Passive Building IAQ Study

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phius con
MILWAUKEE 2025

Objectives

- Our intent is to convey findings from an IAQ study of an award winning Phius passive building.
- We hope that our experience will help you to improve IAQ design for your projects
- You will also gain understanding of some of the real world issues that impact IAQ in multi-family buildings

ARNOLD DEVELOPMENT

JEFFREY M. WHITE ▪ ARCHITECT

Second and Delaware

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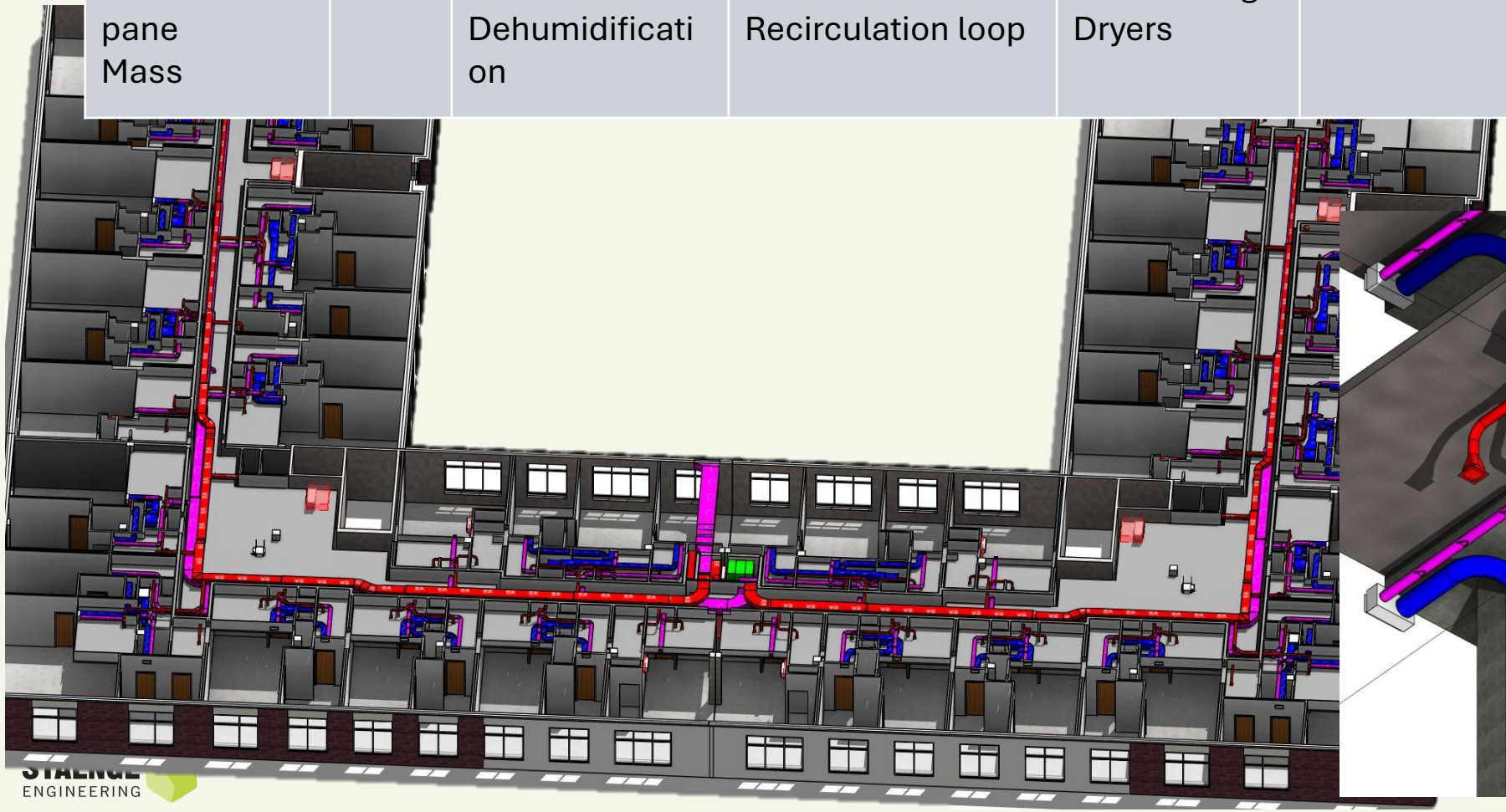
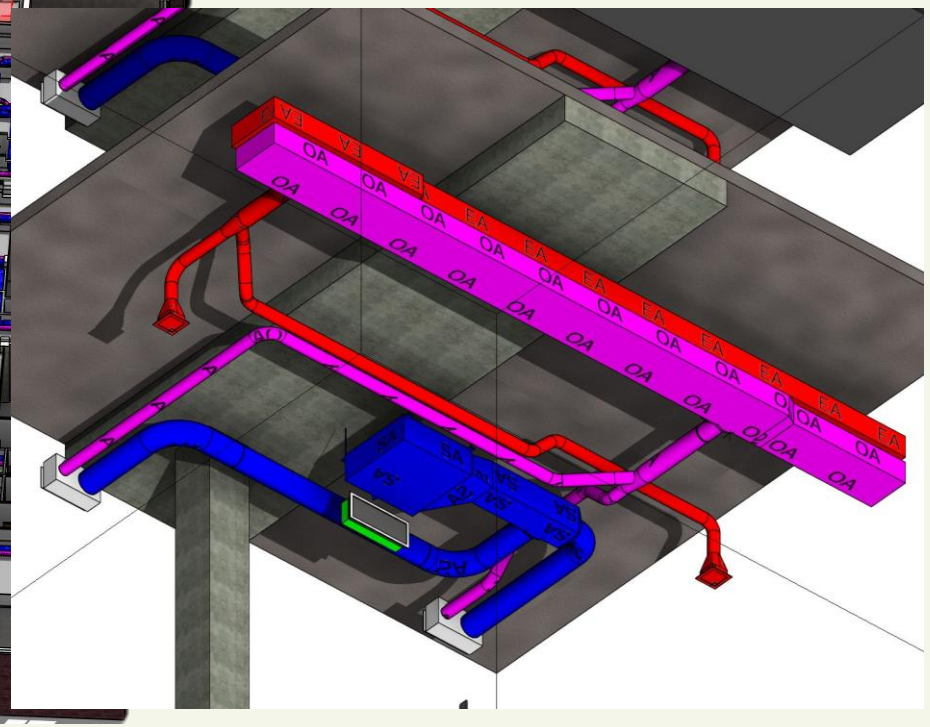
2nd and Delaware Reported Air Quality Concerns

Owner Concern	Description
1 – ERV Filters	ERV filters are costly. They require change-out every 3 months. Supplier has reduced the depth of the bag filters and owner is concerned this will require more frequent change-out.
2 – Material build-up in wall mounted indoor units	Material is building up in wall mounted indoor units. The operations staff are not able to clean the material off of the fans and coils. TMI (the service contractor) has quoted a cost of $1,500 per unit to clean the fans and coils.
3 – Soot build-up in some apartments	Some occupants have complained about soot build-up on walls in apartments.
4- Very dirty filters for fan coils in apartments in some apartments	When maintenance staff do their quarterly filter change, some of the filters look extremely dirty. Filter change is costly.

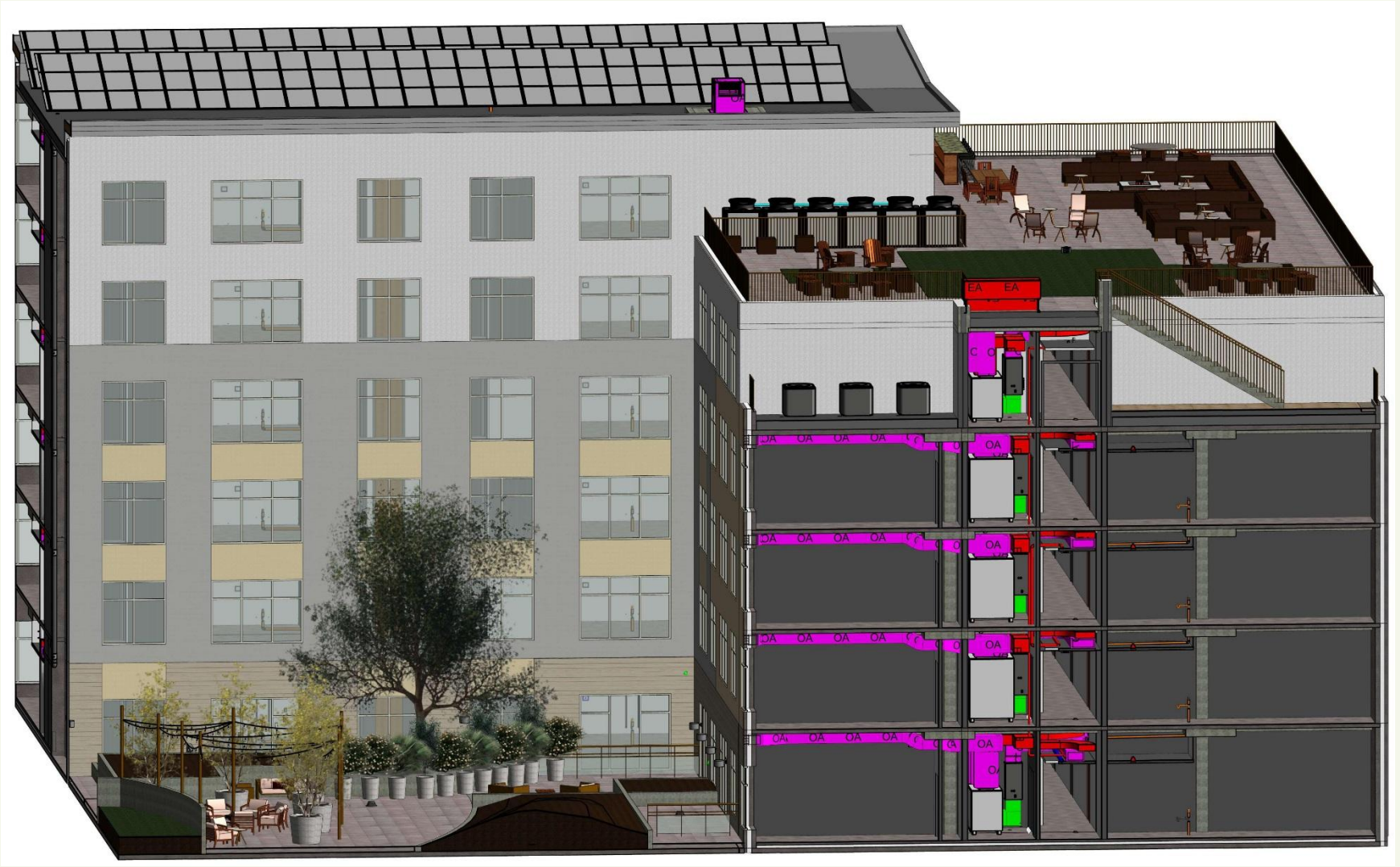
Second and Delaware

Envelope	HVAC	Ventilation	HW System	Appliances	Renewable Energy	Design Complete	Occupied Date
Walls: R33 Roof: R50 Windows: 3-pane Mass	VRF	Semi-Central – One ERV / floor with Dehumidification	Capstone Combined Heat and Power – Recirculation loop	Energy Star with Condensing Dryers	150 kW Solar PV	2015	2020



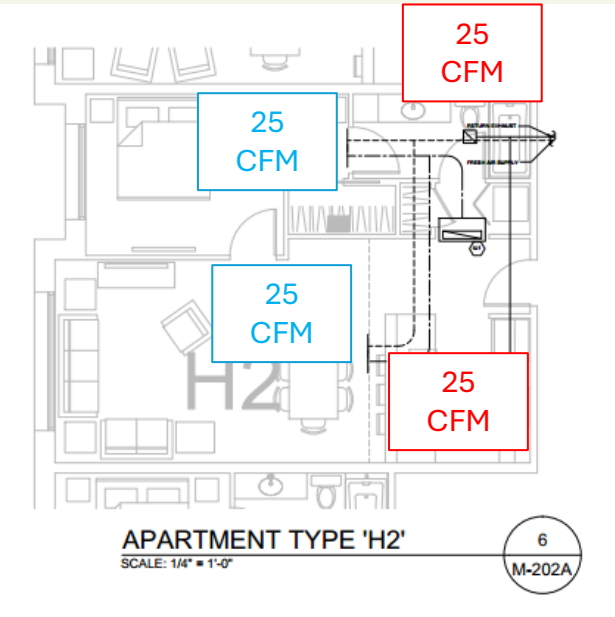


Ventilation Strategy



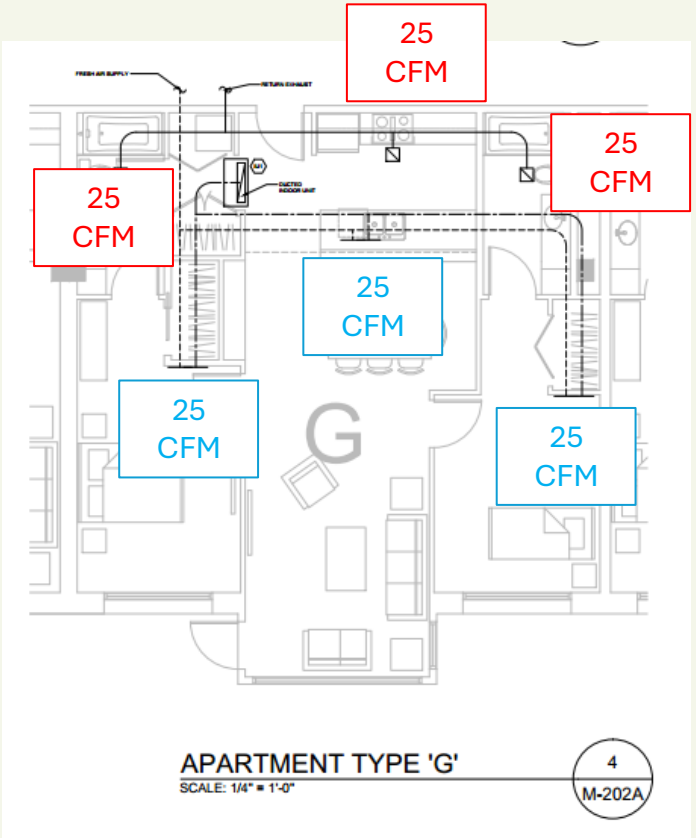
2nd and Delaware

1 and 2 Bedroom Units



- Ventilation Code: 2012 IMC
- Recirculating range hoods in kitchens
- MERV 13 filtration in Ventilation and in HVAC (ducted units only)

HVAC Recirculation = 2 ACH
Ventilation Rate = 0.45 ACH



Apartment	Ventilation Air Required [CFM]	Vent. Air Provided [CFM]	Exhaust Air Required [CFM]	Exhaust Air Provided [CFM]
1 BR	35 CFM	50 CFM	45 CFM	50 CFM
2 BR	46 CFM	75 CFM	65 CFM	75 CFM

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Expert Help!

Experience

Aclima, Inc.
10 yrs 10 mos

- **Chief Scientist**
  Jun 2016 - Sep 2024 · 8 yrs 4 mos
  San Francisco Bay Area
- **Senior Atmospheric Scientist**
  Dec 2013 - Jun 2016 · 2 yrs 7 mos
  San Fransicso

Staff Scientist
Lawrence Berkeley National Laboratory
Oct 1998 - Nov 2013 · 15 yrs 2 mos

Postdoctoral Research Associate
Sandia National Laboratories
Jun 1995 - Jul 1998 · 3 yrs 2 mos

Melissa Lunden, PhD

Location

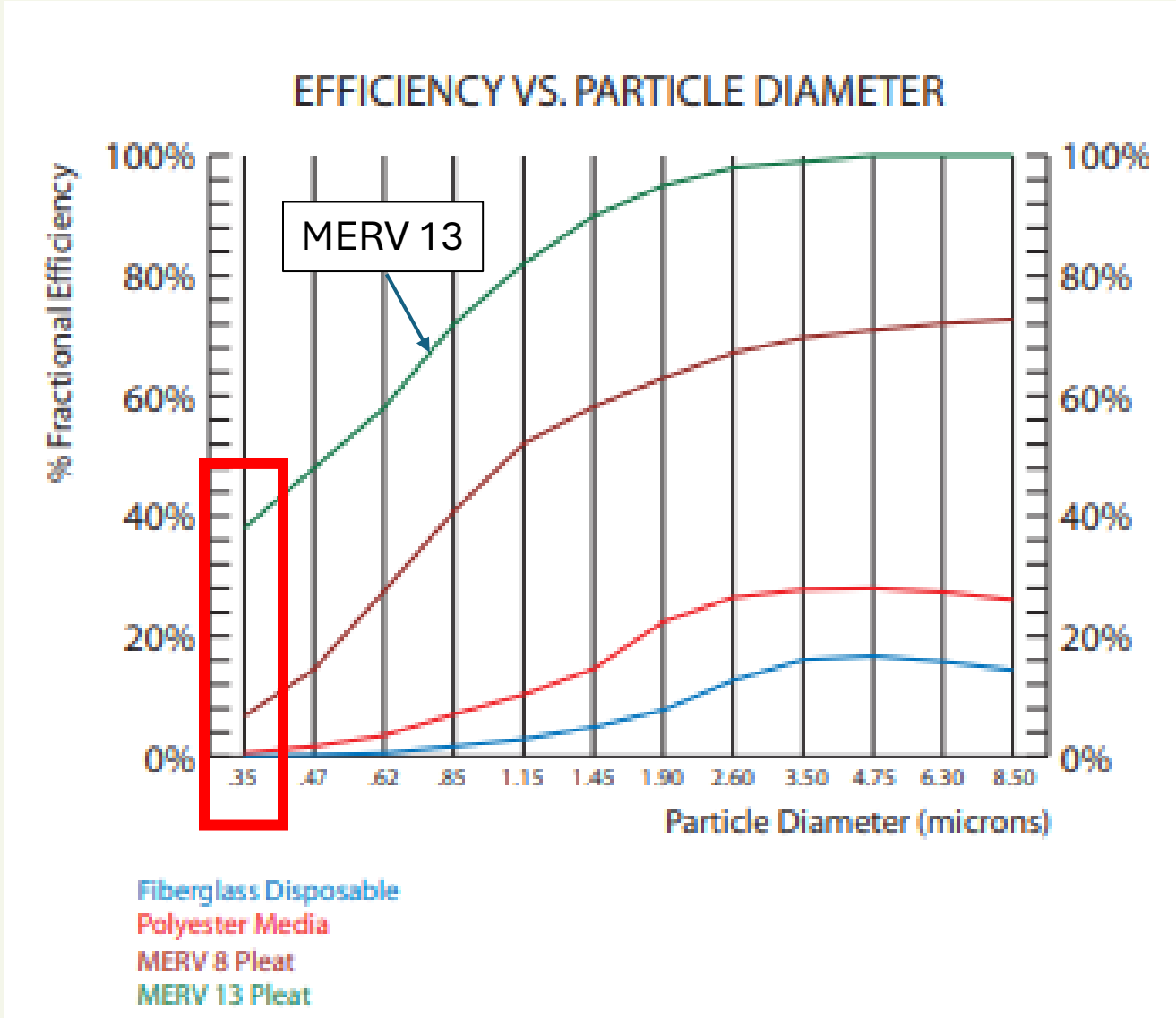

Viewing Deck
Town of Kansas Bridge
Riverfront Heritage Trail
Emery Sapp & Sons - Kansas City Office
Platinum XP
Main St
E 2nd St
Old Townley Lofts
Second + Delaware Apartments
River Bend Lofts
W 2nd St
Askew Saddlery Lofts
Delaware St
Bourgmont Lofts - Art Space Lofts
Bourgmont Lofts - Delaware Lofts
E 3rd St
Gymko
Google Maps

Outdoor Sources

Ultra-fine particles

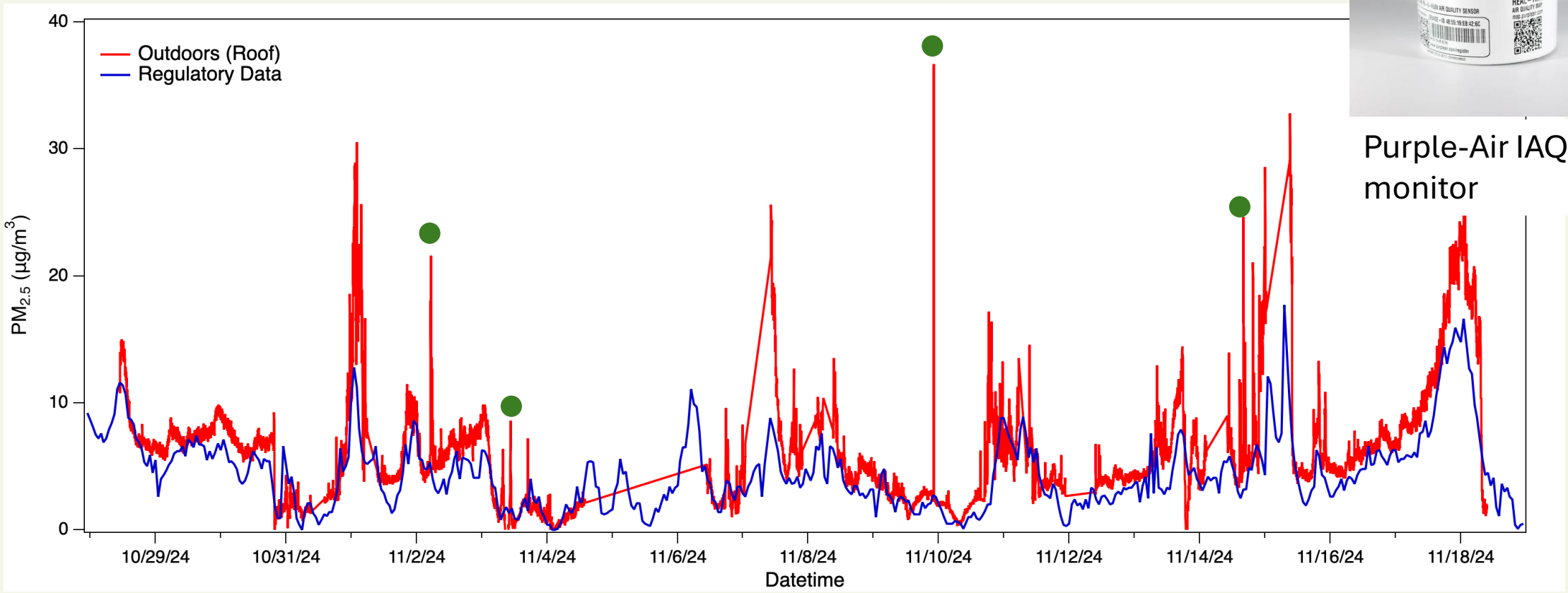
- 0.1 um and smaller
- Un-regulated
- Strong concern about health impacts

SOURCES
- Diesel Exhaust
- Car Exhaust
- Airplane Exhaust
- Power plants



Outdoor data from the Purple Air sensors compare well with the nearby regulatory data

Purple-Air IAQ monitor



Short term elevations in PM concentrations indicate local emissions (examples are marked by a ●). The spikes typically last from a few minutes to an hour.

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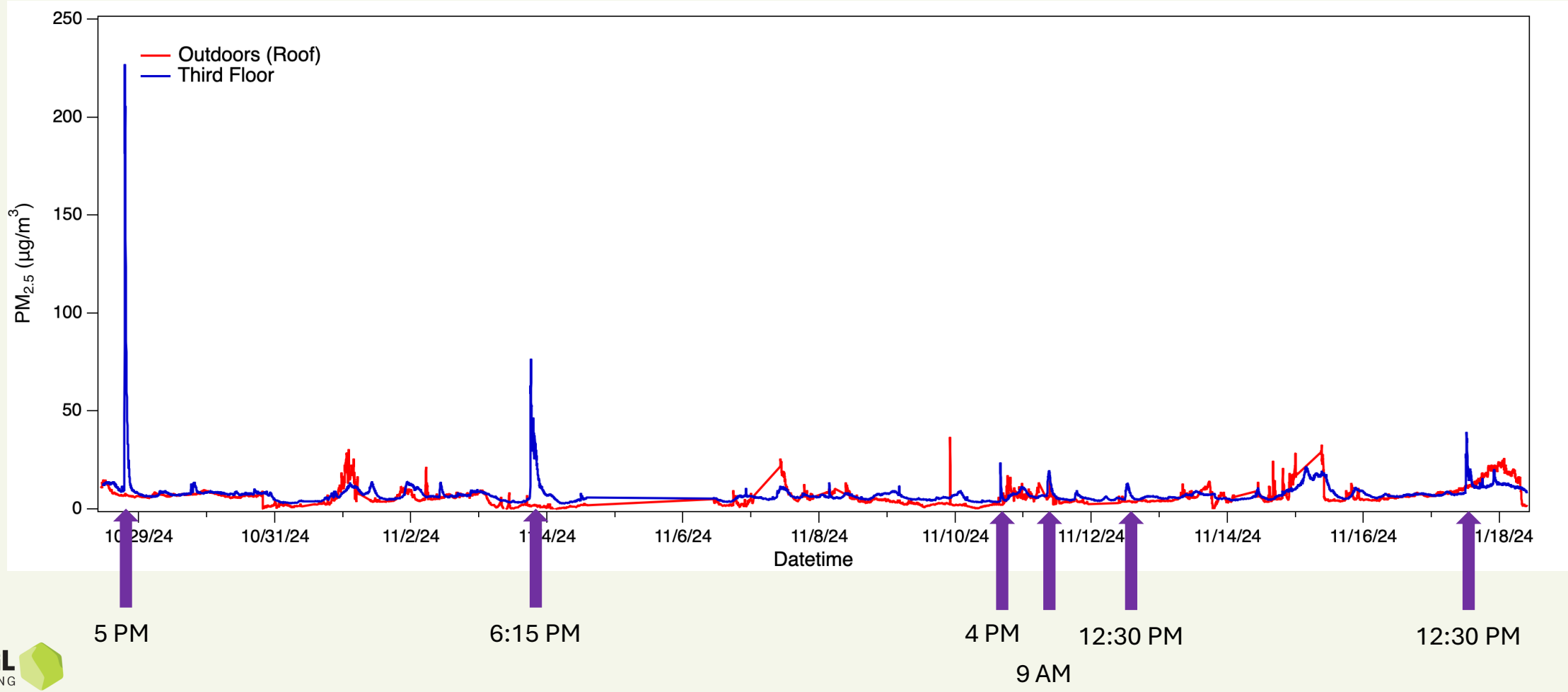
Time series data from the Purple Air sensors show evidence of significant emissions from indoor sources



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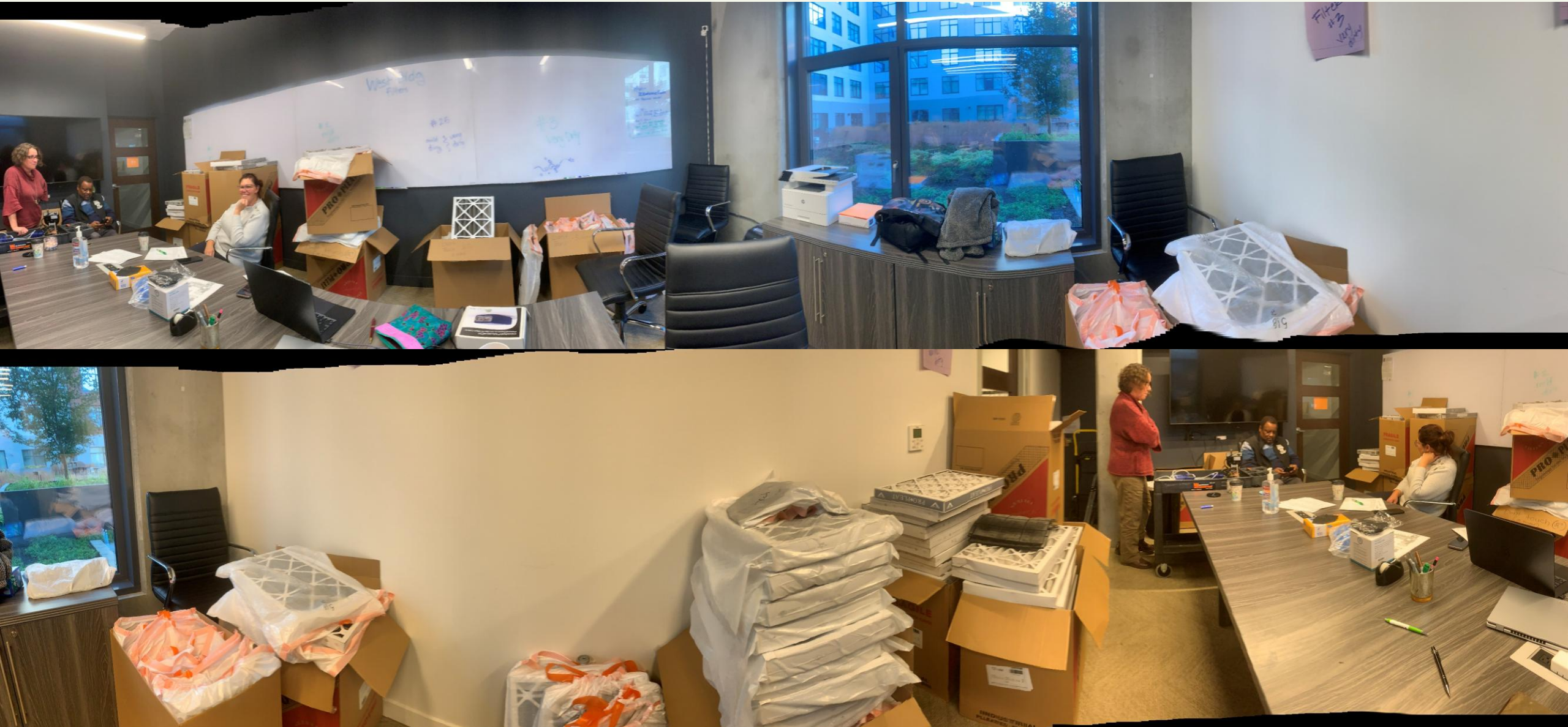
Site visit with measurements to determine sources of observed contaminants



Essential Instruments

Met-Once C12 Black Carbon Monitor

Particles Plus 8306 Particle Counter

Summarizing air pollution concentration data using the floor plan

- Each unit where measurements were taken is labeled by a star.
- Each unit is also labeled by the average concentration for black carbon and PM2.5 measured inside the unit.
- Outdoor concentrations are shown on each diagram for comparison with indoor values.
- Note the units for all concentration data is $\mu g/m^3$.

Observations from the onsite measurements

- Several units had PM2.5 concentrations that were higher than outdoor levels.
- Two units had very high concentrations of PM2.5. There was evidence of air fresheners, regular cooking, and candle use in these two apartment. Both units also had dogs.
- Overall, black carbon concentrations were low.

ROOM COLOR KEY:

= VERY DIRTY FILTER - 3

= MODERATELY DIRTY FILTER - 2

= MOSTLY CLEAN FILTER - 1

= EXHAUST DAMPER CLOSED

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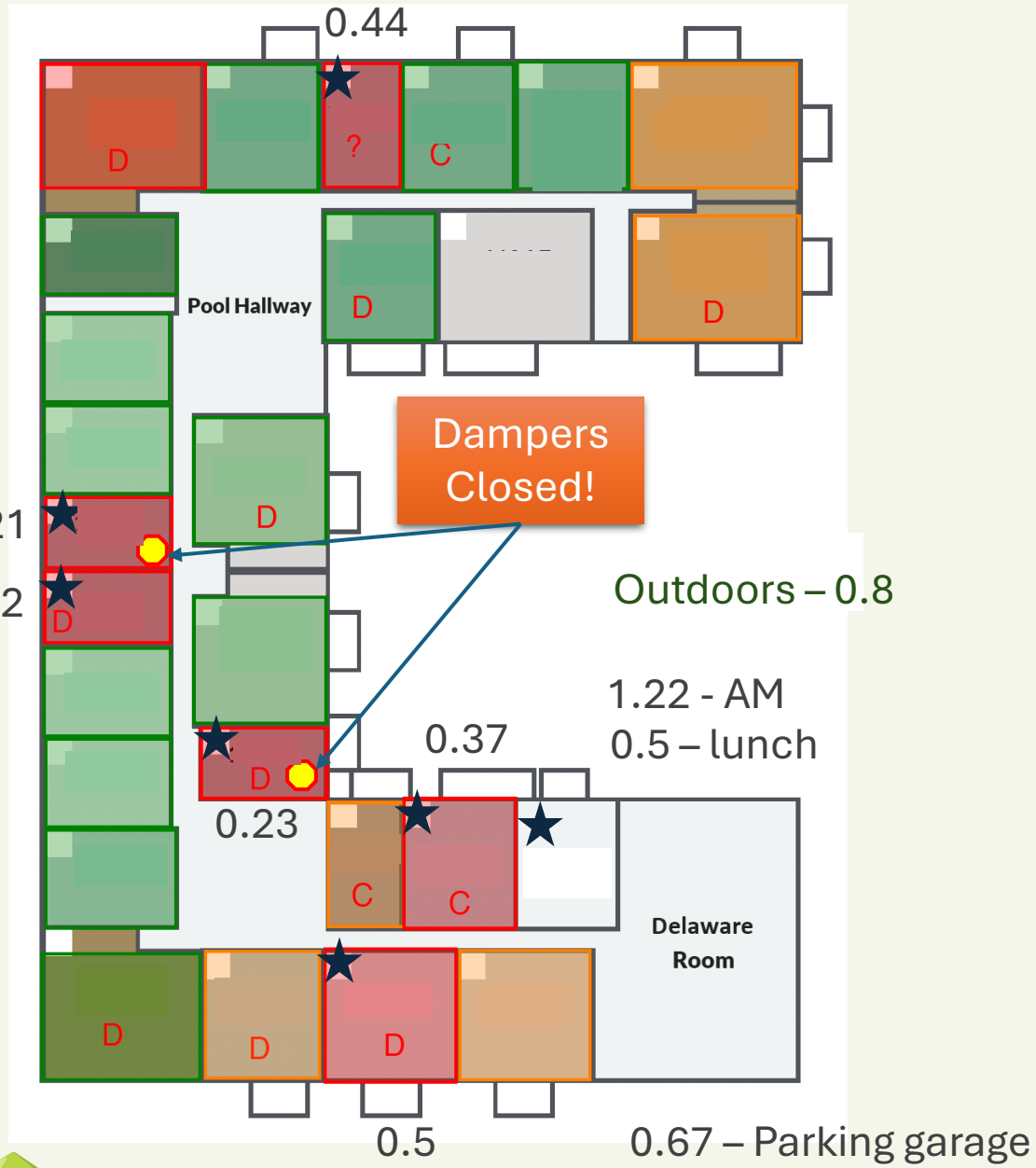
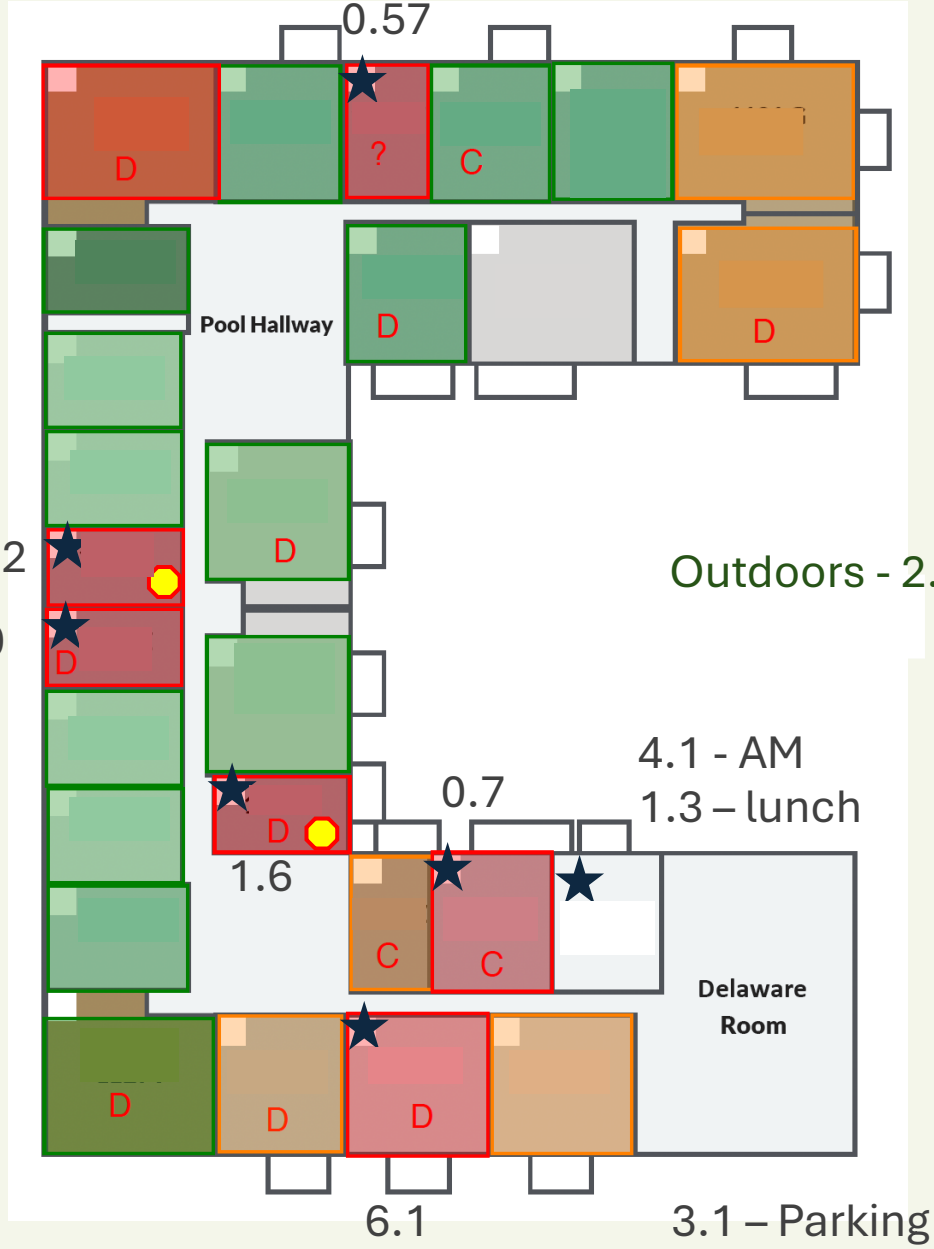
Black Carbon



PM2.5



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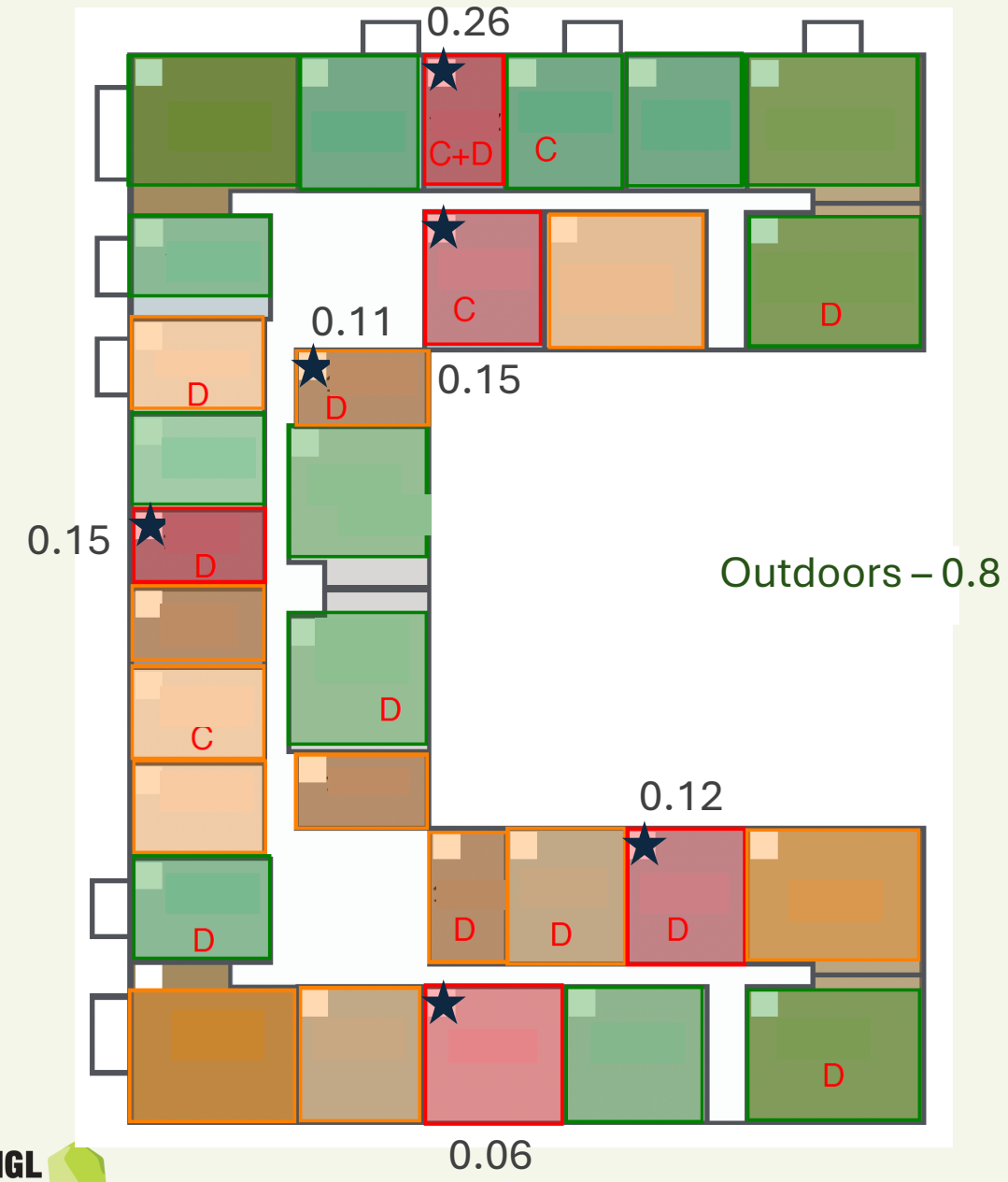
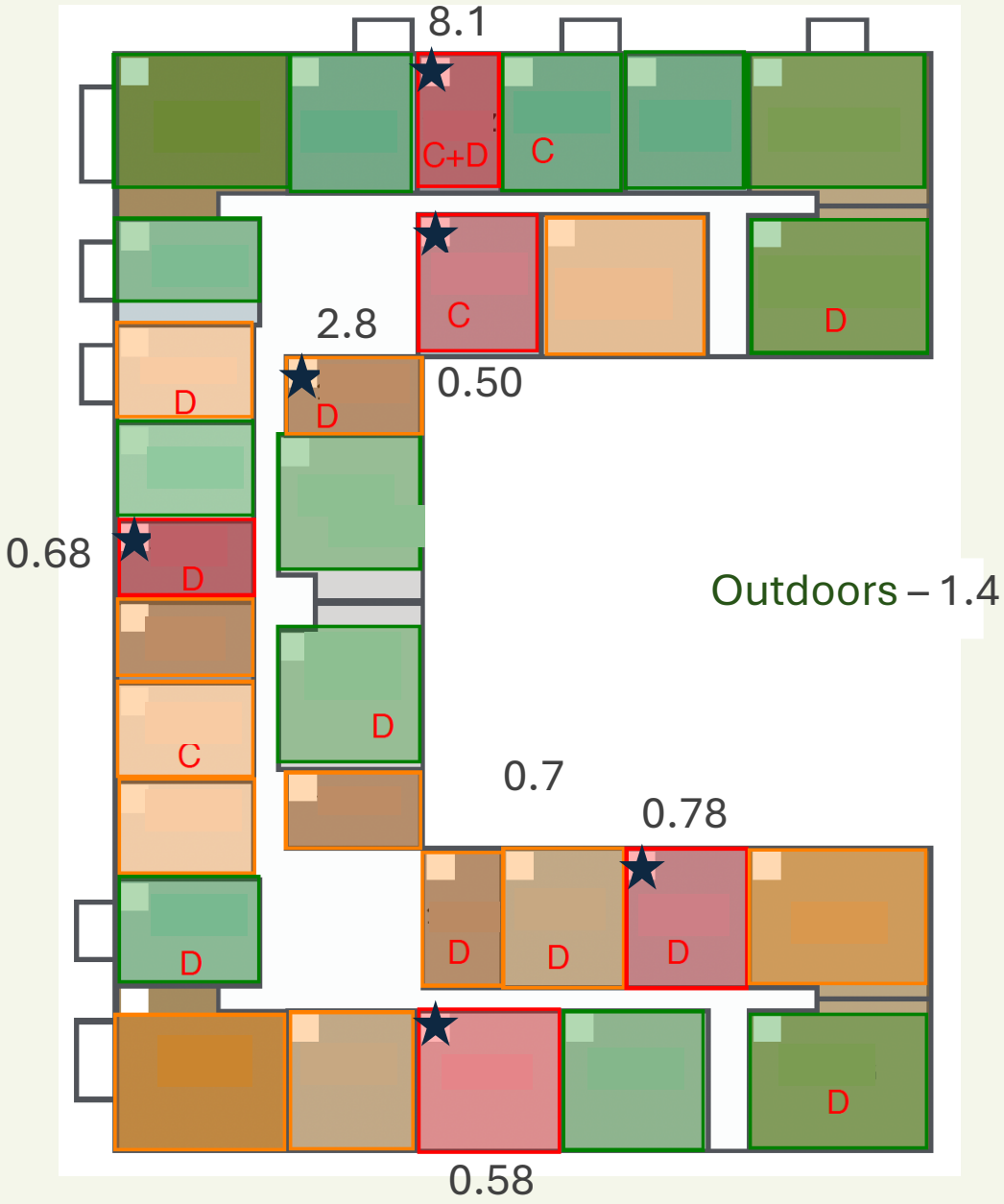
Black Carbon



PM2.5



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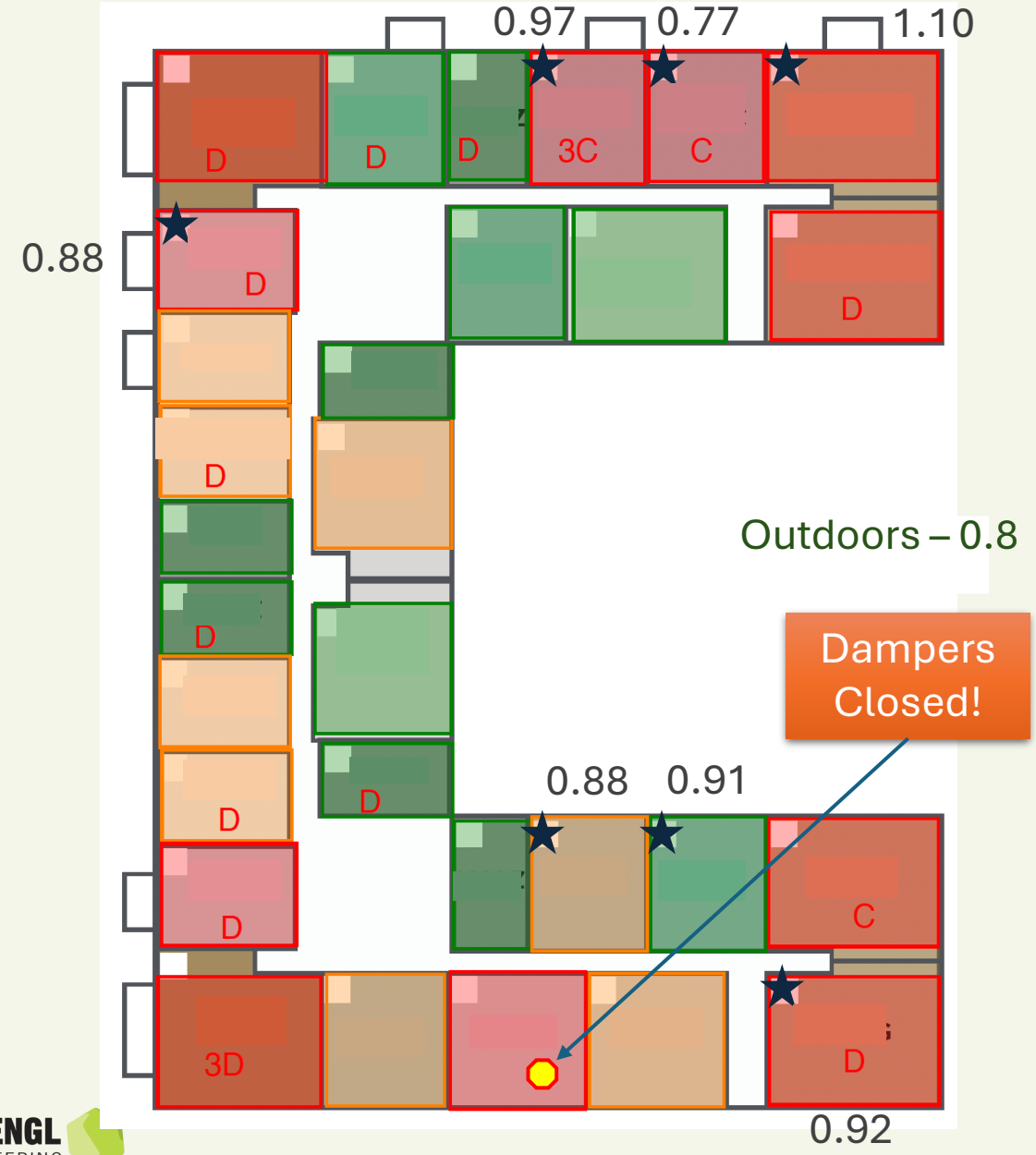
Black Carbon



PM2.5

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Black Carbon

Outdoors – 0.8

PM2.5

Outdoors – 4

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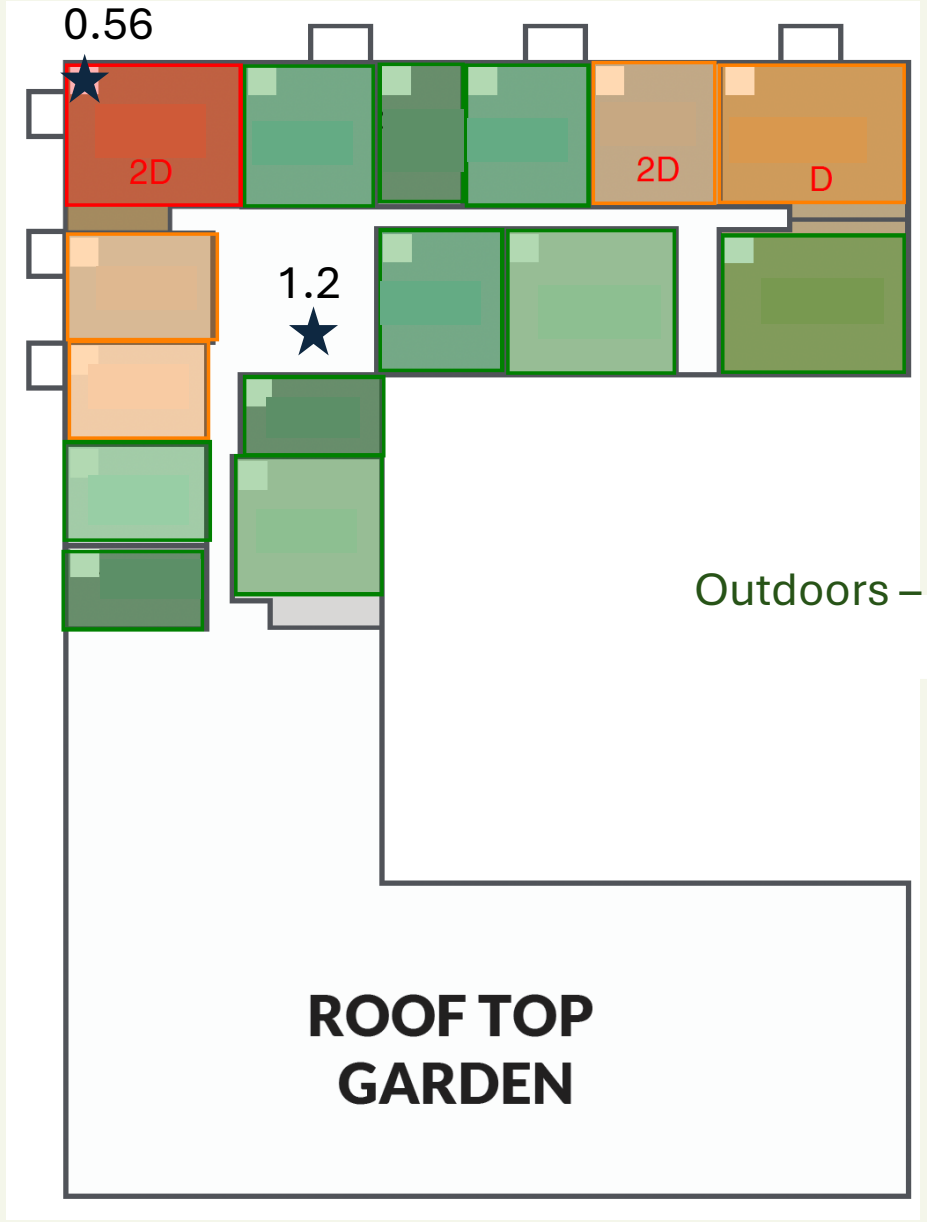
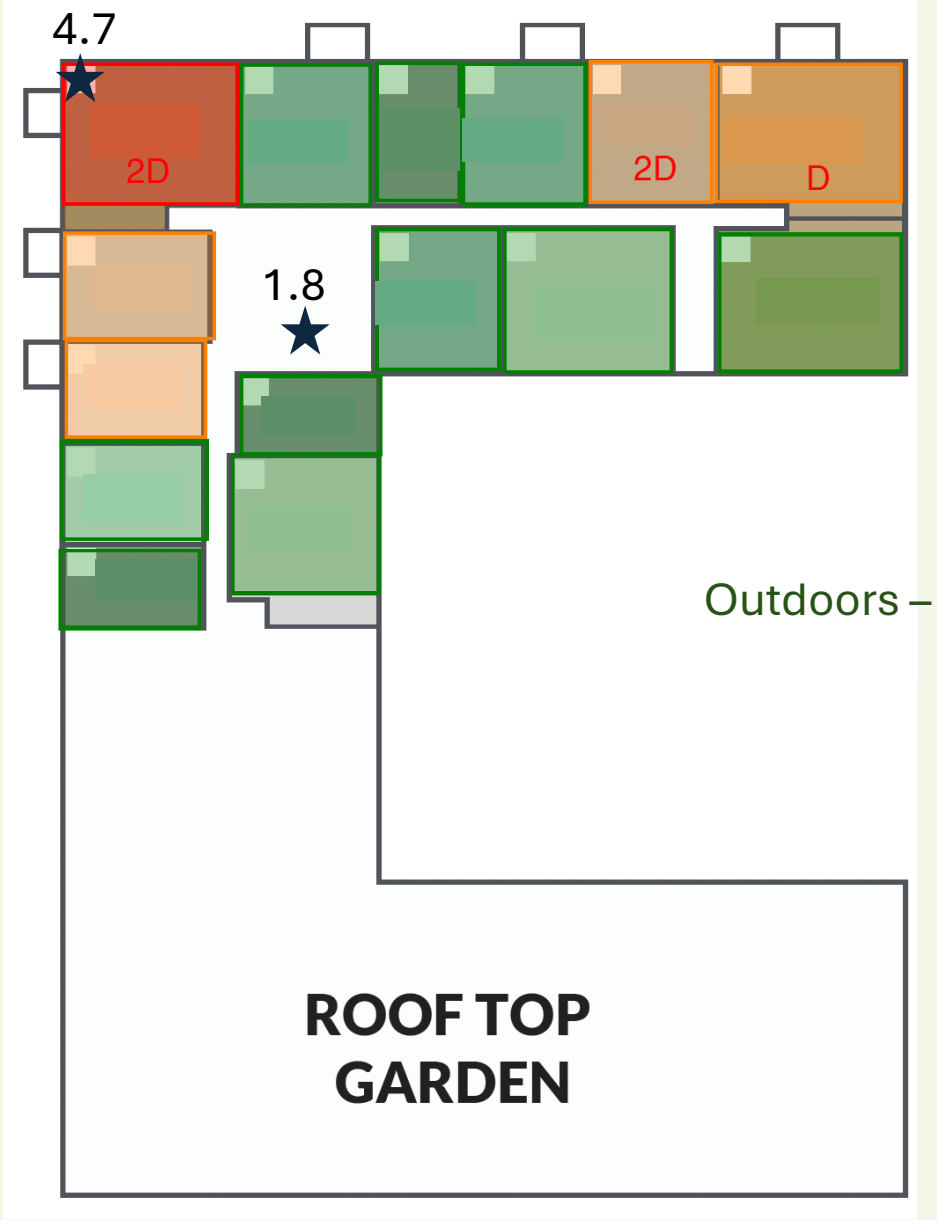
Black Carbon



PM2.5



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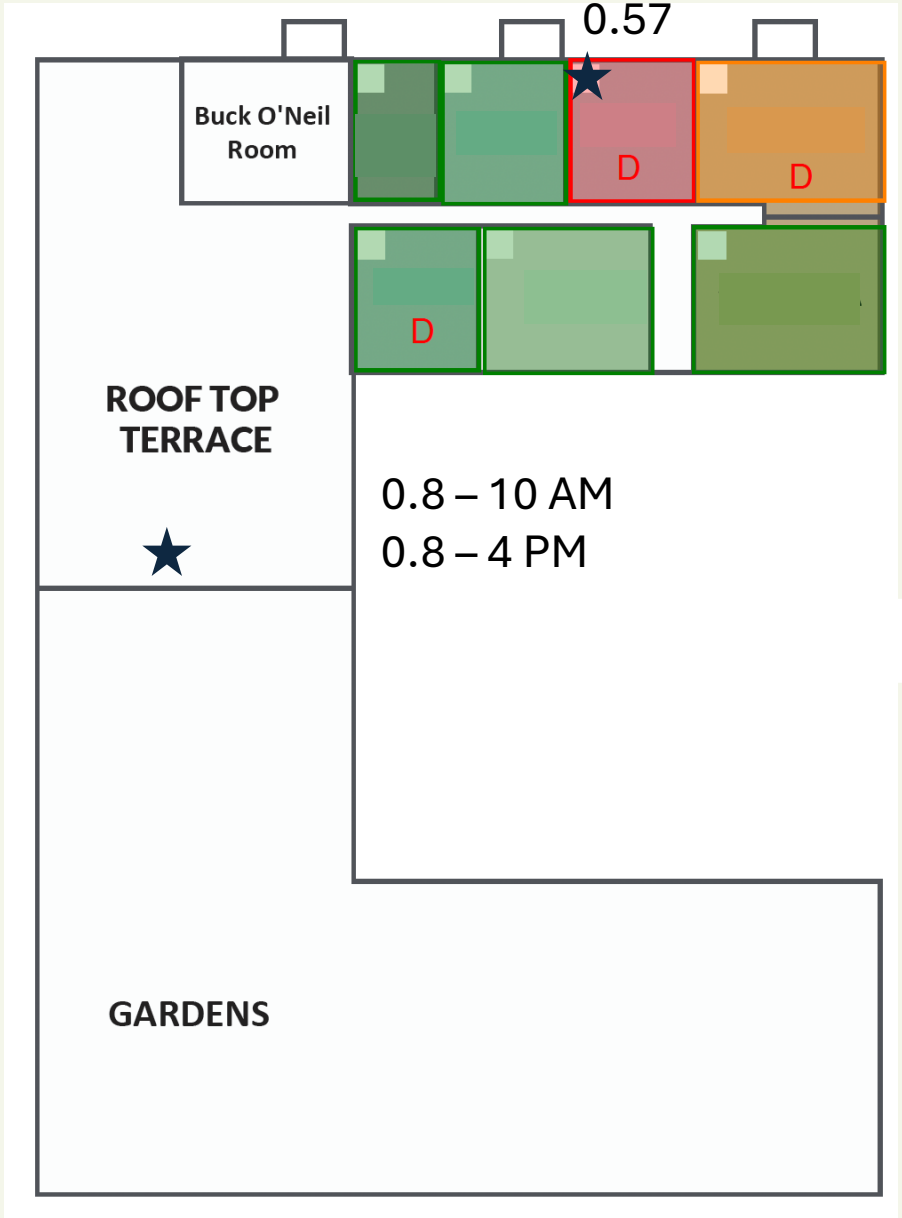
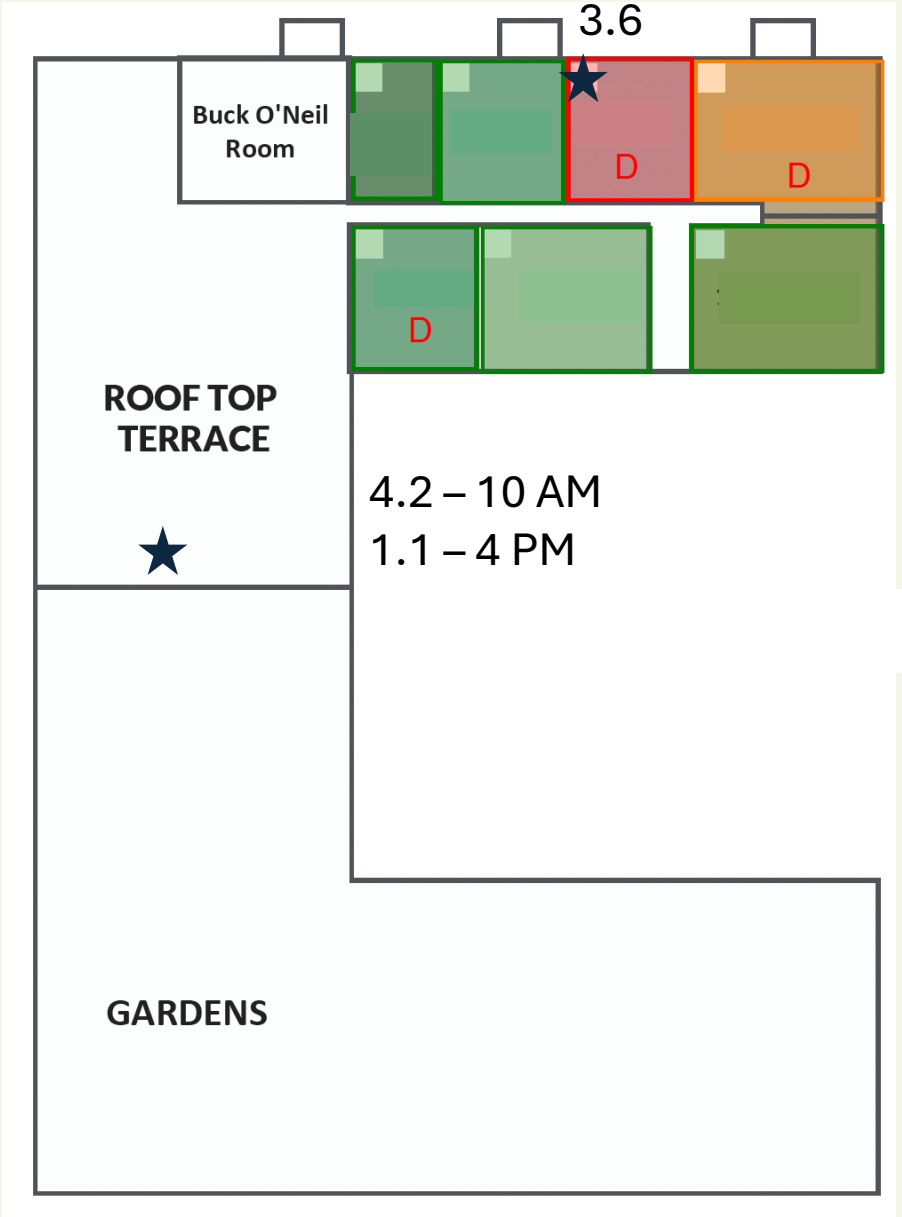
Black Carbon



PM2.5



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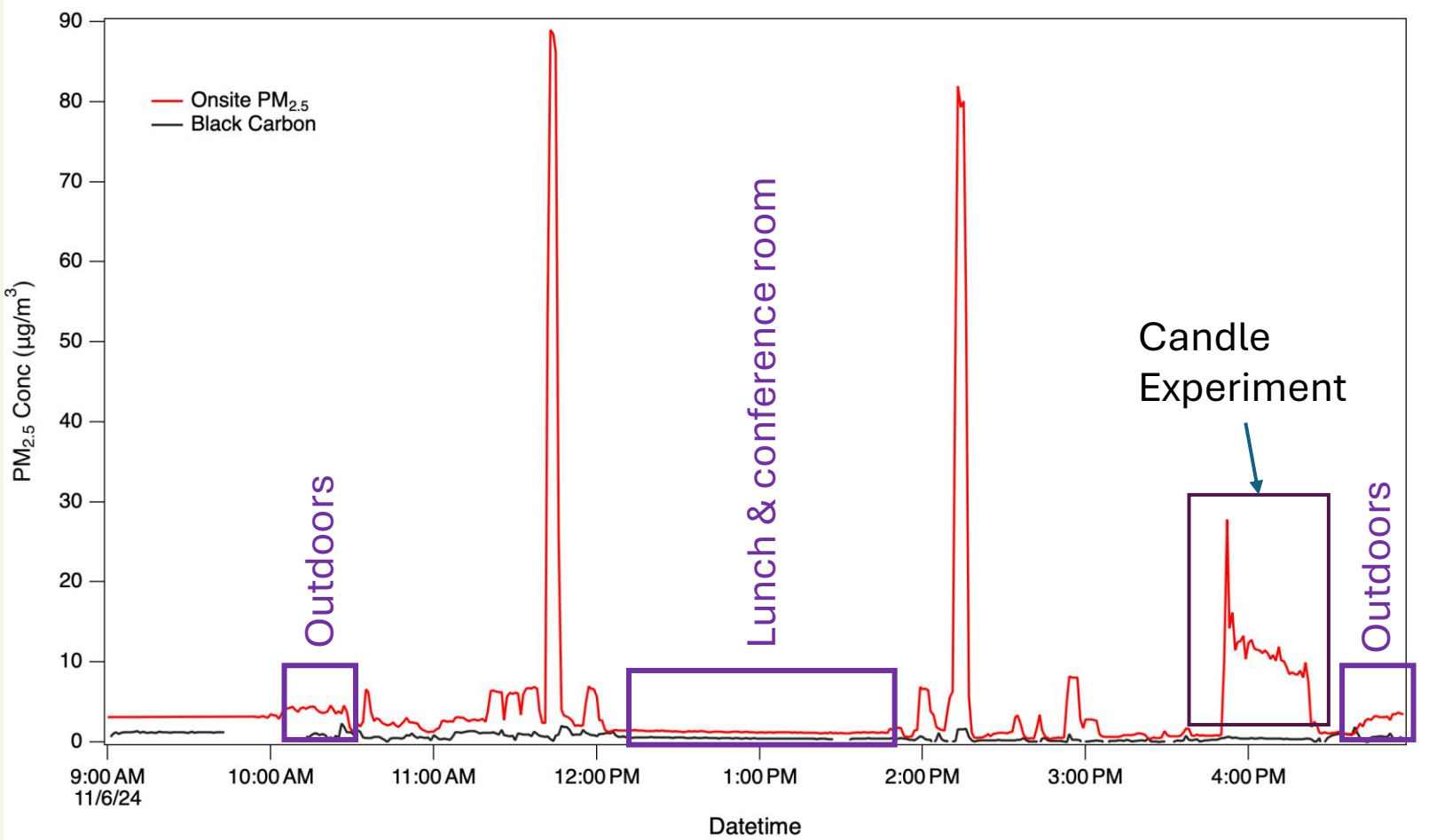
Measurements of PM and Black Carbon on site

- PM and Black Carbon was measured in units that had a heavily soiled or visibly black filter.
- We were in each unit between ~ 4 to 15 minutes.
- Outdoor conditions were measured at the beginning and the end of the day.
- Time series of measurements shows concentration in different apartments that were visited over the day.



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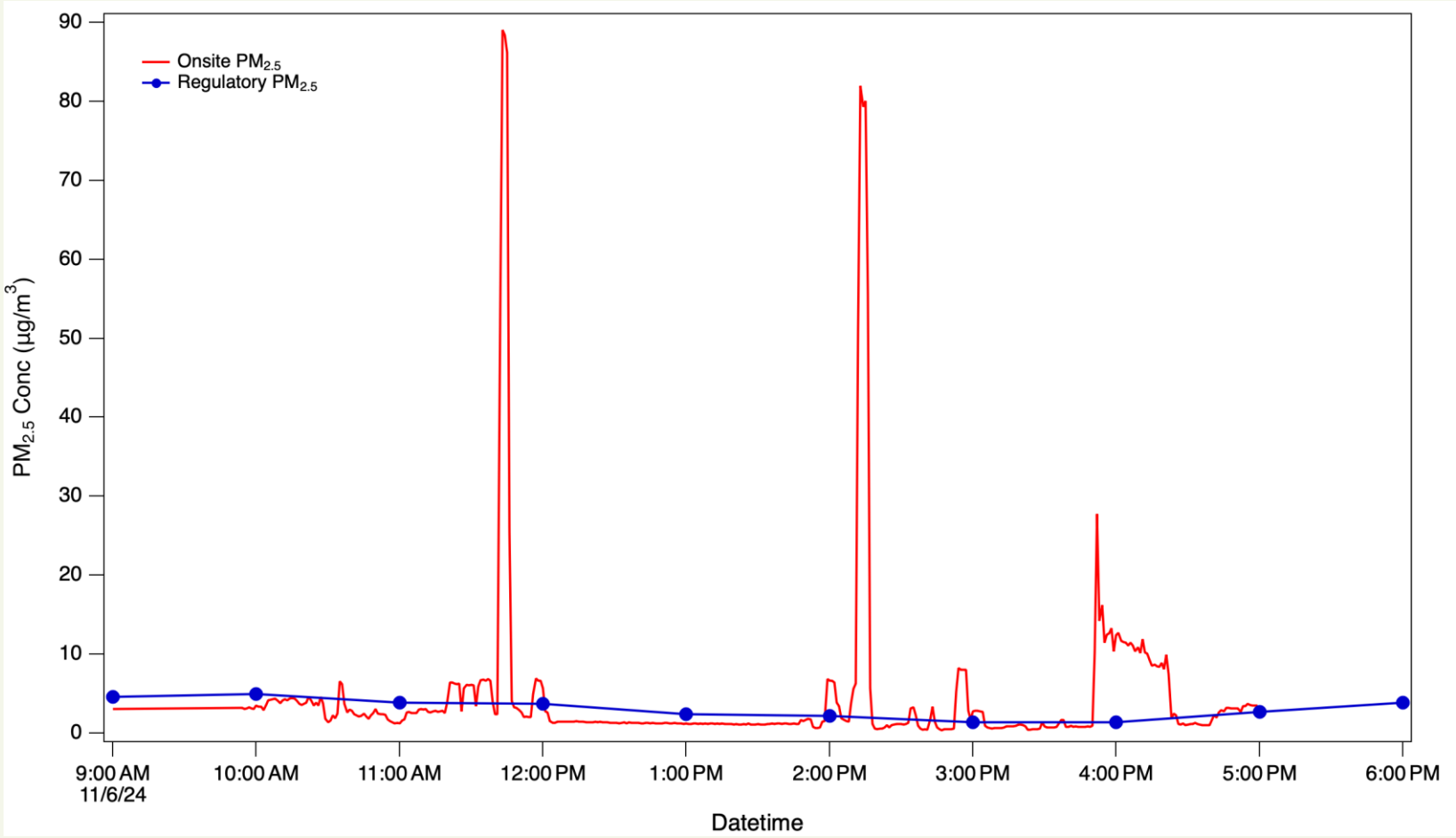
Indoor PM2.5 compared with nearby regulatory data

- Outdoor PM2.5 data is generally larger than indoors
- However, some of the worst units where the PM2.5 levels were significantly higher than outdoors indicating indoor sources.



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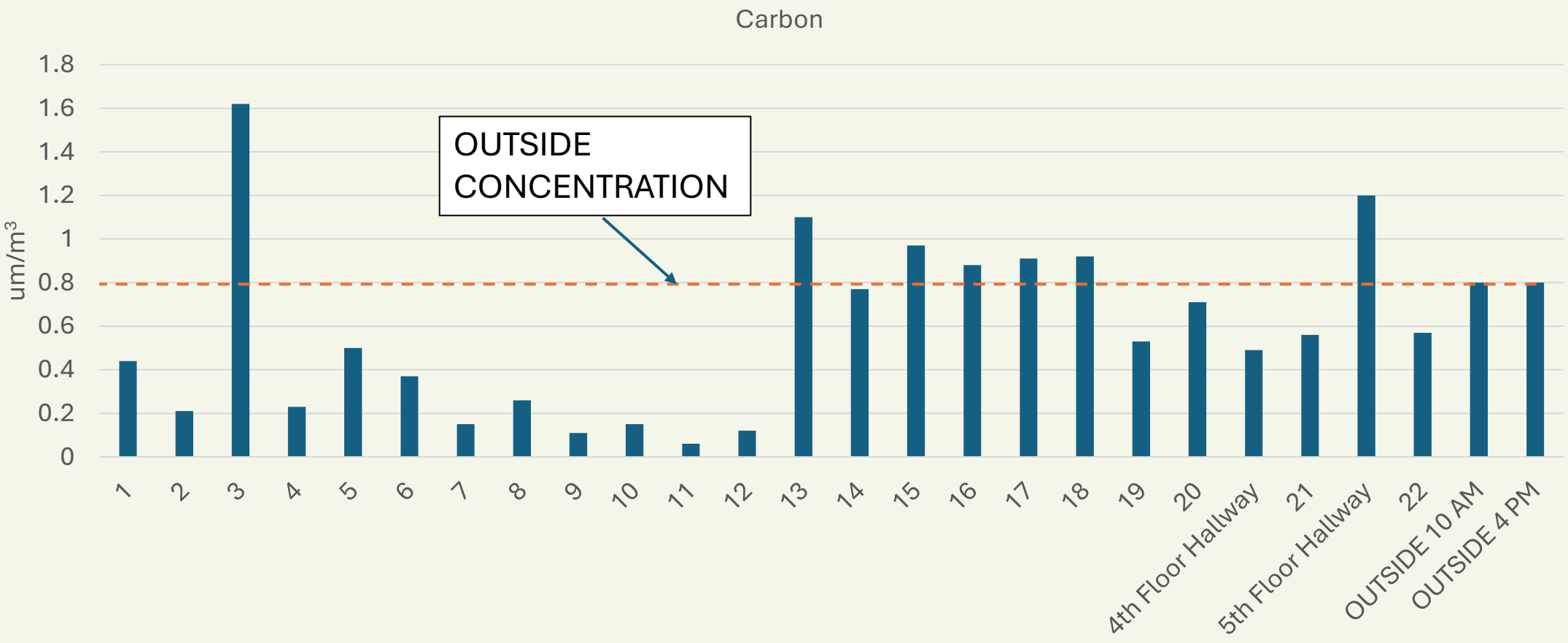
Black Carbon Measurements



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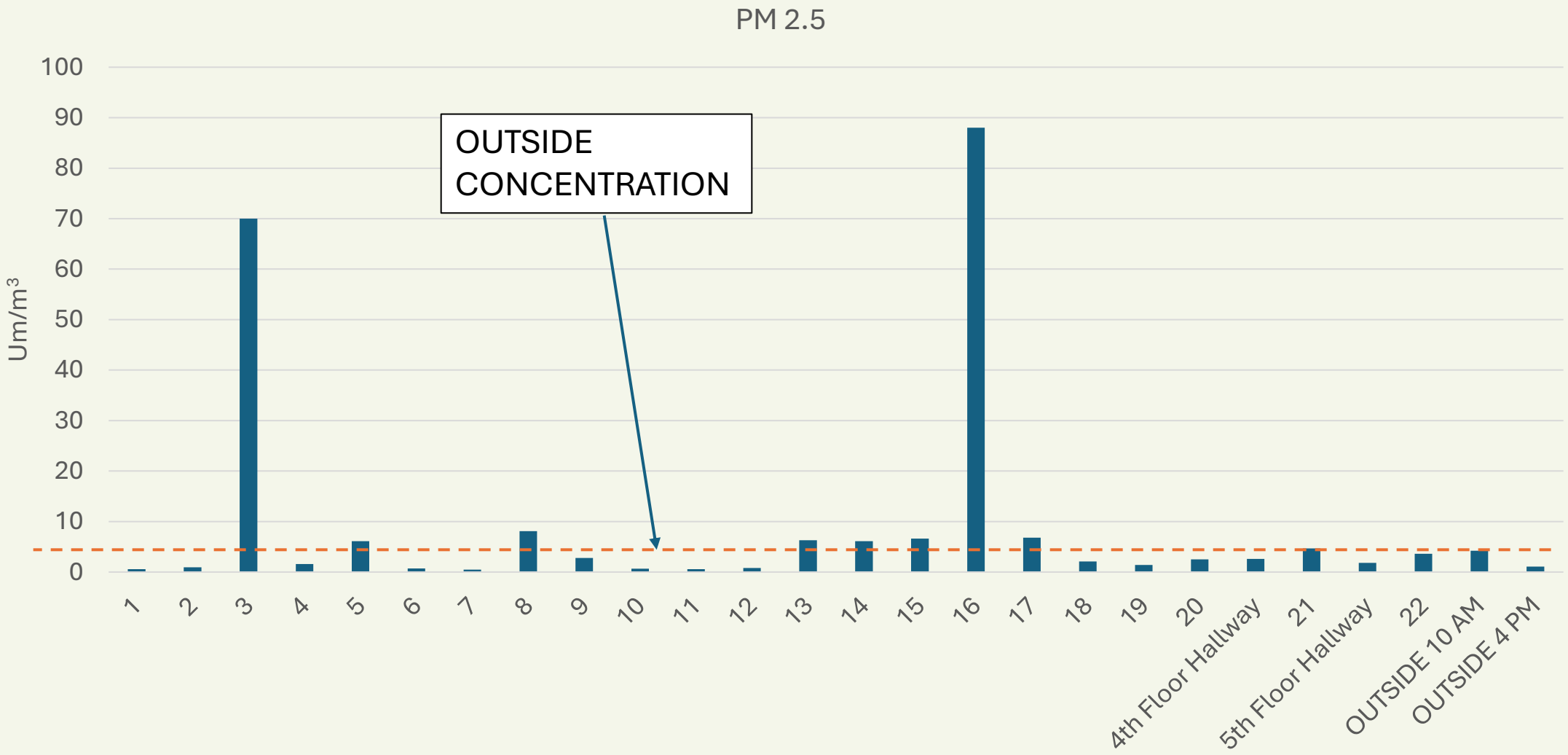

Pets in the Apartments

	Filter Rating	Number	%	w/ Pets	% w Pets?
RED	3	58	21%	38	66%
YELLOW	2	63	23%	29	46%
GREEN	1	154	56%	44	29%
TOTAL		275		111	40%

- Number of times ASHRAE 62.2, and IMC mention pets: 0
- Per animal facility work, pets need 30-40 cfm for air quality

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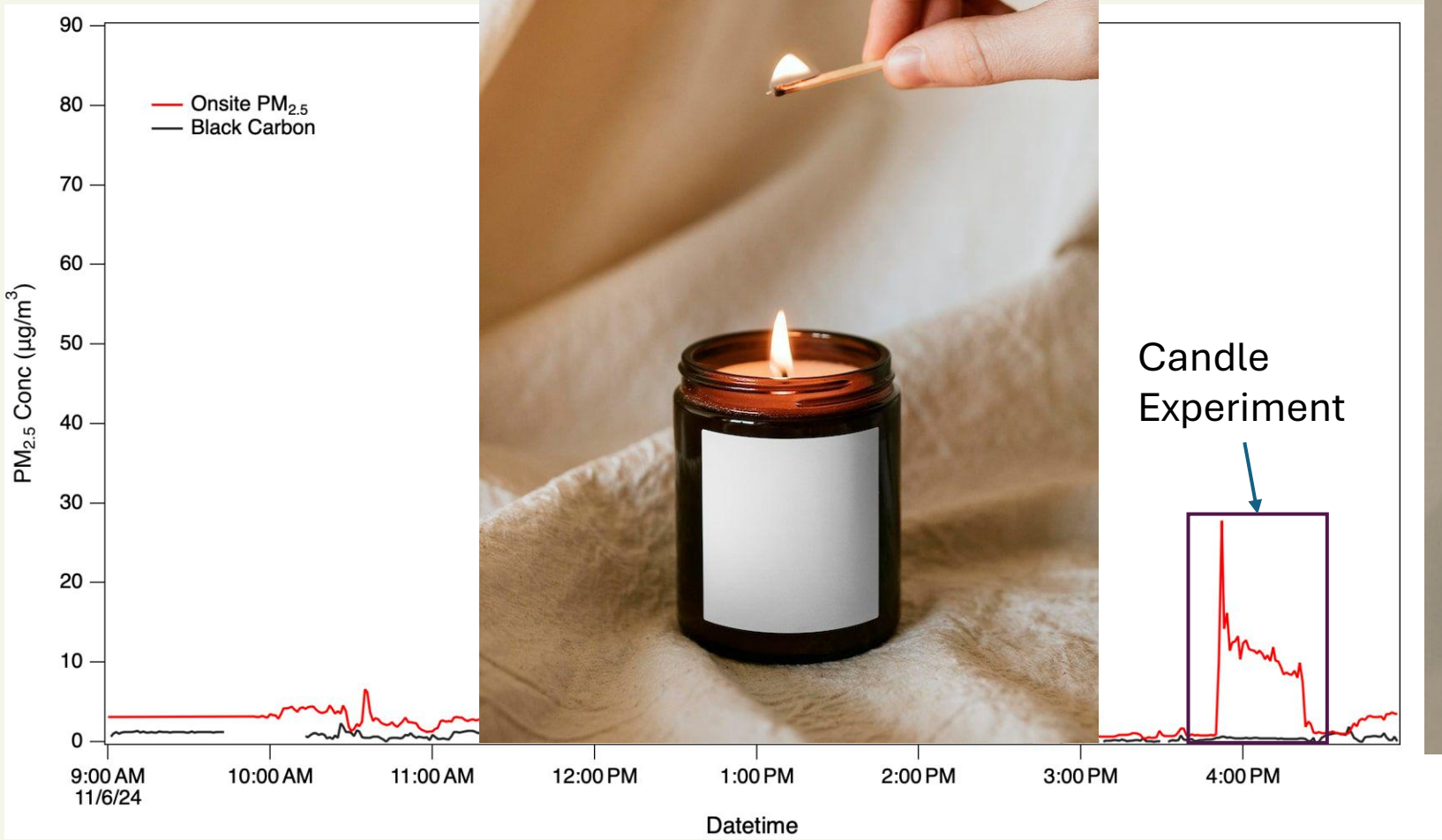
Kitchens

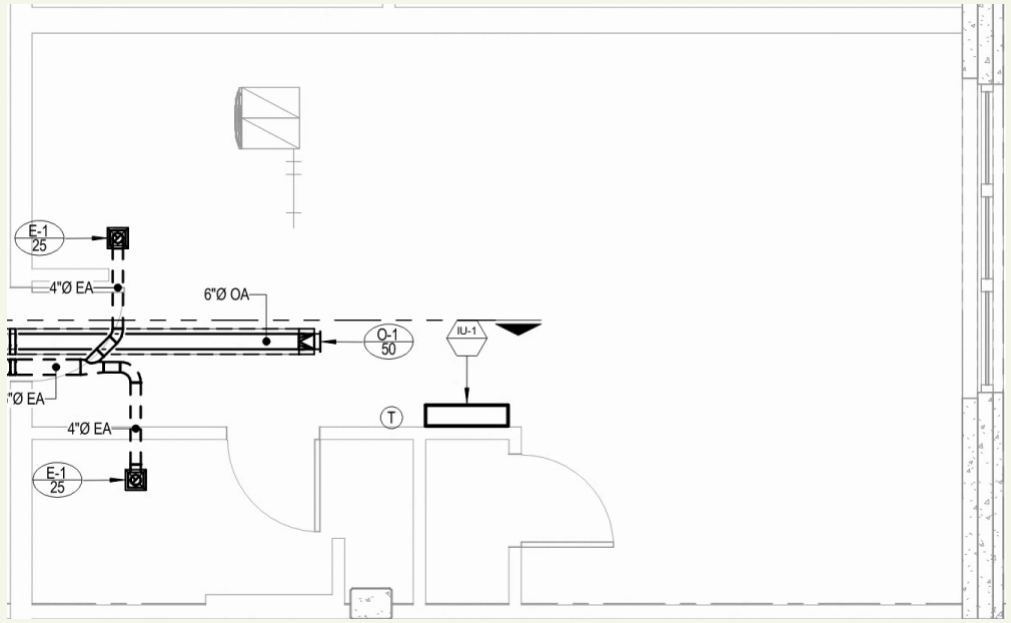
- Visible grease on grilles in apartments where there is a lot of cooking
- Corelates with black filters

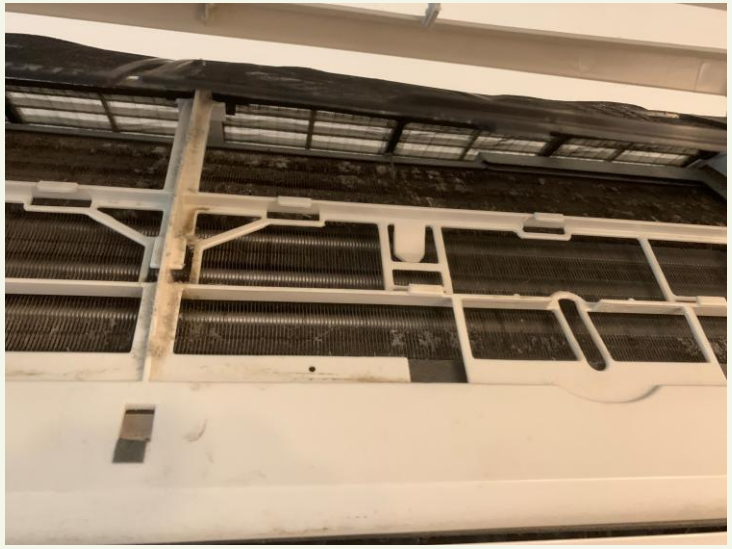
Other Indoor Sources



Candle Experiment

Coil build-up (ductless heads)





ERV Filters

- 12” Deep bag tilters changed to 8” deep
- Non-standard box dimension requires proprietary filter

OBSERVED ERV AIR FLOW RATES

- Several ERVs found not to be delivering design flow rates
- Building staff had not been properly trained to use Building Automation System
- Three rooms were found to have exhaust dampers fully closed

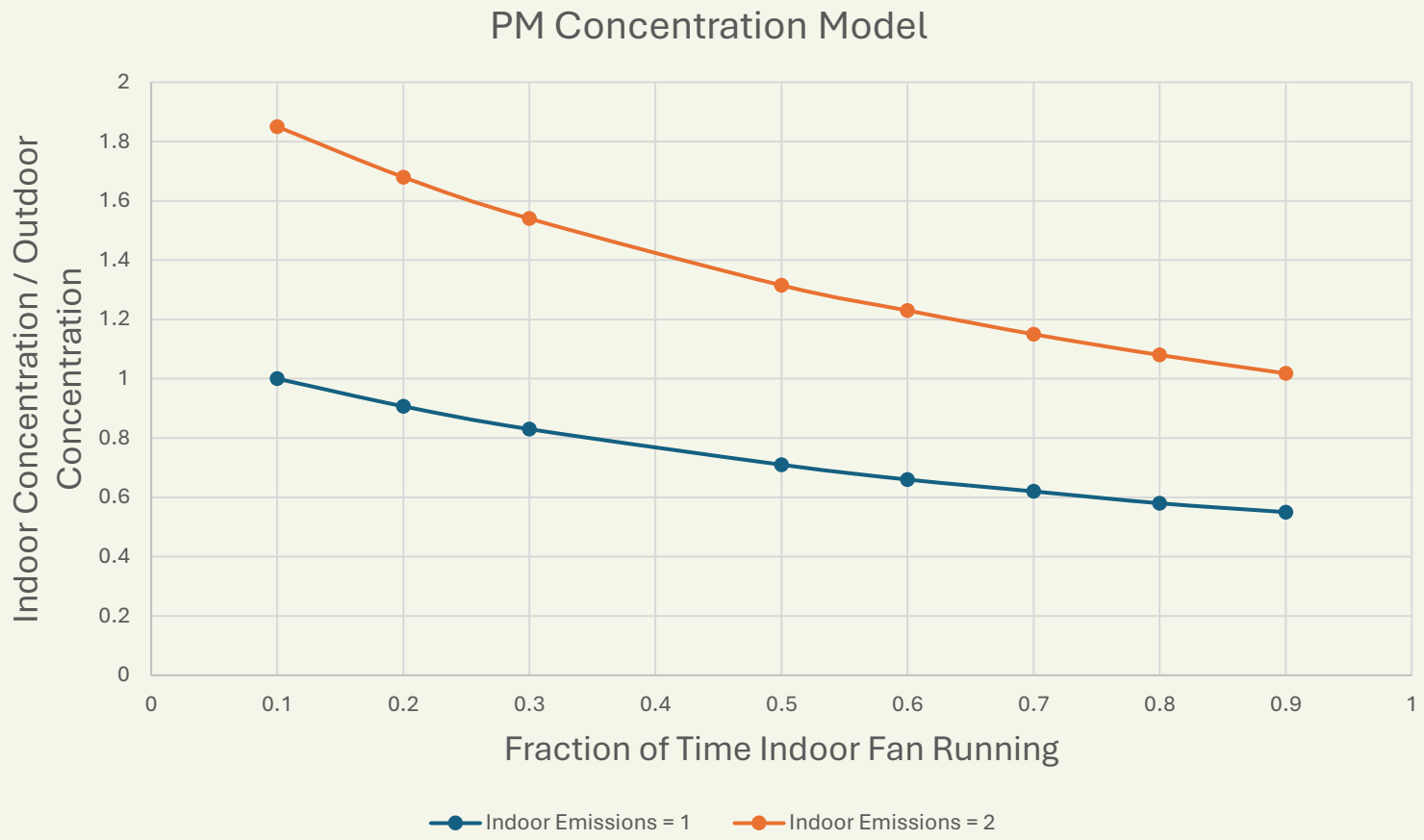
ERV	Design Flows		Observed Flows	
	Supply	Exhaust	Supply	Exhaust
ERV-1-1L	545	545	550	0
ERV-3-1W	1740	1740	1245	
ERV-4-2W	2080	2080	2080	2075
ERV-4-3W	2080	2080	512	2067
ERV-4-4W	2080	2080	2080	
ERV-3-5W	1705	1705	1313	
ERV-2-1F	1515	1515		
ERV-3-1E	1740	1740	1208	1793
ERV-4-2E	2080	2080	2079	2177
ERV-4-3E	2080	2080	2251	2280
ERV-4-4E	2080	2080	2111	2080
ERV-3-5E	1705	1705	1159	863

CONCLUSIONS

- Air quality found to be good for most apartments.
- Contamination of concern is from INDOOR sources, including:
  - Pets
  - Cooking
  - Candles
  - Atomizers (air fresheners)
  - Other
- Generally, building level PM is below outside air PM.
- Some of the ERVs were not operating as designed.
- Some exhaust grilles were found to be closed. Air balance is suspect.
- Indoor sources can be reduced by running indoor fans continuously.

Increased Filtration will Reduce PM

- Simple model to see impact of indoor fan filtration
- Assume MERV 13 filter
- Operating the indoor fan continuously reduces indoor PM, increases energy use



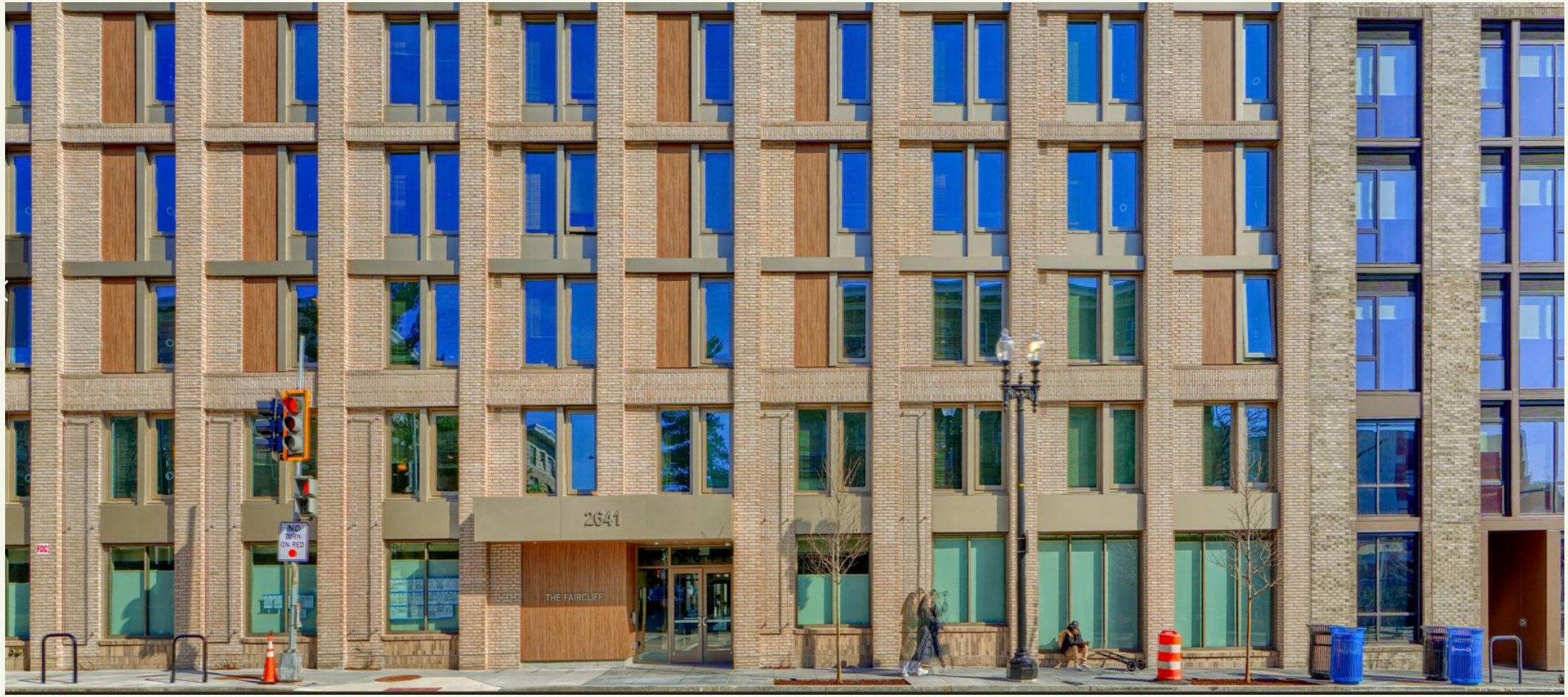
RECOMENDATIONS

- Retro-commission ERVs and check air balance
- Train staff on BAS interface and alarms
- Seek third party source for ERV bag filters
- Apartments with pets may need more frequent filter change and perhaps better filtration.
- Running HVAC fans continuously on low flow will reduce interior PM concentrations

Future Project Recommendations

- Ducted ranges for populations that cook!
- Train staff on systems better
- Educate staff to educate building occupants to reduce interior sources
  - Candles
  - Incense
  - De-oderizors
- Single point ventilation units reduces the cost of filter change
- Plan for fans to operate continuously on low, or cycle to reduce indoor particulate
- Apartment slightly **negatively** pressurized with respect to the corridors to avoid odor migration

Faircliff Plaza



Jonathan Rose Companies

Somerset DEVELOPMENT COMPANY

ECA

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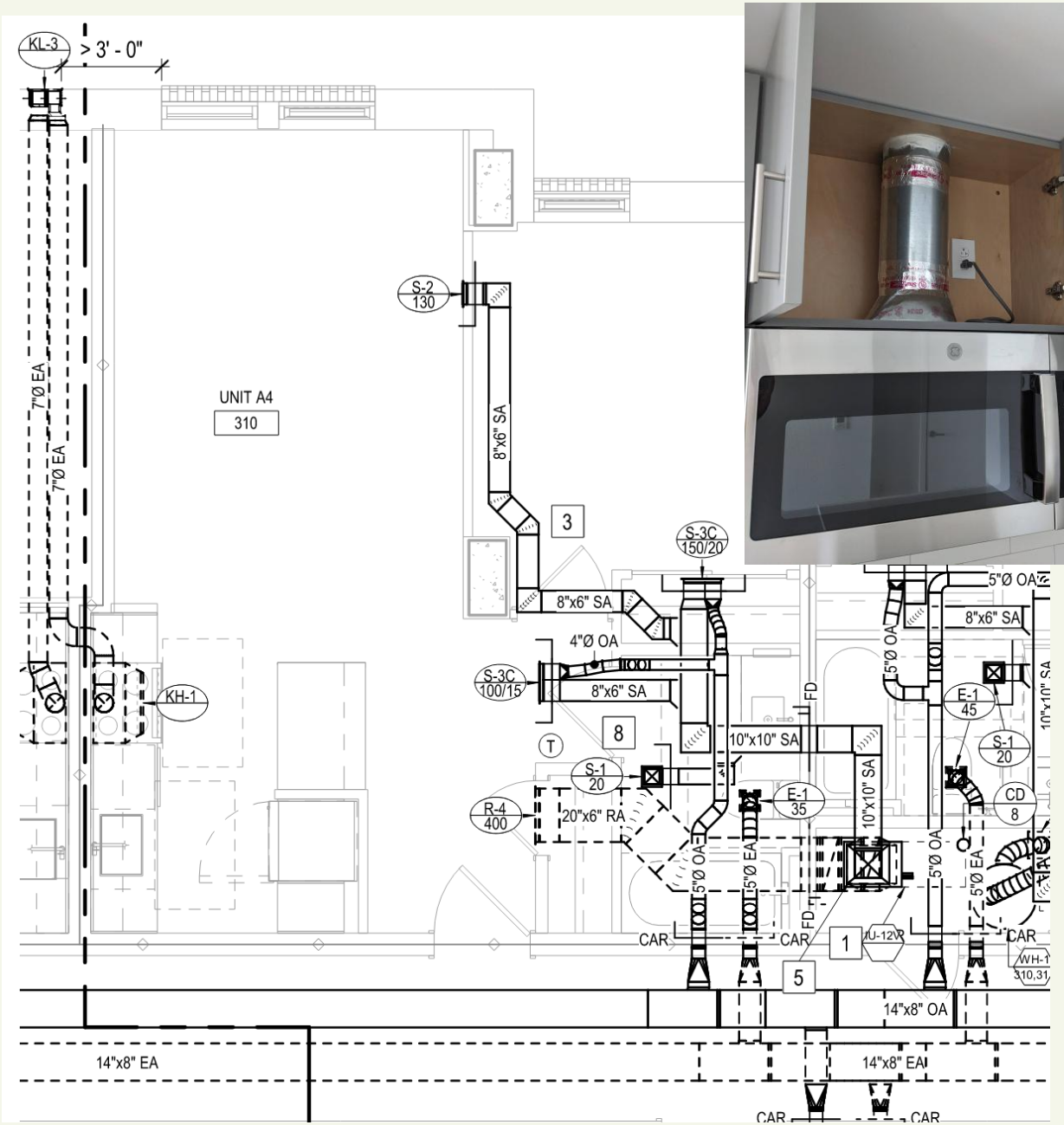
Faircliff Plaza

- Ducted Range Hoods
- Ducted indoor units in all apartments for filtration
- Single ERV/DOAs unit reduces filter change cost
- Heat pump indoor unit accessed from corridor to eliminate need to access apartments for maintenance
- Automatic air-flow dampers on each floor serving CAR dampers at apartments



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High efficiency filtration for recirculating hood

ACTIV AQ: PH-1

Thank You!

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Photo Credit: Ezra Staengl