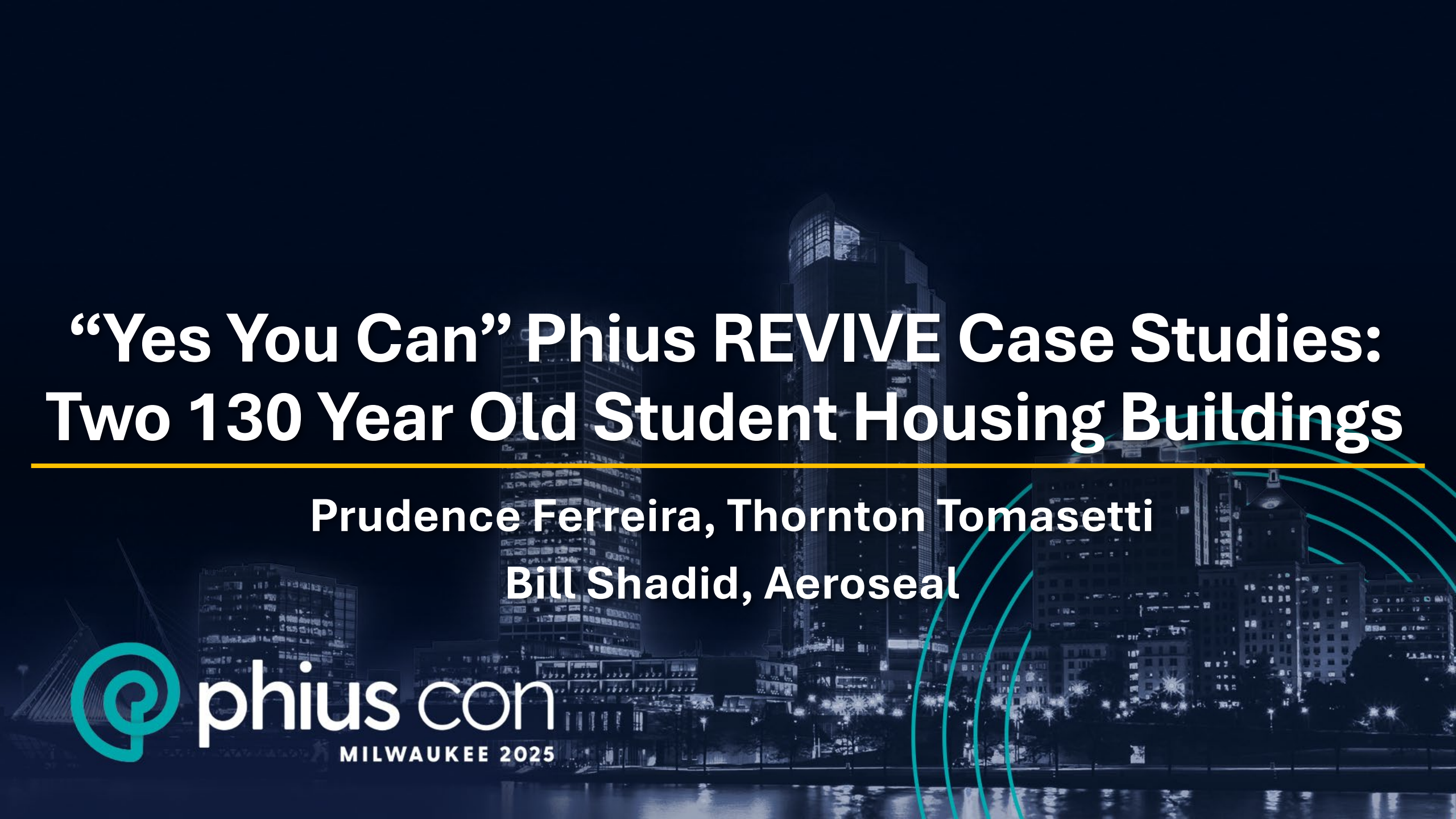
“Yes You Can” Phius REVIVE Case Studies: Two 130 Year Old Student Housing Buildings

Prudence Ferreira, Thornton Tomasetti
Bill Shadid, Aeroseal



Agenda

- Speaker introductions & review what we'll cover
- Project context & goals
- Strategies & prioritization
- Phius strategies & implementation
- Results
- Lessons learned
- Q & A with discussion

Session Speakers

Prudence Ferreira

VP Sustainability + Resilience:
Passive Building Lead
Thornton Tomasetti

Bill Shadid

Business Development Leader:
Architects & Engineers
Aeroseal

Learning Objectives

1. Learn real world, design and field based lessons from two successful Phius REVIVE historic building renovation projects that can be applied to attendee's businesses.

2. Discover challenges and opportunities that are unique to Phius REVIVE projects vs. new construction Phius standards.

3. Define project communications and coordination strategies that lead to the achievement of the Phius REVIVE standard in older buildings to be renovated.

4. Understand that the Phius REVIVE standard can be achieved with older, more historic buildings with thoughtful planning and care during design and construction.

Project Context & Goals

Two Historic Structures To Be Renovated at Harvard University

- Add housing units for graduate students and faculty
- Build sustainable housing that is better for residents and the environment

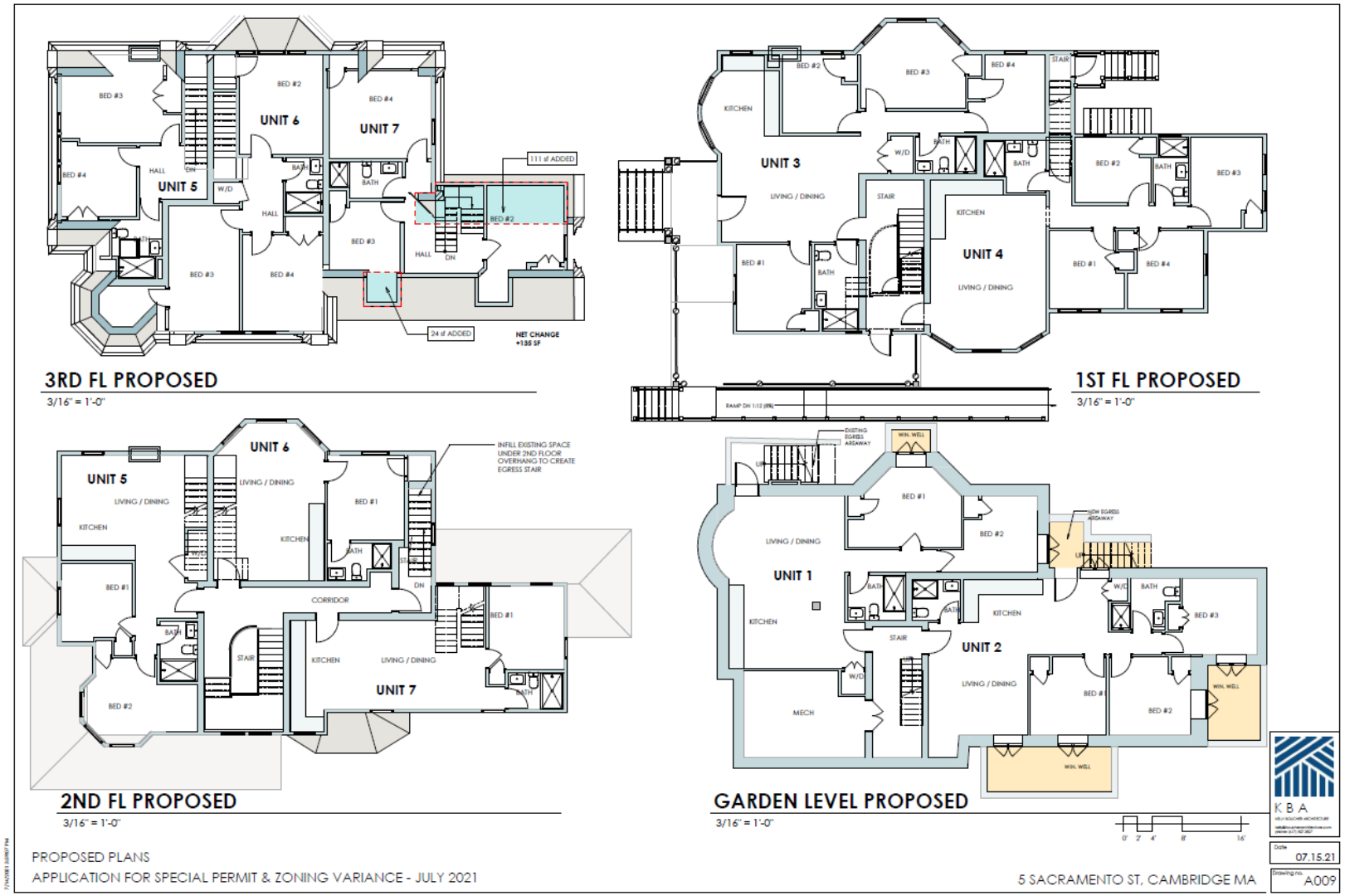
5 Sacramento Street, Cambridge MA

13 Kirkland Place, Cambridge MA

5 Sacramento Street Pre Renovation

- Built in 1891
- Queen Anne Victorian
- Renowned local architect George Fogerty
- 9,260 square feet
- Wood frame construction
- Used as a healthcare clinic prior to renovation
- Goal: renovate to include 5 units

5 Sacramento Street Renovation Plans

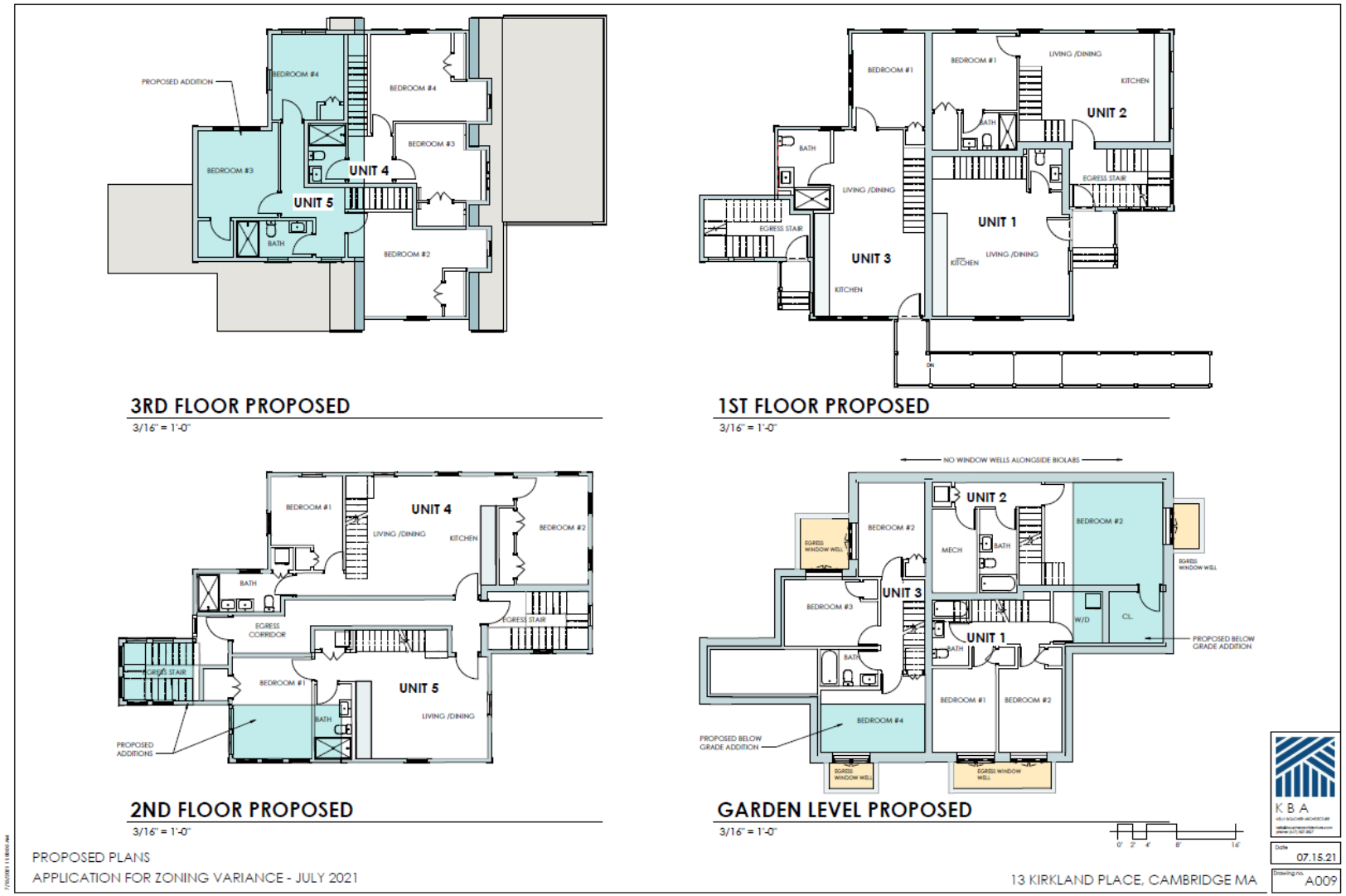


Images courtesy of Kelly Boucher Architecture

13 Kirkland Place Pre Renovation

- Built in 1856 as a 2 story, 14 room single family home
- Expanded in early 1900's
- Bracketed Italianate
- By Isaac Cutler
- 5,386 square feet
- Wood frame construction
- Used as a 3 unit residential building prior to renovation
- Goal: renovate to include 4 units

13 Kirkland Place Renovation Plans

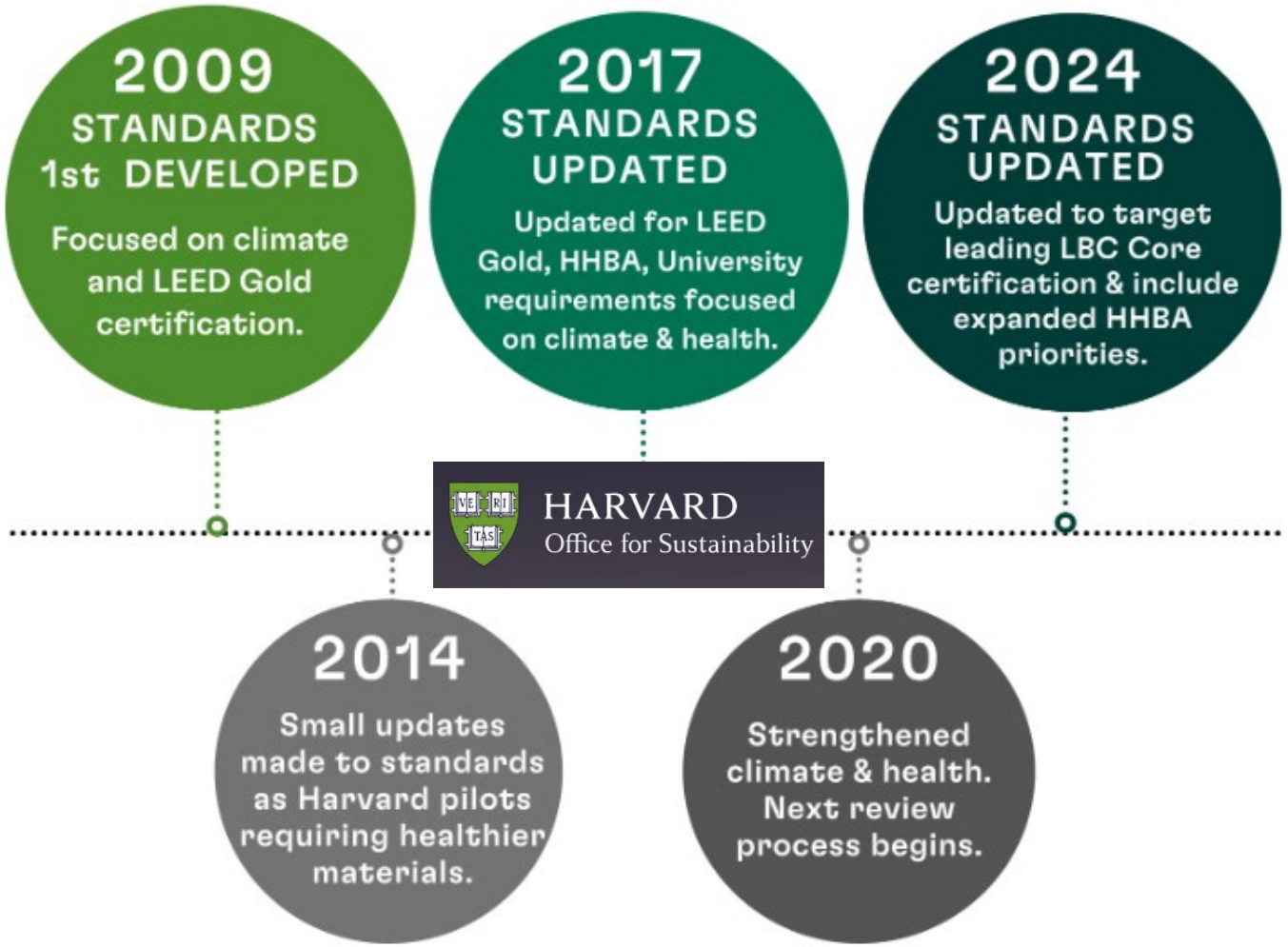


Images courtesy of Kelly Boucher Architecture

Project Details

Project Details/Info	5 Sacramento Street	13 Kirkland Place
Location	Cambridge, MA	Cambridge, MA
Climate Zone	5A-Cool-Humid	5A-Cool-Humid
Building Type	Multifamily	Multifamily
Project Type	Retrofit	Retrofit
# of Stories	4	4
# of Units	5	4

Harvard Sustainability Standards



14 Product Categories for Healthier Materials

The HHBA has expanded its list of interior product categories from five categories in 2017 to 14 categories in 2024.

Achieve 2 Ambitious Sustainability Certifications

phius
CORE REVIVE

CORE
GREEN BUILDING
CERTIFICATION

International Living Future Institute

Phius Core REVIVE 2021

- 1st Question: Can we do Phius REVIVE 2024?
- 2nd Question: What does LBC Core require that aligns with Phius reqs?
- 3rd Question: Can we meet Phius 2021? What are hurdles?
- 3rd Question: Can we do this cost-effectively? How?

Strategies & Prioritization

Passive Building Strategy Development

- Phius Verifier involved in passive building strategy and how that might affect air tightness
- Due to historic preservation requirements, exterior envelope would need to be improved from the inside
- A second wood stud wall was built inside the exterior wall with separation and staggered joints
- Closed cell spray foam to be applied to walls and roof
- AeroBarrier air sealing to be applied after spray foam installed, complemented by targeted manual air sealing

Improving the Envelope From the Inside

Before New “Interior Wall”

After New “Interior Wall” Framed

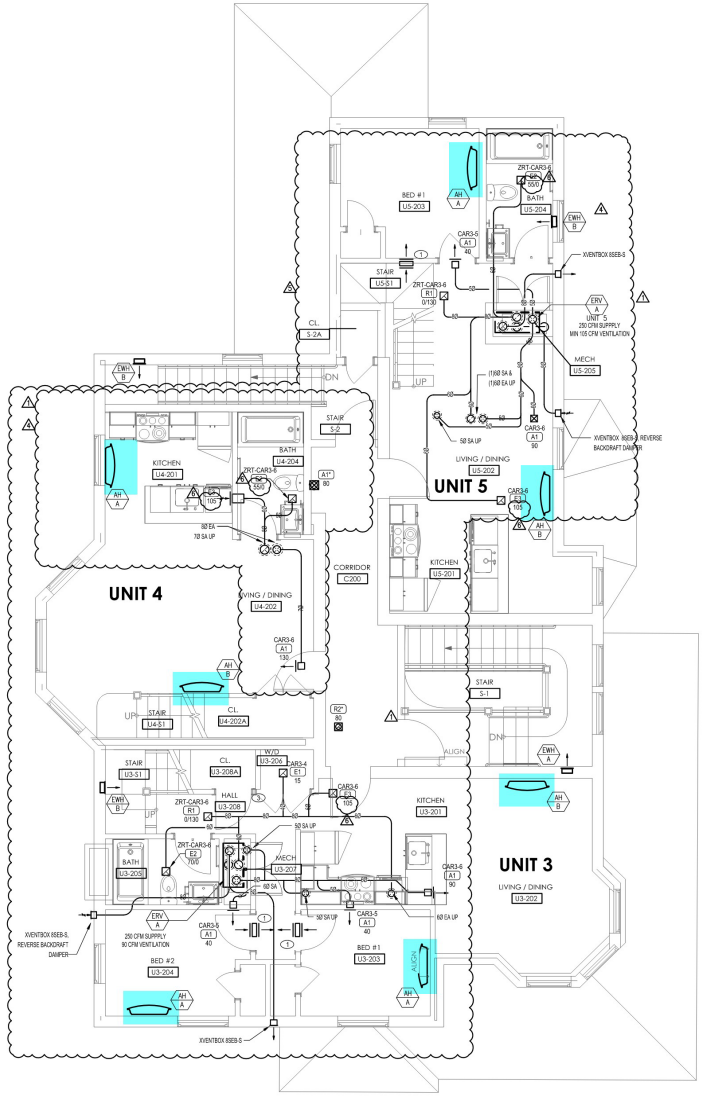
Photos courtesy of Mark Newey, Phius Verifier

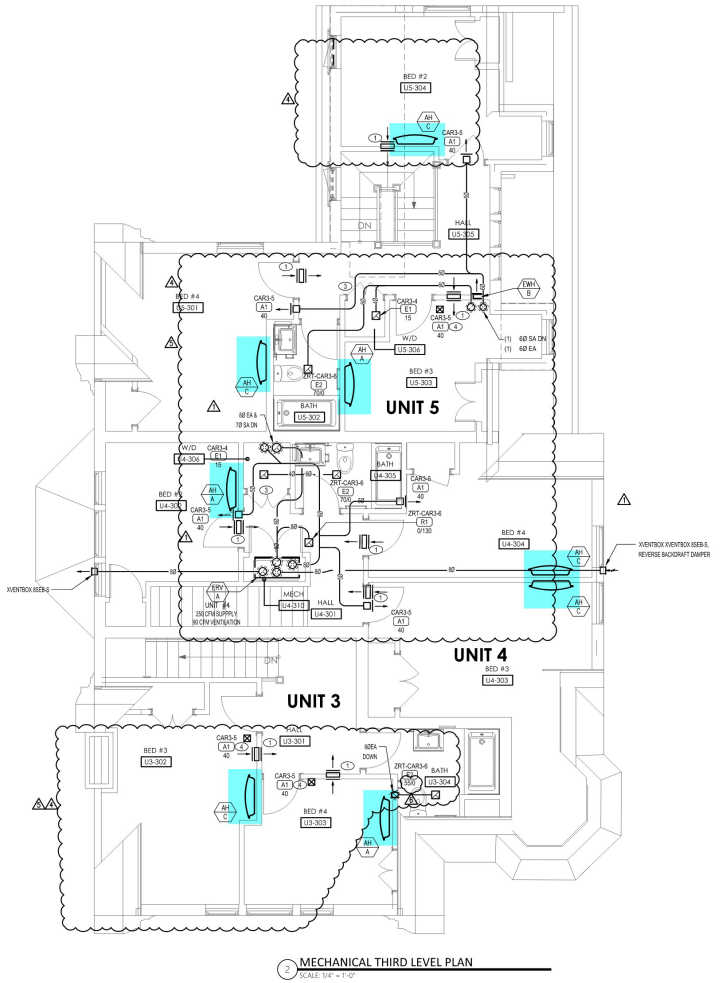
Maintain a Thermal Break With New Framing

Photos courtesy of Mark Newey, Phius Verifier

HVAC Systems

Individual control required for each bedroom





Phius Strategies and Implementation

Passive Building Principles: AIR CONTROL

Zehnder ComfoAir Q350 TR

Airflow range

42 – 154 CFM

Cooling recovery

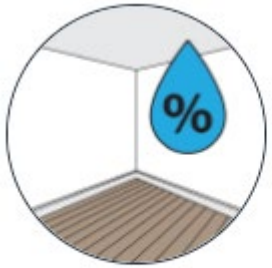
$\eta_{HR,C}$ = 81 %

Specific electric power

$P_{el,spec}$ = 0.36 W/ CFM

Humidity recovery

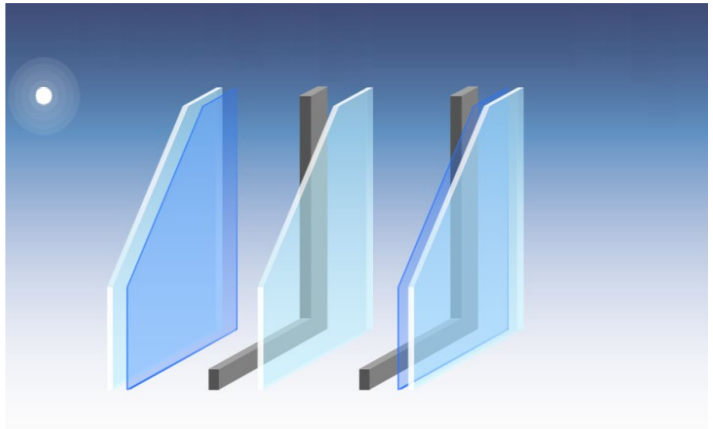
η_x= 75%



Air Humidity

Balanced Ventilation with Heat & Moisture Recovery

Passive Building Principles: RADIATION CONTROL



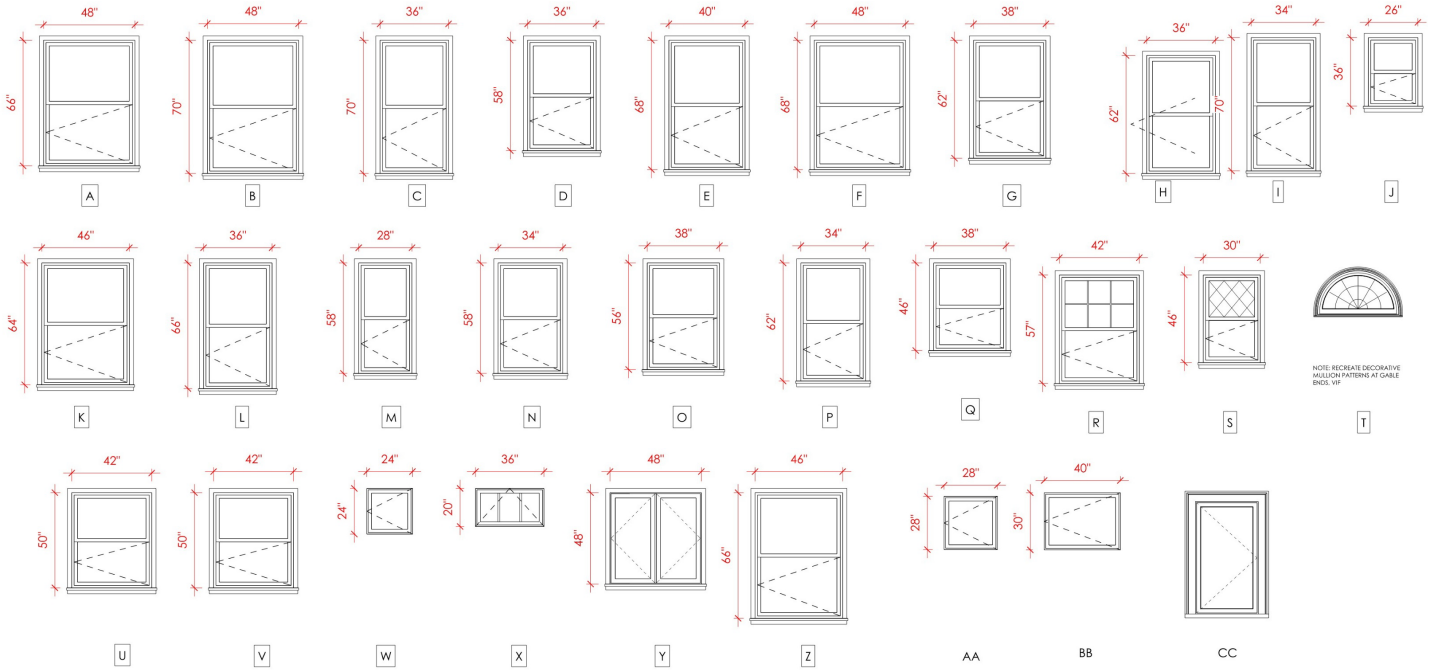
Glazing 1	PLANICLEAR 4 mm COOL-LITE XTREME 70-33
Cavity 1	Krypton 95% 12 mm
Glazing 2	PLANICLEAR 4 mm
Cavity 2	Krypton 95% 12 mm
Glazing 3	ECLAZ ONE PLANICLEAR 4 mm

THERMAL TRANSMISSION NFRC100

Ug Summer	0.4 W/m².K	0.1 Btu/(h.ft².F)
Ug Winter	0.6 W/m².K	0.1 Btu/(h.ft².F)
Angle relative to the vertical	0 °	

SOLAR FACTORS NFRC

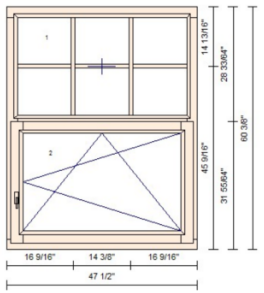
SHGC	0.25
Shading Coefficient (SC)	0.29



Passive Building Principles: RADIATION CONTROL

Bildau & Bussmann Order Nr.: **365002** Project: **5 Sacramento / Avg. 0.13 BTU/hft²F° |** Date/Time: 2022-03-11 / 18:22 Page **50/77**

Item no. 18.2 **1** **pcs**



47R-L
Width 1207 mm = 47-1/2" | Height 1534 mm = 60-3/8"

1 pcs Neher SP 1/94 Insect Screen

1 pcs **greenteQ Window Handle FG61L.ER**
Stainless Steel

6 pair Installation Brackets K-16

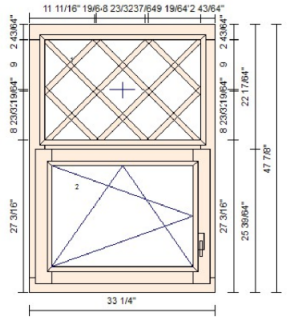
View from Interior

Type: A
Hardware: Direct Set / Tilt/turn right inswing Concealed
Sill profile: Plane + R2
Bars: SDL with internal grid 25.0 mm
Glazing/Filling: 2 x Plth One 4/12Kr/Plc 4/12Kr/4Plth One : Rw(C;Ctr)=33(-2;-5)dB g=0.38 Ug=0.40 SHGC=0.36
Sealing: Silicon colorless

Uw-total: 0.12 BTU Psi : 0.016 BTU (L_g=6.852 m)
Uf-frame: 0.18 BTU (30.47%) Weight: 77.98 kg
Ug-filling: 0.07 BTU (69.53%)

Bildau & Bussmann Order Nr.: **365002** Project: **5 Sacramento / Avg. 0.13 BTU/hft²F° |** Date/Time: 2022-03-11 / 18:22 Page **52/77**

Item no. 19.2 **1** **pcs**



44S-L
Width 845 mm = 33-1/4" | Height 1216 mm = 47-7/8"

1 pcs Neher SP 1/94 Insect Screen

1 pcs **greenteQ Window Handle FG61L.ER**
Stainless Steel

6 pair Installation Brackets K-16

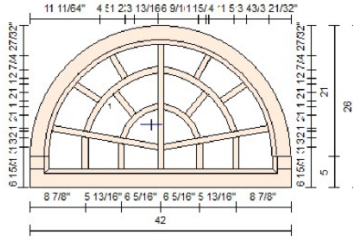
View from Interior

Type: A
Hardware: Direct Set / Tilt/turn left inswing Concealed
Sill profile: Plane + R2
Bars: SDL with internal grid 25.0 mm
Glazing/Filling: 2 x Plth One 4/12Kr/Plc 4/12Kr/4Plth One : Rw(C;Ctr)=33(-2;-5)dB g=0.38 Ug=0.40 SHGC=0.36
Sealing: Silicon colorless

Uw-total: 0.14 BTU Psi : 0.016 BTU (L_g=4.768 m)
Uf-frame: 0.18 BTU (39.42%) Weight: 48.59 kg
Ug-filling: 0.07 BTU (60.58%)

Bildau & Bussmann Order Nr.: **365002** Project: **5 Sacramento / Pine | Krypton Triple G** Date/Time: 2022-04-14 / 17:13 Page **55/76**

Item no. 20.1 **1** **pcs**



45T-F
Width 1067 mm = 42" | Height 660 mm = 26"

6 pair Installation Brackets K-16

View from Interior

Type: A
Hardware: Direct Set
Sill profile: Plane + R2
Bars: SDL w/out internal grid 25.0 mm
Glazing/Filling: 1 x Cool Lite Xtr 70/33 4/12Kr/Plc 4/12Kr/4Eclaz One : Rw(C;Ctr)=33(-2;-5)dB g=0.30 Ug=0.40
Sealing: Silicon colorless

Uw-total: calculation not possible
Weight: 34.56 kg

365002 – 5 Sacramento

Position	Field	Name	(W)	(H)	(W) – frame	(H) – frame	Glass area	Horizontal muntin area	Vertical muntin area	Total Muntin area	muntin/glass area (%)
18.1	1	43R-R	1094 43.07"	646 25.43"	1059	611	647049	26475	30550	57025	8.81%
18.2	1	47R-L	1101 43.35"	646 25.43"	1066	611	651326	26650	30550	57200	8.78%
Position	**Field**	**Name**	**(W)**	**(H)**	**(W) – frame**	**(H) – frame**	**Glass area**	**Total Diagonal muntin area**			**muntin/glass area (%)**
19.1	1	42S-L	739 29.09"	488 19.21"	704	453	318912		97268		30.50%
19.2	1	44S-L	739 29.09"	488 19.21"	704	453	318912		97268		30.50%
19.3	1	46S-L	735 28.94"	486 19.21"	700	451	315700		96912		30.70%
19.4	2	48S-R	745 29.33"	486 19.21"	710	451	320210		97148		30.34%
20.1	1	45T-F	983 38.70"	391 15.39"	948	356	379268.4325	TBD	TBD		

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Passive Building Principles: RADIATION CONTROL

Declare.

EcoVeil Sheer™ Shadecloth: 6850 Series (1% Open) and 6750 Series (3% Open) Mecho

Final Assembly: Edison, New Jersey, USA; Reynosa, Mexico
Life Expectancy: 10 Year Warranty Year(s)
End of Life Options: Take Back Program (https://www.mechoshade.com/about/environmental-commitment/), Recyclable (100% Polyester)

Ingredients:

Shadecloth: Polyethylene Terephthalate; **Lubricant/Auxiliary:** Spin Finish Oil (0.6-1%)[1]; **Dulling Agent:** Titanium dioxide; **Catalyst:** Antimony(III) acetate

[1]LBC Temp Exception RL-004b - Proprietary Ingredients in Declare

Living Building Challenge Criteria: Compliant

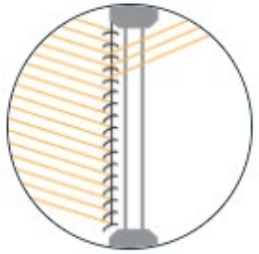
I-13 Red List:
☐ LBC Red List Free
■ LBC Red List Approved
☐ Declared

% Disclosed: 99% at 100ppm
VOC Content: Not Applicable

I-10 Interior Performance: CDPH Standard Method v1.1-2010
I-14 Responsible Sourcing: Not Applicable

MEC-0004
EXP. 01 DEC 2022
Original Issue Date: 2016

MANUFACTURER RESPONSIBLE FOR LABEL ACCURACY
INTERNATIONAL LIVING FUTURE INSTITUTE™ living-future.org/declare



Shading and Daylighting

EcoVeil®
Sustainable and eco-effective shadecloth

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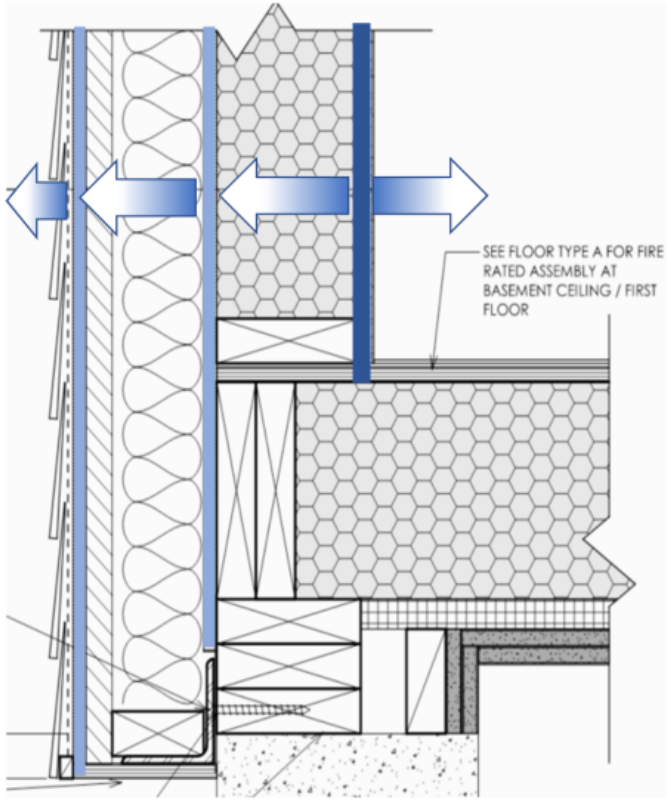
Passive Building Principles: MOISTURE CONTROL

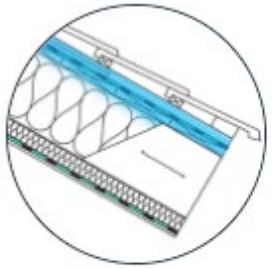
Vapor Profile – HUH New Wall

Vapor Retarder Classes:

- Class I: ≤0.1 perm
- Class II: >0.1 to <1.0 perm
- Class III: >1.0 perm

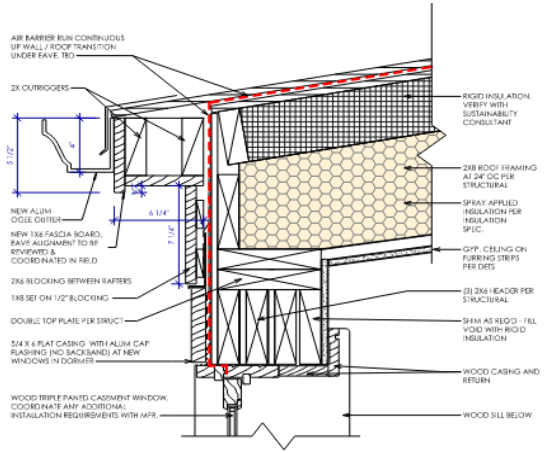
Material	Class	Perm
Wood shingles	Class III	-
Building Wrap	Class III	50
Plywood	Class III	2
Façade Rock	Class III	30
Cavity Rock	Class III	30
Plywood	Class III	2
Closed Spray Foam	Class II	0.35
Aero Barrier	Class I	0.05
GWB	Class III	50
Latex Paint	Class III	5

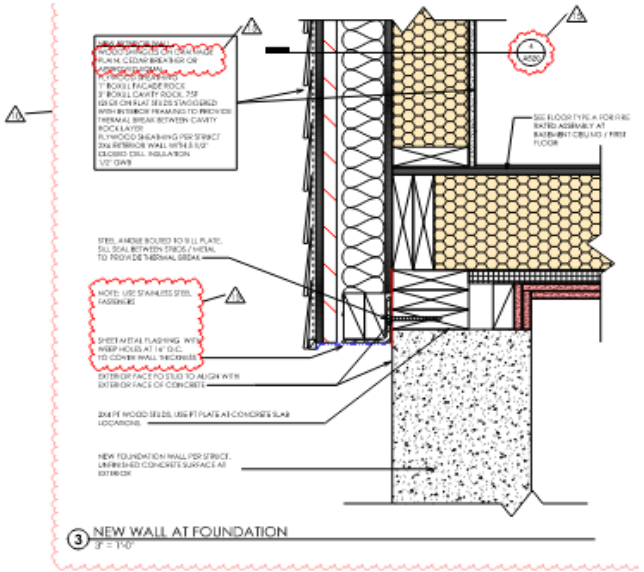




Material Moisture

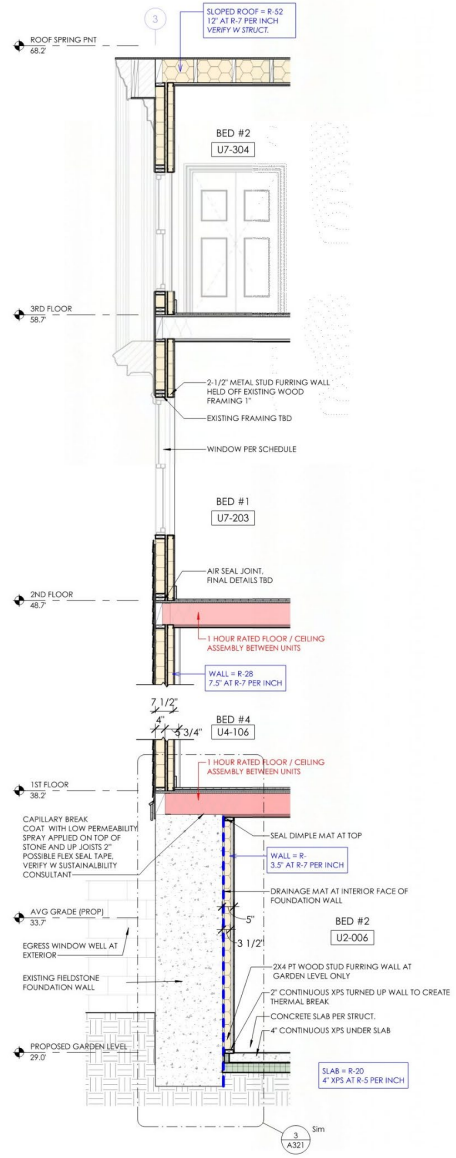
Passive Building Principles: THERMAL CONTROL





- EXISTING STRUCTURE LEFT IN PLACE
- CLOSED CELL SPRAY FOAM INSULATION IN CAVITIES
- ADDITIONAL RIGID FOAM UTILIZED ON SOME ASSEMBLIES

ENCLOSURE	5 SAC	13 KP
• WALLS:	R-35	R-35
• FLOOR:	R-40	R-58
• ROOF:	R-60	R-60
• WINDOWS:	U-0.16	U-0.15



2 TYPICAL WALL SECTION
1/2" = 1'-0"

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Passive Building Principles: THERMAL CONTROL

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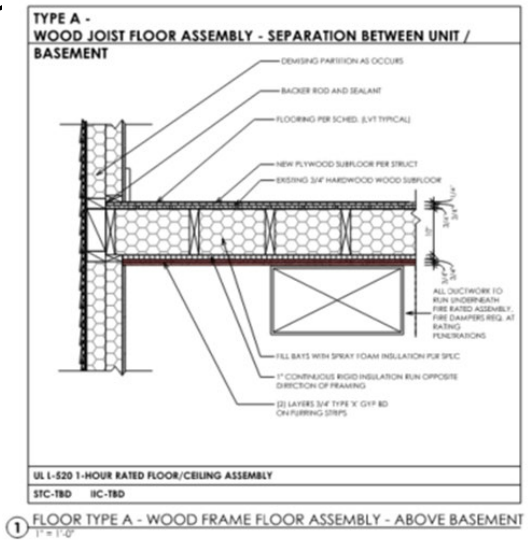
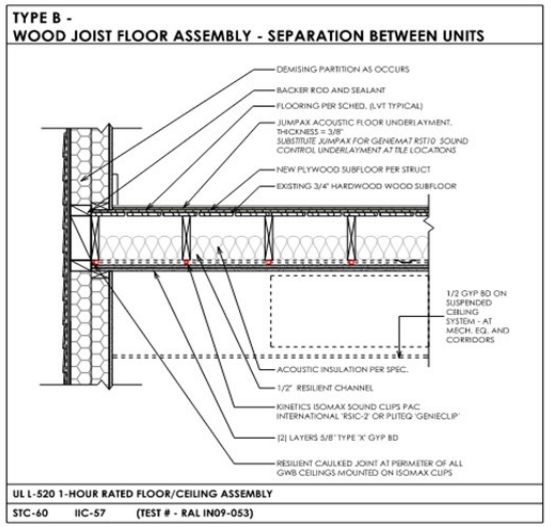
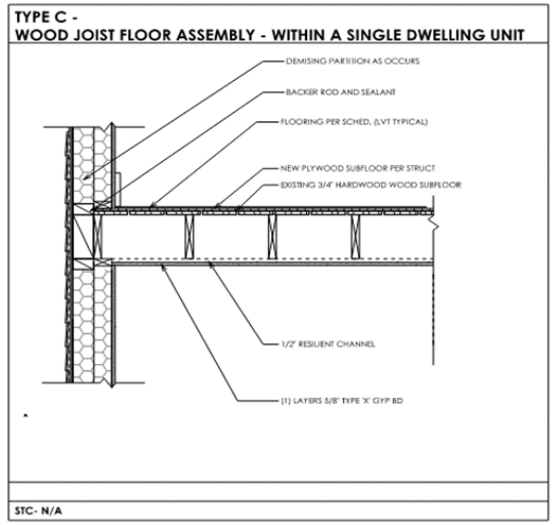
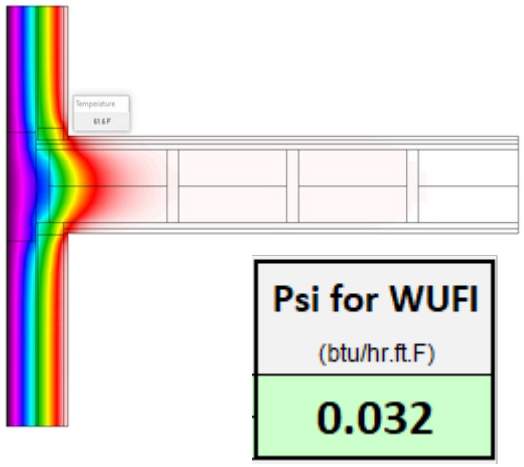
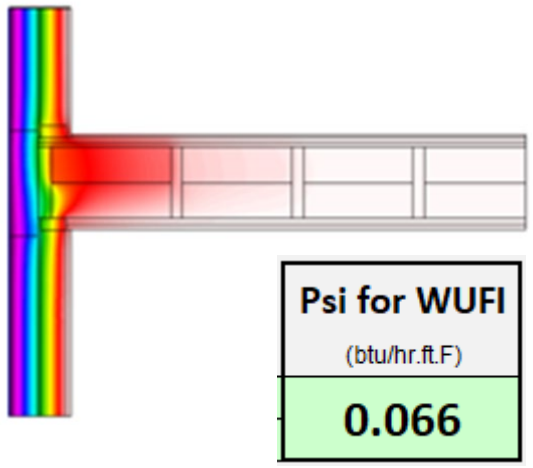


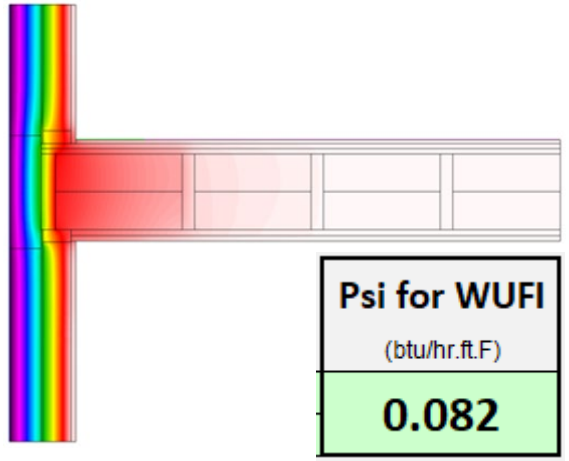
1 FLOOR TYPE A - WOOD FRAME FLOOR ASSEMBLY - ABOVE BASEMENT
1" = 1'-0"











Passive Building Principles: THERMAL CONTROL

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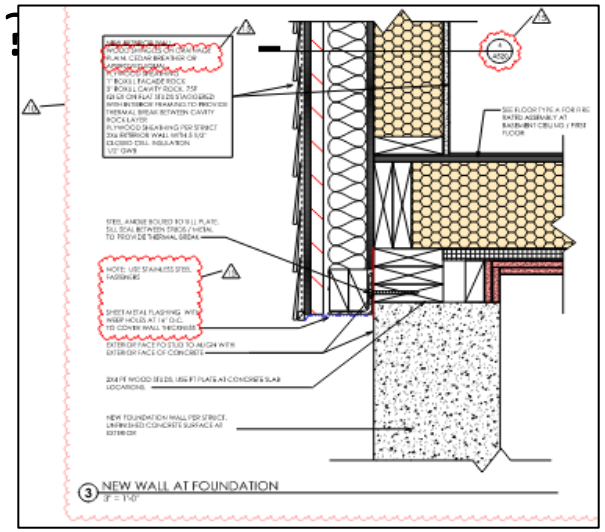
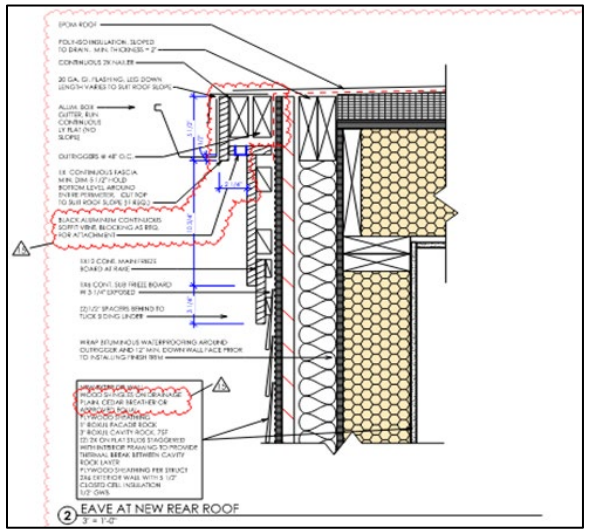
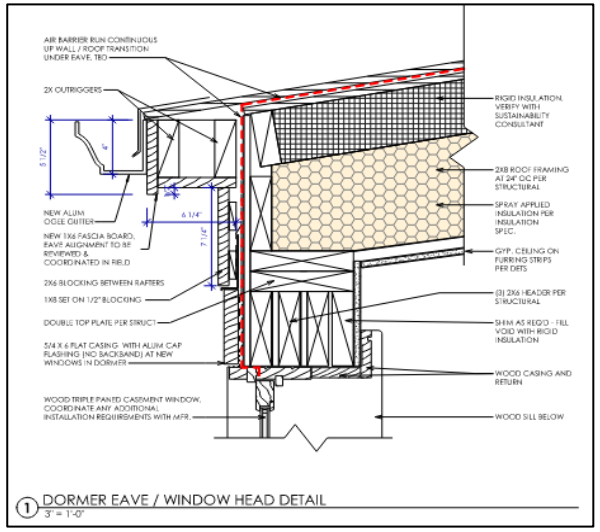
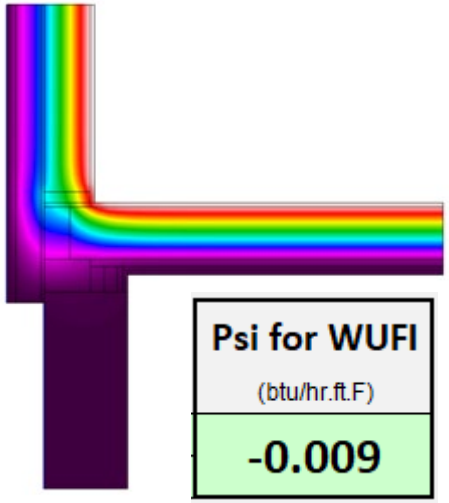
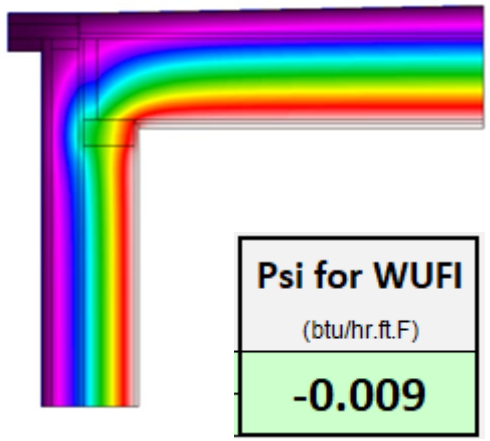
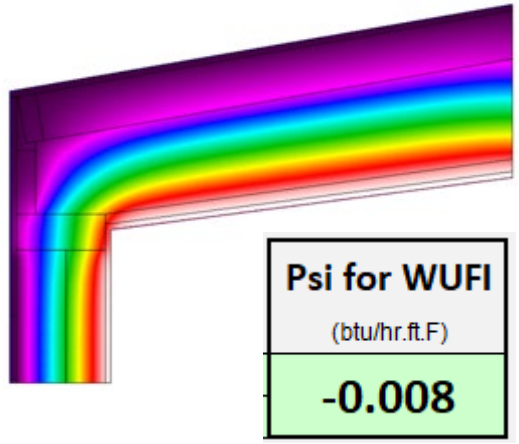




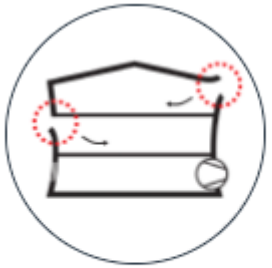




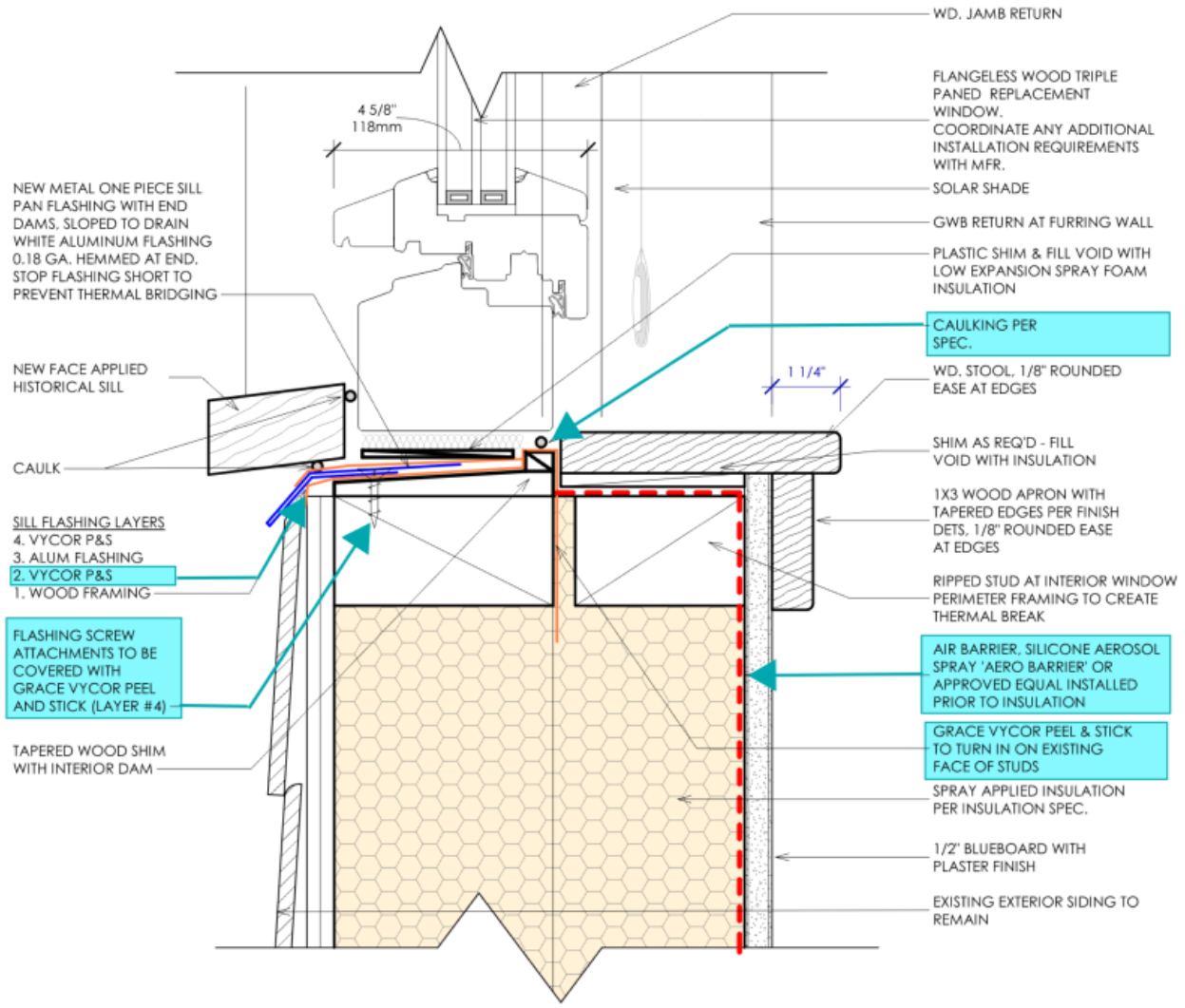




Passive Building Principles: AIR CONTROL



Airtightness



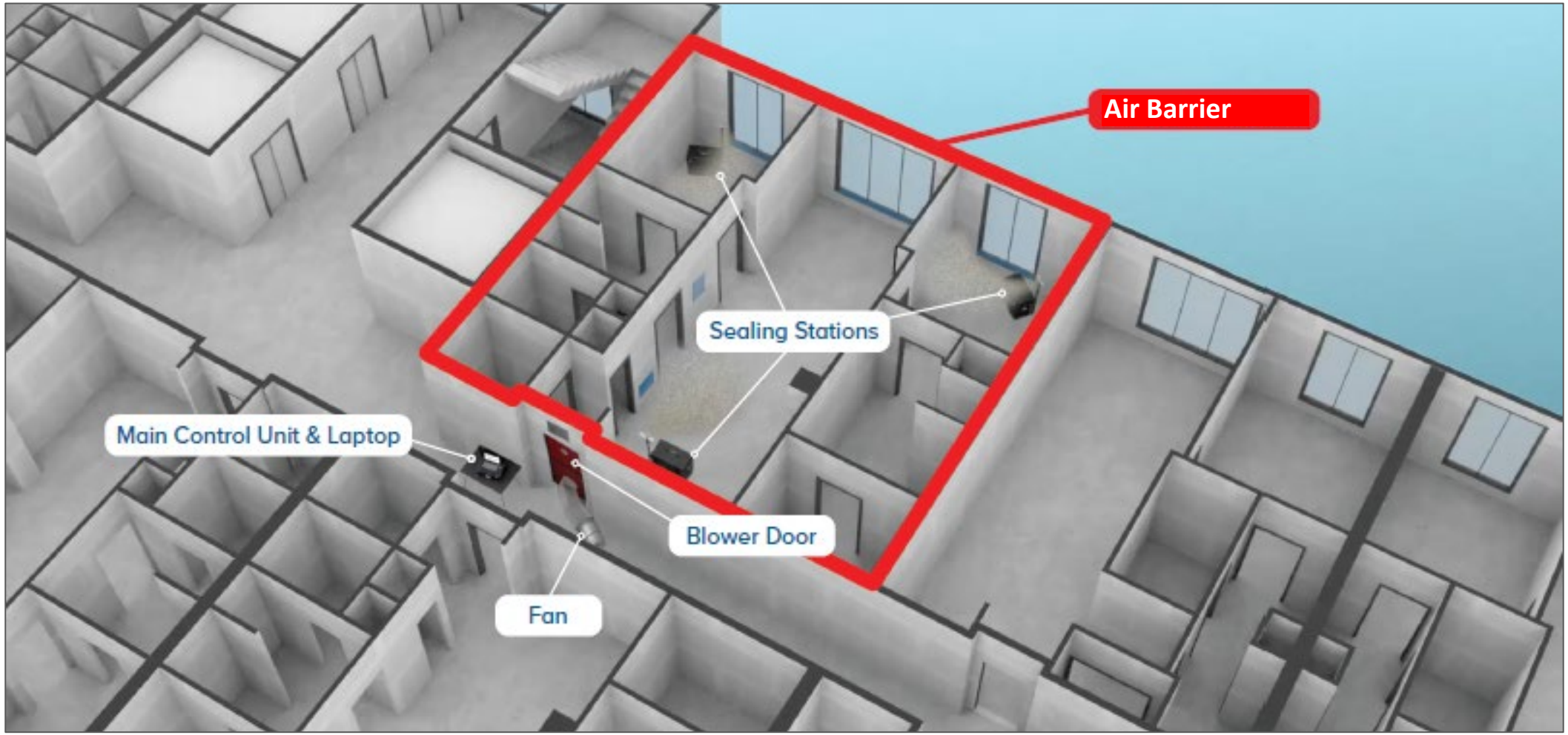
2 WINDOW SILL DETAIL
6" = 1'-0"

Thermal Insulation

- Closed cell spray foam was installed in exterior wall and roof
- Installation was challenging in terms of getting proper depth and coverage
- There were many locations where spray foam had to stop due to framing blockages
- Can still be leakage paths between spray foam and wood studs

Photos courtesy of Mark Newey, Phius Verifier

AeroBarrier Air Sealing Application



AeroBarrier Being Installed in a 2 BR Apartment

Air Sealing the Exterior Envelope: Seal Progression

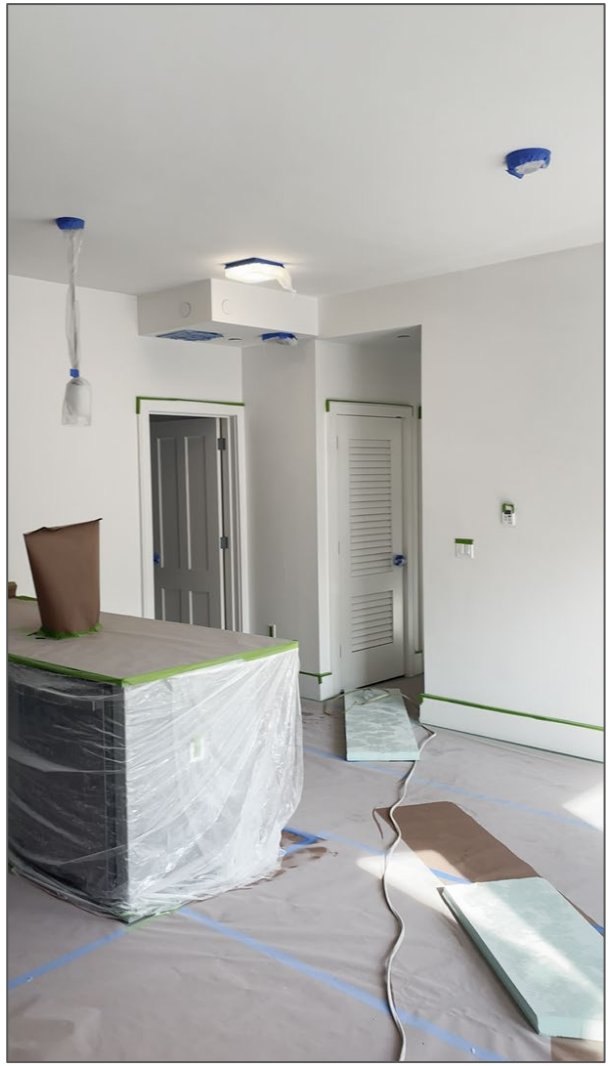
- AeroBarrier applied after closed cell spray foam in place
- Didn't know real leakage until foam installed due to sheathing gaps
- AeroBarrier seals exterior envelope & achieves air leakage goal
- Issues with contractor run blower door tests

- AeroBarrier compartmentalizes individual apartment units, achieving air leakage goal for each unit

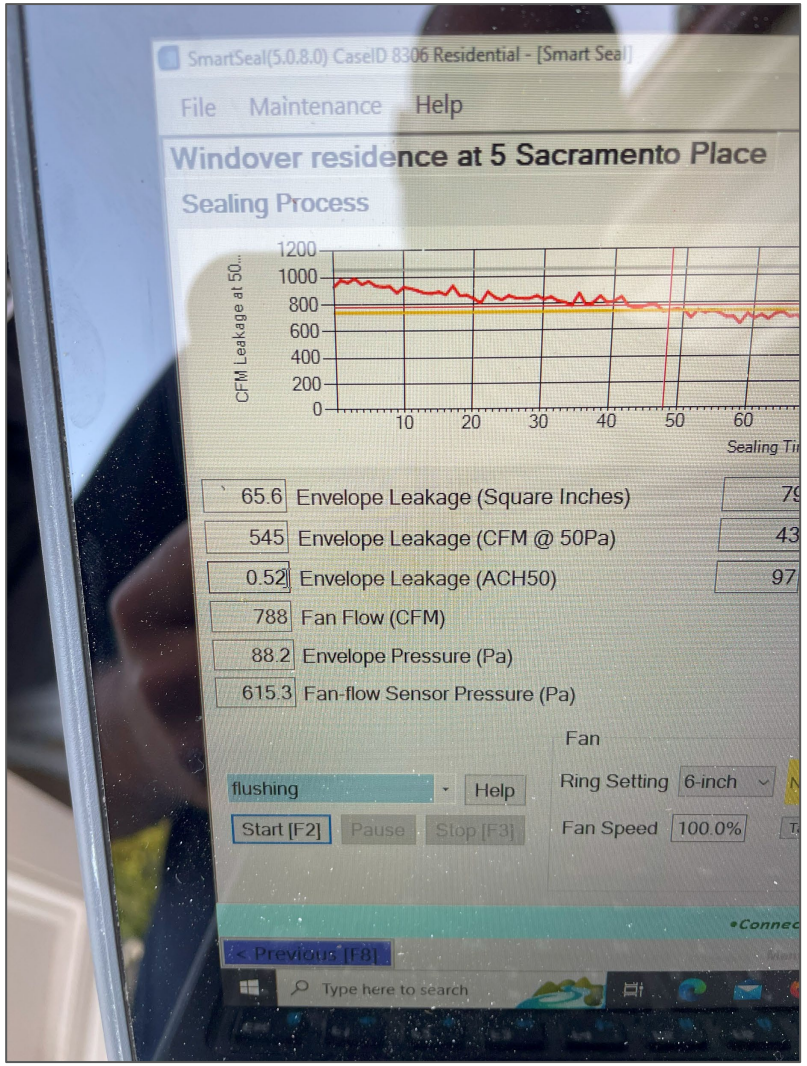
- 6-9 months later, contractor is failing final whole building blower door tests
- Potential causes were new penetrations & framing shrinkage over the winter
- AeroBarrier called back to job sites for additional sealing
- Contractor decides to try targeted AeroBarrier sealing at 5 Sacramento St. without success
- AeroBarrier seals whole building exterior envelope again & achieves air leakage goal

Air Sealing the Exterior Envelope: Seal Images

AeroBarrier Set Up Outside



Prep Work Inside for Finished Unit



AeroBarrier Laptop Screen During Seal

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Air Sealing For Compartmentalization

- Compartmentalization was complex due to:
  - Demising walls and floors that didn't line up with the framing and structural system
  - Floor system also a challenge due to a lot of wires, pipes, and ducts fit below the floor
- Contractor experienced difficulty with manual air sealing between units
- AeroBarrier application met compartmentalization leakage requirements in one seal per unit

Photos courtesy of Mark Newey, Phius Verifier

Results

5 Sacramento Street After Renovation

13 Kirkland Place After Renovation

Phius Core REVIVE 2021 Achieved

5 Sacramento

Multifamily • Retrofit

5A - Cool - Humid

5968 sq. ft.

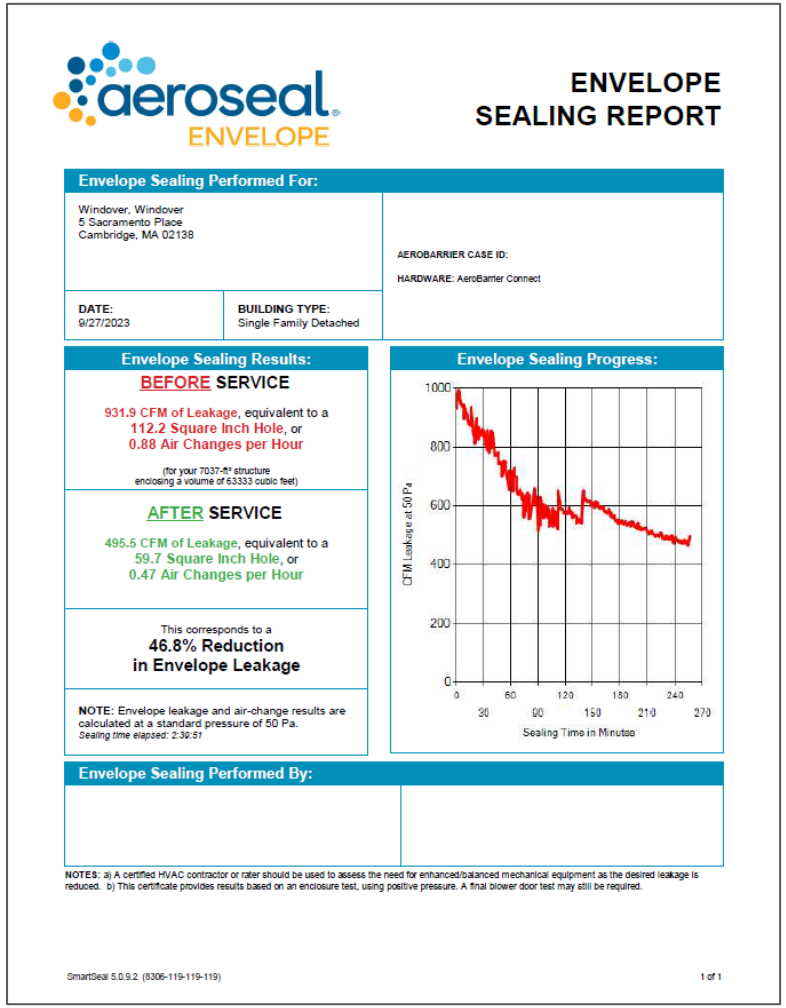
13 Kirkland

Multifamily • Retrofit

5A - Cool - Humid

3618 sq. ft.

Air Leakage Results: Final Envelope Sealing Reports



aeroseal ENVELOPE

ENVELOPE SEALING REPORT

Envelope Sealing Performed For:

Windover, Windover
5 Sacramento Place
Cambridge, MA 02138

AEROBARRIER CASE ID:

HARDWARE: AeroBarrier Connect

DATE: 9/27/2023

BUILDING TYPE: Single Family Detached

Envelope Sealing Results:

BEFORE SERVICE

931.9 CFM of Leakage, equivalent to a
112.2 Square Inch Hole, or
0.88 Air Changes per Hour

(for your 7037-ft² structure enclosing a volume of 63333 cubic feet)

AFTER SERVICE

495.5 CFM of Leakage, equivalent to a
59.7 Square Inch Hole, or
0.47 Air Changes per Hour

This corresponds to a
46.8% Reduction in Envelope Leakage

NOTE: Envelope leakage and air-change results are calculated at a standard pressure of 50 Pa.
Sealing time elapsed: 2:39:51

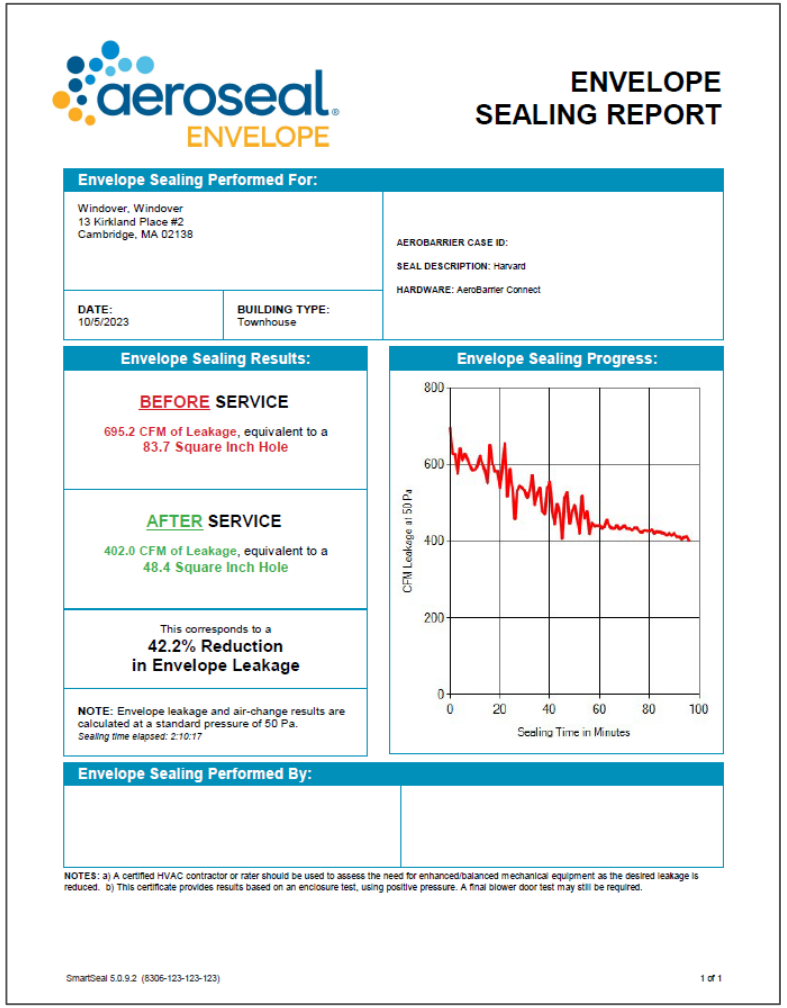
Envelope Sealing Progress:

Envelope Sealing Performed By:

NOTES: a) A certified HVAC contractor or rater should be used to assess the need for enhanced/balanced mechanical equipment as the desired leakage is reduced. b) This certificate provides results based on an enclosure test, using positive pressure. A final blower door test may still be required.

SmartSeal 5.0.9.2 (8306-119-119-119) 1 of 1

5 Sacramento Street



aeroseal ENVELOPE

ENVELOPE SEALING REPORT

Envelope Sealing Performed For:

Windover, Windover
13 Kirkland Place #2
Cambridge, MA 02138

AEROBARRIER CASE ID:

SEAL DESCRIPTION: Harvard

HARDWARE: AeroBarrier Connect

DATE: 10/5/2023

BUILDING TYPE: Townhouse

Envelope Sealing Results:

BEFORE SERVICE

695.2 CFM of Leakage, equivalent to a
83.7 Square Inch Hole

AFTER SERVICE

402.0 CFM of Leakage, equivalent to a
48.4 Square Inch Hole

This corresponds to a
42.2% Reduction in Envelope Leakage

NOTE: Envelope leakage and air-change results are calculated at a standard pressure of 50 Pa.
Sealing time elapsed: 2:10:17

Envelope Sealing Progress:

Envelope Sealing Performed By:

NOTES: a) A certified HVAC contractor or rater should be used to assess the need for enhanced/balanced mechanical equipment as the desired leakage is reduced. b) This certificate provides results based on an enclosure test, using positive pressure. A final blower door test may still be required.

SmartSeal 5.0.9.2 (8306-123-123-123) 1 of 1

13 Kirkland Place

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Final Details & Air Leakage Results

Project Details/Information	5 Sacramento Street	13 Kirkland Place
Location	Cambridge, MA	Cambridge, MA
Climate Zone	5A-Cool-Humid	5A-Cool-Humid
Building Type	Multifamily	Multifamily
Project Type	Retrofit	Retrofit
# of Stories	4	4
# of Units	5	4
Phius Program Ver. Achieved	**Phius CORE REVIVE 2021**	**Phius CORE REVIVE 2021**
Interior Conditioned SF	5968	3618
All Electric?	**Yes**	**Yes**
Air Leakage Achieved	**0.05 CFM50/SF**	**0.054 CFM50/SF**

Final WUFI Results

CASE	kBtu/sf/yr	kBtu/yr	kWh/yr	% kWh/yr Savings
5 SACRAMENTO BASELINE SITE ENERGY	59.03	597,749	175,200	0%
5 SACRAMENTO PHIUS SITE ENERGY	24.41	145,664	42,694	76%
13 KIRKLAND BASELINE SITE ENERGY	59.47	215,129	63,054	0%
13 KIRKLAND PHIUS SITE ENERGY	26.92	97,401	28,548	55%

Lessons Learned

Lessons Learned: 1800's Phius Retrofits

- Frequent blower door tests by the contractor is good, but need to ensure they are properly trained on using the blower door equipment
- Conduct more field investigation of existing conditions before design and construction documents are completed to eliminate surprises during construction
- Include more exterior envelope details in the construction documents
- Consider applying AeroBarrier prior to the spray foam insulation to seal against exterior sheathing and thus identify earlier any existing exterior envelope issues
- If semi-conditioned basement is not in Phius enclosure, it still needs to be ventilated, however spaces outside Phius boundary should not share ventilation with Phius space. Design layout of ventilation system with ease of balancing and testing in mind!
- Improve communication between contractor, passive house professionals, and air sealing subcontractors
- Others??

Questions & Answers/Discussion

Questions/Discussion

Thank You!

Prudence Ferreira

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