



# Airflow Testing Report

Prepared for

Portland Public Schools

August 2021





9700 SW Capitol Hwy, Suite 110  
Portland, OR 97219  
ameresco.com

## PROJECT OVERVIEW

As part of the continuing process to ensure a safe return to in-person learning, Portland Public Schools has contracted with Ameresco to test the airflow and ventilation of all educational and office spaces in each school. The data is reviewed by both Ameresco and PPS personnel to identify any potential shortcomings in the airflow from the HVAC systems. To accomplish this task, Ameresco has partnered with a local NEBB certified Test-Adjust-Balance (TAB) firm, Neudorfer Engineers, who will measure the airflow to each zone with calibrated measurement equipment in accordance with current testing standards and procedures. As part of this effort, HVAC professionals will review the operation of the HVAC equipment serving every educational and office space in each school.

Ameresco is pleased to have partnered with PPS over the last decade as the district's Energy Services Company (ESCO) on six energy efficiency construction projects, four service projects, and numerous energy audits. Our partnership has resulted in reducing over 3,000 tons of CO<sub>2</sub> and other GHG emissions and over \$1,000,000 in utility cost savings per year. Ameresco appreciates this opportunity to play a small role in the safe reopening of schools.

### About Ameresco, Inc.

Founded in 2000, Ameresco, Inc. (NYSE:AMRC) is a leading cleantech integrator and renewable energy asset developer, owner and operator. Our comprehensive portfolio includes energy efficiency, infrastructure upgrades, asset sustainability and renewable energy solutions delivered to clients throughout North America and the United Kingdom. Ameresco's sustainability services in support of clients' pursuit of Net Zero include upgrades to a facility's energy infrastructure and the development, construction, and operation of distributed energy resources. Ameresco has successfully completed energy saving, environmentally responsible projects with Federal, state and local governments, healthcare and educational institutions, housing authorities, and commercial and industrial customers. With its corporate headquarters in Framingham, MA, Ameresco has more than 1,000 employees providing local expertise in the United States, Canada, and the United Kingdom. For more information, visit [www.ameresco.com](http://www.ameresco.com).

## Explanation of ASHRAE Total Effective Air Changes per Hour (ACH<sub>e</sub>) Calculation

ASHRAE has been updating their Building Readiness document to reflect the most current understanding in the engineering community for how to operate and maintain buildings during the pandemic. Their update on 4/27/2021 provided an explanation of the impact air filters and air cleaning devices have on the air in buildings. They provided the methodology, formulas, and an Excel-based tool for determining the equivalent outside air a space is receiving by having a mix of outside air, filtered recirculated air, and additional air filtration or cleaning devices in the room. Here is the explanation from ASHRAE:

### Epidemic Conditions in Place



#### Equivalent Outdoor Air:

The equivalent outdoor air calculation indicates that the outdoor air can be calculated by using the combination of the actual outdoor air, impact of filtration or air cleaning technologies on recirculated air, and the impact of air cleaning technologies in the space.

This is using the principal of filters in series and the effectiveness at reducing particles. For items in series, the initial item would see the recirculated airflow to clean. The second item in the series would see the “cleaned” air from Item 1 and so the impact of Item 1 must be accounted for in Item 2.

As part of the airflow testing project that Portland Public Schools has partnered with Ameresco to complete, we are including the calculation of the Total Effective Air Changes per Hour (ACH<sub>e</sub>) to show the impact of the air filtration that is active in nearly all spaces in the PPS schools. The formula for doing so is:

$$ACH_e = (ACH_{oa} + ACH_f) * E_z + ACH_{ir}$$

where:

- $ACH_{oa}$  = air changes per hour of outside air = outside airflow in cubic feet per minute \* 60 minutes per hour / room volume in cubic feet
- $ACH_f$  = air changes per hour of clean air from filtered recirculated air with filters of the specified MERV rating as determined by ASHRAE
- $E_z$  = Zone Air Distribution Effectiveness = how effective the HVAC system is at circulating and mixing the air to distribute the clean air throughout the room
- $ACH_{ir}$  = the air changes per hour of clean air from portable air filters in the room = number of filters \* CADR \* 60 minutes per hour / room volume in cubic feet
  - CADR = Clear Air Delivery Rate = the CFM of clean air as specified by the manufacturer of the air filter

In order to include these calculations in the airflow testing reports, Ameresco and PPS have made the following assumptions as not all the variables are known:

1. PPS is in process of upgrading the air filters in their HVAC systems to MERV 13 and plans to be complete with that project for the start of the '21-'22 school year. In this report and for the sake of the ACH<sub>e</sub> calculation, we are using the filters that are in place at the time of the measurements, so some of them are still MERV 8.
2. ASHRAE has guidelines for what should be used for the Zone Air Distribution Effectiveness ( $E_z$ ) based on the HVAC system configuration, but they do not provide a value for every HVAC system and room configuration. For the majority of PPS rooms, an  $E_z$  of 0.8 – 1.0 would be most appropriate, so we have made the conservative assumption of using 0.8 for every space as that yields the lower ACH<sub>e</sub>.
3. The CADR for a given air filter is from manufacturer ratings and is based on certain conditions (fan speed, particulate size, filter cleanliness, etc.) that change with operating conditions.



# ***NEUDORFER ENGINEERS INC.***

**TEST REPORT TYPE:  
SURVEY REPORT**

**Portland Public Schools Airflow Testing  
Woodmere ES  
7900 Duke St, Portland, OR 97206**

Job Number: 2021-0297

**Project Completion Date: September 2021**

**Revision Date:**

-

**Revision Number:**

-



## ***SEATTLE***

5516 1<sup>st</sup> Avenue South  
Seattle, Washington 98108  
Phone (206) 621-1810  
Fax (206) 343-9820

## ***PORTLAND***

2501 SE Columbia Way, Suite 230  
Vancouver, Washington 98661  
Phone (503) 235-8924  
Fax (503) 235-8925



**Neudorfer Engineers, Inc.**

Consulting Engineers Seattle, Washington - Portland, Oregon



[www.NeudorferEngineers.com](http://www.NeudorferEngineers.com)

**Portland Public Schools Airflow Testing  
Woodmere ES**

**TABLE OF CONTENTS**

|                        |    |
|------------------------|----|
| Title Sheet            | 3  |
| Report Certification   | 4  |
| Terms                  | 5  |
| Instrument Calibration | 6  |
| Report Summary         | 7  |
| Airflow Survey Report  | 8  |
| TAB Notes              | 10 |
| Floor Layout           | 11 |



**Neudorfer Engineers, Inc.**

Consulting Engineers Seattle, Washington - Portland, Oregon



[www.NeudorferEngineers.com](http://www.NeudorferEngineers.com)

## REPORT TITLE

### CERTIFIED TEST: SURVEY REPORT

---

**Project:** Portland Public Schools Airflow Testing  
Woodmere ES

**NEI Job#:** 2021-0297

**Mechanical Engineer:** NA

**Architect:** NA

**HVAC Contractor:** NA

**TAB Firm:** Neudorfer Engineers Inc  
**Test Engineer:** Zach Mayer



5516 1<sup>st</sup> Ave South  
Seattle, Washington 98108  
Phone (206) 621-1810  
Fax (206) 343-9820



2501 SE Columbia Way, Suite 230  
Vancouver, Washington 98661  
Phone (503) 235-8924  
Fax (503) 235-8925

## CERTIFICATION

### Portland Public Schools Airflow Testing

The data presented in this report is a record of system measurements and final adjustments that have been obtained in accordance with the current edition of the NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems. Any variances from design quantities, which exceed NEBB tolerances, are noted in the Test-Adjust-Balance Report Project Summary.

Significant / Noteworthy Remarks are noted on the General Remarks and General Field Notes pages. Other remarks are noted on individual test sheets.

Noted deficiencies are not the TAB firms responsibility to repair. Prior to issuance of this report, Deficiency Reports are forwarded to our contracted agent.

Warranty is limited to one year from date of this report. Within that time, any discrepancies, ambiguities, or omissions found in this report will be retested, adjusted, or balanced as needed. A written notification will be required.

#### Submitted and Certified by:

NEBB TAB Firm: **Neudorfer Engineers Inc**

Certification No: **3414**

Expiration Date: **March 31, 2023**

Certification Date: **March 31, 2021**

*(Date completed)* *Signed and Sealed by:*

NEBB Supervisor: **Mike Vawter P.E.**

NEBB Supervisor: **Eric Stotts**





# Neudorfer Engineers, Inc.

Consulting Engineers Seattle, Washington - Portland, Oregon



www.NeudorferEngineers.com

## TERMS AND ABBREVIATIONS

**Project:** **Portland Public Schools Airflow Testing**

|                                                                                                                                                                        |                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| <b>AC or ACU</b> Air Conditioner or Air Conditioning Unit                                                                                                              | <b>HEPA</b> High Efficiency Particulate Arrestance                                                            |
| <b>AH or AHU</b> Air Handler or Air Handling Unit                                                                                                                      | <b>HP</b> Horsepower                                                                                          |
| <b>AVG</b> Average                                                                                                                                                     | <b>HVAC</b> Heating Ventilation and Air Conditioning                                                          |
| <b>BHP</b> Brake Horsepower                                                                                                                                            | <b>HWS</b> Heating Water Supply                                                                               |
| <b>CAV</b> Constant Air Volume                                                                                                                                         | <b>HWR</b> Heating Water Return                                                                               |
| <b>CBV</b> Calibrated Balancing Valve<br>(Circuit Setter)                                                                                                              | <b>HX</b> Heat Exchanger                                                                                      |
| <b>CC</b> Cooling Coil                                                                                                                                                 | <b>HZ</b> Hertz, cycle per second                                                                             |
| <b>CD</b> Ceiling Diffuser                                                                                                                                             | <b>in.</b> inches                                                                                             |
| <b>CFM</b> Cubic Feet per Minute                                                                                                                                       | <b>in.w.g.</b> inches of water gauge                                                                          |
| <b>CH</b> Chiller                                                                                                                                                      | <b>Kfactor</b> Correction factor to the free area need to<br>calculate CFM.                                   |
| <b>CHWS</b> Chilled Water Supply                                                                                                                                       | <b>KW</b> Kilowatts                                                                                           |
| <b>CHWR</b> Chilled Water Return                                                                                                                                       | <b>LAT</b> Leaving Air Temperature                                                                            |
| <b>CP</b> Circulating Pump                                                                                                                                             | <b>LWG</b> Low Wall Grille                                                                                    |
| <b>CR</b> Ceiling Register                                                                                                                                             | <b>LWR</b> Low Wall Register                                                                                  |
| <b>CRAC</b> Computer Room Air Conditioner                                                                                                                              | <b>LWT</b> Leaving Water Temperature                                                                          |
| <b>CRU</b> Computer Room Unit                                                                                                                                          | <b>MAU</b> Make-up Air Hanging Unit                                                                           |
| <b>CT</b> Cooling Tower                                                                                                                                                | <b>MBH</b> 1,000 BTUH                                                                                         |
| <b>CU</b> Condenser Unit                                                                                                                                               | <b>N/A</b> Not Applicable                                                                                     |
| <b>CUH</b> Cabinet Unit Heater                                                                                                                                         | <b>OSA</b> Outside Air                                                                                        |
| <b>CWS</b> Condenser Water Supply                                                                                                                                      | <b>OBD</b> Opposed Blade Damper                                                                               |
| <b>CWR</b> Condenser Water Return                                                                                                                                      | <b>ΔP</b> Pressure Drop.                                                                                      |
| <b>DAT</b> Discharge Air Temperature                                                                                                                                   | <b>PH</b> Phase                                                                                               |
| <b>DB</b> Dyr Bulb                                                                                                                                                     | <b>PSI</b> Pounds per Square Inch                                                                             |
| <b>DD</b> Direct Drive                                                                                                                                                 | <b>RA</b> Return Air                                                                                          |
| <b>DDC</b> Direct Digital Controls: EMS Control<br>System for the HVAC                                                                                                 | <b>RAD</b> Radiator                                                                                           |
| <b>Des.</b> Design                                                                                                                                                     | <b>RAT</b> Return Air Temperature                                                                             |
| <b>Dia.</b> Diameter                                                                                                                                                   | <b>RF</b> Return Fan                                                                                          |
| <b>Disch.</b> Discharge                                                                                                                                                | <b>RH</b> Relative Humidity                                                                                   |
| <b>EA</b> Exhaust Air                                                                                                                                                  | <b>RHC</b> Reheat Coil                                                                                        |
| <b>EAT</b> Entering Air Temperature                                                                                                                                    | <b>RPM</b> Revolutions per Minute                                                                             |
| <b>Economizer</b> Controls and components that allow an<br>air handler to logically utilize outdoor air<br>for cooling as opposed to the use of<br>mechanical cooling. | <b>RTU</b> Roof Top Unit                                                                                      |
| <b>EF</b> Exhaust Fan                                                                                                                                                  | <b>SA</b> Supply Air                                                                                          |
| <b>EG</b> Exhaust Grille                                                                                                                                               | <b>SAT</b> Supply Air Temperature                                                                             |
| <b>EMCS</b> Energy Management Control System                                                                                                                           | <b>S.F.</b> Service Factor                                                                                    |
| <b>ERU</b> Energy Recovery Unit                                                                                                                                        | <b>SF</b> Supply Fan                                                                                          |
| <b>E.S.P.</b> External Static Pressure                                                                                                                                 | <b>SFD</b> Smoke/Fire Damper                                                                                  |
| <b>HRC</b> Heat Recovery Coil                                                                                                                                          | <b>SP</b> Static Pressure                                                                                     |
| <b>EWT</b> Entering Water Temperature                                                                                                                                  | <b>sq.ft.</b> square feet                                                                                     |
| <b>FCU</b> Fan Coil Unit                                                                                                                                               | <b>Suct.</b> Suction                                                                                          |
| <b>FD</b> Fire Damper                                                                                                                                                  | <b>SWG</b> Sidewall Grille                                                                                    |
| <b>FLA</b> Full Load Amperage: Maximum<br>amperage a motor can draw.                                                                                                   | <b>SWR</b> Sidewall Register                                                                                  |
| <b>Flow Hood</b> Instrument that captures air and<br>converts the reading to CFM.                                                                                      | <b>TAB</b> Test; Adjust; and Balance                                                                          |
| <b>FHT</b> Fume Hood Test                                                                                                                                              | <b>TSP</b> Total Static Pressure: Difference<br>between the entering and leaving<br>static pressure of a fan. |
| <b>FPB</b> Fan Powered Box                                                                                                                                             | <b>UH</b> Unit Heater                                                                                         |
| <b>FPM</b> Feet per Minute                                                                                                                                             | <b>VAV</b> Variable Air Volume; box that<br>contains a motorized damper that<br>modulates airflow.            |
| <b>FR</b> Field Report                                                                                                                                                 | <b>VD</b> Volume Damper                                                                                       |
| <b>FT</b> Foot, Feet                                                                                                                                                   | <b>VFD</b> Variable Frequency Drive                                                                           |
| <b>FTU</b> Fan Terminal Unit                                                                                                                                           | <b>Velgrid</b> Instrument that reads used to read<br>velocity in feet per minute.                             |
| <b>GPM</b> Gallons per Minute                                                                                                                                          | <b>VVT</b> Variable Volume Terminal                                                                           |
| <b>HC</b> Heating Coil                                                                                                                                                 | <b>WC</b> Water Column                                                                                        |
| <b>TDH</b> Pressure Difference across the entering<br>and leaving side of a pump.                                                                                      | <b>W.G.</b> Water Gauge                                                                                       |
|                                                                                                                                                                        | <b>WB</b> Wet Bulb                                                                                            |

## INSTRUMENT CALIBRATIONS

### Portland Public Schools Airflow Testing

|                                |                                   |                            |                     |
|--------------------------------|-----------------------------------|----------------------------|---------------------|
| <b>Instrument Type</b>         | Air Data Meter with Flowhood      | <b>Instrument Serial #</b> | <b>M00475</b>       |
| <b>Instrument Manufacturer</b> | <b>Shortridge</b>                 | <b>Calibration Date</b>    | <b>11/4/2020</b>    |
| <b>Instrument Model Number</b> | <b>ADM 870</b>                    | <b>Calibration Due</b>     | <b>11/4/2021</b>    |
| <b>Instrument Type</b>         | Differential Pressure Water Meter | <b>Instrument Serial #</b> | <b>W14090</b>       |
| <b>Instrument Manufacturer</b> | <b>Shortridge</b>                 | <b>Calibration Date</b>    | <b>10/16/2020</b>   |
| <b>Instrument Model Number</b> | <b>HDM-250</b>                    | <b>Calibration Due</b>     | <b>10/16/2021</b>   |
| <b>Instrument Type</b>         | Psychrometer                      | <b>Instrument Serial #</b> | <b>8084305</b>      |
| <b>Instrument Manufacturer</b> | <b>Extech</b>                     | <b>Calibration Date</b>    | <b>10/13/2020</b>   |
| <b>Instrument Model Number</b> | <b>RH390</b>                      | <b>Calibration Due</b>     | <b>10/13/2021</b>   |
| <b>Instrument Type</b>         | Tachometer                        | <b>Instrument Serial #</b> | <b>B185B5022P</b>   |
| <b>Instrument Manufacturer</b> | <b>Nidec</b>                      | <b>Calibration Date</b>    | <b>10/11/2020</b>   |
| <b>Instrument Model Number</b> | <b>MT-200</b>                     | <b>Calibration Due</b>     | <b>10/11/2021</b>   |
| <b>Instrument Type</b>         | Amp Probe                         | <b>Instrument Serial #</b> | <b>33380179WS</b>   |
| <b>Instrument Manufacturer</b> | <b>Fluke</b>                      | <b>Calibration Date</b>    | <b>10/9/2020</b>    |
| <b>Instrument Model Number</b> | <b>323 Clamp Meter</b>            | <b>Calibration Due</b>     | <b>10/9/2021</b>    |
| <b>Instrument Type</b>         | Digital Thermometer               | <b>Instrument Serial #</b> | <b>45400509WS</b>   |
| <b>Instrument Manufacturer</b> | <b>Fluke</b>                      | <b>Calibration Date</b>    | <b>10/9/2020</b>    |
| <b>Instrument Model Number</b> | <b>52 II</b>                      | <b>Calibration Due</b>     | <b>10/9/2021</b>    |
| <b>Instrument Type</b>         | Manometer                         | <b>Instrument Serial #</b> | <b>M00475</b>       |
| <b>Instrument Manufacturer</b> | <b>Shortridge</b>                 | <b>Calibration Date</b>    | <b>11/4/2020</b>    |
| <b>Instrument Model Number</b> | <b>ADM 870</b>                    | <b>Calibration Due</b>     | <b>11/4/2021</b>    |
| <b>Instrument Type</b>         | Thermal Anemometer                | <b>Instrument Serial #</b> | <b>AVM440742003</b> |
| <b>Instrument Manufacturer</b> | <b>Alnor Instruments</b>          | <b>Calibration Date</b>    | <b>11/9/2020</b>    |
| <b>Instrument Model Number</b> | <b>AVM 440</b>                    | <b>Calibration Due</b>     | <b>11/9/2021</b>    |
| <b>Instrument Type</b>         | Ultrasonic Flow Meter             | <b>Instrument Serial #</b> | <b>N5K1435T</b>     |
| <b>Instrument Manufacturer</b> | <b>Fuji</b>                       | <b>Calibration Date</b>    | <b>10/14/2020</b>   |
| <b>Instrument Model Number</b> | <b>Portaflow-C</b>                | <b>Calibration Due</b>     | <b>10/14/2021</b>   |



|          |                                               |
|----------|-----------------------------------------------|
| PROJECT  | Portland Public Schools Airflow Testing       |
| LOCATION | Woodmere ES; 7900 Duke St, Portland, OR 97206 |

## REPORT SUMMARY

This project has been surveyed per plans and specifications using the National Environmental Balancing Bureau (NEBB) standards and procedures.

The scope of work for this project was to assess the current airflows for each classroom, office, and special purpose space. Air changes per hour were calculated along with the % of OSA for the spaces and any deficiencies found for each piece of equipment has been noted in the following report.

All ventilation equipment was commanded to run by the BMS system. Ventilation units were measured with a flowhood on the supply outlets. Outside air was recorded with a flowhood on the OSA louvre where accessible. AK factors were calculated from flowhood readings. The remaining OSA values were recorded with a velgrid. AHU supply air was recorded by a summation of the outlets as recorded by flowhood or velgrid when appropriate. Outside air was recorded with a velgrid or airfoil and calculated by the free area method.

The measured airflows in this report represent the performance of the equipment at the time of measurement, which vary over time based on operating conditions. There are factors outside the control of Neudorfer that impact airflow, and variance in those factors is expected and normal. One significant factor is the MERV rating and condition of the air filters on the equipment. During the summer of 2021, PPS began upgrading the filters on all their fan systems to MERV 13. Those upgraded filters are more effective at capturing particles but also impact the amount of airflow from the equipment. These filter changes were occurring while the airflow measurement project was happening, so some schools had the new filters, and some had the old filters at the time of measurement. On the data page included this report, there is a line stating whether or not the upgraded filters were in place at the time of measurement.

## AIRFLOW SURVEY REPORT

|                |                                               |
|----------------|-----------------------------------------------|
| Project:       | Portland Public Schools Airflow Testing       |
| Location:      | Woodmere ES; 7900 Duke St, Portland, OR 97206 |
| Filter Status: | Upgraded                                      |

| Room           | Equipment Info |                | Room Dimensions |            |           |             |             | Airflow Measurements |               |      | Calculated ACH                |                           |                       |                                                                   |                                                                      | Notes                           |
|----------------|----------------|----------------|-----------------|------------|-----------|-------------|-------------|----------------------|---------------|------|-------------------------------|---------------------------|-----------------------|-------------------------------------------------------------------|----------------------------------------------------------------------|---------------------------------|
|                | Served By      | Equipment Type | Room Length     | Room Width | Room Area | Room Height | Room Volume | Total CFM Supply     | OA CFM Supply | OA % | Air Changes per Hour (supply) | Air Changes per Hour (OA) | # of Portable Filters | Total Effective Air Changes per Hour (ACH_e) with Portable Filter | Total Effective Air Changes per Hour (ACH_e) without Portable Filter |                                 |
| First Floor    |                |                |                 |            |           |             |             |                      |               |      |                               |                           |                       |                                                                   |                                                                      |                                 |
| Rm 46          | SF-1           | AHU            | 29.9            | 32.0       | 957       | 11.5        | 11,003      | 510                  | 510           | 100% | 2.8                           | 2.8                       | 1                     | 3.6                                                               | 2.2                                                                  | Note #1.                        |
| Rm 40          | SF-1           | AHU            | 29.9            | 32.0       | 957       | 11.5        | 11,003      | 335                  | 335           | 100% | 1.8                           | 1.8                       | 1                     | 2.9                                                               | 1.5                                                                  | Note #1.                        |
| Rm 47          | SF-1           | AHU            | 29.9            | 32.0       | 957       | 11.5        | 11,003      | 450                  | 459           | 102% | 2.5                           | 2.5                       | 1                     | 3.4                                                               | 2.0                                                                  | Note #1.                        |
| Rm 39          | SF-1           | AHU            | 29.9            | 32.0       | 957       | 11.5        | 11,003      | 320                  | 320           | 100% | 1.7                           | 1.7                       | 1                     | 2.8                                                               | 1.4                                                                  | Note #1.                        |
| Rm 48          | SF-1           | AHU            | 29.9            | 32.0       | 957       | 11.5        | 11,003      | 400                  | 400           | 100% | 2.2                           | 2.2                       | 1                     | 3.2                                                               | 1.7                                                                  | Note #1.                        |
| Rm 38          | SF-1           | AHU            | 29.9            | 32.0       | 957       | 11.5        | 11,003      | 450                  | 450           | 100% | 2.5                           | 2.5                       | 1                     | 3.4                                                               | 2.0                                                                  | Note #1.                        |
| 37A            | SF-1           | AHU            | 7.5             | 19.9       | 149       | 8.3         | 1,239       | 70                   | 70            | 100% | 3.4                           | 3.4                       | 1                     | 15.3                                                              | 2.7                                                                  |                                 |
| 37B            | SF-1           | AHU            | 7.5             | 9.6        | 72        | 8.3         | 598         | 25                   | 25            | 100% | 2.5                           | 2.5                       | 1                     | 28.1                                                              | 2.0                                                                  |                                 |
| Library 37     | SF-1           | AHU            | 32.6            | 30.3       | 988       | 11.4        | 9,540       | 500                  | 500           | 100% | 3.1                           | 3.1                       | 1                     | 4.2                                                               | 2.5                                                                  |                                 |
| Library 37C    | SF-1           | AHU            | 29.9            | 33.7       | 1,008     | 11.5        | 11,588      | 460                  | 460           | 100% | 2.4                           | 2.4                       | 1                     | 3.3                                                               | 1.9                                                                  |                                 |
| Cafeteria 33   | Café H&V       | AHU            | 60.0            | 58.5       | 3,510     | 17.1        | 60,021      | 4,070                | 4,070         | 100% | 3.4                           | 3.4                       | 1                     | 2.9                                                               | 2.7                                                                  | Note #1.                        |
| 35             | -              | -              | 20.0            | 36.5       | 730       | 14.2        | 11,624      | -                    | -             | -    |                               |                           |                       |                                                                   |                                                                      | Open and shared with Cafeteria. |
| 31             | Dining Rm FCU  | FCU            | 19.3            | 21.0       | 405       | 9.0         | 3,803       | 560                  | 560           | 100% | 8.8                           | 8.8                       | 1                     | 11.2                                                              | 7.1                                                                  |                                 |
| 32             | Kitchen FCU    | FCU            | 27.5            | 26.5       | 856       | 10.9        | 9,330       | 376                  | 233           | 62%  | 2.4                           | 1.5                       | 1                     | 3.5                                                               | 1.9                                                                  | Note #2.                        |
| 32A            | -              | -              | -               | -          | -         | -           | -           | -                    | -             | -    | 0                             | 0                         | 0                     | N/A                                                               | 0.0                                                                  | This is the walk-in cooler.     |
| 32B            | -              | -              | -               | -          | -         | -           | -           | -                    | -             | -    | 0                             | 0                         | 0                     | N/A                                                               | 0.0                                                                  | This is a closet.               |
| Rm 1           | Kitchen FCU    | FCU            | 20.6            | 20.9       | 431       | 8.0         | 3,969       | 51                   | 32            | 62%  | 0.8                           | 0.5                       | 1                     | 4.5                                                               | 0.6                                                                  | Note #2.                        |
| Conf. Room 05A | Kitchen FCU    | FCU            | 10.8            | 6.4        | 69        | 7.9         | 546         | 58                   | 36            | 62%  | 6.4                           | 4.0                       | 1                     | 33.5                                                              | 4.9                                                                  |                                 |
| Gym 7          | Gym AHU        | AHU            | 50.1            | 82.0       | 4,108     | 22.8        | 93,667      | 5,630                | 5,630         | 100% | 3.6                           | 3.6                       | 1                     | 3.1                                                               | 2.9                                                                  |                                 |
| 7A             | Gym Office FCU | FCU            | 22.6            | 15.4       | 348       | 9.8         | 3,411       | 305                  | 305           | 100% | 5.4                           | 5.4                       | 1                     | 8.9                                                               | 4.3                                                                  |                                 |
| 7B             | Gym Office FCU | FCU            | 13.8            | 22.5       | 311       | 9.8         | 3,043       | 270                  | 270           | 100% | 5.3                           | 5.3                       | 1                     | 9.4                                                               | 4.3                                                                  |                                 |
| 7C             | Gym Office FCU | FCU            | 12.4            | 11.7       | 145       | 9.8         | 1,422       | 200                  | 200           | 100% | 8.4                           | 8.4                       | 1                     | 17.7                                                              | 6.8                                                                  |                                 |
| Rm 8           | SF-1           | AHU            | 29.9            | 30.0       | 897       | 11.5        | 10,316      | 185                  | 185           | 100% | 1.1                           | 1.1                       | 1                     | 2.4                                                               | 0.9                                                                  |                                 |
| Rm 9           | SF-1           | AHU            | 29.9            | 30.0       | 897       | 11.5        | 10,316      | 205                  | 205           | 100% | 1.2                           | 1.2                       | 1                     | 2.5                                                               | 1.0                                                                  |                                 |

 Date: 7/15/2021

 Readings By: Mayer

## AIRFLOW SURVEY REPORT

|                |                                               |
|----------------|-----------------------------------------------|
| Project:       | Portland Public Schools Airflow Testing       |
| Location:      | Woodmere ES; 7900 Duke St, Portland, OR 97206 |
| Filter Status: | Upgraded                                      |

| Room           | Equipment Info |                | Room Dimensions |            |           |             |             | Airflow Measurements |               |      | Calculated ACH                |                           |                       |                                                                   |                                                                      | Notes                                    |
|----------------|----------------|----------------|-----------------|------------|-----------|-------------|-------------|----------------------|---------------|------|-------------------------------|---------------------------|-----------------------|-------------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------|
|                | Served By      | Equipment Type | Room Length     | Room Width | Room Area | Room Height | Room Volume | Total CFM Supply     | OA CFM Supply | OA % | Air Changes per Hour (supply) | Air Changes per Hour (OA) | # of Portable Filters | Total Effective Air Changes per Hour (ACH_e) with Portable Filter | Total Effective Air Changes per Hour (ACH_e) without Portable Filter |                                          |
| First Floor    |                |                |                 |            |           |             |             |                      |               |      |                               |                           |                       |                                                                   |                                                                      |                                          |
| 12             | SF-1           | AHU            | 14.9            | 21.2       | 348       | 11.2        | 3,898       | 50                   | 50            | 100% | 0.8                           | 0.8                       | 2                     | 8.6                                                               | 0.6                                                                  | Note #2.                                 |
| Rm 13          | SF-1           | AHU            | 29.9            | 30.0       | 897       | 11.5        | 10,316      | 145                  | 145           | 100% | 0.8                           | 0.8                       | 1                     | 2.2                                                               | 0.7                                                                  |                                          |
| Rm 14          | SF-1           | AHU            | 2.9             | 30.0       | 87        | 11.5        | 1,001       | 95                   | 95            | 100% | 5.7                           | 5.7                       | 1                     | 20.1                                                              | 4.6                                                                  |                                          |
| Rm 15          | SF-1           | AHU            | 30.0            | 30.0       | 900       | 11.5        | 10,350      | 190                  | 190           | 100% | 1.1                           | 1.1                       | 1                     | 2.4                                                               | 0.9                                                                  |                                          |
| Rm 16          | SF-1           | AHU            | 30.0            | 30.0       | 900       | 11.5        | 10,350      | 195                  | 195           | 100% | 1.1                           | 1.1                       | 1                     | 2.4                                                               | 0.9                                                                  |                                          |
| Rm 21          | SF-1           | AHU            | 30.0            | 30.0       | 900       | 11.5        | 10,350      | 190                  | 190           | 100% | 1.1                           | 1.1                       | 1                     | 2.4                                                               | 0.9                                                                  |                                          |
| Rm 22          | SF-1           | AHU            | 29.9            | 30.0       | 897       | 11.5        | 10,316      | 250                  | 250           | 100% | 1.5                           | 1.5                       | 1                     | 2.7                                                               | 1.2                                                                  |                                          |
| Rm 23          | SF-1           | AHU            | 30.0            | 42.7       | 1,281     | 11.6        | 14,860      | 255                  | 255           | 100% | 1.0                           | 1.0                       | 1                     | 1.9                                                               | 0.8                                                                  |                                          |
| Rm 24          | SF-1           | AHU            | 30.0            | 42.6       | 1,278     | 11.6        | 14,825      | 475                  | 475           | 100% | 1.9                           | 1.9                       | 1                     | 2.6                                                               | 1.5                                                                  |                                          |
| Rm 25          | SF-1           | AHU            | 29.9            | 30.0       | 897       | 11.5        | 10,316      | 205                  | 205           | 100% | 1.2                           | 1.2                       | 1                     | 2.5                                                               | 1.0                                                                  | OSA small 590 CFM, OSA big 6,255 CFM     |
| Rm 26          | SF-1           | AHU            | 29.9            | 30.0       | 897       | 11.6        | 10,405      | 95                   | 95            | 100% | 0.5                           | 0.5                       | 1                     | 1.9                                                               | 0.4                                                                  |                                          |
| 27             | SF-1           | AHU            | 24.9            | 17.3       | 522       | 11.4        | 5,951       | 80                   | 80            | 100% | 0.8                           | 0.8                       | 1                     | 3.3                                                               | 0.6                                                                  | Note #2.                                 |
| 28             | -              | -              | 10.8            | 8.0        | 129       | 9.0         | 1,161       | -                    | -             | -    | 0                             | 0                         | 1                     | 13.4                                                              | 0.0                                                                  | Ventilation supplied by adjacent spaces. |
| Main Office 29 | SF-1           | AHU            | 24.8            | 17.8       | 441       | 11.5        | 5,077       | 125                  | 125           | 100% | 1.5                           | 1.5                       | 1                     | 4.3                                                               | 1.2                                                                  | Note #2.                                 |
| 29A            | SF-1           | AHU            | 15.5            | 15.0       | 233       | 11.5        | 2,674       | 50                   | 50            | 100% | 1.1                           | 1.1                       | 1                     | 6.7                                                               | 0.9                                                                  |                                          |
| P1             | Bard HP        | HP             | 27.0            | 31.5       | 851       | 8.0         | 6,804       | 850                  | 105           | 12%  | 7.5                           | 0.9                       | 1                     | 7.8                                                               | 5.5                                                                  |                                          |
| P2             | Bard HP        | HP             | 27.0            | 31.5       | 851       | 7.9         | 6,719       | 681                  | 340           | 50%  | 6.1                           | 3.0                       | 1                     | 6.9                                                               | 4.6                                                                  |                                          |
| P3             | Bard HP        | HP             | 27.1            | 37.4       | 1,014     | 8.0         | 8,108       | 875                  | 225           | 26%  | 6.5                           | 1.7                       | 1                     | 6.7                                                               | 4.8                                                                  |                                          |
| P4             | Bard HP        | HP             | 27.1            | 37.4       | 1,014     | 8.0         | 8,108       | 970                  | 130           | 13%  | 7.2                           | 1.0                       | 1                     | 7.2                                                               | 5.2                                                                  |                                          |
|                |                |                |                 |            |           |             |             |                      |               |      |                               |                           |                       |                                                                   |                                                                      |                                          |
|                |                |                |                 |            |           |             |             |                      |               |      |                               |                           |                       |                                                                   |                                                                      |                                          |
|                |                |                |                 |            |           |             |             |                      |               |      |                               |                           |                       |                                                                   |                                                                      |                                          |
|                |                |                |                 |            |           |             |             |                      |               |      |                               |                           |                       |                                                                   |                                                                      |                                          |
|                |                |                |                 |            |           |             |             |                      |               |      |                               |                           |                       |                                                                   |                                                                      |                                          |

Date: 7/15/2021

Readings By: Mayer

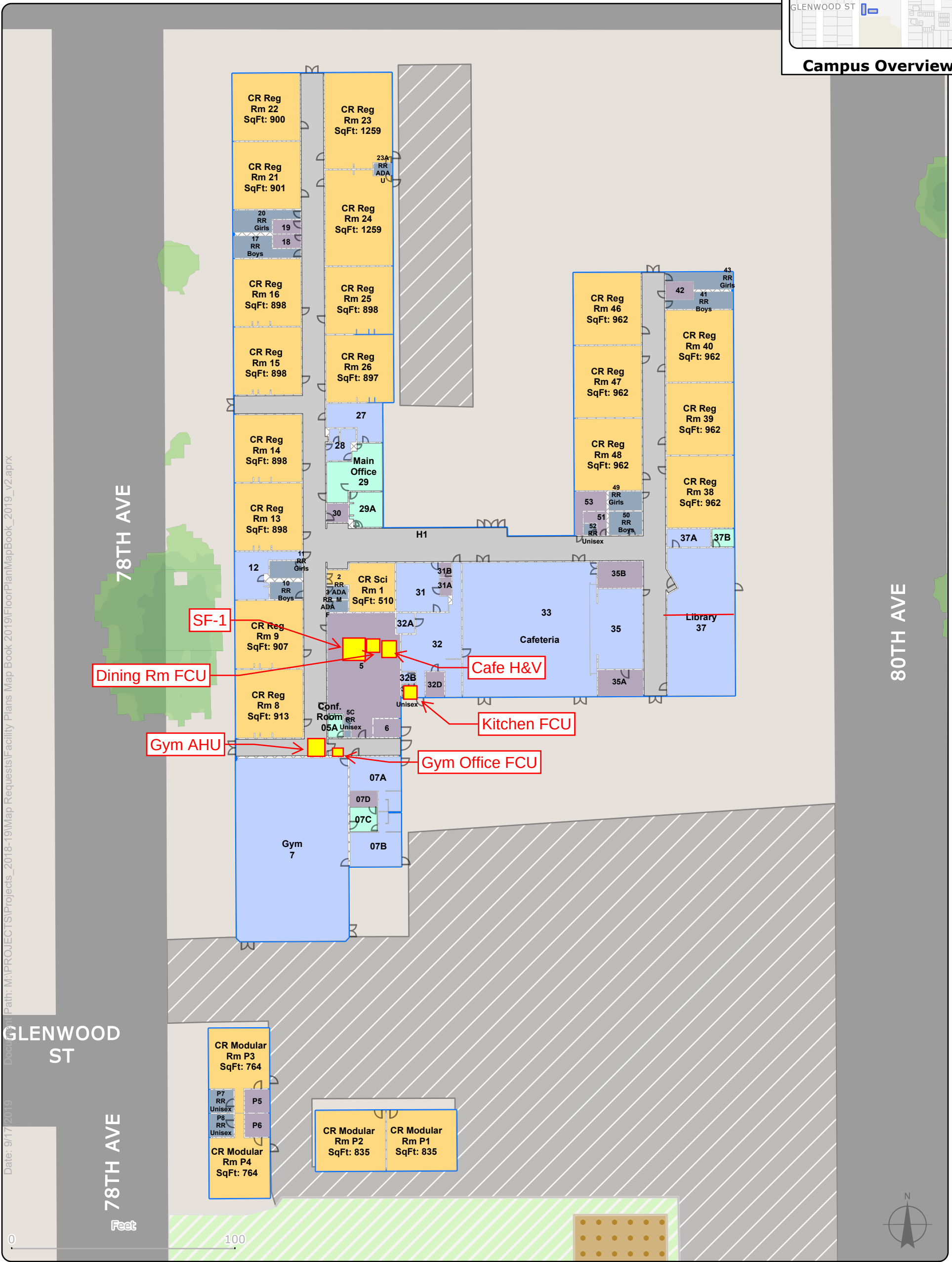
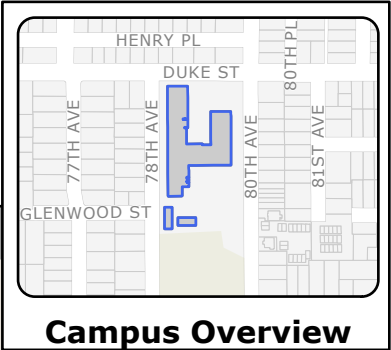


Project: Portland Public Schools Airflow Testing

Location: Woodmere ES; 7900 SE Duke St, Portland, OR 97206

| NOTE # | NOTE DESCRIPTION                                                                          |
|--------|-------------------------------------------------------------------------------------------|
| 1      | Space has sloped ceiling, average ceiling height was used for calculation of room volume. |
| 2      | Non-rectangular room.                                                                     |

WOODMERE: First Floor



| Space Use |                 | School Grounds |                     |
|-----------|-----------------|----------------|---------------------|
|           | Classroom       |                | Campus Footprints   |
|           | Office          |                | Athletic Field      |
|           | Rest Room       |                | Playground: Paved   |
|           | Special Purpose |                | Playground: Unpaved |
|           | Corridor        |                | Streets             |
|           | Other           |                | Doors               |
|           | Stairs/Elevator |                |                     |

Total Number Of Rooms By Classification

|                  |                     |
|------------------|---------------------|
| Classrooms: 23   | Special Purpose: 14 |
| Office Spaces: 5 | Storage: 12         |