Worcester Public Schools

Ventilation Assessment
&
COVID-19
Mitigation Strategies

for

Quinsigamond Elementary School
Worcester, MA

January 31, 2021

Prepared by:

Nault Architects Inc
71 Hope Ave
Worcester, MA 10603

Seaman Engineering Corporation
22 West St, Unit C
Milbury, MA 01527

&

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:

Quinsigamond Elementary School:
Quinsigamond Elementary School is located in the South Quadrant of Worcester at 14 Blackstone River Road. The School was built in 1997 (including an overall renovation to the original portion of the building), houses grades PK-06, has 51 classrooms and the building is 118,198 square feet. The widows are original to the 1997 construction / renovation.

C. Table of Contents:

1) Mechanical Ventilation Report

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

This report briefly describes the existing ventilation systems at the Quinsigamond Elementary 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 Quinsigamond Elementary School to address the current pandemic condition.

CCM #1 – Pre & Post Purge Ventilation – 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.

Most of the HVAC systems supporting the Quinsigamond Elementary School are 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.

Many of the classroom HVAC systems supporting the Quinsigamond Elementary School are close to meeting the 3 ACH requirement at approx. 2.5 ACH. The gymnasium, auditorium and cafeteria HVAC systems have the ability to increase outdoor air (O.A.) for higher O.A. ventilation and air exchange rates subject to outdoor ambient conditions and equipment limitations. Many of the classrooms HVAC systems throughout the building cannot support additional outside air as they are at their systems design capacity.

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

The cafetoria and multi-purpose air handling systems may support improved filtration up to a maximum of MERV 13 pending testing and verification. Most other systems in the building will not support increased filtration above MERV 8 either due to physical equipment limitations (i.e., fan coils limited to 1" filters) or due to fan capacity limitations. Increased filter efficiency can lead to faster filter loading and a potential reduction in ventilation air for systems not designed to support this filtration level.

Systems retrofitted with MERV 13 must be tested and adjusted to accommodate the pressure drop associated with the increased filter efficiency. In addition, more frequent filter changes would be expected to limit reduction in ventilation air as the filters load.

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 to help clean the air within that space. 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 as it is 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 Quinsigamond Elementary 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 Quinsigamond Elementary School comply with current ventilation codes with few exceptions noted herein. However, 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 Quinsigamond Elementary School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
General Classrooms	MAU Systems	CCM - #1 ECCM - #1 or #3 (*see note below)
Art Classrooms	MAU Systems	Increase O.A. ventilation to code minimum (may require system work). CCM - #1 & #2; ECCM - #3
Cafeteria	AHU System	CCM - #1, #2 & #3 ECCM - #3
Gymnasium	HV Unit	CCM - #1 & #2 ECCM - #3
Admin. & Guidance Office	MAU Systems	CCM - #1 ECCM - #1 or #3 (*see note below)

*<u>Note</u>: *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:

A majority of the classrooms in the building are heated with 2-pipe fan coil units. These units are fed with hot water and chilled water from the central boiler and chiller plant. Most of the units 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 fan coil units recirculate heated or neutral air within the room they serve. A DDC space thermostat controls the operation of the hydronic valve in the units as well as the fan with occupied and unoccupied schedules. The fan coils appear to be programmed for continuous fan mode during occupied periods with discharge air temperature varying based on deviation from space temperature setpoint. During unoccupied periods, the fans cycle off and only cycle on with the associated hot water valve opening when there is a need for heating.

Outdoor air for a majority of the classroom spaces is supported by multiple gas-fired heating and ventilation (HV) units supporting dedicated outdoor air systems (DOAS) to each classroom fan coil. The units are identified as MAU-#. These units are configured as 100% outside air systems with no recirculation air. The units have intake dampers, filter sections, gas-fired furnaces, and supply fans. The units have 2" thick pleated filters with an estimated MERV rating of 8.

These MAU units may be able to support improved filtration of MERV 11 or potentially even MERV 13 however, any improvement in filtration must be confirmed thru unit airflow testing to evaluate if the unit can support the added pressure drop from higher filtration without risk of reducing airflow. As these unit's convey 100% outside air, they not filtering contaminated space air but only outside air and as such the space air quality would not benefit greatly by increasing filtration at the risk of a potential reduction in air volume from higher pressure drop faster loading higher MERV filters.

The system delivers approx. 450 CFM of outdoor air to the respective ducted fan coil units that serve most typical classroom spaces. The system also exhausts 325 CFM from each classroom thereby placing the rooms under a slight positive pressure.

Classroom exhaust is generally supported by roof exhaust fans connecting to the supporting rooms via above ceiling ductwork and vertical duct chases. The exhaust fans appear to exhaust just the minimum amount of outside air for ventilation.

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 zone air distribution effectiveness of 0.8, as most classrooms with the current DOAS systems have are, a room size of 900 SF with 26 occupants (25 students + 1 teacher) would require 460 CFM of outdoor. Hence the current systems operating at 450 CFM provide close to the code required outdoor air to the rooms.

Art Rooms:

The art room is supported by the same type of fan coil units and outdoor air systems that supply the normal classroom systems. These rooms are supplied with the same amount of outside air (450 CFM typically) as the standard classrooms with corresponding similar exhaust rates.

Per the current code, art rooms require higher ventilation levels than general use classrooms with a driving factor being required exhaust air. For art rooms 0.7 CFM of exhaust is required along with the associated make-up air. It appears the buildings ventilation levels for the art rooms is non-compliant with current code in regard to the exhaust rate.

Offices:

Like most other areas of the building offices ventilation needs are also supported by common 100% outside units supply air to respective ducted space fan coil units. The units outdoor air values vary but appear to comply with current ventilation codes.

Gymnasium & Cafeteria:

The gymnasium and cafeteria are heated and ventilated through the use of gas fired HV units located within mechanical rooms. The HV units are fitted with a mixing box, filter section, hot water coil and fan. In addition, each has a return fan. The cafeteria system also has a chilled/hot water coil mounted in the ductwork. The filters on HV units are 2" thick pleated filters with an estimated MERV rating of 8.

The filters for the HV units may be able to be increased to a MERV level as high as MERV 13 pending testing and confirmation of fan capabilities. If increased to MERV 13, more frequent replacement of the filters shall be requiring to avoid reduction in airflow as filters load.

The existing design drawings do not reflect the outdoor air volume for these systems. However, the control drawings for both the gymnasium and cafeteria systems reflect the utilization of CO_2 sensors with controls for demand ventilation reset of space CO_2. These reset controls should be disabled to ensure outdoor air levels are kept at design levels during the pandemic condition.

Controls:

Most of the major HVAC systems supporting the school are controlled by a building energy management system (EMS). The EMS system was installed and is currently supported by Automated Building Systems, Inc (ABS). Although a further review with the EMS vendor would be required to ascertain the extent of this system it is our current understanding that the system controls all the AHU, HV and MAU units as well as most of the fan coil units, exhaust fans, etc.…

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.

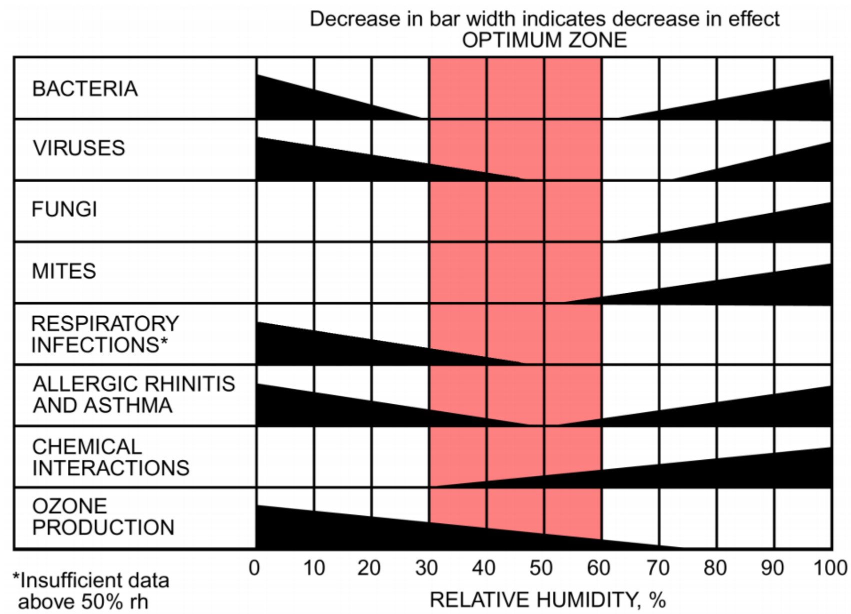

Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

The Quinsigamond Elementary 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. Although newer or renovated structures, such as Quinsigamond Elementary School often have a fair 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 Quinsigamond Elementary School have a design outdoor air exchange rate of 2.5 below the bare minimum criteria. 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 and therefore is not under ventilated. 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.

	Quinsigamond Elem. School IAQ Sampling Summary										
									Original	Original	
Space Tested	Temp.	Humidity	CO_2	TVOC	HCHO	Room Area	Room Ht.	Volume	Design OA	OA Air	Notes
	°F	% RH	%	ppm	ppm	SqFt	Ft	Cubic Feet	CFM	ACH	
1st Floor											
Cafeteria 100	75.1	28.8	434	0.6	0.05	2990	14.75	44103	0	0	
Quinsigamond Rm 102	76.1	24.5	481	1.37	0.1	1497	10.5	15719	1305	5	
Upper Lobby	71.5	26.6	463	1.06	0.14	1342	11.41	15312	450	1.8	
Main Office/Waiting 106	71.5	24.8	507	1.41	0.26	772	9.91	7651	450	3.5	1
Library 111	71	24.9	437	0.56	0.1	2485	10.91	27111	450	1	
Classroom 117	74.4	29.5	442	0.81	0.11	1105	10.91	12056	450	2.2	
Classroom 127	73.8	29.2	592	1.35	0.18	944	10	9440	450	2.9	1
Gym	73.4	27.5	450	0.6	0.1	6419	33.16	212854	0	0	
2nd Floor											
Computer Lab 200	71.1	32.7	467	1.05	0.1	1286	10	12860	450	2.1	
Computer Lab 201	73.9	29.3	448	0.89	0.14	1449	10	14490	450	1.9	
Classroom 203	73.7	27.5	461	0.72	0.1	941	10	9410	450	2.9	
Teachers Rm 212	72.6	26.1	442	0.91	0.09	565	9.91	5599	400	4.3	
Classroom 217	73	29.7	452	0.82	0.1	999	10.91	10899	450	2.5	
Classroom 222	73.6	26.5	444	0.69	0.08	1099	10	10990	450	2.5	
Classroom 223	71.4	275	452	0.83	0.1	1074	10	10740	450	2.5	
3rd Floor											
Classroom 300	72	31.1	558	0.98	0.12	1280	9.75	12480	450	2.2	
Classroom 301	71.8	29	458	0.75	0.11	1448	10	14480	450	1.9	
Classroom 308	71.9	25.7	480	0.83	0.14	929	10	9290	450	2.9	
Art 320	71.8	29.1	482	0.85	0.09	1295	9.33	12082	450	2.2	
Classroom 321A	72.7	28.6	457	0.86	0.09	767	9.16	7026	450	3.8	
Classroom 324	71.3	30.2	461	0.75	0.1	837	9.16	7667	450	3.5	
Classroom 325	72.3	28.2	480	0.7	0.11	1417	9.16	12980	450	2.1	

IAQ Summary Table Notes:

1. *TVOC's and CH_2O higher than anticipated for an office type space. Suggest further review of ventilation systems serving the areas and review of cleaners used.*

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.

Quinsigamond 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. Velocity (FPM)	Proposed CCM #	Proposed ECCM #	Notes
MAU-1	West and Mid	2400	2400	100	(2) 16x25x2 (2) 16x20x2	8	113	1	1, 3	a
MAU-2	West and East	5400	5400	100	(4) 12x32x2 (4) 12x25x2 (2) 16x16x2 (1) 16x25x2	8	134	1	1, 3	a
MAU-3	West and East	4050	4050	100	(2) 20x25x2 (2) 20x20x2	8	36	1	1, 3	a
MAU-4	North	3400	3400	100	(2) 20x25x2 (2) 20x20x2	8	148	1	1, 3	a
MAU-5	South	9600	9600	100	N/A	8	64	1	1, 3	a
MAU-6	N/A	2400	2400	100	N/A	8	N/A	1	1, 3	a
HV-1	Gym (South)	11500	N/A	N/A	N/A	8	N/A	1, 2, 3	3	c, d
HV-2	North	3500	N/A	N/A	N/A	8	N/A			c
HV-3	Cafeteria (North)	7000	N/A	N/A	(1) 16x25x2 (1) 16x20x2 (4) 12x25x2 (4) 12x20x2	8	352	1, 2, 3	1, 2, 3	c, d
AHU-1	Quinsig Rm 102 (East)	4500	1305	29	(2) 20x25x2 (2) 12x20x2 (2) 16x20x2	8	308	1, 2, 3	1, 2, 3	b, c, d

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. *For the Quinsig. Room ECCM #1 – Portable Air Filtration is noted as a possible option to improve air cleaning and changeover during pandemic conditions. It shall be noted that multiple units would be recommended in each due to the large spaces.*

c. *CCM # 3 - Improved Filtration is predicated on the unit being able to support such filtration. ECCM #2 – UV-C Light Sterilization for Cafeteria and Quinsig. room may be effective due to the extended length of return air duct to allow installation of such.*

d. *Disable any CO_2 demand ventilation reset or occupancy sensor-based system shutdown (during scheduled occupied periods) during pandemic conditions.*

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 Quinsigamond Elementary 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.

CCM #1 – 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 Quinsigamond Elementary School are capable of implementing this measure.

CCM #2 – Increased Ventilation

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.

The gymnasium, cafeteria and multi-purpose room HVAC systems have the ability to increase outdoor air for increase outdoor air ventilation and air change rate. Many of the classrooms HVAC systems throughout the building cannot support this measure as they already provide 100% outside air and are at their design capacity.

CCM #3 – Improved Filtration

Improve filtration of 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.

Higher filtration on 100% outdoor air MAU systems is not as critical as they do not recirculate space air albeit improved filtration possibly as high as MERV 11 may be considered subject to unit fan capabilities. Filtration of MERV 13 may be possible on the three (3) HV units and one AHU unit subject to system testing. Most, room fan coil units cannot 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 under the respective schools for applicable recommendations.

ECCM #1: Portable Room Purifiers

Portable room air purifiers could be used in select areas to help clean the air within that space. 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: Bi-Polar 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 Quinsigamond Elementary Schools case they could be installed in the supply air duct of the respective mixed air handling systems as well as the dedicated outdoor air systems and/or fan coil units. WPS has already begun to incorporate Bipolar Ionization extensively throughout the Quinsigamond Elementary 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 on 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

Quinsigamond Elementary School

Room Name / Number	Space Use	Net Floor Area (SF)	4% of Net Area	Number of Windows by Type: 1 DBL HUNG 3.92	2 DBL HUNG 5.33	3 DBL HUNG 3.00	4 DBL HUNG 1.56	5 DBL HUNG 6.57	6 DBL HUNG 10.00	7 DBL HUNG 6.67	8 DBL HUNG 5.00	9 CASEMENT 9.72	Total open Area (SF)	Difference between actual and required SF	PASS?	Additional Notes
Basement																
No Occupied Spaces																
First Floor																
100 - Cafeteria	café	2990	119.6									9	87.50	32.10	NO	
101 - Kitchen	kitchen	1456	58.24								4		20.00	38.24	NO	
101A - Kitchen Storage	storage	102	4.08										0.00	4.08	NO	
102 - Quinsigamond Room	comm. Room	1497	59.88							6			40.00	19.88	NO	
102C - Coat Room	support	54	2.16										0.00	2.16	NO	
102K - Kitchenette	kitchen	183	7.32										0.00	7.32	NO	
102S - Storage	storage	94	3.76										0.00	3.76	NO	
102E - Office	office	138	5.52										0.00	5.52	NO	
102F - Office	office	138	5.52										0.00	5.52	NO	
105G - Girl's	toilet	147	5.88										0.00	5.88	NO	
105M - Boy's	toilet	147	5.88										0.00	5.88	NO	
106 - Main Office	office	647	25.88							4			26.67	-0.79	YES	
106A - Waiting	support	125	5										0.00	5.00	NO	
106C - Conference	conference	304	12.16										0.00	12.16	NO	
106D - Kitchenette	kitchen	39	1.56										0.00	1.56	NO	
106E - Toilet A	toilet	45	1.8										0.00	1.80	NO	
106F - Toilet B	toilet	45	1.8										0.00	1.80	NO	
106G - Assistant Principal	office	216	8.64										0.00	8.64	NO	
108 - Principal	office	285	11.4							4			26.67	-15.27	YES	
109 - Room	support	159	6.36							2			13.33	-6.97	YES	
110 - Principal	office	430	17.2							4			26.67	-9.47	YES	
111 - Library	media	2485	99.4							12			80.00	19.40	NO	
111MR - Server	support	174	6.96										0.00	6.96	NO	
111WR - Work Room	office	69	2.76										0.00	2.76	NO	
112 - Psych	office	230	9.2										0.00	9.20	NO	
113 - Adj Counselling	office	298	11.92							3			20.00	-8.08	YES	
114 - Nurse	nurse	498	19.92							3			20.00	-0.08	YES	
114E - Exam	nurse	112	4.48										0.00	4.48	NO	
115 - De-escalation	office	464	18.56										0.00	18.56	NO	
Boy's Room	toilet	261	10.44										0.00	10.44	NO	
Girl's Room	toilet	263	10.52										0.00	10.52	NO	
117	classroom	1105	44.2							9			60.00	-15.80	YES	
117A - Toilet	toilet	55	2.2										0.00	2.20	NO	
118	classroom	1272	50.88							9			60.00	-9.12	YES	
118A - Toilet	toilet	64	2.56										0.00	2.56	NO	
120	classroom	1283	51.32							5			33.33	17.99	NO	
120A - Toilet	toilet	49	1.96										0.00	1.96	NO	
121	classroom	1228	49.12							5			33.33	15.79	NO	
121A - Toilet	toilet	49	1.96										0.00	1.96	NO	
123	classroom	1133	45.32							5			33.33	11.99	NO	
123A - Toilet	toilet	49	1.96										0.00	1.96	NO	
124J - Cust	support	125	5										0.00	5.00	NO	
125	classroom	386	15.44							1			6.67	8.77	NO	
127	classroom	944	37.76							4			26.67	11.09	NO	
129	classroom	944	37.76							4			26.67	11.09	NO	
Gymnasium Lobby	gym	1285	51.4										0.00	51.40	NO	
Women's	toilet	240	9.6										0.00	9.60	NO	
Men's	toilet	245	9.8										0.00	9.80	NO	
Cust	support	43	1.72										0.00	1.72	NO	
Gymnasium	gym	6419	256.76										0.00	256.76	NO	
132 - Gym Storage	storage	658	26.32										0.00	26.32	NO	

Second Floor															
200 - Computer Lab	classroom	1286	51.44					4					26.26	25.18	NO
201 - Computer Lab	classroom	1449	57.96					8					52.53	5.43	NO
202	classroom	854	34.16							4			26.67	7.49	NO
203	classroom	941	37.64					4					26.26	11.38	NO
204	classroom	996	39.84							4			26.67	13.17	NO
205	classroom	925	37					4					26.26	10.74	NO
206	classroom	925	37							4			26.67	10.33	NO
207	classroom	925	37					4					26.26	10.74	NO
208	classroom	925	37							4			26.67	10.33	NO
209	classroom	917	36.68					4					26.26	10.42	NO
210	classroom	915	36.6							4			26.67	9.93	NO
211	classroom	501	20.04					3					19.70	0.34	NO
212 - Teacher's Room	support	565	22.6							3			20.00	2.60	NO
213	classroom	501	20.04										0.00	20.04	NO
Boy's Room	toilet	366	14.64										0.00	14.64	NO
Girl's Room	toilet	374	14.96										0.00	14.96	NO
Storage	storage	223	8.92										0.00	8.92	NO
216	classroom	223	8.92						2				20.00	-11.08	YES
217	classroom	999	39.96					9					59.09	-19.13	YES
218	classroom	999	39.96					9					59.09	-19.13	YES
220	classroom	261	10.44					1					6.57	3.87	NO
221	classroom	1080	43.2					5					32.83	10.37	NO
221S	office	188	7.52										0.00	7.52	NO
222	classroom	1099	43.96					5					32.83	11.13	NO
222S	office	178	7.12										0.00	7.12	NO
223	classroom	1074	42.96					5					32.83	10.13	NO
223S	office	97	3.88										0.00	3.88	NO
224J - Cust	support	54	2.16										0.00	2.16	NO
224S - Storage	storage	81	3.24										0.00	3.24	NO
225	classroom	380	15.2					1					6.57	8.63	NO
227	classroom	942	37.68					4					26.26	11.42	NO
228	classroom	912	36.48					4					26.26	10.22	NO
229	classroom	914	36.56					4					26.26	10.30	NO
Third Floor															
300	classroom	1280	51.2	16									62.67	-11.47	YES
301	classroom	1448	57.92	20									78.33	-20.41	YES
302	classroom	842	33.68	8									31.33	2.35	NO
303	classroom	928	37.12	6									23.50	13.62	NO
304	classroom	978	39.12		4								21.33	17.79	NO
305	classroom	930	37.2	6									23.50	13.70	NO
306	classroom	932	37.28	8									31.33	5.95	NO
307	classroom	928	37.12	8									31.33	5.79	NO
308	classroom	929	37.16	8									31.33	5.83	NO
309	classroom	914	36.56	6									23.50	13.06	NO
310	classroom	913	36.52	6									23.50	13.02	NO
311	classroom	653	26.12			2							6.00	20.12	NO
312	classroom	343	13.72			2							6.00	7.72	NO
Boy's Room	toilet	241	9.64										0.00	9.64	NO
Girl's Room	toilet	249	9.96										0.00	9.96	NO
313 - Office	office	142	5.68										0.00	5.68	NO
313A - Office	office	90	3.6										0.00	3.60	NO
313B - Staff Office	office	74	2.96										0.00	2.96	NO
317 - Storage	storage	128	5.12										0.00	5.12	NO
318 - Art Storage	storage	363	14.52										0.00	14.52	NO
320 - Art Room	classroom	1295	51.8			4							12.00	39.80	NO
321A	classroom	767	30.68			2							6.00	24.68	NO
321B	classroom	550	22			2							6.00	16.00	NO
322J - Cust	support	54	2.16										0.00	2.16	NO
323	classroom	949	37.96			2							6.00	31.96	NO
323S	storage	96	3.84										0.00	3.84	NO
324	classroom	837	33.48			2							6.00	27.48	NO
324S	storage	69	2.76										0.00	2.76	NO
325 - Music	classroom	1417	56.68				6						9.33	47.35	NO
325S	storage	626	25.04										0.00	25.04	NO

Window Type	Width	Height	Projection	Venting
1 - Double Hung	23.5	24	-	3.92
2 - Double Hung	32	24	-	5.33
3 - Double Hung	32	13.5	-	3.00
4 - Double Hung	32	7	-	1.56
5 - Double Hung	30.5	31	-	6.57
6 - Double Hung	40	36	-	10.00
7 - Double Hung	30	32	-	6.67
8 - Double Hung	30	24	-	5.00
9 - Double Casement	14	50	-	9.72

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)