendations made by the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) as well as those from the Harvard T.H. Chan School of Public Health and other industry sources. All to assist in further mitigating virus transmission through the buildings heating, ventilation, and air conditioning (HVAC) systems.

B. EVALUATION

The following evaluation is based on visual observation of systems and equipment and excludes any operational testing which we understand is on-going by WPS. Evaluation includes information obtained from Worcester Public Schools on current air filters as well as existing building mechanical plans when available. In some cases, equipment was not accessible, and assessment was based only on original design drawings where available.

General Classrooms & Misc. Areas:

A majority of the classrooms in the building are heated and ventilated with classroom unit ventilators (UV) and radiation. The UV's are fitted with air 1" thick filters with an estimated MERV rating of 7 or 8 which is typical for units of this type. These units can support a maximum filter efficiency of MERV 8.

The classroom unit ventilators are connected to louvers along exterior walls with each having an outdoor air damper and associated control to allow outdoor air to enter the classroom space through the unit ventilator. The building energy management system (EMS) control the UV's. The control drawings do not indicate a detailed sequence however, typically during occupied periods, the unit fans would be configured to run continuous to provide space ventilation and electric operators modulate the heating valve, face & bypass dampers (where applicable) and mixing dampers to maintain space temperature setpoint. During unoccupied periods, the fans cycle off and only cycle on with the associated heating valve opening when there is a need for heating or economizer (OA) cooling. Control operation should be verified to insure continuous ventilation during occupied periods.

There is another AHU/HV unit located under the floor, in the area of Classroom #4 & #5 on A side, which services an undefined area as the classrooms above have unit ventilators. Further investigation is required to verify this unit's service.

For a standard classroom, current code would require 10 CFM per person of outside air plus 0.12 CFM per SF. For a system with a presumed zone air distribution effectiveness of 1.0, a room size of 900 SF with 26 occupants (25 students + 1 teacher) would require 368 CFM of outdoor air (460 CFM if ZDE = 0.8). Balancing of systems, where present could confirm outdoor airflow rates.

Bathroom and local exhaust requirements are supported by sidewall and roof mounted centrifugal exhaust fans of unknown capacity.

Science & Art Rooms:

There are no assigned science or art classrooms indicated on the plans.

Per the current code, science rooms and art rooms require higher ventilation levels than general use classrooms with a driving factor being required exhaust air. For science laboratories 1 CFM per SF of exhaust is required and for art rooms 0.7 CFM of exhaust is required along with the associated make-up air. In addition, rooms of this nature cannot recirculate air beyond the space served. If no rooms are specifically assigned to these purposes, then these requirements may not apply.

Cafeteria, Gymnasium and Library:

The cafeteria, gymnasium and library spaces are each served by an AHU/HV unit. Each of these units has a mixing box, filter section, heating coil and supply fan. The units utilize 2" thick MERV 8 filters and due to the systems age we suspect they cannot support filtration above MERV 8. Increased filtration efficiency can lead to faster filter loading and a potential reduction in ventilation air for systems not designed to support this filtration level. The units deliver air to the respective spaces via a ducted supply and return system.

The gymnasium ventilation needs are based on a percentage of play area and spectator area. Play area requires an outdoor air volume of 0.3 CFM per SF whereas the spectator area requires 7.5 CFM per person plus 0.06 CFM per SF. The zone air distribution effectiveness is 0.8 based on ceiling supply and ceiling returns. With actual spectator area unknown, presuming the entire gym is play area, would yield a required outdoor air rate of 770 CFM.

The cafeteria ventilation needs are based on occupancy and floor area with 7.5 CFM per person plus 0.18 CFM per SF. The zone air distribution effectiveness is 0.8 based on ceiling supply and ceiling returns. With a presumed occupant load of 100 people the required outdoor air rate of 1,400 CFM.

The library ventilation needs are based on occupancy and floor area with 5 CFM per person plus 0.12 CFM per SF. The zone air distribution effectiveness is 0.8 based on ceiling supply and ceiling returns. With a presumed occupant load of 30 people the required outdoor air rate of 409 CFM.

Per the original drawings, all the AHU systems listed meet minimum outside meet current ventilation standards with 1,600 CFM to both the café and gym systems and 1,800 to the library. However, the control drawings do reflect both CO2 and occupancy sensors for the gym and café systems which can disable systems during periods of no occupancy and lower outdoor air volumes based on actual occupant density. This occupancy feature should be disabled during pandemic conditions to allow for pre-occupancy and post-occupancy purge ventilation of the space (see CCM #1) and the CO2 reset feature should be adjusted to maintain higher ventilation levels.

Office:

The office spaces as well as the teachers' lounge and other misc. spaces are served by an AHU/HV unit. The unit has a mixing box, filter section, heating coil and supply fan. The units utilize 2" thick MERV 8 filters and due to the systems age we suspect they cannot support filtration above MERV 8. Increased filtration efficiency can lead to faster filter loading and a potential reduction in ventilation air for systems not designed to support this filtration level. The units deliver air to the respective spaces via a ducted supply and return system.

The ventilation needs of an office space vary somewhat by space type however for general office space the outdoor air required is 5 CFM per person plus 0.06 CFM per SF. The zone air distribution effectiveness is 0.8 based on ceiling supply and ceiling returns.

The original drawings for this system reflect a percentage of outdoor air of approx. 67% which is very high for this type of space. As such the system appears to meet and exceed the outdoor air ventilation levels required by code.

Controls:

Most of the major HVAC systems supporting the school are controlled by a building energy management system (EMS). The EMS system is currently supported by Alerton as represented by ABS.

The gym and café systems incorporate both CO_2 and occupancy sensors for the gym and café systems. This occupancy feature should be disabled during pandemic conditions to allow for pre-occupancy and post-occupancy purge ventilation of the space (see CCM #1) and the CO_2 reset feature should be adjusted to maintain higher ventilation levels.

The operating schedule for much of the equipment is based on the school's occupancy schedule. The schedule is adjustable via the front-end computer workstation.

C. IAQ & Ventilation Summary

IAQ Summary:

During our inspection we obtained spot measurements of air quality in various locations throughout the school. Measurements taken were limited to:

- Temperature (°F)
- Relative Humidity (% RH)
- CO_2 (carbon dioxide in ppm)
- CH_2O (formaldehyde in ppm)
- Total Volatile Organic Compounds (TVOC in ppm)

The readings were taken at a specific moment in time and may vary during the day based on space occupancy, use and activities as well as the operational state of the HVAC systems. For example, most all spaces surveyed were unoccupied or very lightly occupied and as such most all CO_2 levels were low since space CO_2 is primarily generated by occupants.

In addition, we noted some elevated TVOC levels and/or formaldehyde levels in areas which would not generally be expected to have such elevated levels. Although TVOC's (which includes formaldehyde) may come from varied sources such as cleaners, air fresheners and such, formaldehyde levels are often from off-gassing of furnishings or building materials. It is important to note that elevated levels of TVOC's may have been partially caused by recent enhanced cleaning measures or due to ventilation systems that were not in full operation at the time.

Measurements taken included space humidity. Humidity levels has been found to play a role in the controlling the spread of COVID-19. ASHRAE recommends winter humidity levels be kept between 40% to 50% and summer humidity levels between 50% and 60% with a summer target of 50%. Maintaining humidity levels within the above ranges has been found to limit the growth and transmission of certain bacteria and viruses as well as supports respiratory function. The below chart is taken from the 2020 ASHRAE Handbook – HVAC Systems and Equipment and reflects the impact of space humidity on the increase or decrease of effect on various space contaminants. This chart only reflects increase or decrease of effect from humidity and does not intend to imply that there is zero growth or impact of a certain contaminant when the sloped bar graph zero's out.

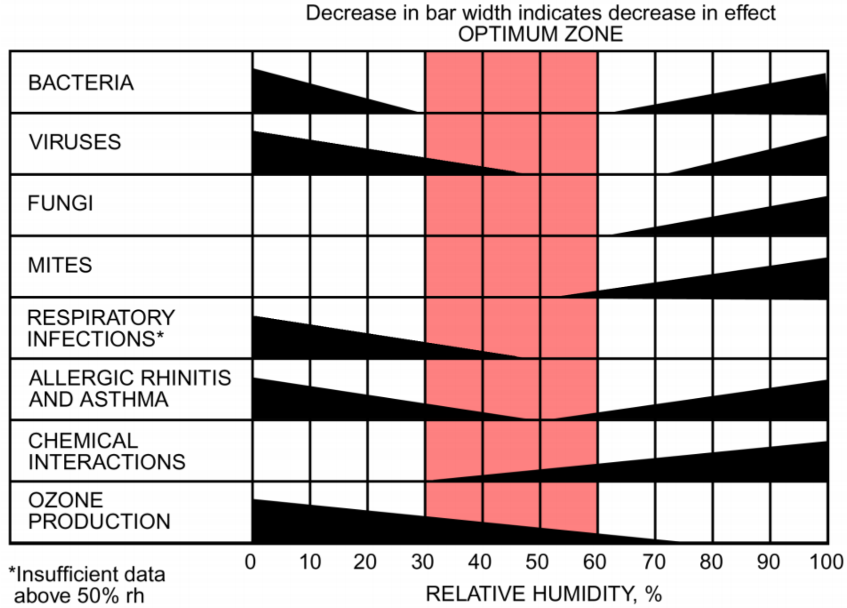

Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

The Francis J. McGrath School HVAC systems have no active humidity control. Space dehumidification is limited only to those areas which have air conditioning cooling. However, this dehumidification is not actively controlled by a humidity setpoint. Moisture removal only occurs when these systems are operating in the cooling mode. As such, space humidity may climb above 60% during periods when low thermal loads require less cooling (i.e., a cool damp day) or swing above and below 60% as the systems cycle based on space temperature.

Caution must be taken when considering adding active humidification to existing buildings as it is imperative that the buildings thermal envelope and vapor barriers be reviewed. Older structures, such as Francis J. McGrath School often have poor vapor barrier the varying wall and window construction and thermal characteristics may limit the ability for active humidification. Adding humidity in the wintertime without consideration of the building construction could result in moisture condensation on windows and within wall assemblies which may create a damaging and unhealthy condition for the building and its occupants. Review of the building envelope should take place prior to consideration of the addition of any humidification system. As such, our recommendations contained with this report exclude active humidification control until such time as the envelope can be reviewed.

The IAQ readings taken during the time of the inspection are contained within the table below. In addition, the table reflects the outdoor air exchange rate in the rooms based on design data from existing plans.

The document entitled “5-Step Guide to Checking Ventilation Rates in Classrooms” from the Harvard T.H. Chan School of Public Health recommends a target outdoor air exchange rate during these pandemic conditions. The document identifies 5 air changes per hour (ACH) and above as "excellent" down to a 3 ACH being considered "bare minimum". Many of the general classrooms in the Francis J. McGrath School appear to have the ability to support and outdoor air exchange rate of 3 however testing would be required to confirm. When the outdoor air exchange rate is lower than the target 5 ACH, the document recommends the following strategies:

1. Increase outdoor air (see CCM #2)
2. Use MERV 13 filters (or greater) on recirculated air (see CCM #3)
3. Add portable air cleaners with HEPA filters to the classroom (see ECCM #1)

It should be made clear however, that a room that has less that what this document considers the bare minimum outdoor air exchange rate may meet or exceed the most current ventilation standards dependent on the pace occupancy and therefore may not be considered under ventilated by code standards. The 5 ACH or greater recommendation is meant to address the pandemic conditions being experienced as this level of ACH would equate to nearly 100% outside air requirement for a conventional mixed air cooling & heating system.

The following tables describe areas and systems where the above measures as well as others presented in this report may be applied.

McGrath Elem. School IAQ Sampling Summary

Space Tested	Temp.	Humidity	CO2	TVOC	HCHO	Room Area	Room Ht.	Volume	Original Design OA	Original OA Air	Notes
	°F	% RH	%	ppm	ppm	SqFt	Ft	Cubic Feet	CFM	ACH	
1st Floor											
Classroom 11	69	23.3	440	1.21	0.06	1091	8.33	9088	375	2.5	
Classroom 14	70.1	22.3	440	1.21	0.08	1650	8.33	13745	417	1.8	
Boys 14A	67.4	25.3	452	1.1	0.08	133	8.416	1119	N/A	N/A	
Classroom 21	70.9	21	439	1.19	0.07	766	8.416	6447	333	3.1	
Gymnasium & Café	71.9	22.4	455	1.25	0.06	4105	23.083	94756	4200	2.7	
Kitchen 26	71.3	21.2	446	1.3	0.06	284	8.416	2390	625	15.7	
2nd Floor											
Classroom 34	65.1	26	465	1.39	0.2	666	8.5	5661	188	2	
Classroom 35	66.9	24.9	432	1.35	0.15	819	8.583	7029	417	3.6	
Library 30	73.3	22.3	439	1.27	0.05	1427	8.416	12010	1200	6	
Classroom 41	68.9	25.7	475	1.33	0.08	1046	9.5	9937	313	1.9	
Teachers Lounge	70.4	22.9	446	1.3	0.05	381	8.416	3206	320	6	
Health Suite 43	71.8	25	492	1.3	0.05	148	8.416	1246	217	10.5	
General Office Room 45	72.6	22.3	493	1.3	0.05	577	8.416	4856	453	5.6	
Principal	73.2	22.2	490	1.31	0.05	154	8.5	1309	87	4	

Note: As noted previously, the TVOC readings tended to drift up during the study, possibly due to a calibration issue, as such, the readings in this report were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

Ventilation System Summary & Recommendations:

The following table is based on original design drawings and reflect most of the systems which provide ventilation air to the building. The units ID tag, area served, ventilation data and filter efficiencies are listed. The table also reflects possible COVID Control Measures (CCM) and Enhanced COVID Control Measures (ECCM) described later in this report which may apply to such systems to improve performance either during pandemic conditions and/or post pandemic conditions.

McGrath Elem. School Ventilation System Summary

Unit ID	Area Served	Exist. Supply CFM	Exist. O.A. CFM	Exist. O.A. %	Exist. Filter Qty & Size	Exist. Filter MERV Rating	Exist. Filter Vel. (FPM)	Proposed CCM #	Proposed ECCM #	Notes
HV-A/AHU-3	2nd Flr Admin	2025	1350	67	N/A	8	N/A	#1, #2	#1, #3	a
HV-B/AHU-4	Library	3650	1825	50	N/A	8	N/A	#1, #2	#1, #3	
HV-C/AHU-1	Gym	6,400	1,600	25	N/A	8	N/A	#1, #2	#3	b
HV-D/AHU-2	Café	6,400	1,600	25	N/A	8	N/A	#1, #2	#3	b
Misc UV's	varies	varies	varies	varies	varies	8	varies	#1, #2	#1, #3	a
Note: AHU-1 and 2 designation need to be confirmed with control vendor as control drawings does not clarify.										

Ventilation System Summary Notes:

a. *For individual classrooms and other areas noted, ECCM #1 – Portable Air Filtration and/or ECCM #3 – Ionization, are noted as possible options to improve air cleaning and changeover during pandemic conditions.*

b. *Disable occupancy sensors and adjust CO2 demand ventilation reset to ensure elevated outdoor air levels during occupied periods.*

II. COVID-19 HVAC MITIGATION MEASURES

A. HVAC COVID-19 CONTROL MEASURES

In line with the current American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) and those from the Harvard T.H. Chan School of Public Health - 5-Step Guide to Checking Ventilation Rates in Classrooms, as well as other industry recommendations the following HVAC COVID Control Measures (CCM's) are presented for consideration to assist in mitigating virus transmission thru the HVAC systems.

The ASHRAE Epidemic Task Force recommends several measures to assist in COVID-19 mitigation with more aggressive action with epidemic conditions in place (ECiP) and post-epidemic conditions in place (P-ECiP). For ECiP conditions in place the HVAC COVID-19 Control Measures (CCM) that could be readily applied to the Francis J. McGrath School surveyed are outline herein. Refer to the Ventilation System Summary Table for applicable CCM recommendations.

It is imperative that all systems be maintained and checked to confirm proper operation in line with their original design, adjusted where applicable, as described herein. In addition, a Testing and Balancing company should be enlisted to adjust and confirm all systems are properly achieving their design outdoor air, supply air and exhaust air levels.

<u>CCM #1</u> – Pre & Post Purge

Pre and post purge ventilation of occupiable spaces using outside air introduced the HVAC systems. This would be accomplished by starting the ventilation systems in occupied mode (i.e., OA at design or higher) 4 hours prior to schedule building occupancy and maintain the occupied mode for 4-hours after occupancy ends.

Most of the HVAC systems supporting the Francis J. McGrath School are capable of implementing this measure.

<u>CCM #2 – Increased Ventilation</u>

Increase outdoor air ventilation for improved space dilution where systems allow. This would entail increasing the minimum outdoor air damper positions on all mixed air style systems within the limits of the equipment capacity and overriding any demand ventilation reset schemes (i.e., CO_2 reset). A control sequence would need to be implemented for the respective air handlers which would limit the outdoor air volume to the unit's respective capability such that proper control of the discharge air can be maintained as well as freeze protection of coils. In addition, sequence would need to include limitation based on boiler plant and cooling system capabilities and summertime moisture limitations. For buildings which have anti-freeze in water-based heating and/or cooling systems concern of unitary coil freeze up is reduced.

Most of the HVAC systems supporting the Francis J. McGrath School appear to be capable of implementing this measure.

CCM #3 – Improved Filtration

Improve filtration to up to MERV-13 on air handling systems, especially those which recirculate air. In addition, if possible, as filters are replaced provide sealant or gasketing between and/or around filters to reduced air bypass around filter sections.

All the HVAC systems including the AHU/HV's, RTU and classroom unit ventilators are not able to support filtration in excess of MERV 8. All replacement filters for these terminal units should meet MERV 8 requirements.

Prior to implementation of higher filtration levels in excess of MERV 8, existing equipment capabilities must be reviewed to verify it can support the added pressure drop imposed by MERV-13 filtration. Testing and balancing to confirm current airflow, pressure drops, and fan motor power coupled with manuf. published data would be required to confirm the unit's capability for improved filtration.

B. ENHANCED HVAC COVID-19 CONTROL MEASURES

In addition to the suggested above measures below are some Enhanced HVAC COVID-19 Control Measures (ECCM) which could be considered for implementation. Refer to the Ventilation System Summary Table for applicable recommendations.

ECCM #1: Portable Room Purifiers

Portable room air purifiers could be used in select areas and rooms to help clean the air within the room. These could be applied in areas such as those where the population is in a higher risk group of developing COVID-19 complications or anywhere where real time space cleaning is required such as the nurse's office. Products which include HEPA filters and fans with air exchange rate appropriate for the size room should be selected.

ECCM #2: UV-C Light Sterilization

UV-C lights can be inserted in equipment and ductwork to help neutralize viruses as it is exposed to the light. UV technology has been studied and used extensively, primarily in hospital settings for virus and bacteria control and in the general HVAC primarily to prevent build-up on coils. To properly mitigate the virus an extended run of return air duct would need to be identified to allow for adequate exposure to UV-C light since a light bar just at the unit coil or filter will primarily just prevent build-up of mold, bacteria, and viruses on those surfaces.

ECCM #3: Bipolar Ionization

Air ionizers are meant to be installed in the supply air duct or plenum downstream of fans and filters. They are also offered as portable units for room application. In Francis J. McGrath Schools case, they could be installed in the supply air duct of the respective mixed air handling systems and unit ventilators as well as portable units could be considered. WPS has already begun to incorporate Bipolar Ionization extensively throughout the Francis J. McGrath School to address the current pandemic condition.

Air ionizers appear to be showing quite a bit of promise for low system impact in retrofit applications. For years, these products have been used to primarily clean air of dust and particles by forcing the particles to bind together and either drop out of the breathing zone and/or better be able to be captured by HVAC system air filters by making particles larger. Recently, there are studies which claim to show that ionizers work on neutralizing virus's in the space prior to needing to draw these pollutants back to the units where filters and/or other cleaning technology such as UV-C could occur.

ASHRAE has not taken a definitive stance on Bipolar Ionization with regard to virus mitigation as of yet and has deferred to CDC's comment that it is still considered an emerging technology in this regard. Bipolar Ionization has been used for decades primarily for the removal of particles within the air. During that period, its use was focused more in facilities such as convention centers, airports, casinos and the like as there are large amounts of occupant and activity generated pollutants. Only recently has Bipolar Ionization been looked at for virus mitigation which is why ASHRAE and CDC still view it as an emerging technology being that there are not extensive 3rd party studies and reviews of its capability in this regard.

That said, even ignoring its potential virus neutralizing capabilities, the ability of the product to bind smaller particles into larger particles results in an overall desirable indoor air quality benefit in that it increases the capabilities of air filters to filter the air as well as promotes particles to drop out of the breathing zone. We do, however, recommend the technology be provided on systems that meet code required outdoor air ventilation levels as this technology is not a replacement for outdoor air.

Inevitably, during an epidemic, the best approach is a multi-faceted one and should include the above HVAC strategies as well as proper housekeeping (cleaning of spaces and surfaces), occupant actions (hand cleaning, wearing masks, social distancing, following recommended CDC guidelines) and other mitigation strategies.

2) Natural Ventilation Summary

Francis J. McGrath Elementary School

Room Name / Number	Space Use	Net Floor Area (SF)	4% of Net Area	A 1.46 HOPPER	B 1.43 HOPPER	C 2.13 HOPPER	D 1.54 HOPPER	E 1.32 HOPPER	F 1.94 HOPPER	G 1.58 HOPPER	H 1.43 HOPPER	J 1.52 HOPPER	Total open Area (SF)	Difference between actual and required SF	PASS?	Additional Notes
First Floor																
Room 11	classroom	1091	43.64			2	2						7.34	36.30	NO	
Room 11A	toilet	33	1.32										0.00	1.32	NO	
Room 11B	toilet	33	1.32										0.00	1.32	NO	
Room 11D	storage	199	7.96										0.00	7.96	NO	
Room 11E - Custodian	support	39	1.56										0.00	1.56	NO	
Room 12	classroom	1237	49.48		2								2.87	46.61	NO	
Room 12A	storage	139	5.56										0.00	5.56	NO	
Room 12B	storage	119	4.76										0.00	4.76	NO	
Room 12C	entry	134	5.36										0.00	5.36	NO	
Room 13	classroom	757	30.28	4									5.83	24.45	NO	
Room 14A / 14B	classroom	1650	66	4									5.83	60.17	NO	
Boy's Room 14A	toilet	165	6.6										0.00	6.60	NO	
Girl's Room 14B	toilet	1147	45.88										0.00	45.88	NO	
Room 14D	support	315	12.6										0.00	12.60	NO	
Room 15	classroom	755	30.2	4									5.83	24.37	NO	
Room 16 - Teacher's Station	support	118	4.72										0.00	4.72	NO	
Room 21	classroom	756	30.24										0.00	30.24	NO	
Room 21A - Storage	storage	84	3.36										0.00	3.36	NO	
Boy's Room - 22A	toilet	96	3.84										0.00	3.84	NO	
Girl's Room 22B	toilet	97	3.88										0.00	3.88	NO	
PTO	support	266	10.64										0.00	10.64	NO	
Phys Ed Office	office	115	4.6										0.00	4.60	NO	
Phys Ed Toilet	toilet	33	1.32										0.00	1.32	NO	
Room 24 - Gymnasium	Gym	1984	79.36										0.00	79.36	NO	
Room 24A - Gym Storage	Gym	283	11.32										0.00	11.32	NO	
Stage / Art Room	classroom	720	28.8										0.00	28.80	NO	
Stage Storage	storage	107	4.28										0.00	4.28	NO	
Cafeteria	café	2120	84.8										0.00	84.80	NO	
Room 25A	storage	72	2.88										0.00	2.88	NO	
Room 26 - Kitchen	kitchen	283	11.32										0.00	11.32	NO	
Room 26 - Freezer	kitchen	50	2										0.00	2.00	NO	
Room 26 - Refrigerator	kitchen	35	1.4										0.00	1.40	NO	
Room 26 - Toilet	toilet	26	1.04										0.00	1.04	NO	
Room 26B - Storage	storage	48	1.92										0.00	1.92	NO	
Room 27 - Custodian	support	68	2.72										0.00	2.72	NO	
Room 27 - Toilet	toilet	43	1.72										0.00	1.72	NO	
Room 27A	support	112	4.48										0.00	4.48	NO	
Second Floor																
Room 30 - Library	media	1427	57.08										0.00	57.08	NO	
Room 30A - Office	office	76	3.04										0.00	3.04	NO	
Room 30B - PreSchool	classroom	258	10.32										0.00	10.32	NO	
Room 30B - PreSchool	classroom	204	8.16										0.00	8.16	NO	
Room 30C - Primary Resource	support	302	12.08										0.00	12.08	NO	
Room 30C - Toilet	toilet	42	1.68										0.00	1.68	NO	
Room 31	classroom	670	26.8					2					2.65	24.15	NO	
Room 32 - Deaf Room Therapy	classroom	778	31.12					2					2.65	28.47	NO	
Room 32	toilet	32	1.28										0.00	1.28	NO	
Room 32C - Teacher's Station	office	118	4.72										0.00	4.72	NO	
Room 32D - Storage	storage	24	0.96										0.00	0.96	NO	
Room 33	classroom	781	31.24					2					2.65	28.59	NO	
Room 33A	toilet	32	1.28										0.00	1.28	NO	
Room 33B	support	18	0.72										0.00	0.72	NO	
Room 34	classroom	665	26.6					2					2.65	23.95	NO	
Room 35	classroom	818	32.72		2								2.87	29.85	NO	
Room 36A / Room 36B	classroom	1710	68.4		2				2				6.76	61.64	NO	
Room 36A - Boy's Room	toilet	165	6.6										0.00	6.60	NO	
Room 36B - Girl's Room	toilet	148	5.92										0.00	5.92	NO	
Room 36D	entry	311	12.44										0.00	12.44	NO	
Room 37	classroom	815	32.6		2				2				6.76	25.84	NO	
Room 38 - Teacher's Station	support	118	4.72										0.00	4.72	NO	
Room 41	classroom	1045	41.8							6	2		12.35	29.45	NO	
Room 41 - Storage	storage	112	4.48										0.00	4.48	NO	
Room 42 - Teacher's Lounge	support	380	15.2										0.00	15.20	NO	
Room 42A - Staff	support	72	2.88										0.00	2.88	NO	
Room 42B - Men's	toilet	80	3.2										0.00	3.20	NO	
Room 43 - Health Suite	health	147	5.88										0.00	5.88	NO	
Room 43A	toilet	70	2.8										0.00	2.80	NO	
Room 43B - Exam	health	70	2.8										0.00	2.80	NO	
Room 43C - Storage	storage	15	0.6										0.00	0.60	NO	
Room 44A - Storage	storage	39	1.56										0.00	1.56	NO	
Room 45 - General Office	office	577	23.08										0.00	23.08	NO	
Room 45A - Storage	storage	48	1.92										0.00	1.92	NO	
Room 45B	toilet	25	1										0.00	1.00	NO	
Room 46 - Conference Room	conference	152	6.08										0.00	6.08	NO	
Principals Office	office	154	6.16										0.00	6.16	NO	
Assistant Principal	office	99	3.96			2							4.25	-0.29	YES	

Window Type	Width	Hieght	Projection	Venting
A - Hopper	31	29	3.5	1.46
B - Hopper	30	29	3.5	1.43
C - Hopper	59.5	28	3.5	2.13
D - Hopper	35.5	28	3.5	1.54
E - Hopper	26.5	28	3.5	1.32
F - Hopper	52	28	3.5	1.94
G - Hopper	39	26	3.5	1.58
H - Hopper	33	26	3.5	1.43
J - Hopper	38.5	24	3.5	1.52

Room Color Key	
(green)	Rooms that meet or exceed the minimum code required ventilation
(yellow)	Rooms that do not meet the code required ventilation, but have operable windows.
(red)	Rooms that do not have operable windows (either fixed or none present)