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MORRISON HERSHFIELD

DESIGN LIMITS FOR FRAMED WALL ASSEMBLIES DEPENDENT ON MATERIAL CHOICES FOR SHEATHING MEMBRANES AND EXTERIOR INSULATION

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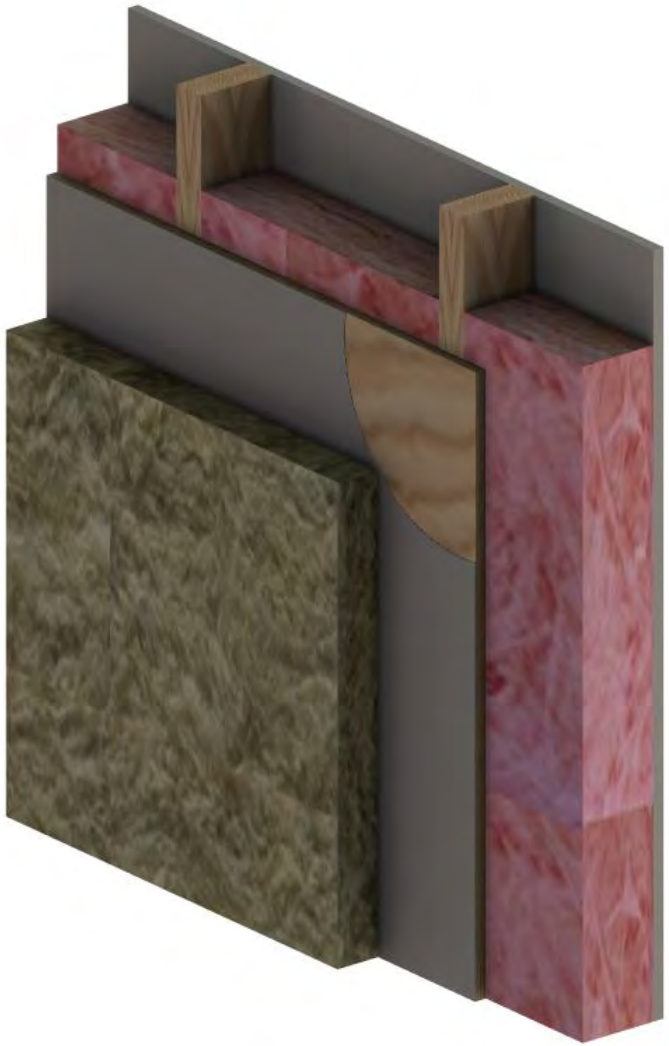
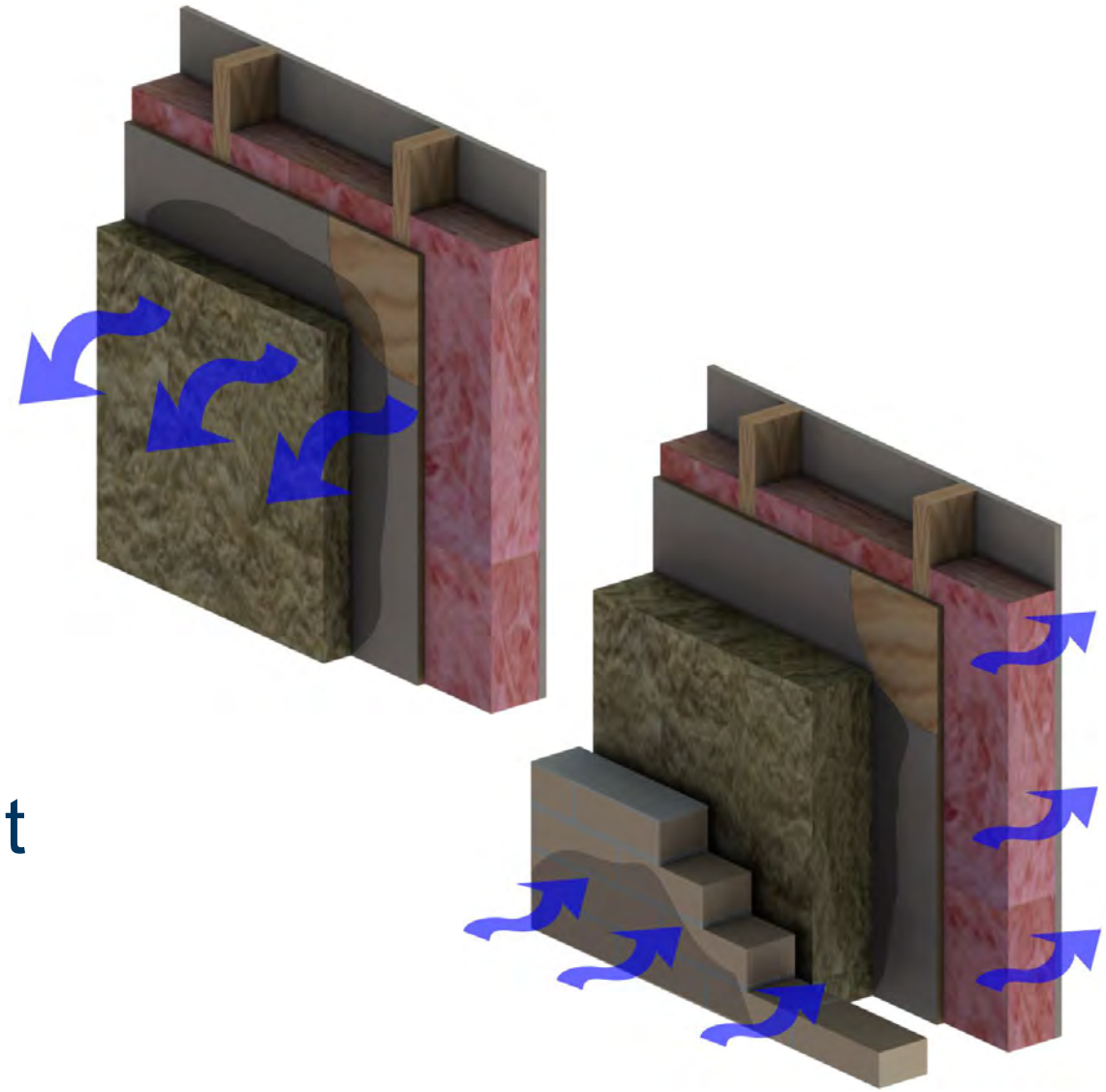
Outline

- Introduction
- Design Limits Framework
- Key Findings
- Conclusions



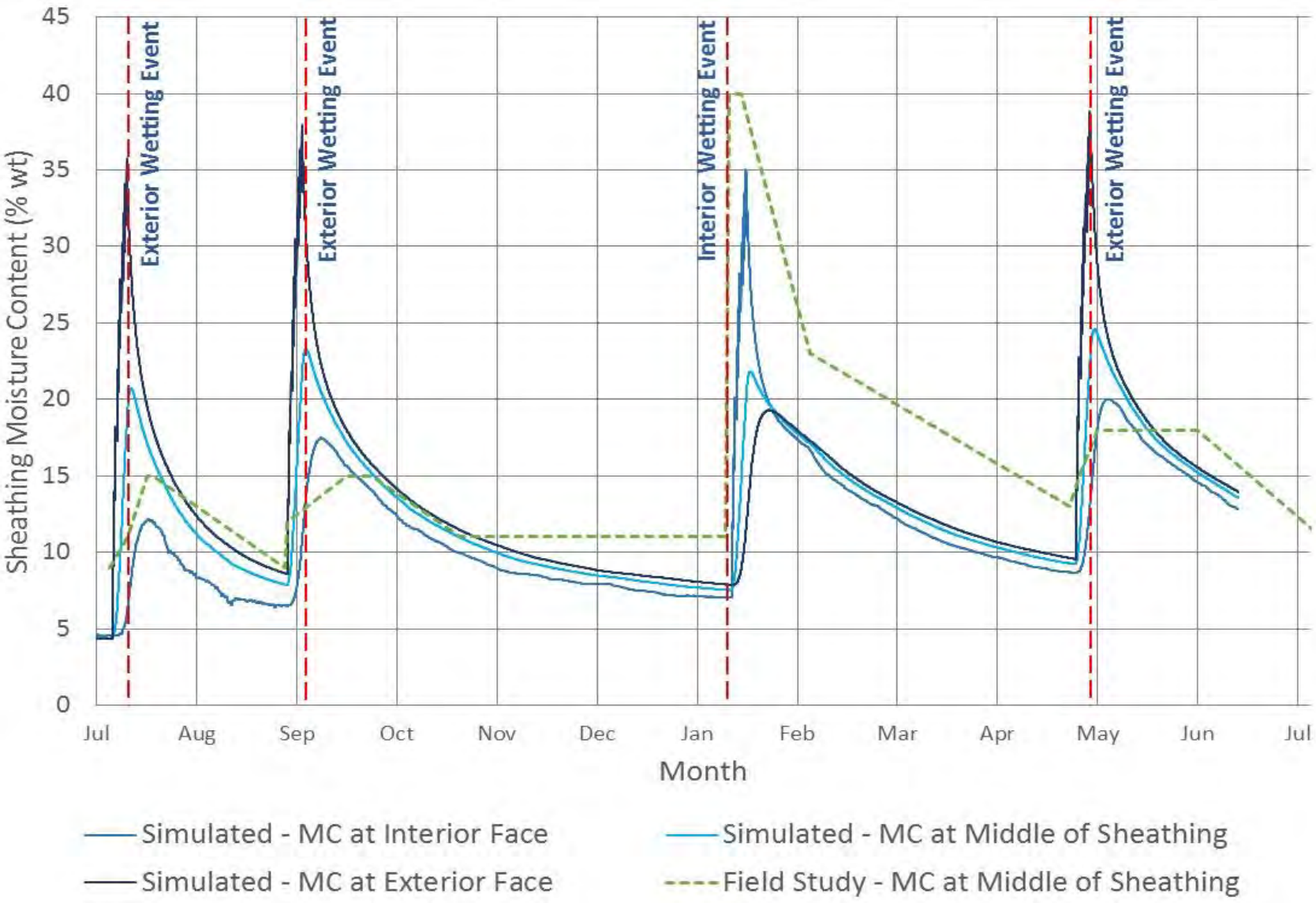
Introduction

- Hygrothermal performance based on wetting and drying
- Ideal permeance to stop inward vapour but still allow drying
- Lack of framework to evaluate and compare assemblies
- Building upon past research to evaluate assemblies under different conditions



Calibration

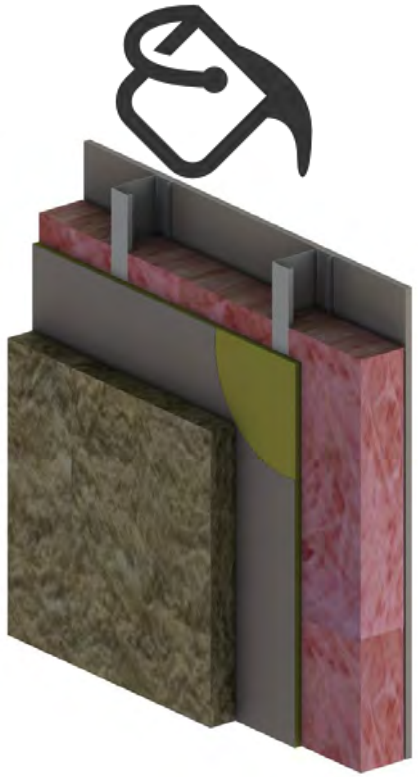
- Calibrated models with test hut data
- Compared assemblies exposed to leaks



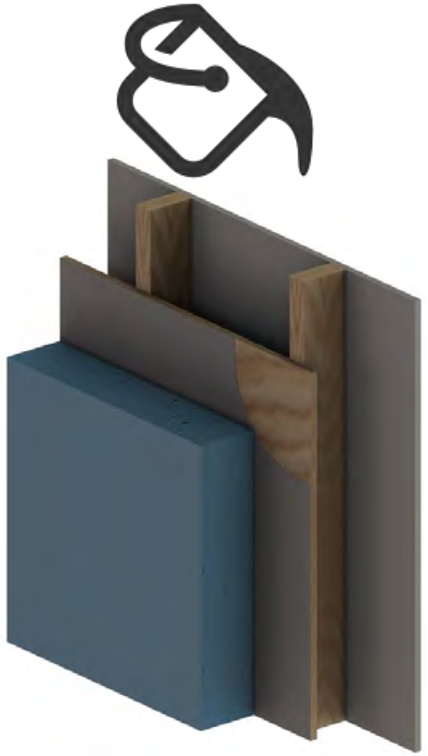
Design Limits

- Limits where assembly/structure can no longer meet the design criteria

- Maximum Indoor Humidity
- Minimum Insulation Ratio
- Maximum Rain Penetration
- Minimum Vapour Permeance

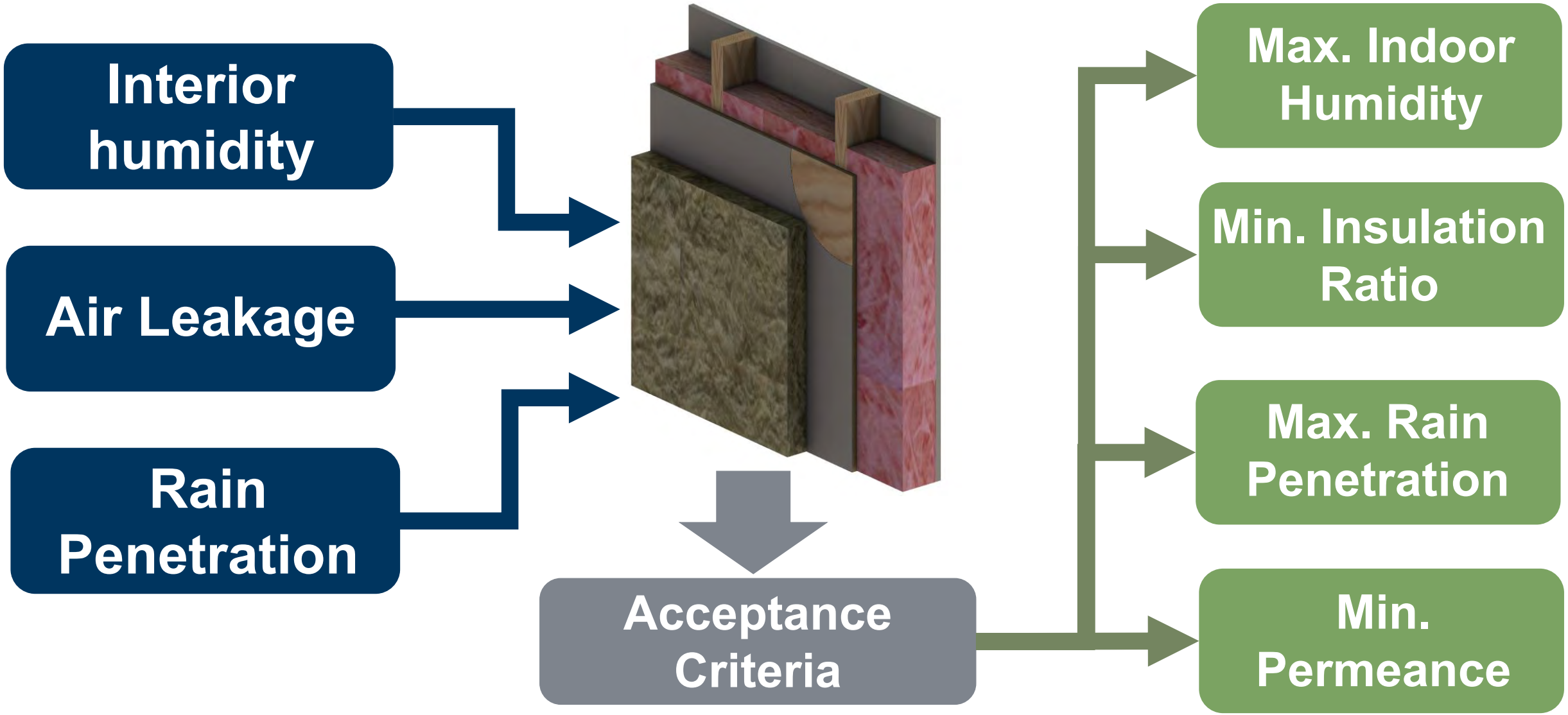


Moisture Tolerance



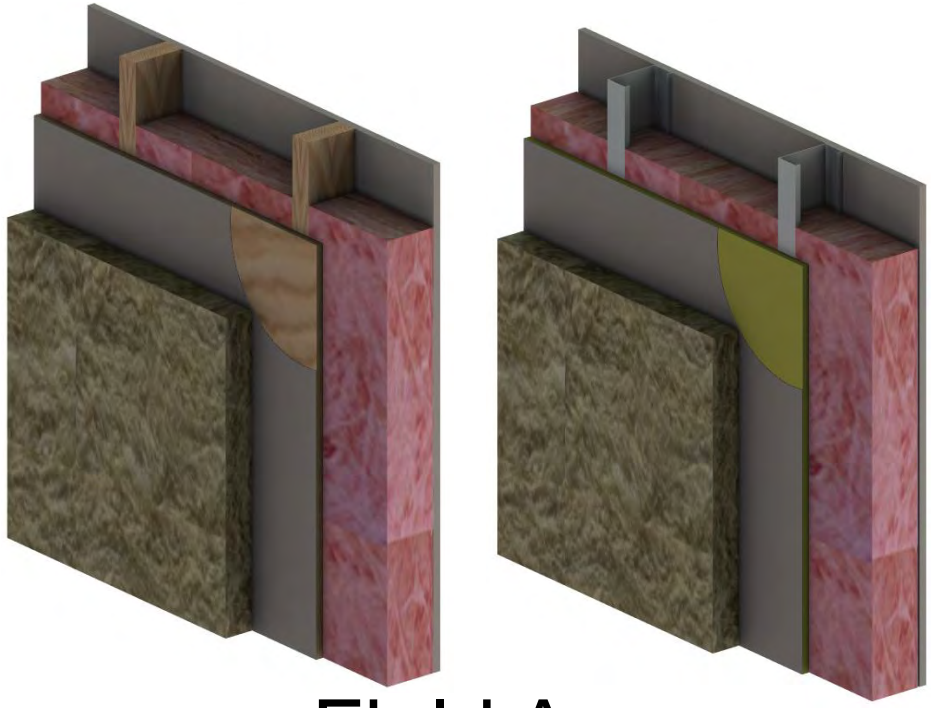
Moisture Tolerance

Design Limits Framework

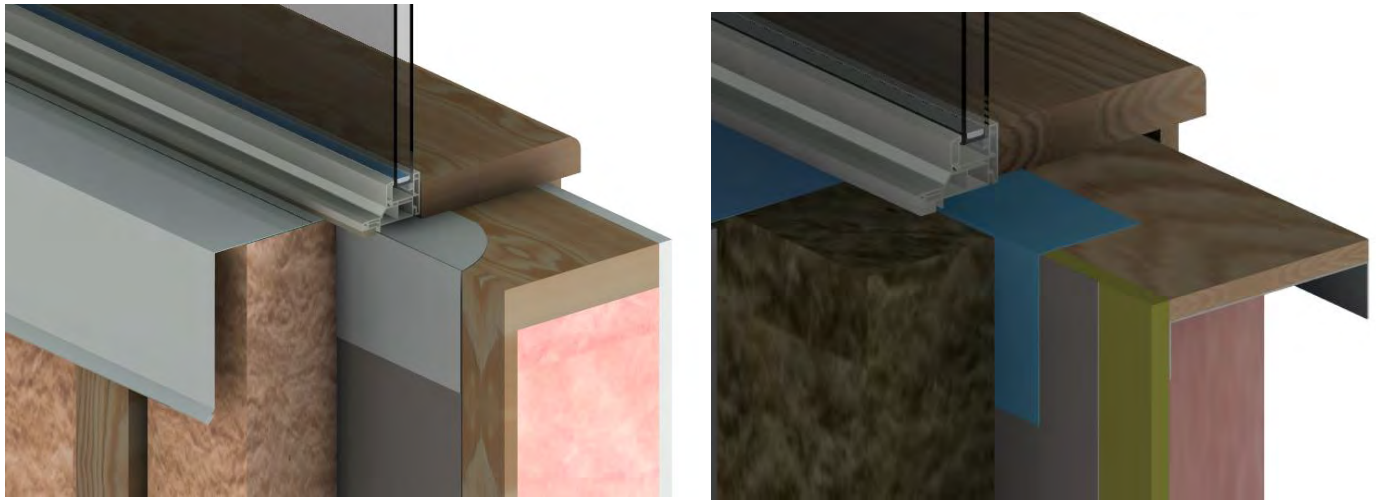


Assemblies

- Wood frame and steel frame assemblies
- 3 Canadian Climates: Vancouver, Toronto, Edmonton



Field Area
(1-D)



Window Sills
(2-D)

Interior Humidity

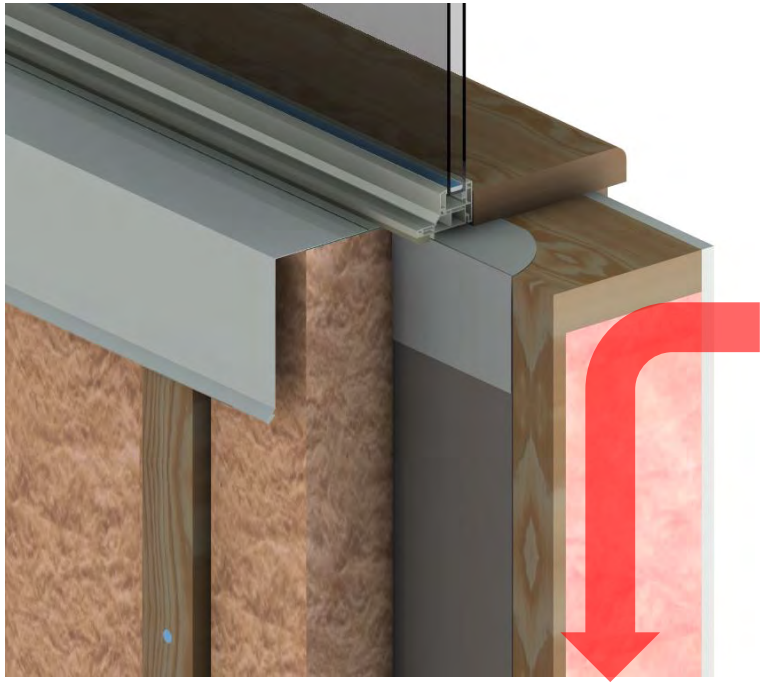
- Based on vapour pressure difference
- Residential buildings with uncontrolled humidity in heating climates

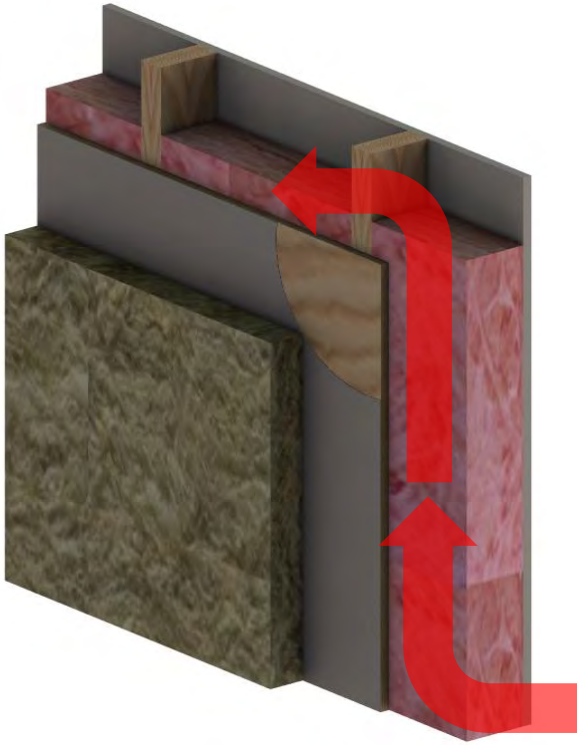
Location	Interior Temperature °C (°F)	Medium Humidity Indoor RH	High Humidity Indoor RH
Vancouver	21 (70)	35% - 55%	40% - 60%
Toronto	21 (70)	25% - 30%	35% - 50%
Edmonton	21 (70)	20% - 40%	25% - 45%

- Two scenarios:
  - Medium humidity load: ΔVP 540 Pa
  - High humidity load: ΔVP 750 Pa

Air Leakage

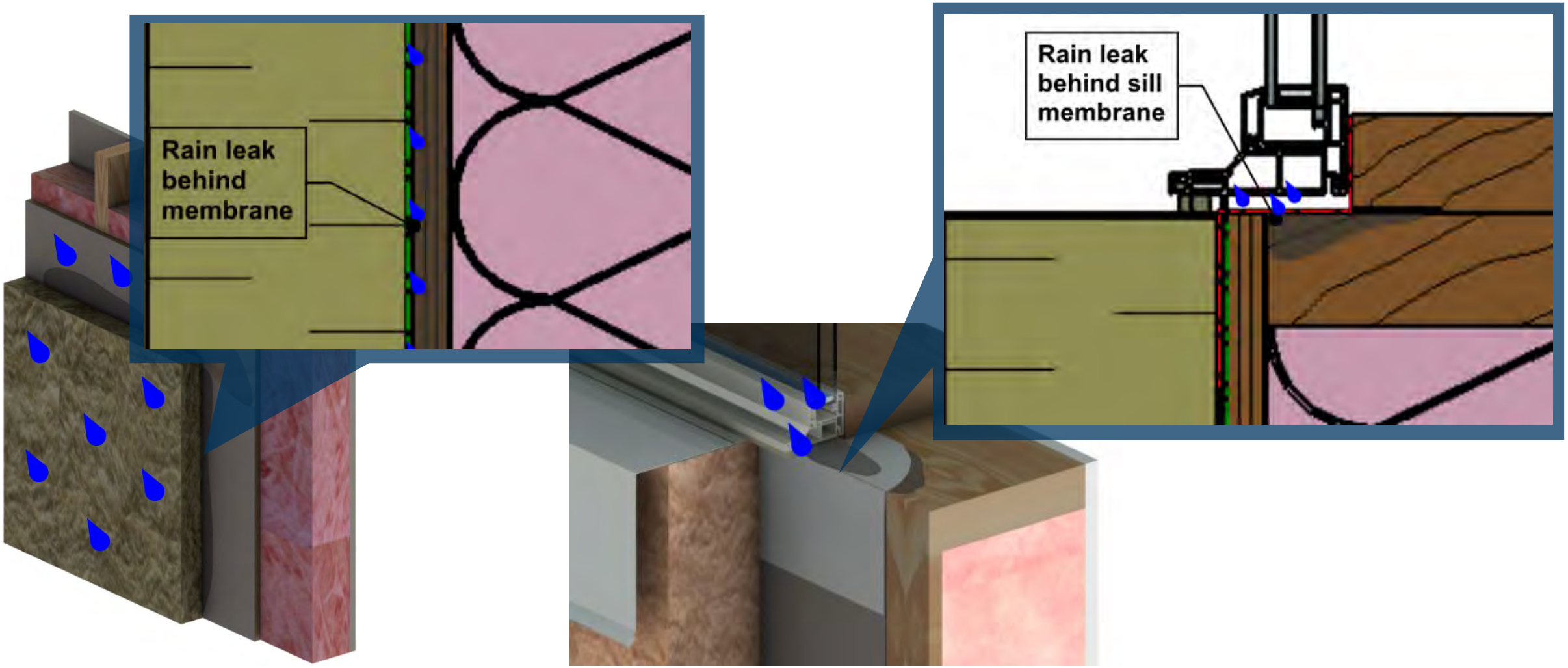
- Extfiltration from interior bypassing interior vapour control layer
  - Interior face of sheathing
  - Underside of wood framing at sill
- Cases with and without air leakage considered





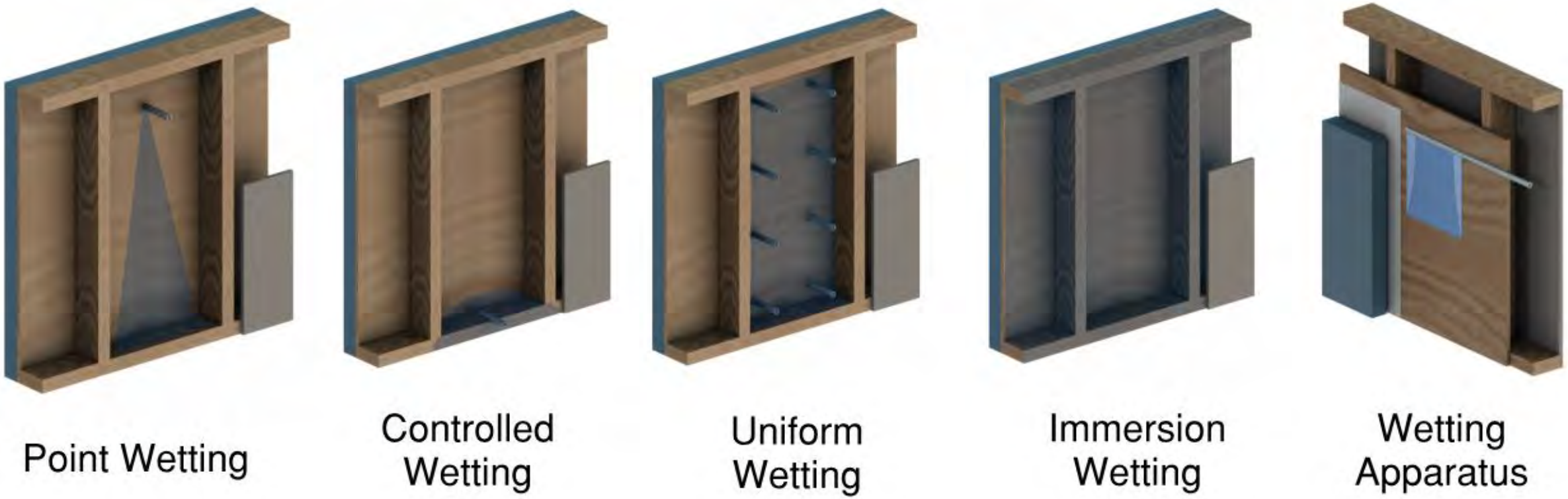
Rain Penetration

- Simulated rain leak behind WRB



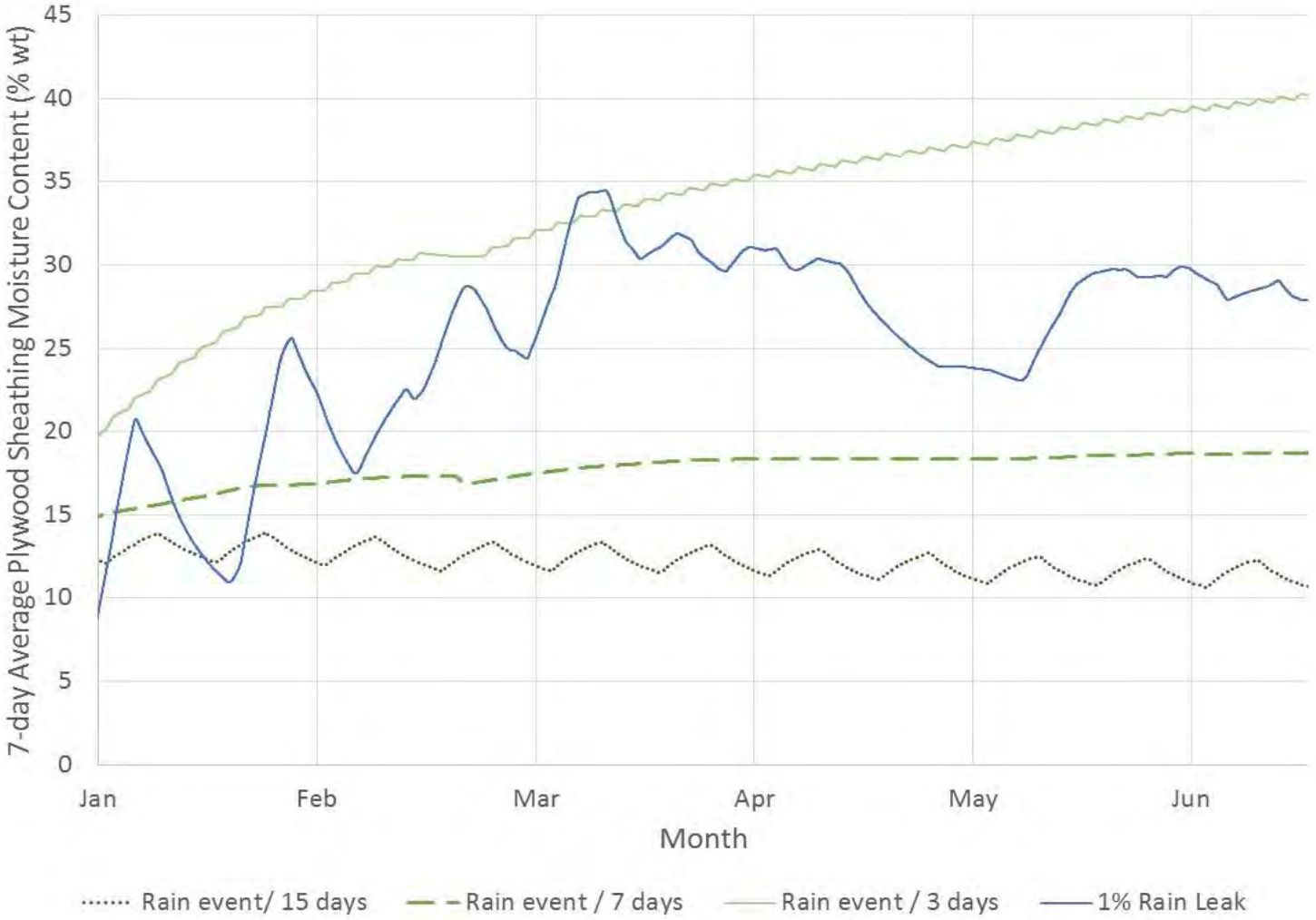
Rain Penetration Rates

- Various ways of wetting done
  - Tests favoured regular wetting intervals
- Rain varies in intensity, frequency, and duration



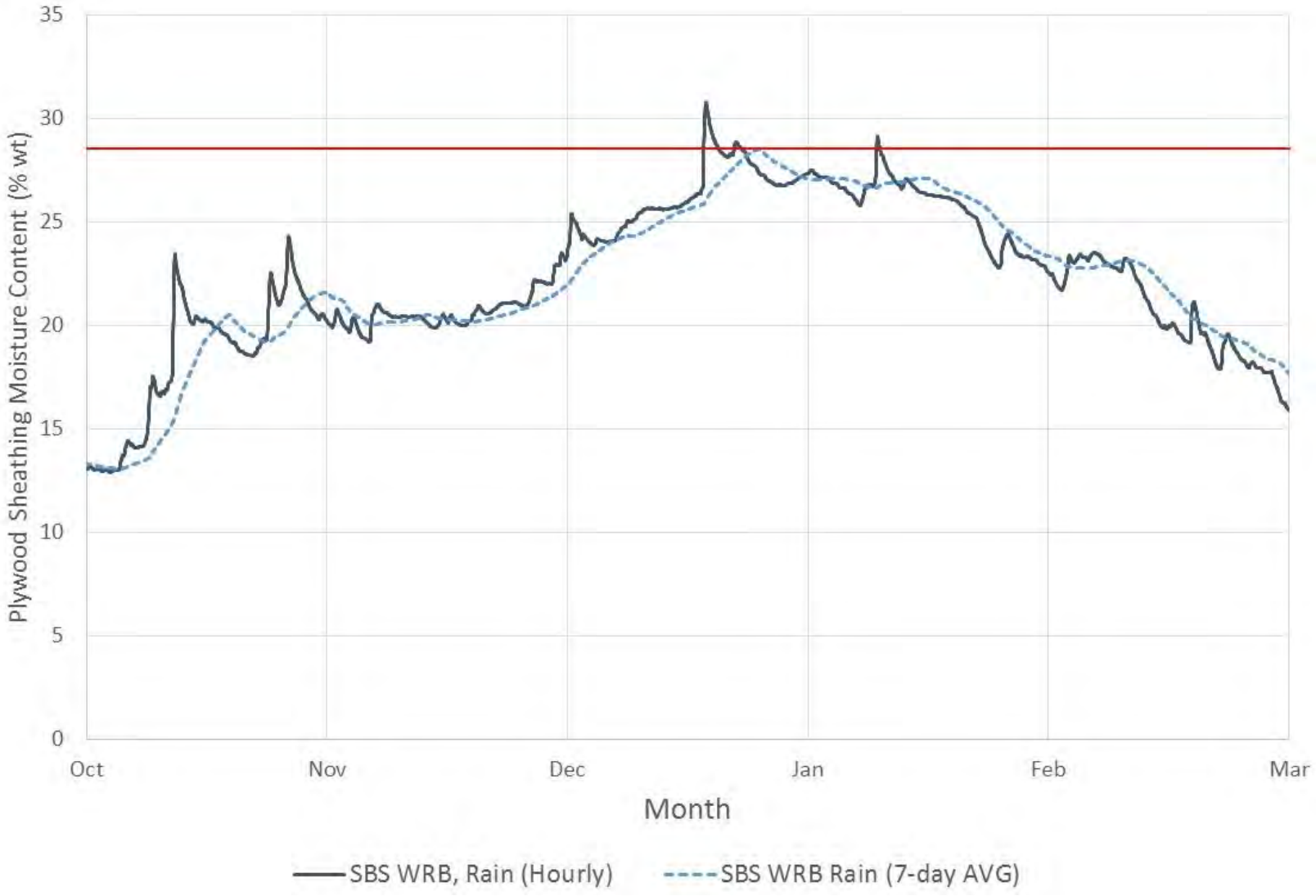
Rain Penetration Rates

- Rain penetration rate based on percentage of incidental driving rain

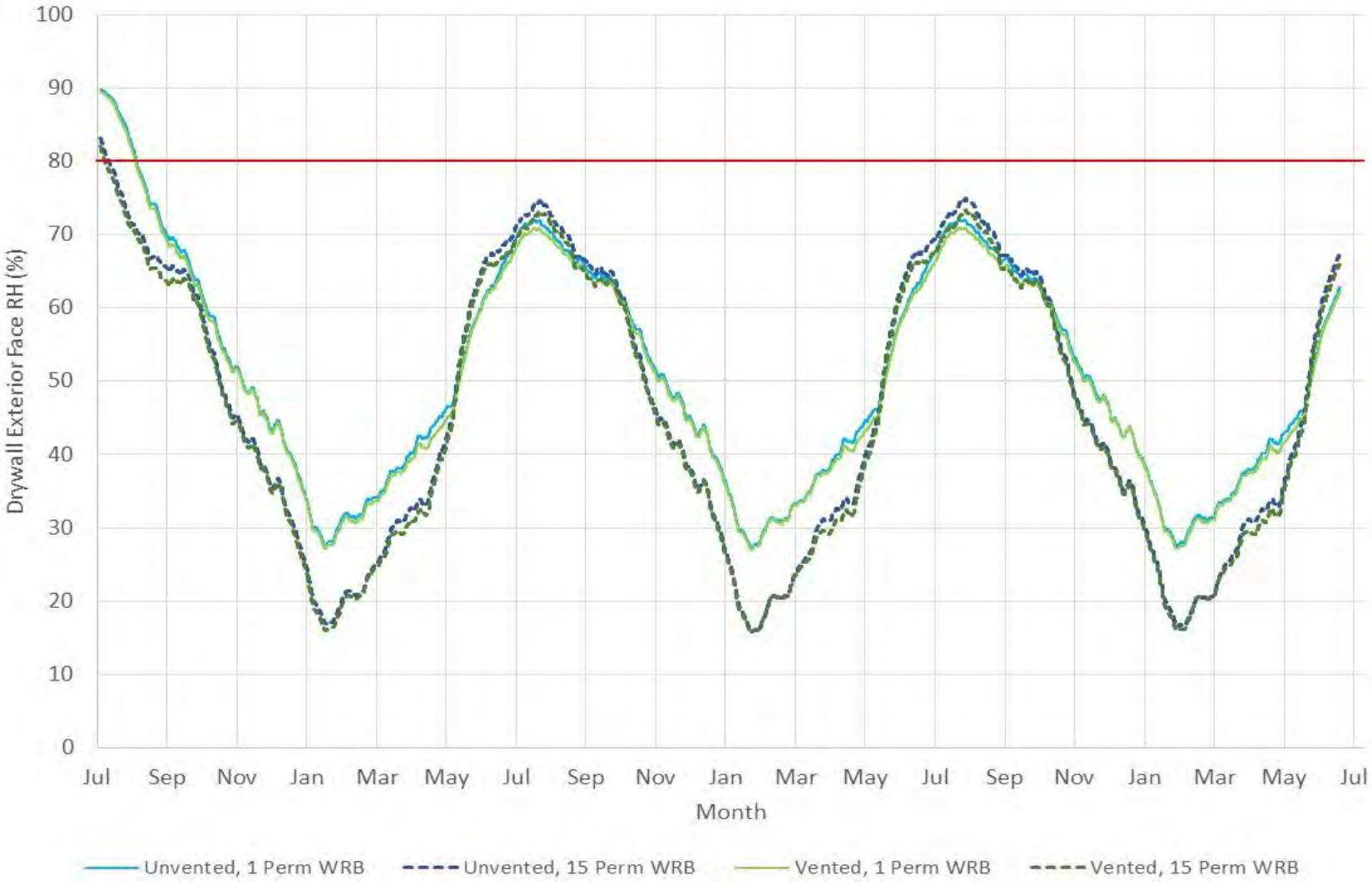


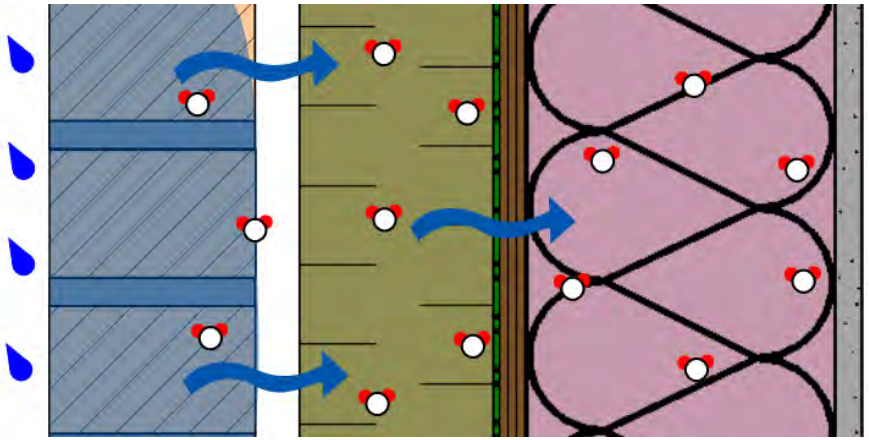
Acceptance Criteria

- Wood products:
  - 7-day running average MC ≤ 28% wt
- Gypsum products:
  - 30-day running average surface RH ≤ 80%



Inward Vapour Drive

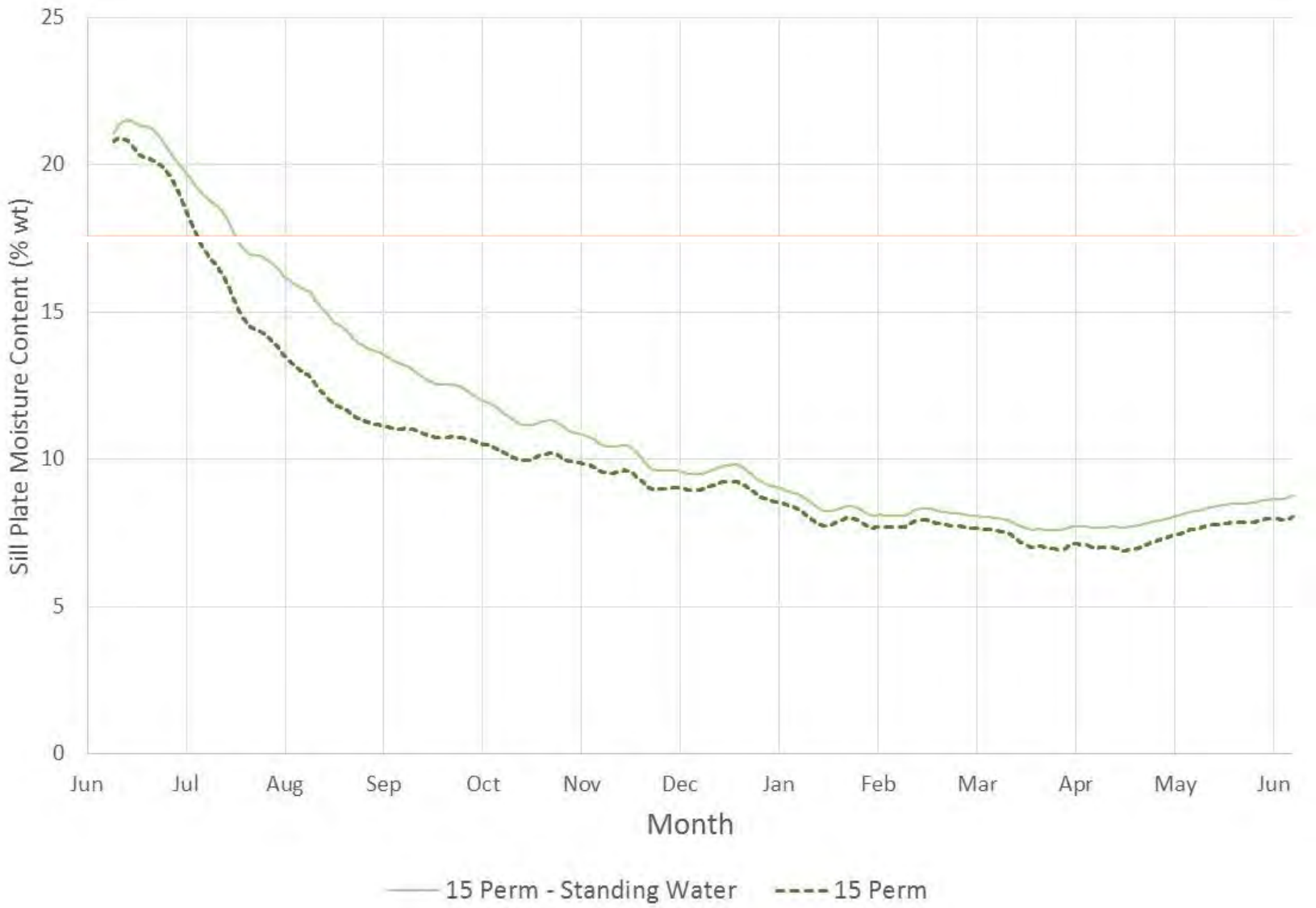




Absorptive brick cladding in field area

Drywall RH of wood frame wall with brick cladding without air leakage in Toronto

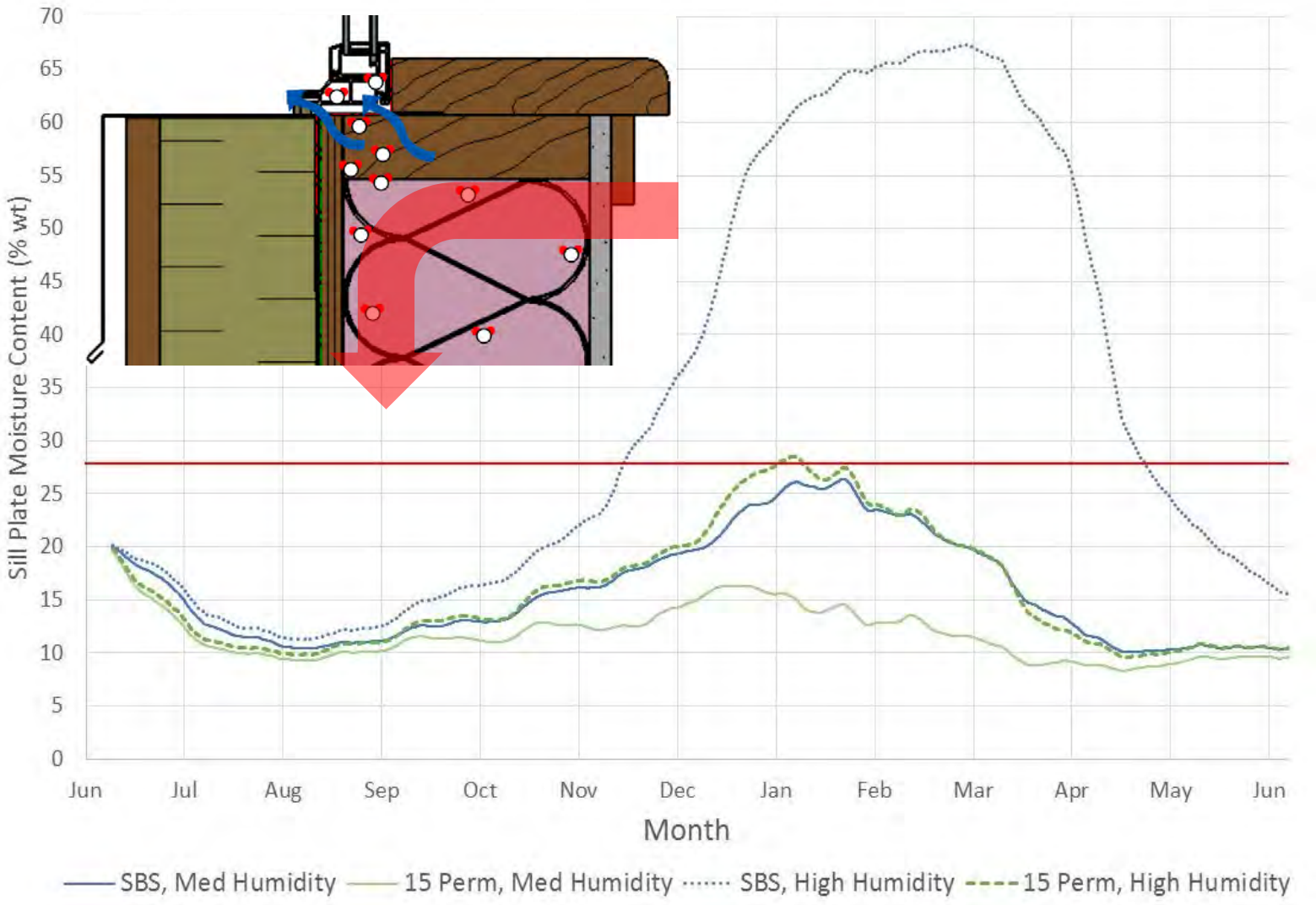
Inward Vapour Drive



Simulated standing water over sill

Sill moisture content with medium humidity without air leakage in Vancouver

Maximum Indoor Humidity



Sill moisture content in Vancouver

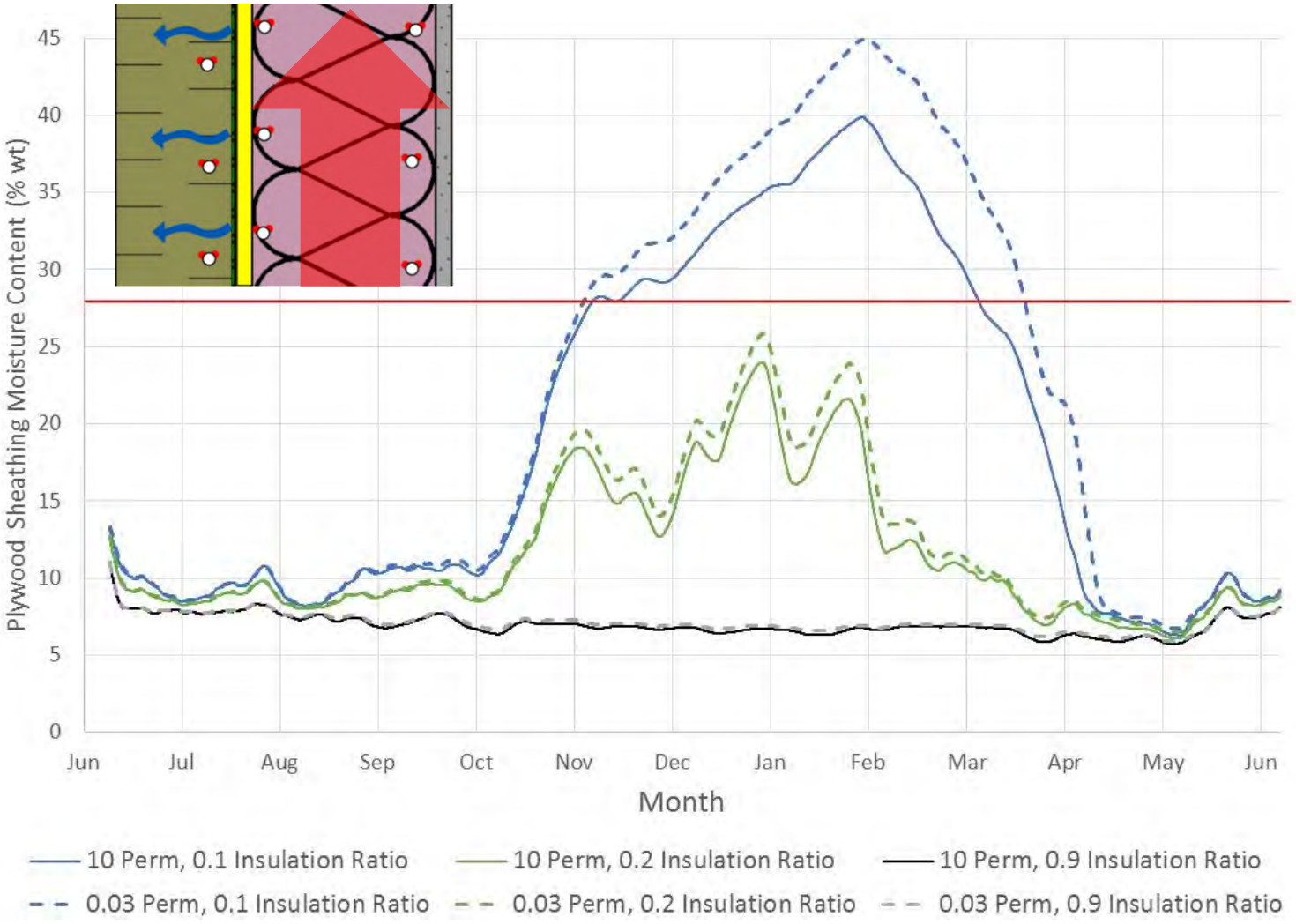
- Membrane permeance is critical to moisture accumulation at window sills

Membrane Permeance (US Perms)	Max. Humidity
0.03 (SBS) – 15	Medium (540Pa ΔVP)

Insulation Ratio and Permeable Membranes

- Insulation ratio is more effective at reducing sheathing moisture accumulation than high perm membranes

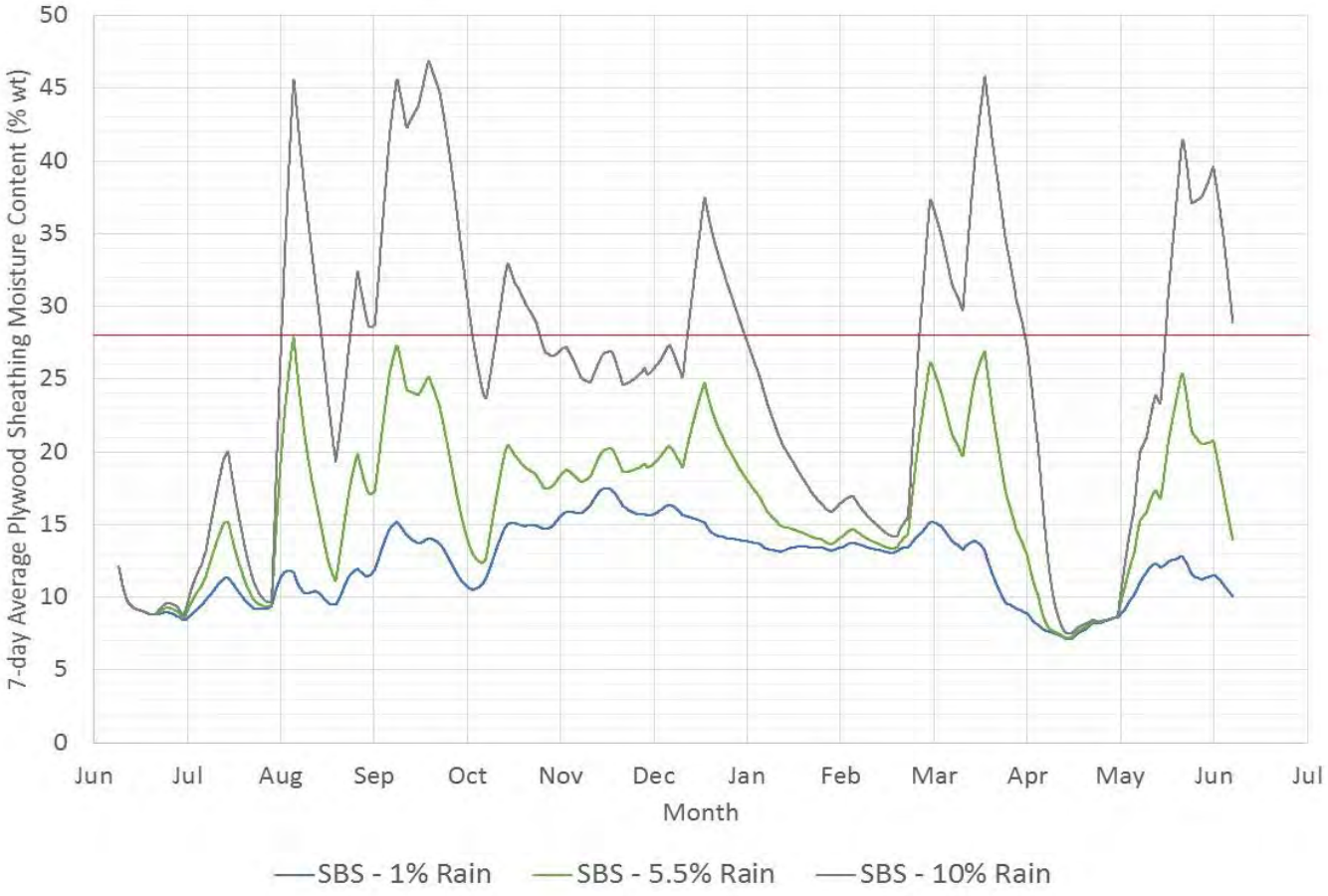
Membrane Permeance (US Perm)	Medium Humidity (540Pa ΔVP)	High Humidity (750Pa ΔVP)
0.03 (SBS)	0.20	0.60
1		
10		0.55
50	0.15	



Sheathing MC with Air Leakage in Edmonton

Maximum Rain Penetration

- Greater tolerance to rain leaks with high perm membranes



Sheathing MC in Toronto

Split insulated wood frame wall in Toronto

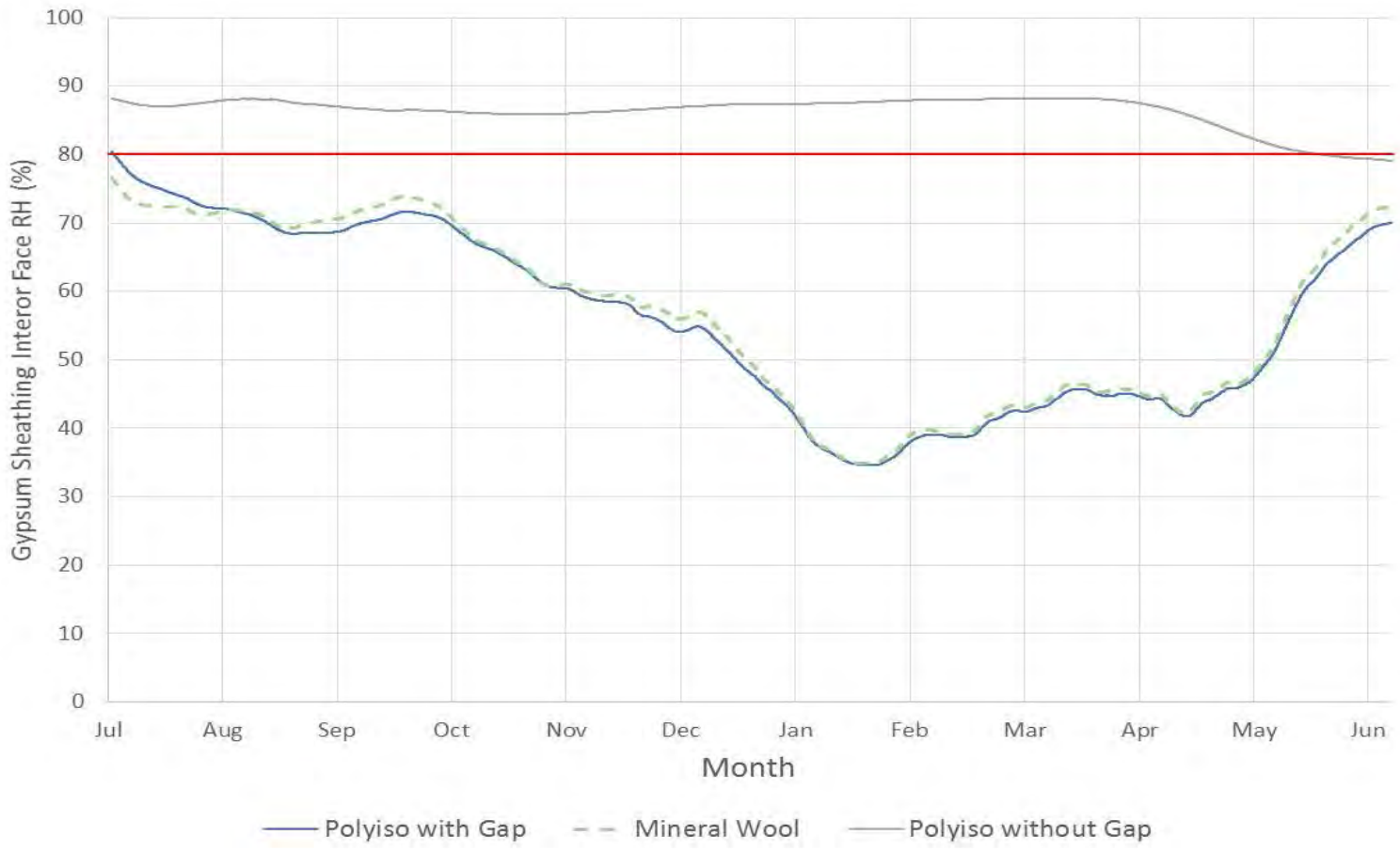
Wall Membrane Permeance	Max. Allowable Driving Rain %
0.03 US Perm (SBS)	5.50%
1 US Perm	5.50%
10 US Perm	5.50%
50 US Perm	5.75%

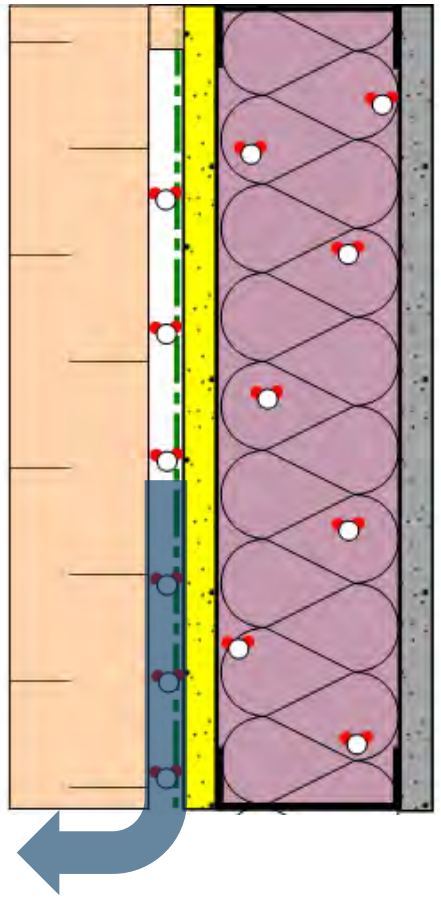
Wood sill in Toronto

Sub Sill Membrane Permeance	Max. Allowable Driving Rain %
0.03 US Perm (SBS)	0.5%
1 US Perm	0.5%
10 US Perm	1%
15 US Perm	1%

Low Permeable Insulation

- Drying can be provided with a diffusion path
- Benefits of high perm membranes realized with ¼” (6mm) gap





Gypsum sheathing RH with 50 Perm WRB membranes without Air Leakage in Toronto

Conclusion

- Design limits quantify performance of assemblies
  - High vapour permeable membranes have greater tolerance for moisture at window sills
  - Vapour permeance of membranes less relevant at higher Insulation ratios
  - Benefits of high vapour permeable membranes outweigh concerns of inward vapour drive from standing water at sill
  - Low vapour permeable insulation can benefit from high vapour permeable membranes with a small drainage gap between the insulation and sheathing
- Identify locations in assembly more susceptible to moisture and how best to deal with them
- Design tool that includes other assemblies and climates to help designers

Thank you!

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