

# **Worcester Public Schools**

## **Ventilation Assessment & COVID-19 Mitigation Strategies**

for

### **Dr. Arthur F. Sullivan Middle 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 or 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:**

### Dr. Arthur F Sullivan Middle School:

Dr. Arthur F. Sullivan Middle School is located in the South Quadrant of Worcester at 140 Apricot Street. The School was built in 1992, houses grades 7-9, has 72 classrooms and the building is 167,000 square feet. The windows are original to the 1992 construction.

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## **1) Mechanical Ventilation Report**

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## **I. EXECUTIVE SUMMARY**

This report briefly describes the existing ventilation systems at the Dr. Arthur F. Sullivan Middle 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<sub>2</sub> (carbon dioxide in ppm), CH<sub>2</sub>O (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 Sullivan Middle 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 Sullivan Middle 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 Sullivan Middle School are below the 3 ACH requirement, however, are capable of increasing outdoor air to some degree 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.

Several of the main air handling units have fan types which may be capable of supporting the added pressure loss from higher efficiency filters. Per the original design schedules these units are those that support a majority of the classroom spaces such as AHU-1, 2, 3, 7 & 8. These systems must be tested to confirm they can support the improved filters and then 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 virus which becomes exposed to the light.

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

WPS has begun to incorporate Bipolar Ionization extensively throughout the Sullivan Middle 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 Sullivan Middle 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 Sullivan Middle School to address the current pandemic condition.

| Space                               | Exist. O.A. Vent. Systems | Recommendations                                                    |
|-------------------------------------|---------------------------|--------------------------------------------------------------------|
| <b>General Classrooms</b>           | Air Handlers              | CCM - #1, #2 & #3<br>ECCM - #1 or #3 (*see note below)             |
| <b>Science &amp; Art Classrooms</b> | Air Handlers              | CCM - #1, #2 #3 (add exhaust)<br>ECCM - #1 or #3 (*see note below) |
| <b>Cafetorium</b>                   | Air Handlers              | CCM - #1 #2 & #3<br>ECCM - #3                                      |
| <b>Gymnasium</b>                    | Air Handlers              | CCM - #1 & #2<br>ECCM - #3                                         |
| <b>Admin. Office</b>                | Air Handlers              | CCM - #1 & #2<br>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<sub>2</sub> (carbon dioxide in ppm)
- CH<sub>2</sub>O (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<sub>2</sub> levels were low since space CO<sub>2</sub> 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:

| <u>Distribution Configuration</u>                            | <u>ZDE</u> |
|--------------------------------------------------------------|------------|
| 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 ventilated by four (4) constant volume rooftop air handling units. These units consist of return fans, exhaust and mixing dampers, hot water coils and supply fans. Hot water is fed to these units from the building's central boiler plant. The units are fitted with 2" thick air filters with an estimated efficiency of MERV 8.

These air handling systems appear to be capable of supporting increased filtration, pending testing, up to a maximum of MERV 13 (see CCM-#3). 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 air handlers deliver conditioned air to the classrooms and associated spaces via a ducted supply air system and a partially ducted plenum return air system. The air is supplied as tempered air with space heating accomplished through perimeter radiation.

As these are mixed air systems, the amount of outdoor air delivered to each space varies based on the amount of supply air being introduced. According to the design drawings the percentage of outdoor air from each of the four units varies from 30 to 40%.

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 the classrooms would be 1.0 as the design supply air temperature should be within 15°F of space temperature. As such, an average classroom of 740 SF with 26 occupants (25 students + 1 teacher) would require 349 CFM. At the current 40% mixed air percentage, current plans would indicate outdoor air of 260 CFM which is below the required ventilation level.

### Science & Art Rooms:

The science rooms and the former art room are supported by the same central RTU units as the normal classrooms. The current science and art rooms are approx. 850 SF in size and are each supplied with 650 CFM of supply air of which 260 CFM is outside air.

Per the current code, science rooms and art rooms require higher ventilation levels than general use classrooms and the air from these spaces cannot be recirculated to other areas.

Art rooms require 0.7 CFM/SF of exhaust and science rooms require 1.0 CFM per SF of exhaust. As such, it appears the ventilation levels are not compliant with current code. Additional exhaust and associated make-up air (possible portion from plenum) would be required to prevent recirculation and bring these spaces up to current code. However, if the science rooms are used more as physics rooms and do not involve the use of chemicals and gas, they could be considered normal classrooms.

Per the control drawings, these systems incorporate CO2 based outdoor air demand ventilation reset. This reset should be disabled to allow for improved ventilation during all scheduled occupied periods.

#### Gymnasium & Cafeteria:

The gymnasium is supplied with air from one (1) 11,000 CFM air handler (AHU-3) located on the roof. The air handler is a mixed air unit which introduces a percentage of outside air (plans reflect 29%, 3,190 CFM) into the recirculating air stream. The cafetorium is supplied with air from one (1) 18,300 CFM air handler (AHU-3) located on the roof. The air handler is a mixed air unit which introduces a percentage of outside air (plans reflect 31%, 5,163 CFM) into the recirculating air stream.

Each unit consists of a return fan, exhaust and mixing dampers, hot water coil and supply fan. Hot water is fed to this units from the building's central boiler plant. The units are fitted with 2" thick air filters with an estimated efficiency of MERV 8. The air handlers do not appear to be capable of supporting air filtration in excess of MERV 8.

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. With actual spectator area unknown, presuming the entire gym is play area would yield a required outdoor air rate of 2,280 CFM. The current unit yields 3,190 CFM which would afford for a fair number of occupants.

The cafetorium ventilation needs vary based on cafeteria or multi-use assembly. For multi-use assembly current code 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. With actual occupant loading unknown, the design air of 5,163 CFM would accommodate several hundred occupants.

Per the control drawings, the gym and cafetorium systems incorporate space occupancy sensors to control the units occupied mode. These should be disabled to allow for improved ventilation during all scheduled occupied periods.

### Administration Offices:

The office areas are cooled and ventilated by one (1) variable air volume rooftop air handling units. These unit consist of a return fan, exhaust and mixing dampers and supply fans. The design drawings do not reflect heat to this unit. Space heating is accomplished thru a mix of supply air VAV zone terminals with hot water coils and perimeter radiation. The unit is fitted with 2” thick air filters with an estimated efficiency of MERV 8. The air handlers do not appear to be capable of supporting air filtration in excess of MERV 8.

The office air handler delivers conditioned (cooled and ventilated only) air to the offices and associated spaces via a ducted supply air system and a partially ducted plenum return air system. As noted previously, the spaces are supported with VAV terminals that have a minimum airflow of 50% of their scheduled maximum. The design and control drawings do not reflect variable speed drives or other means to support a reduction in supply airflow when the VAV terminals closed so it is unclear how this is addressed.

As this is a mixed air system, the amount of outdoor air delivered to each space varies based on the amount of primary air being introduced through the respective VAV terminal. According to the design drawings the percentage of outdoor air from the central systems is 15% of the design supply air which is somewhat low to support typical office loading with a VAV type system.

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 15% 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 30%. This would help maintain proper outdoor airflow to the various spaces as there VAV terminals vary volume. The current control drawings show no OA flow station reflected to ensure ventilation is being 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.

### Controls:

Most of the air handling systems supporting the school are controlled by a building energy management system (EMS). The EMS system is currently supported by ABS. It appears the system may not have active control of the VAV terminals.

Many of the units include CO<sub>2</sub> based demand ventilation reset. The gym and cafetorium system incorporate occupancy sensors as well. These reset controls should be overridden during the pandemic to ensure increased ventilation of the spaces. Additional controls on the Office VAV system may be required to increase outdoor air.

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:

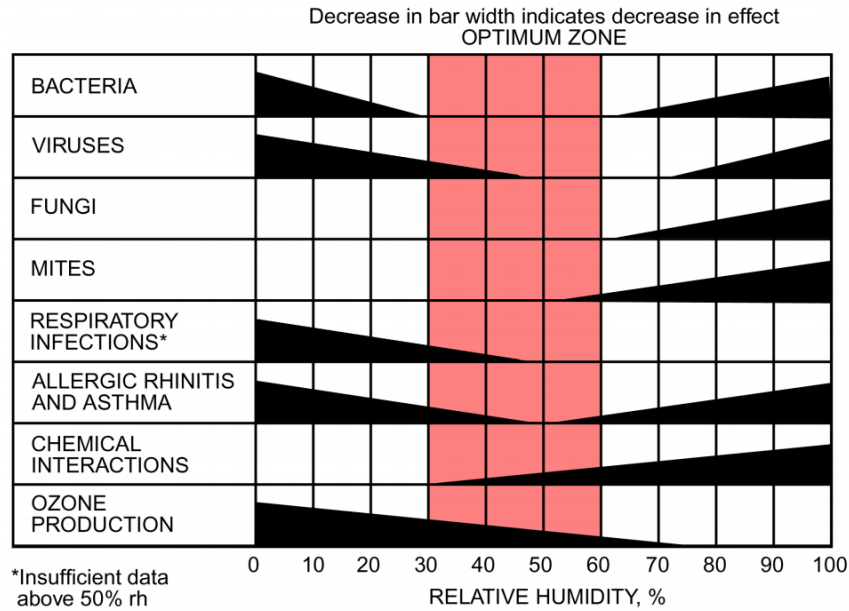
During our inspection we obtained spot measurements of air quality in various locations throughout the school. Measurements taken were limited to:

- Temperature (°F)
- Relative Humidity (% RH)
- CO<sub>2</sub> (carbon dioxide in ppm)
- CH<sub>2</sub>O (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<sub>2</sub> levels were low since space CO<sub>2</sub> 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 Sullivan Middle 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 structures, such as Sullivan Middle 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 Sullivan Middle School have an outdoor air exchange rate of below 3 and do not meet 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 than 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.



| Sullivan Middle School IAQ Sampling Summary |             |                  |          |             |             |                   |                |                      |                  |               |       |
|---------------------------------------------|-------------|------------------|----------|-------------|-------------|-------------------|----------------|----------------------|------------------|---------------|-------|
| Space Tested                                | Temp.<br>°F | Humidity<br>% RH | CO2<br>% | TVOC<br>ppm | HCHO<br>ppm | Room Area<br>SqFt | Room Ht.<br>Ft | Volume<br>Cubic Feet | Design OA<br>CFM | OA Air<br>ACH | Notes |
| <b>Level 1</b>                              |             |                  |          |             |             |                   |                |                      |                  |               |       |
| Workout Room 153                            | 71.3        | 20.7             | 431      | 1.56        | 0.21        | 1126              | 16.916         | 19047                | 480              | 1.5           |       |
| Classroom 105                               | 70.8        | 23.7             | 443      | 1.34        | 0.19        | 696               | 8.916          | 6206                 | 260              | 2.5           |       |
| Boys Locker 141                             | 72.3        | 18.6             | 437      | 1.48        | 0.2         | 543               | 8.916          | 4841                 | 258              | 3.2           |       |
| Gym 155/156                                 | 73.4        | 15.2             | 459      | 1.4         | 0.19        | 7602              | 26.75          | 203354               | 3190             | 0.9           |       |
| Home Economics 112                          | 71.4        | 22.4             | 457      | 1.38        | 0.2         | 714               | 9              | 6426                 | 260              | 2.4           |       |
| Science 120                                 | 72.9        | 17.2             | 440      | 1.38        | 0.2         | 862               | 8.916          | 7686                 | 230              | 1.8           |       |
| Indust. Tech. Commun. 125                   | 72.2        | 16.7             | 433      | 1.36        | 0.18        | 756               | 8.75           | 6615                 | 272              | 2.5           |       |
| Classroom 133                               | 71.6        | 18               | 433      | 1.36        | 0.19        | 1110              | 8.916          | 9897                 | 440              | 2.7           |       |
| <b>Level 2</b>                              |             |                  |          |             |             |                   |                |                      |                  |               |       |
| Classroom 206                               | 73.6        | 21.9             | 445      | 1.43        | 0.2         | 696               | 8.916          | 6206                 | 260              | 2.5           |       |
| Boys 210B                                   | 73.8        | 21.4             | 463      | 1.45        | 0.2         | N/A               | 9              | N/A                  | N/A              | N/A           |       |
| Science 214                                 | 74          | 20.9             | 464      | 1.97        | 0.19        | 861               | 9              | 7749                 | 260              | 2             |       |
| Library 216                                 | 73.3        | 20.4             | 461      | 1.44        | 0.19        | 4132              | 8.916          | 36841                | 780              | 1.3           |       |
| Elec Rm 215E                                | 73.9        | 19.9             | 470      | 1.5         | 0.18        | 525               | 8.416          | 4418                 | 120              | 1.6           |       |
| Spec. Ed. Science 226                       | 73.9        | 16.9             | 438      | 1.39        | 0.19        | 720               | 8.916          | 6420                 | 260              | 2.4           |       |
| Classroom 232                               | 73.8        | 16.4             | 445      | 1.38        | 0.2         | 746               | 8.916          | 6651                 | 260              | 2.3           |       |
| Large Group Instruction 217                 | 71.2        | 16.1             | 451      | 1.4         | 0.19        | N/A               | 9.083          | N/A                  | 400              | N/A           |       |
| Cafeteria 251                               | 72          | 20.6             | 470      | 1.37        | 0.2         | 4224              | 11.5           | 48576                | 4337             | 5.4           |       |
| Music Classroom 249                         | 71.9        | 25.4             | 466      | 1.38        | 0.2         | N/A               | 17.416         | N/A                  | 465              | N/A           |       |
| Faculty Dining 255                          | 71.6        | 22.1             | 470      | 1.4         | 0.2         | N/A               | 8.916          | N/A                  | 465              | N/A           |       |
| Food Prep 233                               | 71.7        | 20.7             | 477      | 1.37        | 0.19        | N/A               | 8.83           | N/A                  | 2932             | N/A           |       |
| Music Classroom 246                         | 72.3        | 19.1             | 491      | 1.37        | 0.18        | N/A               | 8.916          | N/A                  | 260              | N/A           |       |
| Principals Room 244                         | 73          | 18               | 497      | 1.43        | 0.21        | N/A               | 8.66           | N/A                  | 64               | N/A           |       |
| General Office 241                          | 72.6        | 18.8             | 512      | 1.43        | 0.2         | N/A               | 8.66           | N/A                  | 56               | N/A           |       |
| <b>Level 3</b>                              |             |                  |          |             |             |                   |                |                      |                  |               |       |
| Classroom 303                               | 73.1        | 22.9             | 465      | 1.61        | 0.14        | 714               | 9              | 6426                 | 260              | 2.4           |       |
| Art 316                                     | 71.3        | 20.7             | 454      | 1.84        | 0.14        | 855               | 8.916          | 7623                 | 260              | 2             |       |
| Spec. Ed. 309                               | 73          | 19.8             | 496      | 1.73        | 0.15        | N/A               | 8.583          | N/A                  | 80               | N/A           |       |
| Art 322                                     | 68.5        | 22.2             | 429      | 1.66        | 0.16        | 855               | 8.916          | 7623                 | 260              | 2             |       |
| Classroom 333                               | 69.9        | 19.7             | 428      | 1.66        | 0.13        | 746               | 9              | 6714                 | 260              | 2.3           |       |
| Health Classroom 365                        | 73.4        | 17.8             | 505      | 1.47        | 0.19        | 709               | 8.83           | 6260                 | 260              | 2.5           |       |
| Large Group Instruct. 363/364               | 73.6        | 18               | 467      | 1.47        | 0.19        | 900               | 8.916          | 8024                 | 200              | 1.5           |       |
| Nurse 358                                   | 73.2        | 17.9             | 463      | 1.48        | 0.18        | 190               | 8.66           | 1645                 | 56               | 2             |       |
| Rect. 361                                   | 73.6        | 13.3             | 494      | 1.49        | 0.15        | 126               | 8.916          | 1123                 | N/A              | N/A           |       |
| Sm Group 349                                | 73.2        | 16               | 448      | 1.51        | 0.15        | 348               | 8.916          | 3103                 | N/A              | N/A           |       |
| Office 346                                  | 73.3        | 16               | 447      | 1.5         | 0.18        | 108               | 8.916          | 963                  | 41               | 2.6           |       |
| Teacher's Lounge 339                        | 73.1        | 18               | 435      | 1.52        | 0.15        | N/A               | 8.583          | N/A                  | 220              | 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.

| Sullivan Middle 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   |
| AHU-1                                             | Part D and E    | 37425             | 14970           | 40            | (28) 20x25x2<br>(28) 16x25x2 | 8                         | 214                      | #1, #2, #3     | #1, #3          | a, c, d |
| AHU-2                                             | Part C and D    | 48825             | 19530           | 40            | N/A                          | 8                         | N/A                      | #1, #2, #3     | #1, #3          | a, c, d |
| AHU-3                                             | Cafeteria       | 18,300            | 5,670           | 31            | N/A                          | 8                         | N/A                      | #1, #2, #3     | #3              | c, d    |
| AHU-4                                             | Kitchen         | 11,000            | 11,000          | 100           | (15) 16x25x2<br>(5) 16x20x2  | 8                         | 208                      | N/A            | N/A             |         |
| AHU-5                                             | Gymnasium       | 11000             | 3240            | 29            | (15) 16x25x2<br>(5) 16x20x2  | 8                         | 208                      | #1, #2         | #3              | c, d    |
| AHU-6                                             | Administration  | 6600              | 1000            | 15            | (15) 16x25x2<br>(5) 16x20x2  | 8                         | 125                      | #1, #2         | #1, #3          | a, b    |
| AHU-7                                             | Part C          | 11125             | 4950            | 44            | (15) 16x25x2<br>(5) 16x20x2  | 8                         | 210                      | #1, #2, #3     | #1, #3          | a, c, d |
| AHU-8                                             | Maint. And Shop | 11650             | 3500            | 30            | N/A                          | 8                         | N/A                      | #1, #2, #3     | #3              | c, d    |

*Ventilation System Summary Notes:*

- a. For individual classrooms and other areas noted, ECCM #1 – Portable Air Filtration and/or ECCM #3 – Ionization, are noted as possible options to improve air cleaning and changeover during pandemic conditions.
- b. To improve the ventilation effectiveness and outdoor airflow control of VAV systems we recommend airflow stations be added to the supply fan, outdoor air, and exhaust air of the unit.
- c. Disable any occupancy sensor-based system shutdown (during scheduled occupied periods) or CO2 based demand control ventilation 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 Sullivan Middle 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 air handling systems supporting the Sullivan Middle 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., CO2 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 air handling systems supporting the Sullivan Middle School are capable of implementing this measure subject to outdoor ambient conditions and equipment limitations. For the unit serving the administration area, more extensive control related work shall be required as described in this report to accomplish this CCM.

### 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. Prior to implementation of higher filtration levels, existing equipment capabilities must be reviewed and tested to verify if they 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 manufacturer published data would be required to confirm the unit's capability for improved filtration.

A majority of the main 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 Sullivan Middle Schools case they could be installed in the supply air duct of the respective mixed air handling systems. WPS has already begun to incorporate Bipolar Ionization extensively throughout the Sullivan Middle 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 3<sup>rd</sup> 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**

Sullivan Middle 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                         | B |                      |                                           |       |                  |
| <b>Level One</b>                        |           |                     |                |                           |   |                      |                                           |       |                  |
| <b>Part A</b>                           |           |                     |                |                           |   |                      |                                           |       |                  |
| Room 141 - Boys Locker Room             | gym       | 640                 | 25.6           |                           |   | 0.00                 | 25.60                                     | NO    |                  |
| Room 141L - Toilet                      | toilet    | 124                 | 4.96           |                           |   | 0.00                 | 4.96                                      | NO    |                  |
| Room 141C - Custodian                   | support   | 17                  | 0.68           |                           |   | 0.00                 | 0.68                                      | NO    |                  |
| Room 142 - Drying                       | gym       | 131                 | 5.24           |                           |   | 0.00                 | 5.24                                      | NO    |                  |
| Room 143 - Showers                      | gym       | 135                 | 5.4            |                           |   | 0.00                 | 5.40                                      | NO    |                  |
| Room 144                                | office    | 116                 | 4.64           |                           |   | 0.00                 | 4.64                                      | NO    |                  |
| Room 144L - Bath                        | toilet    | 69                  | 2.76           |                           |   | 0.00                 | 2.76                                      | NO    |                  |
| Room 145                                | office    | 147                 | 5.88           |                           |   | 0.00                 | 5.88                                      | NO    |                  |
| Room 146 - Equipment Storage            | storage   | 1156                | 46.24          |                           |   | 0.00                 | 46.24                                     | NO    |                  |
| Room 147 - Trash                        | support   | 145                 | 5.8            |                           |   | 0.00                 | 5.80                                      | NO    |                  |
| Room 148 - Receiving                    | support   | 253                 | 10.12          |                           |   | 0.00                 | 10.12                                     | NO    |                  |
| Room 149 - Maint Shop                   | support   | 328                 | 13.12          |                           |   | 0.00                 | 13.12                                     | NO    |                  |
| Room 149M - Water Service               | support   | 93                  | 3.72           |                           |   | 0.00                 | 3.72                                      | NO    |                  |
| Room 150                                | storage   | 289                 | 11.56          |                           |   | 0.00                 | 11.56                                     | NO    |                  |
| Room 151                                | storage   | 183                 | 7.32           |                           |   | 0.00                 | 7.32                                      | NO    |                  |
| Room 152 - Grounds Equipment            | storage   | 647                 | 25.88          |                           |   | 0.00                 | 25.88                                     | NO    |                  |
| Room 152S - Gym Storage                 | storage   | 333                 | 13.32          |                           |   | 0.00                 | 13.32                                     | NO    |                  |
| Room 153 - Technology Shop              | classroom | 1144                | 45.76          |                           |   | 0.00                 | 45.76                                     | NO    |                  |
| Room 153D - Finish Room                 | storage   | 51                  | 2.04           |                           |   | 0.00                 | 2.04                                      | NO    |                  |
| Room 153S - Shop Storage                | storage   | 230                 | 9.2            |                           |   | 0.00                 | 9.20                                      | NO    |                  |
| Room 154 - Technology Shop              | classroom | 1049                | 41.96          |                           |   | 0.00                 | 41.96                                     | NO    |                  |
| Room 154 - Computers                    | classroom | 89                  | 3.56           |                           |   | 0.00                 | 3.56                                      | NO    |                  |
| Room 155 / 166 - Gymnasium Boys / Girls | gym       | 7600                | 304            |                           |   | 0.00                 | 304.00                                    | NO    |                  |
| <b>Part B</b>                           |           |                     |                |                           |   |                      |                                           |       |                  |
| Room 138 - Adaptive Exercise            | support   | 829                 | 33.16          |                           |   | 0.00                 | 33.16                                     | NO    |                  |
| Room 138S - Gym Storage                 | storage   | 377                 | 15.08          |                           |   | 0.00                 | 15.08                                     | NO    |                  |
| Room 139                                | office    | 160                 | 6.4            |                           |   | 0.00                 | 6.40                                      | NO    |                  |
| Room 139L                               | toilet    | 65                  | 2.6            |                           |   | 0.00                 | 2.60                                      | NO    |                  |
| Room 140 - Girls Locker Room            | gym       | 1473                | 58.92          |                           |   | 0.00                 | 58.92                                     | NO    |                  |
| Room 140L - Toilet                      | toilet    | 159                 | 6.36           |                           |   | 0.00                 | 6.36                                      | NO    |                  |
| Room 140C - Custodian                   | support   | 18                  | 0.72           |                           |   | 0.00                 | 0.72                                      | NO    |                  |
| <b>Part C</b>                           |           |                     |                |                           |   |                      |                                           |       |                  |
| Room 127                                | storage   | 150                 | 6              |                           |   | 0.00                 | 6.00                                      | NO    |                  |
| Room 129                                | storage   | 515                 | 20.6           |                           |   | 0.00                 | 20.60                                     | NO    |                  |
| Room 130B                               | toilet    | 236                 | 9.44           |                           |   | 0.00                 | 9.44                                      | NO    |                  |
| Room 130C                               | support   | 67                  | 2.68           |                           |   | 0.00                 | 2.68                                      | NO    |                  |
| Room 130G                               | toilet    | 226                 | 9.04           |                           |   | 0.00                 | 9.04                                      | NO    |                  |
| Room 131                                | classroom | 751                 | 30.04          |                           |   | 0.00                 | 30.04                                     | NO    |                  |
| Room 132                                | classroom | 751                 | 30.04          |                           |   | 0.00                 | 30.04                                     | NO    |                  |
| Room 133                                | classroom | 1114                | 44.56          |                           |   | 0.00                 | 44.56                                     | NO    |                  |
| Room 134                                | classroom | 1114                | 44.56          |                           |   | 0.00                 | 44.56                                     | NO    |                  |
| Room 135                                | classroom | 1114                | 44.56          |                           |   | 0.00                 | 44.56                                     | NO    |                  |
| Room 136                                | classroom | 1114                | 44.56          |                           |   | 0.00                 | 44.56                                     | NO    |                  |
| <b>Part D</b>                           |           |                     |                |                           |   |                      |                                           |       |                  |
| Room 109 - Guidance                     | office    | 126                 | 5.04           |                           |   | 0.00                 | 5.04                                      | NO    |                  |
| Room 109S                               | storage   | 92                  | 3.68           |                           |   | 0.00                 | 3.68                                      | NO    |                  |
| Room 111 - Reception Waiting            | office    | 167                 | 6.68           |                           |   | 0.00                 | 6.68                                      | NO    |                  |
| Room 112                                | classroom | 713                 | 28.52          | 2                         |   | 21.08                | 7.44                                      | NO    |                  |
| Room 113 - Assistant Principal          | office    | 208                 | 8.32           |                           |   | 0.00                 | 8.32                                      | NO    |                  |
| Room 114                                | classroom | 869                 | 34.76          | 2                         |   | 21.08                | 13.68                                     | NO    |                  |
| Room 115 - Teacher's Lounge             | support   | 515                 | 20.6           |                           |   | 0.00                 | 20.60                                     | NO    |                  |
| Room 115A - Lav                         | toilet    | 45                  | 1.8            |                           |   | 0.00                 | 1.80                                      | NO    |                  |
| Room 115B - Lav                         | toilet    | 45                  | 1.8            |                           |   | 0.00                 | 1.80                                      | NO    |                  |
| Room 116                                | classroom | 862                 | 34.48          | 2                         |   | 21.08                | 13.40                                     | NO    |                  |
| Room 118                                | classroom | 871                 | 34.84          | 2                         |   | 21.08                | 13.76                                     | NO    |                  |
| Room 118P                               | storage   | 661                 | 26.44          |                           |   | 0.00                 | 26.44                                     | NO    |                  |
| Room 119                                | storage   | 768                 | 30.72          |                           |   | 0.00                 | 30.72                                     | NO    |                  |
| Room 120                                | classroom | 868                 | 34.72          | 2                         |   | 21.08                | 13.64                                     | NO    |                  |
| Room 121                                | classroom | 897                 | 35.88          |                           |   | 0.00                 | 35.88                                     | NO    |                  |
| Room 122                                | classroom | 870                 | 34.8           | 2                         |   | 21.08                | 13.72                                     | NO    |                  |
| Room 123                                | storage   | 377                 | 15.08          |                           |   | 0.00                 | 15.08                                     | NO    |                  |
| Room 124                                | classroom | 868                 | 34.72          | 2                         |   | 21.08                | 13.64                                     | NO    |                  |
| Room 125                                | classroom | 1225                | 49             |                           |   | 0.00                 | 49.00                                     | NO    |                  |
| Room 125D - Dark Room                   | classroom | 184                 | 7.36           |                           |   | 0.00                 | 7.36                                      | NO    |                  |
| Room 125V - Dark Room Vestibule         | entry     | 50                  | 2              |                           |   | 0.00                 | 2.00                                      | NO    |                  |
| Room 125S                               | storage   | 232                 | 9.28           |                           |   | 0.00                 | 9.28                                      | NO    |                  |
| Room 126                                | classroom | 712                 | 28.48          | 2                         |   | 21.08                | 7.40                                      | NO    |                  |
| <b>Part E</b>                           |           |                     |                |                           |   |                      |                                           |       |                  |
| Room 101                                | classroom | 715                 | 28.6           | 2                         |   | 21.08                | 7.52                                      | NO    |                  |
| Room 102                                | classroom | 710                 | 28.4           | 2                         |   | 21.08                | 7.32                                      | NO    |                  |
| Room 103                                | classroom | 716                 | 28.64          | 2                         |   | 21.08                | 7.56                                      | NO    |                  |
| Room 104                                | classroom | 716                 | 28.64          | 2                         |   | 21.08                | 7.56                                      | NO    |                  |
| Room 105                                | classroom | 709                 | 28.36          | 2                         |   | 21.08                | 7.28                                      | NO    |                  |
| Room 106                                | classroom | 708                 | 28.32          | 2                         |   | 21.08                | 7.24                                      | NO    |                  |
| Room 107                                | classroom | 709                 | 28.36          | 2                         |   | 21.08                | 7.28                                      | NO    |                  |
| Room 108                                | classroom | 707                 | 28.28          | 2                         |   | 21.08                | 7.20                                      | NO    |                  |
| Room 110B - Boys Room                   | toilet    | 235                 | 9.4            |                           |   | 0.00                 | 9.40                                      | NO    |                  |
| Room 110C - Cust                        | support   | 67                  | 2.68           |                           |   | 0.00                 | 2.68                                      | NO    |                  |
| Room 110G - Girls                       | toilet    | 229                 | 9.16           |                           |   | 0.00                 | 9.16                                      | NO    |                  |



Level Two

Part A

|                                |            |      |        |   |  |  |       |        |     |                            |
|--------------------------------|------------|------|--------|---|--|--|-------|--------|-----|----------------------------|
| Room 239C - Custodian          | support    | 34   | 1.36   |   |  |  | 0.00  | 1.36   | NO  |                            |
| Room 239M - Men's              | toilet     | 217  | 8.68   |   |  |  | 0.00  | 8.68   | NO  |                            |
| Room 239W - Women's            | toilet     | 251  | 10.04  |   |  |  | 0.00  | 10.04  | NO  |                            |
| Room 240 - Reception / Waiting | office     | 290  | 11.6   |   |  |  | 0.00  | 11.60  | NO  |                            |
| Room 241 - General Office      | office     | 935  | 37.4   |   |  |  | 0.00  | 37.40  | NO  |                            |
| Room 241S - Closet             | storage    | 16   | 0.64   |   |  |  | 0.00  | 0.64   | NO  |                            |
| Room 242 - Work Room           | office     | 122  | 4.88   |   |  |  | 0.00  | 4.88   | NO  |                            |
| Room 242S - Closet             | storage    | 15   | 0.6    |   |  |  | 0.00  | 0.60   | NO  |                            |
| Room 243 - Principal           | office     | 181  | 7.24   | 2 |  |  | 21.08 | -13.84 | YES |                            |
| Room 243L - Lav                | toilet     | 45   | 1.8    |   |  |  | 0.00  | 1.80   | NO  |                            |
| Room 244 - Conference          | conference | 247  | 9.88   | 2 |  |  | 21.08 | -11.20 | YES |                            |
| Room 244L - Lav                | toilet     | 45   | 1.8    |   |  |  | 0.00  | 1.80   | NO  |                            |
| Room 245 - Vault               | support    | 137  | 5.48   |   |  |  | 0.00  | 5.48   | NO  |                            |
| Room 246 - Music Room          | classroom  | 704  | 28.16  | 2 |  |  | 21.08 | 7.08   | NO  |                            |
| Room 246S - Music Room Storage | storage    | 303  | 12.12  |   |  |  | 0.00  | 12.12  | NO  |                            |
| Room 247 - Music Classroom     | classroom  | 696  | 27.84  | 2 |  |  | 21.08 | 6.76   | NO  |                            |
| Room 248 - Practice            | classroom  | 47   | 1.88   |   |  |  | 0.00  | 1.88   | NO  |                            |
| Room 249 - Misc Classroom      | classroom  | 763  | 30.52  | 5 |  |  | 52.71 | -22.19 | YES | Windows at 3rd Floor Level |
| Room 250 - Music Classroom     | classroom  | 803  | 32.12  | 5 |  |  | 52.71 | -20.59 | YES | Windows at 3rd Floor Level |
| Room 251 - Cafetorium          | café / aud | 7163 | 286.52 |   |  |  | 0.00  | 286.52 | NO  |                            |
| Room 251E - Control Room       | support    | 73   | 2.92   |   |  |  | 0.00  | 2.92   | NO  |                            |
| Room 251L - Lift               | lift       | 40   | 1.6    |   |  |  | 0.00  | 1.60   | NO  |                            |
| Room 251P - Stage              | stage      | 797  | 31.88  |   |  |  | 0.00  | 31.88  | NO  |                            |
| Room 251S - Storage            | storage    | 93   | 3.72   |   |  |  | 0.00  | 3.72   | NO  |                            |
| Room 252 - Practice            | classroom  | 41   | 1.64   |   |  |  | 0.00  | 1.64   | NO  |                            |

Part B

|                             |         |      |        |   |  |  |       |        |    |  |
|-----------------------------|---------|------|--------|---|--|--|-------|--------|----|--|
| Room 253 - Faculty Dining   | support | 7877 | 315.08 | 2 |  |  | 21.08 | 294.00 | NO |  |
| Room 254 - Dish Wash        | support | 192  | 7.68   |   |  |  | 0.00  | 7.68   | NO |  |
| Room 255 - Food Preparation | support | 1997 | 79.88  |   |  |  | 0.00  | 79.88  | NO |  |
| Room 256 - Office           | office  | 87   | 3.48   |   |  |  | 0.00  | 3.48   | NO |  |
| Room 257 - Freezer          | support | 129  | 5.16   |   |  |  | 0.00  | 5.16   | NO |  |
| Room 258 - Cooler           | support | 123  | 4.92   |   |  |  | 0.00  | 4.92   | NO |  |
| Room 259 - Dry Storage      | storage | 590  | 23.6   |   |  |  | 0.00  | 23.60  | NO |  |
| Room 260 - Receiving        | support | 228  | 9.12   |   |  |  | 0.00  | 9.12   | NO |  |
| Room 261 - Corridor         | common  | 65   | 2.6    |   |  |  | 0.00  | 2.60   | NO |  |
| Room 262 - Lockers          | support | 74   | 2.96   |   |  |  | 0.00  | 2.96   | NO |  |
| Room 262L - Lav             | toilet  | 42   | 1.68   |   |  |  | 0.00  | 1.68   | NO |  |
| Room 263 - Lockers          | support | 77   | 3.08   |   |  |  | 0.00  | 3.08   | NO |  |
| Room 263L - Lav             | toilet  | 43   | 1.72   |   |  |  | 0.00  | 1.72   | NO |  |
| Room 264                    | support | 49   | 1.96   |   |  |  | 0.00  | 1.96   | NO |  |
| Room 265 - Non-Food Storage | support | 223  | 8.92   |   |  |  | 0.00  | 8.92   | NO |  |

Part C

|           |           |     |       |   |  |  |       |        |     |  |
|-----------|-----------|-----|-------|---|--|--|-------|--------|-----|--|
| Room 227  | classroom | 277 | 11.08 | 1 |  |  | 10.54 | 0.54   | NO  |  |
| Room 229  | classroom | 237 | 9.48  | 2 |  |  | 21.08 | -11.60 | YES |  |
| Room 230B | toilet    | 240 | 9.6   |   |  |  | 0.00  | 9.60   | NO  |  |
| Room 230C | support   | 67  | 2.68  |   |  |  | 0.00  | 2.68   | NO  |  |
| Room 230G | toilet    | 231 | 9.24  |   |  |  | 0.00  | 9.24   | NO  |  |
| Room 231  | classroom | 716 | 28.64 | 2 |  |  | 21.08 | 7.56   | NO  |  |
| Room 232  | classroom | 715 | 28.6  | 2 |  |  | 21.08 | 7.52   | NO  |  |
| Room 233  | classroom | 715 | 28.6  | 2 |  |  | 21.08 | 7.52   | NO  |  |
| Room 234  | classroom | 714 | 28.56 | 2 |  |  | 21.08 | 7.48   | NO  |  |
| Room 235  | classroom | 708 | 28.32 | 2 |  |  | 21.08 | 7.24   | NO  |  |
| Room 236  | classroom | 706 | 28.24 | 2 |  |  | 21.08 | 7.16   | NO  |  |
| Room 237  | classroom | 712 | 28.48 | 1 |  |  | 10.54 | 17.94  | NO  |  |
| Room 238  | classroom | 713 | 28.52 | 2 |  |  | 21.08 | 7.44   | NO  |  |

Part D

|                                    |           |      |        |   |  |  |       |       |    |                  |
|------------------------------------|-----------|------|--------|---|--|--|-------|-------|----|------------------|
| Room 209 - Spec Edu                | classroom | 204  | 8.16   |   |  |  | 0.00  | 8.16  | NO |                  |
| Room 209S                          | storage   | 505  | 20.2   |   |  |  | 0.00  | 20.20 | NO |                  |
| Room 211 - Small Group Class       | classroom | 295  | 11.8   |   |  |  | 0.00  | 11.80 | NO |                  |
| Room 212                           | classroom | 713  | 28.52  | 2 |  |  | 21.08 | 7.44  | NO |                  |
| Room 214 - Science                 | classroom | 852  | 34.08  | 2 |  |  | 21.08 | 13.00 | NO |                  |
| Room 216 - Library                 | media     | 3288 | 131.52 | 8 |  |  | 84.33 | 47.19 | NO |                  |
| Room 216P - Workroom               | office    | 237  | 9.48   |   |  |  | 0.00  | 9.48  | NO |                  |
| Room 216AV - AV Storage            | storage   | 264  | 10.56  |   |  |  | 0.00  | 10.56 | NO |                  |
| Room 217 - Large Group Instruction | classroom | 1208 | 48.32  | 2 |  |  | 21.08 | 27.24 | NO | Part of "Part A" |
| Room 218                           | office    | 131  | 5.24   |   |  |  | 0.00  | 5.24  | NO |                  |
| Room 219                           | classroom | 705  | 28.2   | 2 |  |  | 21.08 | 7.12  | NO |                  |
| Room 220                           | storage   | 147  | 5.88   |   |  |  | 0.00  | 5.88  | NO |                  |
| Room 221                           | classroom | 712  | 28.48  | 2 |  |  | 21.08 | 7.40  | NO |                  |
| Room 223                           | classroom | 719  | 28.76  | 2 |  |  | 21.08 | 7.68  | NO |                  |
| Room 224 - Science                 | classroom | 854  | 34.16  | 2 |  |  | 21.08 | 13.08 | NO |                  |
| Room 225                           | classroom | 716  | 28.64  | 2 |  |  | 21.08 | 7.56  | NO |                  |
| Room 226                           | classroom | 711  | 28.44  | 2 |  |  | 21.08 | 7.36  | NO |                  |

Part E

|                       |           |     |       |   |  |  |       |      |    |  |
|-----------------------|-----------|-----|-------|---|--|--|-------|------|----|--|
| Room 201              | classroom | 715 | 28.6  | 2 |  |  | 21.08 | 7.52 | NO |  |
| Room 202              | classroom | 710 | 28.4  | 2 |  |  | 21.08 | 7.32 | NO |  |
| Room 203              | classroom | 716 | 28.64 | 2 |  |  | 21.08 | 7.56 | NO |  |
| Room 204              | classroom | 716 | 28.64 | 2 |  |  | 21.08 | 7.56 | NO |  |
| Room 205              | classroom | 708 | 28.32 | 2 |  |  | 21.08 | 7.24 | NO |  |
| Room 206              | classroom | 708 | 28.32 | 2 |  |  | 21.08 | 7.24 | NO |  |
| Room 207              | classroom | 704 | 28.16 | 2 |  |  | 21.08 | 7.08 | NO |  |
| Room 208              | classroom | 709 | 28.36 | 2 |  |  | 21.08 | 7.28 | NO |  |
| Room 210B - Boys Room | toilet    | 236 | 9.44  |   |  |  | 0.00  | 9.44 | NO |  |
| Room 210C - Cust      | support   | 67  | 2.68  |   |  |  | 0.00  | 2.68 | NO |  |
| Room 210G - Girls     | toilet    | 233 | 9.32  |   |  |  | 0.00  | 9.32 | NO |  |

Level Three

Part A

|                                  |           |     |       |  |  |  |      |       |    |  |
|----------------------------------|-----------|-----|-------|--|--|--|------|-------|----|--|
| Room 313 - Guidance              | office    | 172 | 6.88  |  |  |  | 0.00 | 6.88  | NO |  |
| Room 315 - Assistant Principal   | office    | 173 | 6.92  |  |  |  | 0.00 | 6.92  | NO |  |
| Room 317 - Waiting Room          | office    | 225 | 9     |  |  |  | 0.00 | 9.00  | NO |  |
| Room 339 - Teacher's Lounge      | support   | 525 | 21    |  |  |  | 0.00 | 21.00 | NO |  |
| Room 340 - Hall / Waiting        | common    | 428 | 17.12 |  |  |  | 0.00 | 17.12 | NO |  |
| Room 341 - Office                | office    | 80  | 3.2   |  |  |  | 0.00 | 3.20  | NO |  |
| Room 342 - Office                | office    | 92  | 3.68  |  |  |  | 0.00 | 3.68  | NO |  |
| Room 343 - Office                | office    | 76  | 3.04  |  |  |  | 0.00 | 3.04  | NO |  |
| Room 344 - Small Group Classroom | classroom | 306 | 12.24 |  |  |  | 0.00 | 12.24 | NO |  |
| Room 345 - Office                | office    | 108 | 4.32  |  |  |  | 0.00 | 4.32  | NO |  |
| Room 346 - Office                | office    | 106 | 4.24  |  |  |  | 0.00 | 4.24  | NO |  |
| Room 347 - Office                | office    | 106 | 4.24  |  |  |  | 0.00 | 4.24  | NO |  |
| Room 348 - Office                | office    | 108 | 4.32  |  |  |  | 0.00 | 4.32  | NO |  |
| Room 349 - Small Group Classroom | classroom | 347 | 13.88 |  |  |  | 0.00 | 13.88 | NO |  |
| Room 350 - Office                | office    | 117 | 4.68  |  |  |  | 0.00 | 4.68  | NO |  |
| Room 351 - Office                | office    | 90  | 3.6   |  |  |  | 0.00 | 3.60  | NO |  |
| Room 352 - Office                | office    | 90  | 3.6   |  |  |  | 0.00 | 3.60  | NO |  |
| Room 353 - Office                | office    | 87  | 3.48  |  |  |  | 0.00 | 3.48  | NO |  |
| Room 354 - Waiting               | common    | 331 | 13.24 |  |  |  | 0.00 | 13.24 | NO |  |
| Room 355 - Counseling            | office    | 102 | 4.08  |  |  |  | 0.00 | 4.08  | NO |  |
| Room 356 - Office                | office    | 67  | 2.68  |  |  |  | 0.00 | 2.68  | NO |  |
| Room 357 - Counseling            | office    | 107 | 4.28  |  |  |  | 0.00 | 4.28  | NO |  |
| Room 358 - Nurse                 | office    | 196 | 7.84  |  |  |  | 0.00 | 7.84  | NO |  |
| Room 359 - Rest                  | support   | 91  | 3.64  |  |  |  | 0.00 | 3.64  | NO |  |
| Room 359L - Lav                  | toilet    | 44  | 1.76  |  |  |  | 0.00 | 1.76  | NO |  |
| Room 360 - Treatment             | support   | 194 | 7.76  |  |  |  | 0.00 | 7.76  | NO |  |
| Room 361 - Rest                  | support   | 137 | 5.48  |  |  |  | 0.00 | 5.48  | NO |  |
| Room 362 - Rest                  | support   | 78  | 3.12  |  |  |  | 0.00 | 3.12  | NO |  |
| Room 363 - Large Group Classroom | classroom | 435 | 17.4  |  |  |  | 0.00 | 17.40 | NO |  |
| Room 364 - Large Group Classroom | classroom | 445 | 17.8  |  |  |  | 0.00 | 17.80 | NO |  |
| Room 365                         | classroom | 706 | 28.24 |  |  |  | 0.00 | 28.24 | NO |  |
| Room 365S - Storage              | storage   | 122 | 4.88  |  |  |  | 0.00 | 4.88  | NO |  |
| Room 367L - Lav                  | toilet    | 49  | 1.96  |  |  |  | 0.00 | 1.96  | NO |  |
| Room 368L - Lav                  | toilet    | 47  | 1.88  |  |  |  | 0.00 | 1.88  | NO |  |

Part B

No occupied spaces at this level.

Part C

|                       |           |     |       |   |  |  |       |        |     |  |
|-----------------------|-----------|-----|-------|---|--|--|-------|--------|-----|--|
| Room 325              | classroom | 715 | 28.6  | 2 |  |  | 21.08 | 7.52   | NO  |  |
| Room 326              | classroom | 722 | 28.88 | 2 |  |  | 21.08 | 7.80   | NO  |  |
| Room 327              | classroom | 258 | 10.32 | 1 |  |  | 10.54 | -0.22  | YES |  |
| Room 329              | classroom | 257 | 10.28 | 2 |  |  | 21.08 | -10.80 | YES |  |
| Room 330B - Boy's     | toilet    | 242 | 9.68  |   |  |  | 0.00  | 9.68   | NO  |  |
| Room 330C - Custodian | support   | 67  | 2.68  |   |  |  | 0.00  | 2.68   | NO  |  |
| Room 336 - Girl's     | toilet    | 231 | 9.24  |   |  |  | 0.00  | 9.24   | NO  |  |
| Room 331              | classroom | 717 | 28.68 | 2 |  |  | 21.08 | 7.60   | NO  |  |
| Room 332              | classroom | 717 | 28.68 | 2 |  |  | 21.08 | 7.60   | NO  |  |
| Room 333              | classroom | 719 | 28.76 | 2 |  |  | 21.08 | 7.68   | NO  |  |
| Room 334              | classroom | 717 | 28.68 | 2 |  |  | 21.08 | 7.60   | NO  |  |
| Room 335              | classroom | 708 | 28.32 | 2 |  |  | 21.08 | 7.24   | NO  |  |
| Room 336              | classroom | 710 | 28.4  | 2 |  |  | 21.08 | 7.32   | NO  |  |
| Room 337              | classroom | 712 | 28.48 | 2 |  |  | 21.08 | 7.40   | NO  |  |
| Room 338              | classroom | 713 | 28.52 | 2 |  |  | 21.08 | 7.44   | NO  |  |

Part D

|                                     |           |     |       |   |  |   |       |       |    |  |
|-------------------------------------|-----------|-----|-------|---|--|---|-------|-------|----|--|
| Room 309                            | classroom | 204 | 8.16  |   |  |   | 0.00  | 8.16  | NO |  |
| Room 309S                           | storage   | 499 | 19.96 |   |  |   | 0.00  | 19.96 | NO |  |
| Room 311 - Small Business Classroom | classroom | 295 | 11.8  |   |  |   | 0.00  | 11.80 | NO |  |
| Room 312                            | classroom | 714 | 28.56 | 2 |  |   | 21.08 | 7.48  | NO |  |
| Room 314                            | classroom | 889 | 35.56 |   |  | 2 | 14.88 | 20.69 | NO |  |
| Room 316                            | classroom | 882 | 35.28 |   |  | 2 | 14.88 | 20.41 | NO |  |
| Room 318 - Art Room                 | classroom | 873 | 34.92 | 2 |  |   | 21.08 | 13.84 | NO |  |
| Room 318S - Storage                 | storage   | 245 | 9.8   |   |  |   | 0.00  | 9.80  | NO |  |
| Room 318K - Kiln                    | support   | 141 | 5.64  |   |  |   | 0.00  | 5.64  | NO |  |
| Room 319                            | classroom | 722 | 28.88 | 2 |  |   | 21.08 | 7.80  | NO |  |
| Room 320 - Art                      | classroom | 872 | 34.88 | 2 |  |   | 21.08 | 13.80 | NO |  |
| Room 320S - Storage                 | storage   | 187 | 7.48  |   |  |   | 0.00  | 7.48  | NO |  |
| Room 321                            | classroom | 714 | 28.56 | 2 |  |   | 21.08 | 7.48  | NO |  |
| Room 322 - Art                      | classroom | 874 | 34.96 |   |  | 2 | 14.88 | 20.09 | NO |  |
| Room 323                            | classroom | 734 | 29.36 | 2 |  |   | 21.08 | 8.28  | NO |  |
| Room 324 - Science                  | classroom | 888 | 35.52 |   |  | 2 | 14.88 | 20.65 | NO |  |

Part E

|                       |           |     |       |   |  |  |       |      |    |  |
|-----------------------|-----------|-----|-------|---|--|--|-------|------|----|--|
| Room 301              | classroom | 715 | 28.6  | 2 |  |  | 21.08 | 7.52 | NO |  |
| Room 302              | classroom | 710 | 28.4  | 2 |  |  | 21.08 | 7.32 | NO |  |
| Room 303              | classroom | 716 | 28.64 | 2 |  |  | 21.08 | 7.56 | NO |  |
| Room 304              | classroom | 716 | 28.64 | 2 |  |  | 21.08 | 7.56 | NO |  |
| Room 305              | classroom | 708 | 28.32 | 2 |  |  | 21.08 | 7.24 | NO |  |
| Room 306              | classroom | 708 | 28.32 | 2 |  |  | 21.08 | 7.24 | NO |  |
| Room 307              | classroom | 703 | 28.12 | 2 |  |  | 21.08 | 7.04 | NO |  |
| Room 308              | classroom | 709 | 28.36 | 2 |  |  | 21.08 | 7.28 | NO |  |
| Room 310B - Boys Room | toilet    | 237 | 9.48  |   |  |  | 0.00  | 9.48 | NO |  |
| Room 310C - Cust      | support   | 67  | 2.68  |   |  |  | 0.00  | 2.68 | NO |  |
| Room 310G - Girls     | toilet    | 230 | 9.2   |   |  |  | 0.00  | 9.20 | NO |  |

| Window Type | Width | Hieght | Projection | Venting |
|-------------|-------|--------|------------|---------|
| A - Awning  | 40    | 29     | 22         | 10.54   |
| B - Awning  | 41    | 22     | 17         | 7.44    |

| 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)           |