Green Roof Technology – Materials, Performance and Design

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Xero Flor International

Baptist University, October 11th, 2010

Green Roof, Eco Roof, Roof Garden?

specialized roofing system that supports vegetation growth on rooftops

Green roofs in Europe

Roof garden in Japan

Xero flor

Intensive Systems

Fairmont Waterfront Hotel, Vancouver

Features

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

Extensive Systems

401 Richmond, Toronto

Features

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

Multiple Benefits for Urban Areas

Long Term Care Facility, Toronto

- Reduce energy demand
- Mitigate urban heat island
- Reduce stormwater runoff
- Improve air quality
- Replace displaced landscape
- Enhance biodiversity
- Provide recreational spaces

LEED Credits for Green Roofs

Full Credits (3 possible points)

SS 7.2	Heat Island Effect, Roof (1)
SS 6.1&6.2	Stormwater Design (1-2)

Contributing Credits (12 possible points)

EA 1	Optimize Energy Performance (1-2)
SS 5.1&5.2	Site Development (1-2)
WE 1	Water Efficient Landscaping (2-4)
MR 4	Recycled Content (1)
MR 5	Regional Materials (1)
RP 1	*Regional Priority (1-2)*

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SS Credit 7.2 Heat Island Effect: Roof (1)

- ***Intent: Reduce heat island to minimize impact on microclimate and human and wildlife habitat***
- ***Req.: Install combination of high albedo and vegetated roof surfaces to meet the criteria:***

  $$(A_{SRI}/0.75) + (A_{GR}/0.5) >= A_{TOTAL}$$

- **Design Strategies:**
  - **Plants lower heat island effect through evaporative cooling and reduction of heat absorbing surfaces**
  - **High vegetation coverage maximizes benefits**
  - **Sufficient moisture available for cooling effects**

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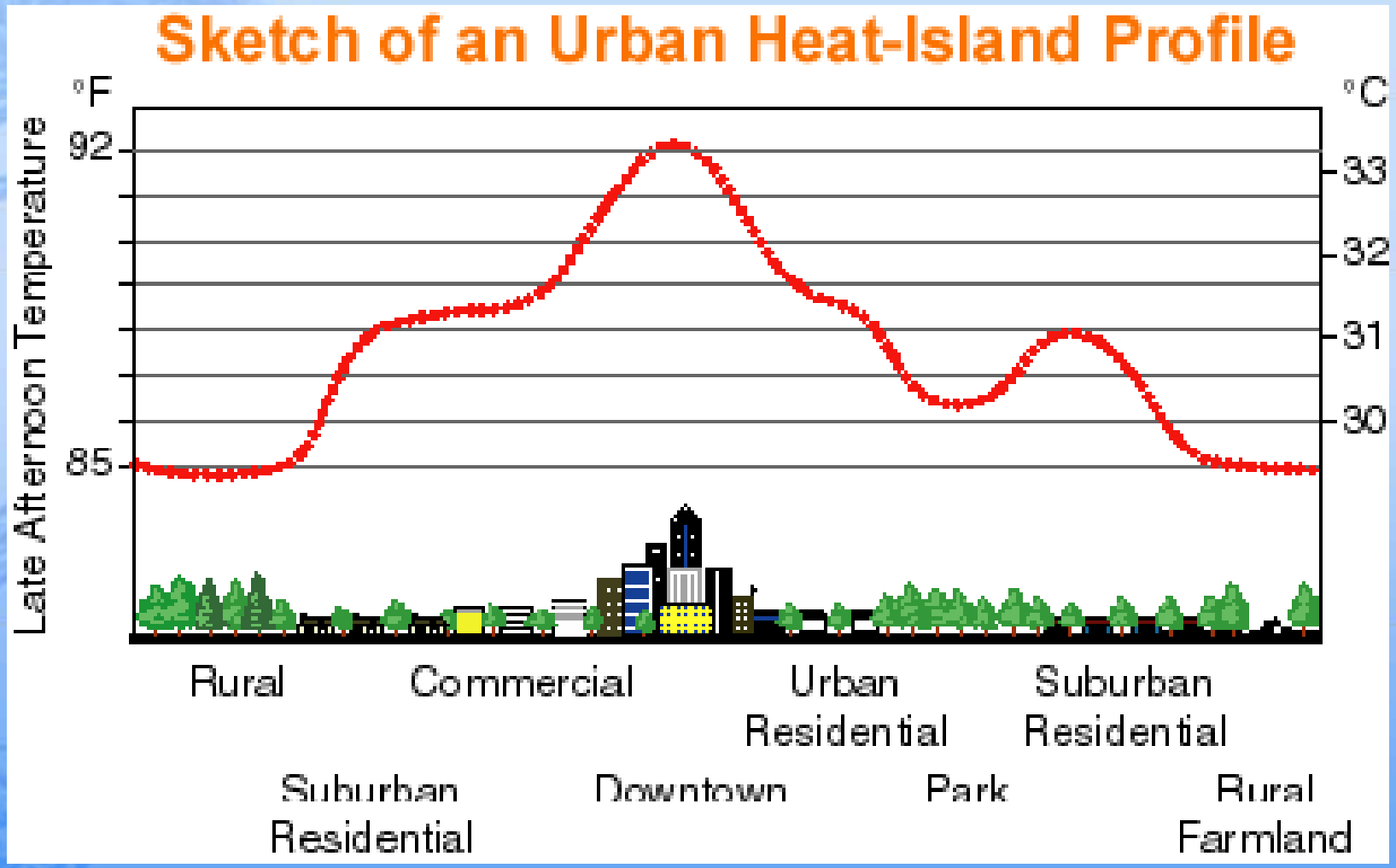
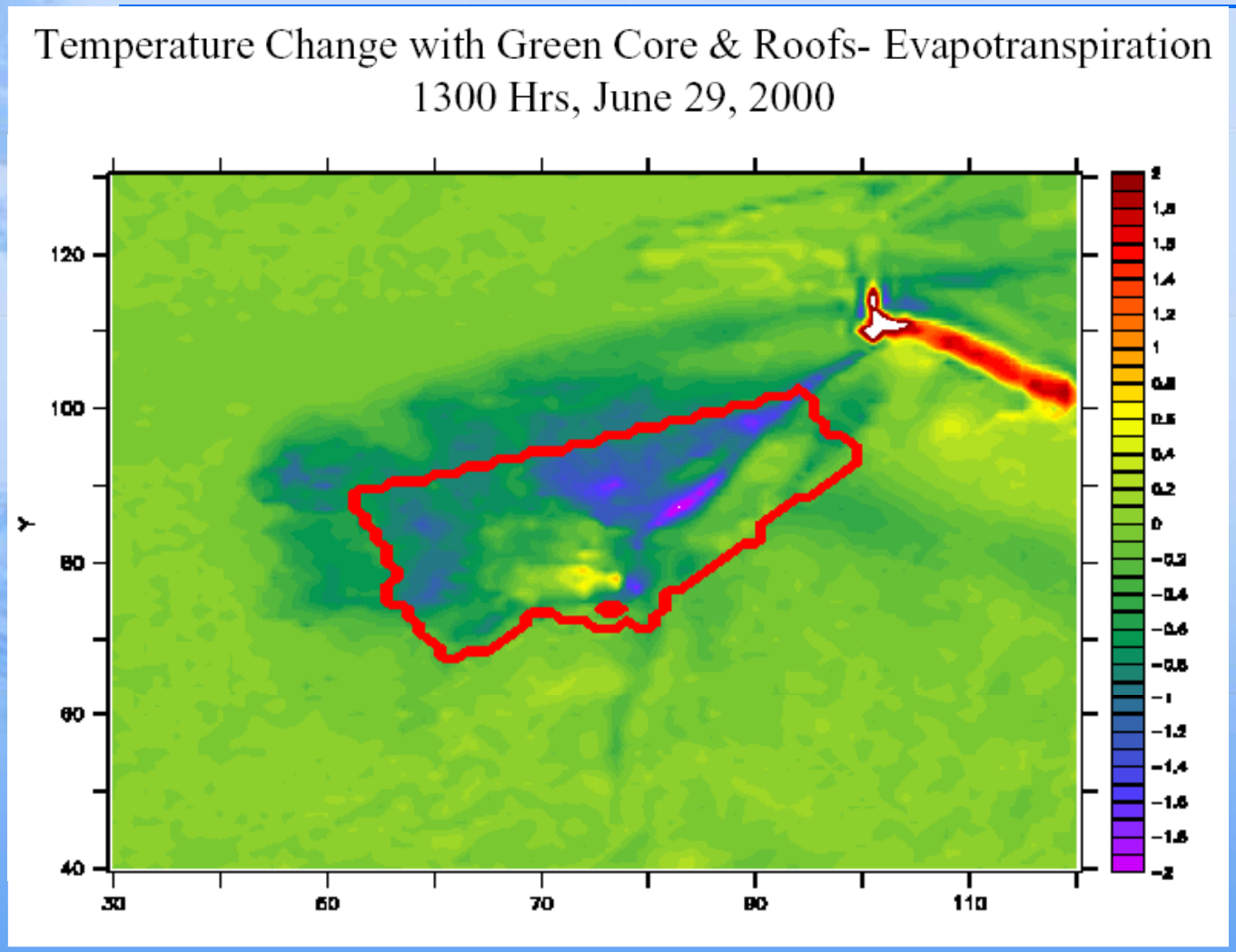
Urban Heat Island



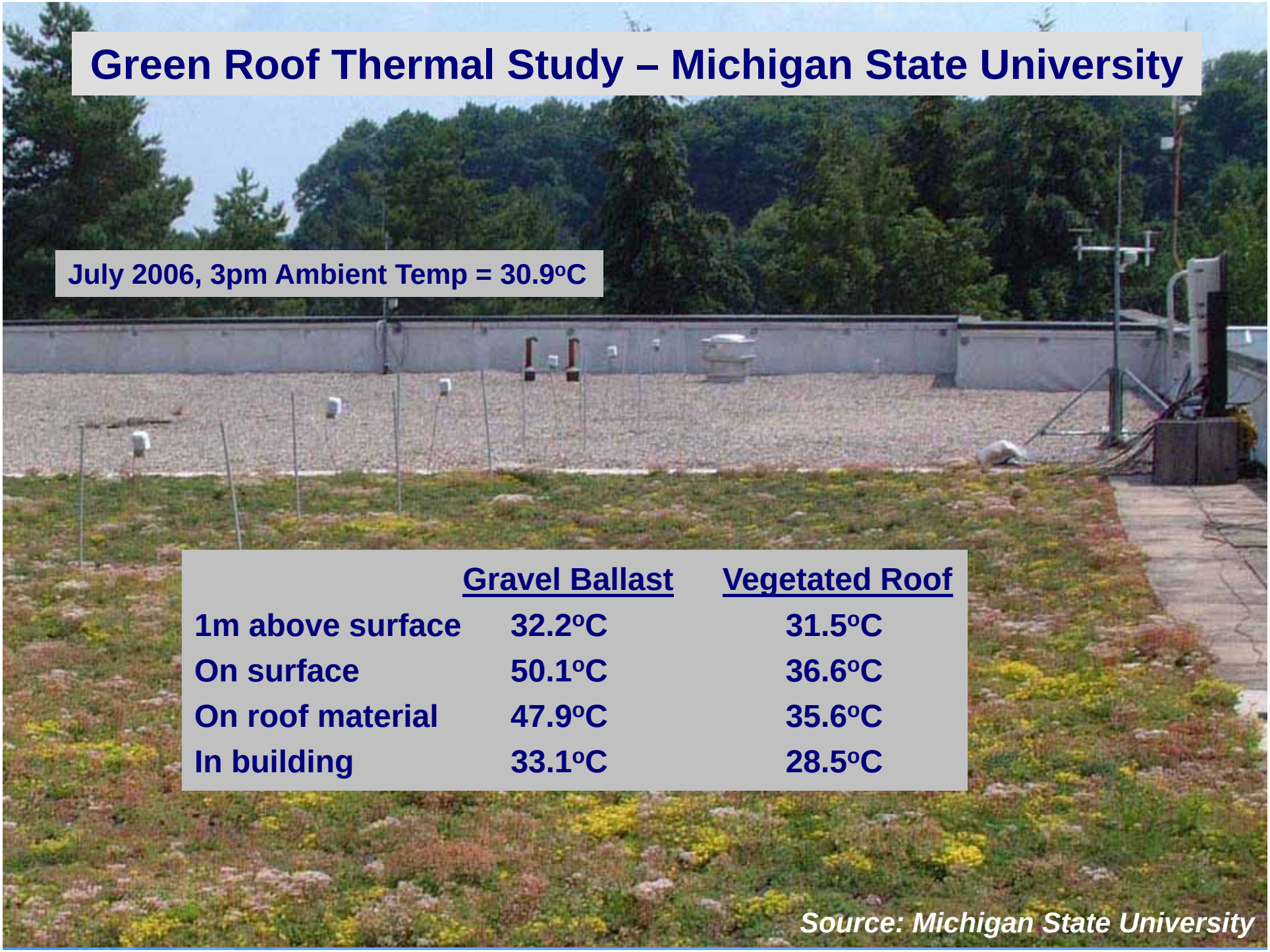
Source: Urban Heat Island Group, LBNL

Urban Heat Island Mitigation



Source: Environment Canada

Green Roof Thermal Study – Michigan State University



July 2006, 3pm Ambient Temp = 30.9°C

	Gravel Ballast	Vegetated Roof
1m above surface	32.2°C	31.5°C
On surface	50.1°C	36.6°C
On roof material	47.9°C	35.6°C
In building	33.1°C	28.5°C

Source: Michigan State University

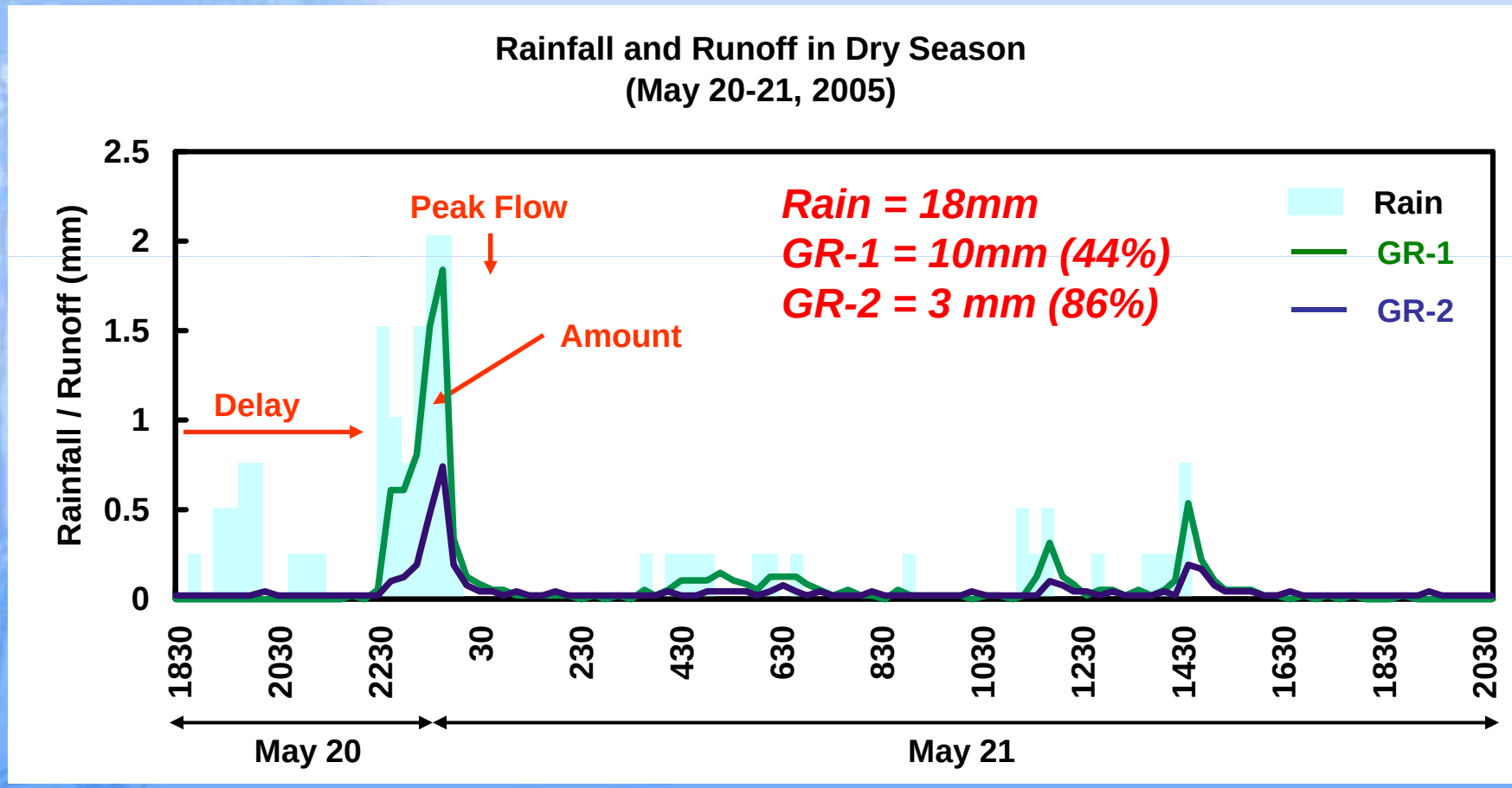
SS Credit 6.1 Stormwater Design, Quantity Control (1)

- ***Intent: Limit disruption of natural water hydrology by reducing impervious cover and increasing on-site infiltration***
- ***Req.: Implement stormwater management plan to promote infiltration and reduce site runoff***
- **Design Strategies:**
  - **Maximize medium depth within structural limit**
  - **Use high-performance water retention layers**
  - **Work in conjunction with other stormwater management measures**

Green Roof Field Monitoring - BCIT

Source: BCIT

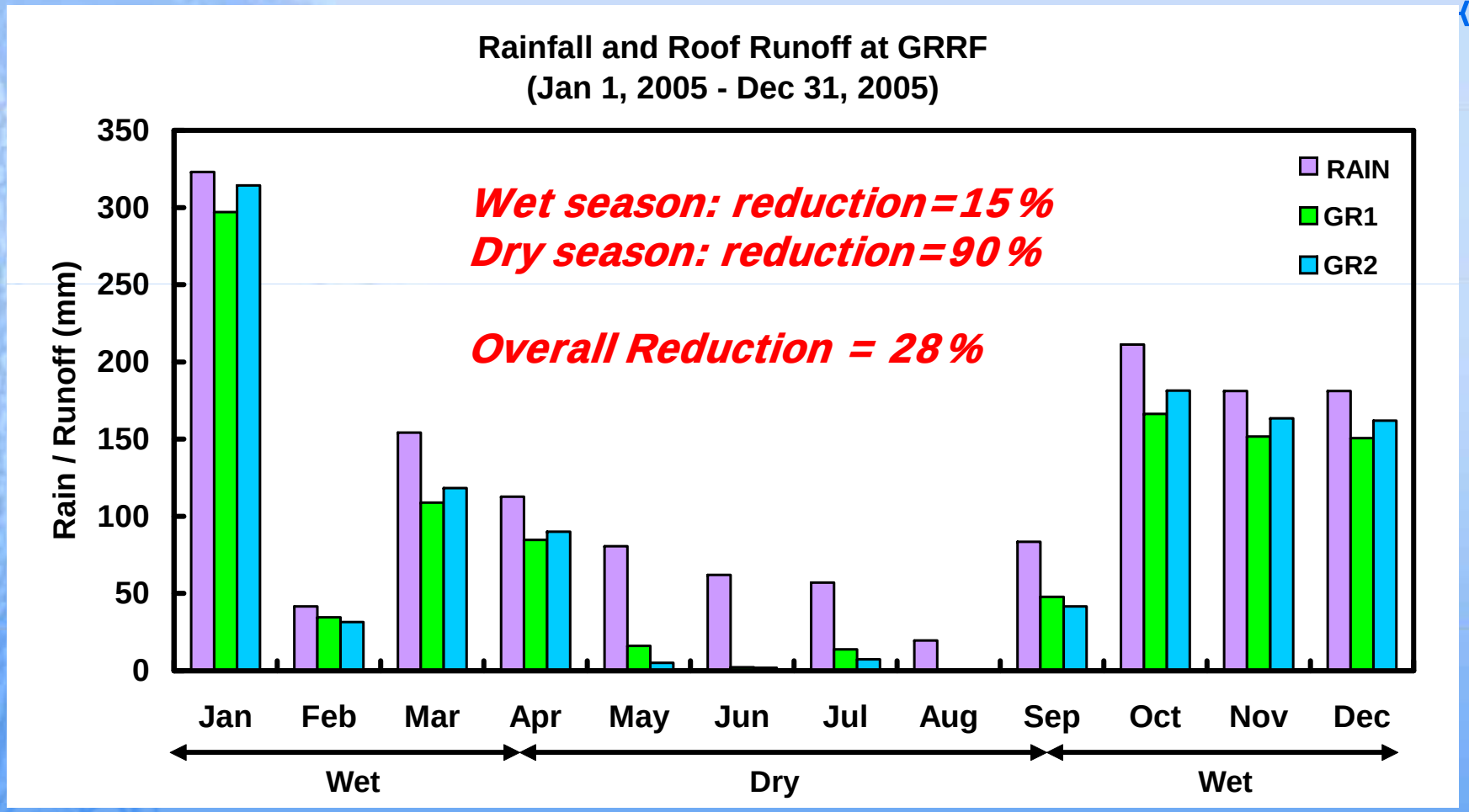
Stormwater Runoff Retention - BCIT



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

Source: BCIT

Stormwater Runoff Retention - BCIT



Source: BCIT

SS Credit 6.2 Stormwater Design, Quality Control (1)

- ***Intent: Limit disruption and pollution of natural water flow by managing stormwater runoff***
- ***Req.: Use BMPs to treat runoff from 90% of average annual rainfall, remove 80% of the average annual post development total suspended solids from it***
- **Design Strategies:**
  - **Use water retention layers to retain runoff and filter fabric to capture its suspended solids**
  - **Use "clean" substrate and avoid over-fertilizing**
  - **Consider specialized "soil-less" substrate**

Energy & Atmosphere

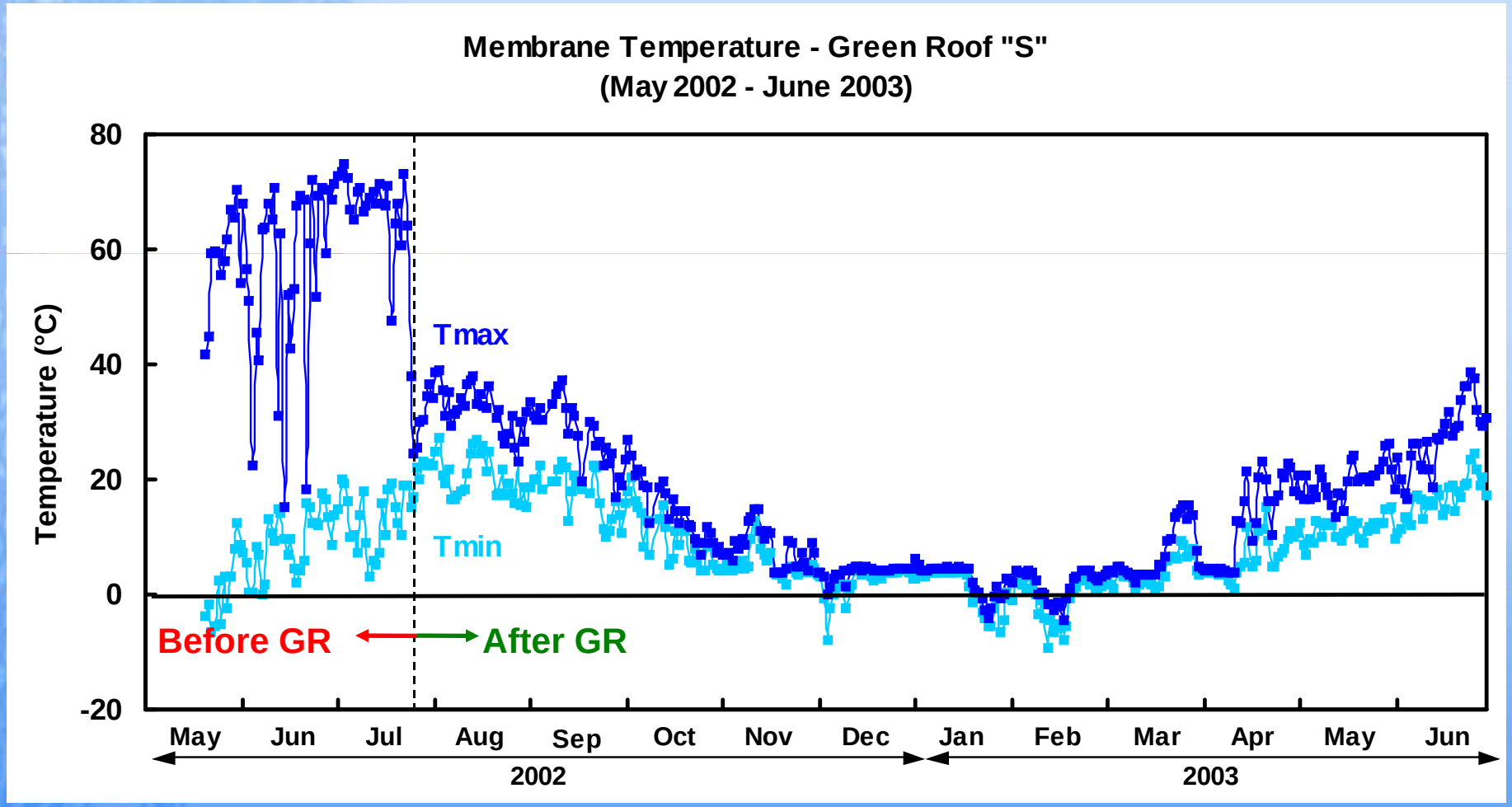
EA 1 Optimize Energy Performance (1-2)

- ***Intent: Increase energy performance above the baseline in the prerequisite standard to reduce impacts associated with excessive energy use***
- ***Strategy: Green roofs (and other measures) reduce energy use for space conditioning of buildings***
- **Contributions from green roofs:**
  - **Increase energy efficiency of roofing system and reduce building energy use**

Eastview Community Centre, Toronto

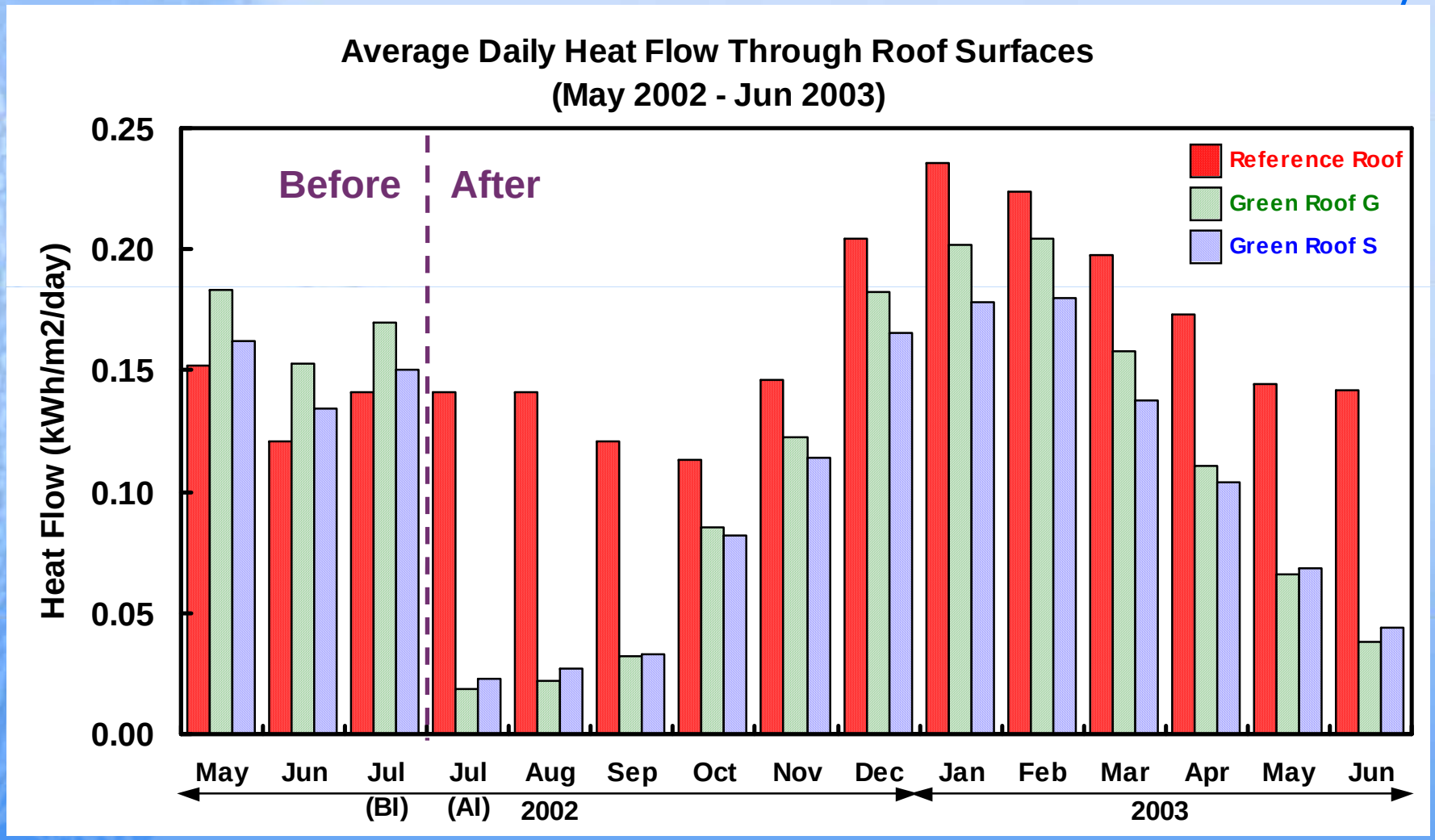
Eastview Neighbourhood Community Centre, Toronto

Roof Membrane Temperature



Source: NRC-IRC

Energy Efficiency



Source: NRC-IRC

Roof Service Life Extension

- Reduce heat aging
- Reduce thermal cycling
- Reduce ultra-violet degradation
- Reduce physical damage (e.g. foot traffic & hail)
- European experience: green roof last twice as long

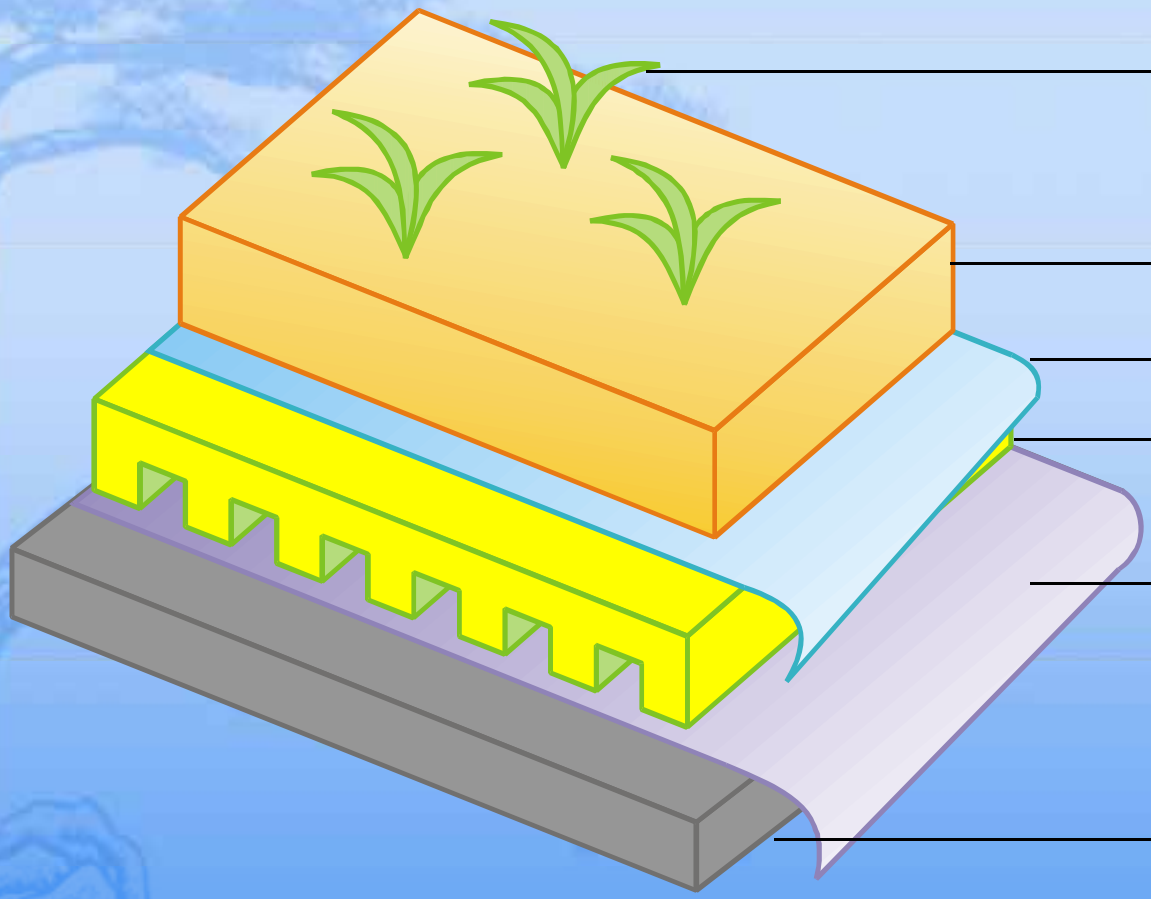
WE 1 Water Efficient Landscaping,
Reduce by 50% (2)
No Potable Water Use or No Irrigation (4)

- ***Intent: Limit or eliminate the use of potable water or other natural water resources for landscape irrigation***
- ***Req.: Reduce irrigation using potable water by 50% from mid-summer baseline; no permanent irrigation systems; temporary for plant establishment only.***
- **Design strategies:**
  - **Drought tolerant plants (sedums & succulents) and vegetation mats to reduce irrigation needs**
  - **Use high performance water retention layers**

Xero floor

Water Retention Layer – Hygroscopic Slab

Principal Components



Vegetation

Growing medium

Filter layer

Drainage layer

Root resistant layer

Roof assembly
(Conventional or PMRA)

Plant-in-Place Method

6” Depth, 25 lb/sqft system
(K. Scholz-Barth)

Installation

At 18 months

At 36 months

Pre-Grown Vegetation Mats

Xero Flor Cultivation Field – Princeton, ON, Canada

Pre-cultivated Vegetation Mats

Private Residence, North Vancouver, BC, Canada

Installation - Materials

Meadowlark Town Houses, Edmonton, AB

Installation – Base Layers

Meadowlark Town Houses, Edmonton, AB

Installation – Vegetation Mats

Meadowlark Town Houses, Edmonton, AB

Crew = 4; Area = 800 m^2; Time = 2 days

Meadowlark Town Houses, Edmonton, AB

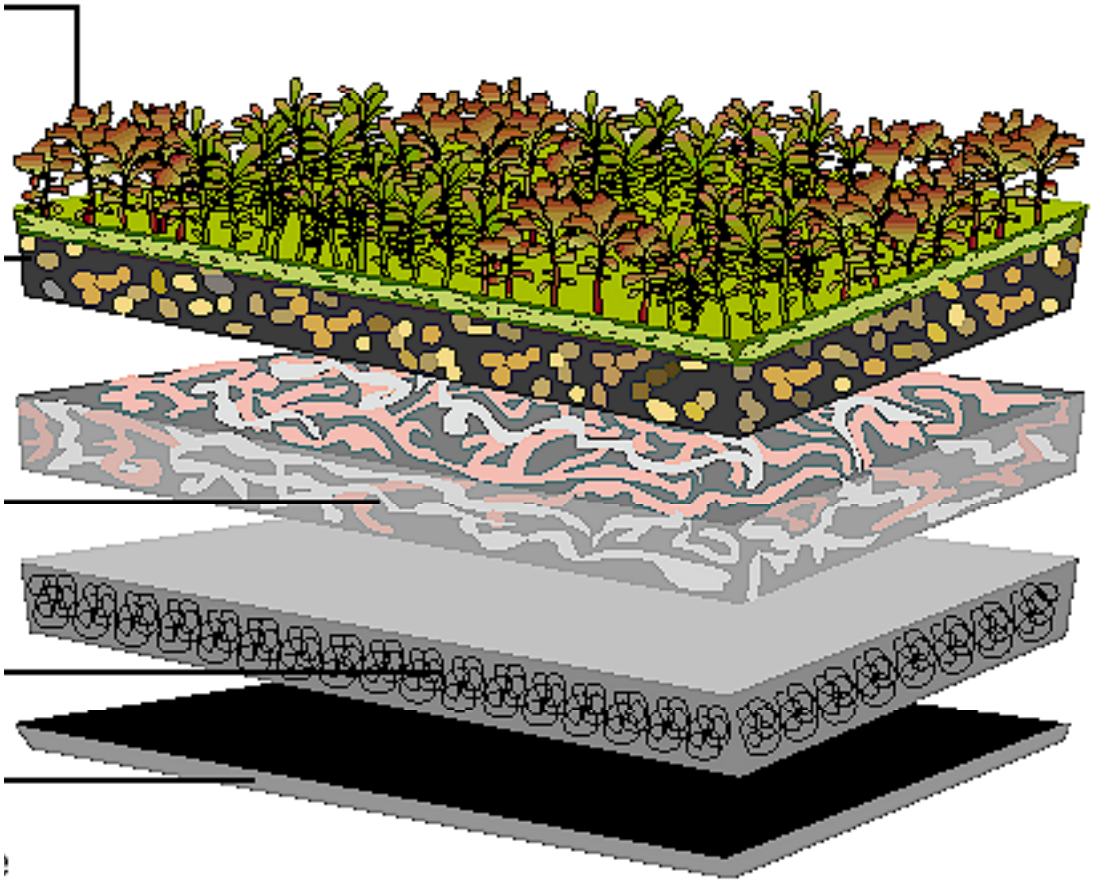
Basic Xero Flor Green Roof System

Pre-cultivated
Vegetation Mat

Water Retention Layer

Drainage / Filter Layer

Root Barrier
Roofing Assembly



Saturated Weight = 50 kg/m^2
Water Retention = 27 L/m^2

Plants for Extensive Green Roofs

- Contributes to various benefits of green roofs
- Selection considerations
  - Climate – hardiness zone, wind, precipitation
  - Harsher/extreme conditions on rooftops
  - Hardy, drought tolerant, minimal nutrient needs, self-generating
  - Low maintenance
- Irrigation and Fire hazards
- Low maintenance ≠ No maintenance

Typical Plants - Succulents






Natural Habitat of Sedum

Sea-to-Sky Highway, BC, Canada

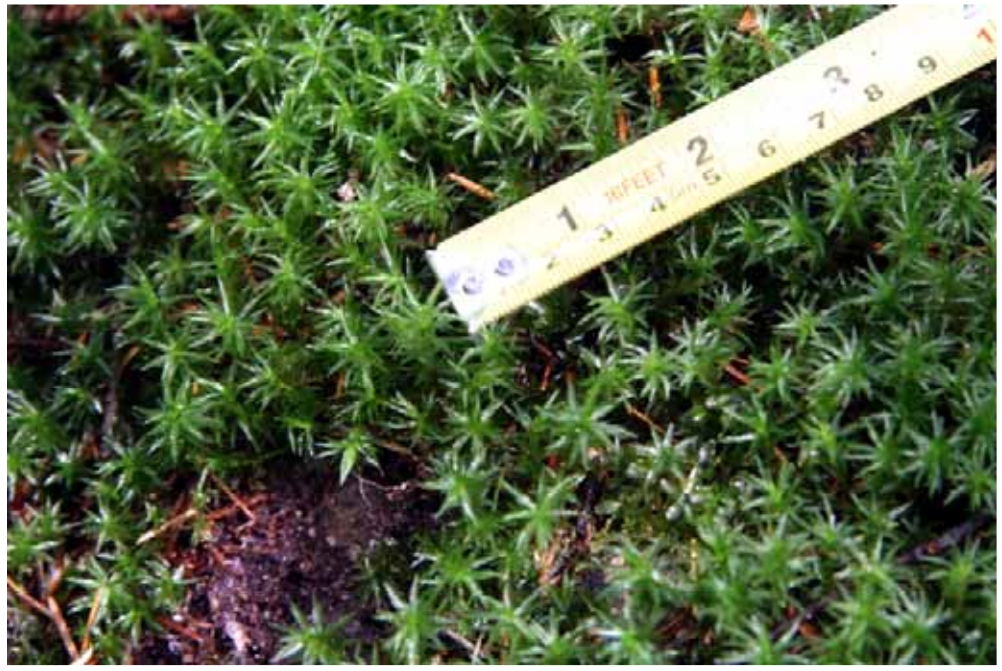
Native Plants

- Increased use of native plants on green roofs
- Lower plant maintenance
- Promote biodiversity on green roofs
- Not all native plants do well on green roofs – check natural habitats

Flowering perennials on green roofs

Mosses

- Retain runoff
- Improve air quality
- Enhance biodiversity



Mosses, Vancouver, BC, Canada

Water Retention Comparison

Components	Thickness	Dry Weight	Saturated Weight	Water Retention
Typical Lightweight Growing Medium	25 mm 1.0”	15.4 kg/m^2 3.1 psf	24.8 kg/m^2 5.1 psf	9.3 L/m^2 0.37”
XF159 Water Retention Fleece	10 mm 0.4”	1.2 kg/m^2 0.2 psf	10.3 kg/m^2 2.1 psf	9.1 L/m^2 0.36”
XF107 Hygroscopic Roll	25 mm 1.0”	1.6 kg/m^2 0.3 psf	23.9 kg/m^2 4.9 psf	22.3 L/m^2 0.88”

XF301 Pre-cultivated Vegetation Systems

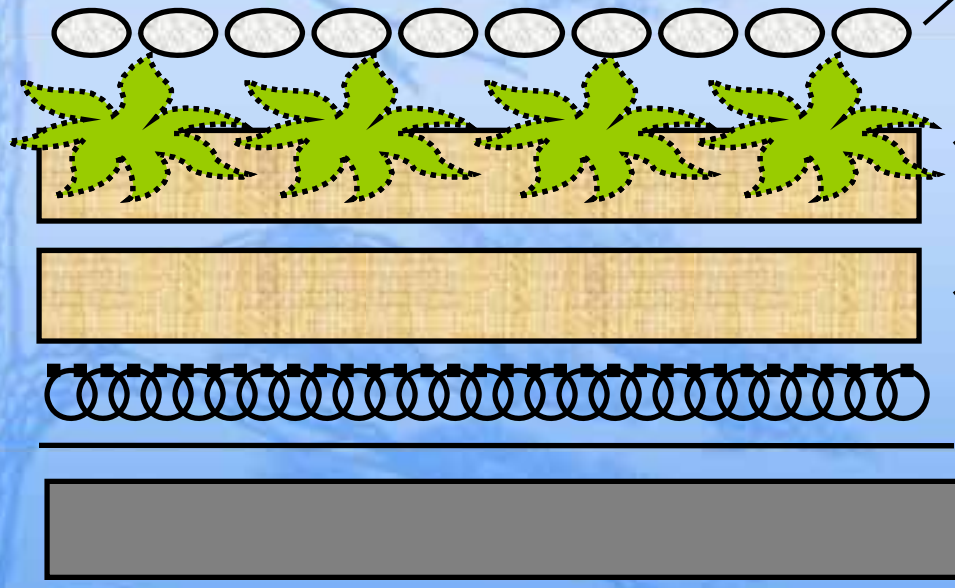
Water Retention Layer	Build up Height	Saturated Weight	Water Retention Capacity
XF159 Moisture Retention Fleece	56 mm 2.2”	49 kg/m2 10 psf	27 L/m2 1.1”
XF159 (2) Moisture Retention Fleece	66 mm 2.6”	59 kg/m2 12 psf	36 L/m2 1.4”
XF107 Hygroscopic Roll	70 mm 2.8”	62kg/m2 13 psf	40 L/m2 1.6”
XF107S Hygroscopic Slab	105 mm 4.2”	94 kg/m2 19 psf	67 L/m2 2.6”

Design Load

XF301 with Hygroscopic Slab XF107S

Composite Seed Mat

XF319 – Variations (pre-grown option)



Ballast

Seed Composite mat
XF 319 (30mm)

Water retention layer
(XF159, XF107, XF107S)

Drainage blanket XF108H
(15mm)

Root barrier XF112

Roofing
Assembly

Staring from: Buildup Height = 60 mm (2.4”)
Saturated Weight = 59 kg/m^2 (12 psf)
Retention Capacity = 28 L/m^2 (1.1")

xero floor

Composite Seed Mat

XFC cultivation field, Princeton, ON, Canada

Composite Seed Mat

Bus Depot, Germany

Composite Seed Mat

Bus Depot, Germany

Case Study – Ford Green Roof

Courtesy: Don Russell (Xero Flor America)
Joy Schmidt (Xero Flor Canada)

World Largest Green Roof – 10.4 acre
Ford Rouge Plant, Dearborn, Michigan

Ford Rouge plant, Dearborn, Michigan, USA

Business Case on the Green Roof

- Federal legislation may require companies to clean stormwater before discharge.
- Our site is heavily built-upon. Stormwater runoff causes flooding, shutting down key operations.
- A main goal in our site renovation is to reduce and clean stormwater runoff.
- Our business comparison included the potential cost of installing a stormwater treatment facility.

Why Ford Consider A Green Roof?

- The roof is one component of a site-wide stormwater management program.
- It minimizes and cleans stormwater runoff.
- It provides a habitat for birds and bees.
- Its vegetation absorbs carbon dioxide and releases oxygen.
- It increases the roof's lifespan.

Roof Design Issues

- Structural steel needs are increased.
- Water and root resistant membranes are important concerns.
- Future roof maintenance requirements should be minimal.
- Roof penetrations should be possible later.

Initial Research

- Trials were conducted at Michigan State University
- First plan was to develop a system in association with McDonough-Braugart
- A modular tray system was evaluated
- Native plants were compared with sedums
- Substrate mixtures were evaluated

Comparison – Sedums & Native Plants

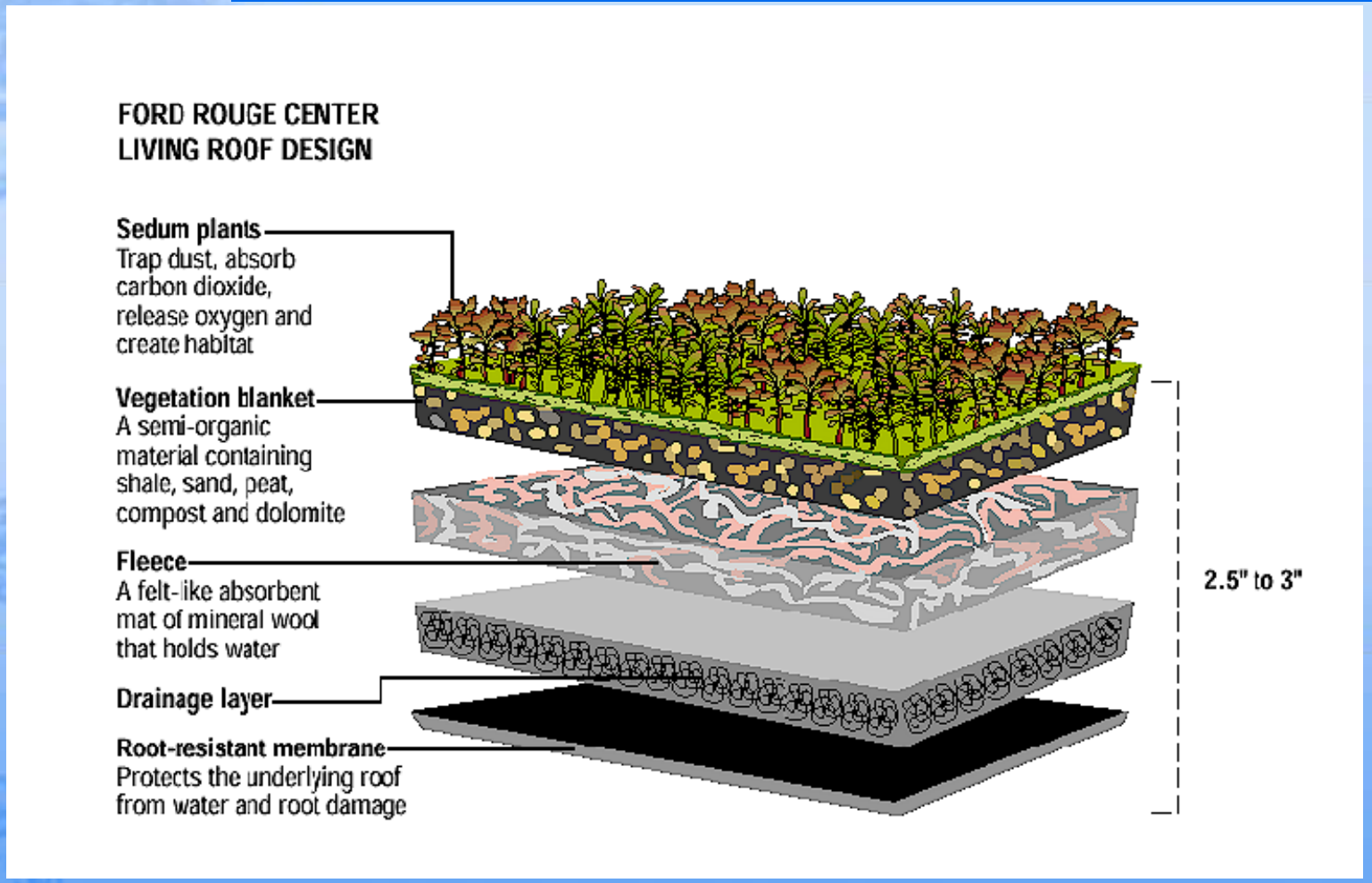
Knowledge Gained

- Topsoil is not a necessary substrate component
- Weed tolerance increases with substrate depth
- Water retention is a function of substrate depth
- Modular trays are difficult to manipulate / heavy
- No need for Ford to reinvent the wheel

Xero Flor System is Selected!

- It is a lightweight, extensive system
- The German company has a long history
- Vegetation mats are grown at ground level
- Roof placement compares to installing turf
- Challenge – growing and installing the vegetation in one season

XF Green Roof System



Cultivate Vegetation Mats on Site

Harvesting Vegetation Mats

Pallets Awaiting Shipment

Transport of Pallets onto Roof

Installation of Root Barrier

Installation of Base Components

Transport of Materials with Carts

Installation of Vegetation Mat

Temporary Irrigation System

Complete Coverage!

Ford Rouge plant, Dearborn, Michigan, USA

Promote Biodiversity of Plants

Ford Rouge plant, Dearborn, Michigan, USA

Restore Habitats for Birds & Insects

Ford Rouge plant, Dearborn, Michigan, USA

Home to Birds and Insects

Ford Rouge plant, Dearborn, Michigan, USA

Biodiversity Study (2009)

Ford Rouge plant, Dearborn, Michigan, USA

Thank You!

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