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Laminated Wood Roof Deck Case Study

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Abstract

- ✓ The case study is of an institutional building in the lower-mainland of British Columbia, where JRS was asked to investigate a large wood roof structure under construction which was wetted before the roof membrane was applied. The presentation will outline the background, the problems encountered, and the techniques employed in order to undertake the hygrothermal modelling in an attempt to determine possible solutions and predict potential consequences with different scenarios.

Location - UBC

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Lower Auditorium Roof

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Interior (completed)

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Background

- ✓ Building under construction
- ✓ Late fall 2010
- ✓ Laminated wood roof deck structure
- ✓ Protected during construction with temporary tarp roof
- ✓ Concerns raised about moisture content of wood
- ✓ JRS not part of construction team
- ✓ Schedule and durability of main concern

Auditorium Roof During Construction

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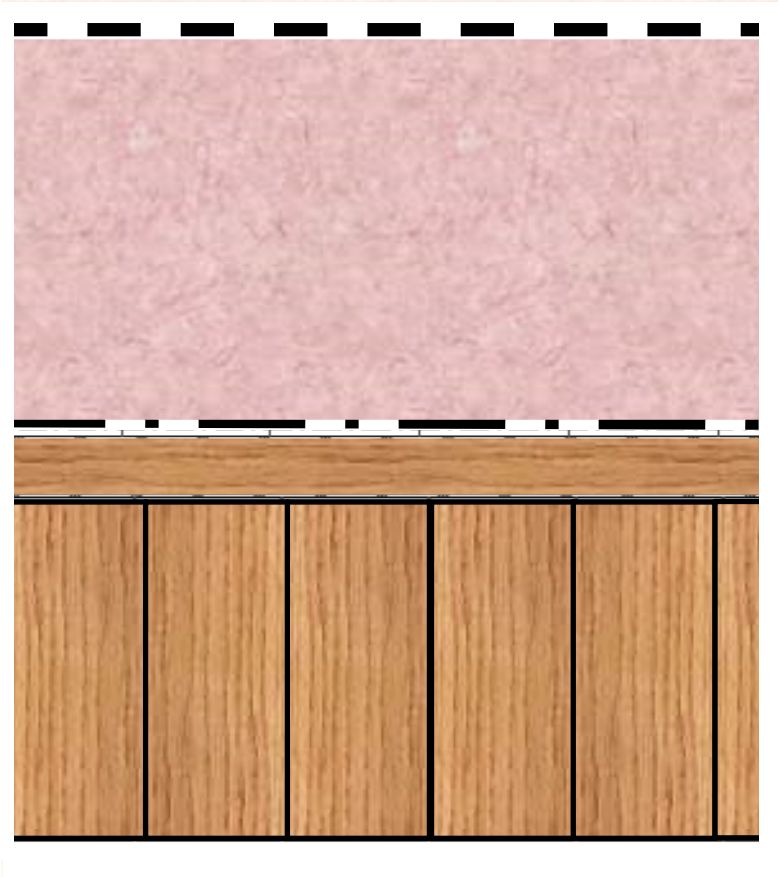
Roof Assembly

- TPO roof membrane
- 4” polyisocyanurate insulation
- SA AVB membrane
- 5/8” plywood sheathing
- 2x4 SPF laminated wood deck



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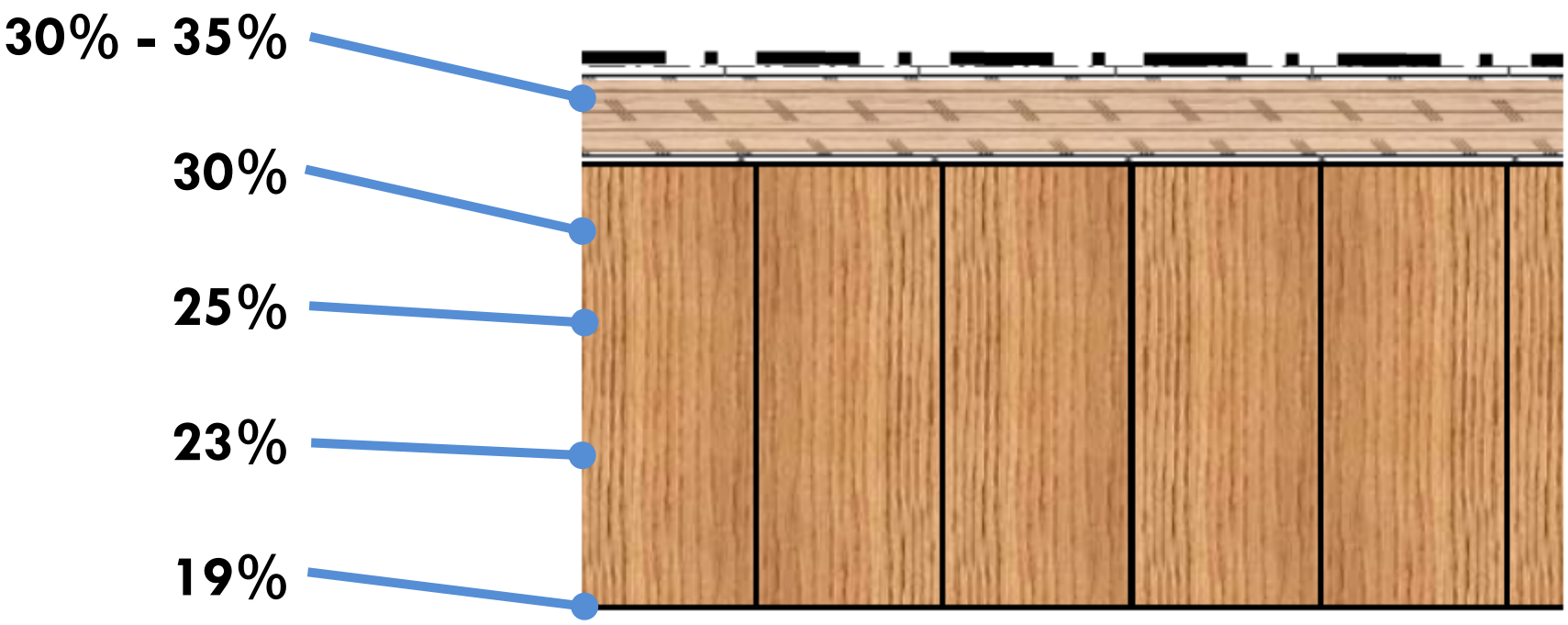
Moisture Contents

	Moisture Content				
Location	**2x4**				**Plywood**
Approx. distance from underside	**0”**	**1.25”**	**2.25”**	**3”**	**3.5”**
SW corner of upper roof	12%	17%	19%	20%	22%
NE corner of upper roof				20%	35%
NW corner of upper roof				20%	34%
NE corner of lower auditorium roof	19%	23%	25%	30%	30%

Moisture Content Profile



NE Corner Lower Auditorium Roof

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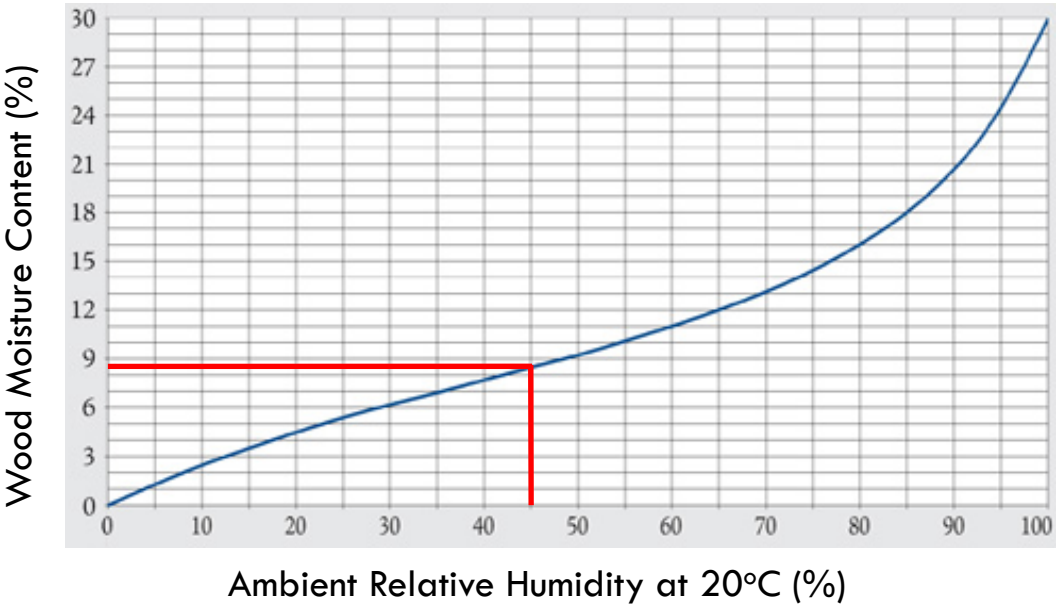
Risk

- ✓ The risk of deterioration is proportional to the moisture content (MC) in the wood (above 19%) and temperature.
- ✓ When the MC is above the fibre saturation point (~30%), the germination and colonization of fungal spores will substantially increase.
- ✓ The moisture content at the CIRS roof in some locations surpassed these thresholds and was at risk of deterioration.
- ✓ While 19% is widely acknowledged as being this threshold, practically, if the moisture content is brought to the lower 20% range (20% - 24%) and in a drying trend, we would judge the risk to be acceptably low.

Equilibrium Moisture Content



- Wood will eventually dry out to come into equilibrium with surrounding humidity
- How long?

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Moisture Movement in Wood

- ✓ Moisture movement in wood is complex
  - ➢ Species of wood is large variable in cell structure which greatly affects moisture transport
  - ➢ The relative humidity of surrounding air: Wood exposed to moisture in air will either gain or lose moisture depending on the relative vapour pressures
  - ➢ The temperature of the wood. Moisture will be transported from the surface of the wood, and through the interior of the wood at higher temperatures.
  - ➢ Temperature distribution of the wood. Moisture within the wood will travel from higher temperature regions to colder regions.
- ✓ WUFI Pro was used as computer modelling to account for all of these phenomenon acting together under different conditions.

Assumptions

- ✓ Material properties used in the modeling were taken from the WUFI database.
- ✓ The WUFI database file, “Vancouver; cold year”, was used for outdoor conditions.
- ✓ The assembly was assumed to be fully protected from rain – no moisture load.
- ✓ Solar heating of the roof was not considered as the lower roof is shaded, and the upper roof is covered by white TPO.

2 Approaches

- ✓ **Option A - Proceeding with construction**
  - ➢ Installing the roof insulation and membrane
  - ➢ Drying the wood (to the interior) over time.

- ✓ Option B – Accelerated drying
  - ➢ Removing any installed insulation, AVB membrane, and plywood
  - ➢ Heating exterior, interior or both
  - ➢ Moving heated air over 2x4 wood decking

Option A (pine) Low MC

Modeling Parameters

- Exterior Conditions: Vancouver Outdoor (Cold Year)
- Plywood: 22% MC
- 2x4 (Pine): 19% MC
- Interior Conditions: 20 °C & 30% RH

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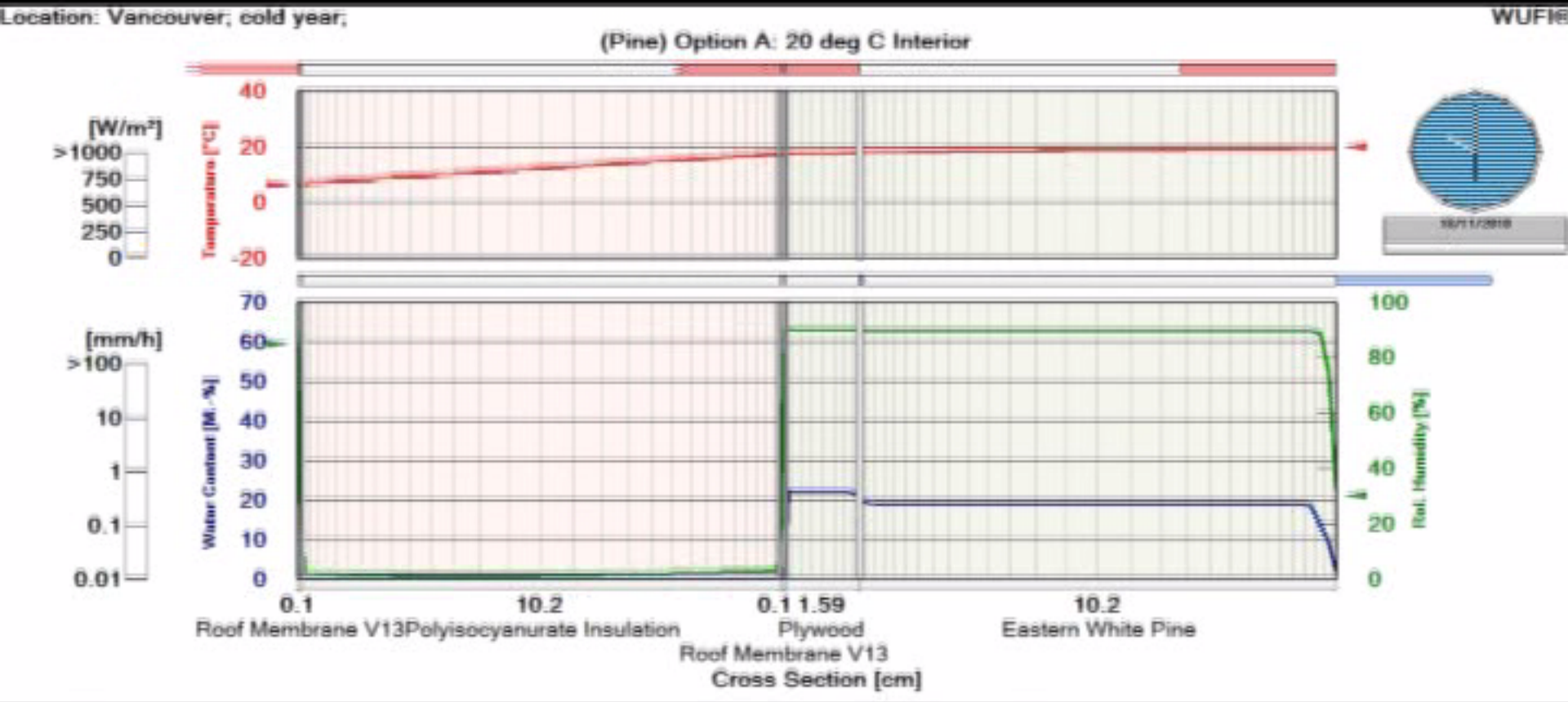
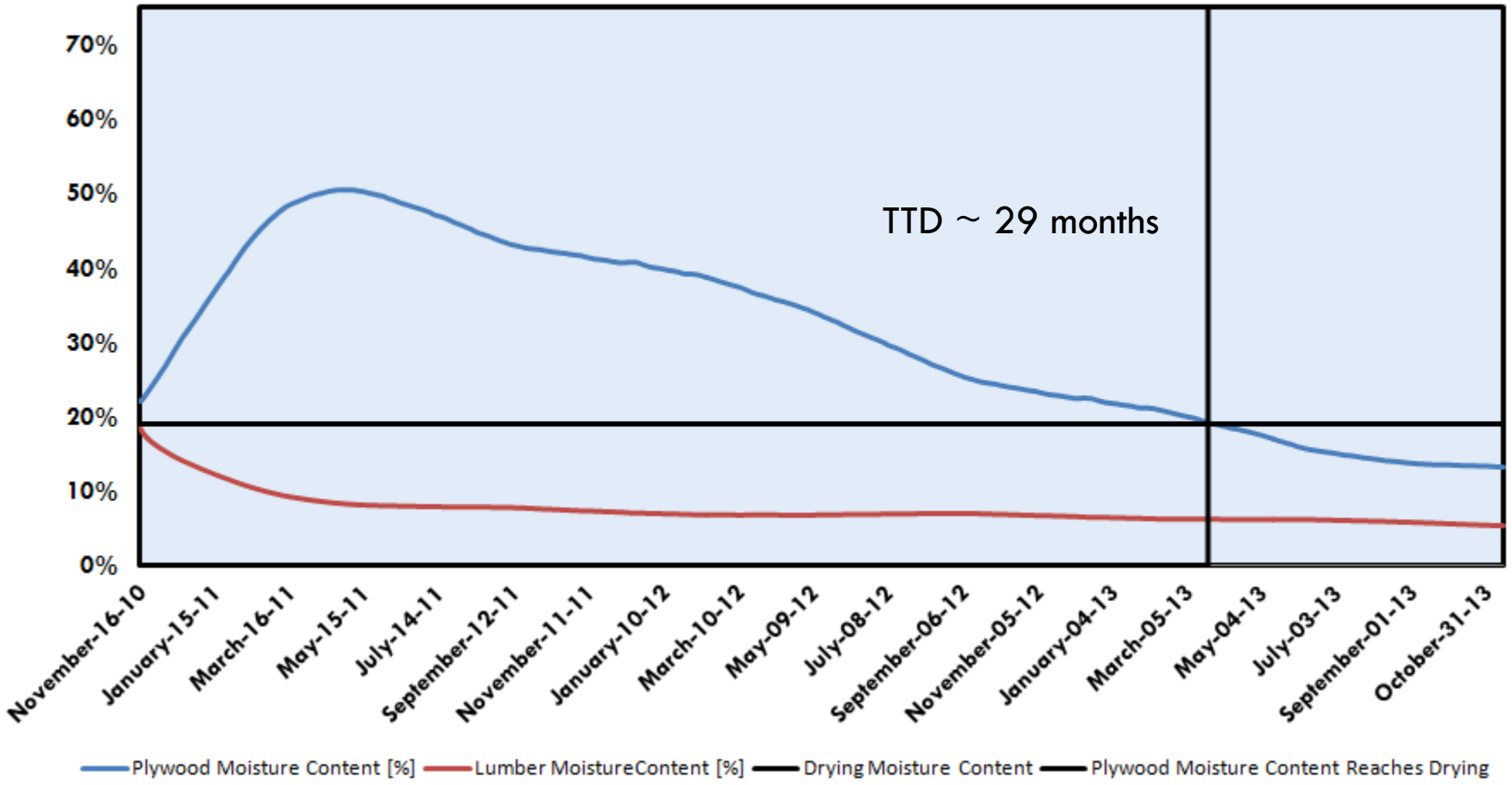
WUFI Output Film



Option A (pine) Low MC



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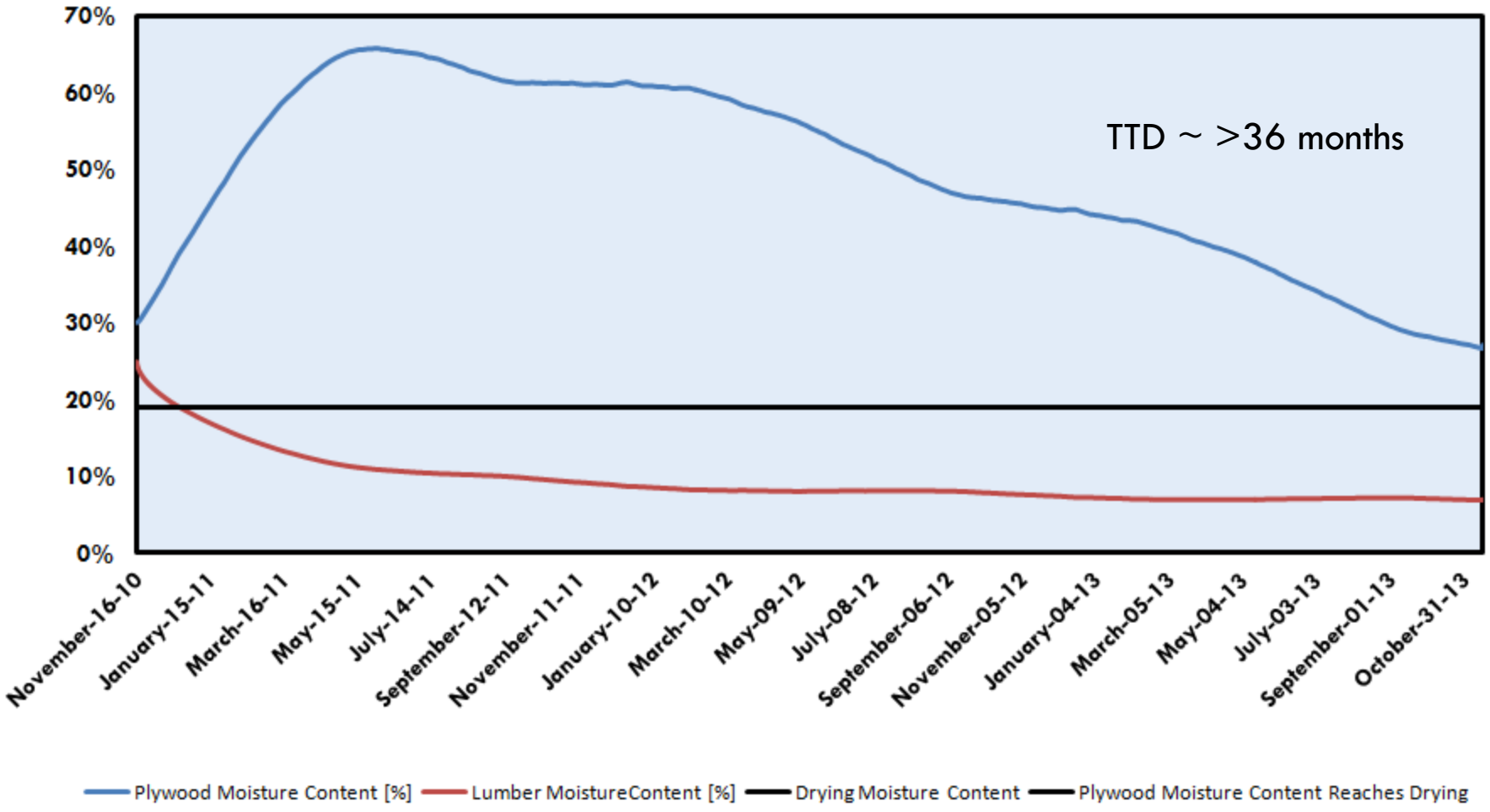
Option A (pine) High MC

Modeling Parameters

- Exterior Conditions: Vancouver Outdoor (Cold Year)
- Plywood: 30% MC
- 2x4 (Pine): 25% MC
- Interior Conditions: 20 °C & 30% RH

Option A (pine) High MC



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Option A (spruce) High MC

Modeling Parameters

- Exterior Conditions: Vancouver Outdoor (Cold Year)
- Plywood: 30% MC
- 2x4 (Spruce): 25% MC
- Interior Conditions: 20 °C & 30% RH

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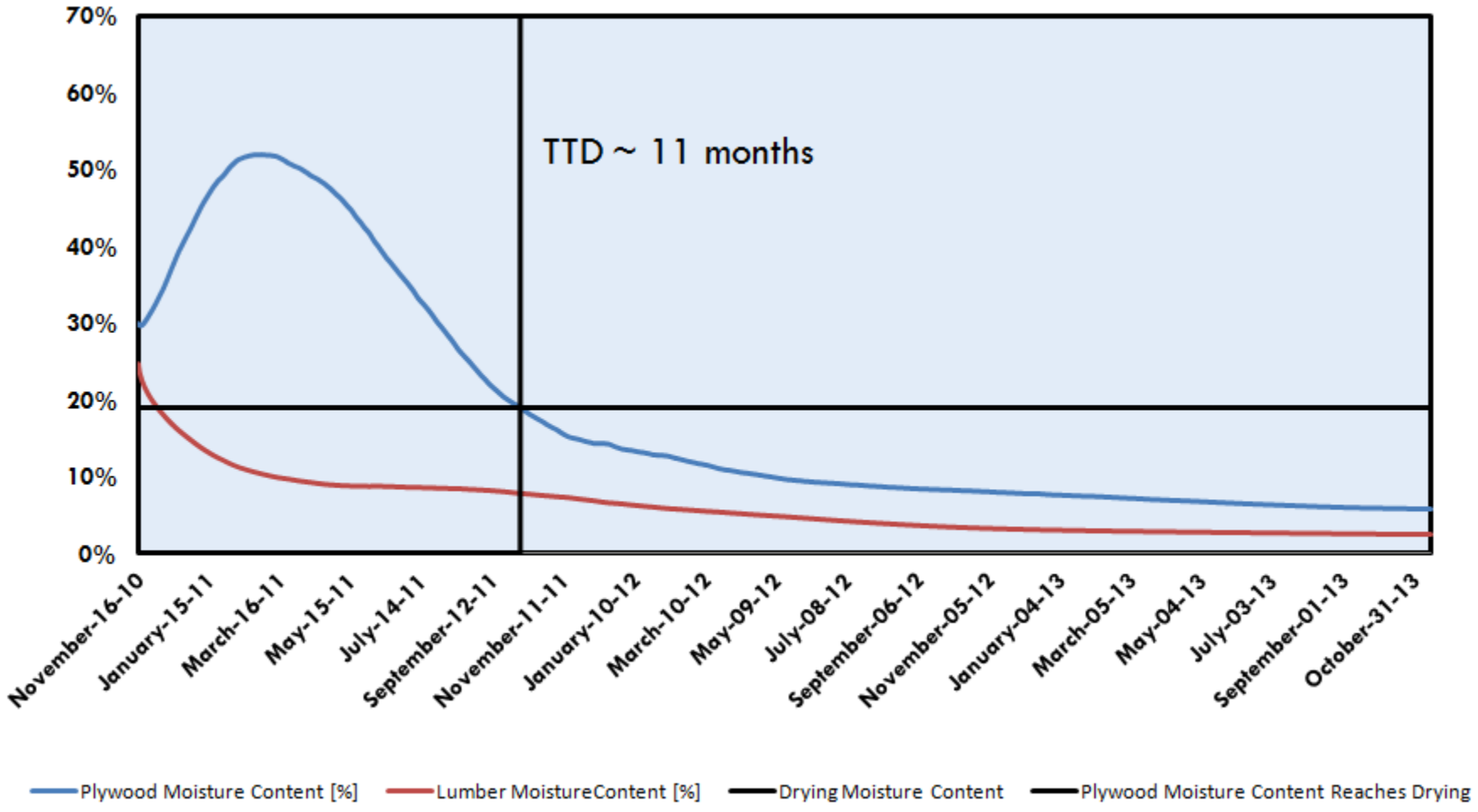
Option A (spruce) High MC



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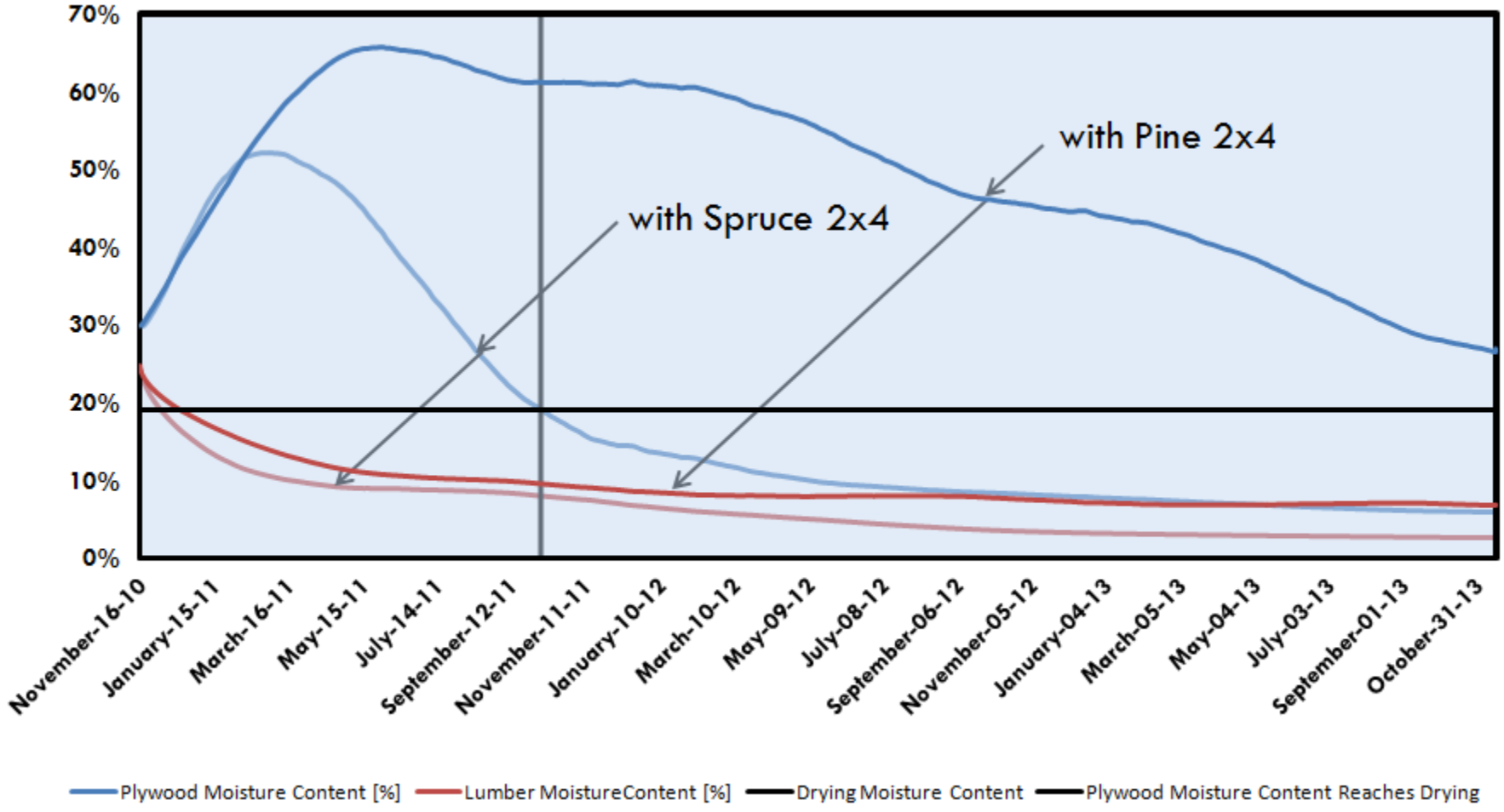
Limitations

- ✓ Vapour diffusion factors in WUFI database vary significantly.
- ✓ Has a major impact on results
- ✓ **2x4 Laminated Wood Deck Species "S-P-F"**
  - ➢ White Spruce (Picea glauca)
  - ➢ Engelmann Spruce (Pice aengelmannii)
  - ➢ Lodgepole Pine (Pinus contorta)
  - ➢ Alpine Fir (Abies lasiocarpa)

WUFI Diffusion resistance factors

➢ Eastern White Pine	4427	(0.7)	NA
➢ Southern Yellow Pine	1734	(1.9)	NA
➢ Spruce	552	(5.9)	NA
➢ Spruce	132	(24.8)	Vienna
➢ Spruce, radial	130	(25.2)	Fr-IBP
➢ Scand. Spruce, tangential	108	(30.4)	NTNU
➢ Spruce, tangential	83	(39.5)	LTH
➢ Scand. Spruce, tangential	50	(65.6)	NTNU
➢ Pine, tangential	50	(65.6)	NTNU

Option A High MC



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Option A Conclusions

- ✓ With AVB membrane and plywood in place, moisture movement generally too slow
- ✓ 11 months to > 36 months
- ✓ Exterior insulation no positive benefit

2 Approaches

- ✓ Option A - Proceeding with construction
  - ➢ Installing the roof insulation and membrane
  - ➢ Drying the wood (to the interior) over time.

- ✓ **Option B – Accelerated drying**
  - ➢ Removing any installed insulation, AVB membrane, and plywood
  - ➢ Heating exterior, interior or both
  - ➢ Moving heated air over 2x4 wood decking

Option B (spruce) High MC

Modeling Parameters

- "Exterior" Conditions: 30 °C & 40% RH
- 2x4 (Spruce): 25% MC
- Interior Conditions: 30 °C & 40% RH

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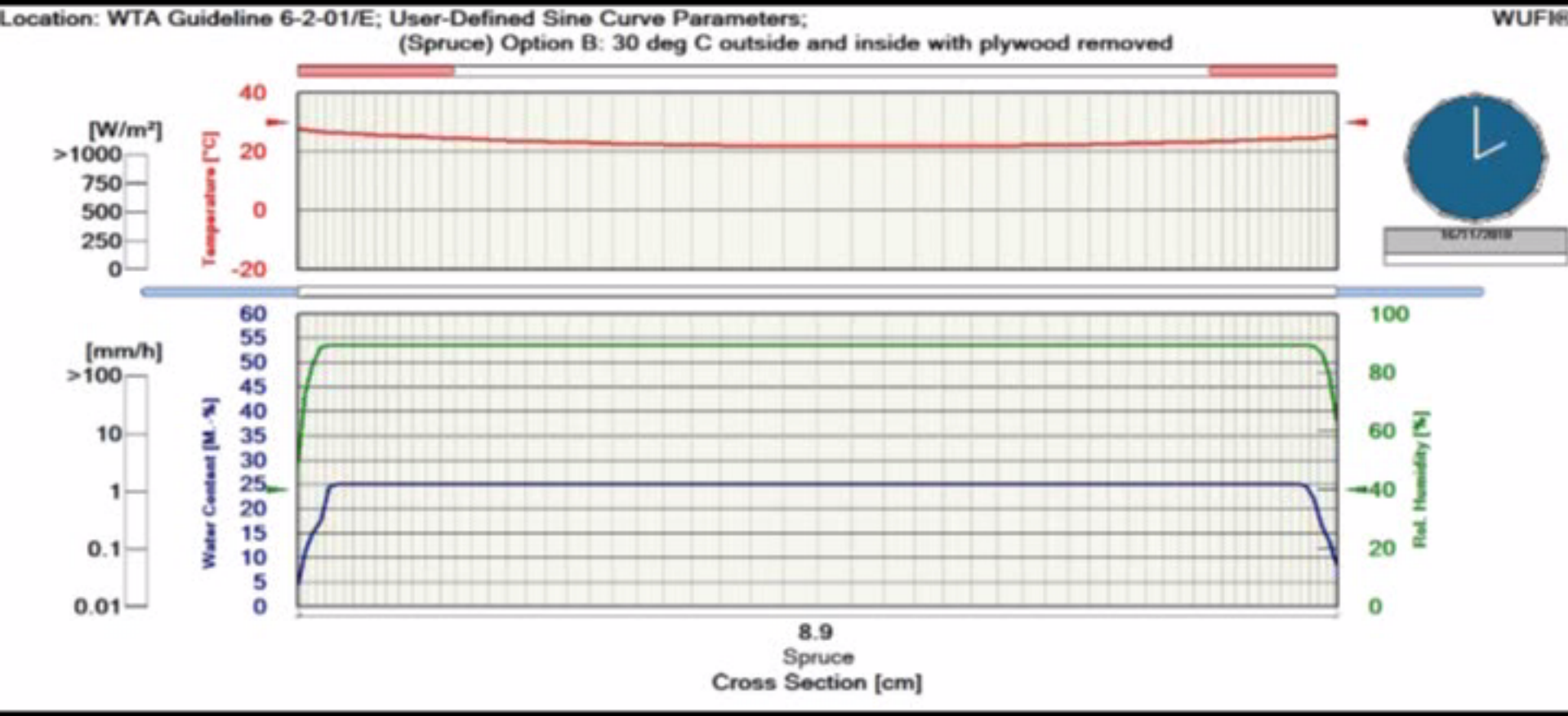
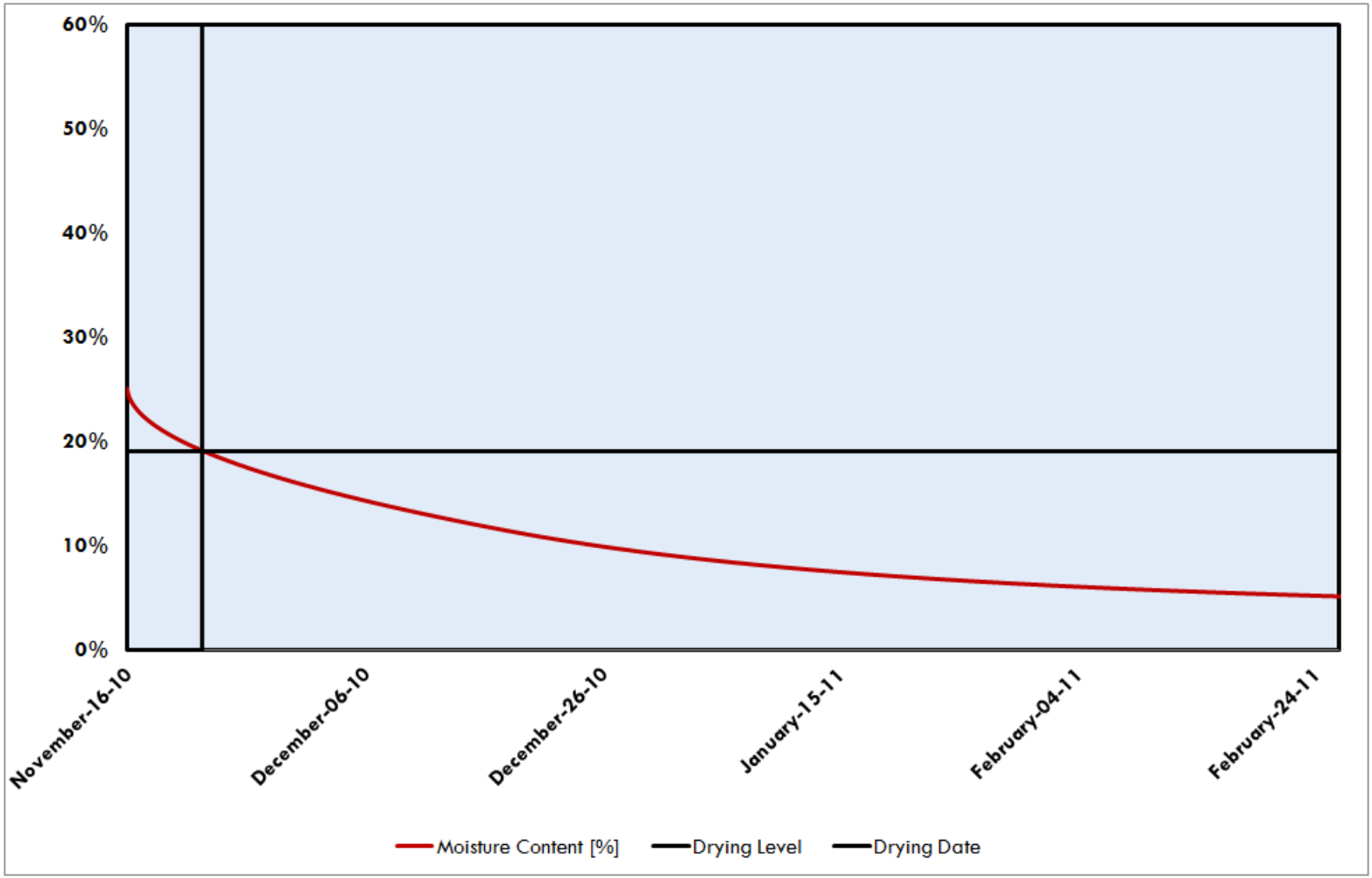
WUFI Output Film



Option B (spruce) High MC



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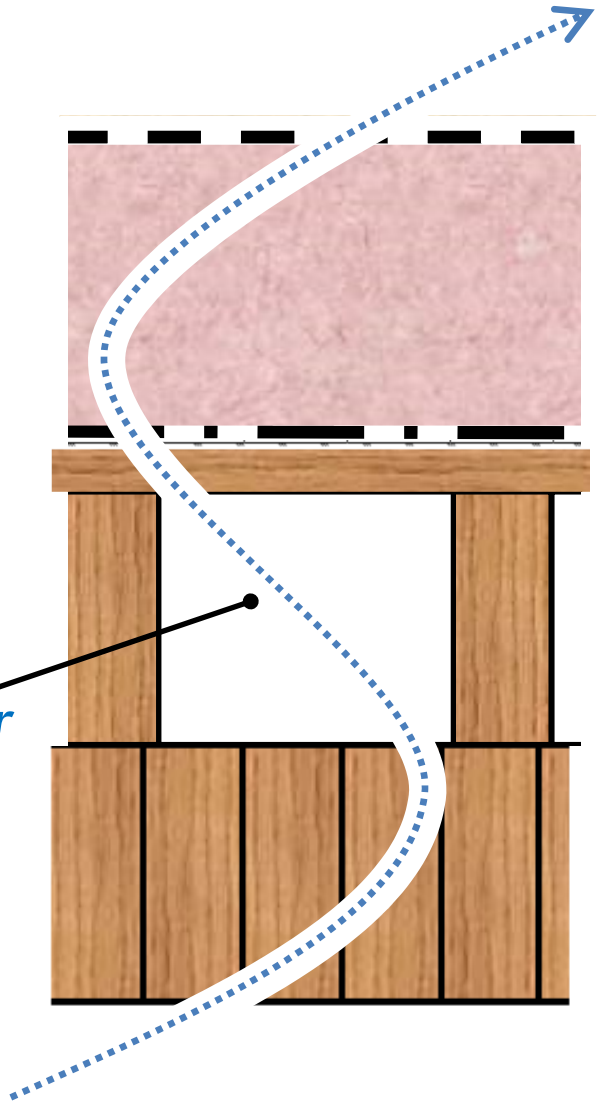
Option B Conclusions

- ✓ Without AVB membrane and plywood in place, largest source of moisture is removed and drying can occur in both directions
- ✓ Controlling conditions over both surfaces, wood will discharge moisture from two directions concurrently
- ✓ Drying to acceptable levels within weeks

Implemented Solution

- TPO roof membrane
- 4” polyisocyanurate insulation
- SA AVB membrane
- plywood sheathing
- 2x4 wood strapping, cavity <u>open to interior</u>

  temporarily vented to exterior with fan during construction
- 2x4 SPF laminated wood deck



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Implemented Solution (spruce) High MC

Modeling Parameters

- Exterior Conditions: 20 °C & 30% RH
- 2x4 (Spruce): 25% MC
- Interior Conditions: 20 °C & 30% RH

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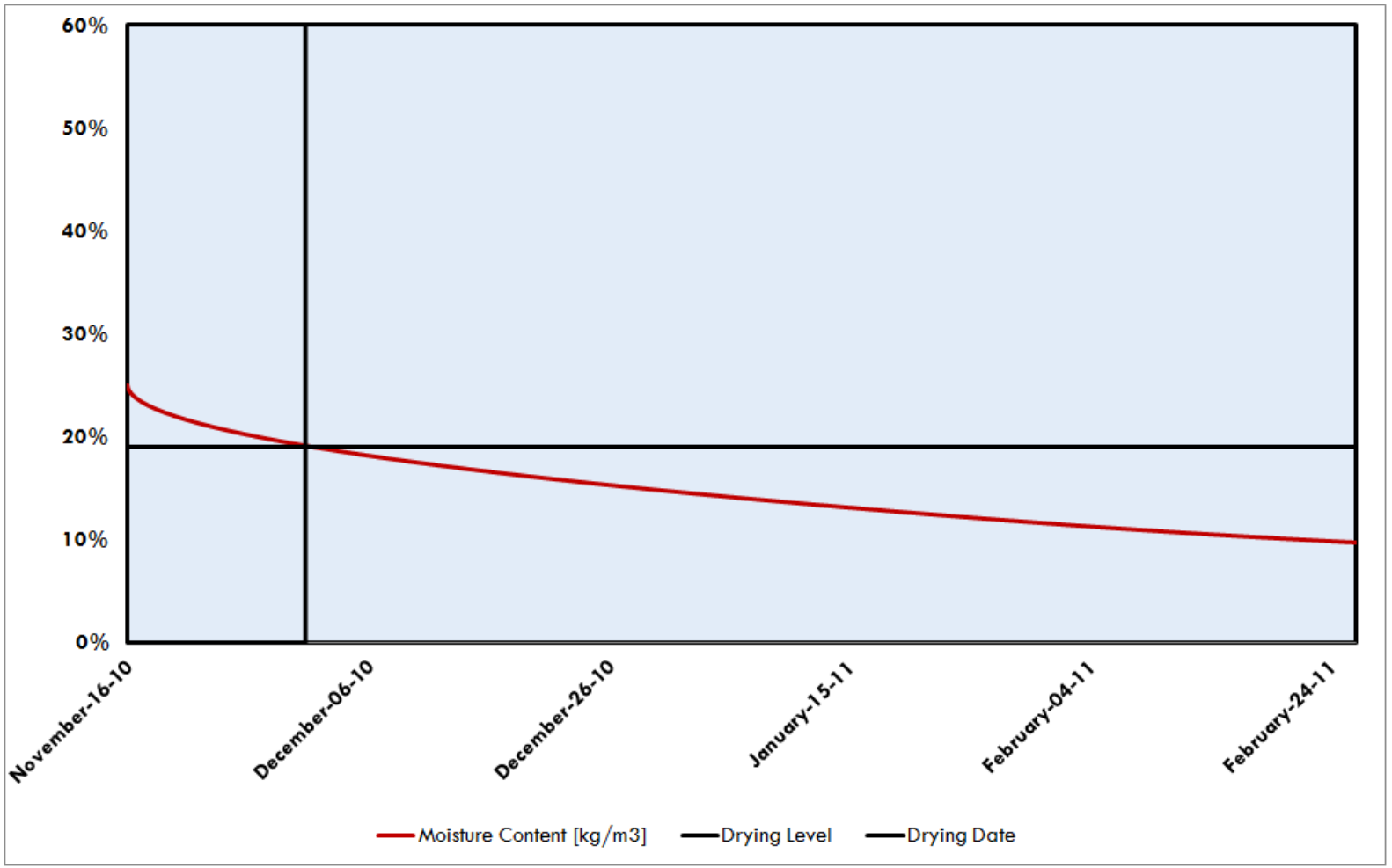
Implemented Solution



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Summary

When the MC is above the fibre saturation point of the wood (~30%), the germination and colonization of fungal spores will substantially increase.

The roof structure's MC in *some locations* had surpassed these thresholds and was at risk of deterioration.

While 19% is generally acknowledged as being the acceptable MC if the moisture content was brought to the range below 25%) and in a drying trend, we would judge the risk to be acceptably low.

Summary

Doing nothing (proceeding with construction)

- Drying would take in the order of a year or more, with any significant drying not starting until the summer months.
- Risk of deterioration developing
- Obviously not a practical approach

Summary

Applying heat to the underside with AVB membrane and plywood installed (either with or without insulation)

- Will at first drive the existing moisture in the wood to the top surface and then begin a slow drying process to the interior.
- This process will take many months (over 6) due to the relatively slow process of moving moisture through wood, first in one direction and then in the other.
- Not a practical approach.

Summary

Removing the plywood and AVB barrier membrane and applying dry heat from both the top and bottom

- Wood will discharge moisture from two directions at the same time.
- Depending on the temperature of the air, its relative humidity and its distribution over the wood surface, drying to an acceptable level could occur in the range of 1 to 3 weeks

Thank You

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Text

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