



Airflow Testing Report

Prepared for

Portland Public Schools

January 2022





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 CO₂ 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.

Explanation of ASHRAE Total Effective Air Changes per Hour (ACH_e) 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_e) 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_e 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_e.
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 Marshall HS

Job Number: 2021-0297

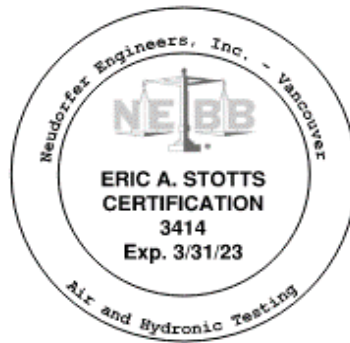
Project Completion Date: January 2022

Revision Date: - Revision Number: -



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Consulting Engineers Seattle, Washington - Portland, Oregon



www.NeudorferEngineers.com

**Portland Public Schools Airflow Testing
Marshall HS**

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Neudorfer Engineers, Inc.

Consulting Engineers Seattle, Washington - Portland, Oregon



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REPORT TITLE

CERTIFIED TEST: SURVEY REPORT

Project: Portland Public Schools Airflow Testing
Marshall HS

NEI Job#: 2021-0297

Mechanical Engineer: NA

Architect: NA

HVAC Contractor: NA

TAB Firm: Neudorfer Engineers Inc
Test Engineer: Justin Davis



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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**

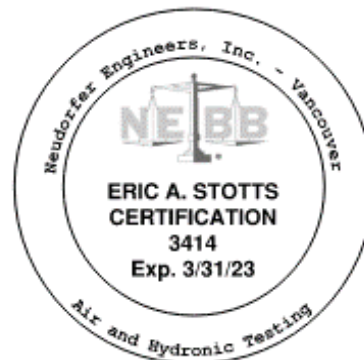
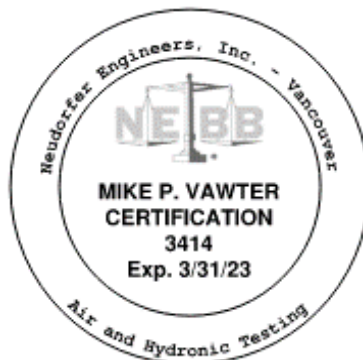
Expiration Date: **March 31, 2023**

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**

AC or ACU Air Conditioner or Air Conditioning Unit

AH or AHU Air Handler or Air Handling Unit

ACH Air Changes per Hour

AVG Average

BHP Brake Horsepower

CAV Constant Air Volume

CBV Calibrated Balancing Valve
(Circuit Setter)

CC Cooling Coil

CD Ceiling Diffuser

CFM Cubic Feet per Minute

CH Chiller

CHWS Chilled Water Supply

CHWR Chilled Water Return

CP Circulating Pump

CR Ceiling Register

CRAC Computer Room Air Conditioner

CRU Computer Room Unit

CT Cooling Tower

CU Condenser Unit

CUH Cabinet Unit Heater

CWS Condenser Water Supply

CWR Condenser Water Return

DAT Discharge Air Temperature

DB Dry Bulb

DD Direct Drive

DDC Direct Digital Controls: EMS Control
System for the HVAC

Des. Design

Dia. Diameter

Disch. Discharge

EA Exhaust Air

EAT Entering Air Temperature

Economizer Controls and components that allow an
air handler to logically utilize outdoor air
for cooling as opposed to the use of
mechanical cooling.

EF Exhaust Fan

EG Exhaust Grille

EMCS Energy Management Control System

ERU Energy Recovery Unit

E.S.P. External Static Pressure

HRC Heat Recovery Coil

EWT Entering Water Temperature

FCU Fan Coil Unit

FD Fire Damper

FSD Fire Smoke Damper

FLA Full Load Amperage: Maximum
amperage a motor can draw.

Flow Hood Instrument that captures air and
converts the reading to CFM.

FHT Fume Hood Test

FPB Fan Powered Box

FPM Feet per Minute

FR Field Report

FT Foot, Feet

FTU Fan Terminal Unit

GPM Gallons per Minute

HC Heating Coil

TDH Pressure Difference across the entering
and leaving side of a pump.

HEPA High Efficiency Particulate Absorbing

HP Horsepower

HVAC Heating Ventilation and Air Conditioning

HWS Heating Water Supply

HWR Heating Water Return

HX Heat Exchanger

HZ Hertz, cycle per second

in. inches

in.w.g. inches of water gauge

Kfactor Correction factor to the free area need to
calculate CFM.

KW Kilowatts

LAT Leaving Air Temperature

LBWG Low Wall Grille

LWR Low Wall Register

LWT Leaving Water Temperature

MAU Make-up Air Handling Unit

MBH 1,000 BTUH

N/A Not Applicable

OSA Outside Air

OBD Opposed Blade Damper

ΔP Pressure Drop.

PH Phase

PSI Pounds per Square Inch

RA Return Air

RAT Return Air Temperature

RF Return Fan

RH Relative Humidity

RHC Reheat Coil

RPM Revolutions per Minute

RTU Roof Top Unit

SA Supply Air

SAT Supply Air Temperature

S.F. Service Factor

SF Supply Fan

SFD Smoke/Fire Damper

SP Static Pressure

sq.ft. square feet

Suct. Suction

SWG Sidewall Grille

SWR Sidewall Register

TAB Test; Adjust; and Balance

TSP Total Static Pressure: Difference
between the entering and leaving
static pressure of a fan.

UH Unit Heater

VAV Variable Air Volume; box that
contains a motorized damper that
modulates airflow.

VD Volume Damper

VFD Variable Frequency Drive

Velgrid Instrument that reads used to read
velocity in feet per minute.

VVT Variable Volume Terminal

WC Water Column

W.G. Water Gauge

WB Wet Bulb



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Consulting Engineers Seattle, Washington - Portland, Oregon



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INSTRUMENT CALIBRATIONS Portland Public Schools Airflow Testing

Marshall HS

Instrument Type	Air Data Meter with Flowhood	Instrument Serial #	M97410
Instrument Manufacturer	Shortridge	Calibration Date	10/4/2021
Instrument Model Number	ADM 860	Calibration Due	10/4/2022

Instrument Type	Differential Pressure Water Meter	Instrument Serial #	W12178
Instrument Manufacturer	Shortridge	Calibration Date	10/4/2021
Instrument Model Number	HDM-250	Calibration Due	10/4/2022

Instrument Type	Psychrometer	Instrument Serial #	181128924
Instrument Manufacturer	Extech	Calibration Date	10/1/2021
Instrument Model Number	RH390	Calibration Due	10/1/2022

Instrument Type	Tachometer	Instrument Serial #	B185B5022P
Instrument Manufacturer	Nidec	Calibration Date	10/1/2021
Instrument Model Number	MT-200	Calibration Due	10/1/2022

Instrument Type	Amp Probe	Instrument Serial #	33380179WS
Instrument Manufacturer	Fluke	Calibration Date	10/1/2021
Instrument Model Number	323 Clamp Meter	Calibration Due	10/1/2022

Instrument Type	Digital Thermometer	Instrument Serial #	45400509WS
Instrument Manufacturer	Fluke	Calibration Date	10/1/2021
Instrument Model Number	52 II	Calibration Due	10/1/2022

Instrument Type	Manometer	Instrument Serial #	M97410
Instrument Manufacturer	Shortridge	Calibration Date	10/4/2021
Instrument Model Number	ADM 860	Calibration Due	10/4/2022

Instrument Type	Thermal Anemometer	Instrument Serial #	AVM440808002
Instrument Manufacturer	Alnor Instruments	Calibration Date	9/22/2021
Instrument Model Number	AVM 440	Calibration Due	9/22/2022

Instrument Type	Ultrasonic Flow Meter	Instrument Serial #	N1F1823T
Instrument Manufacturer	Fuji	Calibration Date	9/20/2021
Instrument Model Number	Portaflow-C	Calibration Due	9/20/2022



PROJECT	Portland Public Schools Airflow Testing
LOCATION	Marshall HS; 3905 SE 91st Ave, Portland, OR 97266

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: Marshall HS; 3905 SE 91st Ave, Portland, OR 97266
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	
Lower Level 2																
G-11	-	-	20.7	22.0	455	11.4	5,192	-	-	-	0.0	0.0	1	11.0	0.0	Ventilation is provided by adjacent spaces.
G-14	SF-10	AHU	11.5	12.1	139	9.0	1,252	135	135	100%	6.5	6.5	1	50.7	5.2	
G-15	SF-10	AHU	12.9	14.0	181	9.0	1,625	220	220	100%	8.1	8.1	1	41.6	6.5	
G-16	SF-10	AHU	12.1	15.7	190	12.7	2,413	-	-	-	0.0	0.0	1	23.6	0.0	Ventilation is provided by adjacent spaces.
G-12	-	-	15.7	18.8	295	12.6	3,719	-	-	-	0.0	0.0	1	15.3	0.0	Ventilation is provided by adjacent spaces.
G-17	SF-10	AHU	15.1	24.6	371	12.6	4,680	375	375	100%	4.8	4.8	1	16.0	3.8	
G-17A	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
G-18	SF-10	AHU	15.1	24.6	371	12.6	4,680	155	155	100%	2.0	2.0	1	13.8	1.6	
G-18A	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
G-19	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is a vestibule.
G-19A	SF-10	AHU	11.3	22.1	250	12.5	3,122	810	810	100%	15.6	15.6	1	30.7	12.5	Non-rectangular room.
G-1	-	-	19.1	22.0	420	12.5	5,253	-	-	-	0.0	0.0	1	10.9	0.0	Ventilation is provided by adjacent spaces.
G-2	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
G-2A	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
G-3	SF-10	AHU	11.5	22.1	254	12.6	3,202	290	290	100%	5.4	5.4	1	22.1	4.3	
G-7	SF-10	AHU	33.2	76.4	2,536	12.7	32,213	2,445	2,445	100%	4.6	4.6	1	5.4	3.6	
G-6	-	-	15.5	38.8	601	9.2	5,533	-	-	-	0.0	0.0	1	10.3	0.0	Ventilation is provided by adjacent spaces.
G-8	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This is a transformer room being used for storage.
G-4	SF-10	AHU	32.2	50.2	1,616	15.8	25,540	1,930	1,930	100%	4.5	4.5	1	5.9	3.6	
G-5A	SF-10	AHU	19.5	33.3	649	8.9	5,779	720	720	100%	7.5	7.5	1	15.8	6.0	
G-5	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is a shower.
G-24	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is a shower.
G-23	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
G-24A	SF-10	AHU	19.5	33.3	649	8.9	5,779	110	110	100%	1.1	1.1	1	10.8	0.9	

Date: 1/26/2022

Readings By: Justin Davis

Some HVAC equipment for this site has not yet been tested. This version of the report is a draft with the information available at this time. Once all data has been collected, a final report will be published.



AIRFLOW SURVEY REPORT

Project: Portland Public Schools Airflow Testing
Location: Marshall HS; 3905 SE 91st Ave, Portland, OR 97266
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	
Lower Level 2																
G-29	SF-10	AHU	32.2	50.2	1,616	15.8	25,540	1,400	1400	100%	3.3	3.3	1	4.9	2.6	
G-27	-	-	14.1	30.0	423	19.3	8,164	-	-	-	0.0	0.0	1	7.0	0.0	Ventilation is provided by adjacent spaces.
G-22	-	-	15.5	38.8	601	9.2	5,533	-	-	-	0.0	0.0	1	10.3	0.0	Ventilation is provided by adjacent spaces.
G-10	SF-10	AHU	33.2	84.4	2,802	12.7	35,586	1,780	1780	100%	3.0	3.0	1	4.0	2.4	Non-rectangular room..
Lower Level 1																
Gym A-33	SF-9	AHU	97.0	122.3	11,863	31.7	376,060	39,670	13091	33%	6.3	2.1	0	N/A	4.7	
A-34	SF-11	AHU	9.9	11.2	111	8.2	909	50	0	0%	3.3	0.0	1	65.1	2.4	Note #1
A-34A	-	-	6.6	10.3	68	12.9	877	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
A-37A	-	-	6.6	10.4	69	9.8	673	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
A-37	SF-11	AHU	9.9	11.3	112	8.2	917	115	0	0%	7.5	0.0	1	67.5	5.4	Note #1
A-30	SF-11	AHU	28.2	65.8	1,856	10.1	18,741	1,635	0	0%	5.2	0.0	1	6.8	3.8	Non-rectangular room, Note #1.
A-30A	SF-11	AHU	10.1	12.7	128	10.0	1,283	250	0	0%	11.7	0.0	1	52.9	8.4	Note #1
A-30B	SF-11	AHU	9.5	10.6	101	10.0	1,007	220	0	0%	13.1	0.0	1	66.0	9.4	Note #1
A-30C	SF-11	AHU	11.9	12.7	151	10.1	1,526	260	0	0%	10.2	0.0	1	44.7	7.4	Note #1
A-30D	SF-11	AHU	9.5	10.6	101	10.0	1,007	150	0	0%	8.9	0.0	1	63.0	6.4	Note #1
A-30F	SF-11	AHU	8.0	10.7	86	9.9	847	165	0	0%	11.7	0.0	1	75.7	8.4	Note #1
A-30H	SF-11	AHU	10.7	10.7	114	10.0	1,145	165	0	0%	8.6	0.0	1	56.0	6.2	Note #1
A-27A	SU-4	AHU	11.8	19.7	232	11.3	2,627	255	120	47%	5.8	2.7	1	26.1	4.4	Non-rectangular room.
A-27B	SU-4	AHU	9.7	15.3	148	11.3	1,677	245	115	47%	8.8	4.1	1	40.6	6.6	
A-27C	SU-4	AHU	9.7	15.7	152	11.2	1,706	240	113	47%	8.4	4.0	1	39.8	6.4	
A-27	SU-4	AHU	27.4	28.1	770	11.2	8,623	1,020	479	47%	7.1	3.3	1	12.0	5.4	
Rm A-26/A-28	SU-4	AHU	40.0	76.0	3,040	11.6	35,264	2,535	1191	47%	4.3	2.0	1	4.9	3.3	A28 and A26 are one room.
A-26A	SU-4	AHU	7.0	10.1	71	9.2	650	85	40	47%	7.8	3.7	1	93.6	5.9	
A-40	SF-7	AHU	27.1	32.2	873	12.0	10,471	2,435	779	32%	14.0	4.5	1	15.8	10.4	

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Lower Level 1																
A-26B	-	-	10.1	17.7	179	12.5	2,235	-	-	-	0.0	0.0	1	25.5	0.0	This space is used for storage.
A-22B	SU-4	AHU	11.4	19.5	222	13.1	2,912	510	240	47%	10.5	4.9	1	27.5	8.0	
A-22A	SU-4	AHU	8.1	8.1	66	1.2	79	60	28	47%	45.7	21.5	1	758.6	34.6	
Rm A-22	SU-4	AHU	40.2	68.6	2,758	11.6	31,990	2,450	1152	47%	4.6	2.2	1	5.3	3.5	
Rm A-25	SU-4	AHU	26.1	47.5	1,240	11.3	14,009	1,750	823	47%	7.5	3.5	1	9.7	5.7	
Rm A-21	SU-4	AHU	39.8	46.0	1,831	15.0	27,462	2,000	940	47%	4.4	2.1	1	5.4	3.3	
A-14	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
Rm A-13	SU-1	AHU	27.1	45.8	1,241	11.3	14,025	1,733	364	21%	7.4	1.6	1	9.5	5.5	
A-12	SU-1	AHU	14.8	19.0	281	9.7	2,728	235	49	21%	5.2	1.1	1	24.7	3.8	
A-11A	SU-1	AHU	12.2	19.8	242	11.3	2,730	180	38	21%	4.0	0.8	1	23.8	2.9	
Room A-11	-	-	15.0	27.7	416	11.0	4,571	-	-	-	0.0	0.0	0	N/A	0.0	This is a corridor/storage.
Rm A-10	SU-1	AHU	25.8	47.6	1,228	11.1	13,632	1,690	355	21%	7.4	1.6	1	9.7	5.5	
Rm A-9	SU-1	AHU	25.8	41.1	1,060	11.1	11,770	1,045	219	21%	5.3	1.1	1	8.8	3.9	
Rm A-8	SU-1	AHU	27.9	30.0	837	11.2	9,374	1,180	248	21%	7.6	1.6	1	11.6	5.6	
Rm A-5	SU-1	AHU	25.8	39.5	1,019	11.0	11,210	890	187	21%	4.8	1.0	1	8.6	3.5	
Rm A-4	SU-1	AHU	25.8	39.8	1,027	11.2	11,501	1,110	233	21%	5.8	1.2	1	9.2	4.3	
Rm A-1	SU-1	AHU	26.5	51.8	1,373	11.3	15,512	1,195	251	21%	4.6	1.0	1	7.1	3.4	
Rm A-43	SF-7	AHU	29.0	29.8	864	14.0	12,099	0	0	0%	0.0	0.0	1	4.7	0.0	Volume dampers fully closed.
A-38A	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This is a mechanical room.
Cafeteria A-38	SF-7	AHU	66.6	150.0	9,990	12.2	121,878	12,550	4016	32%	6.2	2.0	1	5.1	4.6	
A-41E	SF-8	AHU	18.2	29.2	531	9.0	4,783	0	0	0%	0.0	0.0	1	11.9	0.0	Note #2. No airflow to diffusers.
A-41B	SF-8	AHU	7.1	8.2	58	8.9	518	0	0	0%	0.0	0.0	1	110.0	0.0	Note #2. No airflow to diffusers.
A-41C	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is a restroom.
A-42	SF-8	AHU	11.6	20.6	239	10.4	2,485	0	0	0%	0.0	0.0	1	22.9	0.0	Note #2. No airflow to diffusers.

Date: 1/26/2022

Readings By: Justin Davis

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AIRFLOW SURVEY REPORT

Project: Portland Public Schools Airflow Testing
Location: Marshall HS; 3905 SE 91st Ave, Portland, OR 97266
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	
Lower Level 1																
A-41F	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is the walk-in cooler.
A-41G	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	N/A	This space does not exist as per the plans.
A-41	SF-8	AHU	56.2	58.5	3,288	11.2	36,822	0	0	0%	0.0	0.0	1	1.5	0.0	Note #2. No airflow to diffusers.
A-40A	SF-8	AHU	20.0	50.0	1,000	11.6	11,600	2,695	2479	92%	13.9	12.8	1	16.0	11.1	
A-40	SF-7	AHU	29.9	32.2	963	12.1	11,650	2,535	811	32%	13.1	4.2	1	14.6	9.7	Note #2
First Floor																Non-rectangular room.
Rm B-32	SF-4	AHU	27.9	29.5	823	11.3	9,300	1,460	686	47%	9.4	4.4	1	13.3	7.1	
Rm B-30	SF-4	AHU	27.9	29.5	823	11.3	9,300	1,070	503	47%	6.9	3.2	1	11.4	5.2	
Conf. Rm. B-28A	SF-4	AHU	9.8	14.2	139	11.2	1,559	220	103	47%	8.5	4.0	1	43.0	6.4	
Conf. Rm. B-29	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This is an electrical closet.
Rm B-28	SF-4	AHU	27.9	29.5	823	11.3	9,300	1,220	573	47%	7.9	3.7	1	12.1	6.0	
B-27B	SF-4	AHU	14.0	27.1	379	11.3	4,287	295	139	47%	4.1	1.9	1	16.4	3.1	
B-27A	SF-4	AHU	27.9	14.7	410	11.3	4,634	415	195	47%	5.4	2.5	1	16.4	4.1	
Rm B-26	SF-4	AHU	27.9	29.4	820	11.3	9,269	845	397	47%	5.5	2.6	1	10.3	4.1	
Rm B-25	SF-4	AHU	27.9	29.4	820	11.3	9,269	920	432	47%	6.0	2.8	1	10.7	4.5	
Rm B-24	SF-4	AHU	28.0	28.0	784	11.3	8,859	535	251	47%	3.6	1.7	1	9.2	2.7	
B-18B	SU-1	AHU	27.9	29.6	826	11.2	9,249	865	182	21%	5.6	1.2	1	10.3	4.1	
B-18A	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	N/A	B-18A and B-18B are one room.
Rm B-16	SU-1	AHU	28.0	29.5	826	11.4	9,416	1,120	235	21%	7.1	1.5	1	11.3	5.3	
Rm B-17	SU-1	AHU	27.1	60.1	1,629	11.3	18,404	1,200	252	21%	3.9	0.8	1	6.0	2.9	B-17 and B-15 are one room.
Rm B-15	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	N/A	
B-14	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	N/A	B14 and B-13 are one room.
Rm B-13	SU-1	AHU	29.1	49.3	1,435	10.0	14,346	1,180	248	21%	4.9	1.0	1	7.6	3.6	
Rm B-12	SU-1	AHU	27.6	31.0	856	11.3	9,668	1,085	228	21%	6.7	1.4	1	10.9	5.0	

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AIRFLOW SURVEY REPORT

Project: Portland Public Schools Airflow Testing
Location: Marshall HS; 3905 SE 91st Ave, Portland, OR 97266
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																
Conf. Rm. B-12A	SU-1	AHU	9.6	14.3	137	11.3	1,551	195	41	21%	7.5	1.6	1	42.3	5.6	
Conf. Rm. B-11	SU-1	AHU	9.6	13.6	131	9.0	1,175	145	30	21%	7.4	1.6	1	54.0	5.5	
Rm B-10	SU-1	AHU	19.6	29.3	574	11.3	6,489	755	159	21%	7.0	1.5	1	13.9	5.1	
Rm B-9	SU-1	AHU	27.9	29.5	823	11.3	9,300	1,083	227	21%	7.0	1.5	1	11.3	5.1	
Rm B-8	SU-1	AHU	27.9	29.5	823	11.3	9,300	1,140	239	21%	7.4	1.5	1	11.5	5.4	
Rm B-6	SU-1	AHU	27.5	29.5	811	11.3	9,167	945	198	21%	6.2	1.3	1	10.8	4.6	
Library B-1	SU-1	AHU	70.6	78.7	5,556	12.0	66,675	5,140	1079	21%	4.6	1.0	1	4.3	3.4	
B-1A	SU-1	AHU	12.8	26.6	340	9.0	3,064	215	45	21%	4.2	0.9	1	21.7	3.1	
B-7A	SU-1	AHU	10.0	13.7	137	9.0	1,233	110	23	21%	5.4	1.1	1	50.2	3.9	
B-7B	SU-1	AHU	10.0	12.8	128	9.0	1,152	70	15	21%	3.6	0.8	1	52.2	2.7	
B-71M	SU-1	AHU	13.2	20.3	268	11.2	3,001	480	101	21%	9.6	2.0	1	26.1	7.1	
B-71L	SU-1	AHU	15.0	21.5	323	11.4	3,677	355	75	21%	5.8	1.2	1	19.8	4.3	
B-71K	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	This space is used for storage.
B-71H	SU-1	AHU	10.0	9.4	94	9.1	855	155	33	21%	10.9	2.3	1	74.6	8.0	
Conf. Rm. B-71J	SU-1	AHU	10.0	9.6	96	9.0	864	105	22	21%	7.3	1.5	1	71.3	5.4	
Conf. Rm. B-71G	SU-1	AHU	10.0	9.4	94	9.0	846	105	22	21%	7.4	1.6	1	72.9	5.5	
Conf. Rm. B-71F	SU-1	AHU	9.1	10.8	98	11.3	1,111	200	42	21%	10.8	2.3	1	59.3	8.0	
Conf. Rm. B-71E	SU-1	AHU	10.0	10.8	108	11.3	1,220	250	53	21%	12.3	2.6	1	55.8	9.1	
Conf. Rm. B-71D	SU-1	AHU	9.1	10.8	98	11.3	1,111	170	36	21%	9.2	1.9	1	58.1	6.8	
Conf. Rm. B-71C	SU-1	AHU	10.0	10.8	108	11.3	1,220	165	35	21%	8.1	1.7	1	52.7	6.0	
Conf. Rm. B-71B	SU-1	AHU	9.1	10.8	98	11.3	1,111	240	50	21%	13.0	2.7	1	60.9	9.5	
Conf. Rm. B-71A	SU-1	AHU	10.0	10.8	108	11.3	1,220	255	54	21%	12.5	2.6	1	55.9	9.2	
B-70E	SU-1	AHU	12.7	14.6	185	11.3	2,095	495	104	21%	14.2	3.0	1	37.6	10.4	
B-70C	SU-1	AHU	12.7	14.0	178	11.3	2,009	395	83	21%	11.8	2.5	1	37.1	8.7	

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AIRFLOW SURVEY REPORT

Project: Portland Public Schools Airflow Testing
Location: Marshall HS; 3905 SE 91st Ave, Portland, OR 97266
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																
B-70B	SU-1	AHU	19.5	19.6	382	11.3	4,319	285	60	21%	4.0	0.8	1	16.1	2.9	
Conf. Rm. B-70	SU-1	AHU	27.0	169.2	4,568	11.2	51,166	1,730	363	21%	2.0	0.4	2	3.7	1.5	Non-rectangular room.
B-70A	SU-1	AHU	19.7	20.0	394	11.3	4,452	600	126	21%	8.1	1.7	1	18.8	6.0	Non-rectangular room.
Auditorium B-68	SF-5	AHU	47.2	75.8	3,387	29.5	83,581	Unable to measure					1	N/A	N/A	Note #3
Stage B-68A	-	-	31.5	60.0	1,890	23.4	44,226	-	-	-	0.0	0.0	1	1.3	0.0	Ventilation is provided by adjacent spaces.
B-65	-	-	22.4	30.7	688	22.9	15,748	-	-	-	0.0	0.0	1	3.6	0.0	This space is used for storage.
Rm B-62	SF-6	AHU	29.0	38.4	1,114	20.1	22,383	1,985	695	35%	5.3	1.9	1	6.5	4.0	Non-rectangular room.
B-57A	SF-6	AHU	19.9	30.4	605	9.7	5,868	360	126	35%	3.7	1.3	1	12.5	2.8	
Rm B-57	SF-6	AHU	37.8	44.5	1,682	19.4	32,633	2,970	1040	35%	5.5	1.9	1	5.8	4.1	Non-rectangular room.
Rm B-56	SF-6	AHU	26.0	37.1	965	10.3	9,935	815	285	35%	4.9	1.7	1	9.4	3.7	
B-50	SF-3	AHU	27.9	34.3	957	11.3	10,814	560	370	66%	3.1	2.1	1	7.7	2.4	Non-rectangular room.
B-50A	SF-3	AHU	8.0	12.4	99	9.4	932	50	33	66%	3.2	2.1	1	63.6	2.5	
Rm B-51	SF-3	AHU	27.9	49.7	1,387	11.3	15,669	2,640	1742	66%	10.1	6.7	1	11.4	7.8	
Rm B-49	SF-3	AHU	27.9	24.8	692	11.3	7,819	590	389	66%	4.5	3.0	1	10.8	3.5	
Rm B-48	SF-3	AHU	27.9	29.3	817	11.3	9,237	655	432	66%	4.3	2.8	1	9.5	3.3	
Rm B-47	SF-3	AHU	27.9	29.3	817	11.3	9,237	615	406	66%	4.0	2.6	1	9.3	3.1	
Rm B-46	SF-3	AHU	27.9	29.3	817	11.3	9,237	1,240	818	66%	8.1	5.3	1	12.4	6.2	
Rm B-45	SF-3	AHU	27.9	29.3	817	11.3	9,237	935	617	66%	6.1	4.0	1	10.9	4.7	
Rm B-44	SF-3	AHU	27.9	29.3	817	11.2	9,156	1,815	1198	66%	11.9	7.9	1	15.4	9.2	
Conf. Rm. B-44A	SF-3	AHU	9.5	14.0	133	11.3	1,503	215	142	66%	8.6	5.7	1	44.6	6.6	
Conf. Rm. B-39A	SF-3	AHU	9.5	13.6	129	9.0	1,163	130	86	66%	6.7	4.4	1	54.2	5.2	
B-42	SF-3	AHU	27.9	14.7	410	11.3	4,634	315	208	66%	4.1	2.7	1	15.4	3.2	
B-42A	SF-3	AHU	27.9	14.3	399	11.3	4,508	205	135	66%	2.7	1.8	1	14.8	2.1	
Rm B-39	SF-3	AHU	27.9	60.5	1,688	11.3	19,074	3,205	2115	66%	10.1	6.7	1	10.8	7.8	

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Project: Portland Public Schools Airflow Testing
Location: Marshall HS; 3905 SE 91st Ave, Portland, OR 97266
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 B-40	SF-3	AHU	27.9	29.5	823	11.2	9,218	745	492	66%	4.8	3.2	1	9.9	3.7	
Rm B-38	SF-3	AHU	27.9	26.7	745	11.2	8,343	1,395	921	66%	10.0	6.6	1	14.6	7.8	
Second Floor																
Rm C-33	SF-4	AHU	59.3	27.4	1,625	10.6	17,223	1,130	531	47%	3.9	1.9	1	6.3	3.0	
Rm C-32	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	N/A	C-33 and C-32 are one room.
Conf. Rm. C-30A	SF-4	AHU	14.1	9.9	140	9.5	1,326	250	118	47%	11.3	5.3	1	51.5	8.6	
Rm C-30	SF-4	AHU	29.6	27.3	808	10.6	8,566	480	226	47%	3.4	1.6	1	9.2	2.5	
Rm C-29	SF-4	AHU	29.5	27.0	797	10.6	8,443	715	336	47%	5.1	2.4	1	10.6	3.8	
Rm C-28	SF-4	AHU	36.5	26.8	978	10.6	10,369	950	447	47%	5.5	2.6	1	9.7	4.2	
Rm C-27	SF-4	AHU	45.8	26.9	1,232	10.6	13,059	925	435	47%	4.2	2.0	1	7.6	3.2	
Rm C-20	SU-1	AHU	39.8	26.9	1,071	10.6	11,349	1,575	331	21%	8.3	1.7	1	11.2	6.1	
C-19A	SU-1	AHU	27.2	14.7	400	10.6	4,238	185	39	21%	2.6	0.5	1	15.4	1.9	
C-18B	SU-1	AHU	27.2	14.7	400	10.6	4,238	250	53	21%	3.5	0.7	1	16.1	2.6	
C-18A	SU-1	AHU	27.2	15.9	432	10.6	4,584	215	45	21%	2.8	0.6	1	14.5	2.1	
Rm C-17	SU-1	AHU	29.5	26.8	791	10.6	8,380	1,409	296	21%	10.1	2.1	1	14.2	7.4	
Rm C-16	SU-1	AHU	39.5	27.9	1,102	10.6	11,682	215	45	21%	1.1	0.2	1	5.7	0.8	
Rm C-15	SU-1	AHU	41.0	26.8	1,099	10.6	11,647	1,186	249	21%	6.1	1.3	1	9.4	4.5	
Rm C-13	SU-1	AHU	39.5	26.1	1,031	10.6	10,928	1,504	316	21%	8.3	1.7	1	11.3	6.1	
Rm C-12	SU-1	AHU	39.5	27.9	1,102	10.6	11,682	545	114	21%	2.8	0.6	1	6.9	2.1	
Rm C-10	SU-1	AHU	39.8	27.2	1,083	10.6	11,475	1,306	274	21%	6.8	1.4	1	10.0	5.0	
C-9	-	-	10.7	10.4	111	11.1	1,235	-	-	-	0.0	0.0	1	46.1	0.0	Ventilation is provided by adjacent spaces.
Rm C-8	SF-2	AHU	32.6	28.8	939	10.9	10,234	625	206	33%	3.7	1.2	1	8.3	2.7	
Rm C-7	SF-2	AHU	29.6	27.9	826	10.8	8,919	590	195	33%	4.0	1.3	1	9.4	3.0	
Rm C-6	SF-2	AHU	29.6	27.3	808	10.8	8,727	560	185	33%	3.9	1.3	1	9.4	2.9	

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Second Floor																
Rm C-5	SF-2	AHU	29.5	27.4	808	10.8	8,730	690	228	33%	4.7	1.6	1	10.1	3.5	
Rm C-4	SF-2	AHU	29.5	27.3	805	10.7	8,617	895	295	33%	6.2	2.1	1	11.3	4.6	
Rm C-3	SF-2	AHU	29.6	27.4	811	10.8	8,759	850	281	33%	5.8	1.9	1	10.9	4.3	
Rm C-2	SF-2	AHU	29.6	27.5	814	10.8	8,791	1,435	474	33%	9.8	3.2	1	13.8	7.3	
Rm C-1	SF-2	AHU	29.6	27.5	814	10.8	8,791	1,500	495	33%	10.2	3.4	1	14.1	7.6	
C-55	SF-3	AHU	27.6	37.6	1,038	10.5	10,896	1,000	660	66%	5.5	3.6	1	9.5	4.3	
Rm C-53	SF-3	AHU	28.0	19.6	549	10.6	5,817	450	297	66%	4.6	3.1	1	13.4	3.6	
C-53A	SF-3	AHU	28.0	9.5	266	10.6	2,820	215	142	66%	4.6	3.0	1	23.8	3.5	
Rm C-48	SF-3	AHU	27.9	29.5	823	10.6	8,724	475	314	66%	3.3	2.2	1	9.1	2.5	
Rm C-46	SF-3	AHU	28.2	49.5	1,396	10.6	14,797	1,160	766	66%	4.7	3.1	1	7.5	3.6	
Rm C-47	SF-3	AHU	29.5	27.2	802	10.6	8,505	400	264	66%	2.8	1.9	1	8.9	2.2	
Rm C-45	SF-3	AHU	29.6	27.3	808	10.6	8,566	590	389	66%	4.1	2.7	1	9.8	3.2	
Rm C-44	SF-3	AHU	49.5	27.3	1,351	10.6	14,324	1,120	739	66%	4.7	3.1	1	7.6	3.6	
Conf. Rm. C-44A	SF-3	AHU	28.1	9.5	267	8.6	2,296	410	271	66%	10.7	7.1	1	33.1	8.3	
Rm C-43	SF-3	AHU	29.5	27.3	805	10.6	8,537	650	429	66%	4.6	3.0	1	10.2	3.5	
Rm C-41	SF-3	AHU	29.6	27.3	808	10.6	8,566	550	363	66%	3.9	2.5	1	9.6	3.0	
Rm C-40	SF-3	AHU	29.6	27.3	808	10.6	8,566	1,110	733	66%	7.8	5.1	1	12.7	6.0	
Rm C-39	SF-3	AHU	29.8	27.3	814	10.6	8,624	595	393	66%	4.1	2.7	1	9.8	3.2	
Rm C-38	SF-3	AHU	46.3	27.3	1,264	10.6	13,398	1,510	997	66%	6.8	4.5	1	9.5	5.2	

Date: 1/26/2022

Readings By: Justin Davis

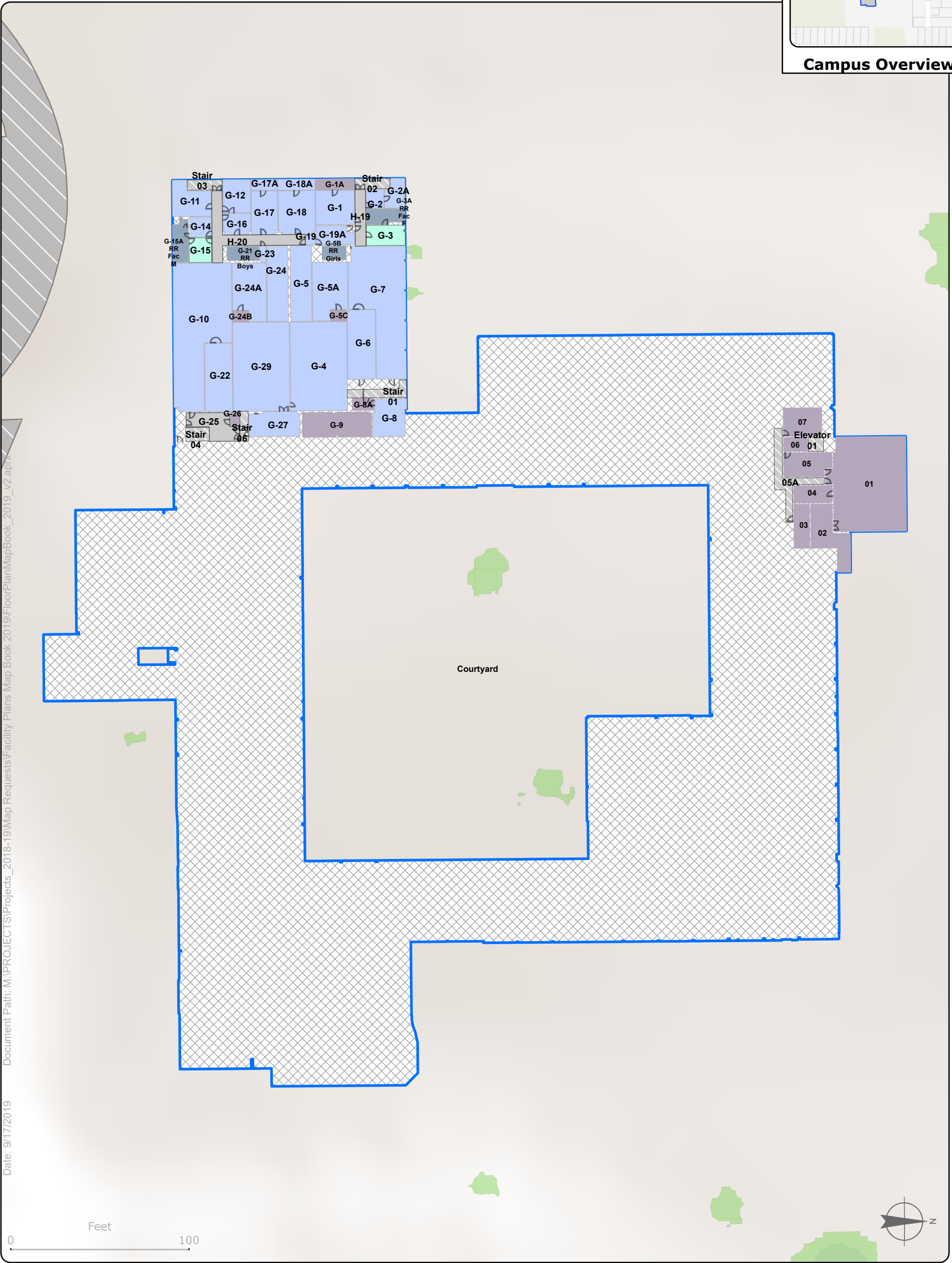
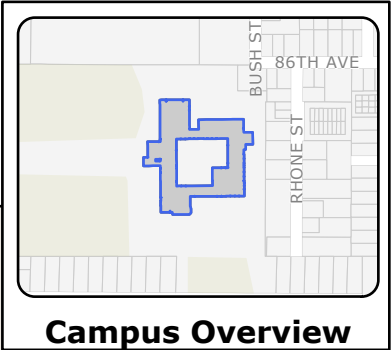
Some HVAC equipment for this site has not yet been tested. This version of the report is a draft with the information available at this time. Once all data has been collected, a final report will be published.



Location: Marshall HS; 3905 SE 91st Ave, Portland, OR 97266

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MARSHALL: Lower Level 2

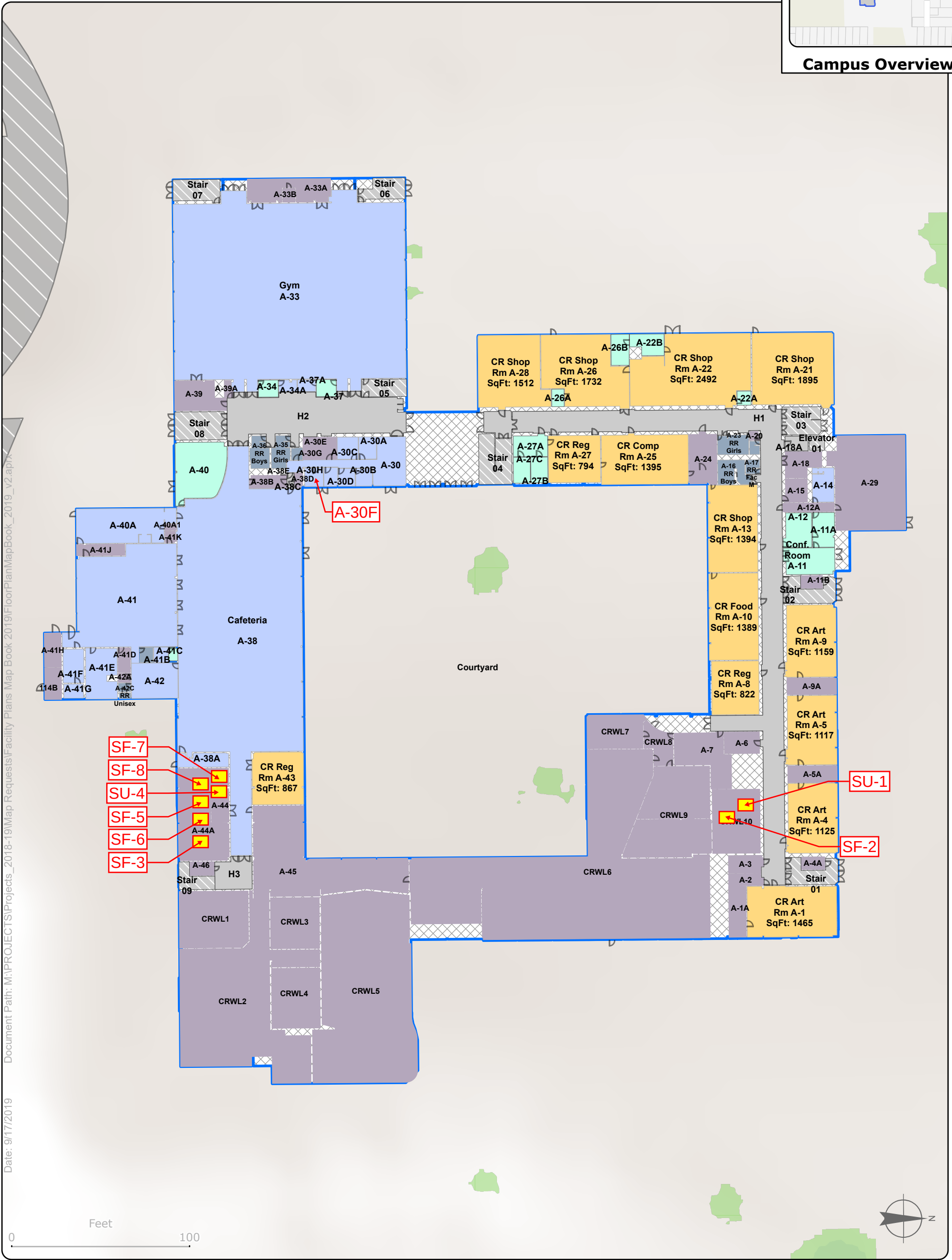
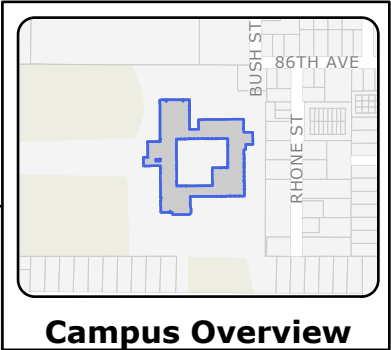


Space Use		School Grounds	
	Classroom		Campus Footprints
	Office		Athletic Field
	Rest Room		Playground: Paved
	Special Purpose		Playground: Unpaved
	Corridor		Streets
	Other		Doors
	Stairs/Elevator		

Total Number Of Rooms By Classification

Classrooms: 0	Special Purpose: 26
Office Spaces: 2	Storage: 8

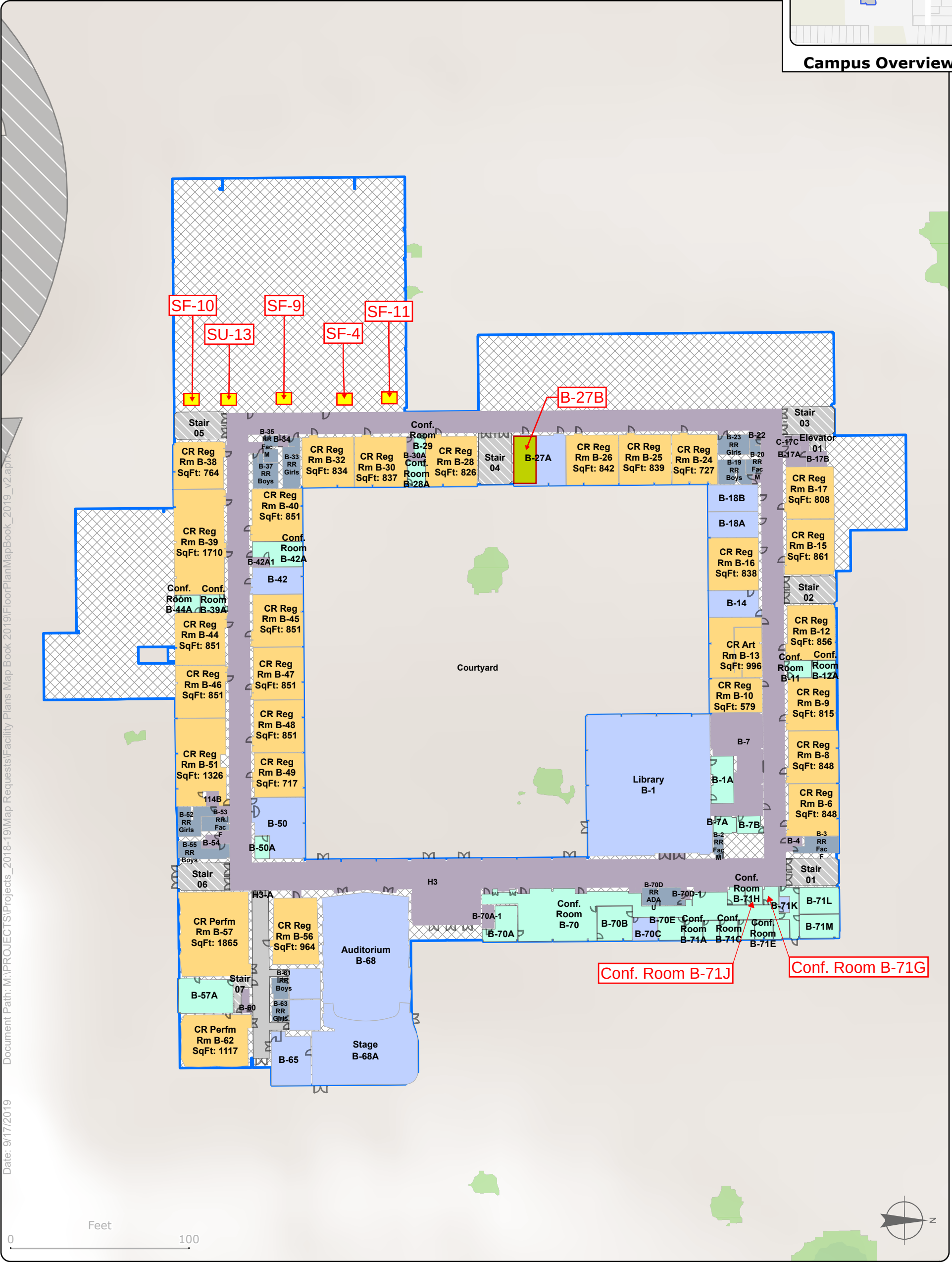
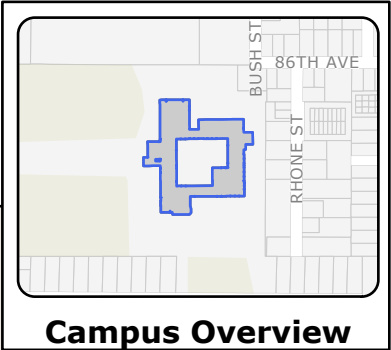
MARSHALL: Lower Level 1



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

<u>Total Number Of Rooms By Classification</u>	
Classrooms: 14	Special Purpose: 20
Office Spaces: 14	Storage: 30

MARSHALL: First Floor

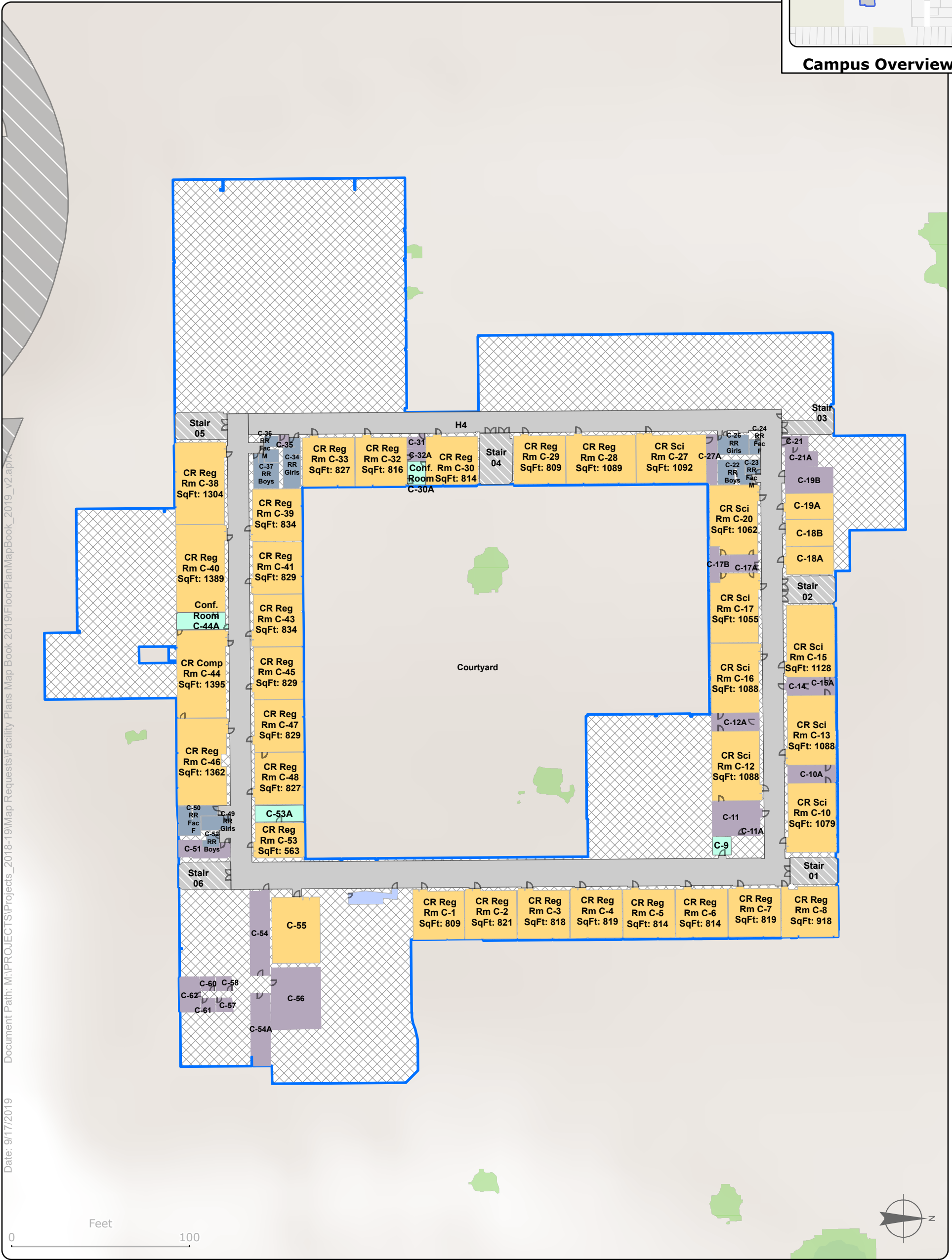
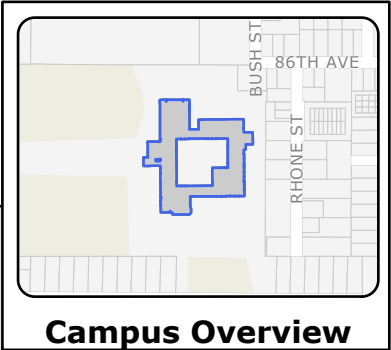


Space Use	School Grounds
Classroom	Campus Footprints
Office	Athletic Field
Rest Room	Playground: Paved
Special Purpose	Playground: Unpaved
Corridor	Streets
Other	Doors
Stairs/Elevator	

Total Number Of Rooms By Classification

Classrooms: 28	Special Purpose: 14
Office Spaces: 27	Storage: 13

MARSHALL: Second 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: 36	Special Purpose: 1
Office Spaces: 4	Storage: 22