Worcester Public Schools

Ventilation Assessment
&
COVID-19
Mitigation Strategies

for

North High School
Worcester, MA

January 31, 2021

<u>Prepared by</u>:

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:

North High School:
North High School is located in the North Quadrant of Worcester at 140 Harrington Way. The School was built in 2011, houses grades 9-12, has 94 classrooms and the building is 192,000 square feet. The widows are original to the 2011 construction.

C. Table of Contents:

1) Mechanical Ventilation Report

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

This report briefly describes the existing ventilation systems at the North High 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 North High 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.

Most of the HVAC systems supporting the North High 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.

Although original design outdoor airflow data for the project was not available from design drawings, we were able to extract some information from control drawings. This information, based on current classroom size, indicates that most of the classrooms appear to meet or exceed the 3 ACH requirement. 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 the outdoor air systems are at their 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 cafeteria, auditorium, library, and office air handling systems may support improved filtration up to a maximum of MERV 13 pending testing and verification. Most other classroom and office systems in the building will not support increased filtration above MERV 8 either due to physical equipment limitations (i.e., fan coils & FVAV's 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 North High 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 North High 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 North High School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
General Classrooms	ERU Systems	CCM - #1 ECCM - #1 or #3 (*see note below)
Art & Science Classrooms	ERU Systems	CCM - #1 ECCM - #1 or #3 (*see note below)
Cafeteria & Auditorium	RTU Systems	CCM - #1, #2 & #3 ECCM - #3
Gymnasium	HV Units	CCM - #1 & #2 ECCM - #3
Admin. & Office	RTU Systems	CCM - #1, #2 & #3 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.

There are no existing HVAC design drawings or equipment schedules available for review of original design intent. As such, we cannot comment on the existing ventilation levels in every instance. Our review is based on review of sheet metal as-built drawings, control drawings as well as our site inspection. If design drawings cannot be found, we suggest field airflow testing as well as further review with the control vendor to establish ventilation levels.

General Classrooms:

A majority of the classrooms in the building are heated and cooled 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, cooled, 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 most of the classroom spaces is supported by four (4) packaged rooftop energy recovery units supporting dedicated outdoor air systems (DOAS). The units are identified as ERU-1, 2, 3 & 4. These units are configured as 100% outside air systems with no recirculation air. The units have intake dampers, filter sections, total energy recovery segment, gas-fired furnaces, exhaust fans and supply fans. The units have 2" thick pleated filters with an estimated MERV rating of 8.

These ERU 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.

Outdoor air to the classrooms is provided through a ducted supply and exhaust system from the ERU units which support variable air volume (VAV) terminals that controls the amount of outdoor air into each classroom. Although there was no available design information from drawings, we were able to obtain design outdoor air rates from existing control drawings which reflects approximately 390 CFM being delivered to typical classrooms.

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 overhead system have, a room size of 710 SF with 26 occupants (25 students + 1 teacher) would require 432 CFM of outdoor (346 CFM if zone effectiveness is 1.0). Per the existing control drawings, it appears the average outdoor air to each classroom is 390 CFM which is slightly under current code levels primarily due to the ventilation effectiveness correction which may or may not apply depending on if the supply air temperature is above 85°F or not.

Art & Science Rooms:

The science and art room areas are supported by the same types of fan coil units and outdoor air systems which supply the normal classroom systems. Per the control drawings it appears that at least the science rooms have the ability to supply higher ventilation rates than the standard classroom. Per the control drawings the art rooms appear to be below the code required ventilation level operating as a standard classroom.

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. It appears the buildings ventilation levels for the science rooms are compliant based on the control drawings. However, the art rooms are supported by the same level of ventilation as the normal classroom systems 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 are higher than standard classrooms however we cannot verify the current code compliance due to lack of in regard to the exhaust rate.

Offices:

The office is supported by a gas-fired HVAC RTU located on the roof. The units are fitted with a mixing box, filter section, gas heat section, DX cooling section supply and return fans. The system serves VAV and FVAV terminals each with FVAV terminals being fitted with 1” MERV 8 filters. The filters on the HVAC RTU units are both 2” and 4”.

The filters for the HVAC/RTU unit, especially the 4" filters 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 required 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 reflect the utilization of CO_2 sensors with controls for demand ventilation reset off space CO_2. These reset controls should be disabled to ensure outdoor air volumes are kept at design levels during the pandemic condition.

Auditorium, Library, Gymnasium & Cafeteria:

The gymnasium, auditorium, library, and cafeteria are heated and ventilated through the use of gas fired HV (for gym) and HVAC RTU (for auditorium, library and cafeteria) units located on the roof. The units are fitted with a mixing box, filter section, gas heat section, DX cooling section (HVAC unit only) supply and return fans. The filters on HV units are 2" thick pleated filters with an estimated MERV rating of 8. The filters on the HVAC RTU units are both 2" and 4".

The filters for the HVAC/RTU units, especially the 4" filters 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 required to avoid reduction in airflow as filters load.

Current code would require the following outdoor air for the respective spaces:

- Gymnasium: 0.3 CFM per SF play area (+ undetermined spectator area)
- Cafeteria: 7.5 CFM per person of outside air plus 0.18 CFM per SF
- Library: 5 CFM per person of outside air plus 0.12 CFM per SF

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 off space CO_2. These reset controls should be disabled to ensure outdoor air volumes 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 Logic (ALC). 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/RTU, 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.

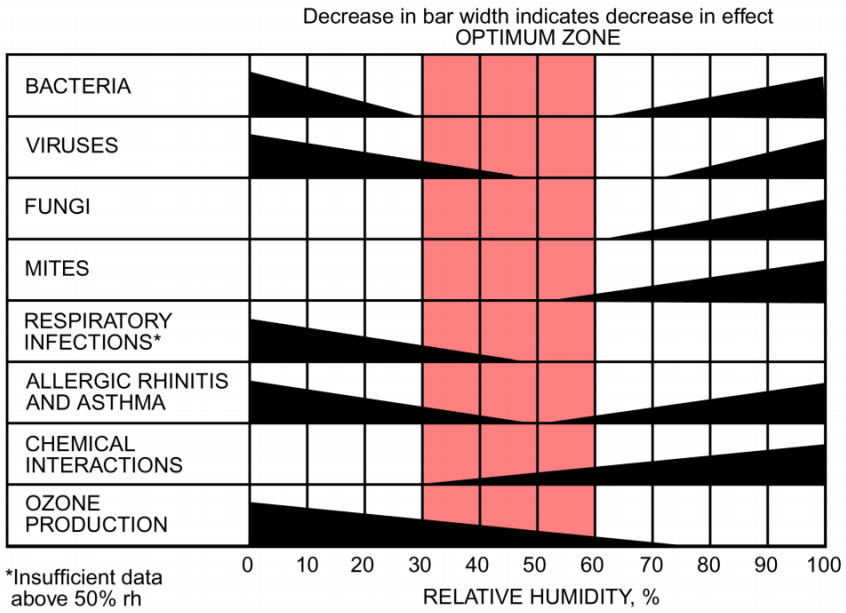

Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

The North High 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 North High 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 North High School have a design outdoor air exchange rate of 3 or greater which is above 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.

North High School IAQ Sampling Summary

Space Tested	Temp. °F	Humidity % RH	CO_2 %	TVOC ppm	HCHO ppm	Room Area SqFt	Room Ht. Ft	Volume Cubic Feet	Design OA CFM	OA Air ACH	Notes
Basement											
Classroom 08	69.5	29.8	461	1.18	0.09	616	8.41	5181	390	4.5	
Boy's Locker Rm	69.2	32.5	429	0.98	0.06	808	8.41	6795	250	2.2	
Weight Rm	68.7	31	426	0.97	0.07	937	8.41	7880	390	3	
Gym	70	29	412	80	0.04	12019	36.5	438694	n/a	n/a	
1st Floor											
Auditorium	63.3	40.4	410	1.35	0.04	4651	27.25	126740	n/a	n/a	
Main Lobby 100	71.3	29.4	456	1.27	0.16	924	12.16	11236	700	3.7	
Main Office 102	71.1	34	532	1.3	0.22	1552	12.16	18872	n/a	n/a	
Head Guidence 102D	71.8	32.9	546	1.33	0.25	182	9	1638	40	1.5	
Principal's 102J	71.7	34	561	1.31	0.21	294	9	2646	40	0.9	
Music 106	71.2	30.5	425	0.74	0.12	1635	11.5	18803	960	3.1	
Art 107	70.2	28.7	430	0.9	0.06	2030	9.75	19793	390	1.2	
NROTC 111	71.6	28	446	0.55	0.12	717	9.75	6991	390	3.3	
Health Waiting Rm 112	71.5	31.7	491	0.37	0.1	254	9	2286	n/a	n/a	
Health Rest Area 112F	70.5	34	518	0.83	0.17	586	10.66	6247	n/a	n/a	
Cafeteria 114	69.5	29.9	440	0.55	0.09	6138	11.91	73104	n/a	n/a	
Life Skills 115	69.2	29.4	413	0.66	0.05	1121	9.75	10930	390	2.1	
Technology Lab 125	69	31	444	0.92	0.13	1671	9.83	16426	390	1.4	
2nd Floor											
Science Lab 204	70.5	26.3	417	0.42	0.09	1423	9.66	13746	1080	4.7	
Classroom 205	70.5	26.5	421	0.55	0.06	707	9.66	6830	390	3.4	
Library 220	70.4	27.6	433	0.47	0.11	4513	10.5	47387	n/a	n/a	
Computer Lab 222	70	31.1	421	0.51	0.08	917	9.66	8858	390	2.6	
Computer Lab 231	70.3	28.9	431	0.34	0.07	708	9.66	6839	390	3.4	
3rd Floor											
Health Science Lab 302	71.3	27.8	421	0.45	0.09	1977	9.75	19276	1080	3.4	
Classroom 307	71.5	25.6	423	0.44	0.06	680	9.75	6630	390	3.5	
Teacher Workroom 314	71.4	26.4	449	0.73	0.09	499	9.75	4865	150	1.8	
Admin Suite 318	71.3	26	436	0.74	0.11	376	9.33	3508	60	1	
Science Lab 328	71	32.8	430	0.64	0.1	1429	9.75	13933	1080	4.7	
Classroom 331	70.9	25	419	0.41	0.06	708	9.75	6903	390	3.4	
4th Floor											
Classroom 401	71.6	27.2	422	0.41	0.09	939	9.75	9155	390	2.6	
Science Lab 404	71.2	27.6	423	0.52	0.08	1515	9.75	14771	1080	4.4	
Small Group Instruction 415	71.4	23.5	418	0.49	0.06	602	9.75	5870	390	4	
Classroom 425	70.9	25.6	424	0.4	0.06	707	9.75	6893	390	3.4	
Computer Lab 432	72	28.7	435	0.51	0.08	708	9.75	6903	390	3.4	

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.

North High 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
MUA-1	1st Floor Kitchen	N/A	N/A	N/A	N/A	8	N/A	N/A	N/A	
ERU-1	A-Wing Classroom	N/A	N/A	N/A	(8) 20x24x2	8	N/A	#1	#1, #3	a
ERU-2	B-Wing Classroom	N/A	N/A	N/A	N/A	8	N/A	#1	#1, #3	a
ERU-3	B-Wing Classroom	N/A	N/A	N/A	(8) 20x24x2	8	N/A	#1	#1, #3	a
ERU-4	A-Wing Class/Off	N/A	N/A	N/A	(6) 20x20x2	8	N/A	#1	#1, #3	a
RTU-L	Library	N/A	N/A	N/A	(3) 24x24x4 (3) 24x24x2 (4) 12x24x2 (4) 12x24x4	8	N/A	#1, #2, #3	#3	b, c
RTU-C	Cafeteria	N/A	N/A	N/A	N/A	8	N/A	#1, #2, #3	#3	b, c
RTU-H	1st Floor B-Wing Office	N/A	N/A	N/A	(3) 24x24x4 (3) 24x24x2 (4) 12x24x2 (4) 12x24x4	8+	N/A	#1, #2, #3	#3	b, c
RTU-A	Auditorium	N/A	N/A	N/A	(6) 24x24x4 (6) 24x24x2 (5) 12x24x2 (5) 12x24x4	8+	N/A	#1, #2, #3	#3	b, c
HV-1	Gym	N/A	N/A	N/A	(12) 20x20x2 (12) 20x24x2 (12) 20x20x1 (12) 20x24x1	8	N/A	#1, #2	#3	b, c

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. *CCM # 3 - Improved Filtration is predicated on the unit being able to support such filtration.*

c. *Disable any CO2 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 North High 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 North High 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, auditorium, and library 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 the OA systems serving these systems 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 ERU 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 HVAC/RTU 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 North High 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. WPS has already begun to incorporate Bipolar Ionization extensively throughout the North High 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

North High School

Room Name / Number	Space Use	Net Floor Area (SF)	4% of Net Area	Number of Windows by Type																		Total open Area (SF)	Difference between actual and required SF	PASS?	Additional Notes
				A HOPPER	2.12	B AWNING	1.22	C1 HOPPER	1.02	C2 HOPPER	1.45	D1 HOPPER	0.90	D2 HOPPER	1.45	L AWNING	6.52	M AWNING	1.00	P AWNING	5.76				
Lower Level																									
001 - Gymnasium	gym	12019	480.76																			0.00	480.76	NO	
001A - Gymnasium Vest	gym	1016	40.64																			0.00	40.64	NO	
002 - Corridor	corridor	470	18.8																			0.00	18.80	NO	
003A - Corridor	corridor	627	25.08																			0.00	25.08	NO	
003B - Corridor East	corridor	775	31																			0.00	31.00	NO	
005A - Storage	storage	112	4.48																			0.00	4.48	NO	
005B - Storage	storage	119	4.76																			0.00	4.76	NO	
007 - Storage	storage	70	2.8																			0.00	2.80	NO	
008 - Classroom / Team Room	classroom	616	24.64																			0.00	24.64	NO	
009 - IDF	support	60	2.4																			0.00	2.40	NO	
010 - Storage	storage	111	4.44																			0.00	4.44	NO	
012 - Girls Locker Room	gym	817	32.68																			0.00	32.68	NO	
012A - PE Office	office	139	5.56																			0.00	5.56	NO	
012B - Girls Toilet / Shower	toilet	441	17.64																			0.00	17.64	NO	
014 - Office	office	138	5.52																			0.00	5.52	NO	
014A - Toilet	toilet	78	3.12																			0.00	3.12	NO	
015 - Weights / Aerobics	gym	937	37.48																			0.00	37.48	NO	
016 - Office	office	138	5.52																			0.00	5.52	NO	
016A - Toilet	toilet	78	3.12																			0.00	3.12	NO	
017 - Uniform Storage	storage	190	7.6																			0.00	7.60	NO	
018 - Boys Locker Room	808	53	2.12																			0.00	2.12	NO	
018A - PE Office	office	145	5.8																			0.00	5.80	NO	
018B - Boys Toilet Shower	gym	436	17.44																			0.00	17.44	NO	
018C - Storage	storage	40	1.6																			0.00	1.60	NO	
019A - Women	toilet	408	16.32																			0.00	16.32	NO	
019B - Men	toilet	222	8.88																			0.00	8.88	NO	
019C - Closet	storage	68	2.72																			0.00	2.72	NO	
020 - Staff	support	57	2.28																			0.00	2.28	NO	
021 - Custodiabn	support	33	1.32																			0.00	1.32	NO	
022 - Classroom / Team Room	classroom	699	27.96																			0.00	27.96	NO	
022A - Sports Equip Storage	storage	647	25.88																			0.00	25.88	NO	
023 - PA	support	32	1.28																			0.00	1.28	NO	

First Floor

100 - Main Lobby	entry	924	36.96														0.00	36.96	NO	
100A - Lobby	entry	180	7.2														0.00	7.20	NO	
101 - Loggia	open	2212	88.48														0.00	88.48	NO	
102 - Main Office	office	1552	62.08														0.00	62.08	NO	
102B - Conference Room	conference	305	12.2														0.00	12.20	NO	
102C - Guidance Conf Room	conference	394	15.76														0.00	15.76	NO	
102D - Office	office	182	7.28											1			6.52	0.76	NO	
102E - Office	office	138	5.52											1			6.52	-1.00	YES	
102F - Office	office	138	5.52											1			6.52	-1.00	YES	
102G - Assessmnt & Acct	office	138	5.52											1			6.52	-1.00	YES	
102H - Data / Proc	office	124	4.96											1			6.52	-1.56	YES	
102J - Office	office	204	8.16											1			6.52	1.64	NO	
102L - Records Vault	storage	394	15.76														0.00	15.76	NO	
102M - Princ Clark	88	238	9.52														0.00	9.52	NO	
102P - Toilet	toilet	52	2.08														0.00	2.08	NO	
102Q - Toilet	toilet	52	2.08														0.00	2.08	NO	
102R - Gear-Up	support	196	7.84														0.00	7.84	NO	
103 - Lower Aud	Aud	2325	93														0.00	93.00	NO	
103A - Aud Vestibule	entry	71	2.84														0.00	2.84	NO	
103B - Tickets	support	40	1.6														0.00	1.60	NO	
103C - Stage	aud	2326	93.04														0.00	93.04	NO	
103D - Green Room	aud	1007	40.28														0.00	40.28	NO	
103F - Storage	storage	59	2.36														0.00	2.36	NO	
103G - Girls	toilet	57	2.28														0.00	2.28	NO	
103H - Boys	toilet	56	2.24														0.00	2.24	NO	
103J - Storage	storage	55	2.2														0.00	2.20	NO	
103k - Stage Lighting	aud	84	3.36														0.00	3.36	NO	
103L - Aud Vest	aud	67	2.68														0.00	2.68	NO	
103M - Storage	storage	81	3.24														0.00	3.24	NO	
103N - Storage	storage	265	10.6														0.00	10.60	NO	
104 - School Store	storage	341	13.64														0.00	13.64	NO	
105A - Women	toilet	173	6.92														0.00	6.92	NO	
105B - Men	toilet	173	6.92														0.00	6.92	NO	
106 - Music Room	classroom	1635	65.4	1						1	1						4.47	60.93	NO	
106A - Instrument Storage	storage	97	3.88														0.00	3.88	NO	
106B - Instrument Storage	storage	147	5.88														0.00	5.88	NO	
106C - Music Office	office	117	4.68														0.00	4.68	NO	
106D - Practice Room 1	office	63	2.52														0.00	2.52	NO	
106E - Music Lab	classroom	230	9.2														0.00	9.20	NO	
106F - Practice 2	classroom	57	2.28														0.00	2.28	NO	
106G - Practice 3	classroom	57	2.28														0.00	2.28	NO	
107 - Art Room	classroom	2030	81.2	1			1		1	2	2						9.30	71.90	NO	
107A - Art Storage Room	storage	210	8.4														0.00	8.40	NO	
107B - Kiln Room	support	71	2.84														0.00	2.84	NO	
107 - Gym Office & Equiptment	office	296	11.84														0.00	11.84	NO	
109 - Drame / Music	classroom	717	28.68				1		1	1	1						4.83	23.85	NO	
110 - IDF	support	66	2.64														0.00	2.64	NO	
111 - NROTC	classroom	717	28.68		2												2.44	26.24	NO	
111A	support	160	6.4		4												4.88	1.53	NO	
111B - Storage	storage	30	1.2														0.00	1.20	NO	
111C - Storage	storage	32	1.28														0.00	1.28	NO	
112 - Waiting Room	office	254	10.16														0.00	10.16	NO	
112A - Health Recep	office	134	5.36														0.00	5.36	NO	
112C - Med Rec	office	75	3														0.00	3.00	NO	
112D - Nurse Pract	office	111	4.44														0.00	4.44	NO	
112E - Adj Couns	office	112	4.48														0.00	4.48	NO	
112F - Rest Area	nurse	586	23.44												1		1.00	22.44	NO	
112G - Nurse	nurse	115	4.6														0.00	4.60	NO	
112H - Exam Room	nurse	124	4.96														0.00	4.96	NO	
112J - Exam Room 2	nurse	118	4.72														0.00	4.72	NO	
112K - Exam Room 3	nurse	134	5.36														0.00	5.36	NO	
112L - Cust	support	24	0.96														0.00	0.96	NO	
112M - Prep Room	nurse	126	5.04														0.00	5.04	NO	
112N - Linens	storage	39	1.56														0.00	1.56	NO	
112P - Storage	storage	30	1.2														0.00	1.20	NO	
112Q - Toilet	toilet	50	2														0.00	2.00	NO	
112R - Toilet	toilet	50	2														0.00	2.00	NO	
113 - NROTC	classroom	961	38.44	1			1		1								4.59	33.85	NO	
113A - Uniform Storage	storage	247	9.88														0.00	9.88	NO	
114 - Cafeteria	café	6138	245.52														0.00	245.52	NO	

114A - Serving Area	café	2566	102.64												0.00	102.64	NO	
115	classroom	1121	44.84			2	2	2	2						9.66	35.18	NO	
115A - Girl's	toilet	72	2.88												0.00	2.88	NO	
115B - Boy's	toilet	72	2.88												0.00	2.88	NO	
116 - Kitchen	kitchen	1786	71.44											3	17.29	54.15	NO	
116A - Kitchen Office	office	119	4.76												0.00	4.76	NO	
116B - Refridge	kitchen	257	10.28												0.00	10.28	NO	
116C - Dry Strorae	kitchen	263	10.52												0.00	10.52	NO	
116D - Refridge	kitchen	89	3.56												0.00	3.56	NO	
116E - Freezer	kitchen	356	14.24												0.00	14.24	NO	
118 - Receiving / Recycling	support	618	24.72												0.00	24.72	NO	
119A - Girl's	toilet	263	10.52												0.00	10.52	NO	
119B - Boy's	toilet	263	10.52												0.00	10.52	NO	
121 - Faculty Dinning	café	764	30.56												0.00	30.56	NO	
122 - Men's Locker Room	support	149	5.96												0.00	5.96	NO	
122A - Men's	toilet	53	2.12												0.00	2.12	NO	
124 - Women's Locker Room	support	149	5.96												0.00	5.96	NO	
124A - Women's	toilet	53	2.12												0.00	2.12	NO	
125 - Techno Robo Lab	classroom	1671	66.84		4										4.88	61.97	NO	
126 - Equuiptment Storage Room	storage	500	20												0.00	20.00	NO	
127 - Technical Serv	support	658	26.32	1		1	1								4.59	21.73	NO	
127A - MDF Room	support	433	17.32												0.00	17.32	NO	
128 - Custodian	support	216	8.64												0.00	8.64	NO	
132 - Main Storage	storage	929	37.16												0.00	37.16	NO	

Second Floor																			
201	classroom	931	37.24	3				1	1					8.70	28.54	NO			
202	classroom	929	37.16	2				1	1					6.59	30.57	NO			
203	classroom	708	28.32			1	1	1	1					4.83	23.49	NO			
204 - Science Lab	classroom	1423	56.92	1		2	2	1	1					9.42	47.50	NO			
204A - Prep Room	support	323	12.92											0.00	12.92	NO			
205	classroom	707	28.28			1	1	1	1					4.83	23.45	NO			
207	classroom	679	27.16			1	1	1	1					4.83	22.33	NO			
208	toilet	72	2.88											0.00	2.88	NO			
209	classroom	707	28.28		2									2.44	25.84	NO			
210 - Science Lab	classroom	1422	56.88	1		1	1	1	1					6.95	49.93	NO			
211	classroom	709	28.36		4									4.88	23.49	NO			
212	classroom	716	28.64	1				1	1					4.47	24.17	NO			
212A - Girl's	toilet	50	2											0.00	2.00	NO			
212B - Boy's	toilet	50	2											0.00	2.00	NO			
213	classroom	707	28.28	1		1	1							4.59	23.69	NO			
214 - Admin Suite	office	415	16.6											0.00	16.60	NO			
214A - Conference	conference	187	7.48											0.00	7.48	NO			
214B - Guidance	office	156	6.24		2									2.44	3.80	NO			
214C - Alumni	office	132	5.28	1										2.12	3.16	NO			
214D - Assistant Principal	office	167	6.68	1		1	1							4.59	2.09	NO			
215	classroom	734	29.36			1	1	1	1					4.83	24.53	NO			
217	classroom	567	22.68			1	1	1	1					4.83	17.85	NO			
217A - IDF	support	105	4.2											0.00	4.20	NO			
218 - Teacher's Workroom	support	448	17.92											0.00	17.92	NO			
219A - Girl's	toilet	263	10.52											0.00	10.52	NO			
219B - Boy's	toilet	263	10.52											0.00	10.52	NO			
220 - Library	media	4513	180.52											0.00	180.52	NO			
220A - Library Workroom	media	286	11.44											0.00	11.44	NO			
220B - Library Office	office	180	7.2											0.00	7.20	NO			
221 - Bay State Jobs	support	699	27.96	1				1	1					4.47	23.49	NO			
222 - Computer Lab	classroom	917	36.68	1		1	1							4.59	32.09	NO			
223	classroom	713	28.52	1				1	1					4.47	24.05	NO			
224 - Toilet	toilet	52	2.08											0.00	2.08	NO			
225	classroom	707	28.28		4									4.88	23.41	NO			
227	classroom	679	27.16	1		1	1							4.59	22.57	NO			
228 - Science Lab	classroom	1425	57		4	1	1	1	1					9.70	47.30	NO			
228A - Prep Room	support	322	12.88											0.00	12.88	NO			
229	classroom	705	28.2	1				1	1					4.47	23.73	NO			
230 - Book Storage	storage	206	8.24											0.00	8.24	NO			
231 - Computer Lab	classroom	708	28.32			1	1	1	1					4.83	23.49	NO			
232 - Computer Lab	classroom	708	28.32		4									4.88	23.45	NO			
233	classroom	935	37.4	1		2	2	2	2					11.77	25.63	NO			
234	classroom	933	37.32	3		1	1	1	1					11.18	26.14	NO			
Third Floor																			
301 - WPC Office	office	714	28.56			1	1	1	1					4.83	23.73	NO			
301A - Break	support	48	1.92											0.00	1.92	NO			
301B - Storage	storage	106	4.24											0.00	4.24	NO			
301C - WPC Lab Coordination	office	143	5.72	1										2.12	3.60	NO			
301D - WPC Coordinator	office	205	8.2	1				1	1					4.47	3.73	NO			
301E - WPC Mentor Coordinator	office	142	5.68	1										2.12	3.56	NO			
302 - Health Sciece Lab	classroom	1977	79.08	3		2	2	2	2					16.01	63.07	NO			
302A - Storage	storage	50	2											0.00	2.00	NO			
302B - Exam	support	96	3.84											0.00	3.84	NO			
302C - Toilet	toilet	184	7.36											0.00	7.36	NO			
303	classroom	714	28.56			1	1	1	1					4.83	23.73	NO			
304 - Science Lab	classroom	1515	60.6	2				1	1					6.59	54.01	NO			
304A - Prep Room	support	322	12.88											0.00	12.88	NO			
305	classroom	714	28.56			1	1	1	1					4.83	23.73	NO			
307	classroom	680	27.2			1	1	1	1					4.83	22.37	NO			
308 - Toilet	toilet	56	2.24											0.00	2.24	NO			
309	classroom	707	28.28		2									2.44	25.84	NO			
310 - Science Lab	classroom	1426	57.04	2		1	1	1	1					9.06	47.98	NO			
311	classroom	709	28.36		4									4.88	23.49	NO			
312	classroom	721	28.84	1	2									4.55	24.29	NO			
313	classroom	707	28.28	1		1	1							4.59	23.69	NO			
314 - Teacher's Workroom	support	499	19.96					2	2					4.70	15.26	NO			
314A - Women's	toilet	48	1.92											0.00	1.92	NO			

314B - Men's	toilet	73	2.92												0.00	2.92	NO	
315	classroom	602	24.08			1	1	1	1						4.83	19.25	NO	
315A - Science Storage	storage	121	4.84												0.00	4.84	NO	
316 - Cust	support	23	0.92												0.00	0.92	NO	
317	classroom	626	25.04			1	1	1	1						4.83	20.21	NO	
317A - IDF	support	105	4.2												0.00	4.20	NO	
318 - Admin Suite	office	376	15.04												0.00	15.04	NO	
318A - Conference	conference	261	10.44	1		1	1								4.59	5.85	NO	
318B - Guidance	office	140	5.6	1											2.12	3.48	NO	
318C - Assistnce Principal	office	156	6.24					1	1						2.35	3.89	NO	
318D - Grad Improv Specialist	office	119	4.76												0.00	4.76	NO	
319A - Girl's	toilet	264	10.56												0.00	10.56	NO	
319B - Boy's	toilet	264	10.56												0.00	10.56	NO	
320 - Science Lab	classroom	1426	57.04	1		1	1	2	2						9.30	47.74	NO	
321	classroom	704	28.16	1				1	1						4.47	23.69	NO	
323	classroom	711	28.44	1				1	1						4.47	23.97	NO	
324 - Toilet	toilet	36	1.44												0.00	1.44	NO	
325	classroom	711	28.44	1		1	1								4.59	23.85	NO	
327	classroom	679	27.16	1		1	1								4.59	22.57	NO	
328 - Science Lab	classroom	1429	57.16		4	1	1	1	1						9.70	47.46	NO	
328A - Science Prep	support	323	12.92												0.00	12.92	NO	
329	classroom	707	28.28	1				1	1						4.47	23.81	NO	
330 - Book Storage	storage	206	8.24												0.00	8.24	NO	
331 - Computer Lab	classroom	708	28.32			1	1	1	1						4.83	23.49	NO	
332	classroom	708	28.32		4										4.88	23.45	NO	
333	classroom	931	37.24	1		2	2	2	2						11.77	25.47	NO	
334	classroom	934	37.36	3		1	1	1	1						11.18	26.18	NO	

Forth Floor																			
401	classroom	939	37.56	2				1	1					6.59	30.97	NO			
402A	classroom	929	37.16	2				1	1					6.59	30.57	NO			
402B	classroom	705	28.2	1		1	1							4.59	23.61	NO			
402C	classroom	704	28.16			1	1	1	1					4.83	23.33	NO			
403 - Computer Lab	classroom	707	28.28			1	1	1	1					4.83	23.45	NO			
404 - Science Lab	classroom	1515	60.6	2				1	1					6.59	54.01	NO			
404A - Prep Room	support	323	12.92											0.00	12.92	NO			
405 - Computer Lab	classroom	707	28.28			1	1	1	1					4.83	23.45	NO			
407	classroom	680	27.2			1	1	1	1					4.83	22.37	NO			
408 - Toilet	toilet	55	2.2											0.00	2.20	NO			
409	classroom	707	28.28		2									2.44	25.84	NO			
410 - Science Lab	classroom	1425	57	2		1	1	1	1					9.06	47.94	NO			
411	classroom	710	28.4		4									4.88	23.53	NO			
412	classroom	720	28.8	1	2									4.55	24.25	NO			
413	classroom	707	28.28	1		1	1							4.59	23.69	NO			
414 - Teacher's Workroom	support	496	19.84		4									4.88	14.97	NO			
414A - Women's	toilet	73	2.92											0.00	2.92	NO			
414B - Men'd	toilet	48	1.92											0.00	1.92	NO			
415	classroom	602	24.08			1	1	1	1					4.83	19.25	NO			
416 - Cust	support	24	0.96											0.00	0.96	NO			
417	classroom	631	25.24			1	1	1	1					4.83	20.41	NO			
417A - IDF	support	106	4.24											0.00	4.24	NO			
418 - Admin Suite	office	262	10.48											0.00	10.48	NO			
418A - Conference Room	conference	261	10.44	1		1	2							6.05	4.39	NO			
418B - Guidance	office	140	5.6	1										2.12	3.48	NO			
418C - Assistant Principal	office	156	6.24					1	1					2.35	3.89	NO			
418D - Adj Counselor	office	119	4.76											0.00	4.76	NO			
419A - Women's	toilet	264	10.56											0.00	10.56	NO			
419B - Men's	toilet	264	10.56											0.00	10.56	NO			
420	classroom	703	28.12		4									4.88	23.25	NO			
421	classroom	704	28.16	1				1	1					4.47	23.69	NO			
422	classroom	705	28.2	1		1	1							4.59	23.61	NO			
423	classroom	706	28.24	1				1	1					4.47	23.77	NO			
424 - Toilet	toilet	36	1.44											0.00	1.44	NO			
425	classroom	707	28.28		4									4.88	23.41	NO			
427	classroom	680	27.2	1		1	1							4.59	22.61	NO			
428 - Science Lab	classroom	1425	57		4	1	1	1	1					9.70	47.30	NO			
428A - Prep Room	support	322	12.88											0.00	12.88	NO			
429	classroom	708	28.32	1				1	1					4.47	23.85	NO			
430 - Book Storage	storage	206	8.24											0.00	8.24	NO			
431 - Computer Lab	classroom	708	28.32			1	1	1	1					4.83	23.49	NO			
432 - Computer Lab	classroom	708	28.32		4									4.88	23.45	NO			
433	classroom	931	37.24	1		2	2	2	2					11.77	25.47	NO			
434	classroom	930	37.2	3		1	1	1	1					11.18	26.02	NO			

Window Type	Width	Hieght	Projection	Venting
A - Hopper	52.5	15.25	4.5	2.12
B - Awning	23.75	15.25	4.5	1.22
C1 - Hopper	17.5	15.25	4.5	1.02
C2 - Hopper	31.25	15.25	4.5	1.45
D1 - Hopper	13.5	15.25	4.5	0.90
D2 - Hopper	31.25	15.25	4.5	1.45
L - Awning	42.75	22	14.5	6.52
M - Awning	62	20	1.75	1.00
P - Awning	36.5	21.75	14.25	5.76

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