

**BCBEC luncheon meeting, Feb 08, 2007**

# **Sustainable Building Envelope – Green Roof Technology**

**Dr. Karen Liu**

**School of Construction and the Environment  
British Columbia Institute of Technology**

## → Presentation Outline

- 1. Introduction**
- 2. Green Roof Materials**
- 3. Green Roof FAQ**
- 4. Standards and Guidelines**
- 5. Green Roof Research at BCIT**



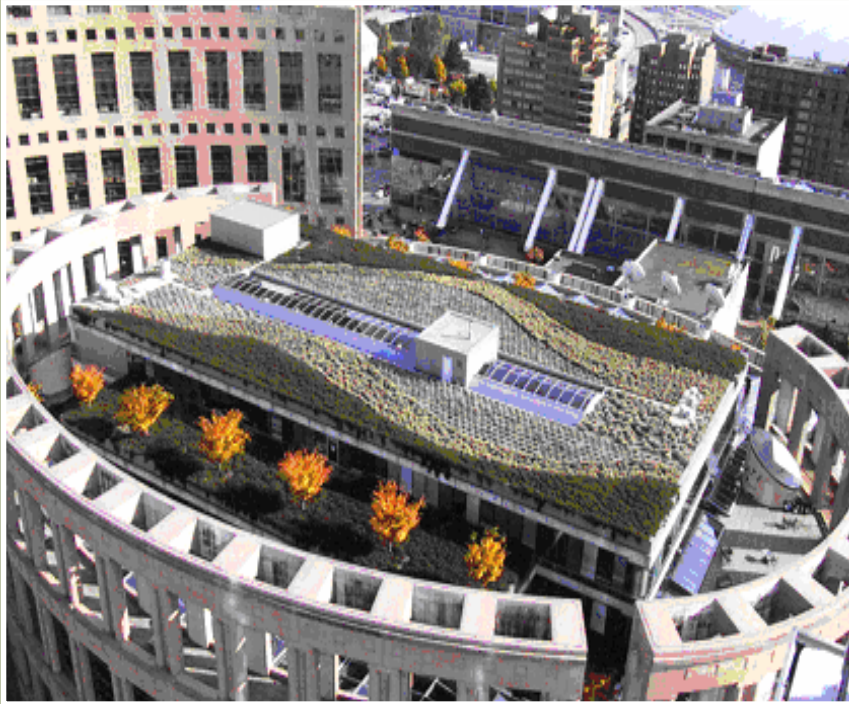
## → What is a Green Roof?

**specialized roofing system that supports  
vegetation growth on rooftops**



*A green roof in Europe*

## → Intensive Systems



***Vancouver Public Library  
(HydroTech)***

### Features

- Deep soil (>200 mm)
- Heavy weight (> 300 kg/m<sup>2</sup>)
- Traditional garden plants and shrubs
- Favourable conditions
- High maintenance
- Park-like setting

## → Extensive Systems



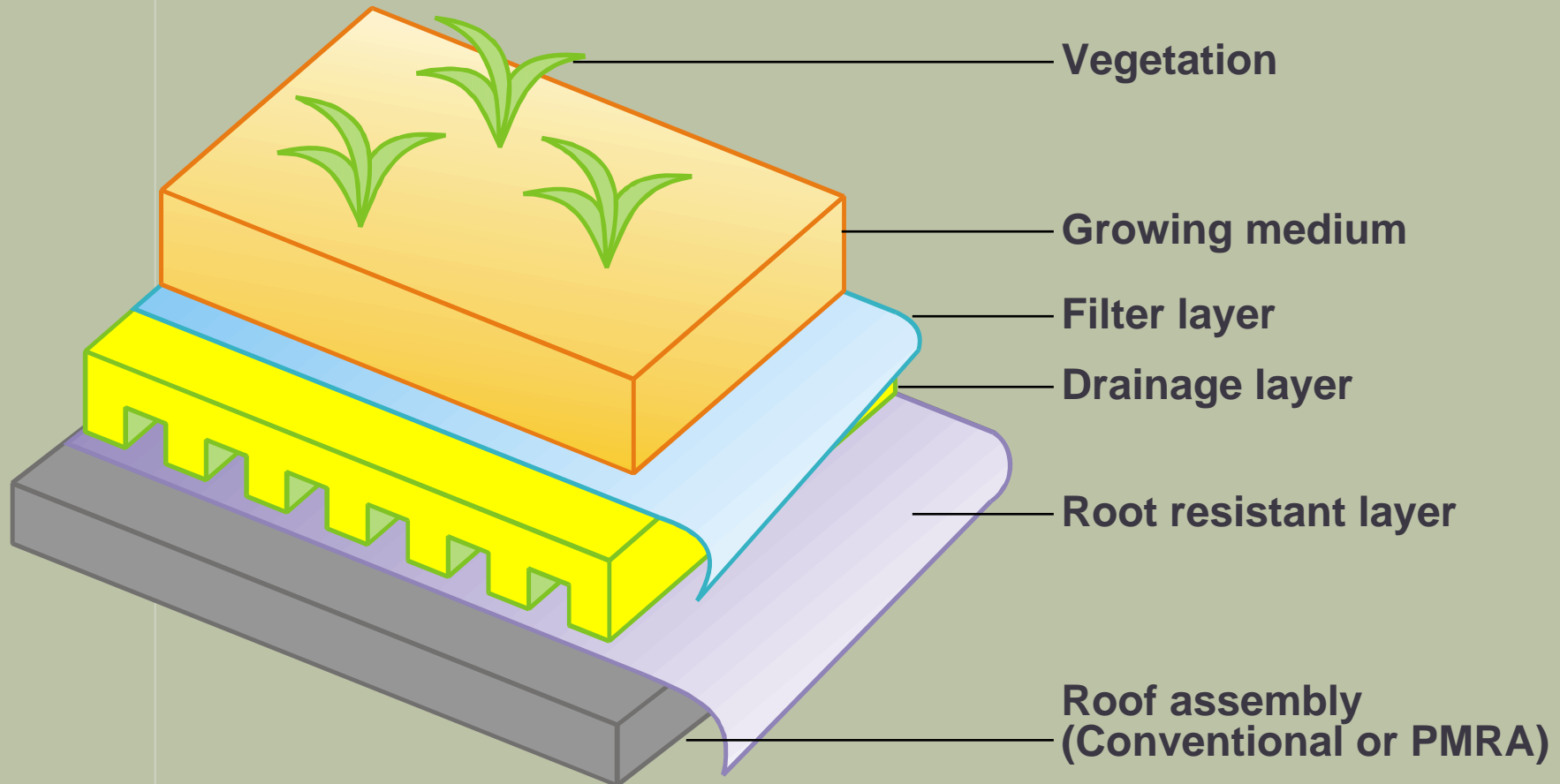
**401 Richmond, Toronto  
(Xero Flor)**

### Features

- **Shallow medium (<200 mm)**
- **Light weight (< 300 kg/m<sup>2</sup>)**
- **Grasses, sedums and herbs**
- **Harsh conditions**
- **Low maintenance**
- **Ecological setting**



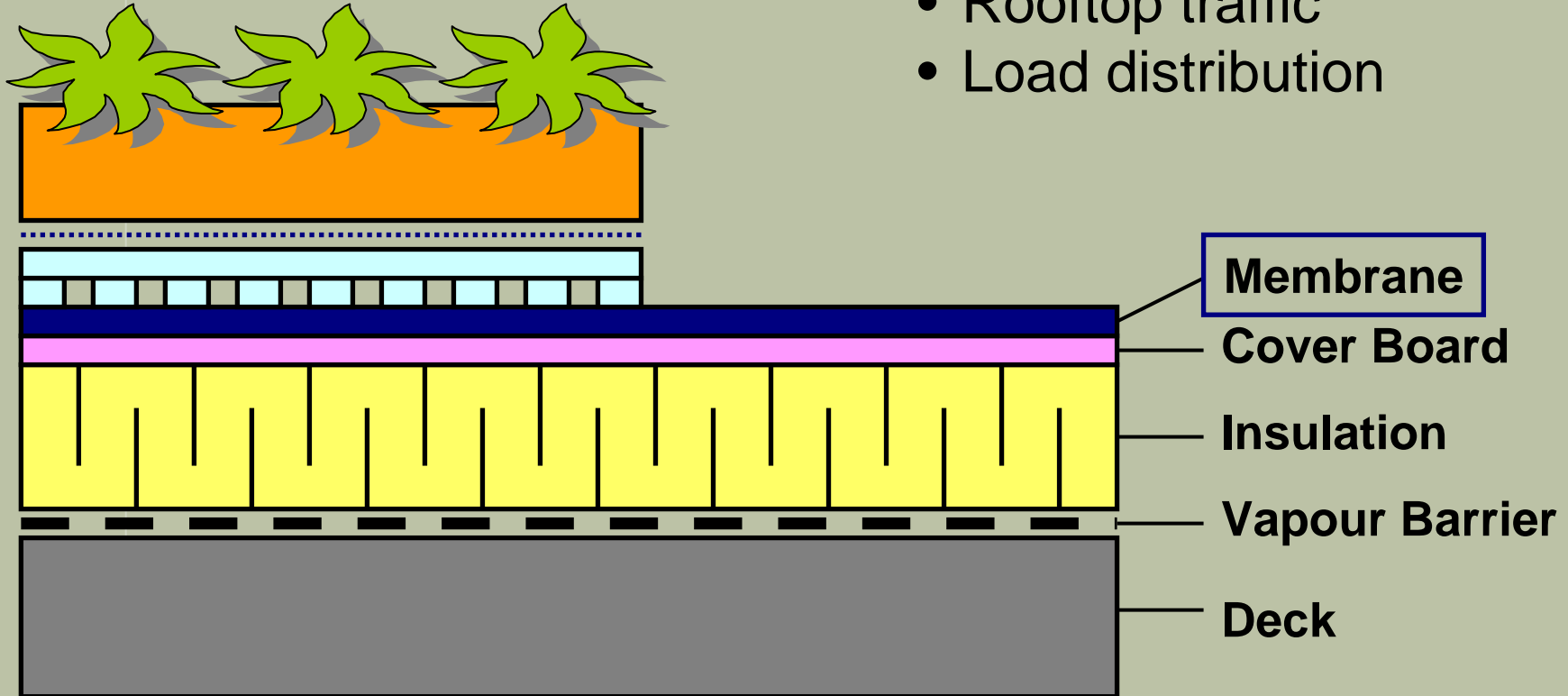
# → Green Roof - Principal Components



## → Green Roof on Conventional Roof

### Considerations:

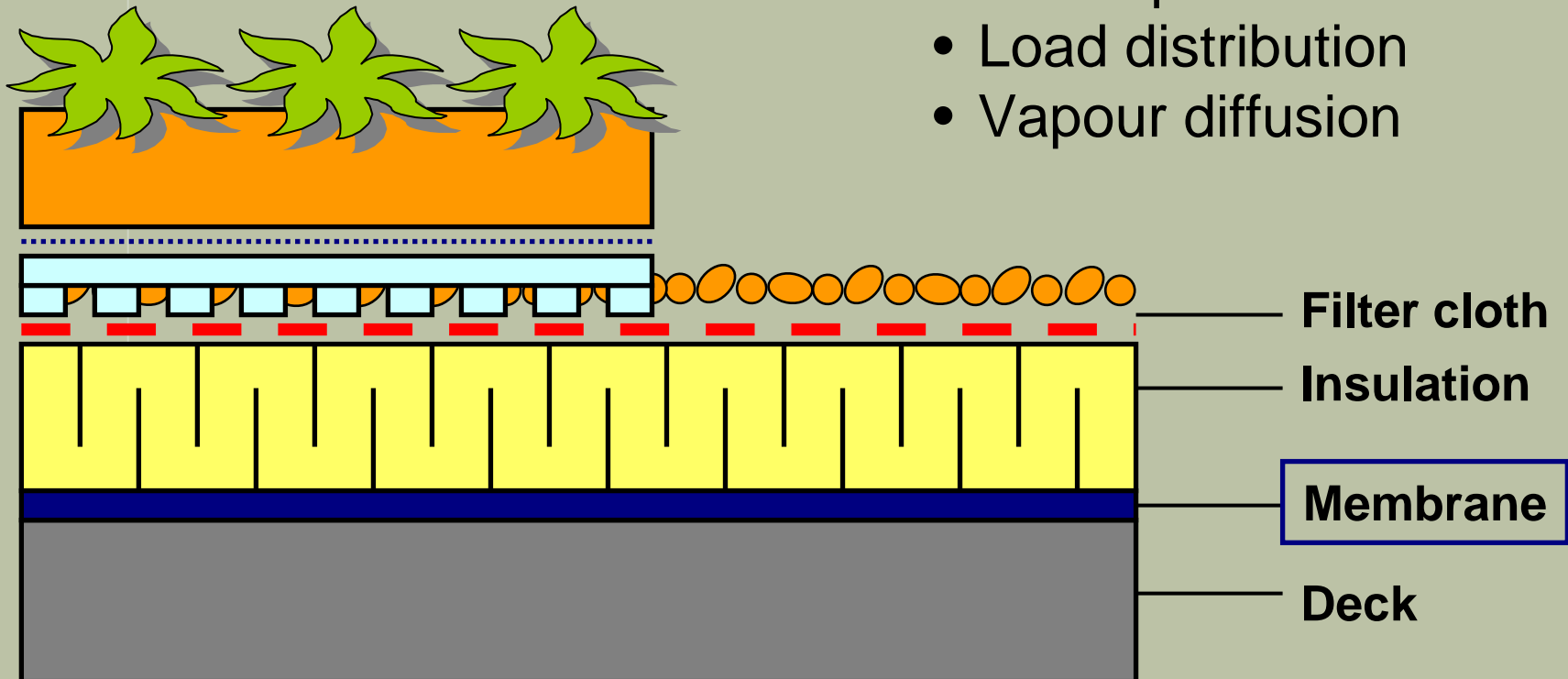
- Rooftop traffic
- Load distribution



## → Green Roof on PMRA

### Considerations:

- Rooftop traffic
- Load distribution
- Vapour diffusion





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## → Root Barrier - Physical



***Root barrier and installation (Source: HydroTech)***

## → Root Barrier - Chemical



***Root barrier chemical treated filter cloth***



## → Drainage Layer

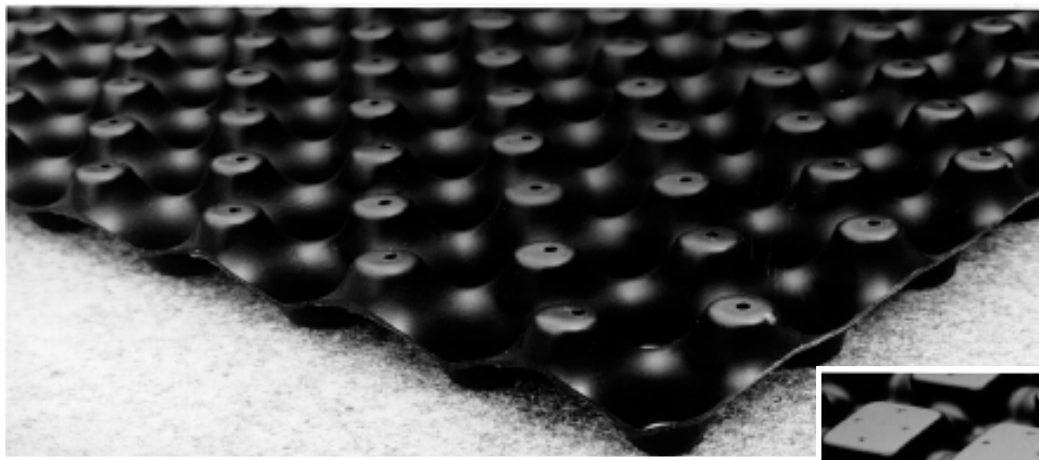


***Extensive – 3D filament mesh***

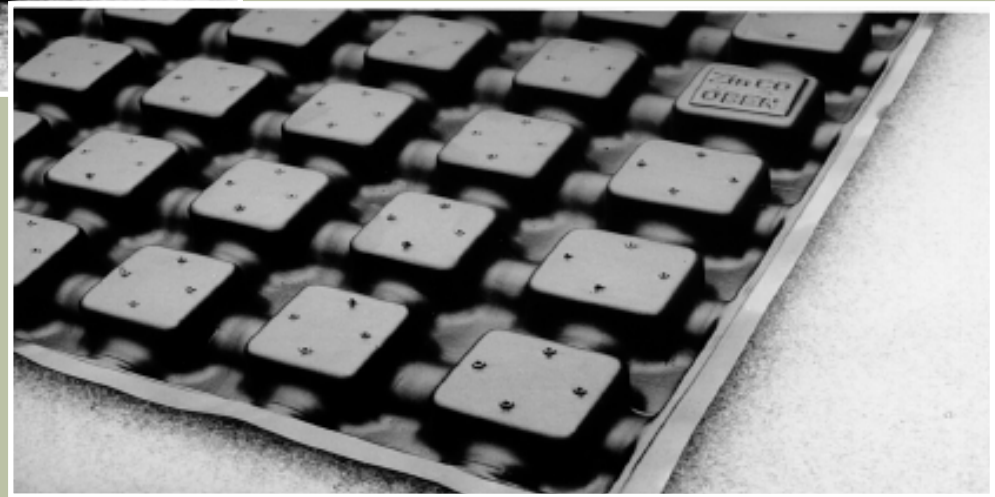


***Extensive – dimpled system***

## → Drainage / Storage Layer

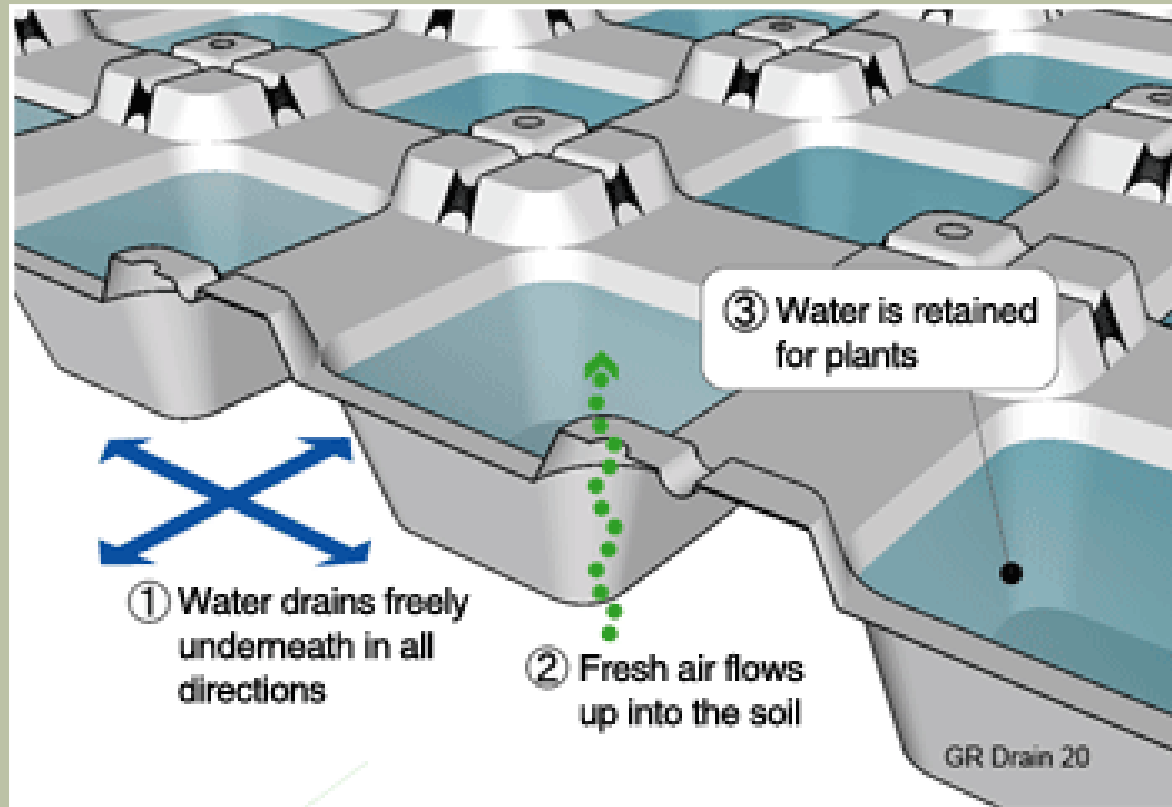


*Extensive – dimple with cups*



*Intensive – drain channel with cups*

## → Drainage / Storage Layer



*Source: [greenrooftops.com](http://greenrooftops.com)*



## → Filter Membrane



**Source: HydroTech**



## → Growing Medium



***Soil is blown onto roof (Source: HydroTech)***

## → Examples – Sedums and Grasses

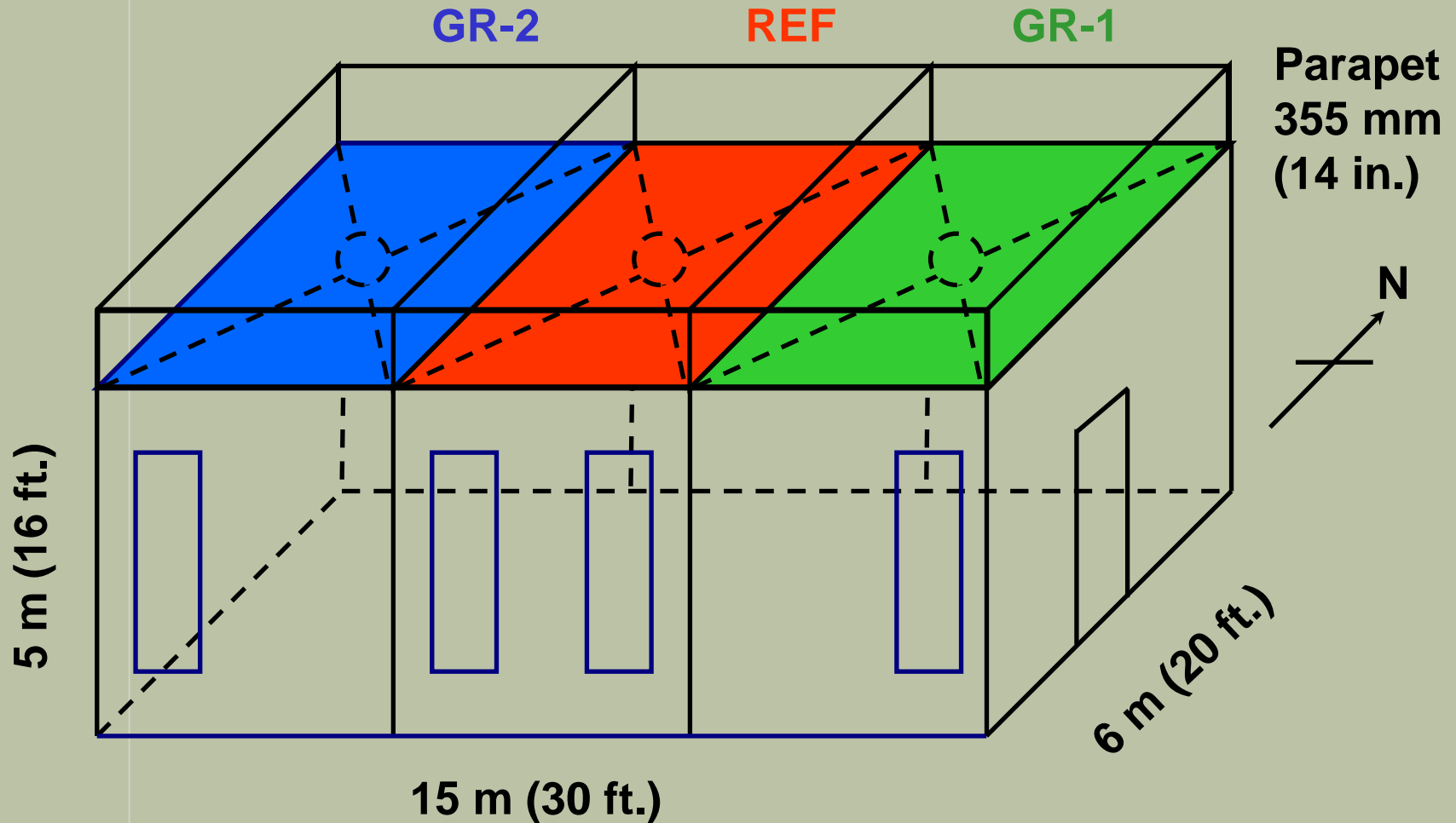


## → Presentation Outline

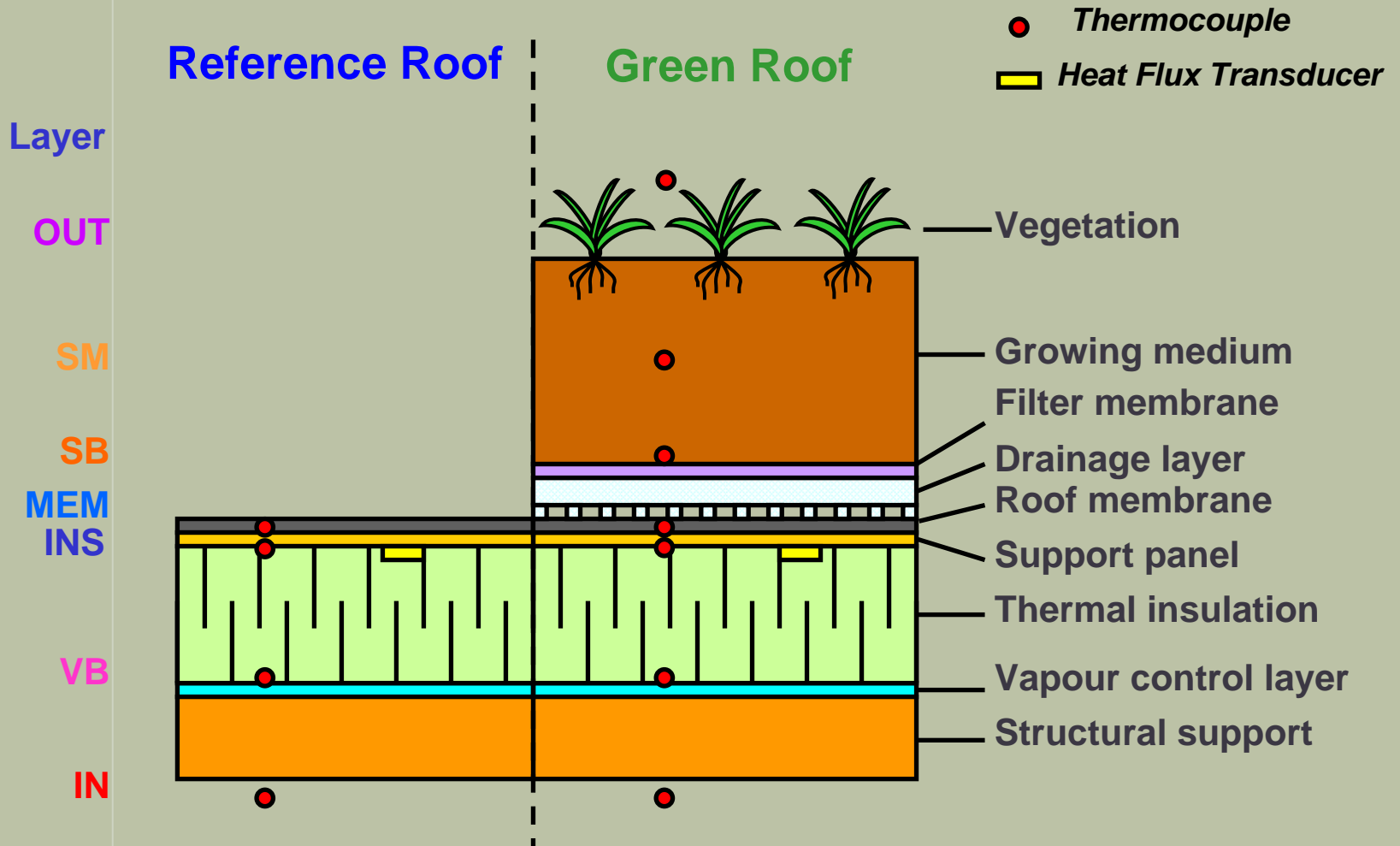
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# → Green Roof Research Facility (GRRF)



# → Cross-Section of GRRF Roof





## → 3 Test Roof Sections

**GR-1**



**GR-2**

**REF**

## → Growing Medium and Vegetation

### Green Roof “GR-1”



**GM = 75 mm, Sedums**

### Green Roof “GR-2”



**GM = 150 mm, Grasses**

***Objectives: Compare performance of GR-1 & GR-2***



## → FAQ #1: Extensive Green Roof

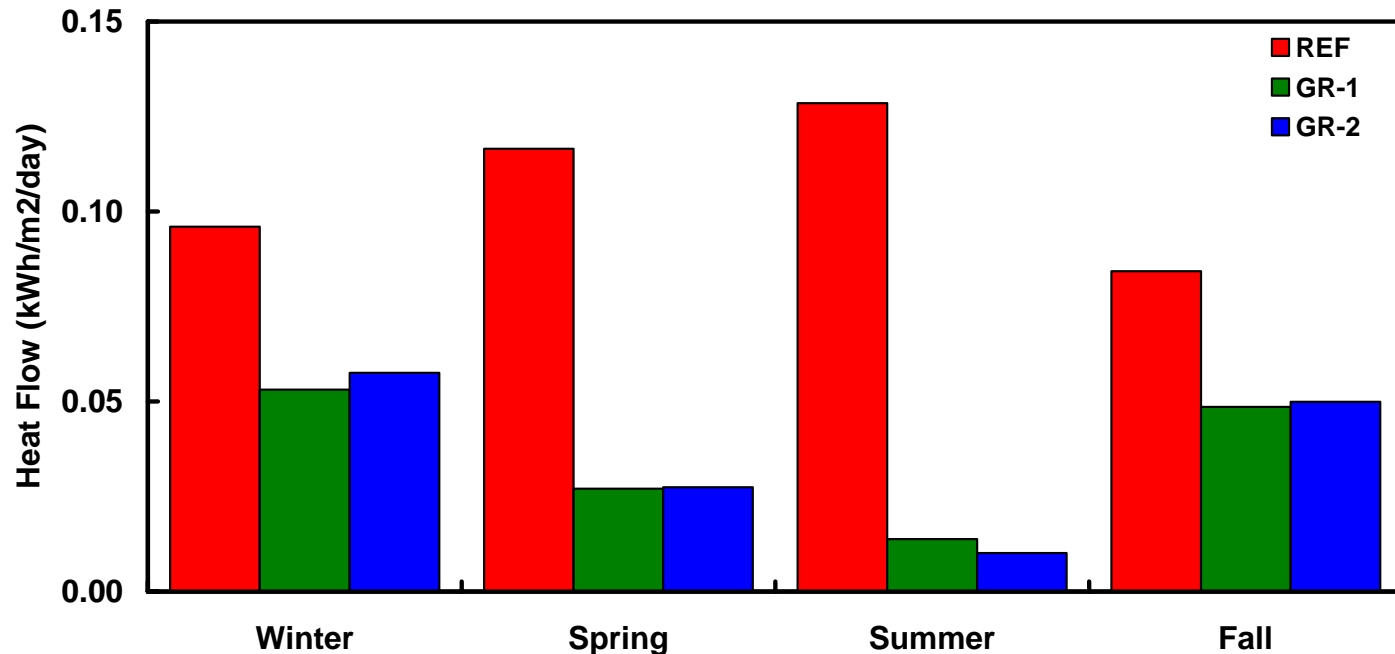
**How much growing medium  
do we need?**



## → Energy Efficiency

### Average Daily Heat Flow Through Roof Surfaces

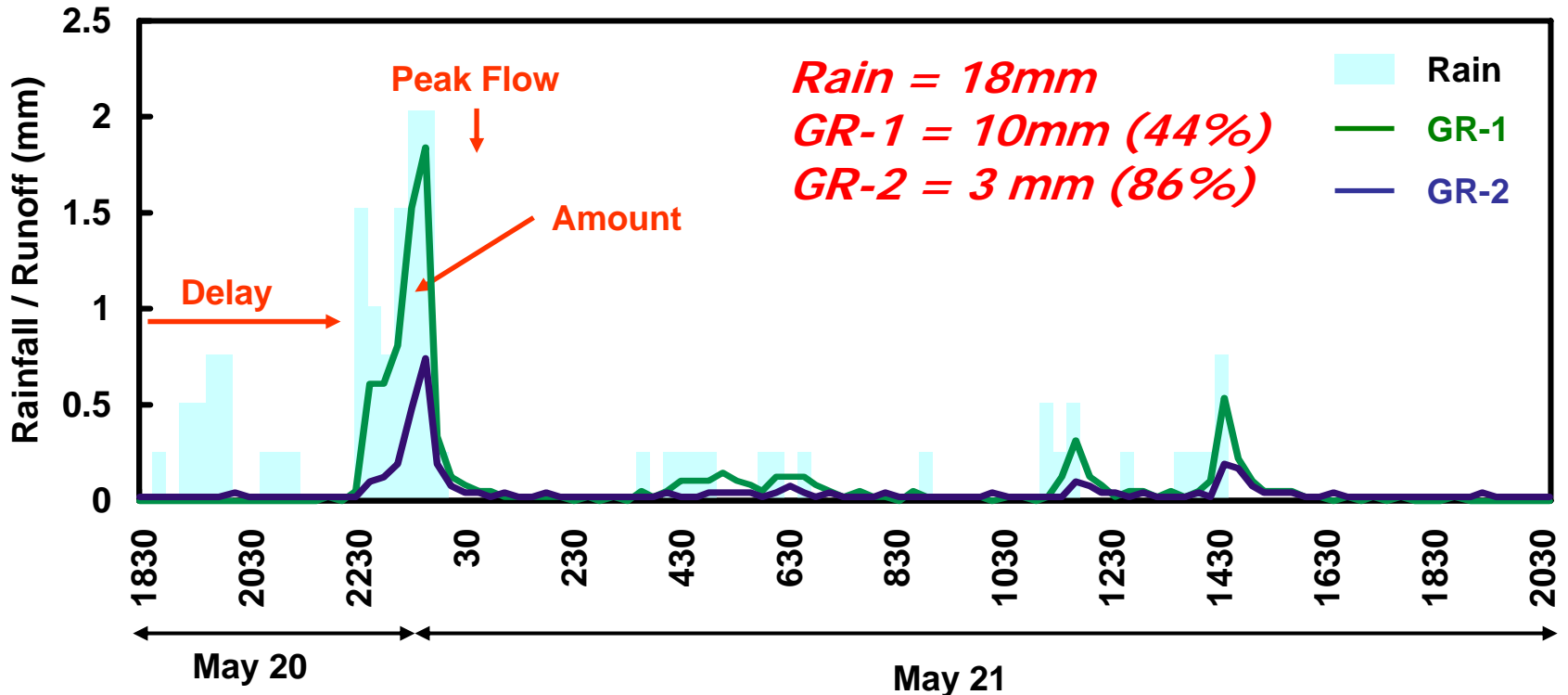
(Jan 1, 2005 – Dec 31, 2005)



**=> Thermally, GR-1 performs similarly to GR-2 in Vancouver**

# → Dry Season Event - Vancouver

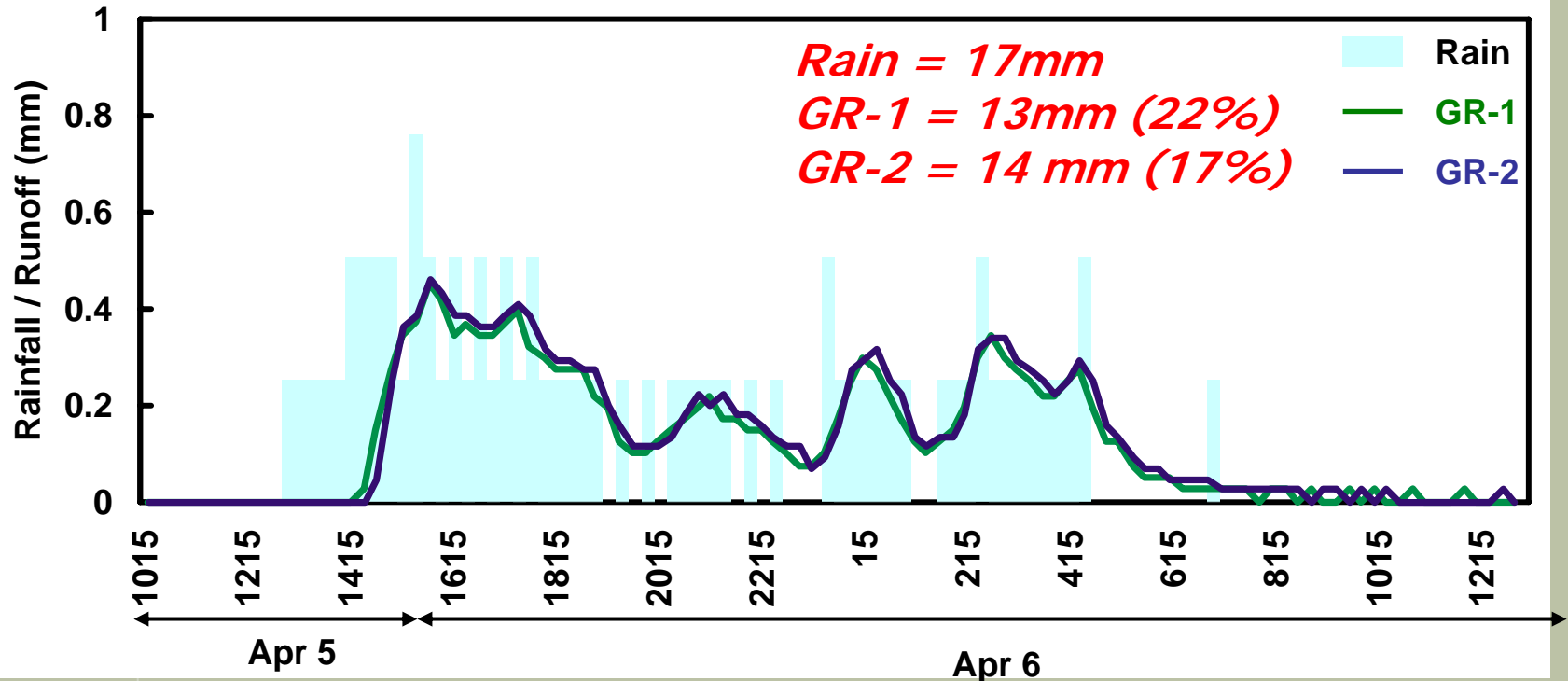
Rainfall and Runoff in Dry Season  
(May 20-21, 2005)



Dry Season: Apr – Sep, total rainfall = 231 mm

# → Wet Season Event - Vancouver

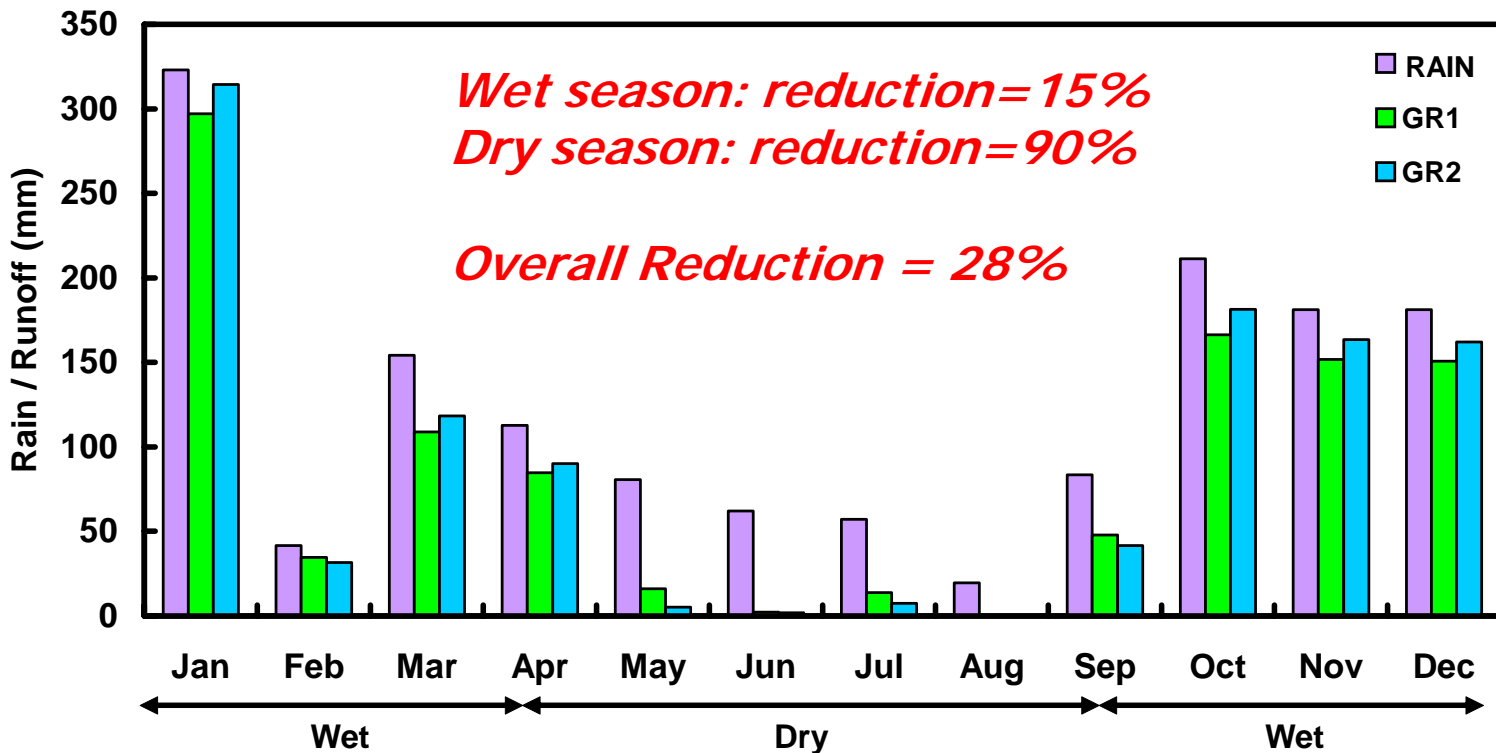
Rainfall and Runoff in Wet Season  
(Apr 5-6, 2005)



Wet Season: Oct – Mar, total rainfall = 1277 mm

## → Runoff Retention

Rainfall and Roof Runoff at GRRF  
(Jan 1, 2005 - Dec 31, 2005)



**⇒ Rain pattern affects retention efficiency of green roofs**

## → Other considerations

### ➤ **Local Climate**

- Vancouver's unique weather pattern
- Summer – mild, dry; Winter – cool, wet

### ➤ **Effects of plant on growing medium**

- Root system cause uneven flow???
- Plant internal water storage, transpiration

## → FAQ #2: Membrane Durability

**Does green roof make a roof membrane last longer?**





## → What affects membrane durability?

### ➤ **Aging**

- Heat, ultra-violet radiation

### ➤ **Mechanical**

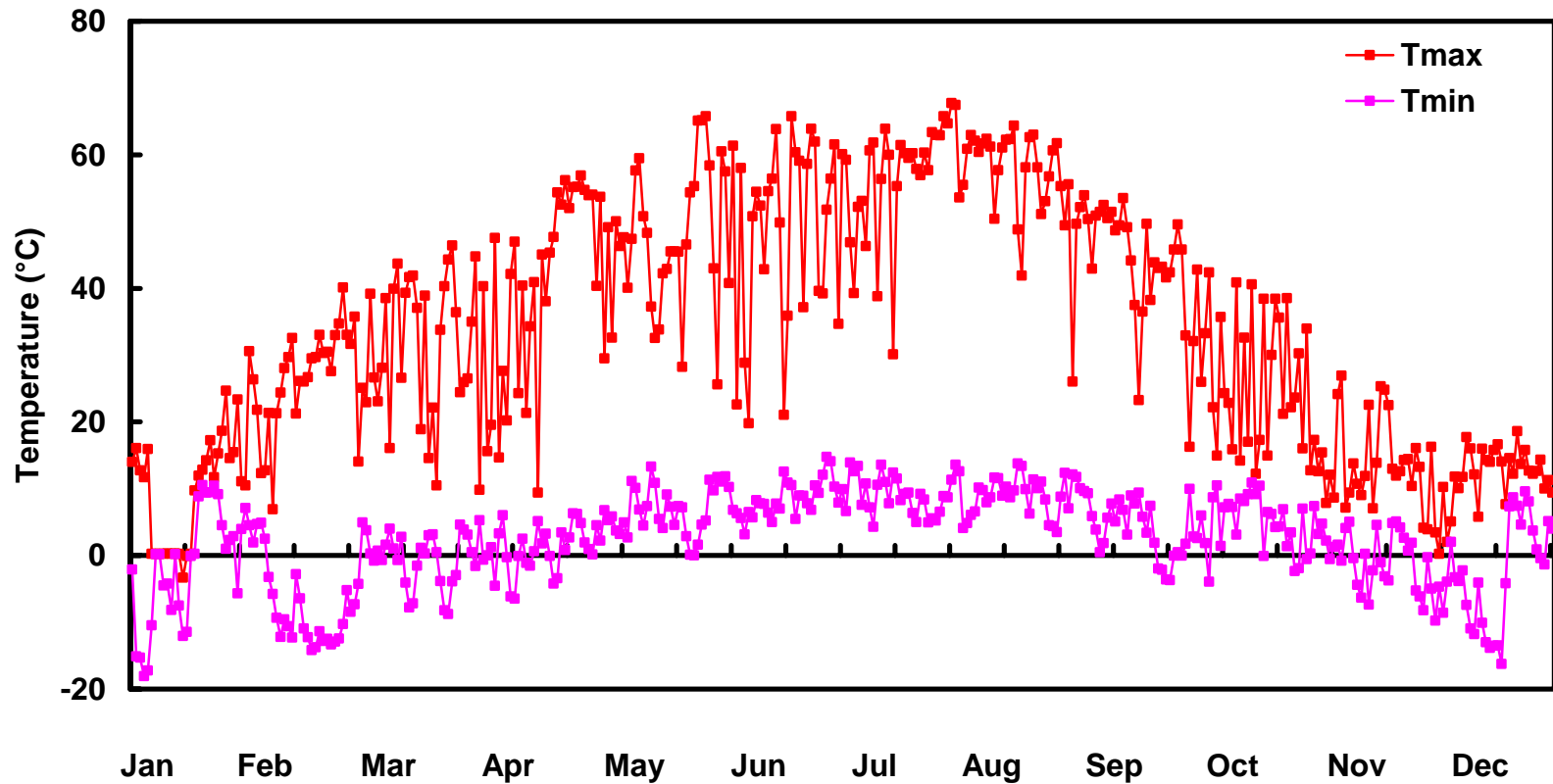
- Thermal stresses, building movement

### ➤ **Physical**

- Wind, puncture (e.g. hail, foot traffic)

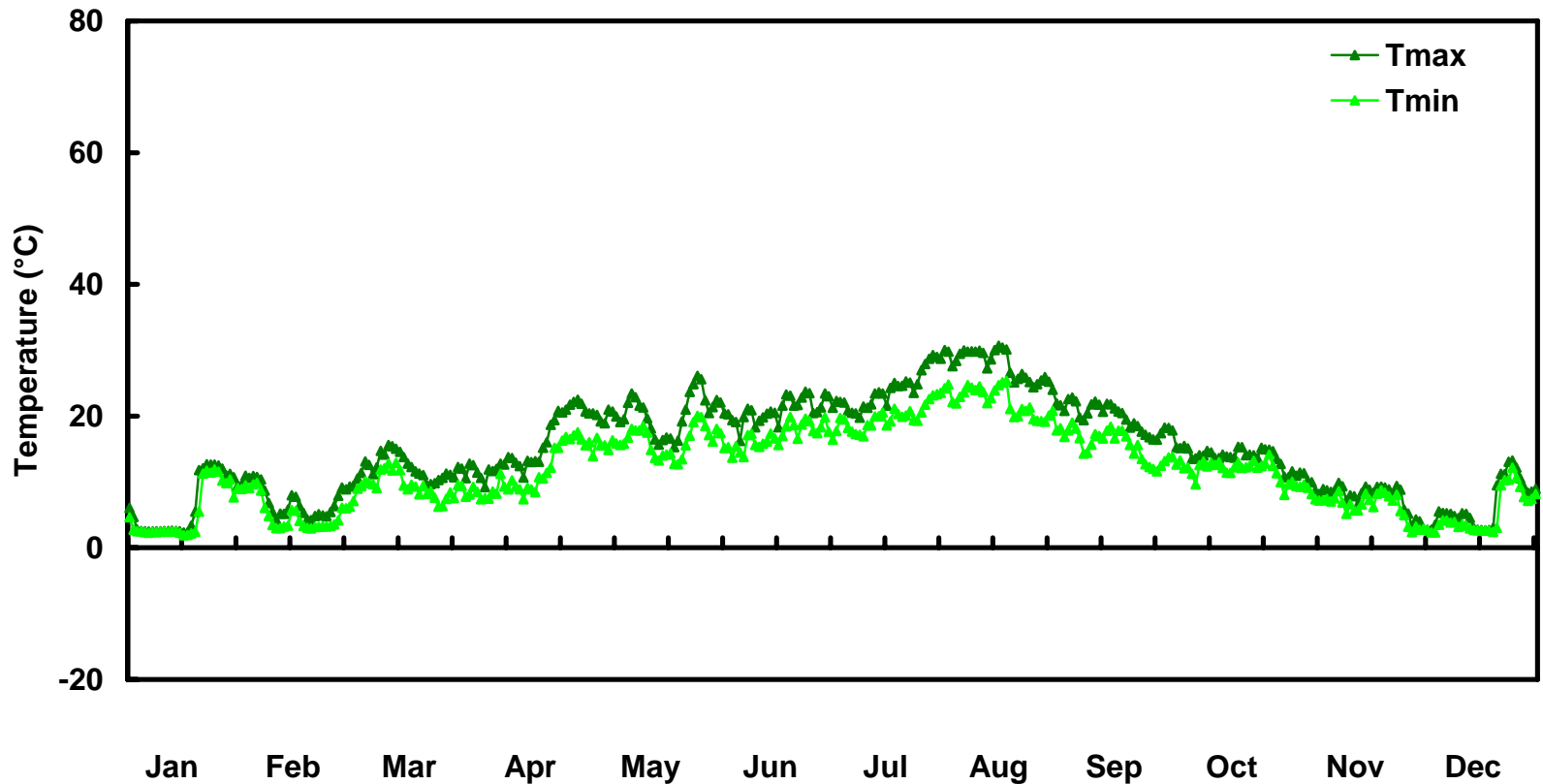
# → Membrane Temperature - Vancouver

Reference Roof, GRRF 2005



# → Membrane Temperature - Vancouver

## Green Roof "GR-1", GRRF 2005



# → Membrane Temperature Statistics

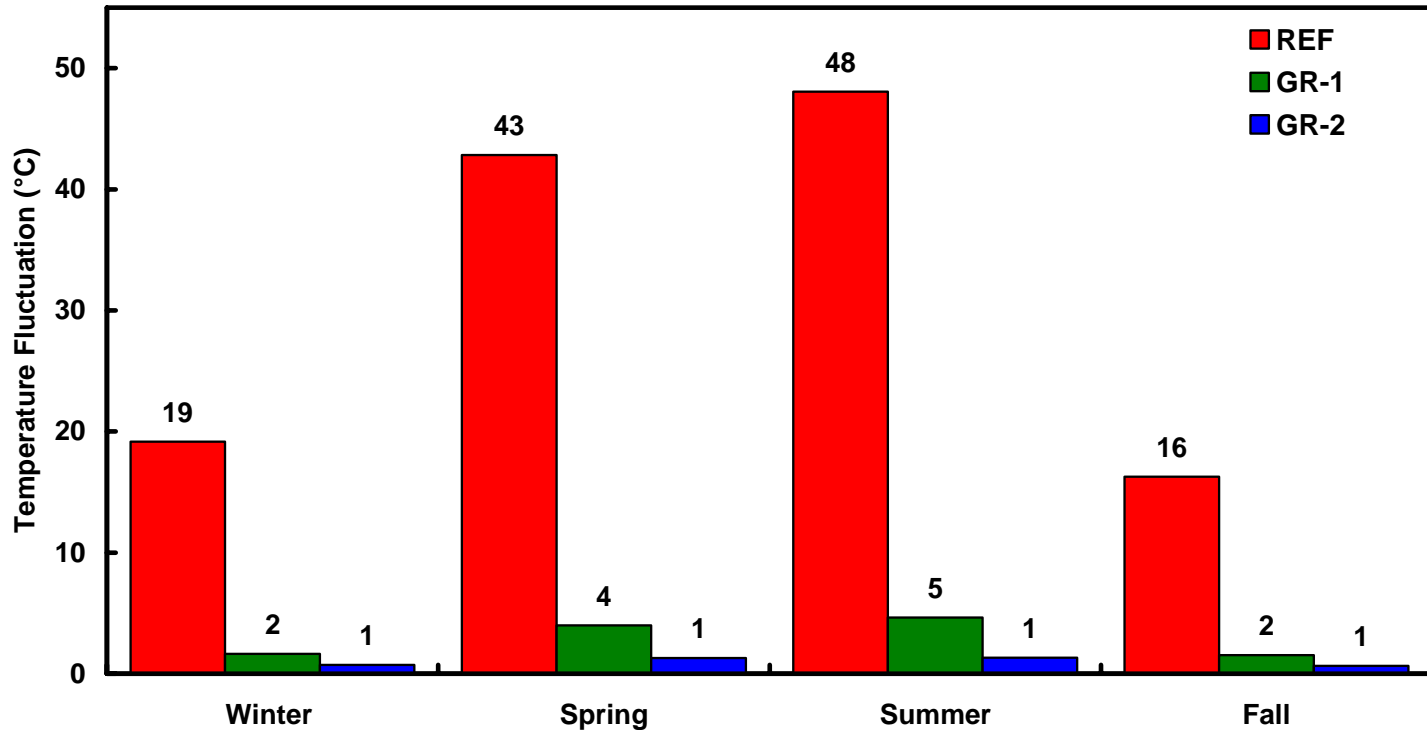
Statistics on Daily Maximum Temperature Jan 1 – Dec 31 ,2005

Temperature Greater Than:	Reference Roof		Green Roof - 1		Green Roof - 2	
	No. of Days	% of Days	No. of Days	% of Days	No. of Days	% of Days
20°C	257	70	121	33	68	19
30°C	206	56	5	1	0	0
40°C	158	43	0	0	0	0
50°C	100	27	0	0	0	0
60°C	41	11	0	0	0	0

**⇒ GRS can slow down the aging process of the roof membrane**

# → Membrane Temperature Fluctuations

Median Daily Membrane Temperature Fluctuations  
(Jan 1, 2005 - Dec 31, 2005)



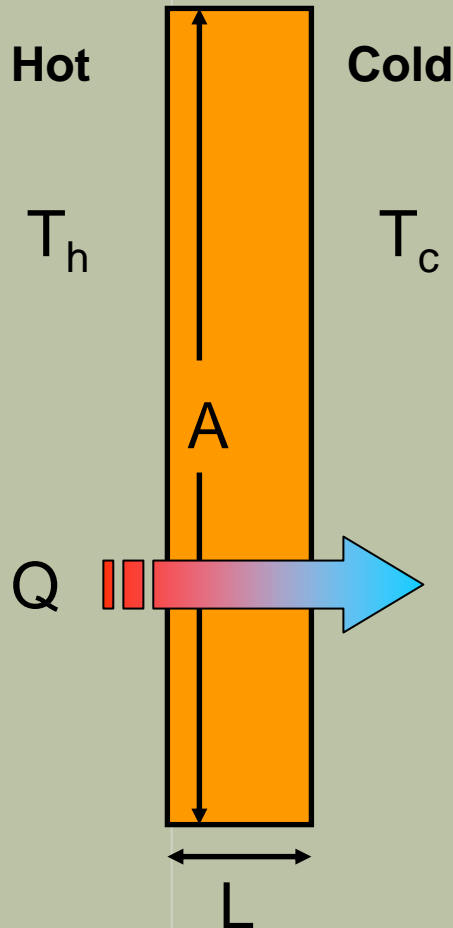
**⇒ GRS can reduce thermal stress on the roof membrane**

## → FAQ #3: Energy Efficiency

**What is the "R" value of a green roof?**



## → What is “R-value”?



Thermal Resistance (R)

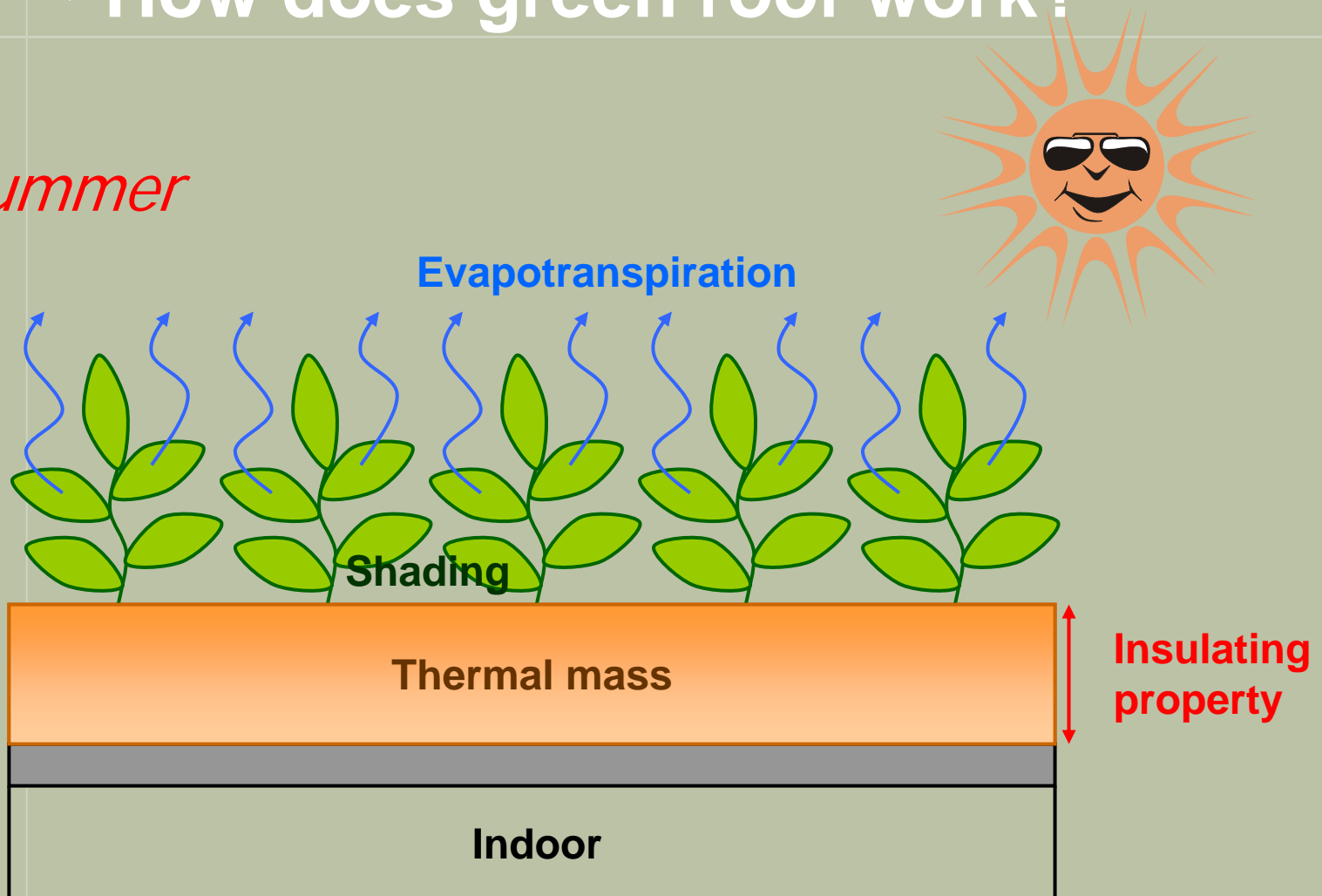
$$R = \frac{t \times A \times \Delta T}{Q}$$

- R-value is a measure of thermal resistance of insulation materials
- SI unit (RSI):  $K \cdot m^2/W$
- Imperial unit (R-value):  $ft^2 \cdot F \cdot h/BTU$



# → How does green roof work?

*Summer*



## → Problem with “R-value”?

- **Green roof cools a building with more than insulation**
  - **Shading**
  - **Evaporative cooling**
  - **Thermal mass**
  
- **R-value of wet soil is low but evaporative cooling is high**
  
- **What about “equivalent” R-value?**

## → FAQ #4: Lightweight Systems

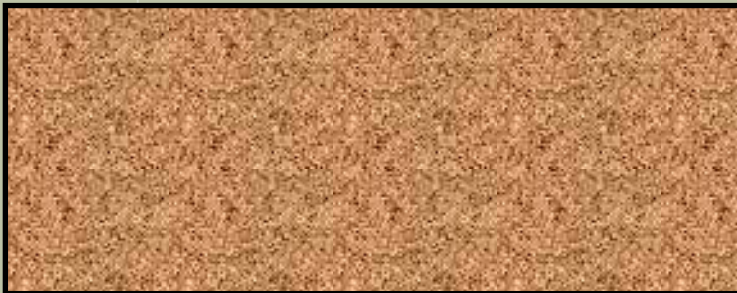
**Can lightweight systems  
perform at holding water?**



## → Extensive Green Roof Systems

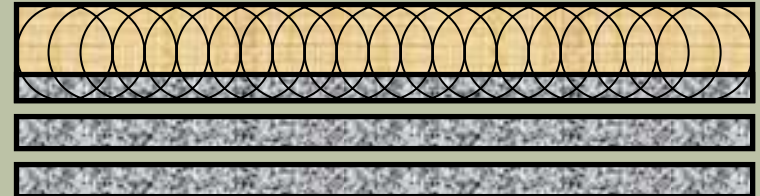
### Generic green roof system (75 mm)

- Generic green roof growing medium (75mm)



### Proprietary green roof system (45 mm)

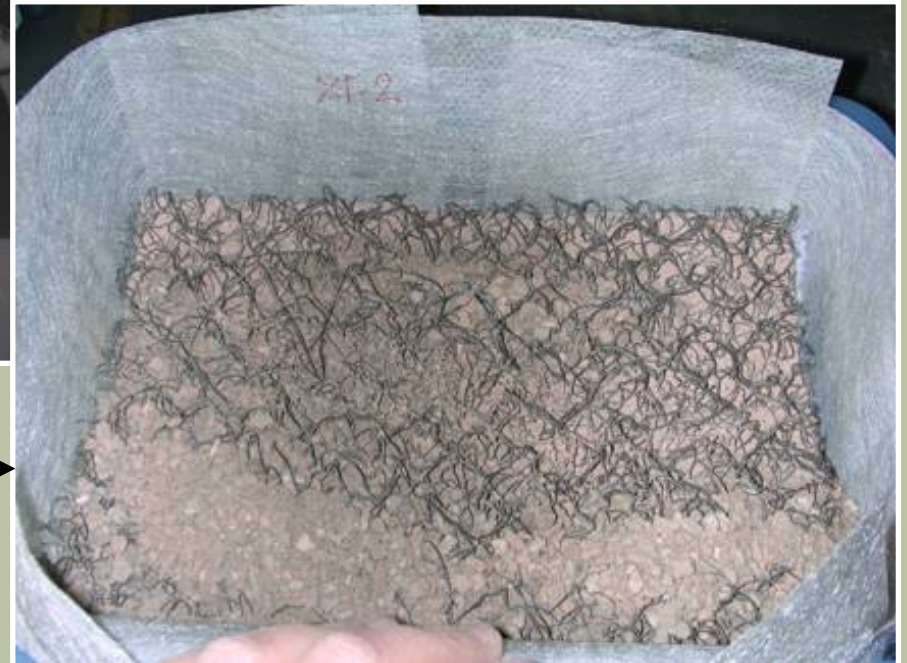
- Vegetation carrier with growing medium (25mm)
- Water retention fleece (10 mm)



# → Water Retention Experiment at BCIT



← Generic green roof growing medium



Proprietary green roof assembly →

⇒ *Measure dry weight*

## → Water Retention Experiment at BCIT



← Submerged for 24h...

Dripped for 2h... →

⇒ *Measure saturated weight*



→ **Saturated Weight and Water Retention**

	<b>Dry Weight</b>	<b>Saturated Weight</b>	<b>Water Retention (L/m<sup>2</sup>)</b>
<b>Generic Extensive GRS</b>	46.3 kg/m <sup>2</sup> 9.4 lb/ft <sup>2</sup>	74.3 kg/m <sup>2</sup> 15.0 lb/ft <sup>2</sup>	28.0
<b>Proprietary Extensive GRS</b>	24.6 kg/m <sup>2</sup> 5.0 lb/ft <sup>2</sup>	49.8 kg/m <sup>2</sup> 10.1 lb/ft <sup>2</sup>	25.3
<b>Comparison</b>	53%	67%	90%

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## → Standards and Guidelines



Materials standards



Installation standards



Guidelines

## → FLL Guidelines – Roof Slopes



### *Runoff increases with roof slope*

- **Minimum 2% for extensive GRS to allow proper positive drainage**
- **>5%: use growing medium with high water storage capacity and vegetation with low water demand**
- **special considerations to protect GRS against shear and sliding for steep slopes**
- **Maximum 45° to avoid danger of sliding**

*GRS on pitched roof (XeroFlor)*

## → FLL Guidelines – Root Penetration

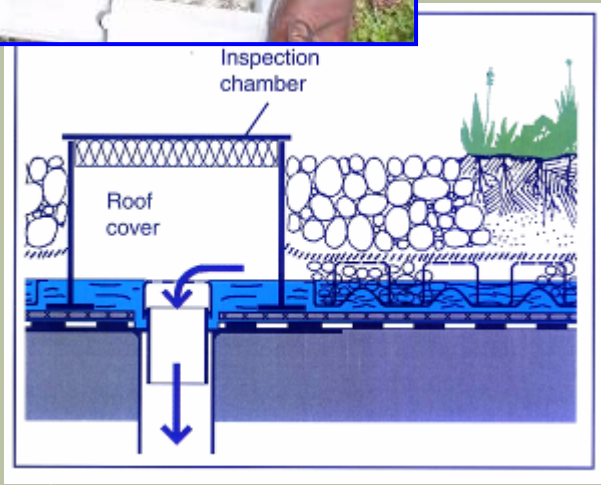
### *Roots can penetrate membrane*



*bamboo*

- Use protective sheeting or special treatment
- Use multiple root-penetration barriers if necessary
- Avoid plants with aggressive roots such as bamboo and variety of Chinese reeds
- Resistance to root penetration should be tested by standard test

## → FLL Guidelines - Drainage



**Roof drain and inspection chamber  
(HydroTech Membrane Corp.).**

### **Maintain proper drainage**

- Roof outlets should be permanently accessible and not covered by greenery or gravel
- Inspection shaft should be installed in outlets that are located within the planted areas
- Avoid plants to grow into the gutters and block drainage path
- Avoid hanging plants that block gutters at eaves on steep slopes

## → FLL Guidelines – Fire Resistance



*Sedums – low fire load*

### *Dried plant materials pose fire risk*

- Use growing medium that meet a composition and depth requirement
- Select vegetation that has a low fire load (e.g. succulents instead of grasses)
- Allow spacing between vegetation areas and any roof penetrations
- Incorporate irrigation system



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## → Green Roof Research at BCIT



***Green Roof Research Facility at BCIT, Great Northern Way Campus***

→ **CAGRT's Partners**

**BCIT-CAGRT**

**Agency**

**NSERC**

**WD**

**REF**

**EC**

**GVRD –**

**SILG**

**Roofing Systems**

**Firestone Building  
Products**

**HydroTech  
Membrane Corp.**

**IKO Industries**

**Sarnafil**

**Siplast**

**Soprema**

**Green Roof Systems**

**Elevated Landscape  
Technologies**

**XeroFlor Canada**

**ZinCo Canada**

**Other Industry**

**Detec System**

**Linnaea Nursery**

**NATS Nursery**

**Nilex/J-Drain**

**Quad-Lock**

**Stream Organics  
Management**



## → Roof Evaluation Module (REM)

- **Comparative performance data**
- **Quantitative 3<sup>rd</sup> party verification**
- **Increased market confidence**



*Roof Evaluation Modules at BCIT*

## → Regional Infrastructure Network

- **Electronic Arts, Burnaby**
- **White Rock Operations Building**
- **Elevated Research Platform, BCIT**



*City of White Rock Operations Building, White Rock, BC*

## → Education

- **Open House**  
Every 3rd Thursday of the month, 3-5 pm  
555 Great Northern Way
- **Green Roof Courses**  
GROW 0001 workshop (4h)  
GROW 1000 part time (18h)  
GROW 3000 full time (45h)
- Visit our web site: [www.greenroof.bcit.ca](http://www.greenroof.bcit.ca)

## → CAGRT Research Team

<b>Maureen Connelly</b>	<b>Research Program Head</b>
<b>Karen Liu</b>	<b>Acting Program Head</b>
<b>Kerly Acosta</b>	<b>Research Faculty</b>
<b>Janet Snell</b>	<b>Research Faculty</b>
<b>John Compton-Smith</b>	<b>Research Analyst</b>
<b>Anita Green</b>	<b>Education Coordinator</b>
<b>Claro Dejerres</b>	<b>Community and Industry Liaison</b>

***Thank You!***