

BCIT School of Construction and the Environment
Centre for the Advancement of Green Roof Technology

→ Green Roof Research

OUTLINE

- Introduction
- Monitoring
- Thermal Performance
- Stormwater Retention
- Guidelines & Standards
- Conclusions



Research Facility, Vancouver, BC.,

BCIT School of Construction and the Environment
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→ Defining a "Green Roof"

Stormwater Mitigation

Thermal Performance

Economic

Health & Social

Habitat & Biodiversity



BCIT Research Facility Phase 1

Specialized roofing system that supports vegetation growth on rooftops.... engineered for environmental solutions

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→ Benefits

SCALE

- Private
- Public
- Site
- Urban
- Global

- Stormwater Management
- Urban Heat Island reduction
- Energy efficiency
- Economic
- Health & Social
- Improve air quality
- Decrease sound transmission
- Provide recreational spaces
- Habitat & biodiversity



Margeurite House, Multi family Development, Vancouver

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→ Intensive system

Intensive

Simple intensive =

Semi intensive

Extensive = virtual nature

Soil Depth > 12"

- Diverse utilization
- Diverse species
- maintenance irrigation
- **Code compliance:** Walkways, railings, lighting, access, egress....



Vancouver Waterfront Plaza

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→ Extensive system

Intensive

Simple intensive =

Semi extensive

Extensive = virtual nature

Soil Depth <6"

- Low weight
- Low maintenance
- Limited species
- Irrigation for Establishment
- Inaccessible



Randall Sharp, Landscape Architecture

The Sechelt Justice Building, BC

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→ Time frames for implementation?

Intensive

Simple Intensive =

Semi extensive

Extensive = virtual nature




Vancouver Public Library

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→ 6 Acres of new water front green

Intensive
Simple intensive =
Semi extensive
Extensive = virtual nature




MCMP Architects WEB

Vancouver Conference Centre Expansion

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→ Real and simulated "green roofs"

Intensive
Simple intensive =
Semi extensive
Extensive = virtual nature
simulated



MCMP Architects WEB

Electronic Arts - Motion Caption Building

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→ 10.4 Acres

Intensive
Simple intensive =
Semi extensive
Extensive = virtual nature




Landscape Architecture Magazine

Ford Motor Company, Dearborn Michigan

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→ Going Green in London to BC



YUL MOK/ASSOCIATED PRESS

Two Mini Cooper 'S' cars with gardens on their roofs, designed by florist Luna Stein, cross Chelsea Bridge in London Monday to mark the opening of the annual Chelsea Flower Show.

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→ Research needs - Phase 1 GRRF

Stormwater Mitigation
Thermal Performance
Economic
Health & Social
Habitat & Biodiversity



"Technical research is required to understand the site level performance and regional scale benefits of green roofs specific to BC tempered coastal climate" *Green Roof Workshop, Vancouver, March 2002.*

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→ Field Research Site- Vancouver



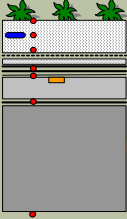
GR-1
GR-2
REF

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→ Materials components

Non reservoir & Reservoir systems

- Planting
- Growing medium
- Filter cloth
- Drainage layer
- Root repellent
- Waterproofing
- Insulation
- Vapour Barrier
- Roof structure



holding cups & retention mats

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1 → Structure & Deck

Green Roof provide dead and Live loads (ASTM):

- precipitation (snow)
- people & equipment
- mature plant weight

Short span; wood frame and concrete vs.

Long span, steel and engineered wood and concrete systems.

Ballast roof replacement



GRRF: Dimensional lumber as a learning tool and demonstration.

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2 → Insulation & Vapour Barrier

Conventional Roof: Insulation is below the waterproof membrane.
Protection board required before waterproof membrane is installed.



IRMA "Inverted Roof": insulation is above the membrane. Membrane is complete before insulation is installed.

Does the green roof count for R-value? Not yet!. Thermal properties of growing medium is driven by moisture content.

GRRF: Kraft laminate vapour barrier, polyisocyanurate insulation with cellulose facers (R28), 4mm rigid asphalt protection board

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3 → Waterproofing Membrane

The building/roof form should drive the waterproof system


TPO
Thermal polyolefin

PVC
Polyvinyl chloride

EPDM
Ethylene propylene

Alternatives:
Hot liquid applied membranes.
Two-ply SBS (Styrene Butadiene Styrene) modified bituminous membrane.
Built up multi-ply.
TPO,PVC,EPDM

Impervious Concrete
Membranes should be inspected and tested.
(Leak Detection Systems) consult Roofing Consultants Institute



GRRF:Two-ply SBS modified bituminous membrane with chemical based root repelling agent in cap sheet.

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4 → Root Repellent

Prevent root penetration into waterproof membrane.


Resistance to root penetration of a GRS should be tested by standard test (FLL)- exposure to aggressive roots

3 approaches:

- An independent element Thermal Plastics, Elastomeric (PVC, Poly, TP8)
- Integral with the water proof system
- Integral with the drainage layer

Subs ribe to chaos theory ...

Avoid plants with aggressive roots: variety of bamboo and Chinese reeds.



GRRF:Two-ply SBS modified bituminous membrane with chemical based root repelling agent in cap sheet.

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5 → Drainage Layer

Discharged runoff once growing medium is saturated.

- Light weight polystyrene board
- Polyethylene roll out sheets
- Extruded plastics forms
- Granular medium (eg pumice)

Reservoir Option - additional storage capacity, irrigation

FLL recommendations non reservoir for extensive, reservoir for intensive



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6 → **Filter Cloth**

Function to preventing fine sediments from clogging drainage system.

Lightweight
Non-woven
Non-biodegradable
Polyester, polypropylene

May be integral will geocomposite drainage layer



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7 → **Growing Medium/ Substrate**

Mix of organic and inorganic matter:

- Deliver plant nutrients requirements.
- Structurally sound:


Drainage & water retention capacity

Porous to provide internal aeration.

Resist excessive compaction

Course Aggregates:
Expanded clay, shale, slate crushed brick, pumice, scoria (lava rock),

Must be quantifiable



% Organic Matter
0, 4, 12, 30?

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8 → **Plants and Planting**

Drivers in Plant selection:

- Climatic: Macro & micro
- Aesthetic
- Native or non native
- Supply & scheduling
- Future maintenance
- Irrigation
- Cost




- Options to investigate
 - Hydroseeding
 - Mats
 - Plugs
 - Pots
 - Self propagating

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→ **Vegetation, Sedums in 75mm**

- Sedum Acre
- Floriferum
- Sedum Sexangulare replacing Sedum Lydium



Specified by: Cornelia Hahn Oberlander Landscape Architect

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→ **Vegetation: Grasses & Fescues on 150mm**

- Festuca scoparia
- Bouteloua gracilis
- Carex glauca

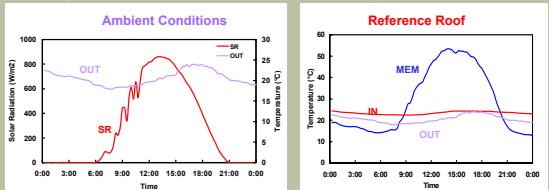
spring broadcast hart fescue seeds



Specified by: Cornelia Hahn Oberlander Landscape Architect

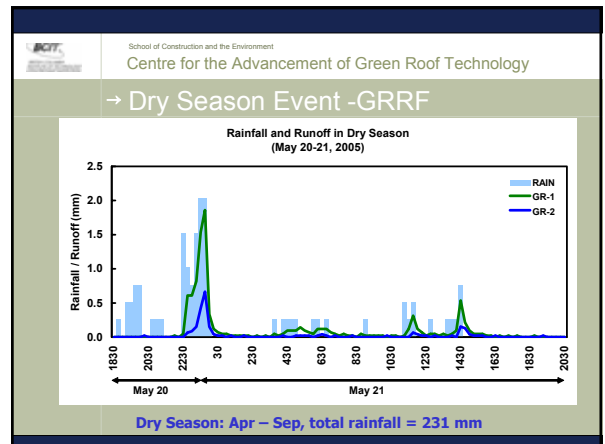
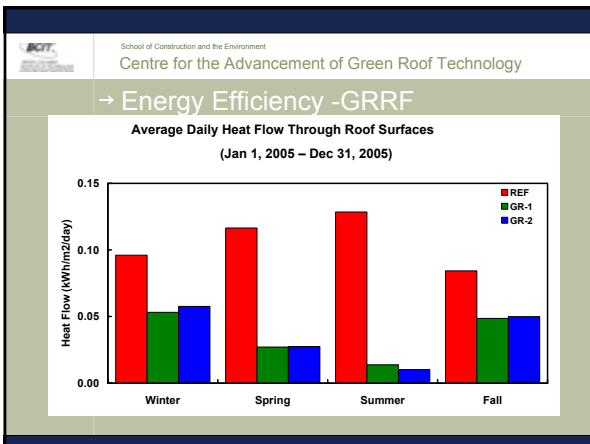
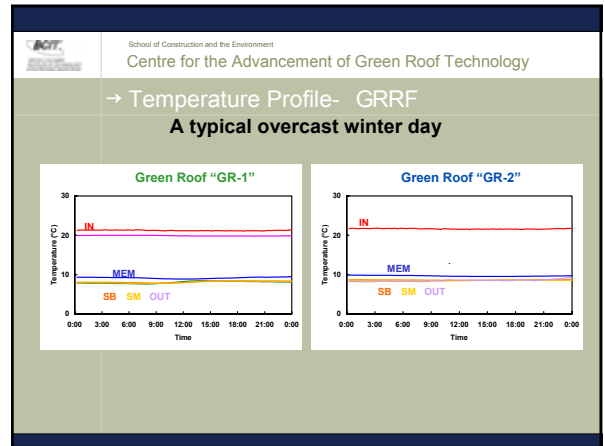
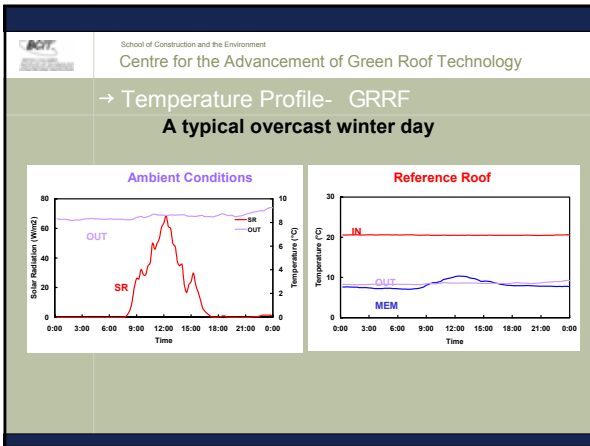
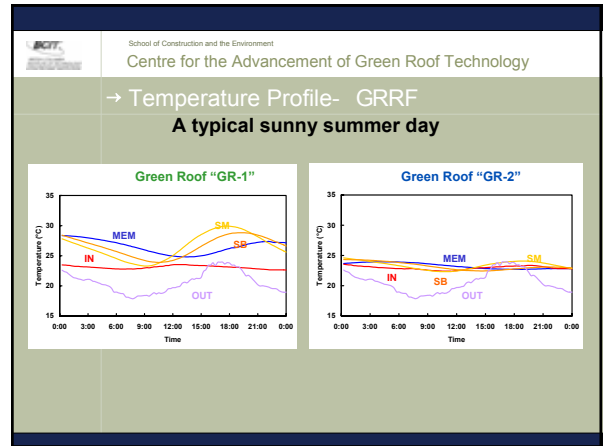
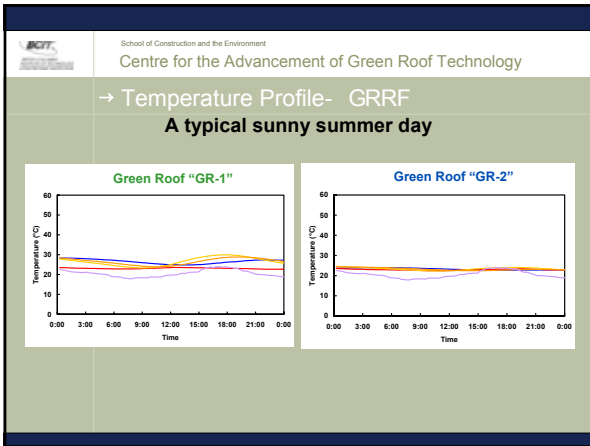
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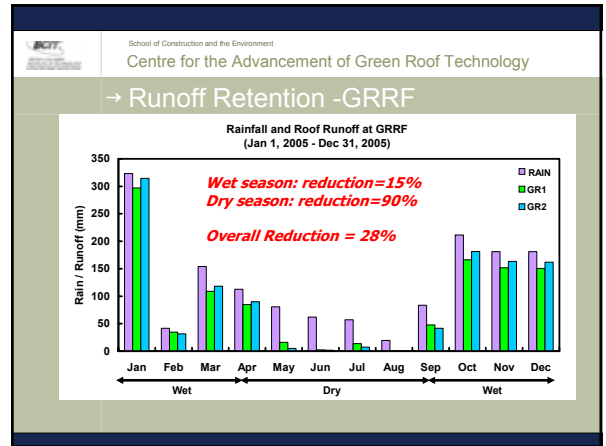
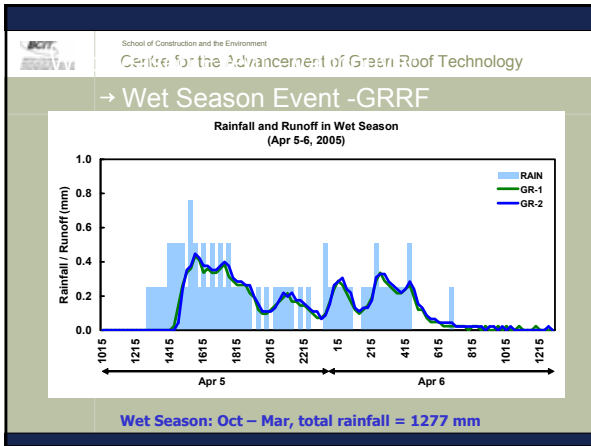
→ **Temperature Profile- GRRF**
A typical sunny summer day




Ambient Conditions

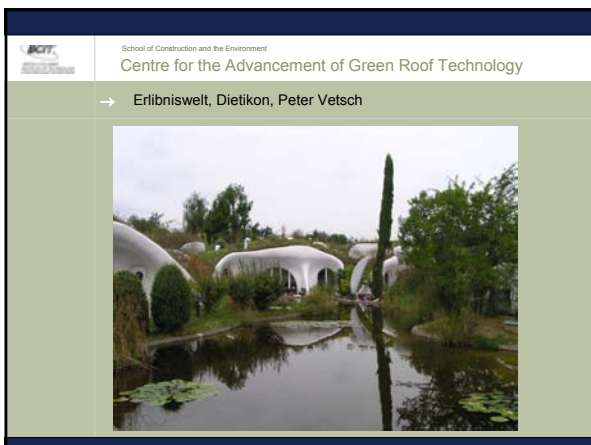
Reference Roof









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- ### → GRRF Phase 1 Conclusions
- 
- The results highlights that it is not solely the depth of the growing medium that affects the stormwater mitigation performance, but rather the combination of the growing medium and plant species.
 - The green roofs delayed runoff, reduced peak flow and runoff volume. The retention efficiency was higher in the dry season (86-94%) than in the wet season (14-19%) due to saturation of growing medium.
 - The average runoff retention of the green roofs was 28% in 2005. For the rain pattern in Vancouver, sedums in 75-mm of growing medium was as effective in retaining runoff as grasses in 150-mm of growing medium.

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- ### → GRRF Phase 1 Conclusions
- The green roofs reduced heat flow through the roof, thus lowering the building's energy demand on space conditioning. They were more effective in reducing heat gain in the summer than heat loss in the winter.
 - Deeper growing medium was more effective in reducing heat gain through the green roof in the hot days. For mild climates such as Vancouver, shallow growing medium (e.g. 75mm) was shown to be sufficient in reducing heat gain into the building effectively.



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→ Design and Construction Principles

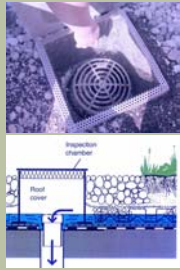
Material and Products		
Slope Roofs		
Roof Drains and penetrations		
Irrigation		
Fire		
Wind load		
FLL Guidelines		
ASTM testing		

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→ Roof Drains

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 vegetation areas
- Avoid plants to grow into the gutters and block drainage path
- Avoid hanging plants that block gutters at eaves on steep slopes



HydroTech Membrane Corp.

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→ Irrigation

Required for plant establishment.


Extensive Systems:

- temporary systems for limited time frame
- overhead or spray.

Intensive Systems:

- long term as per plant demand
- Investigate: surface/ surface drip capillary irrigation

Consider grey water harvesting and recycle/reuse.



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→ Wind loads

Positive & negative pressure

wind strength, direction, shape & height of building

- corners, very high stress levels
- Edges, high stress levels
- Field, generally low

Dormant plants & dried medium are not a ballast for non mechanical laid system

Establishment period extra precautions may be required.


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→ Slope Roofs

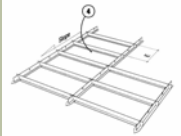
Minimum 2% for proper positive drainage

Runoff increases with roof slope

- >3° (5%): use retention system & growing medium with high water storage capacity and vegetation with low water demand
- >20° (36%) Specific systems to protect against shear and sliding for steep slopes
- >30° (58%) vegetation issues and advanced engineering to Max.45°



GRS on pitched roof, HydroTech



Retention grid for steep slope, Soprema

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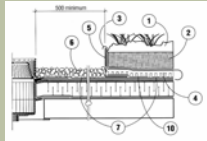
→ Fire Resistance

Intensive

Extensive

Dried plant materials pose fire risk

- Use growing medium that meets a specific mineral composition and 3cm depth requirement
- Select vegetation that has a low fire load (e.g. succulents instead of grasses)
- Allow spacing (> 500 mm, between vegetation areas and any roof penetrations)
- Incorporate irrigation system

Sedums

Soprema Canada

K. Liu

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→ Sihlpost platform at Zurich main railway station

Stormwater Mitigation

Thermal Performance

Economic

Health & Social

Habitat & Biodiversity



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→ "Moos" lake water filtration plant in Wollishfen




1914 Switzerland, 7.4 acres

Driver: cooling required for storage of water, topped with sand, gravel and 8" farm land top soil. 170 species, 6000 specimens of rare orchids, habitat for endangered spiders

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→ "Moos" lake water filtration plant in Wollishfen



90 year old roof asphalt impregnated waterproof membrane, this year replaced at edges with 2 ply torch on.

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→ Parkellee, Basel



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→ Friburg



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→ Materials Standards - ASTM

ASTM's Green Roof Task Force, North America, E06 subcommittee on sustainability <http://www.astm.org>

Active Standards

- E2396-05 Standard Test Method for Saturated Water Permeability of Granular Drainage Media [Falling-Head Method] for Green Roofs
- E2397-05 Standard Practice for Determination of Dead Loads and Live Loads associated with Green Roof Systems
- E2398-05 Standard Test Method for Water Capture and Media Retention of Geocomposite Drain Layers for Green Roofs
- E2399-05 Standard Test Method for Maximum Media Density for Dead Load Analysis of Green Roof Systems
- E2400-06 Standard Guide for Selection, Installation, and Maintenance of Plants for Green Roofs

Work Items

- WK675 Practice for Assessment of Green Roofs
- WK7319 Standard Guide for Use of Expanded Shale, Clay or Slate (ESCS) as a Mineral Component in Growing Media for Green Roof Systems

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→ Concluding discussion

<p>Tenants of sustainable roofing</p> <p>Preserve the environment</p> <p>Conserve energy</p> <p>Extend serviceability</p>	<p>Green roofs are becoming recognized for contributing to urban sustainable development.</p> <p>>As users, providers, caretakers, designers and builders we can each contribute.</p> <p>>Re examination of the all users and their needs.</p> <p>>Optimization of the roof for the specific site and the extended community.</p>	
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→ www.greenroof.bcit.ca

On behalf of the School of
Construction and the
Environment at BCIT,
thank you.



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