CCBST 15TH CANADIAN CONFERENCE ON BUILDING SCIENCE AND TECHNOLOGY

RISK ASSESSMENT OF WATER ACCUMULATION IN WALLS WITH EXTERIOR CONTINUOUS INSULATION

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November 8, 2017

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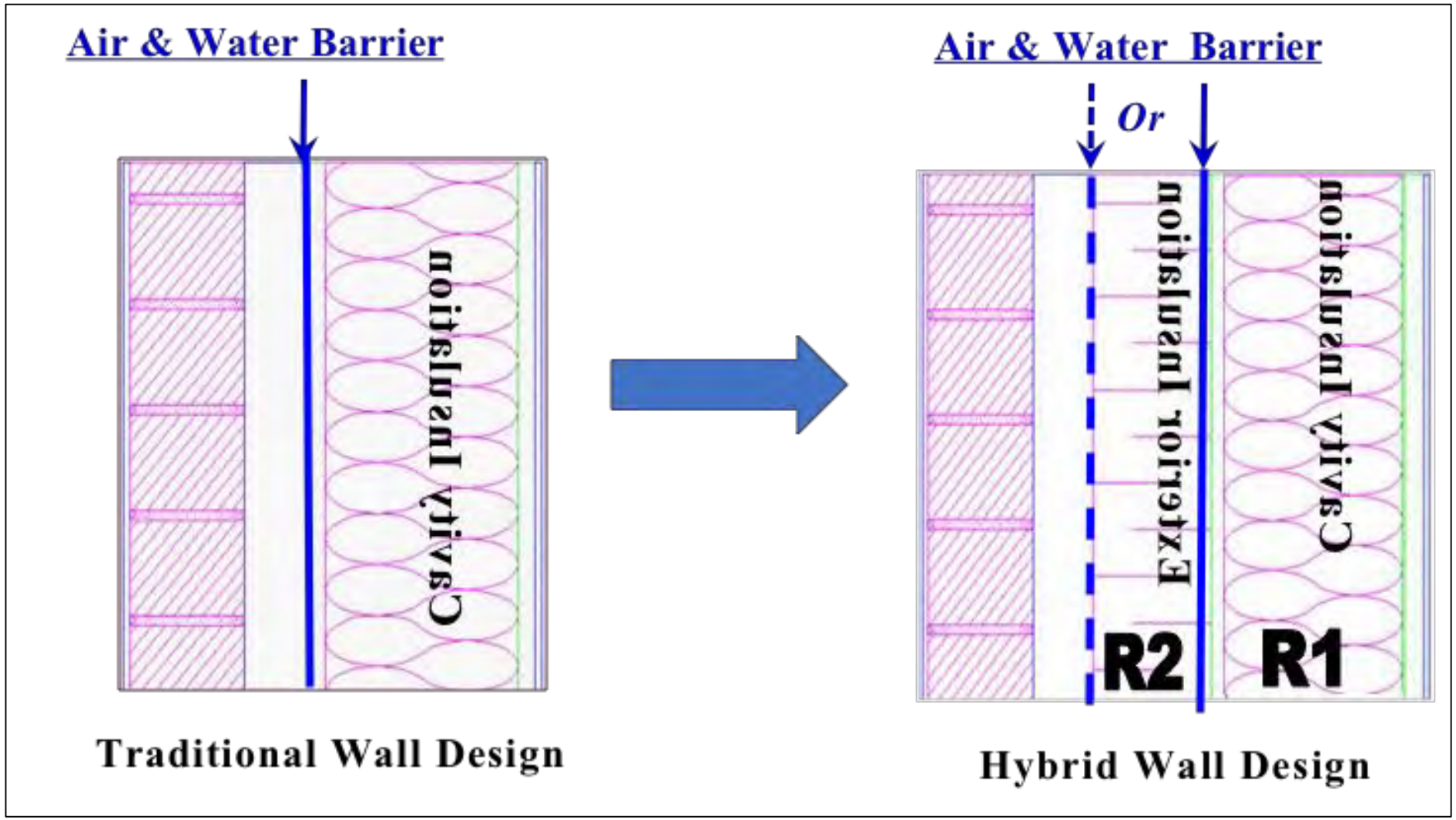
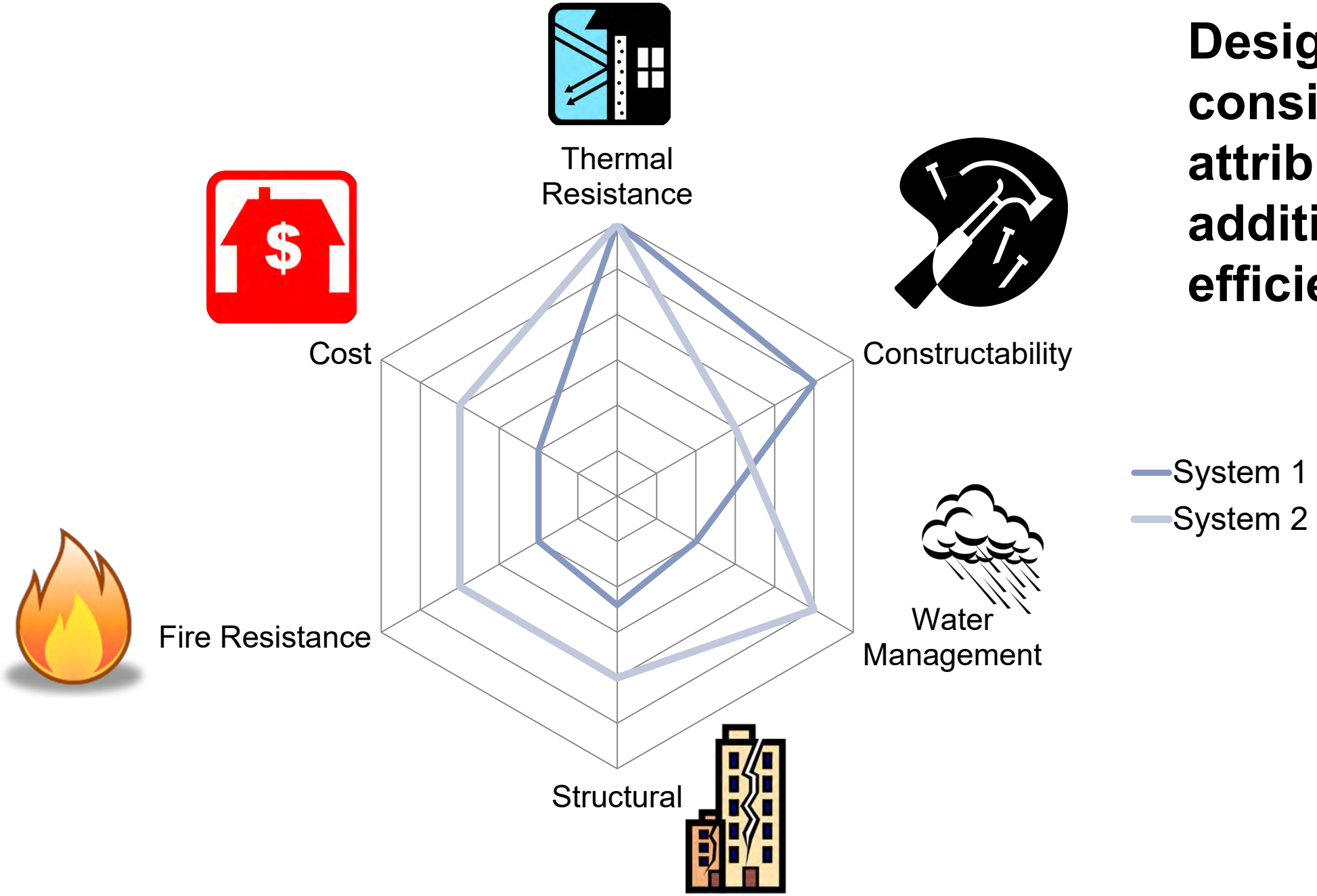
Increased insulation and use of exterior insulation has become "standard" as part of energy efficient new construction.



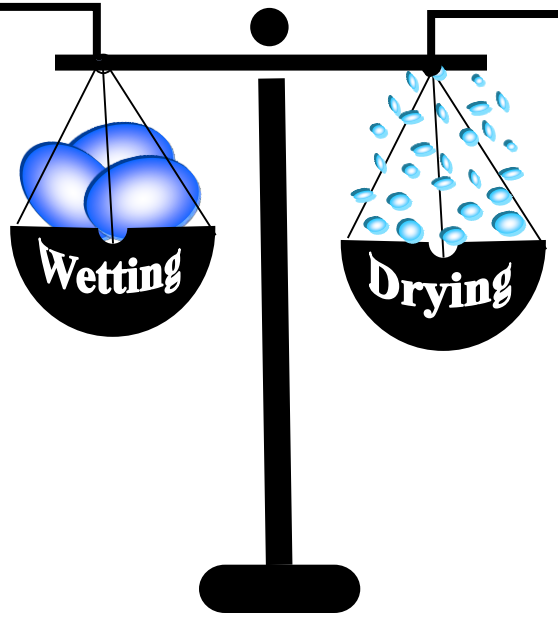
Design needs to consider many attributes in addition to energy efficiency



Water Management Criteria should include Assessment of both Wetting and Drying of the Building Assembly

Minimize

Maximize



Wetting

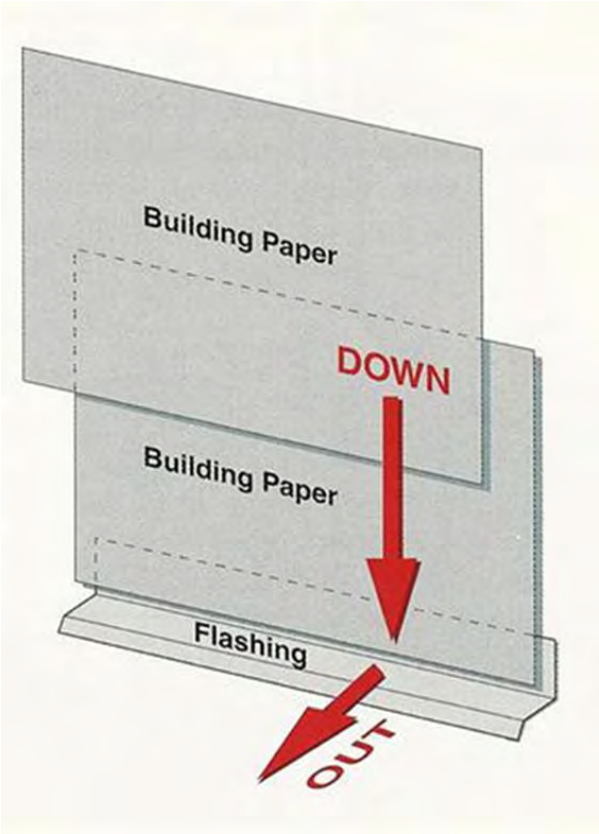
1. Bulk Water
2. Air transport
3. *Diffusion*

Drying

1. Drainage
2. Venting
3. Diffusion

Water Management

- 69% of all construction defect claims are related to moisture penetration through the building envelope (2007 Study by University of Florida)
- Some moisture problems are blamed on increasing energy efficiency
  - *"Building codes adopted in the 1970s and strengthened through the '80s and early '90s, required greater energy efficiency. Paradoxically, the demise of the drafty house had an unintended consequence: When moisture penetrates today's walls, they tend to stay wet."*



Simulation Parameters

Construction

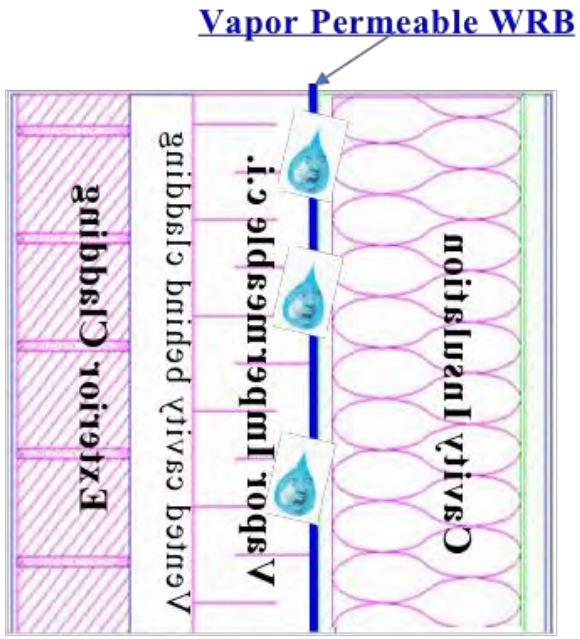
- New Construction
- Retrofit Construction
- Exterior Insulation Vapor Permeability (0.8 Perm-inch & 50 Perm-inch)
- Venting behind vapor impermeable exterior insulation (5mm with 10 ACH)

Climate

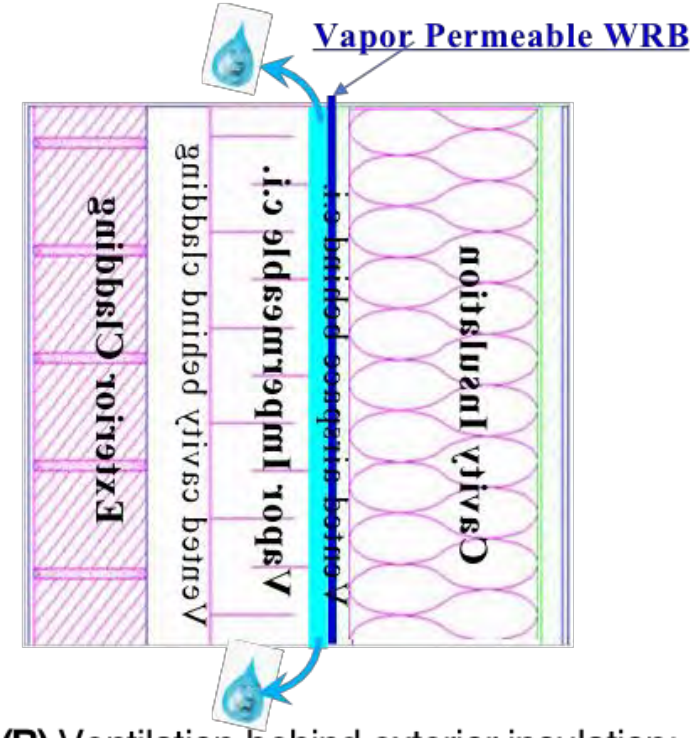
- Calgary, Alberta - CZ 7A;
- Montreal, Quebec - CZ 6A;
- Saint John, New Brunswick - CZ 6A;
- Toronto, Ontario - CZ 6A;
- Vancouver, British Colombia - CZ 5C;
- Winnipeg, Manitoba - CZ 7A.

Water Intrusion Defect

- No Defect
- .5% of Rain .

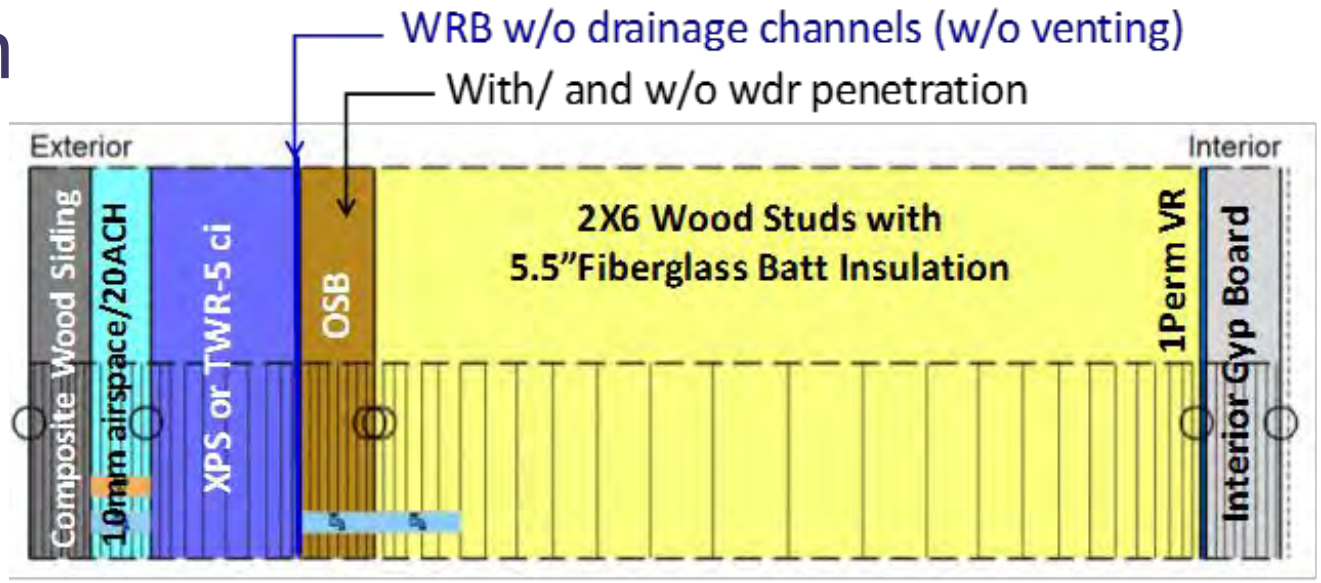


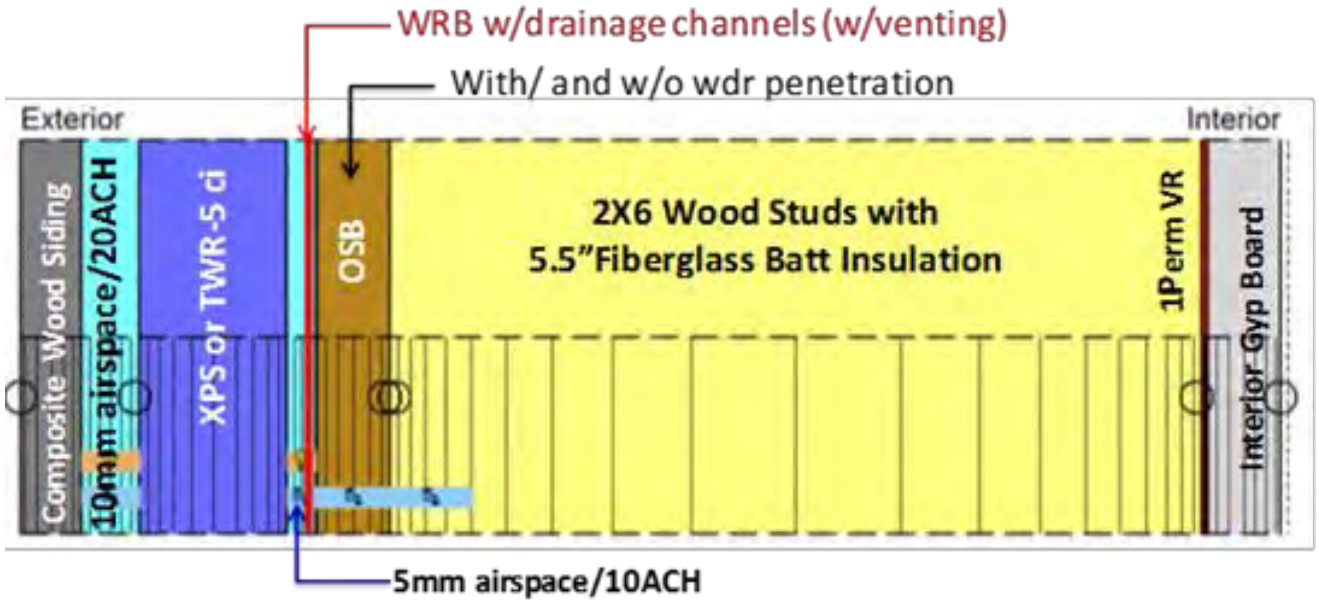
(A) No ventilation behind exterior insulation: Moisture diffuses through vapor permeable WRB but cannot escape through vapor impermeable c.i.



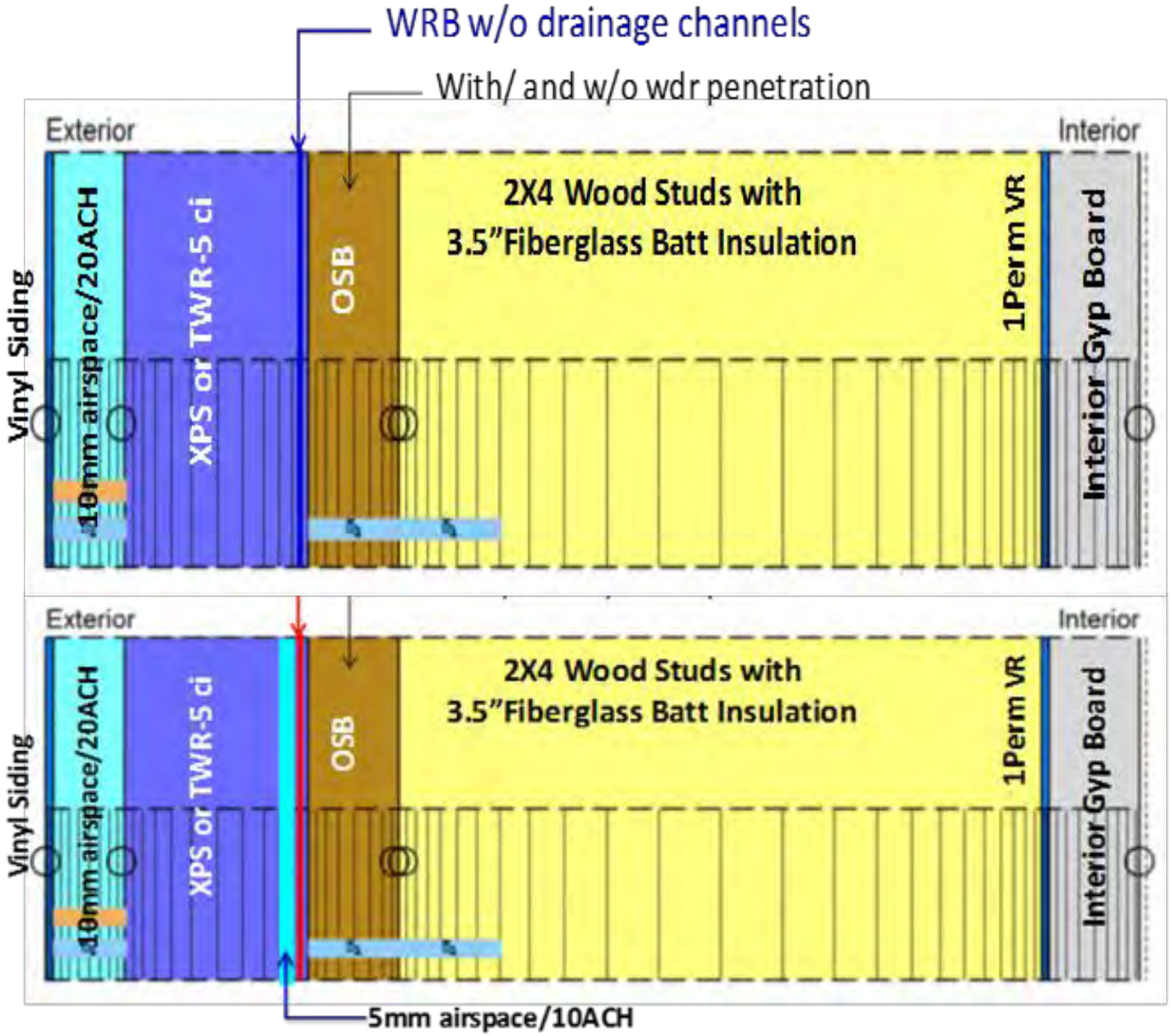
(B) Ventilation behind exterior insulation: Moisture escapes through vapor permeable WRB and is carried outside through venting/ventilation behind c.i.

New Construction





Retrofit Construction



Simulation Outputs

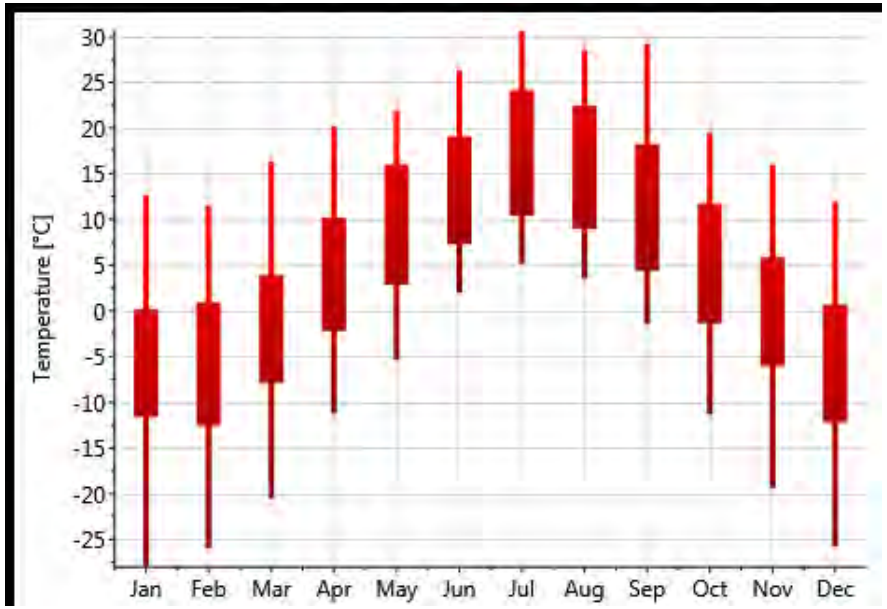
Total Moisture Content of Wall Assembly

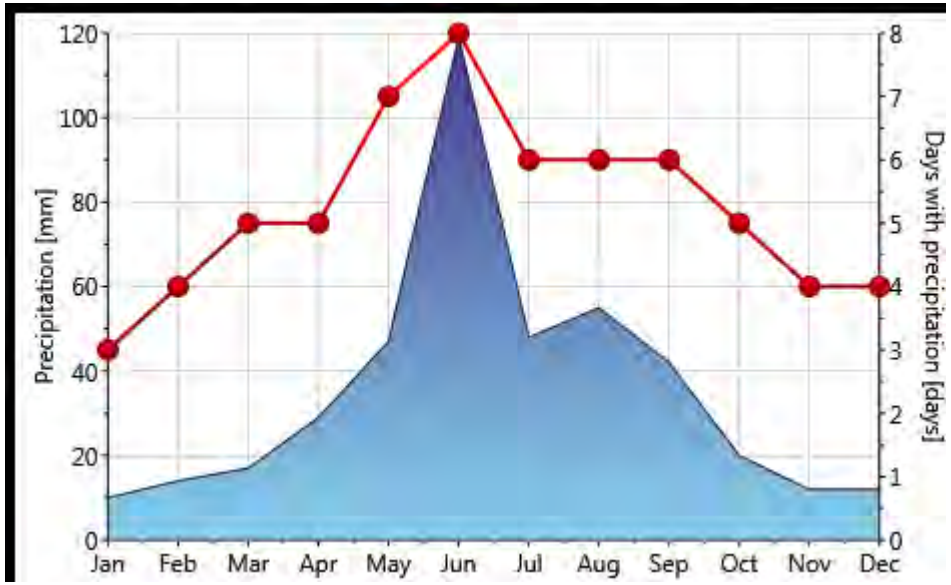
OSB Moisture Content

% Relative Humidity at the OSB/Cavity Insulation Interface

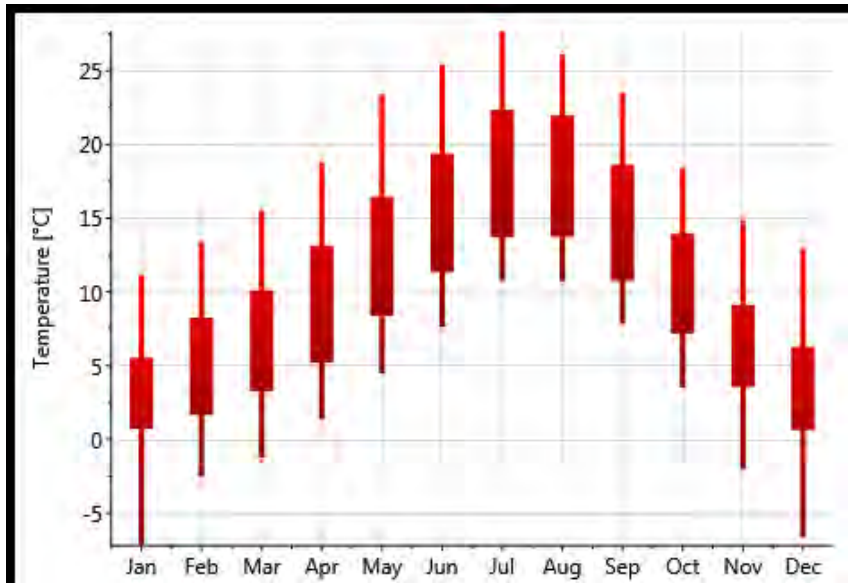
WUFI® Pro 6

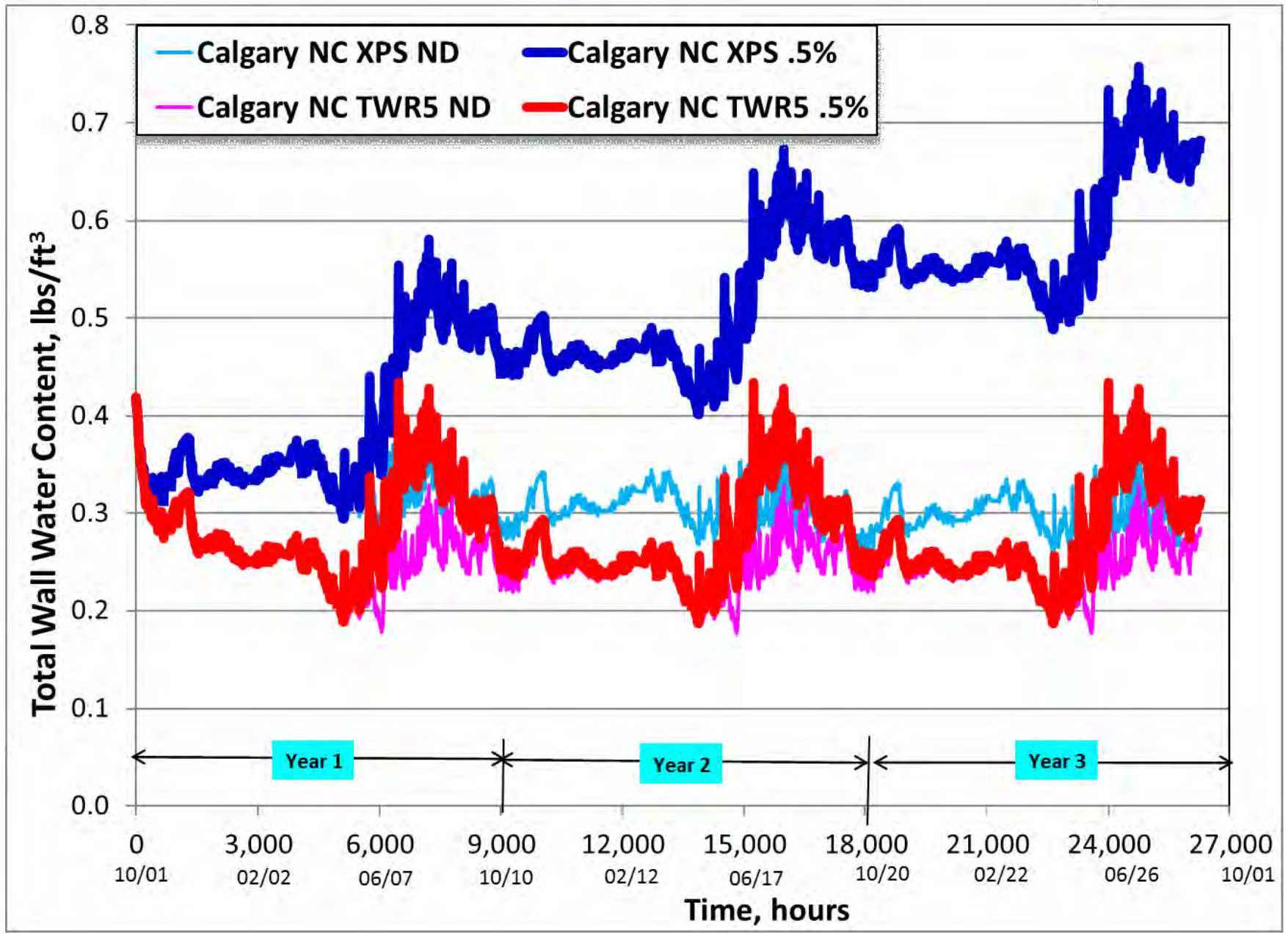
Calgary, AB

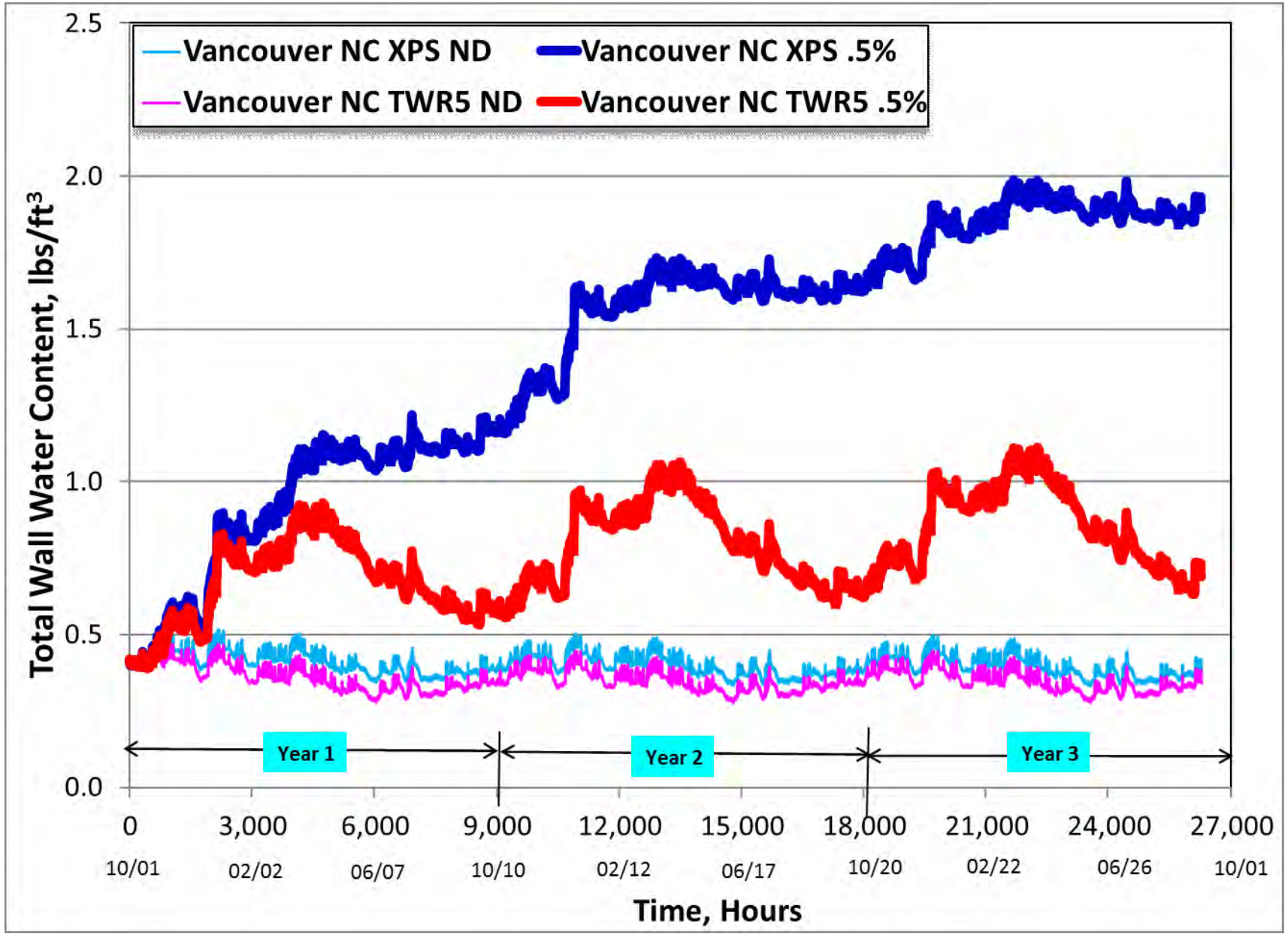

Temperature [°C]
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

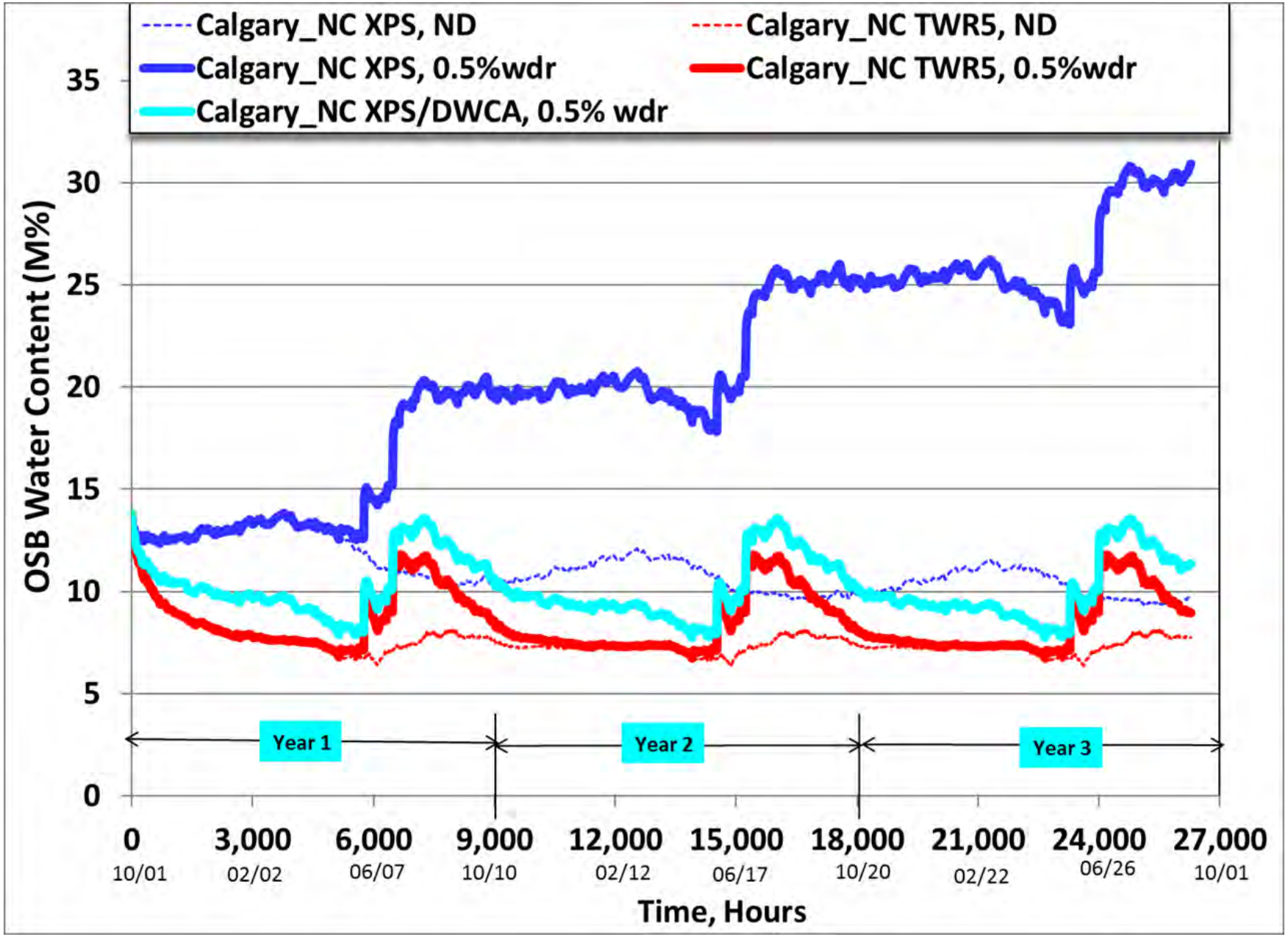

Precipitation [mm]
120
100
80
60
40
20
0
Days with precipitation [days]
8
7
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

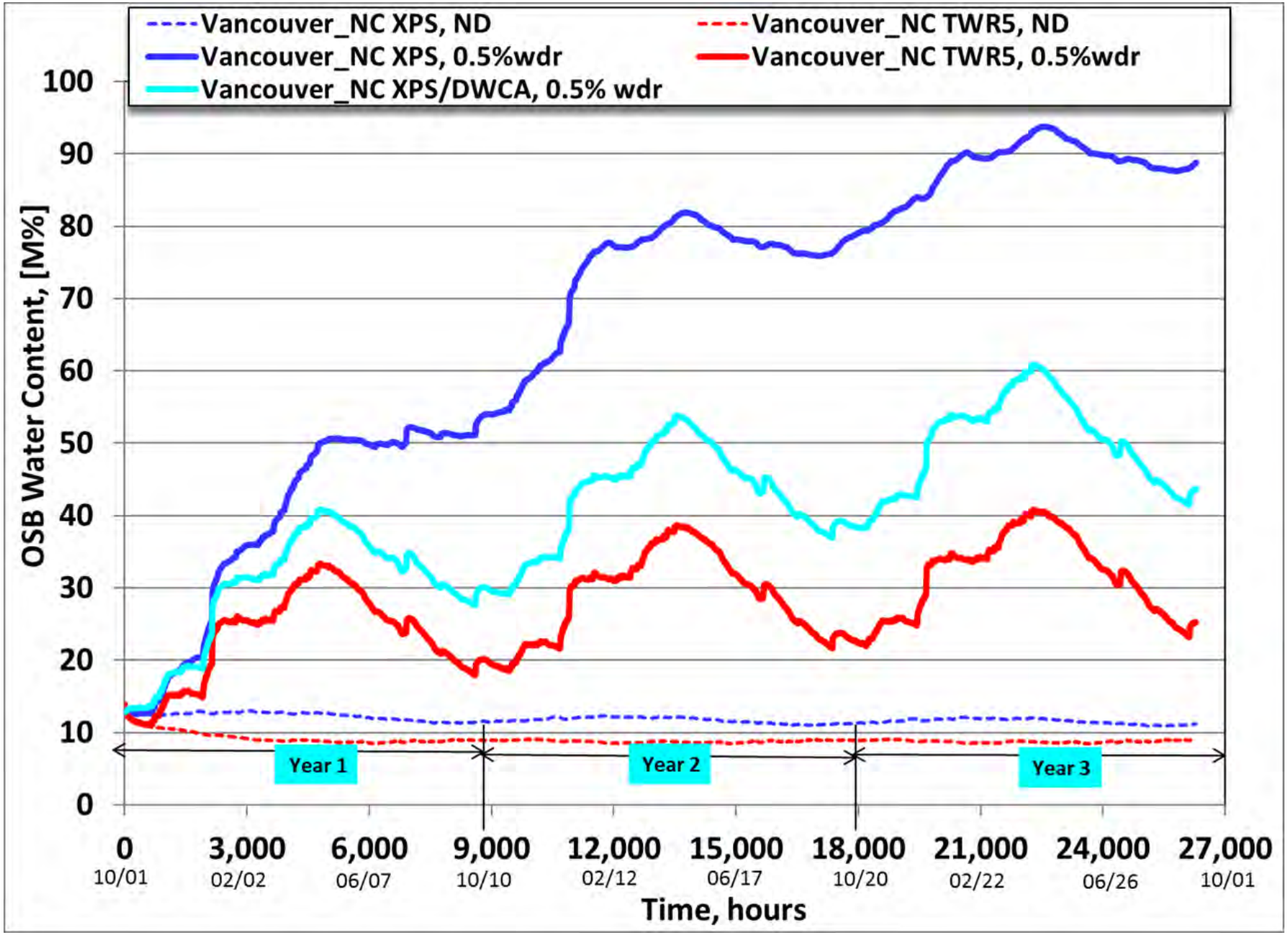
Vancouver, BC

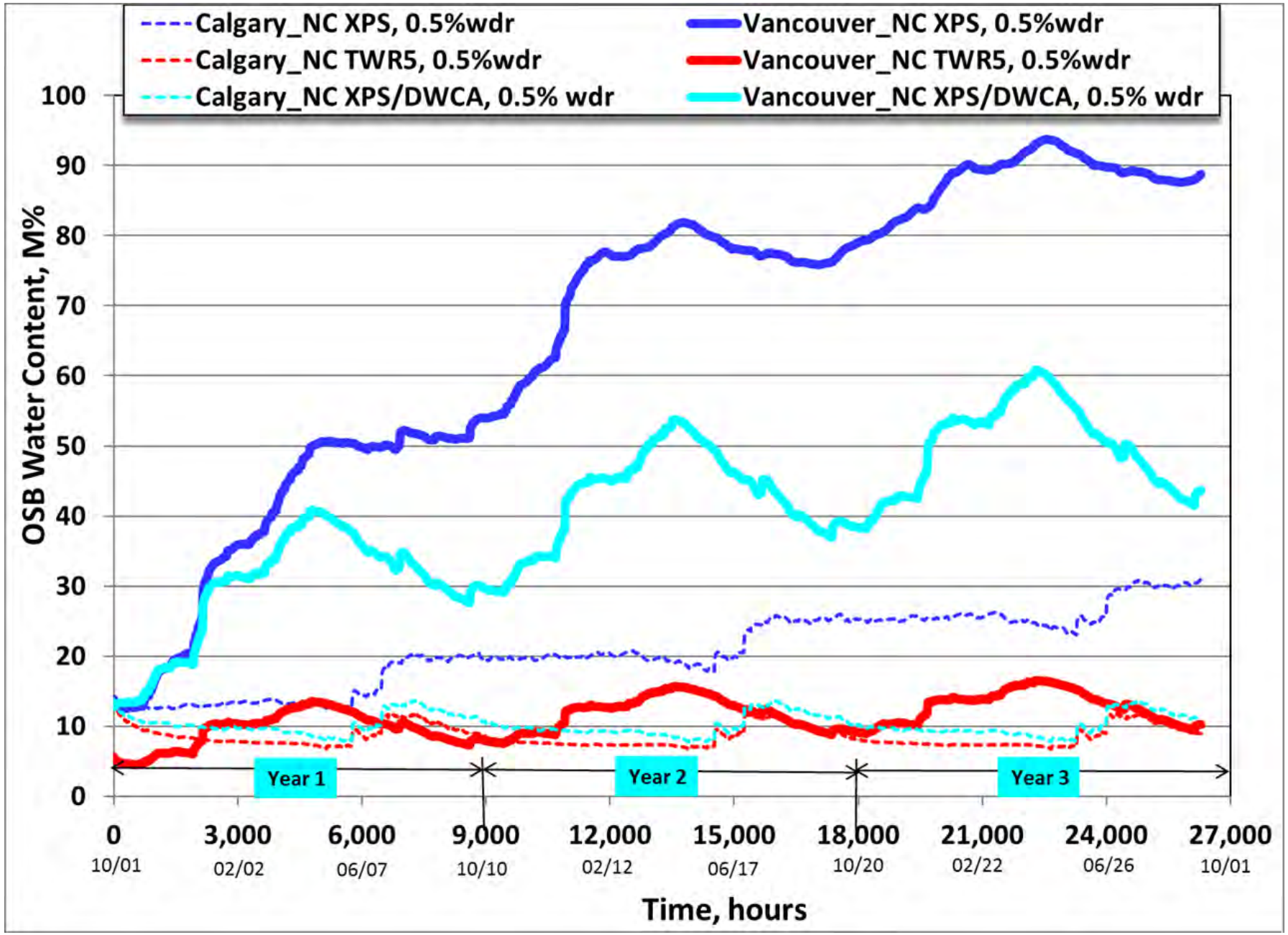


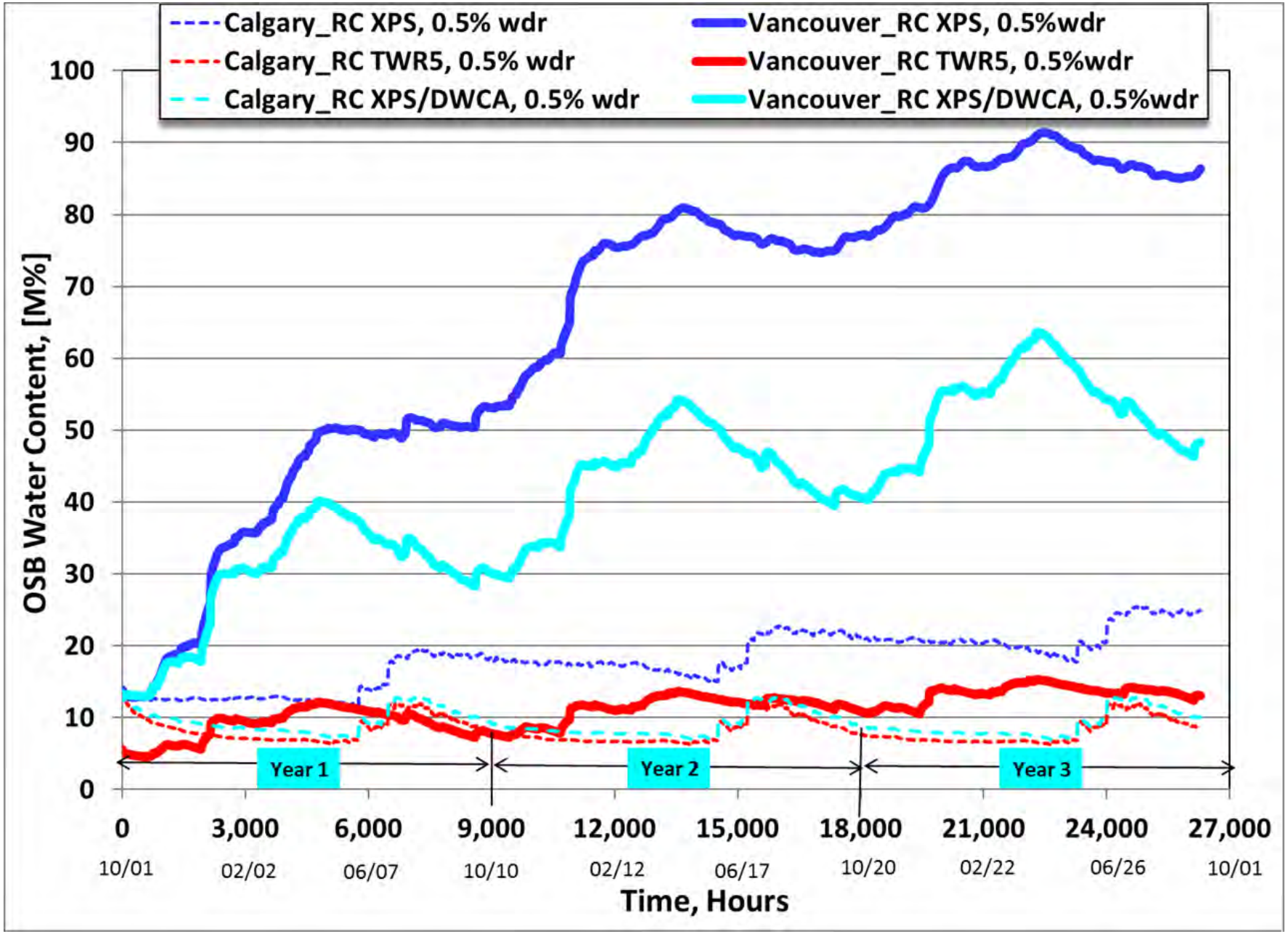

Calgary NC XPS ND
Calgary NC XPS .5%
Calgary NC TWR5 ND
Calgary NC TWR5 .5%
Total Wall Water Content, lbs/ft3
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Year 1
Year 2
Year 3
0
10/01
3,000
02/02
6,000
06/07
9,000
10/10
12,000
02/12
15,000
06/17
18,000
10/20
21,000
02/22
24,000
06/26
27,000
10/01
Time, hours

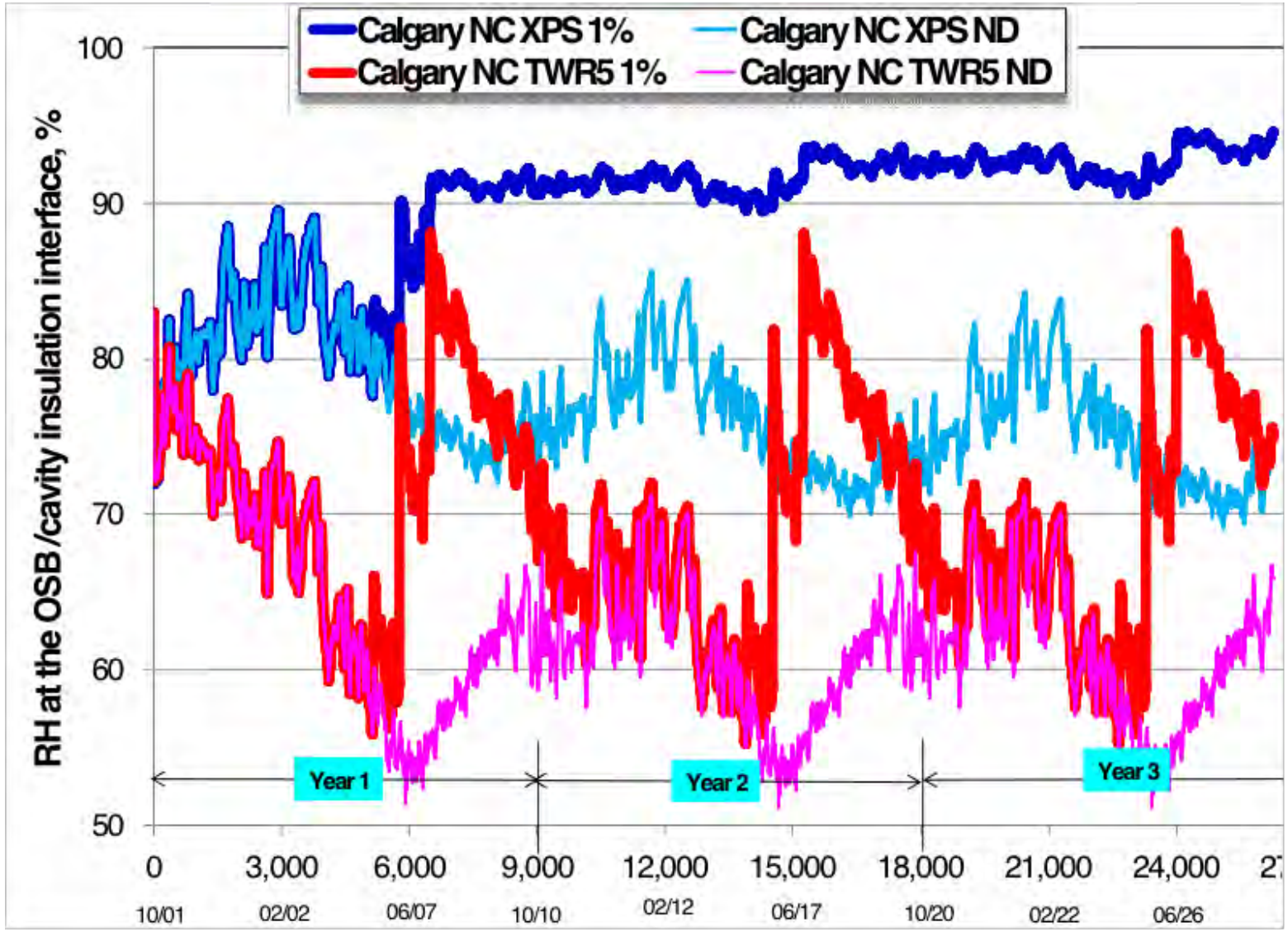

Vancouver NC XPS ND
Vancouver NC XPS .5%
Vancouver NC TWR5 ND
Vancouver NC TWR5 .5%
Total Wall Water Content, lbs/ft³
2.5
2.0
1.5
1.0
0.5
0.0
Year 1
Year 2
Year 3
0
3,000
6,000
9,000
12,000
15,000
18,000
21,000
24,000
27,000
10/01
02/02
06/07
10/10
02/12
06/17
10/20
02/22
06/26
10/01
Time, Hours

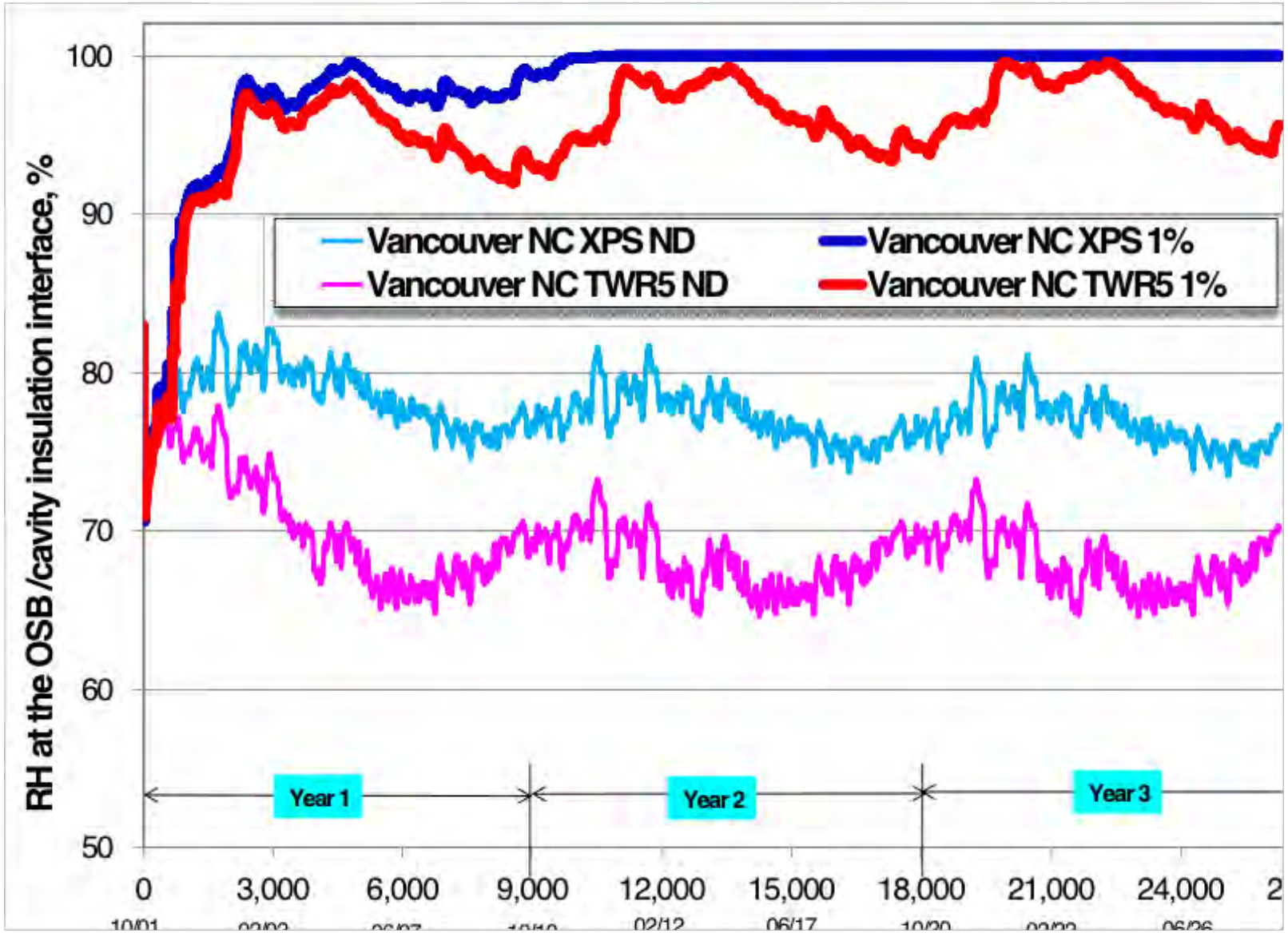

Calgary_NC XPS, ND
Calgary_NC TWR5, ND
Calgary_NC XPS, 0.5%wdr
Calgary_NC TWR5, 0.5%wdr
Calgary_NC XPS/DWCA, 0.5% wdr
OSB Water Content (M%)
35
30
25
20
15
10
5
0
Year 1
Year 2
Year 3
0
10/01
3,000
02/02
6,000
06/07
9,000
10/10
12,000
02/12
15,000
06/17
18,000
10/20
21,000
02/22
24,000
06/26
27,000
10/01
Time, Hours

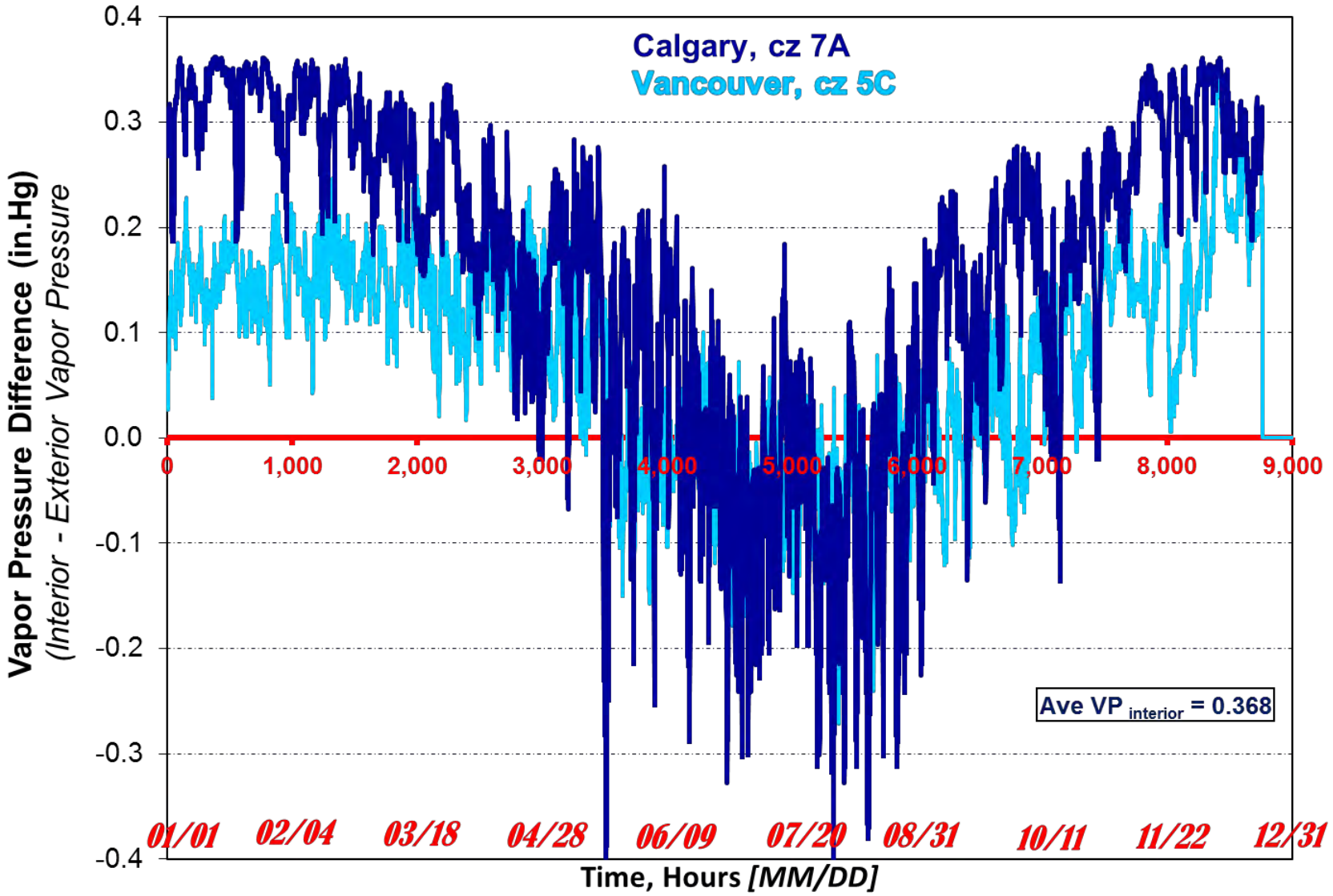

Vancouver_NC XPS, ND
Vancouver_NC TWR5, ND
Vancouver_NC XPS, 0.5%wdr
Vancouver_NC TWR5, 0.5%wdr
Vancouver_NC XPS/DWCA, 0.5% wdr
OSB Water Content, [M%]
100
90
80
70
60
50
40
30
20
10
0
Year 1
Year 2
Year 3
0
10/01
3,000
02/02
6,000
06/07
9,000
10/10
12,000
02/12
15,000
06/17
18,000
10/20
21,000
02/22
24,000
06/26
27,000
10/01
Time, hours


Calgary_NC XPS, 0.5%wdr
Calgary_NC TWR5, 0.5%wdr
Calgary_NC XPS/DWCA, 0.5% wdr
Vancouver_NC XPS, 0.5%wdr
Vancouver_NC TWR5, 0.5%wdr
Vancouver_NC XPS/DWCA, 0.5% wdr
OSB Water Content, M%
100
90
80
70
60
50
40
30
20
10
0
Year 1
Year 2
Year 3
0
10/01
3,000
02/02
6,000
06/07
9,000
10/10
12,000
02/12
15,000
06/17
18,000
10/20
21,000
02/22
24,000
06/26
27,000
10/01
Time, hours


Calgary_RC XPS, 0.5% wdr
Calgary_RC TWR5, 0.5% wdr
Calgary_RC XPS/DWCA, 0.5% wdr
Vancouver_RC XPS, 0.5%wdr
Vancouver_RC TWR5, 0.5%wdr
Vancouver_RC XPS/DWCA, 0.5%wdr
OSB Water Content, [M%]
100
90
80
70
60
50
40
30
20
10
0
Year 1
Year 2
Year 3
0
3,000
6,000
9,000
12,000
15,000
18,000
21,000
24,000
27,000
10/01
02/02
06/07
10/10
02/12
06/17
10/20
02/22
06/26
10/01
Time, Hours


Calgary NC XPS 1%
Calgary NC XPS ND
Calgary NC TWR5 1%
Calgary NC TWR5 ND
RH at the OSB/cavity insulation interface, %
100
90
80
70
60
50
Year 1
Year 2
Year 3
0
3,000
6,000
9,000
12,000
15,000
18,000
21,000
24,000
10/01
02/02
06/07
10/10
02/12
06/17
10/20
02/22
06/26


RH at the OSB/cavity insulation interface, %
100
90
80
70
60
50
Vancouver NC XPS ND
Vancouver NC XPS 1%
Vancouver NC TWR5 ND
Vancouver NC TWR5 1%
Year 1
Year 2
Year 3
0
3,000
6,000
9,000
12,000
15,000
18,000
21,000
24,000
10/01
02/12
06/17


Calgary, cz 7A
Vancouver, cz 5C
Vapor Pressure Difference (in.Hg)
(Interior - Exterior Vapor Pressure
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
01/01
02/04
03/18
04/28
06/09
07/20
08/31
10/11
11/22
12/31
Ave VP interior = 0.368
Time, Hours [MM/DD]

Conclusions & Recommendations

The use of continuous exterior insulation in frame construction is a key strategy to improving thermal performance and achieving an energy efficient building envelope. However, the type of exterior insulation and the way it is added to the wall assembly could often result in reduced moisture management capabilities if incidental water intrusion occurs.

- Materials choices and design detailing could prevent or minimize potential moisture problems so that energy efficiency does not come at the expense of durability.
- Advanced moisture analysis simulations such as WUFI® could be used to compare different design options and materials choices and to assist with design decisions.

Conclusions & Recommendations

The examples discussed show that wall assemblies with a vapor permeable exterior insulation consistently show a higher ability to manage incidental water intrusion when compared to wall assemblies with vapor impermeable exterior insulation:

- Less water accumulation and faster drying rates are consistently observed for TWR5 walls when compared to equivalent XPS walls, for both climates, both new or reside construction
- Additional design provisions to allow for increased drying are recommended for vapor impermeable exterior insulation. The example in this study was providing air venting behind the vapor impermeable exterior insulation board. Another possibility may be the replacement of standard interior vapor retarder with a “smart” vapor retarder that allows for more internal drying.

Conclusions & Recommendations

A significant difference is observed between the two climates being compared in this analysis:

- The drying rates in marine climate 5C are significantly lower than those in climate zone 7A, for all walls. For this reason, climate zone 5C (marine climate) is much less forgiving and the walls are more susceptible to moisture accumulation, even if vapor permeable exterior insulation is used. The main reason for the slow drying rates in marine climates is the low diffusion driving force (low vapor pressure difference across the building enclosure which is inherent for marine climates).
- Because of higher moisture susceptibility in marine climates it is even more critical to avoid installation defects (avoid moisture intrusion) as well as provide every design feature which could assist with drying.

Thank You

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