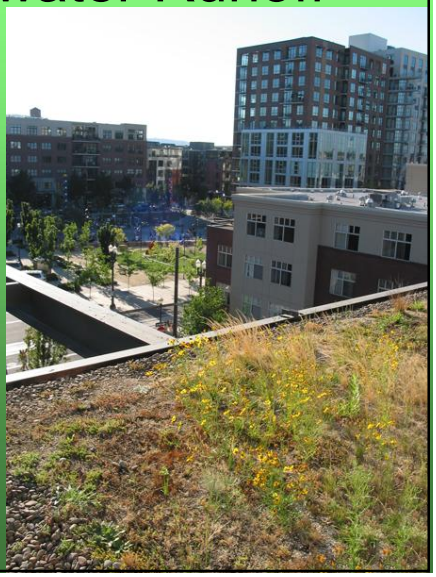
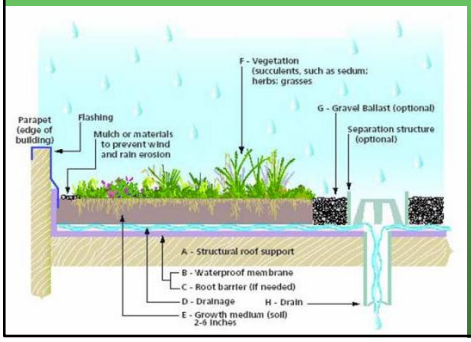
Estimating the Impact of Eco-Roofing on Stormwater Runoff

Jake Macdonald
Steve Pilson





Eco-roofs/Green Roofs

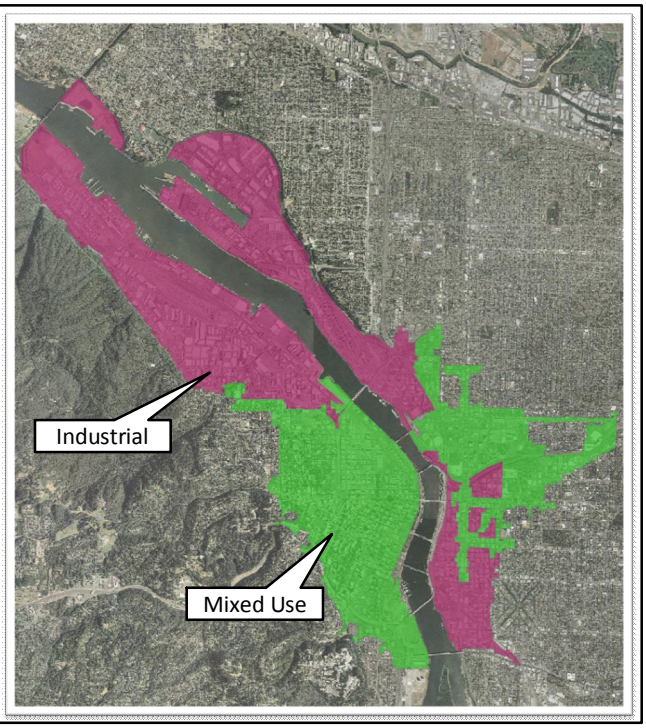
- Usually a thin substrate of soil (<6 in)
- Drought-tolerant plants
- A way to address imperviousness in the city.

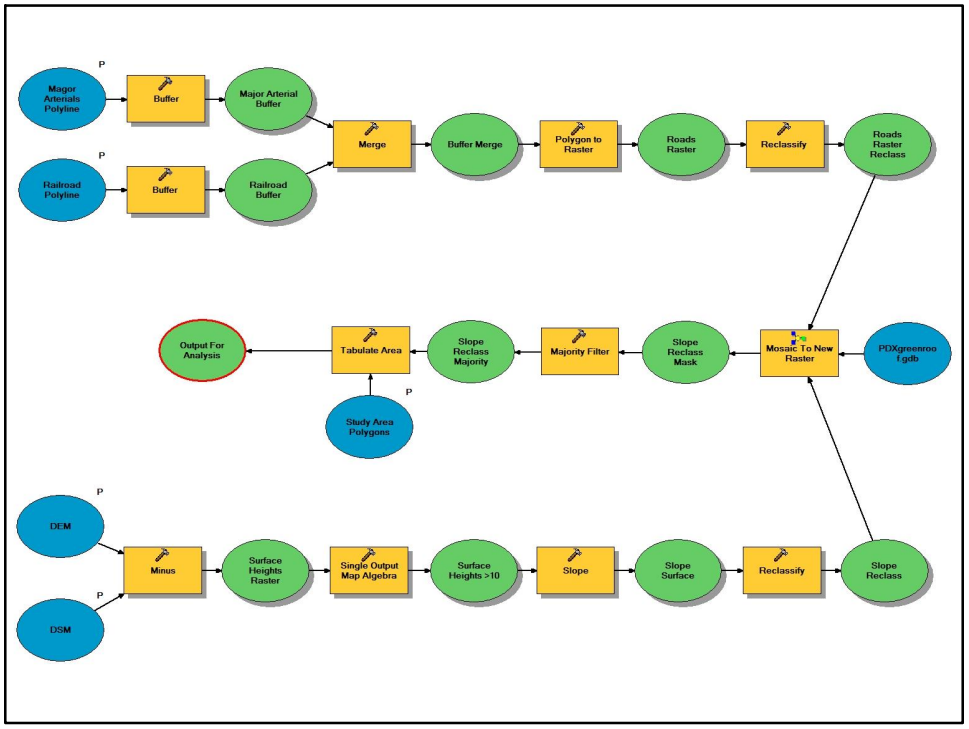
Background

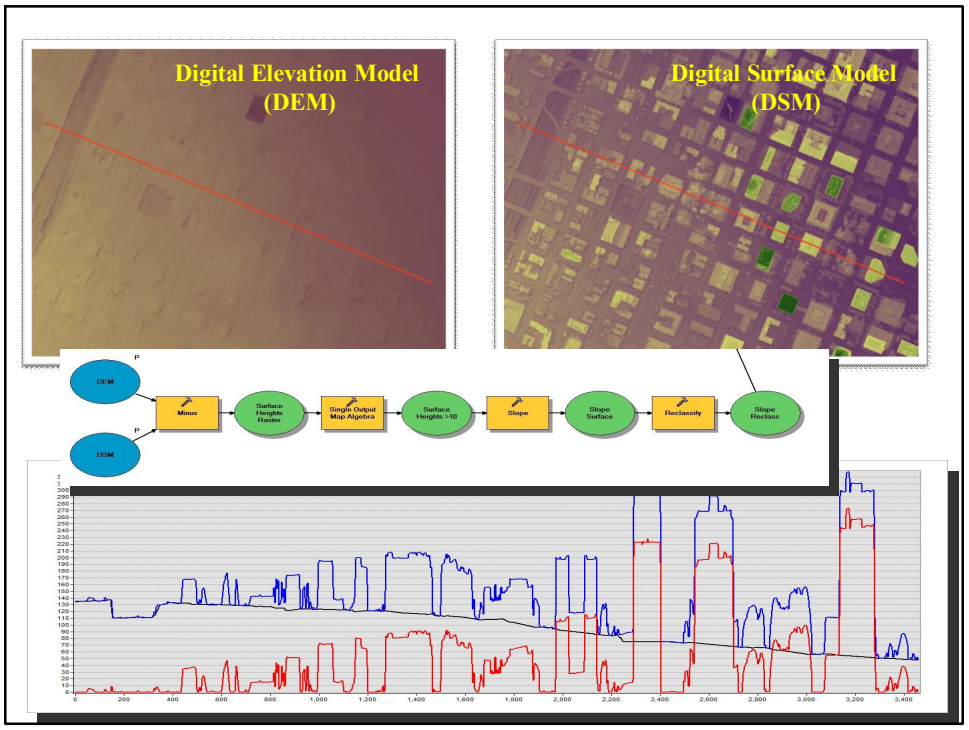
- "The volume reductions for flat roofing scenarios will primarily come from the zones of the watershed where impervious areas are most directly connected to the storm sewer system." (Carter and Jackson, 2007)

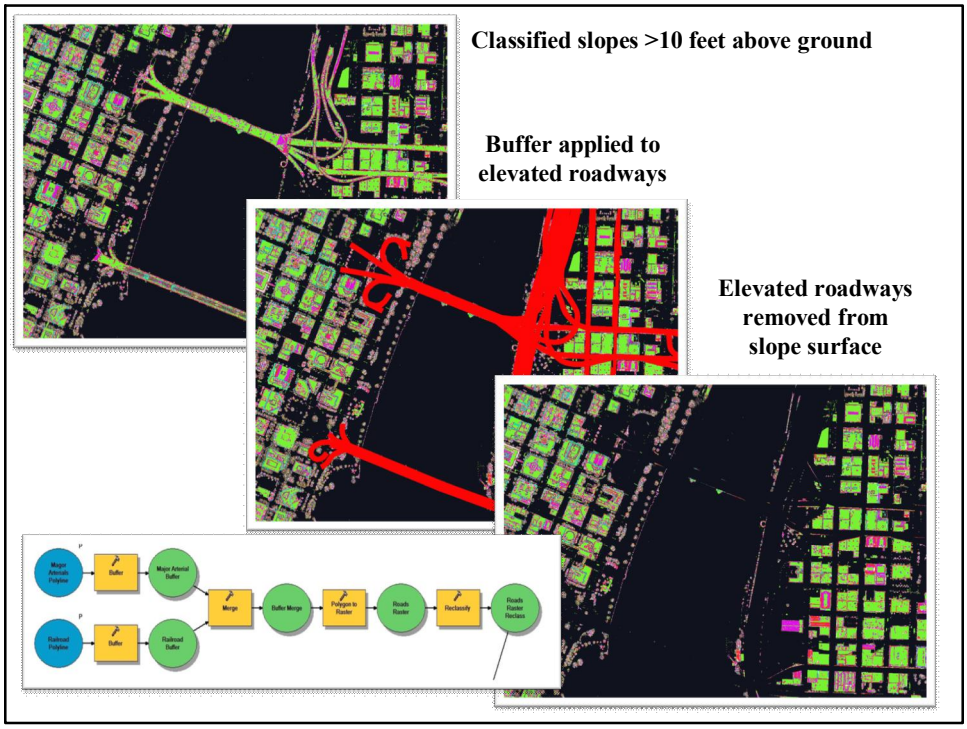
STUDY AREA

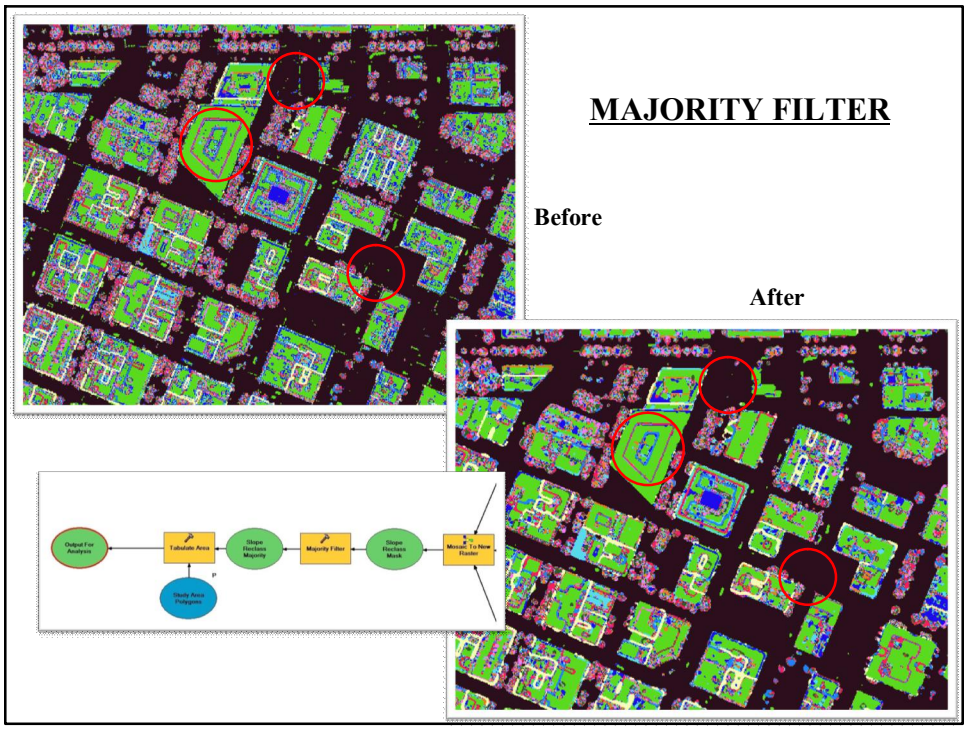
- **Zoned Industrial or Mixed Use**
- **Within Coverage of available LiDAR tile**
- **Confined to the Central City within about 2 miles of the Willamette River**



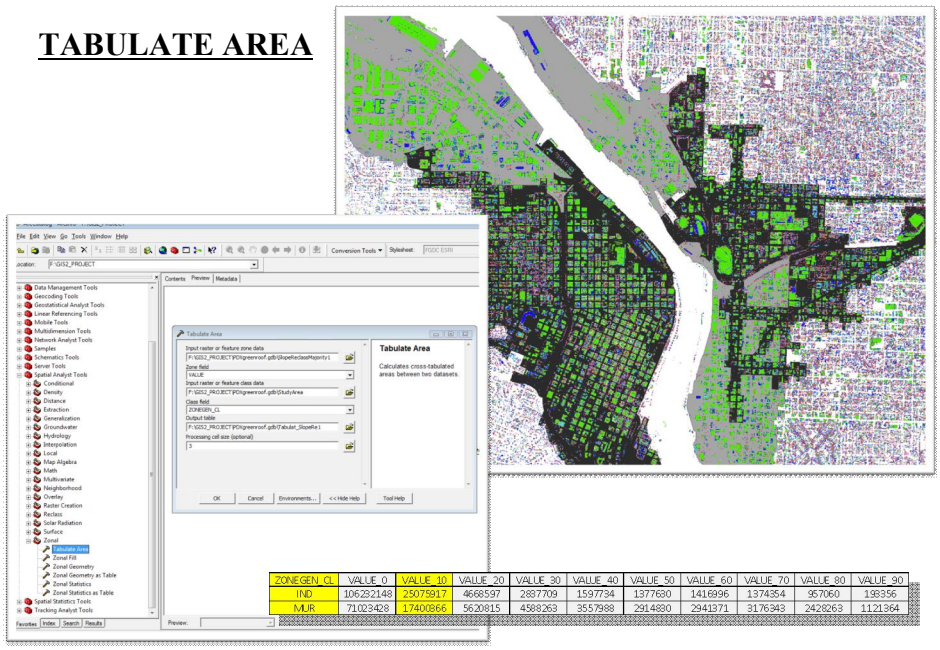

Magor Arterials Polyline
Buffer
Major Arterial Buffer
Railroad Polyline
Buffer
Railroad Buffer
Merge
Buffer Merge
Polygon to Raster
Roads Raster
Reclassify
Roads Raster Reclass
Output For Analysis
Tabulate Area
Slope Reclass Majority
Majority Filter
Slope Reclass Mask
Mosaic To New Raster
PDXgreenroo f.gdb
Study Area Polygons
DEM
DSM
Minus
Surface Heights Raster
Single Output Map Algebra
Surface Heights >10
Slope
Slope Surface
Reclassify
Slope Reclass


Digital Elevation Model (DEM)
Digital Surface Model (DSM)
DEM
DSM
Minus
Surface Heights Raster
Single Output Map Algebra
Surface Heights >10
Slope
Slope Surface
Reclassify
Slope Reclass

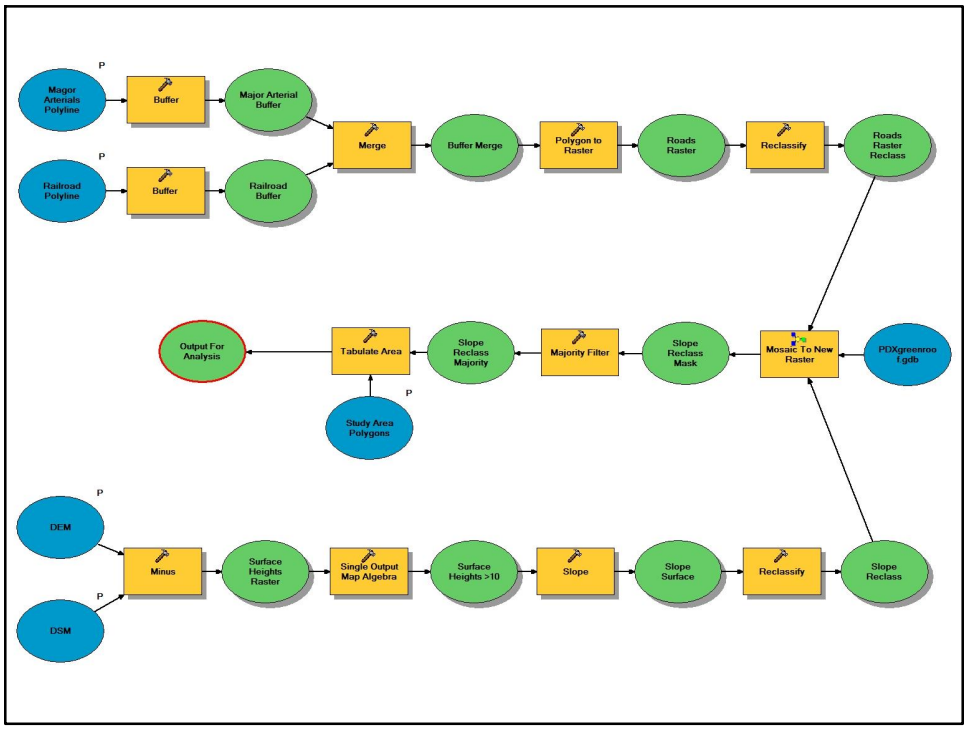

Classified slopes >10 feet above ground
Buffer applied to elevated roadways
Elevated roadways removed from slope surface


MAJORITY FILTER
Before
After

TABULATE AREA



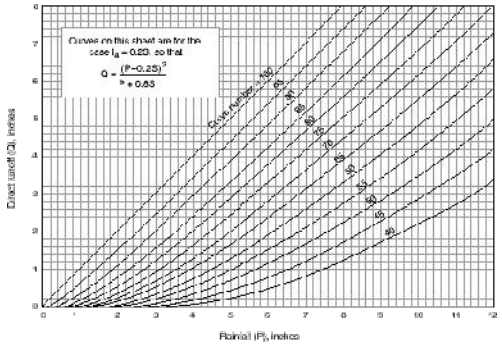
ZONEGEN_CL	VALUE_0	VALUE_10	VALUE_20	VALUE_30	VALUE_40	VALUE_50	VALUE_60	VALUE_70	VALUE_80	VALUE_90
IND	106292148	25075917	4668597	2887709	1597734	1377630	1416996	1374354	957060	199356
MUR	71023428	17400866	5620815	4588263	3557988	2914830	2941371	3176343	2428263	1121364



Hydrologic Modeling

Curve Number

Used as a proxy for absorption/infiltration characteristics of soil & land use types



Common Curve Numbers

Land Use Type	% Imp. Surf.	Curve Numbers (By Soil Groups)
Urban Commercial	85%	89, 92, 94, 95
Urban Industrial	72%	81, 88, 91, 93
Parking/Paved	100%	98, 98, 98, 98
Open Space (Parks, etc.)	-	49, 69, 79, 84

Source: http://www.ecn.purdue.edu/runoff/documentation/scs.htm

Eco-Roof Curve Number

Land Use Type	% Imp. Surf.	Curve Numbers (By Soil Groups)
Urban Commercial	85%	89, 92, 94, 95
Urban Industrial	72%	81, 88, 91, 93
Open Space (Parks, etc.)	-	49, 69, 79, 84
Eco-Roof	-	86; could likely range between 84-88

Calculating Runoff

Runoff Equation:

$$Q = \frac{(P - I_a)^2}{(P-I_a) + S)}$$

$I_a = 0.2S$, so $Q = \frac{(P-0.2S)^2}{(P+.08S)}$

$S = (1000/CN)-10$

Q= Runoff
P= Rainfall
I_a= Initial Abstraction
S= Maximum retention
CN= Curve Number

Calculating Total Runoff for an area

Q (inches)/12 = Q (ft)

Q (ft) X Surface Area (sq. ft.) = Runoff (cubic feet)

Results

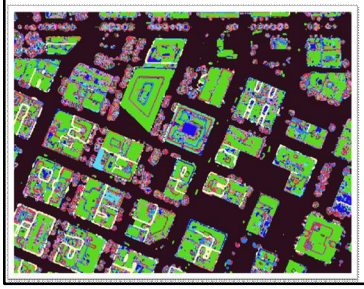
All Flat Roofs Greened (Curve Number 86)

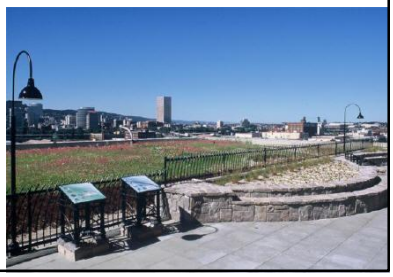
P (in)	0.50	0.83	1.00	1.20	1.50	2.00	2.52	4.43
IND Q (cf)	456,809	709,510	811,418	913,583	1,039,486	1,198,491	1,319,728	1,576,268
MUR Q (cf)	316,983	492,334	563,049	633,942	721,307	831,642	915,769	1,093,784
Total Q (cf)	773,793	1,201,845	1,374,467	1,547,524	1,760,794	2,030,134	2,235,498	2,670,052

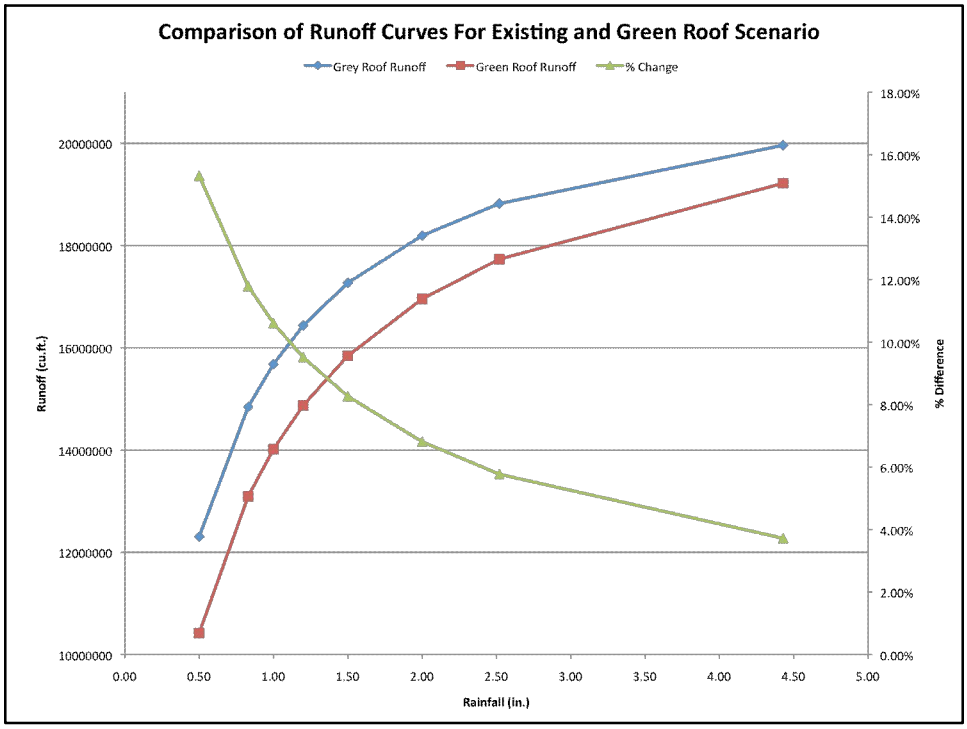
All Flat Roofs Ungreened (Curve Number 98)

P (in)	0.50	0.83	1.00	1.20	1.50	2.00	2.52	4.43
IND Q (cf)	1,570,033	1,742,673	1,793,381	1,836,847	1,882,447	1,930,340	1,961,215	2,014,626
MUR Q (cf)	1,089,458	1,209,254	1,244,441	1,274,602	1,306,244	1,339,478	1,360,902	1,397,964
Total Q (cf)	2,659,491	2,951,926	3,037,822	3,111,450	3,188,691	3,269,818	3,322,117	3,412,590

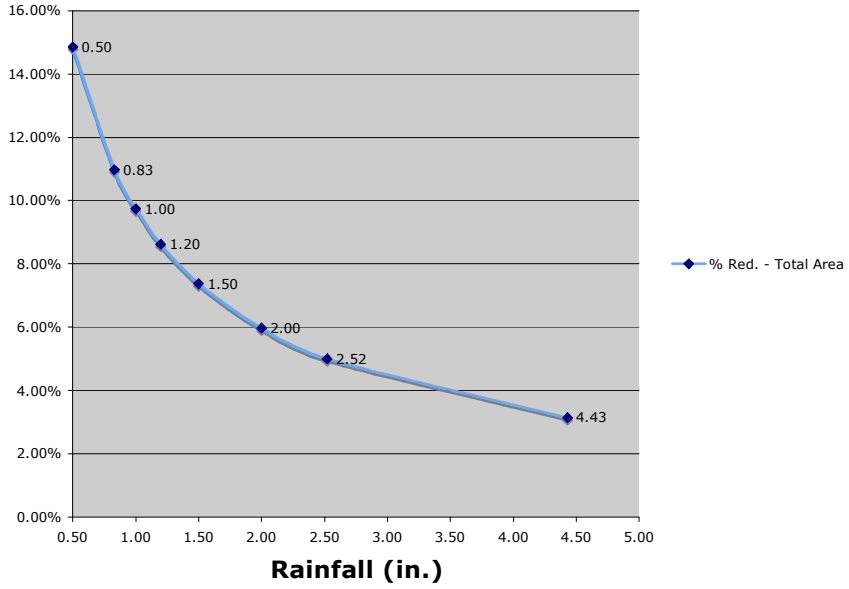
Reduction	1,885,698	1,750,081	1,663,355	1,563,925	1,427,897	1,239,684	1,086,620	742,538
% Reduction	70.90%	59.29%	54.75%	50.26%	44.78%	37.91%	32.71%	21.76%



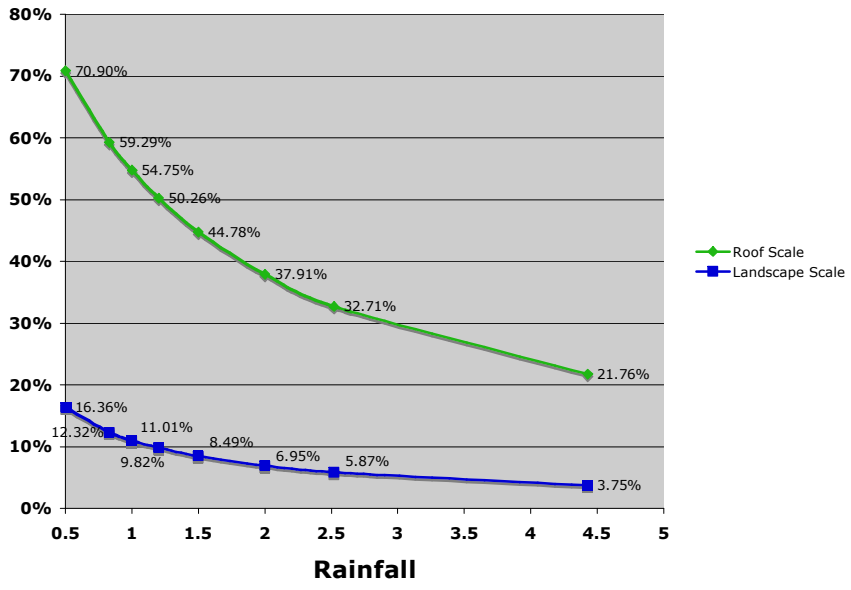




Runoff Change For Whole Area



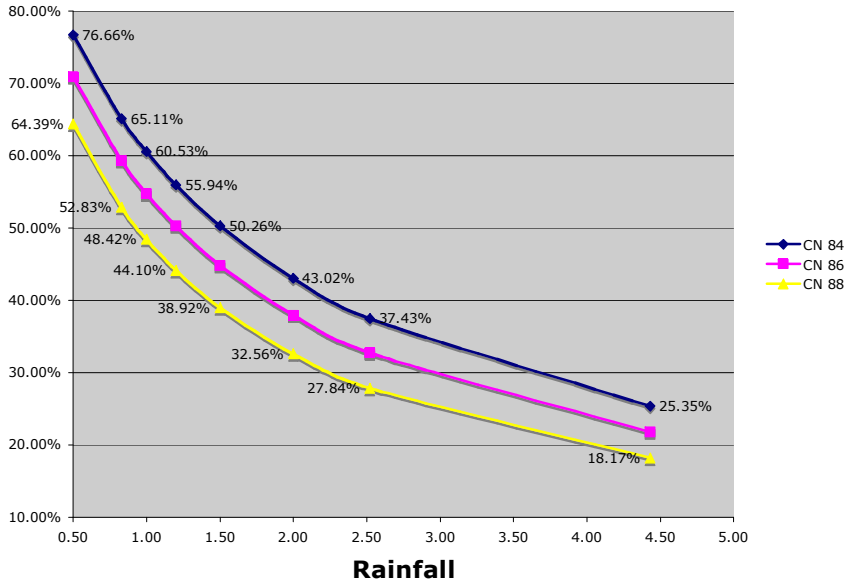
Roof Scale v. Landscape Scale



Effect of Curve Number

	P (in)	0.50	0.83	1.00	1.20	1.50	2.00	2.52	4.43
84	Total Q (cf)	620,685	1,029,925	1,198,979	1,370,849	1,586,025	1,863,235	2,078,813	2,547,467
	Reduction (cf)	2,038,806	1,922,002	1,838,844	1,740,601	1,602,665	1,406,583	1,243,305	865,123
	% Reduction	76.66%	65.11%	60.53%	55.94%	50.26%	43.02%	37.43%	25.35%
86	Total Q (cf)	773,793	1,201,845	1,374,467	1,547,524	1,760,794	2,030,134	2,235,498	2,670,052
	Reduction (cf)	1,885,698	1,750,081	1,663,355	1,563,925	1,427,897	1,239,684	1,086,620	742,538
	% Reduction	70.90%	59.29%	54.75%	50.26%	44.78%	37.91%	32.71%	21.76%
88	Total Q (cf)	946,982	1,392,393	1,566,978	1,739,198	1,947,676	2,205,208	2,397,384	2,792,574
	Reduction (cf)	1,712,509	1,559,533	1,470,845	1,372,251	1,241,014	1,064,610	924,733	620,016
	% Reduction	64.39%	52.83%	48.42%	44.10%	38.92%	32.56%	27.84%	18.17%

Effect of Curve Number



- "For future storm sewer retrofitting options, reductions in peak flow volumes from green roofing could provide economic benefits through decreasing the sizing of culverts and pipes designed for large storm events." (Carter and Jackson, 2007)

Questions?

References:

- Carter, T., Jackson, C.R. 2007. Vegetated Roofs for Stormwater Management at Multiple Spatial Scales. Landscape and Urban Planning 80: 84-94.
- Carter. T., Rasmussen, T. 2006. Hydrologic Behavior of Vegetated Roofs. Journal of the American Water Resources Association 42: 1261-1274.
- Hutchinson, D., Abrams, P., Retzlaff, R., Liptan, T. 2003. Stormwater Monitoring of Two Ecoroofs in Portland, Oregon, USA. *In* Proceedings of Greening Rooftops for Sustainable Communities, Chicago, Illinois, May 29-30, 2003.
- SCS Curve Number Method, http://www.ecn.purdue.edu/runoff/documentation/scs.htm, accessed February 28, 2009.