



Green roof substrate durability

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Outline

- Quick introduction to green roofs
- Current standards and requirements
 - FLL
 - ASTM
 - LEED
- Justification
- Methods
- Results
- Future Work

Green roof systems

- Green roofs are classified based on substrate depth
- Range of design intents

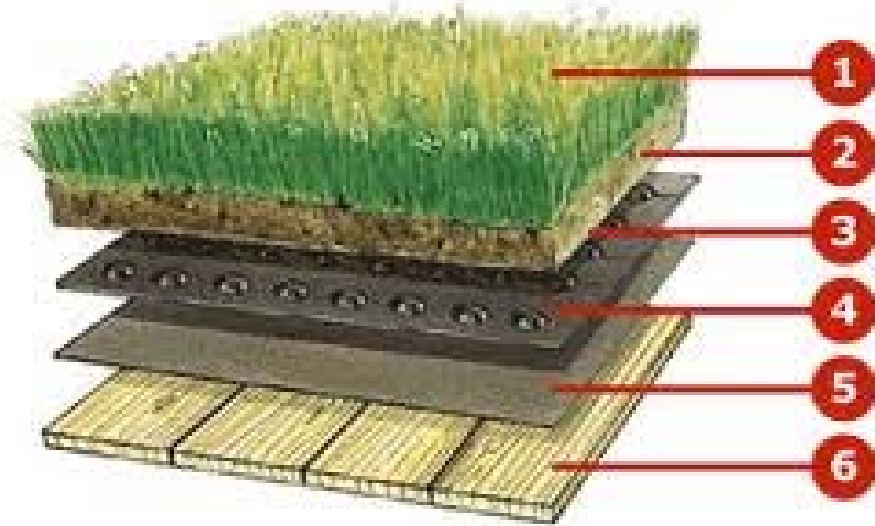


Image: tritonsystems.co.uk

Green Roof Classification

Intensive (cm)	Extensive (cm)	Reference
15-20	5-15	Kosareo and Ries (2007)
>50	N/A	Kohler et al. (2002)
15-35	3-14	Mentens et al. (2006)
>10	<10	Wong et al. (2007)
>30	N/A	Bengtsson et al. (2005)
>10	2-10	Graham and Kim (2005)

Source: Berndtsson, 2010

FLL Standards

- Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FLL)
- FLL is a German landscape industry green roof manual that has been adopted internationally



Image: worldgreenroof.org

FLL Standards: Particle Size Distribution (PSD)

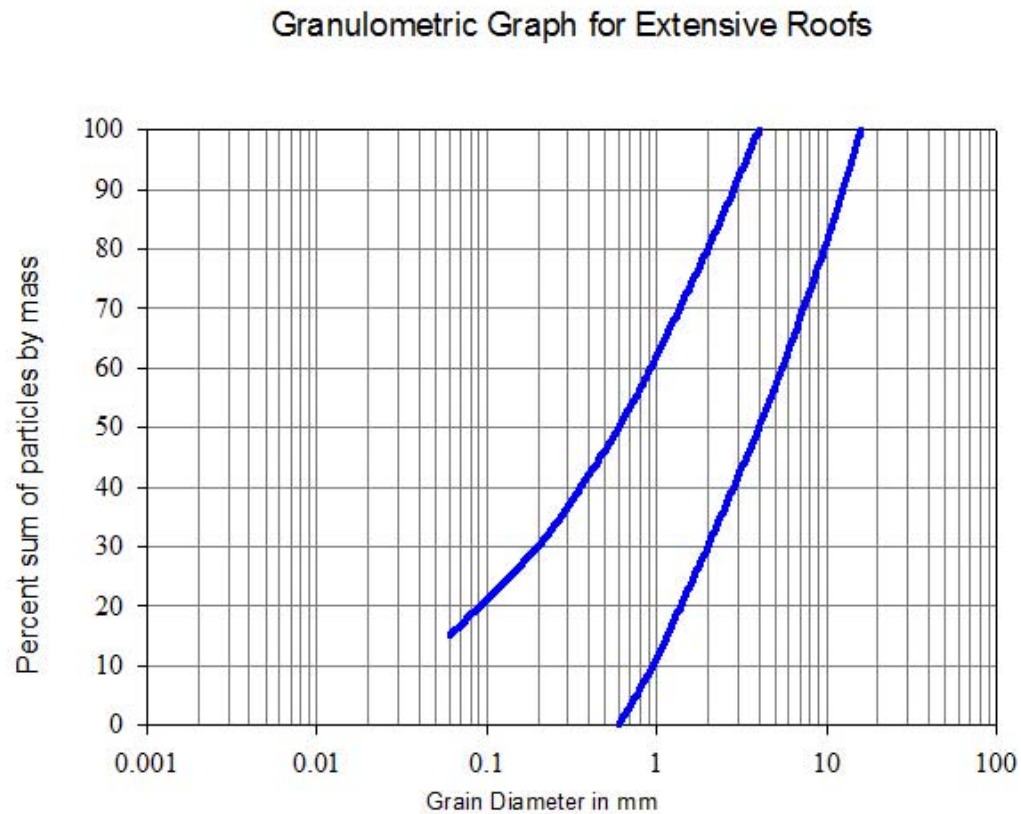


Image: Adapted from FLL 2008 English manual

FLL Standards: Organic matter

- ≤ 65 g/L for extensive substrates
 - FLL, 2008



FLL-based interpretations

- 33% humus, 33% sand, 33% pumice
 - Volumetric? Gravimetric?
 - Canada Public Works Board, 2002
- 6-8% organic and 15-20% organic, different paragraphs
 - Sydney City Council Green Roof Resource Manual, 2010
- 4% or 6%, by construction
 - Loss on Ignition
 - City of Seattle, 2010

FLL Standards: Frost resistance

- 10.2.3 Frost Resistance (FLL, 2008)
 - “Must be insured by the manufacturer”
 - Based on components subjected to high levels of static and/or dynamic stress
 - No methodology or allowable particle loss is suggested



ASTM standards

- E2396: Saturated water permeability of granular drainage media
- E2397: Determination of dead and live loads
- E2398: Water capture and media retention of drain layers
- E2399: Maximum media density for dead load analysis
- E2400: Selection, installation, and maintenance of green roof plants



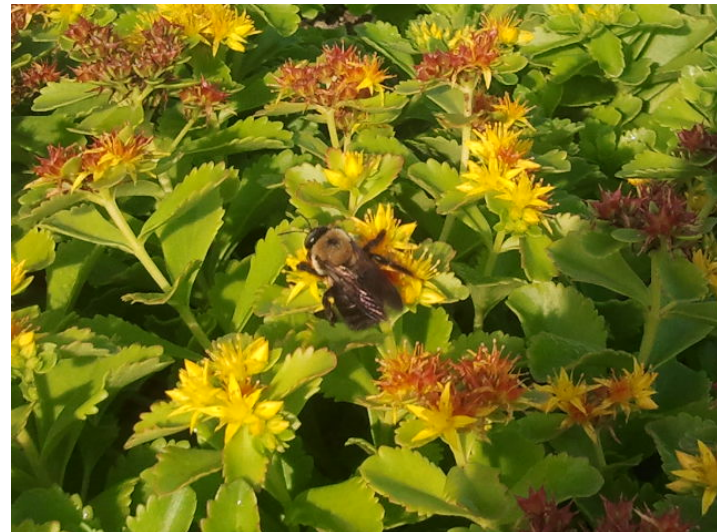
ASTM: ESCS specifications

- ASTM E-2788: Specification for use of ESCS as a mineral component in growing media and drainage layer of GR systems



LEED

- LEED points sometimes drive green roof implementation
 - Restore or protect habitat: 1 point
 - Stormwater quantity control: 1 point
 - Heat island effect (roof): 1 point
 - Rainwater management: 1 point
- If it looks good, it must be good!











Justification



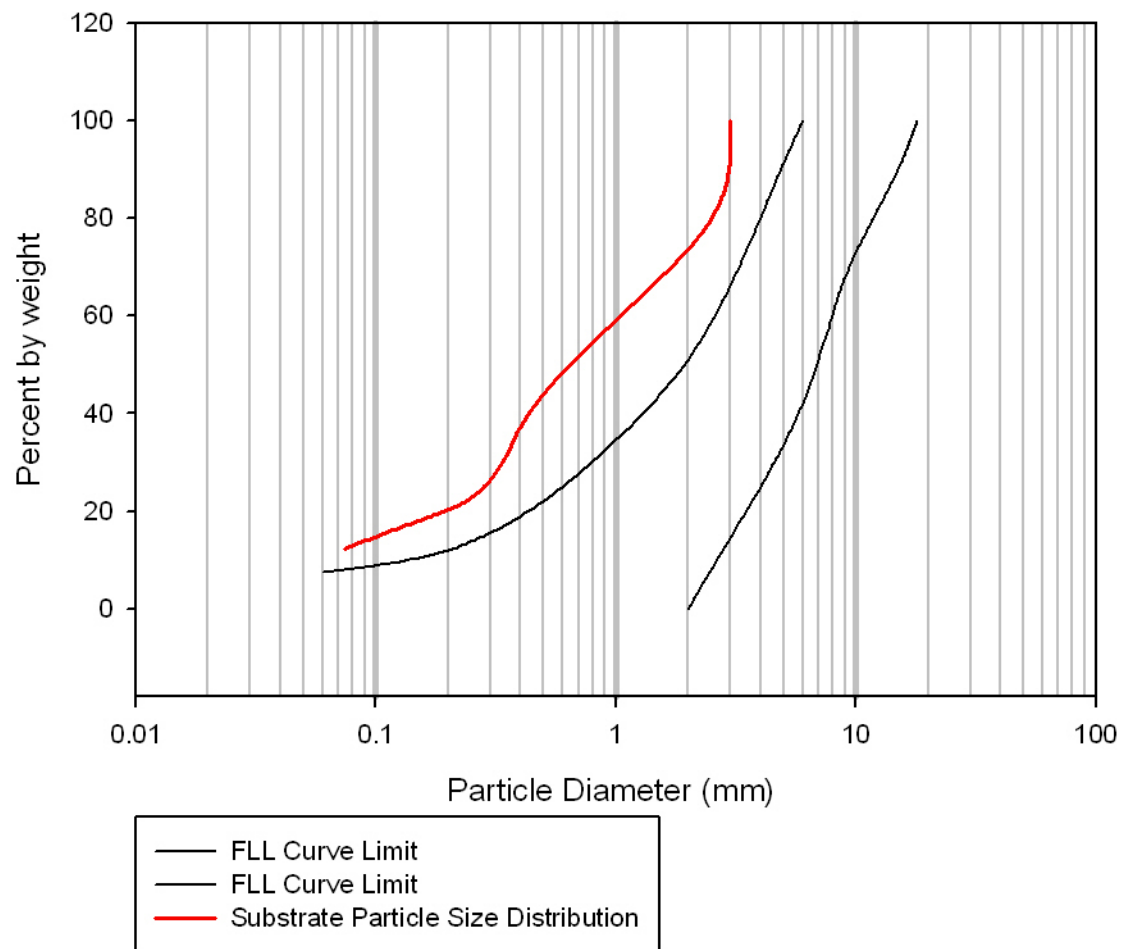
Justification



Justification



Roof A, Installed 2009



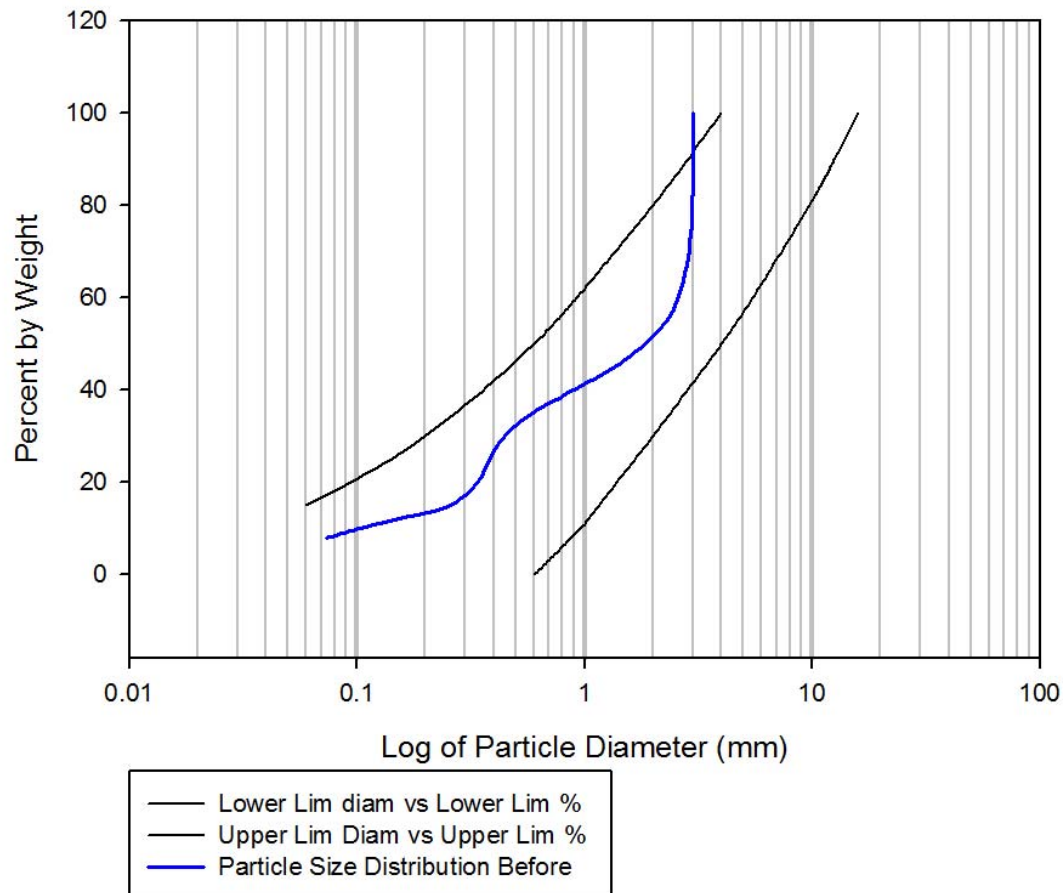
Methods

- Obtain a sample direct from the substrate manufacturer and perform PSD analysis before and after 30 freeze/thaw cycles



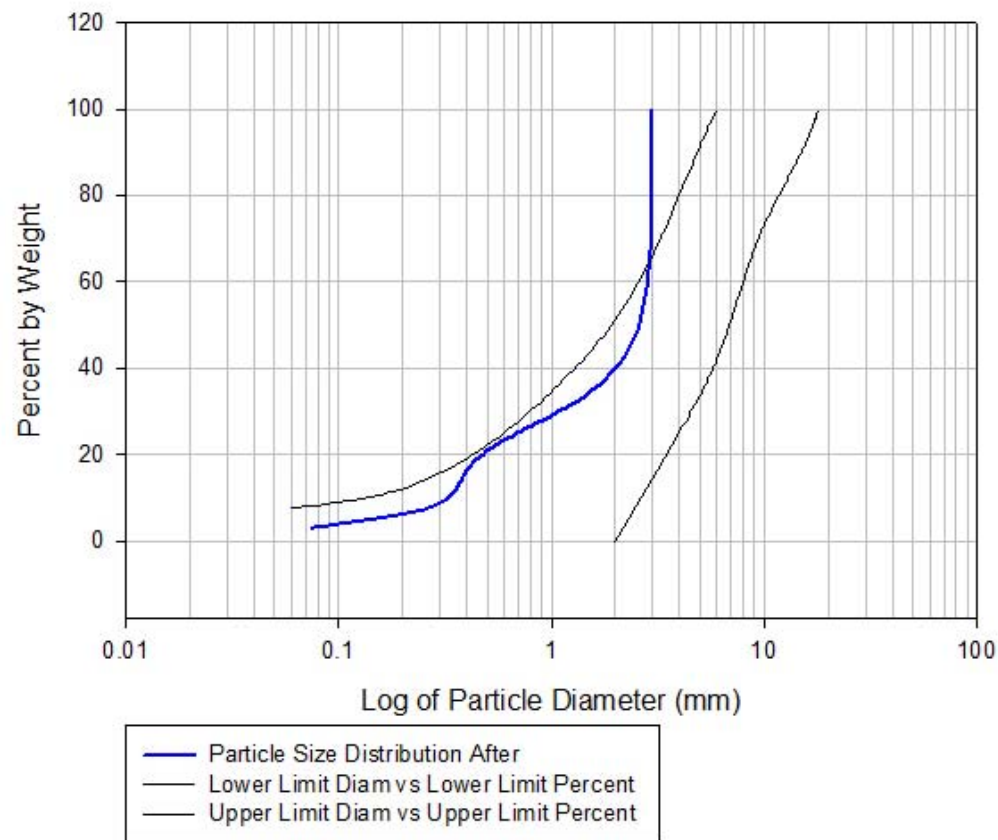
Results: Before 30 cycles

Before 30 Freeze/Thaw Cycles

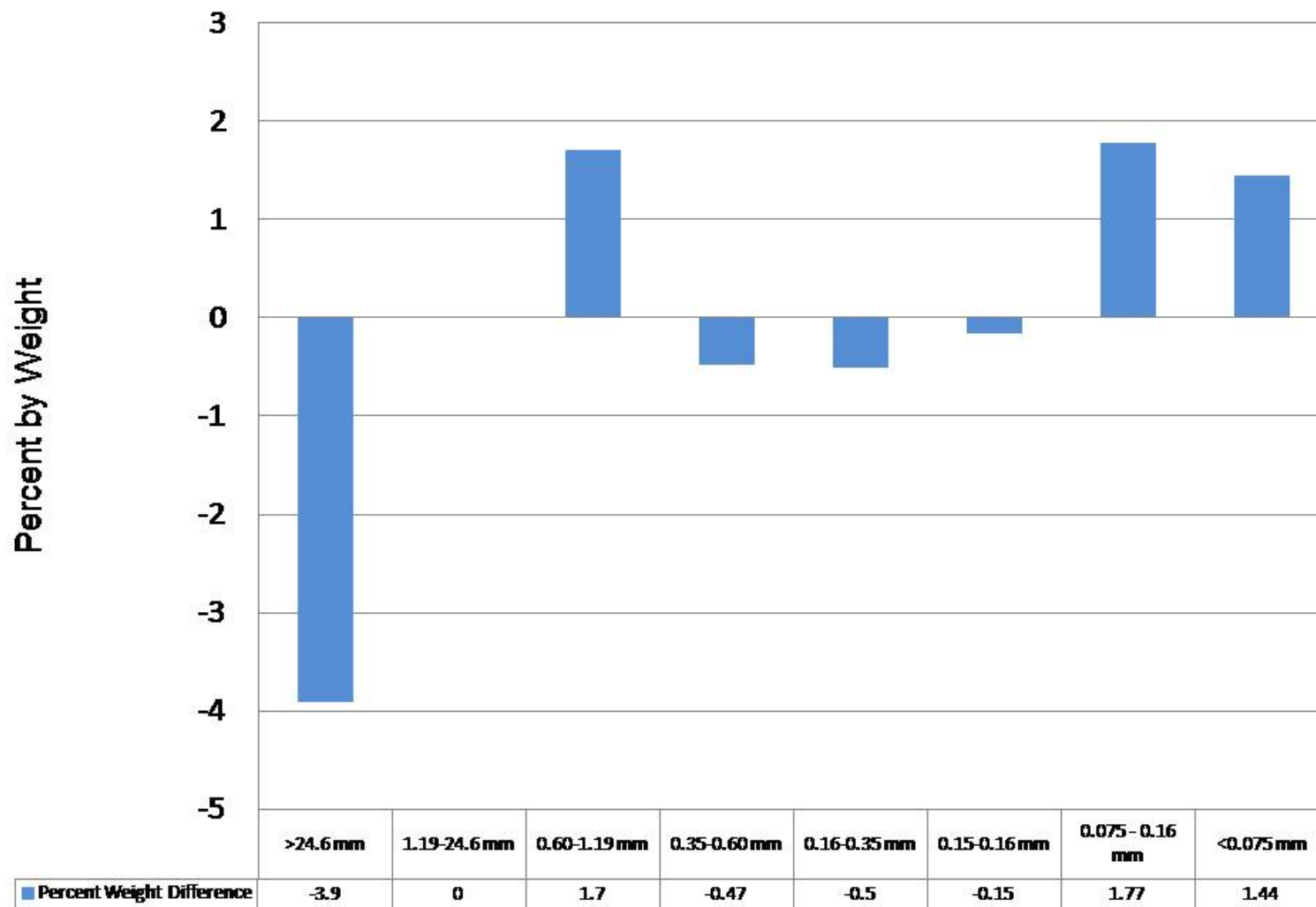


Results: After 30 cycles

After 30 Freeze/Thaw Cycles



Percent weight differences of standard heat-expanded mineral substrate in 8 different particle sizes after 30 freeze-thaw cycles.



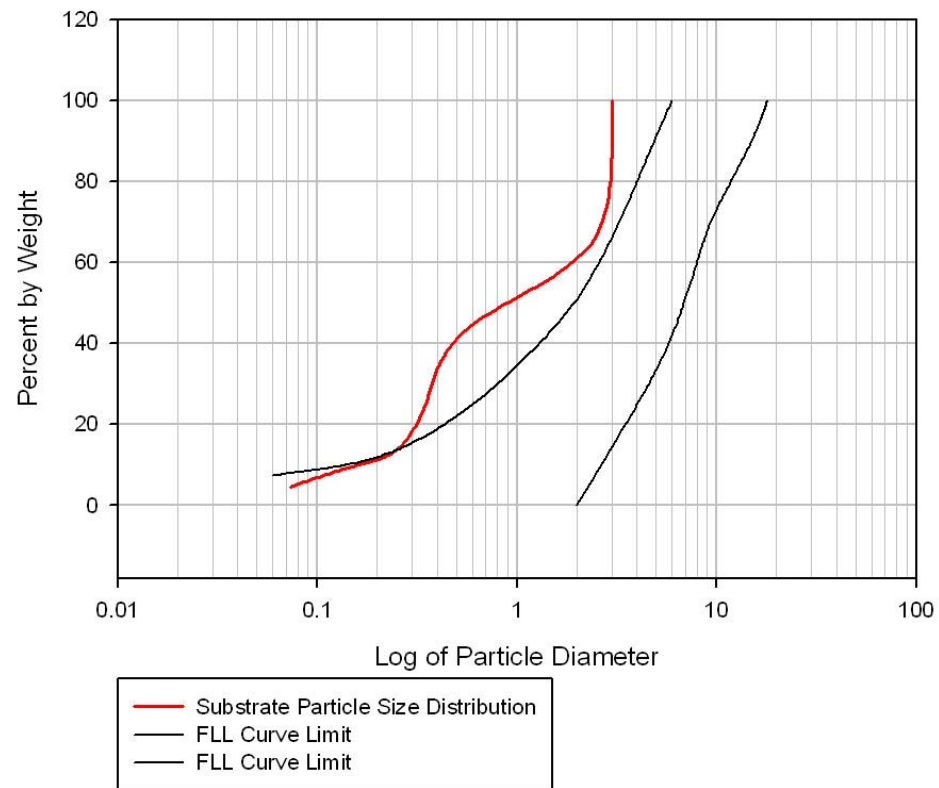
Mature roof sampling

- Sample 3-7 year old green roofs in the Mid-Atlantic, representing the major commercially available substrate blends
- Determine particle size distribution



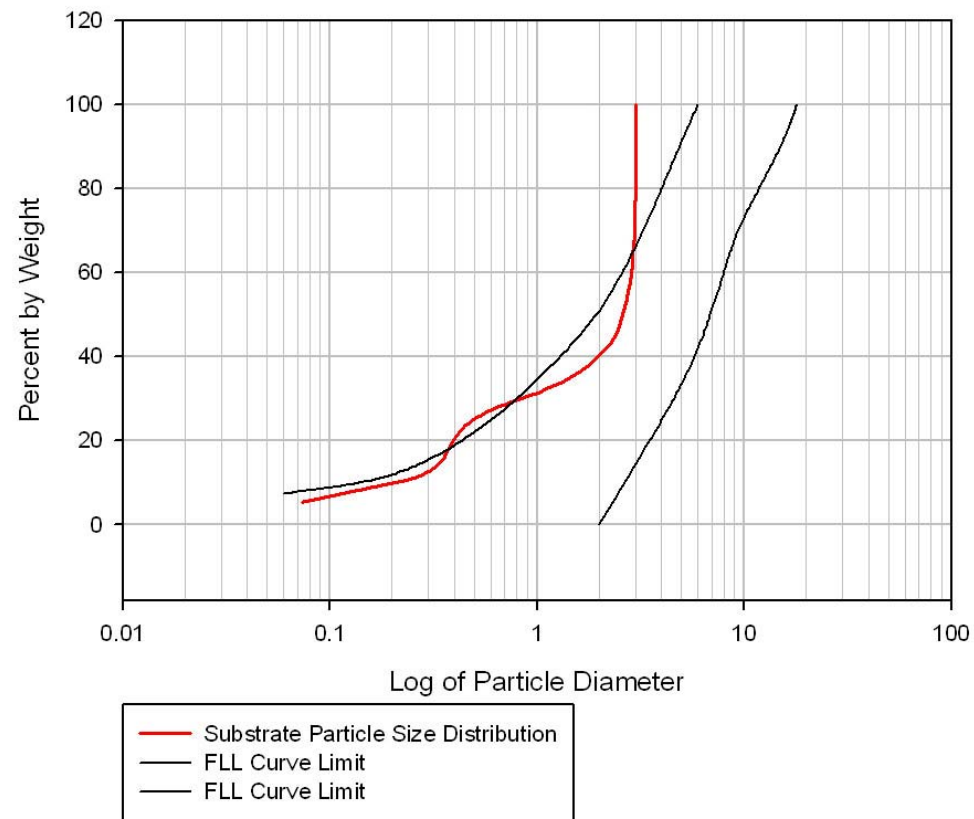
Results

Roof B, Installed 2008



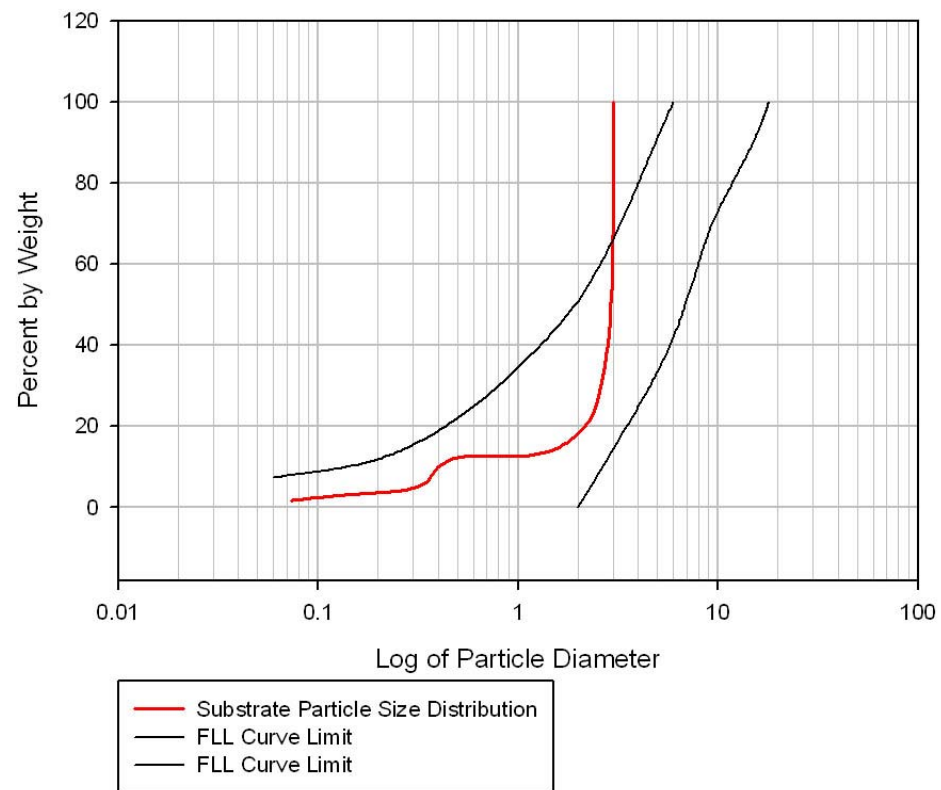
Results

Roof C, Installed 2009



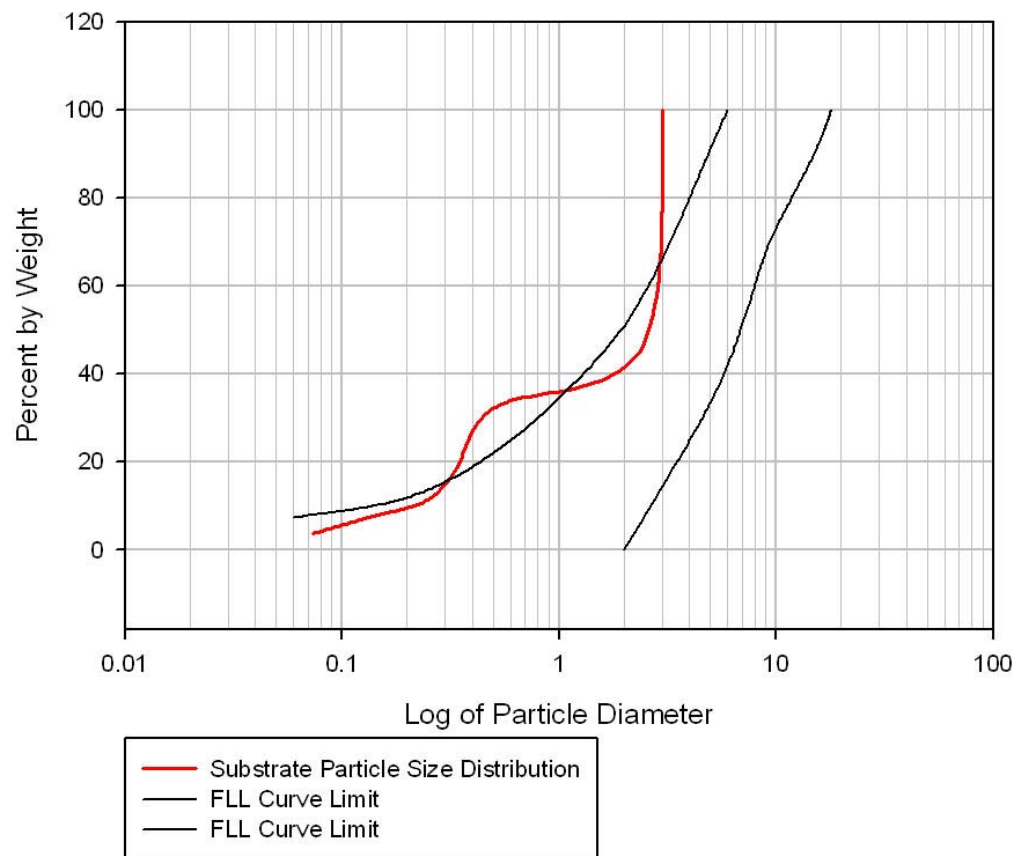
Results

Roof D, Installed 2005



Results

Roof E, Installed 2007



Future Work

- Short term: Analyzing 3 additional commercially available materials, straight from the manufacturer
- Long term: Working to develop a durable, locally-available green roof substrate that will maintain the desired PSD for optimal plant growth.

Questions?

