Building Solutions

Better Buildings Homes Challenge

RESNET 2017 Conference March 3, 2017
Brian Lieburn

Brian Lieburn

- Research Scientist
  - Residential Application Development
- Dow Building Solutions since 2010
- 25 Years in Production Homebuilding
- BS from University of Wisconsin - Stout

Better Buildings Challenge Project

A multi-home, 5 year research project,
in partnership with Cobblestone Homes,
to investigate the performance of building enclosures designed to meet latest energy code requirements.

Research Objectives

Demonstrate ways to:

- Lower the cost of home ownership
- Improve home performance

Produce real world data on:

- Construction cost
- Energy use
- Wall durability performance
- Occupant comfort and perception

Create output useful in construction decisions

Experimental Design

Three homes built for each energy efficiency design

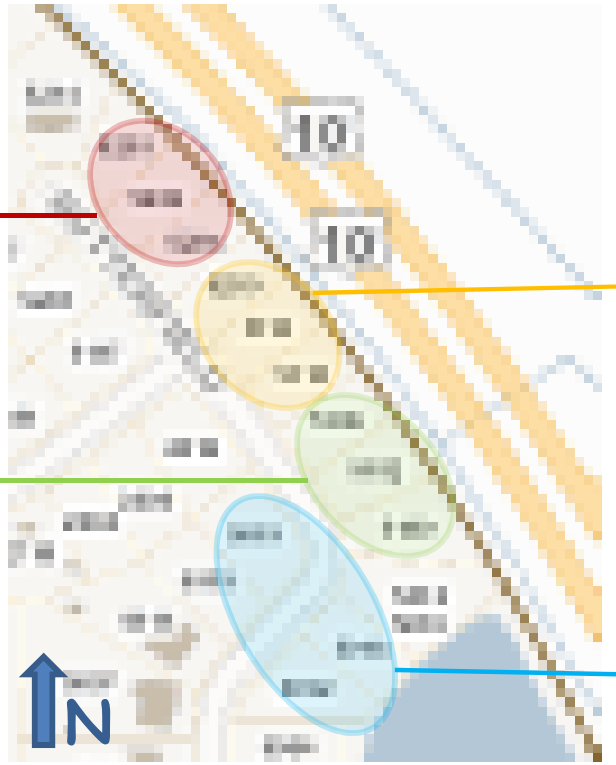
Baseline HERS 82	Meet 2006 IECC Typical Local Practices
2012 Performance Minimum cost HERS 57	Meet 2012 IECC Least Changes & Lowest Possible Price Point
2012 Performance Premium Package HERS 57	Meet 2012 IECC Continuous Insulation & SPF
Beyond Code Premium Package HERS – mid 40s	Exceed 2012 IECC Renewable Ready

Energy Performance Research Neighborhood

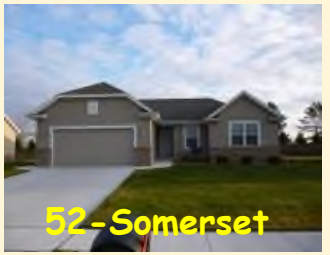
Midland Michigan

Climate Zone 5-6

2006 IECC



2012 IECC



2012 IECC Premium

Beyond 2012 IECC

Foundation & Floor Design

	Fibrous Insulation		Foam Insulation	
	2006 IECC	**2012 IECC**	**2012 IECC**	**High Performance**
Under Floor Slab	None	None	None	R-10 XPS
Rim Joist -Interior	R-19 FG batt	R-19 FG batt	R-16 cc SPF	R-16 cc SPF
Rim Joist – Exterior	None	None	R-5 XPS	R-10 XPS
Basement Wall – Interior Finished	R-13 FG batt	R-19 FG batt	R-5 XPS	R-10 XPS
Basement Wall - Interior Unfinished	R-10 FG vinyl faced	R-15 FG vinyl faced	R-5 PIR	R-10 PIR
Basement Wall – Exterior	None	None	R-10 XPS	R-10 XPS

Above Grade Wall and Ceiling Design

	Fibrous Insulation		Foam Insulation*	
	2006 IECC	**2012 IECC**	**2012 IECC -CI**	**High Performance**
Stud Dimensions	2X6	2X6	2X4	2X6
Interior	R-19 FG batt	R-19 FG batt	R-16 cc SPF	R-31 cc SPF
Exterior	OSB & Housewrap	OSB & Housewrap	R-5.5 SIS	R-5.5 SIS + R-5 XPS
Ceiling	R-38 Dry Blown Cellulose	R-49 Dry Blown Cellulose	R-49 Dry Blown Cellulose*	R-12 2”cc SPF & R-49 Dry Blown Cellulose*


Tyvek


Tyvek
Tyvek
Tyvek

Windows and Mechanical Design

	Fibrous Insulation		Foam Insulation*	
	2006 IECC	**2012 IECC**	**2012 IECC-CI**	**Beyond 2012 IECC**
Windows	U-.35	U-.32	U-.32	U-.28
Furnace	80% AFUE	92% AFUE	92% AFUE	95% AFUE
AC	13 SEER	13 SEER	13 SEER	13 SEER
Water Heating	91% Electric	91% Electric	91% Electric	91% Electric
High Efficiency Lighting	0%	75%	75%	100%

Construction Cost Comparison

Actual Cost Complications

- Lot variations
- Elevation differences
- Material upgrades
- Weather related costs
- Price variations
  - ✓ Price fluctuations throughout the term of the project
  - ✓ Different suppliers or subcontractors
- Invoicing errors
- Quantity variations
  - ✓ Rob Peter to pay Paul
  - ✓ Different subcontractors
  - ✓ Theft
  - ✓ Damage

Actual Cost Comparison

- Exclude costs not related to energy levels
- Equalize all material and labor prices across the board
- Equalize or calibrate quantities
  - ✓ Use consistent areas between same house types
  - ✓ Use an actual material count across same house types
    - ❖ Make adjustments only when needed based on solid, logical and defensible judgments

Cost Summary

Somerset Model - Ranch	Framing, Insulation & Air Sealing	Windows & Exterior Doors	HVAC	Lighting	TOTAL	Premium from Baseline
2006 IECC	$ 14,888	$ 3,356	$ 6,922	$ -	$ 25,166	
2012 IECC - Fiber	$ 15,396	$ 4,545	$ 6,375	$ 100	$ 26,416	$ 1,250.27
2012 CI Dow Premium	$ 19,619	$ 4,545	$ 6,375	$ 100	$ 30,639	$ 5,472.96
Beyond 2012 IECC - Renewable Ready	$ 27,142	$ 5,477	$ 7,675	$ 350	$ 40,644	$ 15,478.09

Kendall Model - 2 story						
2006 IECC	$ 16,886	$ 3,660	$ 6,922	$ -	$ 27,467	
2012 IECC - Fiber	$ 17,215	$ 4,928	$ 6,775	$ 100	$ 29,018	$ 1,550.24
2012 CI Dow Premium	$ 21,086	$ 4,928	$ 6,775	$ 100	$ 32,889	$ 5,421.55
Beyond 2012 IECC - Renewable Ready	$ 28,789	$ 5,828	$ 8,075	$ 350	$ 43,042	$ 15,574.57

Preston Model - Ranch						
2006 IECC	$ 16,945	$ 3,447	$ 6,922	$ -	$ 27,314	
2012 IECC - Fiber	$ 17,744	$ 5,130	$ 6,375	$ 100	$ 29,350	$ 2,035.68
2012 CI Dow Premium	$ 22,297	$ 5,130	$ 6,375	$ 100	$ 33,902	$ 6,588.09
Beyond 2012 IECC - Renewable Ready	$ 29,023	$ 6,146	$ 7,675	$ 350	$ 43,194	$ 15,879.75

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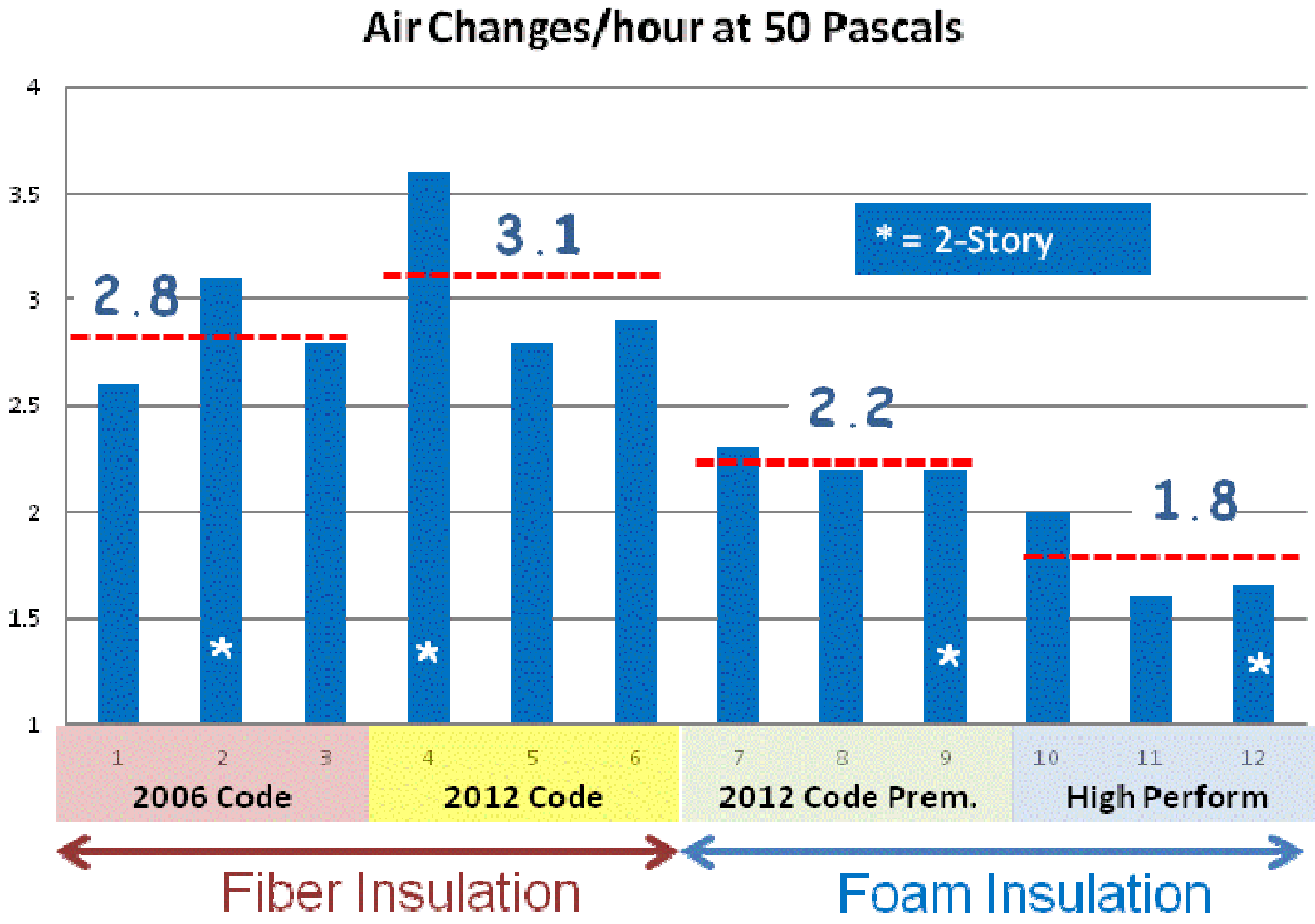
Comparison of Air Leakage



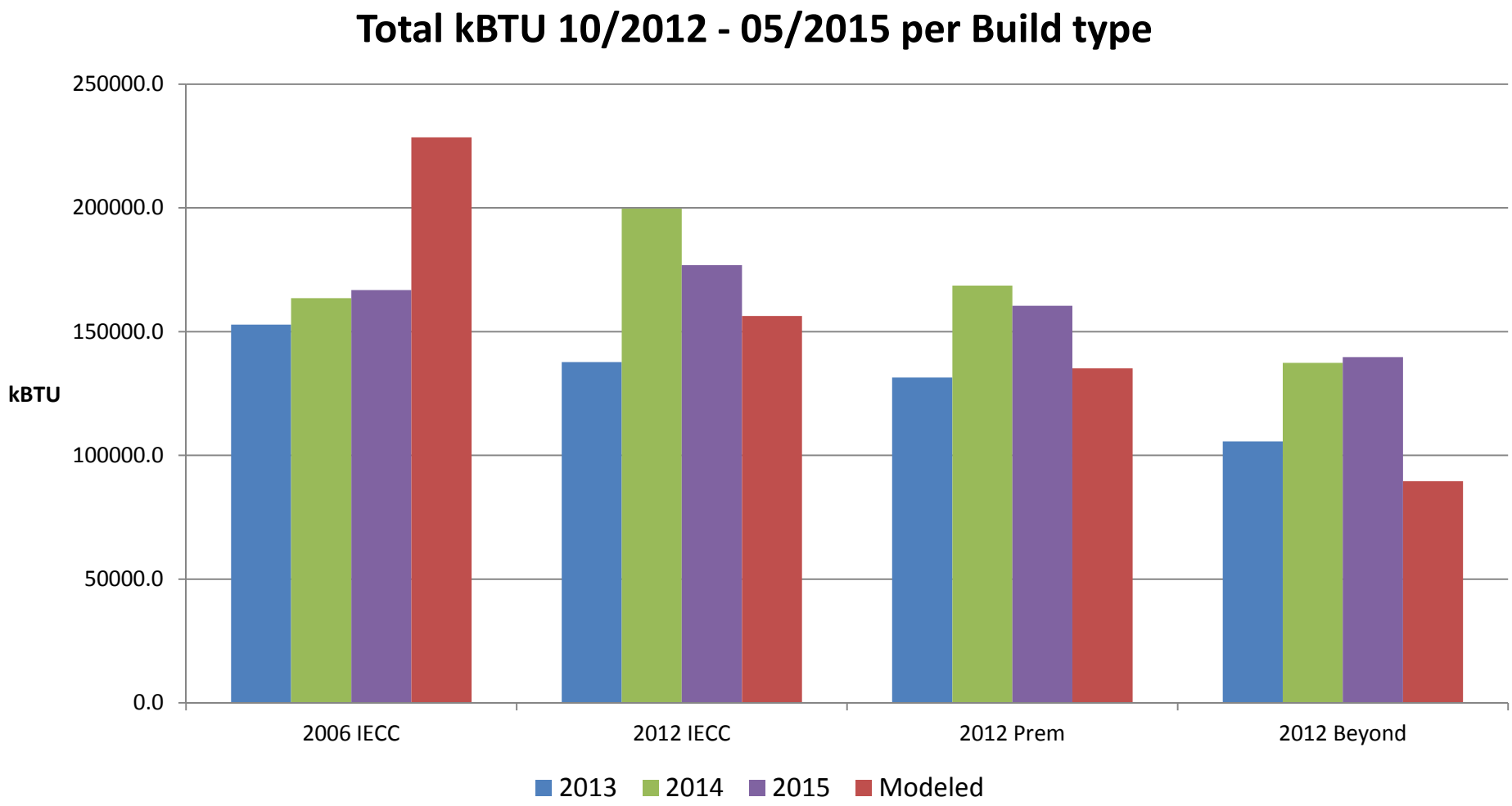
Red dotted line = avg of group

2012 IECC without & with Continuous Insulation

OSB Plus Housewrap

R-5 Continuous Insulation

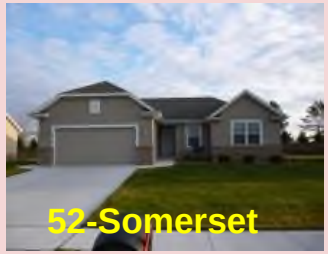
Heating Energy

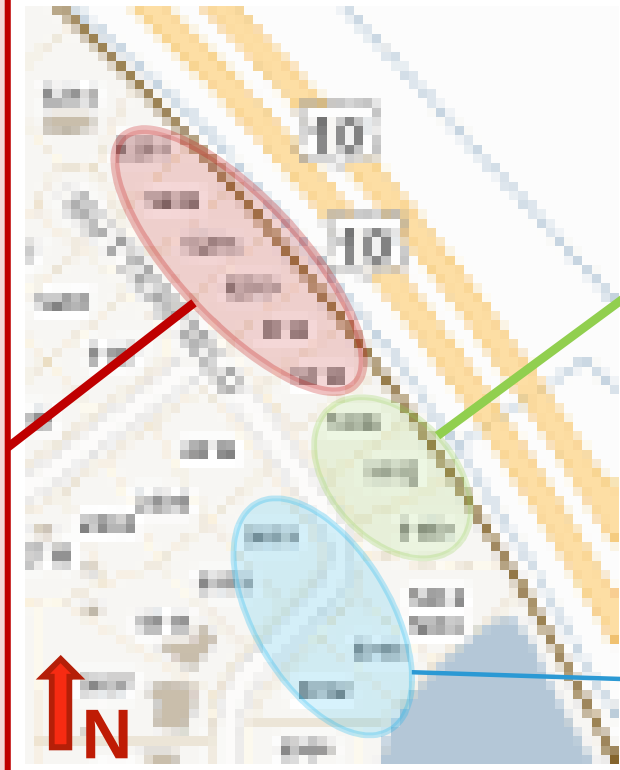


Wall Measured Moisture Comparison

Comparison Cases

2X6 OSB/HW

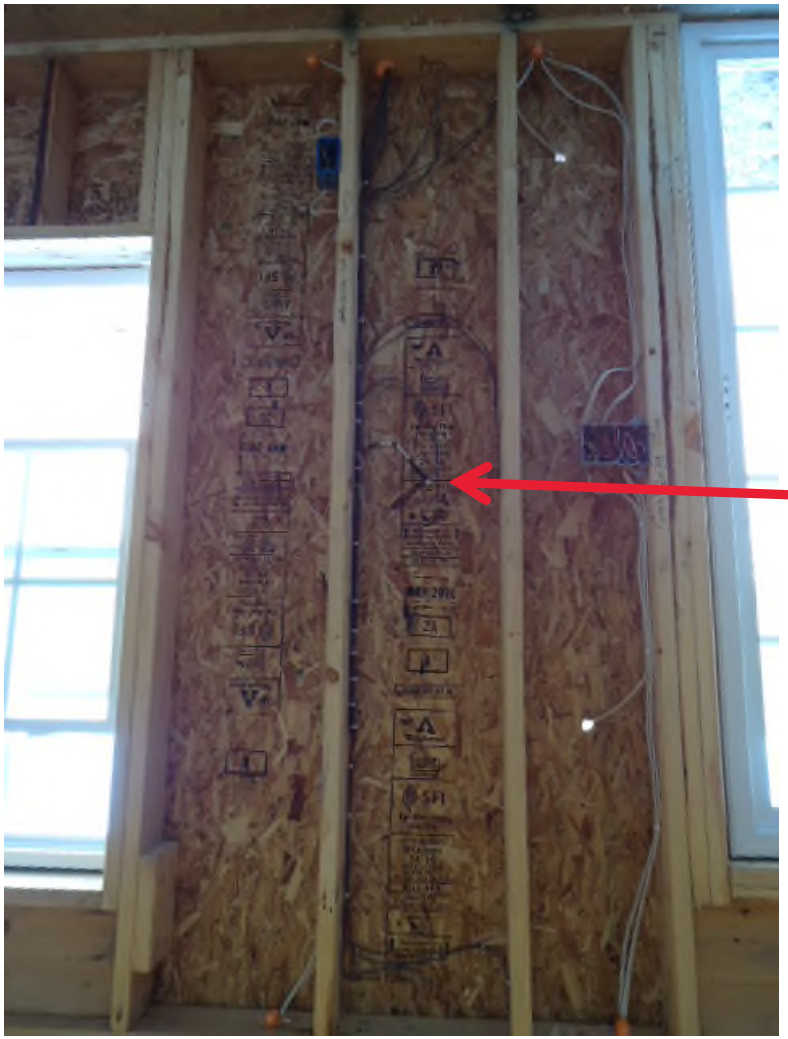


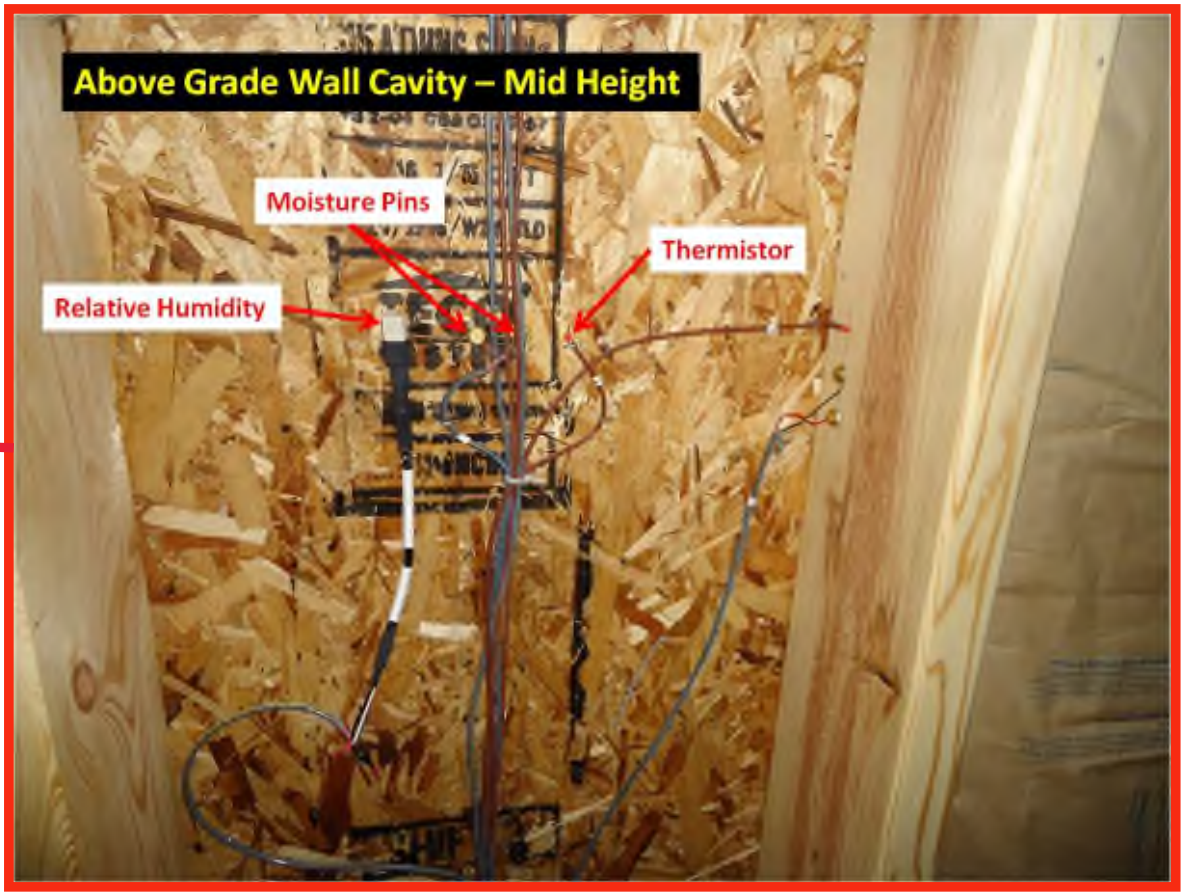


2x4 R5 CI

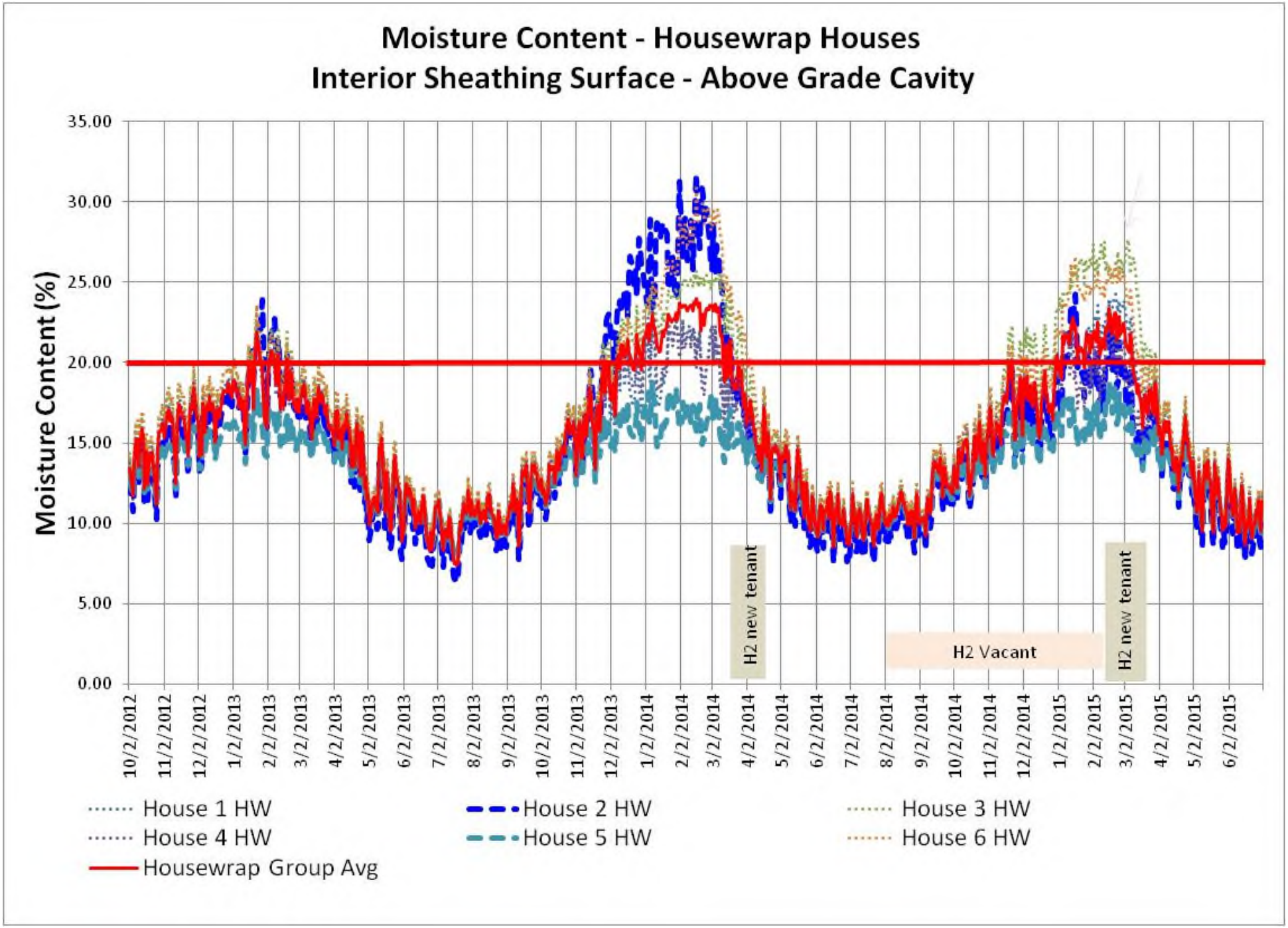
Net Zero Ready Homes

Above Grade Wall Measurement Location

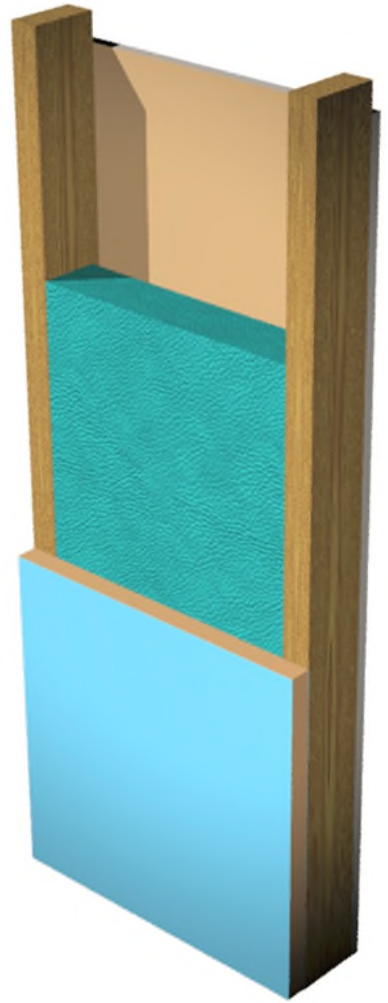


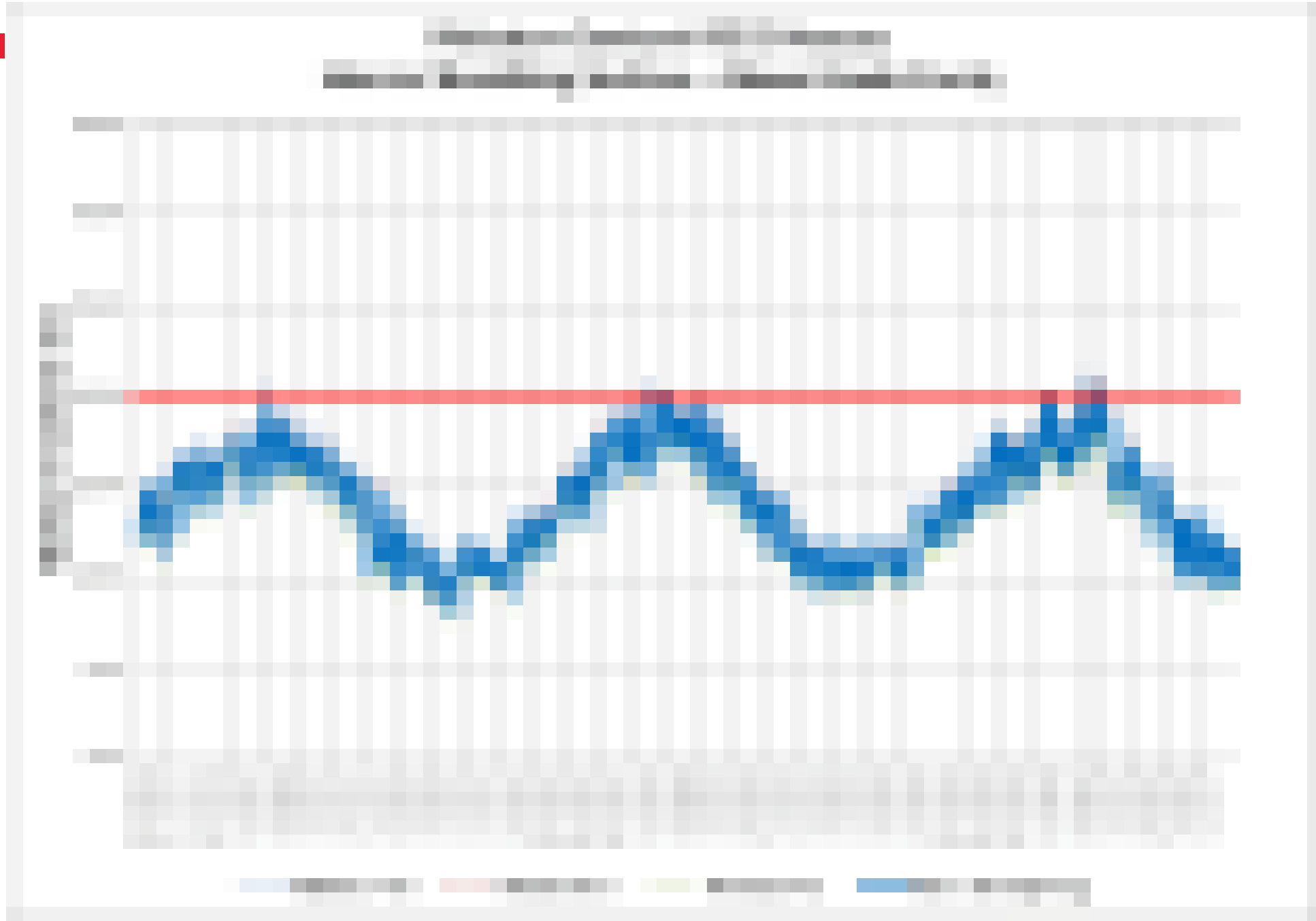


2x6 OSB & HW

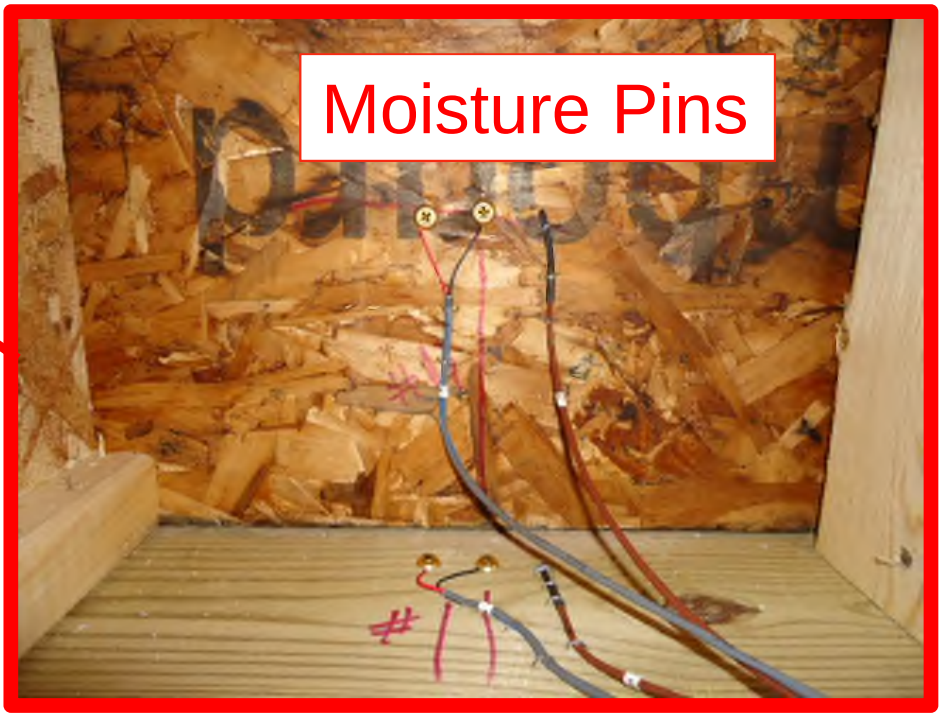

Moisture Content - Housewrap Houses
Interior Sheathing Surface - Above Grade Cavity
Moisture Content (%)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
10/2/2012
11/2/2012
12/2/2012
1/2/2013
2/2/2013
3/2/2013
4/2/2013
5/2/2013
6/2/2013
7/2/2013
8/2/2013
9/2/2013
10/2/2013
11/2/2013
12/2/2013
1/2/2014
2/2/2014
3/2/2014
4/2/2014
5/2/2014
6/2/2014
7/2/2014
8/2/2014
9/2/2014
10/2/2014
11/2/2014
12/2/2014
1/2/2015
2/2/2015
3/2/2015
4/2/2015
5/2/2015
6/2/2015
H2 new tenant
H2 Vacant
H2 new tenant
House 1 HW
House 2 HW
House 3 HW
House 4 HW
House 5 HW
House 6 HW
Housewrap Group Avg

2x4 R5 ci & R16 SPF

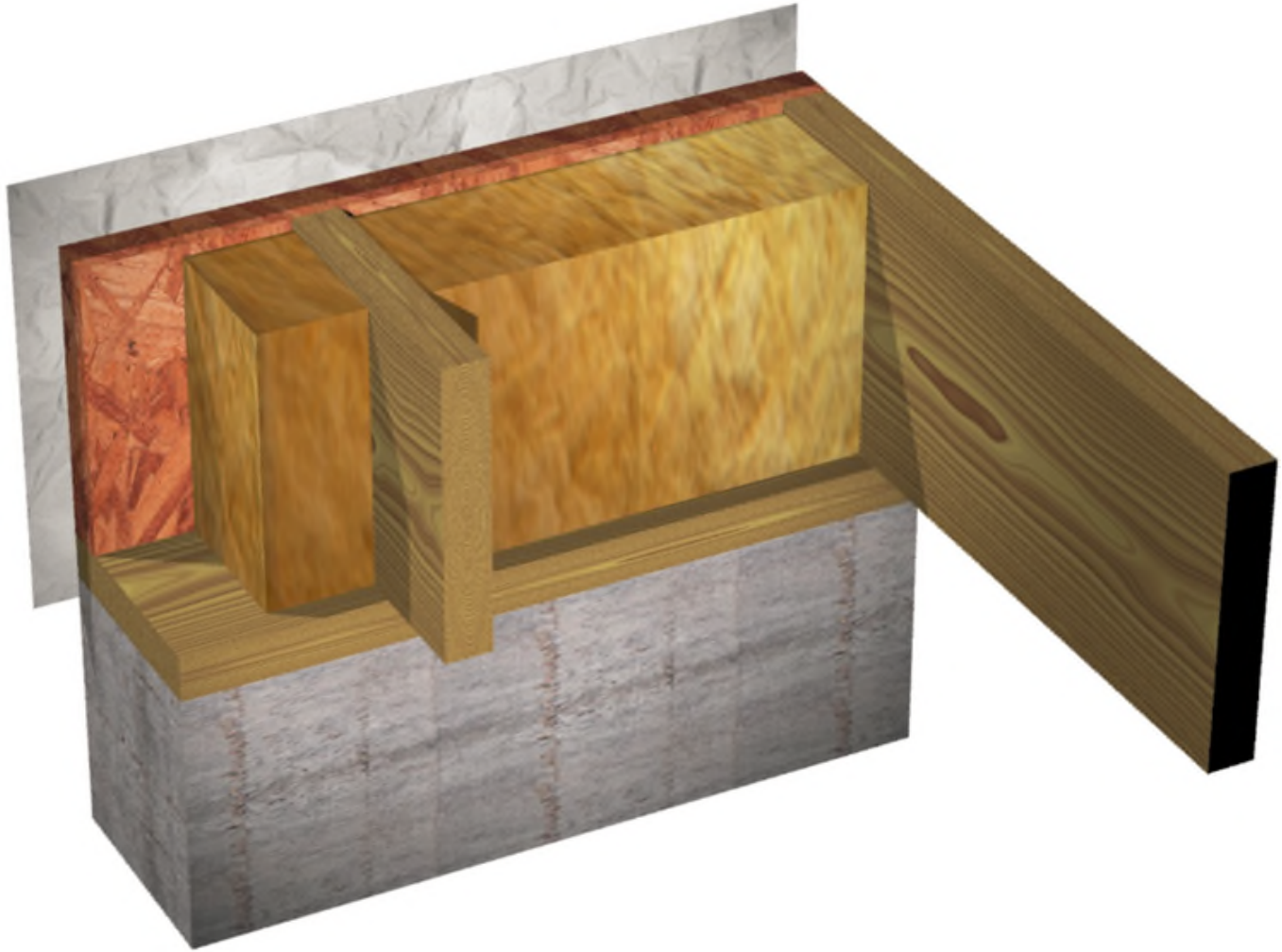


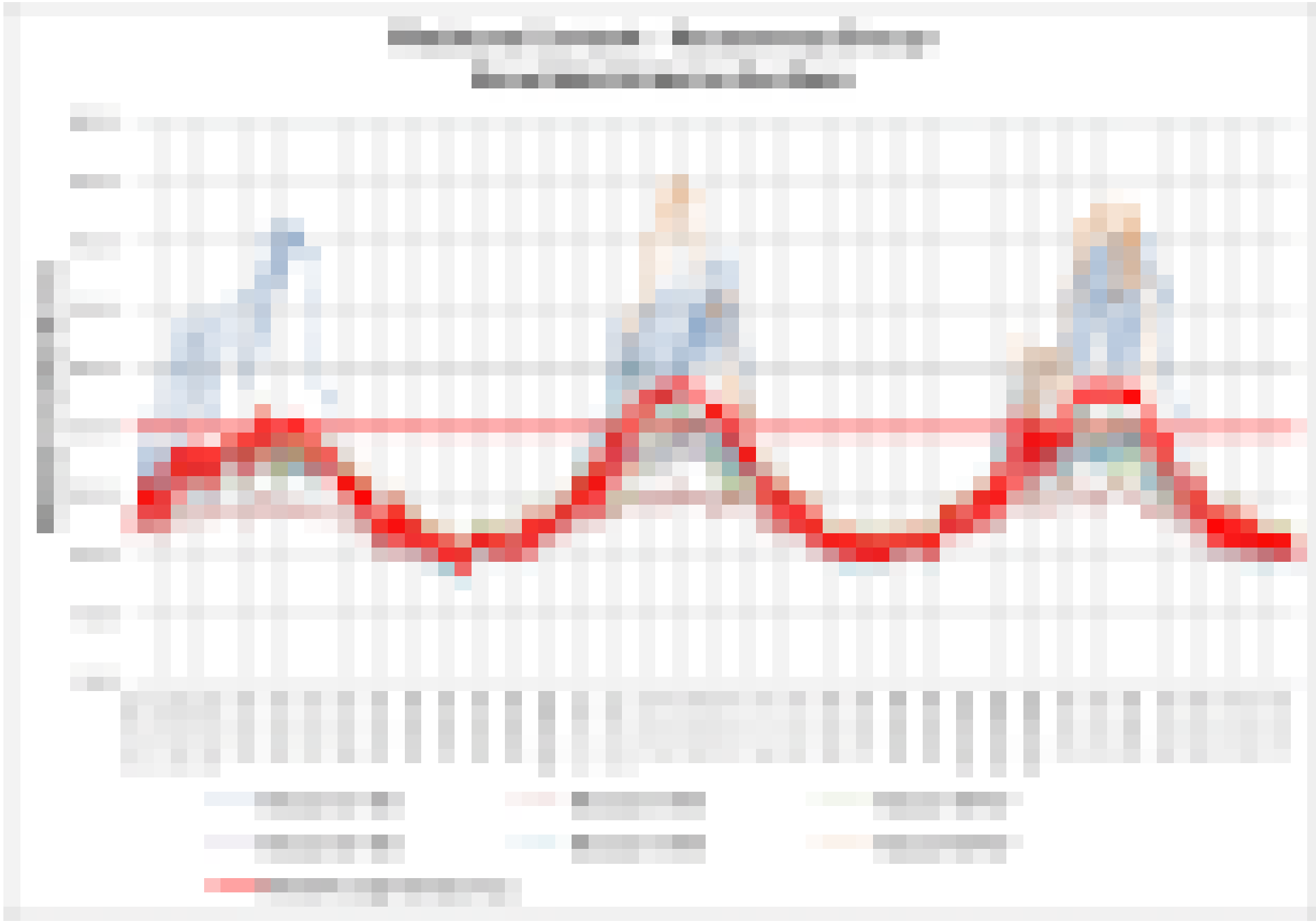


Rim Joist Measurement Location

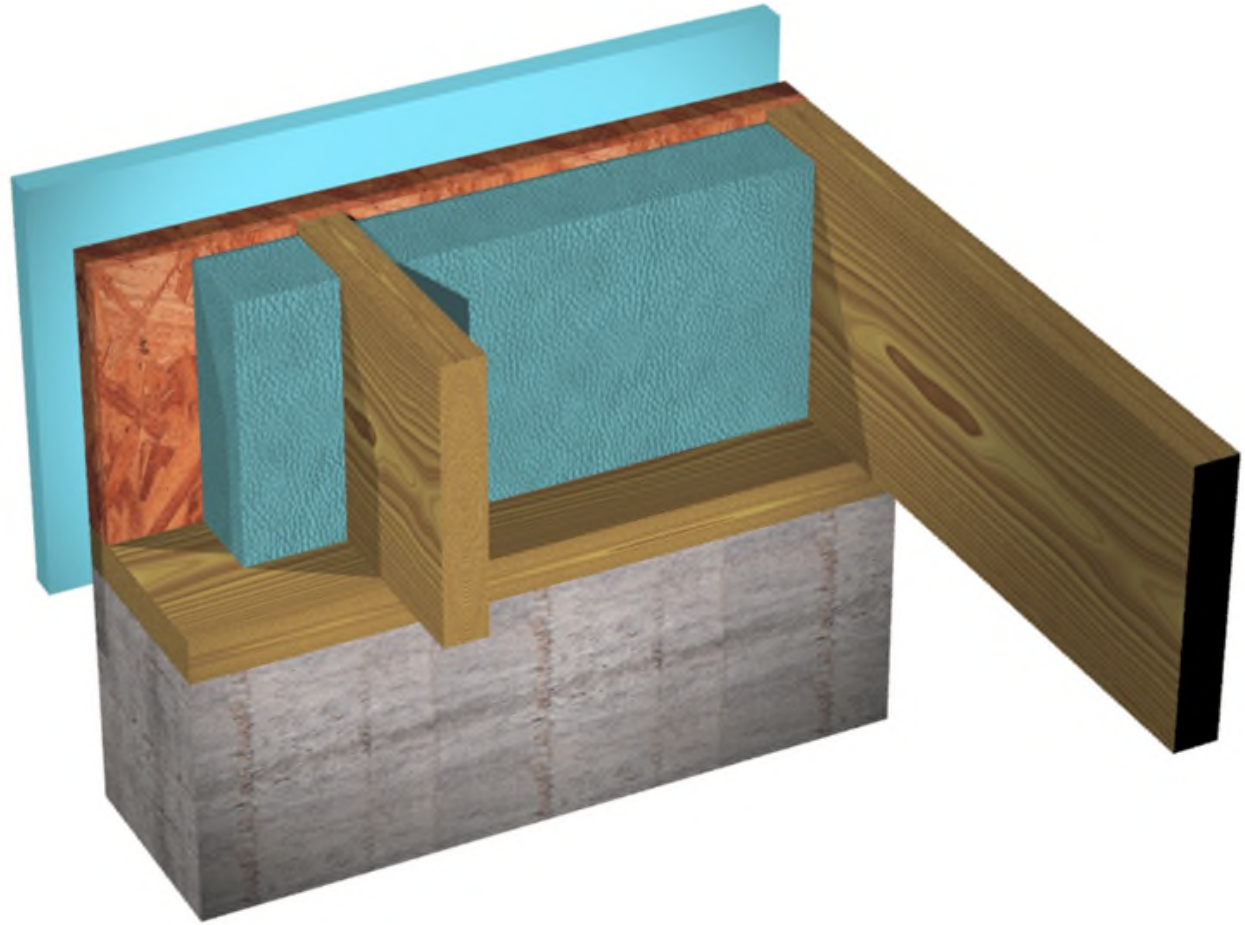


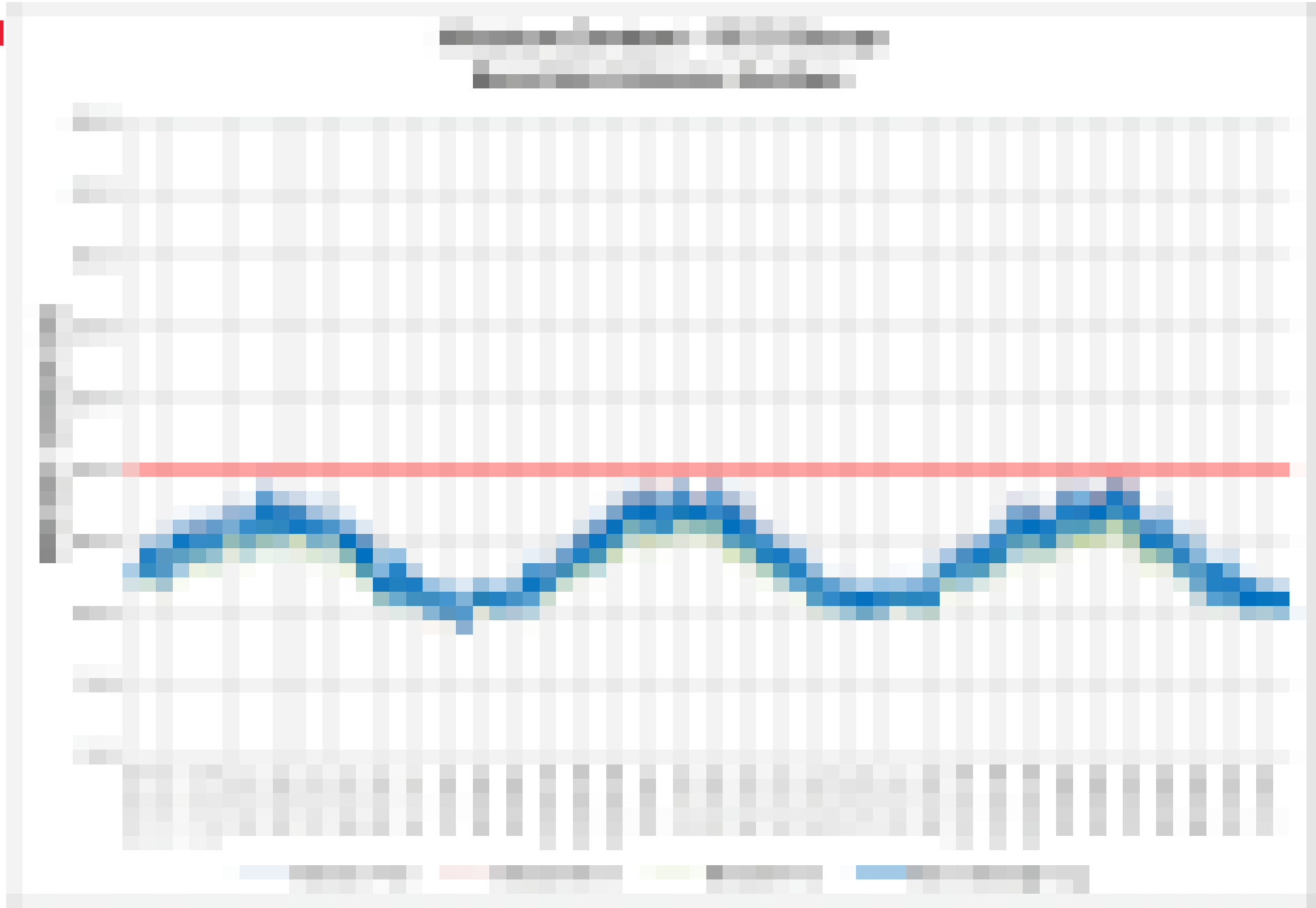
Engineered Rim joist FG & HW





Engineered rim joist R5 ci & SPF





Forensic Inspection of Select Houses

Summer 2015 Forensic Inspections

- Inspect Houses **2,3,6** - elevated measured moisture content
- Inspect House **5** - measured moisture content always below 20%

- Inspections
  - Visual Observation
  - Sampling of OSB for Strength Measurement
  - Swab for Fungal or Microbial Growth – including microscopy

Blower Door

- Compare original 2011 to 2015
- Test under positive pressure

Blower Door

House	Construction	2011 Neg	2015 Neg	Difference	Pos Not Taped	Pos Taped
1	2x6 OSB HW	1180	1204	24	1457	1263
2	2x6 OSB HW	1230	1243	13	1406	1293
3	2x6 OSB HW	1273	1277	4	1401	1330
4	2x6 OSB HW	1424	1326	-98	1558	1356
5	2x6 OSB HW	1272	1345	73	1552	1388
6	2x6 OSB HW	1311	1379	68	1482	1399
7	2x4 CI SPF	1140	925	-215	1031	861
8	2x4 CI SPF	980	834	-146	1069	879
9	2x4 CI SPF	875	757	-118	963	740
10	2x6 CI SPF	742	732	-10	892	728
11	2x6 CI SPF	763	883	120	1031	843
12	2x6 CI SPF	798	883	85	1039	892


NAIL

House 2

House 5 Rim Joist

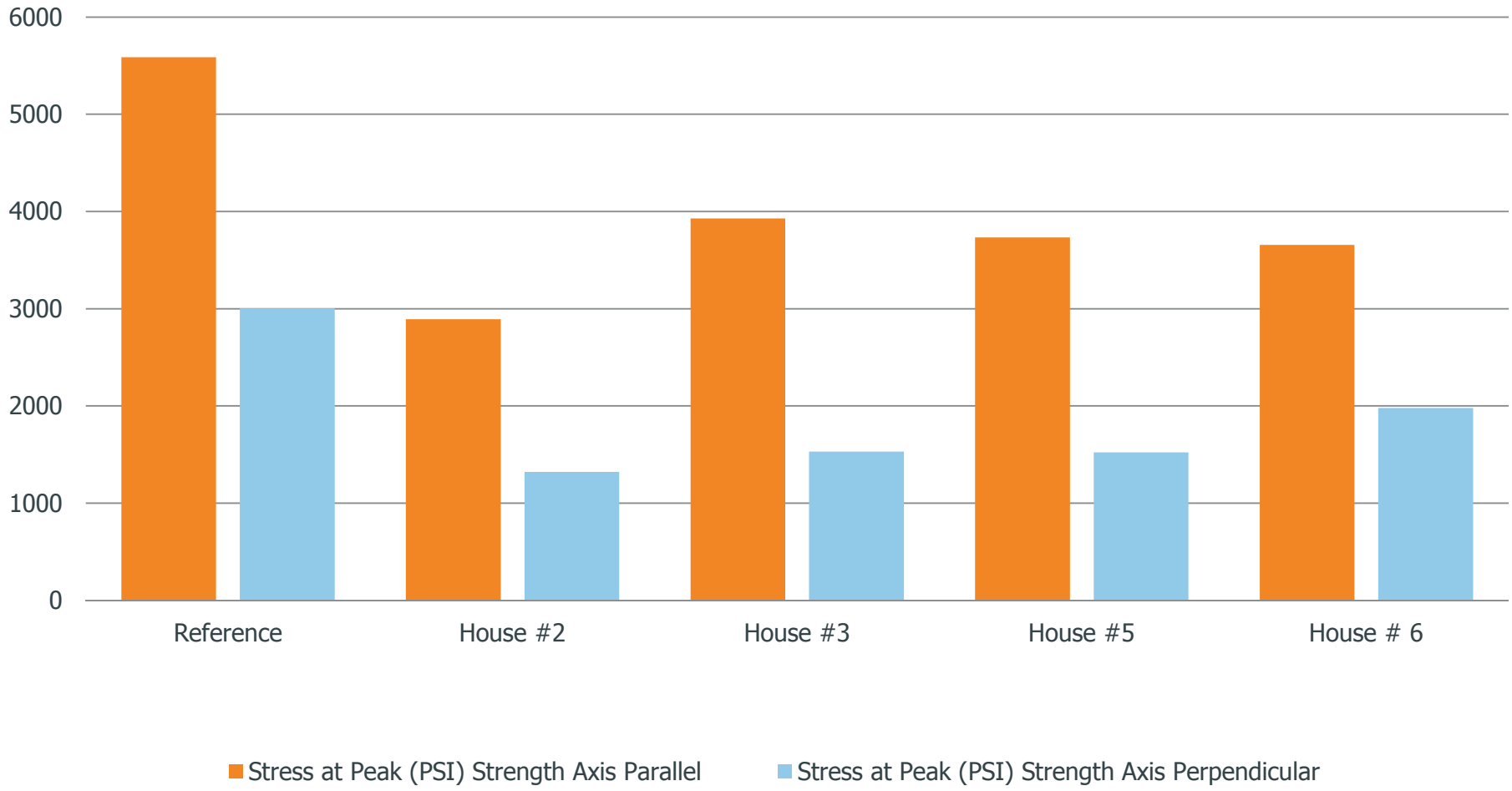
2011

2015

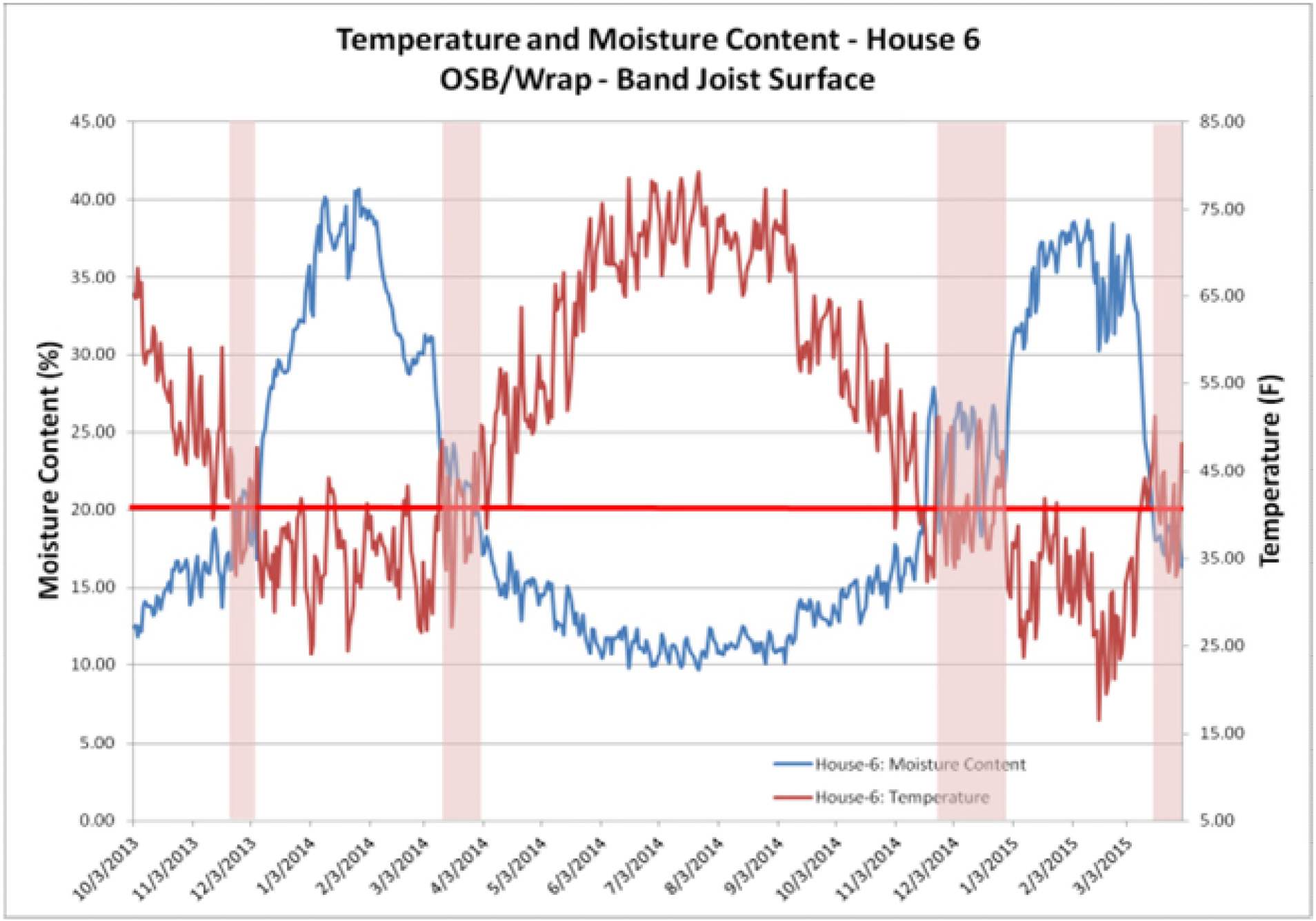
Summary Forensic Findings

	Moisture Content	Above Grade Wall	Rim Joist	Microbial Sampling
House 2	Elevated	Water staining in cavity	No evidence of water	Moderate to heavy fungal growth – wall cavity
House 3	Elevated	Small area of dark staining	No evidence of water	Some fungal growth – rim joist
House 6	Elevated	No evidence of water	Some staining on joist bottom chord	Some fungal growth – rim joist
House 5	Low	Water staining in cavity	Rust on staples	No fungal growth

Small Scale Static Bending Test



- So, Why do we see this – high MC but no real deterioration?


Temperature and Moisture Content - House 6
OSB/Wrap - Band Joist Surface
Moisture Content (%)
Temperature (F)
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
85.00
75.00
65.00
55.00
45.00
35.00
25.00
15.00
5.00
10/3/2013
11/3/2013
12/3/2013
1/3/2014
2/3/2014
3/3/2014
4/3/2014
5/3/2014
6/3/2014
7/3/2014
8/3/2014
9/3/2014
10/3/2014
11/3/2014
12/3/2014
1/3/2015
2/3/2015
3/3/2015
House-6: Moisture Content
House-6: Temperature

Occupant Perception – Key Takeaways

How satisfied are you with the level of warmth in your home when it is cold outside?

2006 IECC	2012 IECC - Fiber	2012 IECC - Foam	Beyond 2012
			

- Utility bills were higher than expected (unaware of impact of MELs)
- Higher than expected utility bills implied poor construction
- Reported thermostat settings don't match measured temperature
- Greater satisfaction with oversized AC
- Dissatisfaction with temperature uniformity throughout home

Summary

- Cost to build to 2012 IECC not as high as predicted
- CI & SPF measure consistently <3ACH@50Pa.
- REMRate Energy predictions for 2006 & ZER did not align with actual
- Slight energy savings with CI & SPF strategies
- OSB & House wrap high MC significant periods every winter
- Occupants matter for energy & moisture performance
- Homeowner education needed

Thank You