Monitoring the Hydrologic and Water Quality Effects of a Simple-Intensive Green Roof

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Why Green Roofs?

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Why Green Roofs?

- Time to peak runoff, and initial runoff, is delayed due to infiltration and storage
- Total volume of runoff is reduced through storage and evapotranspiration
- Pollutants are filtered out during infiltration
- Improve building insulation – reduce heating and cooling loads
- Reduce Urban Heat Island Effect
- Increase longevity of roofing membranes

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Why monitor green roofs?

Develop a long-term dataset that is high resolution both spatially and temporally.

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BIF Green Roof – The Basics

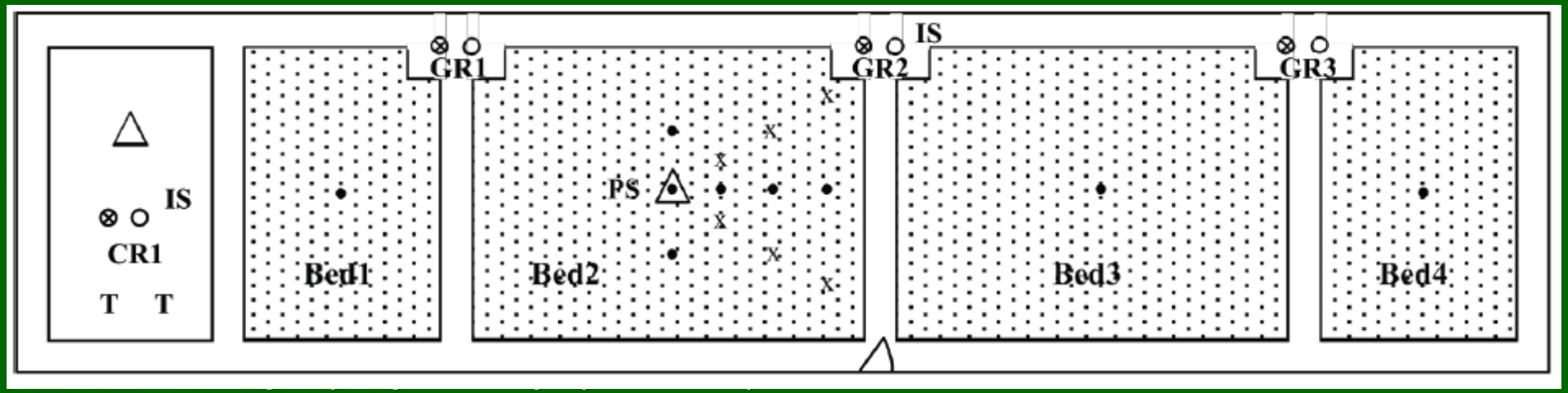
Green Roof

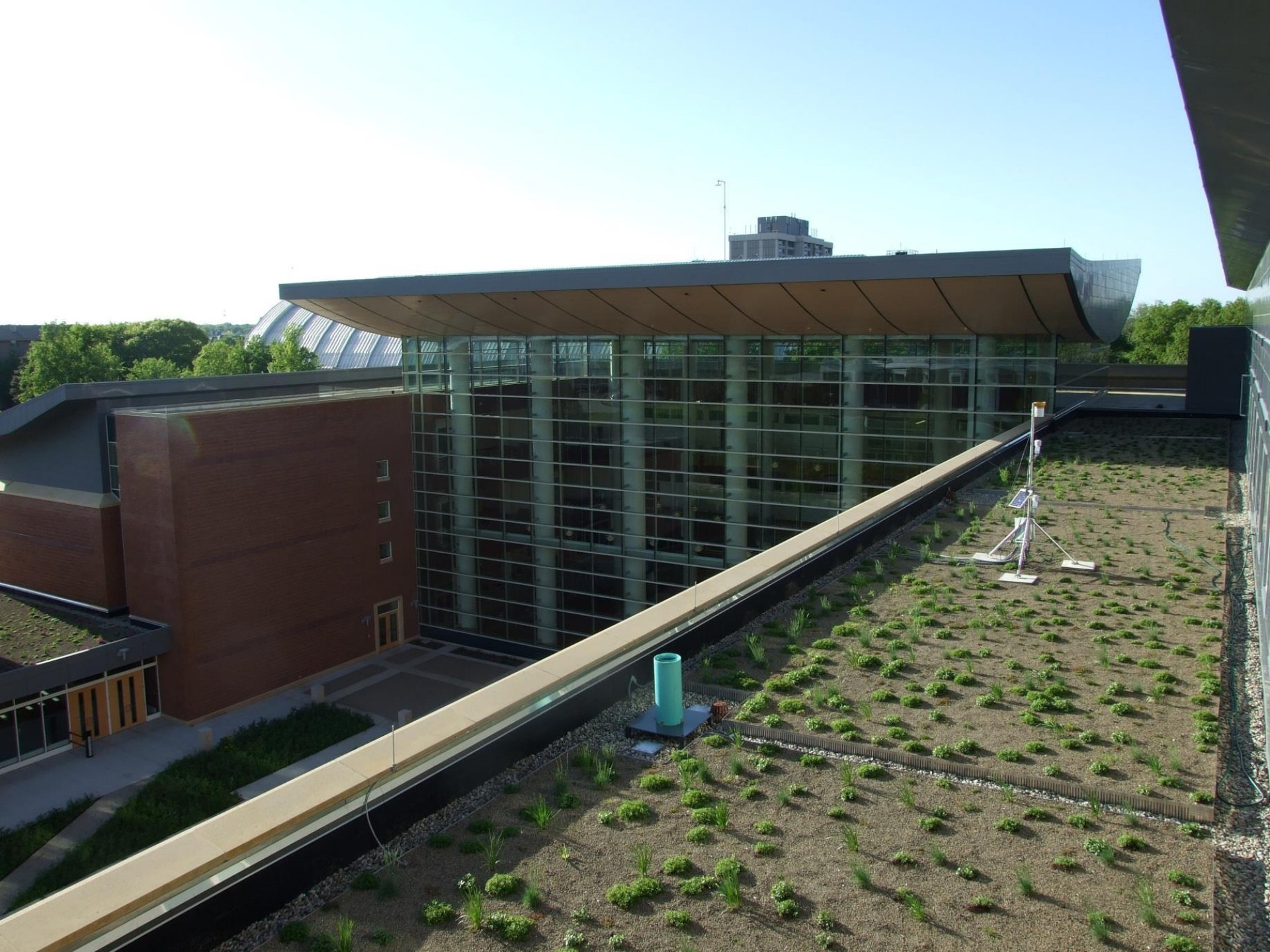
- Four vegetated beds
- 4,000 sq ft

Conventional Roof

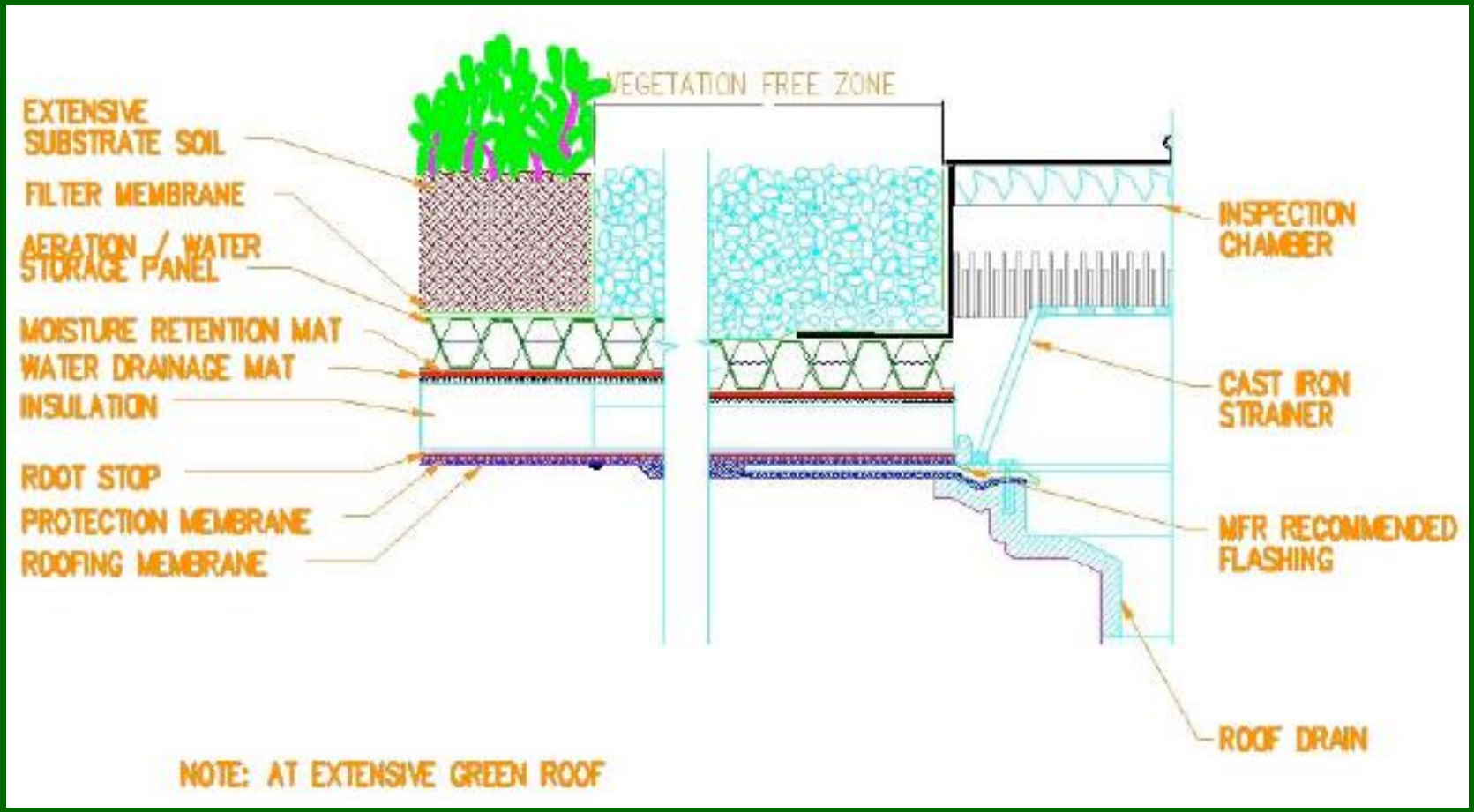
- 800 sq ft

North ⟶





BIF Green Roof – Cross Section



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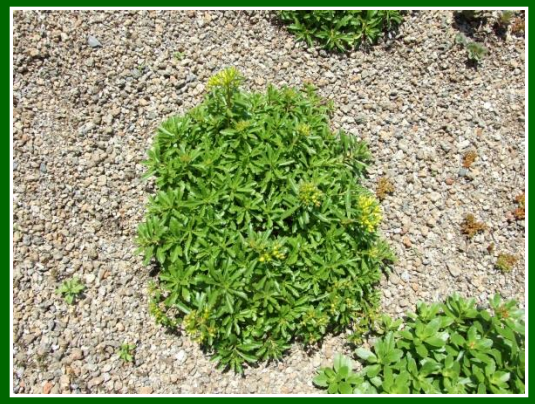
BIF Green Roof – Plants

Name	Common Name
Allium Cernuum	Nodding Wild Onion
Buchloe Dactyloides 'Sharps Improved'	Buffalo Grass
Dianthus Deltoides	Maiden Pinks
Koeleria Glauca	June Grass
Sedum Acre	Stonecrop
Sedum Kamtschaticum	Stonecrop
Sedum Spurium 'Bailey's Gold'	Stonecrop
Sedum 'Ruby Glow'	Stonecrop
Thymus Serphyllum 'Coccineus'	Creeping Thyme



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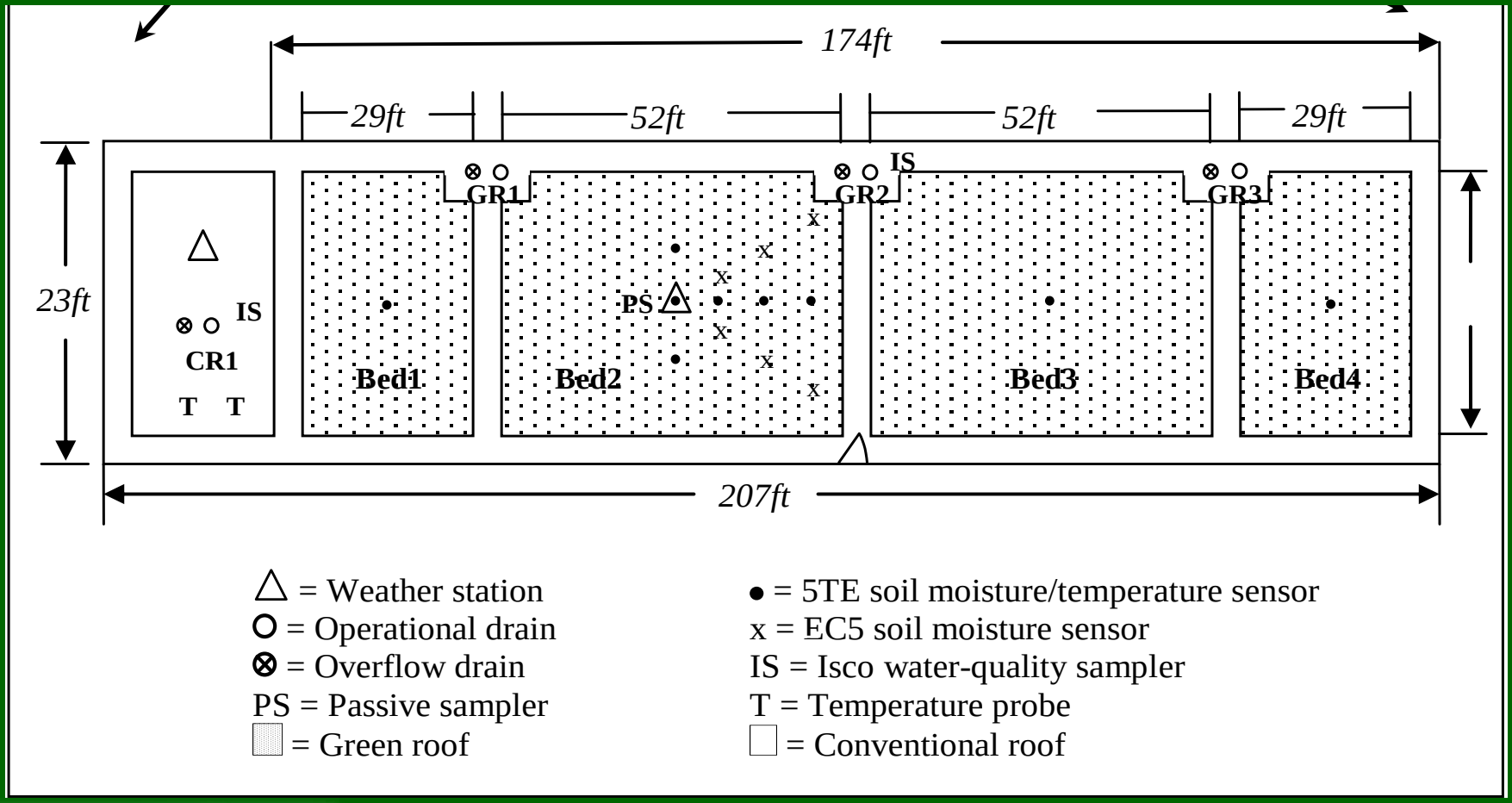
Experimental Setup



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Weather Stations

- 10 ft tripod
- Powered by solar panel with battery backup
- Datalogger (Campbell Scientific CR1000) controls sensors and stores data
- Meteorological and soil data are stored in 1 minutes intervals; flow measurements are stored in 10 second intervals

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RH and Air Temperature Sensors

- Relative humidity and air temperature sensors mounted at two heights above roof, 4 and 8 ft.
  - Data can be used to calculate sensible and latent heat flux

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Pyranometers

- Up-looking and downlooking pyranometers measure incoming and reflected solar radiation
  - Can be used to measure roof albedo

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Rain gage & Anemometer

- Tipping bucket rain gage measures rainfall in 0.01 inch increments
- Ultrasonic anemometer measures horizontal wind speed and direction (conventional roof only)

Soil Moisture and Tempurature Sensors

- Two types of sensors placed in 15 different locations
- Decagon Device EC-5 measured volumetric water content (VWC)
- Decagon Device 5TE measures VWC, electrical conductivity, and soil temperature

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Flow measurement devices

- Multi-stage combination weir and orifice device, retrofit to the existing roof drain
  - 11” diameter PVC plate
  - 4” long by 3” diameter PVC tube
  - Submersible pressure transducer

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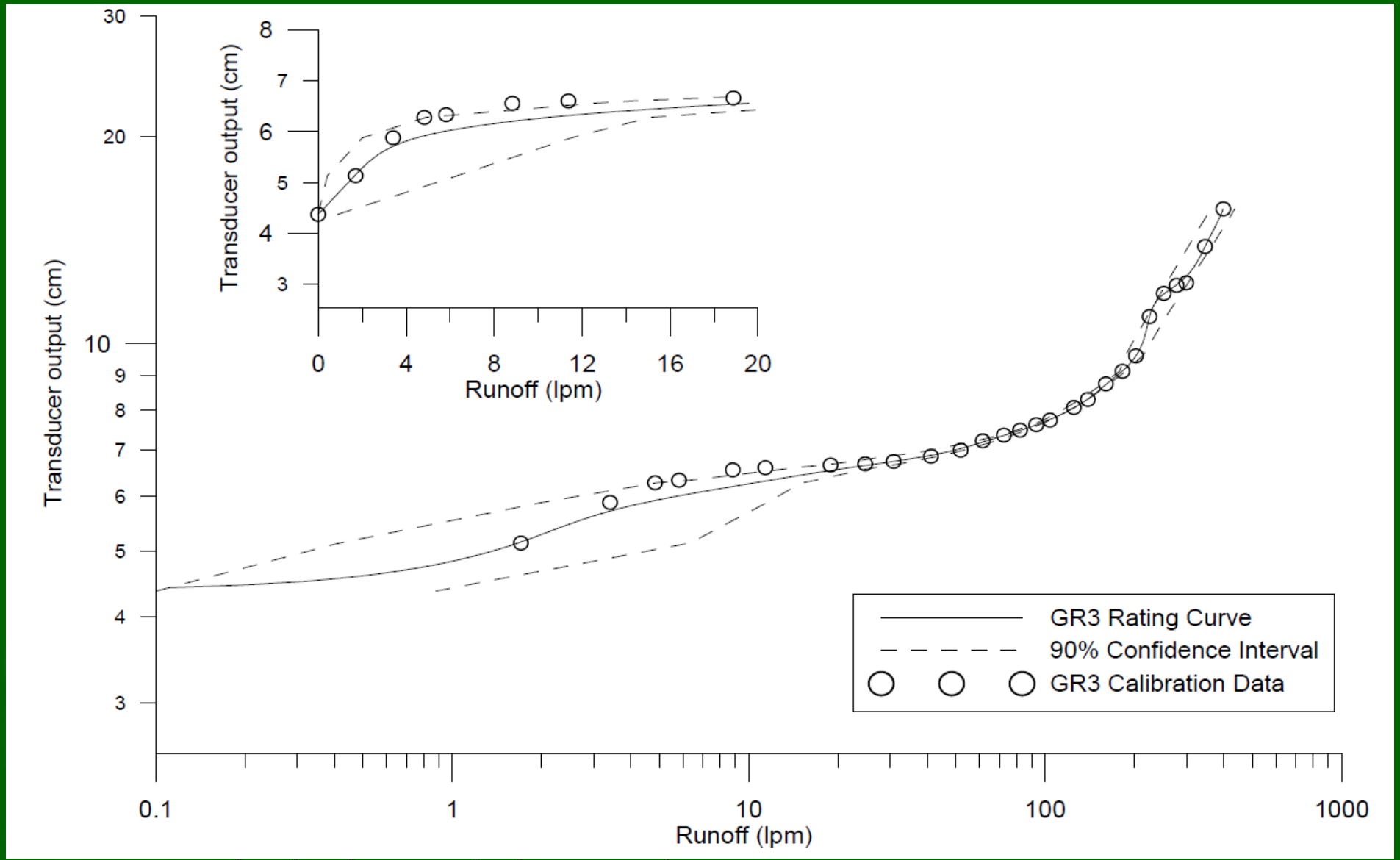
Flow Rating Curve



ISCO Sampler

- ISCO automated samplers will collect water samples from drains during rain events

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Passive Atmospheric Sampler

- Collects atmospheric particulate deposition

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Wireless Communication

- Lantronix WiBox
  - Real-time monitoring and control via remote access

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Green Roof Results

Storm 1 – July 25, 2009

Storm 2 – July 26, 2009

Storm 3 – August 23, 2011

Storm 4 – April 30, 2012

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Storm 1 – Rainfall Data

		Storm 1	
		Conventional Roof	Green Roof
Date		7/25/2009	
Antecedent Soil Moisture	[%]	---	0.25
Precipitation depth	[in]	0.86	0.88
Precipitation duration	[hr]	~ 2	~ 2
Uniform intensity	[in/hr]	0.46	0.45
Peak intensity	[in/hr]	4.8	4.8

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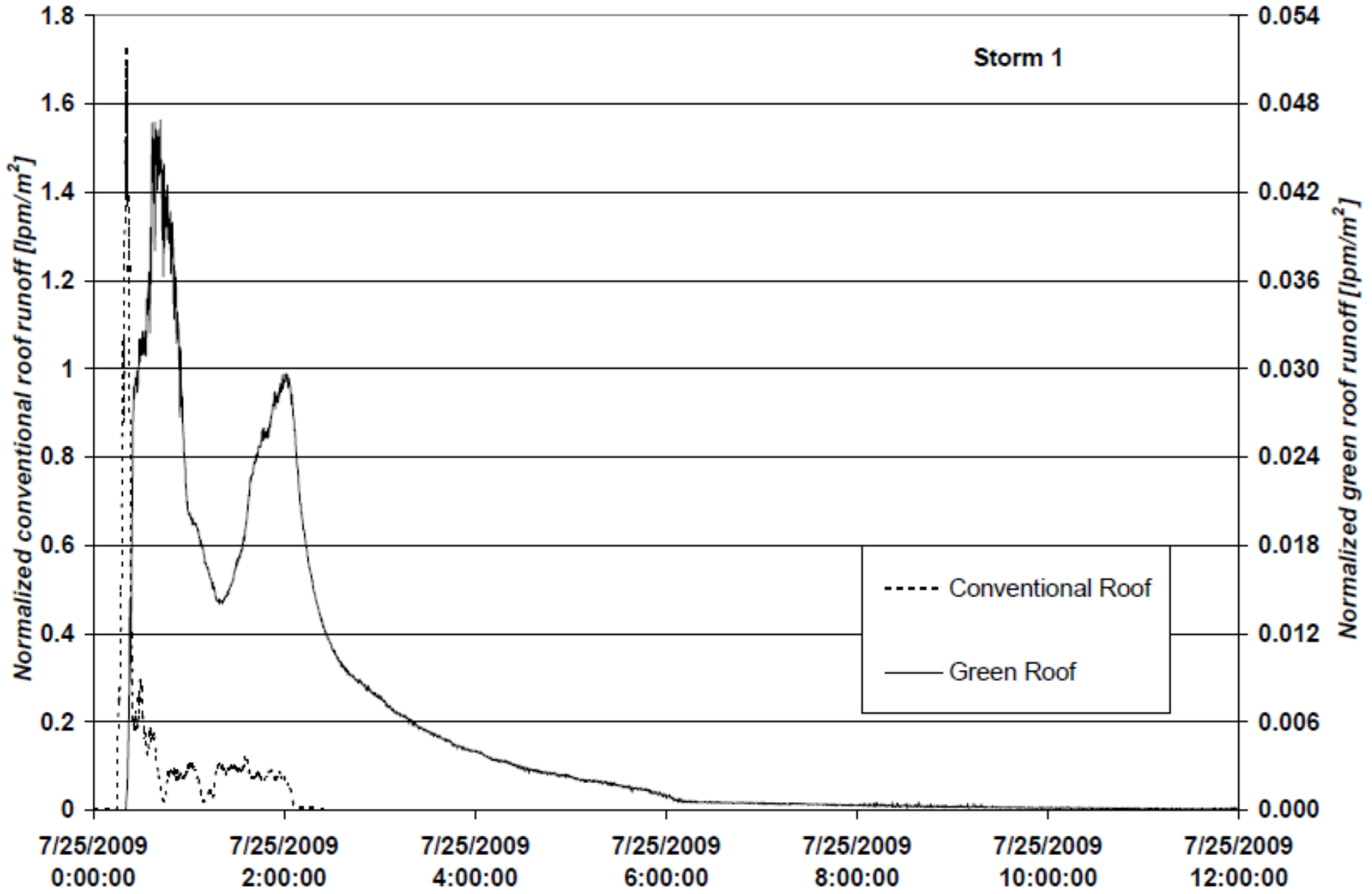
Storm 1 - Hydrograph



Storm 1 - Runoff

		Storm 1	
		Conventional Roof	Green Roof
Date		7/25/2009	
Lag time	[hr]	---	0.33
Peak flow	[lpm]	130.013	17.355
Peak flow reduction	[%]	---	97
Runoff volume	[in]	0.6890	0.1586
Percent retention	[%]	20	82

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Storm 2 – Rainfall Data

		Storm 2	
		Conventional Roof	Green Roof
Date		7/26/2009	
Antecedent Soil Moisture	[%]	---	0.28
Precipitation depth	[in]	0.17	0.18
Precipitation duration	[hr]	1.75	1.75
Uniform intensity	[in/hr]	0.10	0.10
Peak intensity	[in/hr]	1.2	1.2

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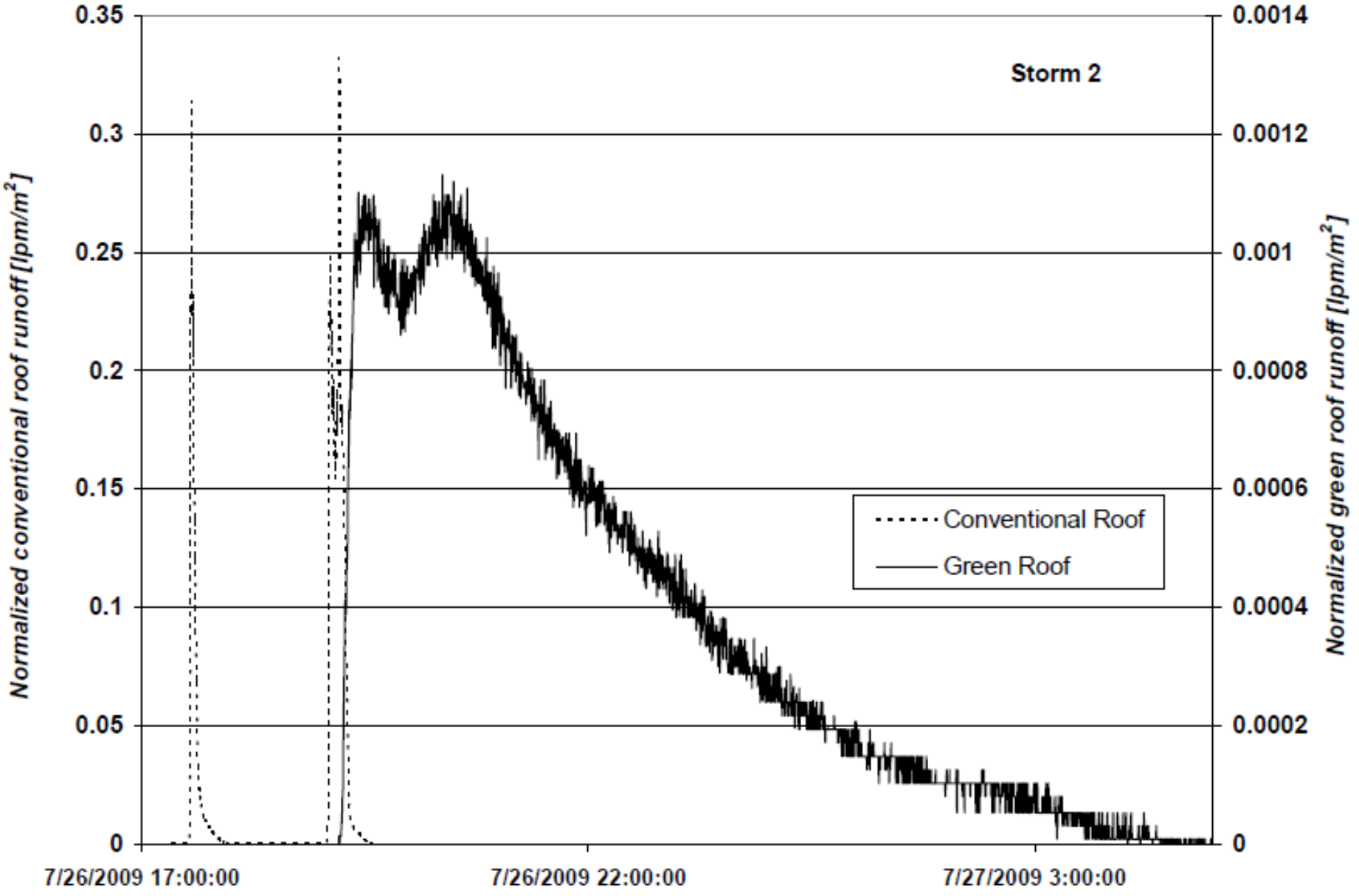
Storm 2 - Hydrograph



Storm 2 - Runoff

		Storm 2	
		Conventional Roof	Green Roof
Date		7/26/2009	
Lag time	[hr]	---	1.16
Peak flow	[lpm]	24.938	~ 0
Peak flow reduction	[%]	---	100
Runoff volume	[in]	0.1328	trace
Percent retention	[%]	21.86	~ 100

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Storm 3 – Rainfall Data

		Storm 3	
		Conventional Roof	Green Roof
Date		8/23/2011	
Antecedent Soil Moisture	[%]	---	---
Precipitation depth	[in]	---	0.97
Precipitation duration	[hr]	---	2.50
Uniform intensity	[in/hr]	---	0.39
Peak intensity	[in/hr]	---	3.6

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Storm 3 - Runoff

		Storm 3	
		Conventional Roof	Green Roof
Date		8/23/2011	
Lag time	[hr]	---	---
Peak flow	[lpm]	---	103.563
Peak flow reduction	[%]	---	---
Runoff volume	[in]	---	0.8025
Percent retention	[%]	---	17

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Storm 4 – Rainfall Data

		Storm 4	
		Conventional Roof	Green Roof
Date		4/30/2012	
Antecedent Soil Moisture	[%]	---	---
Precipitation depth	[in]	---	0.64
Precipitation duration	[hr]	---	3.12
Uniform intensity	[in/hr]	---	0.21
Peak intensity	[in/hr]	---	1.2

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Storm 4 - Runoff

		Storm 4	
		Conventional Roof	Green Roof
Date		4/30/2012	
Lag time	[hr]	---	---
Peak flow	[lpm]	---	4.65
Peak flow reduction	[%]	---	---
Runoff volume	[in]	---	0.07
Percent retention	[%]	---	89

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Conclusions

- Green roof results vary depending on rainfall characteristics and soil conditions
- Green roof peak discharges are decreased for both large and small storms
- Green roof time to peak is increased but less for larger storm
- A greater percent of rainfall is retained by the green roof for smaller events

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On-going and Future Work

- City of Dolton stormwater model and economic analysis
- Analyze water quality samples
- Different soil moisture sensor configuration
- Under roof temp sensors

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Thank You!

University of Illinois Facilities and Services Blue Campus Grant

University of Illinois Civil and Environmental Engineering Department

Illinois-Indiana Sea Grant

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Questions/Comments?

Email: nholloway@baxterwoodman.com

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