Worcester Public Schools

Ventilation Assessment
&
COVID-19
Mitigation Strategies

for

South High School
Worcester, MA

January 31, 2021

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Worcester Public Schools

A. Preface:

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

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

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

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

- **Green Spaces**: meets or exceed the code minimum natural ventilation.

- **Yellow Spaces**: does **not** meet the code minimum natural ventilation, but does have operable window to allow some natural ventilation.

- **Red Spaces**: does not meet the code minimum natural ventilation and does not have any operable windows.

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

B. Building Description:

South High School:

South High School is located in the South Quadrant of Worcester at 170 Apricot Street. The School was built in 1978, houses grades 9-12, has 79 classrooms and the building is 246,000 square feet. The widows are original to the 1978 construction.

C. Table of Contents:

1) Mechanical Ventilation Report

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I. EXECUTIVE SUMMARY

This report briefly describes the existing ventilation systems at the South 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. For enhanced measures, WPS has begun to incorporate Bipolar Ionization (see ECCM-#3) extensively throughout the South High 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 South 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.

Many of the HVAC systems supporting the South High School are below 3 ACH requirement but appear capable of increasing outdoor air subject to outdoor ambient conditions and equipment limitations.

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

A majority of the main RTU air handling systems in the building appear to be capable of supporting increased filtration of MERV 11 and may even be capable of a maximum of MERV 13 pending acceptable testing. Systems 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 could be used in select areas and rooms to help clean the air within the room. These can be especially helpful where rooms have low outdoor air changes per hour and cannot be supplied with additional outdoor air or improved system ventilation.

ECCM #2: UV-C Light Sterilization - UV-C lights could be considered for insertion in equipment and ductwork to help neutralize viruses when 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 viruses' ability to infect.

WPS has begun to incorporate Bipolar Ionization extensively throughout the South 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 many of the occupied areas of the South High School appear to receive at or less than the current code required mechanical ventilation air subject to occupant densities and clarifications and exceptions as noted herein. The outdoor air ventilation levels to many classrooms, especially those served by packaged air-cooled vertical unit ventilators (VUV), was not identified on existing drawings, and would require testing to determine adequacy. 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 South High School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
General Classrooms	Multi-zone Rooftop Units & VUV's	CCM - #1, #2 & #3 ECCM - #1 or #3 (*see note below)
Science & Chemistry Classrooms	Multi-zone Rooftop Units & VUV's	CCM - #1, #2 & #3 (add ERV and/or dedicated exhaust for science) ECCM - #1 or #3 (*see note below)
Art Classroom	Multi-zone Rooftop Unit	CCM - #1, #2 & #3 (add dedicated exhaust) ECCM - #3
Gymnasium & Auditorium	Rooftop Units	CCM - #1, #2 & #3 ECCM - #3
Admin. & Guidance Office	Multi-zone Rooftop Units & VUV's	CCM - #1, #2 & #3 ECCM - #1 or #3 (*see note below)
Trade Shops	Packaged VUV's	CCM - #1, #2 & #3 (add ERV's for automotive and wood shops) ECCM - #3

**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 / 1.2) 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, ventilated and cooled via either packaged air-cooled vertical unit ventilators (VUV) and/or serviced by packaged rooftop multi-zone units. The VUV's incorporate air-cooled DX coils with compressor for cooling and electric heat coils for heating as well as mixing OA dampers. Some newer versions may also include energy recovery segments for tempering of the outdoor air with exhaust air. The units appear to be a mix of original 1976 vintage as manufacture by Edpac to more recent versions as manufactured by Airedale. The existing schedules do not list the amount of outdoor air being delivered by most of these systems. The units are fitted with 2" thick filters with a MERV rating of 8. The fan capacity of these units it typically limited and as such we do not expect them to be able to support and air filter efficiency in excess of MERV 8.

Many of the areas not served by VUV units are supported by fifteen (15) multi-zone style packaged RTU units. Most of these units were retrofits of old hot deck, cold deck style units which initially delivered either warm or cool air to respective zones as needed. The units have supply and exhaust fans, gas heating sections, energy recovery sections and DX coils with associated condenser section.

The main inefficiency with multi-zone style systems is that the unit either cools or heats or blends the supply air to keep a space satisfied thereby imposing a substantial energy penalty by simultaneously heating and cooling. However, as part of a 2007-2008 replacement project, these systems retrofitted with new packaged RTU VAV units with adapter curbs complete with zone dampers thereby converting the system into a hybrid variable air volume style system that would either cool or heat but not do both at the same time. Two of the ventilation draw backs from this type of conversion are as follows:

1. The VAV damper sections are absent airflow stations to ensure proper control of air and associate indoor air quality.
2. The units do not have outdoor airflow monitoring and/or other air quality measuring (i.e., CO_2) controls to ensure proper outdoor air is maintained across operating ranges of the unit. As such, the amount of outdoor air can drop below code minimum as the units and zones vary airflow in response to space thermal loads. Outdoor airflow monitoring or equivalent is required by the current code and indoor air quality standards.

Flow stations and controls should be added to ensure minimum ventilation requirements are met.

These RTU systems appear to be capable of supporting increased filtration up to a maximum of MERV 13 (see CCM-#3) subject to testing. Systems must be tested and adjusted to accommodate the added pressure drop associated with this increased filter efficiency. In addition, more frequent filter changes would be expected to limit reduction in ventilation air as the filters load.

Each of the classroom systems deliver conditioned air to the classroom and associated spaces via a ducted supply air system. The VUV units return air thru the front of the units. Return air for the RTU units is ducted to the respective areas.

All the systems are mixed air systems. For the multi-zone VAV systems the amount of outdoor air delivered to each space varies based on the amount of primary air being introduced through the respective VAV zone damper. The design drawings do not reflect the amount of outside air being introduced to any of the VUV units.

For a standard classroom, current code would require 10 CFM per person of outside air plus 0.12 CFM per SF. The zone air distribution effectiveness for most of the classrooms is 1.0 with some being 0.8 with the lower factor due to the presence of ceiling supply and return terminals coupled with air that may be warmer than 15°F above space in certain areas such as those spaces with greater thermal heat loss. As such, an average classroom of 800 SF with 26 occupants (25 students + 1 teacher) would require 445 CFM inclusive of the 0.8 correction or 356 CFM with the 1.0 factor. For classrooms with OA information, the units appear to come close to complying with current code outdoor air requirements.

As noted previously, various classrooms, especially those in interior spaces, are supported from a VAV system. These terminals deliver a maximum total and primary airflow of approximately 1,000 CFM +/- (varies by room). Based on the supporting RTU systems having between 24 to 43% of outside air, per design, this would yield a maximum of 430 CFM of outside air to a room. This amount is close to meeting current code required outdoor air of 356 CFM to 445 CFM depending on space air distribution effectiveness. However, if the primary air reduces which it does for a typical VAV terminal, the percentage of outdoor air would drop thereby potentially under ventilating the space.

Current mechanical code would require VAV systems such as this to have the ability to maintain the outdoor air volume constant across the unit's variable supply airflow operation. For example, if the unit provided 40% outside air at full airflow, if the units total airflow dropped to 50%, the outdoor airflow quantity should remain constant thereby making the outdoor air percentage 80%. This would help maintain proper outdoor airflow to the various spaces as there VAV terminals vary. The current control drawings show no OA flow station reflected to ensure ventilation is being maintained. An OA flow station should be added to ensure proper OA ventilation is maintained.

In addition, these types of multi-zone systems generally require a higher percentage of outdoor air to achieve compliance with current code and ASHRAE 62.1-Ventilation for Acceptable Indoor Air Quality standards. These standards factor in the individual ventilation needs of various spaces in a multi-zone system as well as the respective VAV terminals minimum and maximum ranges.

During pandemic conditions we recommend any demand ventilation reset schemes be disabled to ensure increase outdoor air to the spaces. In addition, increase of outdoor air and VAV minimum settings would aide in providing additional OA ventilation.

Science & Art Rooms:

The science rooms and the art room are supported by the same VUV and central RTU VAV units as the normal classrooms. They do not appear to have a higher ventilation rate than any other typical classroom system.

Per the current code, science rooms and art rooms require higher ventilation levels than general use classrooms. Art rooms require 0.7 CFM/SF of exhaust and science rooms require 1.0 CFM per SF of exhaust. It appears the ventilation levels to these areas comply with outdoor air requirements but not the exhaust air requirements nor the prohibition on recirculation air, as the lab air mixes with other spaces through the central RTU unit.

As the science rooms mix with the common RTU system more aggressive modifications may be required to address the current deficiency which may include the addition of room exhaust or with the addition of a dedicated energy recovery ventilation unit. As noted for general classrooms, issues noted with VAV control of outdoor air would apply.

The VUV units are limited to MERV 8 filters as noted previously. The RTU air handling systems appear to be capable of supporting increased filtration up to a maximum of MERV 13 (see CCM-#3) subject to testing. Systems must be tested and adjusted to accommodate the added pressure drop associated with this increased filter efficiency. In addition, more frequent filter changes would be expected to limit reduction in ventilation air as the filters load.

Gymnasium & Auditorium:

The gymnasium and auditorium spaces are supplied with packaged rooftop units. The RTU units are mixed air units which introduces a percentage of outside air into the recirculating air stream. Each unit has mixing dampers, angle filter box, gas-fired heating section, supply fan and exhaust fan.

The RTU air handling systems appear to be capable of supporting increased filtration up to a maximum of MERV 13 (see CCM-#3) subject to testing. Systems must be tested and adjusted to accommodate the added pressure drop associated with this increased filter efficiency. In addition, more frequent filter changes would be expected to limit reduction in ventilation air as the filters load.

The gymnasium ventilation needs are based on a percentage of play area and spectator area. Play area requires an outdoor air volume of 0.3 CFM per SF whereas the spectator area requires 7.5 CFM per person plus 0.06 CFM per SF. The zone air distribution effectiveness is 1.0 based on ceiling supply and floor returns.

Per the design drawings each of the three (3) gym units minimum outside air is listed as high as 83% which should be capable of supporting the code required ventilation for the gymnasium with high spectator occupancy levels. The control drawings do reflect occupancy sensor controls. This feature should be disabled during pandemic conditions to allow for pre- and post-purge outdoor air ventilation.

Offices:

The offices are primarily supported by an RTU VAV unit as well as some limited areas with VUV's.

The VUV units are limited to MERV 8 filters as noted previously. The RTU air handling systems appear to be capable of supporting increased filtration up to a maximum of MERV 13 (see CCM-#3) subject to testing. Systems must be tested and adjusted to accommodate the added pressure drop associated with this increased filter efficiency. In addition, more frequent filter changes would be expected to limit reduction in ventilation air as the filters load.

The outdoor air requirements for office spaces tend to be lower than that of classrooms as densities are far lower. The design plans reflect 26% OA for the RTU system serving the office spaces which is a fair percentage to support office space. However, as noted for general classrooms RTU systems, issues noted with VAV control of outdoor air would apply.

Trade Shops:

The trade shops such as automotive and the wood shop are supported by VUV units. The amount of outdoor air from these units is unknown.

Per the current code, the trade shops require higher ventilation levels than general use classrooms. For example, the automotive shop requires 0.75 CFM per SF of exhaust and associated make-up air and the wood shop would require 0.5 CFM per SF of exhaust and make-up air. Although there is some local exhaust in the space it appears the current systems do not support the exhaust air requirements.

The VUV units are limited to MERV 8 filters as noted previously in this report.

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 Alerton as represented by ABS. It appears the system integrates with an existing control system so some adjustments may require control upgrades.

The packaged RTU units have factory furnished controls which control much of their internal operation with the EMS simply commanding occupied, unoccupied modes and potentially resetting temperatures. Reuse of these units may require a unitary control upgrade to achieve some of the indoor air quality (IAQ) measures noted within this report.

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.

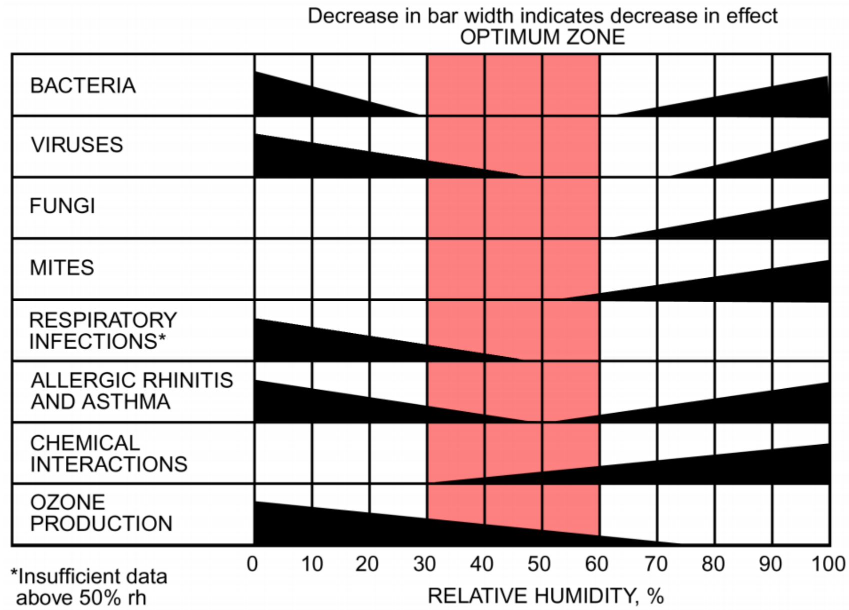

Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

The South 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. Older structures, such as South High School, often have poor vapor barriers. 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 South High School have an outdoor air exchange rate which varies from 2 to above 3 and as such in some cases meeting the bare minimum criteria so long as the system outdoor air can be controlled as noted herein. 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.

		South High School IAQ Sampling Summary									
									Original	**Original**	
Space Tested	**Temp.**	**Humidity**	**CO2**	**TVOC**	**HCHO**	**Room Area**	**Room Ht.**	**Volume**	**Design OA**	**OA Air**	**Notes**
	°F	**% RH**	**%**	**ppm**	**ppm**	**SqFt**	**Ft**	**Cubic Feet**	**CFM**	**ACH**	
Level 1											
Art Room 105	71	18.3	442	0.7	0.09	795	10.41	8276	182	1.3	
Foreign Lang. 113	71.5	19.6	449	0.79	0.08	857	10.41	8921	648	4.4	
Auto/Diesel Class 133	68.5	19.5	464	1.35	0.09	1242	12	14904	615	2.5	
Rotc 134	68.3	20.2	423	1.35	0.1	2011	11.91	23951	N/A	N/A	
Graphics 135	68.7	20.2	437	1.35	0.09	1162	11.91	13839	N/A	N/A	
PreSchool 136	68.6	19.8	425	1.33	0.09	1297	11.91	15447	N/A	N/A	
Automotive Shop	68.5	19.4	448	1.6	0.08	3863	15	57945	N/A	N/A	
Mechanical Drawing 122	67.5	19.8	437	1.31	0.09	1463	10.41	15230	351	1.4	
Special Ed 156	70.5	18.1	445	1.2	0.1	1284	10.41	13366	367	1.6	
Special Ed 154	70.7	18.6	444	1.31	0.08	352	10.41	3664	N/A	N/A	
Special Ed 158	69.7	18.6	441	1.33	0.06	1130	10.41	11763	281	1.4	
Food Training 154A	70.1	19.1	432	1.31	0.07	359	9.91	3558	N/A	N/A	
Distributive Learning 161	71.9	25.2	439	1.31	0.17	821	10.41	8547	304	2.1	
Andy's Attic 165	71.6	21	453	1.35	0.08	1674	15	25110	294	0.7	
Level 2											
Classroom 205	71.6	19	479	1.31	0.09	513	10.41	5340	156	1.8	
Guidence 212	71.9	18.3	476	1.03	0.1	1297	10.5	13619	N/A	N/A	
Health Suite	72	18.1	545	0.93	0.09	700	10.41	7287	220	1.8	
Main Office 221	72.7	17.1	471	1.3	0.12	1283	10.5	13472	148	0.7	
Principal's 222	71.6	17.6	510	1.15	0.11	168	10.5	1764	38	1.3	
Conference 226	72	17.3	482	1.11	0.11	187	10.5	1964	43	1.3	
Art 263	66.7	27.2	435	1.32	0.09	679	10.41	7068	234	2	
Chroral Room 265	63.7	29.7	443	1.31	0.06	1149	9.91	11387	195	1	
Auditorium 270	65.1	26.5	444	0.92	0.07	6783	21.41	145224	3010	1.2	
Cafeteria 281	68.8	21.8	419	1.57	0.06	4228	10.41	44013	N/A	N/A	
Kitchen 285	68.9	22.6	425	1.47	0.06	2301	10.41	23953	N/A	N/A	
Boy's Locker Room	66.5	22.8	440	1.09	0.07	1575	10.58	16664	N/A	N/A	
Gym	65.7	20	433	0.72	0.06	22850	37.41	854819	29873	2.1	
Classroom 243	68.7	18.8	434	0.66	0.09	572	10.41	5955	274	2.8	
Classroom 245	67.6	19	442	0.78	0.04	584	10.41	6079	302	3	
Media Center 250	70.1	21.9	435	1.03	0.1	6265	10.41	65219	2030	1.9	
Control Room 253	70.2	21.2	467	1.35	0.06	541	10.41	5632	122	1.3	
Level 3											
Classroom 302B	72.9	18.4	437	0.89	0.06	1107	10.41	11524	N/A	N/A	
Classroom 305	71.7	19.5	444	1.03	0.1	796	10.41	8286	N/A	N/A	
Classroom 307	79	20.8	450	0.93	0.1	950	10.41	9890	N/A	N/A	
Classroom 313	71.8	18	450	0.89	0.06	1241	10.41	12919	340	1.6	
Classroom 322	68.3	21.6	450	1.3	0.07	753	10.41	7839	443	3.4	
Classroom 324	68	21.8	449	1.25	0.08	1026	10.41	10681	N/A	N/A	
Classroom 327	68.7	21.6	461	1.31	0.1	778	10.41	8099	327	2.4	
Classroom 336	68.3	22	45.3	1.19	0.08	761	10.41	7922	N/A	N/A	
Classroom 353	70.8	18.2	429	0.88	0.1	977	10.41	10171	N/A	N/A	

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.

South 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
RTU-A-1	Academic Level 2	6060	1360	22	(6) 20x25x2 (3) 20x25x4 OA	8	303	#1, #2, #3	#1 or #3	a, b, d
RTU-A-2	Academic Level 2	8000	3850	48	(6) 20x25x2 (3) 20x25x4 OA	8	400	#1, #2, #3	#1 or #3	a, b, d
RTU-A-3	Academic Level 3	8,095	3,450	43	(6) 20x25x2 (3) 20x25x4 OA	8	405	#1, #2, #3	#1 or #3	a, b, d
RTU-A-4	Academic Level 1	5,255	2,770	53	(6) 20x25x2 (3) 20x25x4 OA	8	263	#1, #2, #3	#1 or #3	a, b, d
RTU-A-5	Academic Level 1	7100	1830	26	(6) 20x25x2 (3) 20x25x4 OA	8	355	#1, #2, #3	#1 or #3	a, b, d
RTU-A-6	Academic Level 3	5005	2171	43	(6) 20x25x2 (3) 20x25x4 OA	8	250	#1, #2, #3	#1 or #3	a, b, d
RTU-A-7	Academic Level 3	5690	1960	34	(6) 20x25x2 (3) 20x25x4 OA	8	285	#1, #2, #3	#1 or #3	a, b, d
RTU-A-8	Academic Level 3	6160	1873	30	(6) 20x25x2 (3) 20x25x4 OA	8	308	#1, #2, #3	#1 or #3	a, b, d
RTU-A-9	Academic Level 2	7070	3228	46	(6) 20x25x2 (3) 20x25x4 OA	8	354	#1, #2, #3	#1 or #3	a, b, d
RTU-A-10	Academic Level 2	5295	1379	26	(6) 20x25x2 (3) 20x25x4 OA	8	265	#1, #2, #3	#1 or #3	a, b, d
RTU-A-11	Academic Level 1	4820	1450	30	(6) 20x25x2 (3) 20x25x4 OA	8	241	#1, #2, #3	#1 or #3	a, b, d
RTU-A-12	Academic Level 1	5265	1280	24	(6) 20x25x2 (3) 20x25x4 OA	8	263	#1, #2, #3	#1 or #3	a, b, d
RTU-MS-1	Main Street 2-3	9,745	1,696	17	(6) 20x25x2 (3) 20x25x4 OA	8	488	#1, #2	#3	a, b
RTU-MS-2	Main Street-Mech.	9,115	4,160	46	N/A	8	N/A	#1, #2	#3	b
RTU-M-1	Music Area	7650	1240	16	(6) 20x25x2 (3) 20x25x4 OA	8	383	#1, #2, #3	#3	b, d
RTU-AUD-1	Auditorium	12854	3750	29	(8) 24x24x2	8	402	#1, #2, #3	#3	c, d
RTU-FH-1	Field House	12,000	10,000	83	N/A	8	N/A	#1, #2, #3	#3	c, d
RTU-FH-2	Field House	12,000	10,000	83	N/A	8	N/A	#1, #2, #3	#3	c, d
RTU-FH-3	Field House	12,000	10,000	83	N/A	8	N/A	#1, #2, #3	#3	c, d
VUV's misc.	varies	varies	varies	varies	varies	8	varies	#1, #2	#1 or #3	a, b

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. *To improve the ventilation effectiveness and outdoor airflow control of the multizone VAV systems we recommend airflow stations be added to the supply fan, outdoor air, and* *exhaust air of the unit. In addition, flow stations should be added to each VAV zone to maintain minimum airflows.*

c. *Disable any occupancy sensor-based system shutdown (during scheduled occupied periods) during pandemic conditions.*

d. *Improved filtration up to MERV 13 is subject to testing of respective unit to confirm fan can support the increased resistance.*

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 South 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 South 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.

Most of the HVAC systems supporting the South High School appear capable of implementing this measure subject to outdoor ambient conditions and equipment limitations.

CCM #3 – Improved Filtration

Improve filtration to up to MERV-13 on air handling systems, especially those which recirculate air. In addition, if possible, as filters are replaced provide sealant or gasketing between and/or around filters to reduced air bypass around filter sections. Testing and balancing to confirm current airflow, pressure drops, and fan motor power coupled with manufacturer published data would be required to confirm the unit's capability for improved filtration.

A majority of the main rooftop air handling systems in the building appear to be capable of supporting increased filtration up to a maximum of MERV 13. Systems 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.

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

ECCM #2: UV-C Light Sterilization

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

ECCM #3: Bipolar Ionization

Air ionizers are meant to be installed in the supply air duct or plenum downstream of fans and filters. They are also offered as portable units for room application. In South High Schools case they could be installed in the supply air duct of the respective mixed air handling systems as well as VUV's. WPS has already begun to incorporate Bipolar Ionization extensively throughout the South 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 application. 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 the ionizers work on neutralizing viruses in the space prior to needing to draw these pollutants back to the units where filters and/or other cleaning technology such as UV-C could occur.

ASHRAE has not taken a definitive stance on Bipolar Ionization with regard to virus mitigation as of yet and has deferred to CDC's comment that it is still considered an emerging technology in this regard. Bipolar Ionization has been used for decades primarily for the removal of particles within the air. During that period its use was focused more in facilities such as convention centers, 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

South High School

Room Name / Number	Space Use	Net Floor Area (SF)	4% of Net Area	A (HOPPER) 7.39	B (HOPPER) 7.27	C (HOPPER) 7.39	E (HOPPER) 7.19	G (HOPPER) 7.36	1A (AWNING) 7.09	1B (AWNING) 7.09	Total open Area (SF)	Difference between actual and required SF	PASS?	Additional Notes
Level 1														
101 - Spec Education Resource	classroom	750	30								0.00	30.00	NO	
102 - Spec Education Resource	classroom	788	31.52								0.00	31.52	NO	
102A - Storage	storage	165	6.6								0.00	6.60	NO	
102B - Prep	support	125	5								0.00	5.00	NO	
102C - Storage	support	123	4.92								0.00	4.92	NO	
102D - Prep	support	74	2.96								0.00	2.96	NO	
103 - Infact Room	classroom	791	31.64				1				7.19	24.45	NO	
104 - Infant Room	classroom	979	39.16								0.00	39.16	NO	
104A - Storage	storage	152	6.08								0.00	6.08	NO	
105 - Art Room	classroom	795	31.8								0.00	31.80	NO	
105A - Storage	storage	152	6.08								0.00	6.08	NO	
111 - Family Consumer Sci	classroom	477	19.08								0.00	19.08	NO	
111A - Storage	storage	80	3.2								0.00	3.20	NO	
111B - Prep	support	103	4.12								0.00	4.12	NO	
112 - Family Consumer Sci	classroom	554	22.16								0.00	22.16	NO	
113 - Family Consumer Sci	classroom	857	34.28								0.00	34.28	NO	
114 - Family Consumer Sci	classroom	763	30.52								0.00	30.52	NO	
115 - Family Comsumer Sci	classroom	710	28.4								0.00	28.40	NO	
116 - Foor Prep	support	303	12.12								0.00	12.12	NO	
116A - Storage	storage	43	1.72								0.00	1.72	NO	
117 - Snack Bar	support	219	8.76								0.00	8.76	NO	
118 - Asst Principal	Office	108	4.32								0.00	4.32	NO	
119 - Guidance	Office	105	4.2								0.00	4.20	NO	
119A - Guidance Waiting	support	209	8.36								0.00	8.36	NO	
B10 - Boy's	toilet	219	8.76								0.00	8.76	NO	
G10 - Girl's	toilet	241	9.64								0.00	9.64	NO	
F10 - Faculty	toilet	49	1.96								0.00	1.96	NO	
121 - Storage	storage	456	18.24								0.00	18.24	NO	
121A - Photo Graphic Work Room	classroom	257	10.28								0.00	10.28	NO	
122 - Mechanical Drawings	classroom	1463	58.52								0.00	58.52	NO	
B11 - Boy's + Men's	toilet	257	10.28								0.00	10.28	NO	
G11 - Girl's + Women's	toilet	225	9								0.00	9.00	NO	
131 - Automotive	classroom	3863	154.52								0.00	154.52	NO	
131A - Storage	storage	112	4.48								0.00	4.48	NO	
131B - Storage	storage	115	4.6								0.00	4.60	NO	
131C - Storage	storage	301	12.04								0.00	12.04	NO	
132A - Comp Room	support	67	2.68								0.00	2.68	NO	
132B - Welding Room	support	89	3.56								0.00	3.56	NO	
132C - Paint Room	support	124	4.96								0.00	4.96	NO	
133 - Auto / Diesek Rel	classroom	1242	49.68								0.00	49.68	NO	
133A - Storage	storage	269	10.76								0.00	10.76	NO	
133B - Storage	storage	153	6.12								0.00	6.12	NO	
133C - Storage	storage	83	3.32								0.00	3.32	NO	
134 - Wood Shop	classroom	2011	80.44	2			1				21.97	58.47	NO	
134A - Prep	support	75	3								0.00	3.00	NO	
134B - Storage	storage	101	4.04								0.00	4.04	NO	
134C - Storage	storage	110	4.4								0.00	4.40	NO	
134D - Painting	support	66	2.64								0.00	2.64	NO	
135 - Graphics Shop	classroom	1162	46.48	2							14.78	31.70	NO	
135A - Paper Storage	storage	148	5.92								0.00	5.92	NO	
135B - Compos Room	support	116	4.64								0.00	4.64	NO	
135C - Dark Room	classroom	181	7.24								0.00	7.24	NO	
136	classroom	1297	51.88	4							29.56	22.32	NO	
136A - Storage	storage	101	4.04								0.00	4.04	NO	
1136B - Prep	support	87	3.48								0.00	3.48	NO	
148 - Faculty	support	346	13.84		2						14.55	-0.71	YES	
148A - Men;s	toilet	32	1.28								0.00	1.28	NO	
148B - Women's	toilet	61	2.44								0.00	2.44	NO	
149 - South Works	support	687	27.48		2						14.55	12.93	NO	
151 - Office	Office	97	3.88								0.00	3.88	NO	
152 - Spec Edu	classroom	528	21.12								0.00	21.12	NO	
152A - Storage	storage	81	3.24								0.00	3.24	NO	
152B - Observation	support	110	4.4								0.00	4.40	NO	
154 / 155 - Spec Edu	classroom	959	38.36	2			1				21.97	16.39	NO	
154A - Food Training	classroom	359	14.36								0.00	14.36	NO	
154B - Storage	storage	38	1.52								0.00	1.52	NO	
B12 - Boy's	toilet	249	9.96								0.00	9.96	NO	
G12 - Girl's	toilet	253	10.12								0.00	10.12	NO	
156 - Spec Edu	classroom	1284	51.36								0.00	51.36	NO	
156A - Spec Edu Locker Room	support	415	16.6								0.00	16.60	NO	
157 - Spec Edu	classroom	1126	45.04								0.00	45.04	NO	
158 - Spec Edu	classroom	1130	45.2								0.00	45.20	NO	
159 - Al-Purpose Room	classroom	261	10.44								0.00	10.44	NO	
161 - Distributive Education	classroom	821	32.84								0.00	32.84	NO	
161 - Student Store	support	242	9.68								0.00	9.68	NO	
162 - Spec Edu	classroom	334	13.36								0.00	13.36	NO	
163 - Spec Edu	classroom	330	13.2								0.00	13.20	NO	
164 - Spec	classroom	330	13.2								0.00	13.20	NO	
165 - Storage	storage	1674	66.96								0.00	66.96	NO	
166 - Behavior & Disipline	support	415	16.6								0.00	16.60	NO	
167 - Storage	storage	1533	61.32								0.00	61.32	NO	
168 - Cust	office	119	4.76								0.00	4.76	NO	
168A - Custodian	support	216	8.64								0.00	8.64	NO	
168B - Matron's	support	161	6.44								0.00	6.44	NO	
169 - Receiving	support	523	20.92								0.00	20.92	NO	
169A - Storage	storage	202	8.08								0.00	8.08	NO	
169B - Trash	support	209	8.36								0.00	8.36	NO	

Level 2

201	classroom	490	19.6						2		14.19	5.41	NO
201A	storage	105	4.2								0.00	4.20	NO
201B	storage	77	3.08								0.00	3.08	NO
202	classroom	775	775								0.00	775.00	NO
203	classroom	739	29.56	2					2		28.96	0.60	NO
204	classroom	743	29.72								0.00	29.72	NO
205	classroom	513	20.52								0.00	20.52	NO
206	classroom	225	9								0.00	9.00	NO
207	classroom	200	8								0.00	8.00	NO
211 - Health Office 1	office	143	5.72								0.00	5.72	NO
211 - Health Office 2	office	130	5.2								0.00	5.20	NO
211 - Health Office 3	office	67	2.68								0.00	2.68	NO
211 - Exam	support	67	2.68								0.00	2.68	NO
211 - Health Officce	office	62	2.48								0.00	2.48	NO
211 - Exam	support	84	3.36								0.00	3.36	NO
211 - Exam	support	84	3.36								0.00	3.36	NO
211 - Storage	storage	61	2.44								0.00	2.44	NO
212 - Guidance	office	1297	51.88	2							14.78	37.10	NO
212 - Guidance Office	office	124	4.96								0.00	4.96	NO
212 - Guidance Office	office	96	3.84								0.00	3.84	NO
212 - Guidance Office	office	95	3.8								0.00	3.80	NO
212 - Guidance Office	office	94	3.76								0.00	3.76	NO
212 - Guidance Office	office	96	3.84								0.00	3.84	NO
216 - Assistant Principal	office	212	8.48								0.00	8.48	NO
221 - Main Office	office	1283	51.32								0.00	51.32	NO
221A - Clerk	office	100	4								0.00	4.00	NO
221B - Clerk	office	71	2.84								0.00	2.84	NO
221C - Office	office	93	3.72								0.00	3.72	NO
222 - Principal	office	168	6.72								0.00	6.72	NO
223 - Office	office	110	4.4								0.00	4.40	NO
224 - Private	office	132	5.28								0.00	5.28	NO
225 - Work Room	support	113	4.52								0.00	4.52	NO
225A - Work Room Vault	support	118	4.72								0.00	4.72	NO
G21 - Girl's + Women's	toilet	226	9.04								0.00	9.04	NO
B21 - Boy's + Men's	toilet	256	10.24								0.00	10.24	NO
231	classroom	745	29.8								0.00	29.80	NO
231A	storage	37	1.48								0.00	1.48	NO
232	classroom	751	30.04						2		14.19	15.85	NO
233	classroom	1443	57.72								0.00	57.72	NO
234	classroom	768	30.72								0.00	30.72	NO
235	classroom	774	30.96						2		14.19	16.77	NO
236	classroom	772	30.88						2		14.19	16.69	NO
237	classroom	760	30.4						4		28.37	2.03	NO
238	classroom	776	31.04								0.00	31.04	NO
239	classroom	544	21.76						2		14.19	7.57	NO
239A - Storage	storage	199	7.96								0.00	7.96	NO
240	classroom	188	7.52								0.00	7.52	NO
241	classroom	667	26.68								0.00	26.68	NO
242	classroom	642	25.68								0.00	25.68	NO
243	classroom	572	22.88								0.00	22.88	NO
244	classroom	765	30.6								0.00	30.60	NO
245	classroom	584	23.36								0.00	23.36	NO
246	classroom	780	31.2								0.00	31.20	NO
248 - Teacher's Room	support	275	11							2	14.19	-3.19	YES
Girl's + Women's Room	toilet	206	8.24								0.00	8.24	NO
Boy's + Men's	toilet	200	8								0.00	8.00	NO
Teacher's	support	695	27.8							2	14.19	13.61	NO
250 - Media Center	media	6265	250.6								0.00	250.60	NO
250A - Media Center	media	1072	42.88								0.00	42.88	NO
Tickets	support	33	1.32								0.00	1.32	NO
251 - Office	office	151	6.04								0.00	6.04	NO
251A - Workroom	support	210	8.4								0.00	8.40	NO
251B - Office	office	298	11.92								0.00	11.92	NO
Boy's + Men's	toilet	246	9.84								0.00	9.84	NO
Girl's + Women's Room	toilet	292	11.68								0.00	11.68	NO
253 - Control Room	support	541	21.64								0.00	21.64	NO
253A - Studio	classroom	654	26.16								0.00	26.16	NO
253B - Storage	storage	358	14.32								0.00	14.32	NO
254 - AV Office	office	182	7.28								0.00	7.28	NO
254A / 254B - Conference	conference	204	8.16								0.00	8.16	NO
254 C - Office	office	98	3.92								0.00	3.92	NO
255 - Production	support	544	21.76								0.00	21.76	NO
261 - Office	office	104	4.16								0.00	4.16	NO
262 - Music	music	755	30.2	2							14.78	15.42	NO
263 - Music	music	679	27.16	2							14.78	12.38	NO
264 - Music	music	446	17.84								0.00	17.84	NO
265 - Choral Room	music	1149	45.96								0.00	45.96	NO
265A - Storage	storage	104	4.16								0.00	4.16	NO
266 - Ensemble	music	105	4.2								0.00	4.20	NO
267 - Instrumental	music	267	10.68								0.00	10.68	NO
268 - Instrument Storage	storage	596	23.84								0.00	23.84	NO
269 - Storage	storage	72	2.88								0.00	2.88	NO
Practice - 01	support	62	2.48								0.00	2.48	NO
Practice - 02	support	62	2.48								0.00	2.48	NO
Practice - 03	support	61	2.44								0.00	2.44	NO
Practice - 04	support	60	2.4								0.00	2.40	NO
270 - Auditorium	aud	5287	211.48								0.00	211.48	NO
271 - Stage	aud	1496	59.84								0.00	59.84	NO
281 - Cafeteria	café	4228	169.12	4							29.56	139.56	NO
283 - Teacher's Dining	support	786	31.44			2		2			29.50	1.94	NO
284 - Office	office	86	3.44								0.00	3.44	NO
285 - Kitchen	kitchen	2301	92.04								0.00	92.04	NO
285A - Storage	storage	353	14.12								0.00	14.12	NO
285B - Storage	storage	469	18.76								0.00	18.76	NO
Men's	toilet	64	2.56								0.00	2.56	NO
Women's	toilet	88	3.52								0.00	3.52	NO
Dish Wash	café	297	11.88								0.00	11.88	NO
290 - Gymnasium	gym	22850	914								0.00	914.00	NO
290A - Storage	storage	548	21.92								0.00	21.92	NO
290B - Storage	storage	435	17.4								0.00	17.40	NO
291 - Instructor's Office	office	265	10.6								0.00	10.60	NO
291A - Men's	toilet	80	3.2								0.00	3.20	NO
291B - Women's	toilet	80	3.2								0.00	3.20	NO
Health & Safety Classrooms	classroom	1278	51.12								0.00	51.12	NO
Therapy	support	160	6.4								0.00	6.40	NO
Laundry	support	195	7.8								0.00	7.80	NO
Boy's Shower - 1	gym	185	7.4								0.00	7.40	NO
Boy's Shower - 2	gym	182	7.28								0.00	7.28	NO
Boy's Shower - 3	gym	184	7.36								0.00	7.36	NO
Boy's Shower	gym	304	12.16								0.00	12.16	NO
Team Room	gym	350	14								0.00	14.00	NO
Boy's	toilet	265	10.6								0.00	10.60	NO
Team Room 2	gym	449	17.96								0.00	17.96	NO
Boy's Locker Room	gym	1575	63								0.00	63.00	NO
Storage	storage	506	20.24								0.00	20.24	NO
Pool Room	pool	5755	230.2								0.00	230.20	NO
294 - Instructor's Office	office	112	4.48								0.00	4.48	NO
294A - Toilet	toilet	102	4.08								0.00	4.08	NO
Girl's Shower Rooms	gym	1941	77.64								0.00	77.64	NO
Girl's Locker Rooms	gym	2074	82.96								0.00	82.96	NO
Girl's Locker Room Toilet	toilet	24	0.96								0.00	0.96	NO

Level 3

301 & 311	classroom	880	35.2															0.00	35.20	NO
302A	classroom	670	26.8												2			14.19	12.61	NO
302B	classroom	1107	44.28												2			14.19	30.09	NO
302C - Storage	storage	36	1.44															0.00	1.44	NO
302D - Storage	storage	66	2.64															0.00	2.64	NO
302F - Storage	storage	72	2.88															0.00	2.88	NO
302E - Plants	classroom	1447	57.88												2			14.19	43.69	NO
303	classroom	762	30.48															0.00	30.48	NO
304	classroom	759	30.36															0.00	30.36	NO
305	classroom	769	30.76												2			14.19	16.57	NO
306	classroom	855	34.2															0.00	34.20	NO
307	classroom	950	38												2			14.19	23.81	NO
307A	storage	1112	44.48															0.00	44.48	NO
308 / 312	classroom	1331	53.24															0.00	53.24	NO
309	classroom	869	34.76															0.00	34.76	NO
309A - Storage	storage	64	2.56															0.00	2.56	NO
310	classroom	683	27.32															0.00	27.32	NO
310 - Included above																		0.00	0.00	NO
311 - Included above																		0.00	0.00	NO
313	classroom	1241	49.64															0.00	49.64	NO
314 - Office	office	123	4.92															0.00	4.92	NO
315 - Office	office	133	5.32															0.00	5.32	NO
B30 - Boy's	toilet	192	7.68															0.00	7.68	NO
G30 - Girl's	toilet	209	8.36															0.00	8.36	NO
F30 - Faculty	office	50	2															0.00	2.00	NO
B31 - Boy's + Men's	toilet	201	8.04															0.00	8.04	NO
G31 - Girl's + Women's	toilet	237	9.48															0.00	9.48	NO
321	classroom	363	14.52															0.00	14.52	NO
322	classroom	753	30.12															0.00	30.12	NO
322A - Storage	storage	36	1.44															0.00	1.44	NO
323	classroom	747	29.88												2			14.19	15.69	NO
324	classroom	1026	41.04															0.00	41.04	NO
325	classroom	751	30.04															0.00	30.04	NO
326	classroom	785	31.4															0.00	31.40	NO
327	classroom	778	31.12															0.00	31.12	NO
327A	classroom	144	5.76															0.00	5.76	NO
327B	classroom	105	4.2															0.00	4.20	NO
328	classroom	537	21.48															0.00	21.48	NO
331	classroom	496	19.84															0.00	19.84	NO
331A - Storage	storage	68	2.72															0.00	2.72	NO
331B - Storage	storage	92	3.68															0.00	3.68	NO
332	classroom	627	25.08															0.00	25.08	NO
333	classroom	760	30.4												2			14.19	16.21	NO
334	classroom	654	26.16												2			14.19	11.97	NO
335	classroom	756	30.24												4			28.37	1.87	NO
336	classroom	761	30.44															0.00	30.44	NO
337 & 338	classroom	774	30.96												2			14.19	16.77	NO
348 - Teacher's	support	277	11.08														2	14.19	-3.11	YES
G348 - Girls	toilet	144	5.76															0.00	5.76	NO
W348 - Women's	toilet	38	1.52															0.00	1.52	NO
B348 - Boy's	toilet	143	5.72															0.00	5.72	NO
B348 - Men's	toilet	35	1.4															0.00	1.40	NO
B349 - Teacher's	support	694	27.76														2	14.19	13.57	NO
350 - Media Center	support	1170	46.8															0.00	46.80	NO
351	classroom	810	32.4															0.00	32.40	NO
351A - Storage	storage	80	3.2															0.00	3.20	NO
351B - Storage	storage	111	4.44															0.00	4.44	NO
352	classroom	939	37.56												2			14.19	23.37	NO
353	classroom	977	39.08												2			14.19	24.89	NO
354	classroom	626	25.04															0.00	25.04	NO
355	classroom	571	22.84															0.00	22.84	NO
356	classroom	731	29.24															0.00	29.24	NO
357	classroom	544	21.76															0.00	21.76	NO

Window Type	Width	Height	Projection	Venting
A - Hopper	44.75	21.75	16	7.39
B - Hopper	44.75	21.75	15.75	7.27
C - Hopper	44.75	21.75	16	7.39
E - Hopper	44.25	21.5	15.75	7.19
G - Hopper	44.75	21.5	16	7.36
1A - Awning	46.25	23	14.75	7.09
1B - Awning	46.25	23	14.75	7.09

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)