

# **Trends in Philadelphia Green Roofs**

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**ENVS 662-660**

**10/23/2007**

# Table of Contents

Introduction.....	3
What is a Green Roof?.....	3
Benefits of Green Roofs.....	3
Structure.....	5
Standards.....	5
Structural Guidelines.....	6
Growing Medium.....	6
Plant Choice.....	7
Moisture/Root Barriers, Drainage Strategies, and Leak Detection.....	7
Design Examples.....	7
Insulation Vs. Thermal Mass.....	10
Cost.....	10
Green Roofs Around the World and at Home.....	10
International.....	10
Chicago.....	11
Solar Decathlon, Washington, DC.....	12
Green Roofs In Philadelphia.....	13
Providers.....	13
Implementations.....	14
Residential Implementations.....	16
Before City Council.....	17
Conclusion.....	17

## Introduction

Green roofs have been popular in Germany and other European nations for quite a while, and have made major inroads in US cities like Chicago, Washington DC, and Portland. They provide stormwater management, insulation, protection from UV rays leading to longer roof life, reduction of the urban heat island effect, and reintroduction of wildlife habitat on the footprints of urban buildings. Philadelphia is slowly getting used to the idea, and City Council will soon be considering a policy which could get the idea off the ground. This paper will outline the basics of green roofs, including structure, engineering considerations especially for old buildings, plant choice, and irrigation, followed by an overview of how Philly is doing.

### What is a Green Roof?

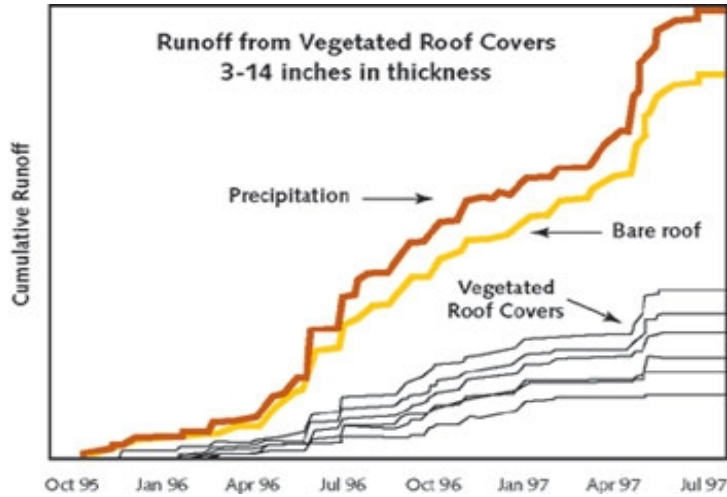
A green roof is a roof is essentially a roof with a layer of vegetation on top. It is distinct from a roof that simply contains potted plants because it constitutes a low-maintenance, contiguous, vegetated layer. A roof can be modified to accommodate a growing medium mixture anywhere from a few inches to several feet thick, with plants ranging from low-growing herbaceous mixes to hardier shrubs and even trees. Temple University landscape architecture professor Edgar David says that “green roofs mimic the natural processes that the buildings replace,” and they they can improve air and water quality.<sup>1</sup>

### Benefits of Green Roofs

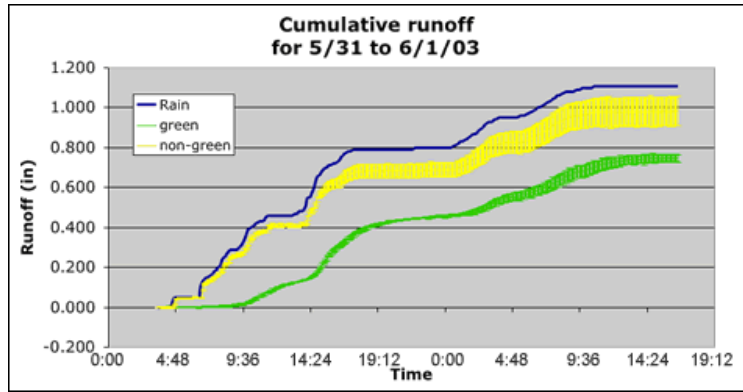
The benefits that rooftop greening can provide are similar to those provided by any green space, especially in cities. They absorb UV rays that degrade traditional roofing materials, extending the life of a roof by up to twice its normal expectancy. Rooftop vegetation acts as an insulator, which helps regulate indoor temperatures, improves indoor acoustics, and saves energy. They can also reduce temperature extremes outside, which helps tame the urban heat island effect. The greenery provides new habitat on the footprint of the structure where birds and insects can make their homes.

Green roofs can have a dramatically beneficial effect on stormwater management in cities by absorbing rain, preventing runoff, lowering runoff velocity, and filtering the water that does drain through. The Whole Building Design Guide website states that the 11.8 acres of green roofs on the Bondorf transportation center in Sindelfingen, Germany has a net zero storm water runoff discharge.<sup>2</sup> According to the PA Stormwater Management Best Management Practice (BMP) manual, green roofs do a better job of reducing pollutant and nutrient releases as they mature, with top efficiency after about a five year establishment period.<sup>3</sup> Municipalities nationwide are working to implement required improvements to their stormwater systems as mandated by EPA's National

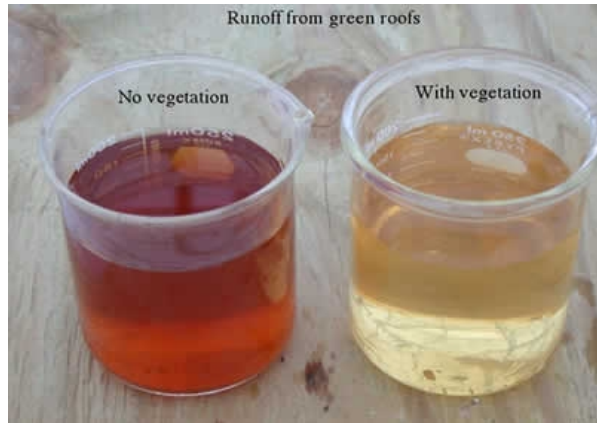
Pollutant Discharge Elimination System (NPDES) stormwater program.<sup>4</sup> Philadelphia would benefit tremendously from better stormwater management since its combined sewer/wastewater system is overwhelmed during heavy rains. The photos and graphs below show some of the stormwater benefits that green roofs can provide.



Source: <http://www.wbdg.org/design/greenroofs.php>



Source: Penn State Green Roof Research



Source: Penn State Green Roof Research

## Structure

There are many ways to build a green roof, and many factors to consider when designing one. Of primary importance is the strength of the structure and the existing roof, which will determine how much additional weight it can carry. Very lightweight systems can add as little as five pounds per square foot dry and 18 pounds wet,<sup>5</sup> whereas roof gardens can add up to 100 pounds per square foot wet.<sup>6</sup> Next, the health of the existing roof must be assessed, and additional waterproofing added as needed. Once weight and waterproofing are considered, the range of designs becomes quite wide. In some cases, there may be a need for not much more than a moisture barrier, root barrier, and growing medium. Other systems include extensive waterproofing with detailed drainage features. Still others use simple modular containers that remind one of flats of seedlings.<sup>7</sup> Flat roofs lend themselves easily to greening, but some slope can be accommodated.



*Green Roof Blocks system with modular 2 x 2 aluminum planters.*

*Source:<http://www.apartmenttherapy.com>*

Green roof designs are broadly categorized into extensive (about eight inches or thinner) and intensive (thicker than about eight inches, up to four feet).<sup>8</sup> Intensive green roofs can be similar to roof gardens or landscaped plazas, but in general there is a distinction between roof gardens that are meant to be accessible and enjoyed, and green roofs which are designed with technical performance in mind<sup>9</sup>, particularly for stormwater management, temperature regulation, and habitat restoration.

## **Standards**

Unfortunately, adoption of green roof technology in the US has been slowed because there are no universally-accepted standards. This is caused partially by a language barrier, since the most advanced documentation is written in German.<sup>10</sup> However, in recent years, the now-international standards body American Society for Testing and Materials (ASTM) has convened a Green Roof Task

Force to publish a set of standards for building and comparing,<sup>11</sup> and that National Roofing Contractors Association has published a Green Roof Systems Manual available for download by registered members.<sup>12</sup> In the meantime, builders have used the German FLL (Forschungsgesellschaft Landschaftentwicklung Landschaftsbau. e.V.)<sup>13</sup> or previous standards for ballasted roofs.<sup>14</sup> The International Green Roof Association states that few countries have standards governing green roofs, but suggests that bodies developing regulations take the following into consideration:

“Building technique (e.g. load bearing capacity, wind uplift protection, fire protection, temperature, noise protection, etc); and the roof technique (waterproofing material and installation, upstands, slope, drainage, etc.). Consideration must also be given to any existing regulations and guidelines for garden and landscape architecture (e.g. soil and plants, lawn, seed mixture, upkeep and maintenance works, etc.). High buildings, according to the particular country, require various regulations regarding the security and fall protection on roofs.”

The lack of widely accepted standards means that different manufacturers, installers, and technical assistance providers, such as state DEPs, provide inconsistent definitions, but it is possible to use a range of specifications to arrive at some basic guidelines. Below are summaries of what I learned from looking at a number of specifications, followed by examples from several providers.

## **Structural Guidelines**

### ***Growing Medium***

One item that is discussed with some consistency is growing medium. Many guides state that specially mixed growing medium, not soil, needs to be used to maximize water retention and filtration capability. Many of these mixes are proprietary and include large proportions of Perlite or other expanded clay products. The PA Stormwater Best Management Practices Draft Manual insists that “Assemblies intended to produce water quality benefits should employ engineered media with 100% mineral content.”<sup>15</sup> In “Green Roof Specifications”, Wark and Wark state:

“Not to be confused with soil, the planting medium is distinguished by its mineral content, which is synthetically produced, expanded clay. The clay is considerably less dense and more absorbent than natural minerals, providing the basis for an ultra-lightweight planting medium. Perlite is a common form of expanded clay and is found in garden nursery planting mix (not planting soil). The types of expanded clays used in green roofs are also used in hydroponics. A large number of planting medium ‘recipes,’ many of them proprietary, are commercially available. The bulk densities of these mixes range from 400 kg/m<sup>3</sup> (25 lb/cf) to 900 kg/m<sup>3</sup> (56 lb/cf) for dry mixes where water absorbencies can be 20–200 percent by weight. Soil is also commonly used in high-maintenance rooftop gardens.”<sup>16</sup>

***Plant Choice***

A wide range of plants can be used, but in general, hardy, drought-tolerant plants are recommended, and tall grasses should be avoided for fire safety reasons. Plants that can be successful without maintenance after the first few seasons should be used, so native species are obvious choices. Low-growing, thin soil succulents, especially from the genus *Sedum* are popular in extensive systems, as are hardy wildflowers and herbs. Intensive systems can include shrubs or even shallowly rooted trees, but all systems should prevent root penetration through the roof.

***Moisture/Root Barriers, Drainage Strategies, and Leak Detection***

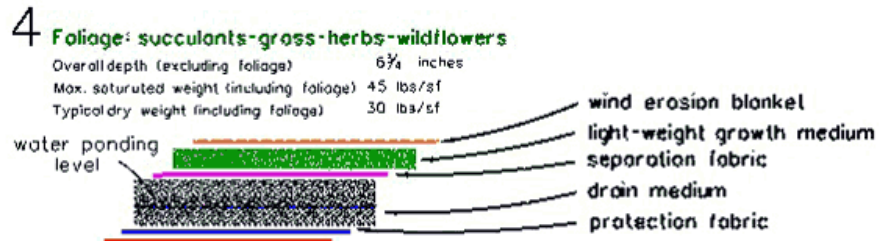
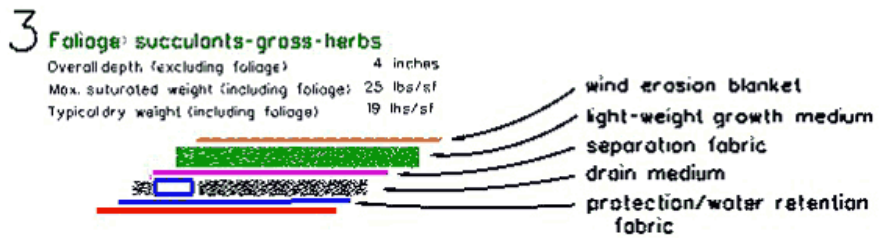
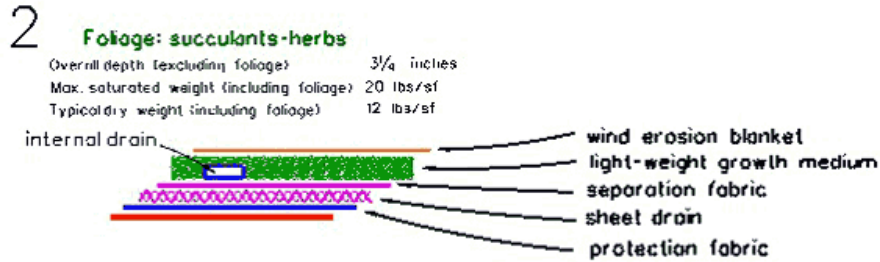
Root penetration can be prevented in a variety of ways. If shallowly rooted grasses and succulents are chosen, then moisture barriers or insulating layers should be sufficient. If root intrusion is a concern, it can be mitigated with a root retardant layer under the drainage medium, such as copper or a mild herbicide.

While it is often desirable to design a system that does not require irrigation, it is imperative that a green roof system have a way of offloading excess water. This can be done quite simply with a gravel layer for simple extensive systems, or with more complex designs employing corrugated materials or drainage conduits. Some installers can provide an electric field vector mapping (EFVM) system, which sends a charge through the moist growing medium and detects any places where it ground by touching a metal structure below. This kind of system would be ideal in larger, heavier applications where early detection and repair is of primary concern.

***Design Examples***

Below are some illustrations of green roof structures that show details of some of the concepts described above.

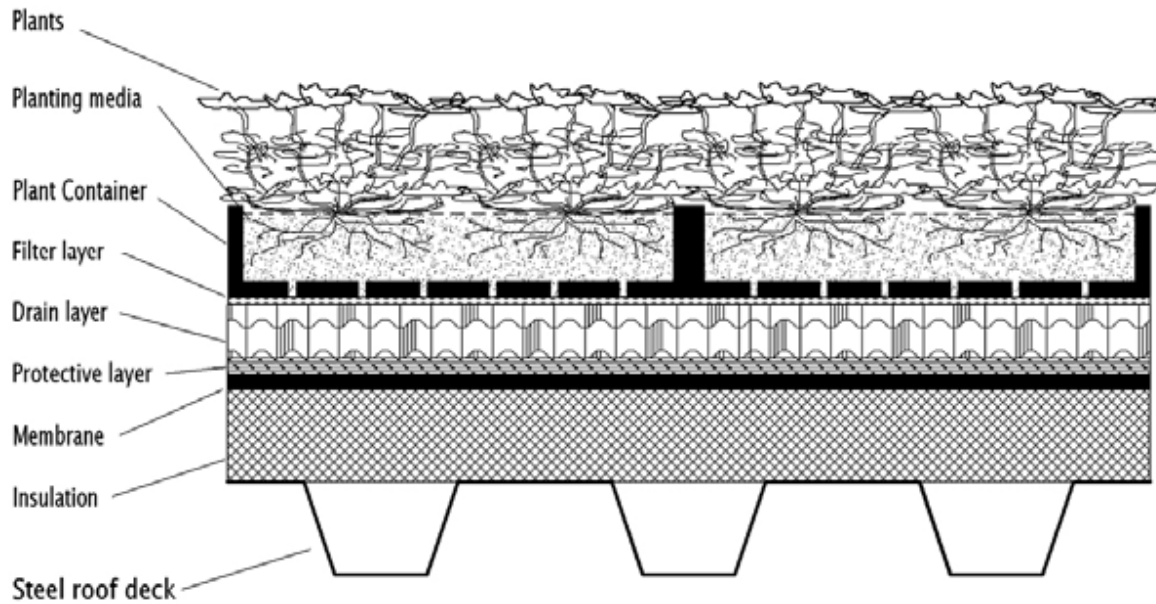
### GENERIC PROFILES EXTENSIVE ROOFMEADOW COVER SYSTEMS



Roofscapes, Inc.  
[www.roofmeadow.com](http://www.roofmeadow.com)

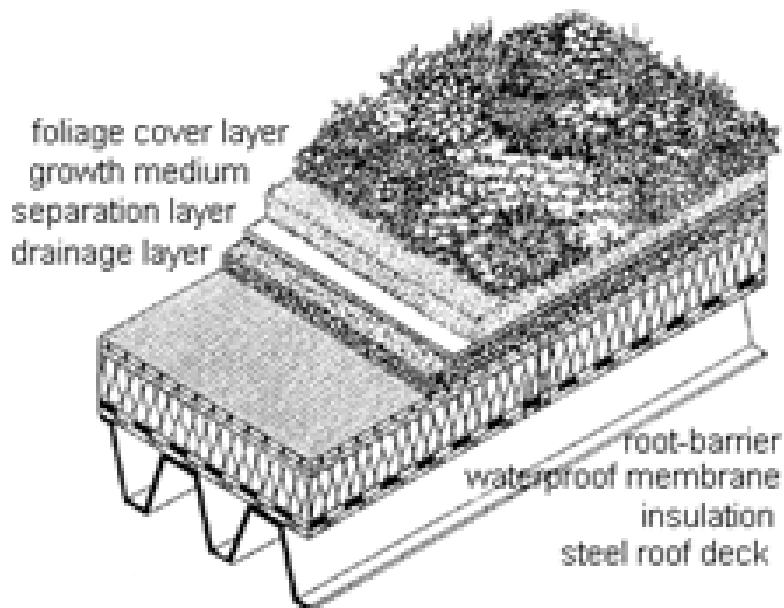
### Extensive Green Roof Construction

Cross section of basic elements



SHADE Consulting, LLC 4/29/03

Source: SHADE Consulting via The Construction Specifier



Generic Extensive Green Roof Courtesy of Optigrün Intl. AG

### ***Insulation Vs. Thermal Mass***

Green roofs can help insulate a building and regulate temperature by adding thermal mass. In warm climates, a green roof may provide all the insulation needed, while a study in Northern California shows that an uninsulated green roof could lower heating bills by 30 percent more than a normal roof with R18 insulation. Furthermore, rigid insulation can be used as a protective layer in the structure of a green roof.<sup>17</sup>

However, measuring the R value of a green roof is complicated since it is more of a thermal mass than an insulator. R value tables for high mass walls have improved over the years, but a green roof's R value and thermal mass change dramatically according to vegetation type, season, and how much water is retained at the time.<sup>18</sup>

### **Cost**

I found highly contradictory information for how to compare the cost of a green roof to a conventional roof. A green roof priced at about \$8-\$15 per square foot looks like a very good deal compared to clay/concrete tile (\$130-\$500), steel or aluminum (\$150-\$240) or slate (\$300-\$600).<sup>19</sup> However, an EPA factsheet states that the costs of traditional built-up roofs or cool membrane roofs start at \$1.25-\$1.50 per square foot.<sup>20</sup> It was unclear if this cost only represents the topmost coating or a more extensive structure. It may be that when insulation and structural fortification are added, those low prices become deceptive. Green roof costs can be altered by factors such as accessibility by heavy equipment, complexity of the project, height of the building, and distance from materials suppliers. However, upkeep is minimal and goes down after the first several years when the plants are established.<sup>21</sup>

However, long green roofs have exceptional long-term benefits such as increased roof life, and reduced impact on stressed stormwater management systems. In a radio address on 10/10/2007, Mayor John Street presented these potential benefits of Green Plan Philadelphia:

“The Plan studied one square-mile area in South Philadelphia to assess the benefits from green roofs. If 25 percent of the properties in the area installed green roofs, the cost would be \$220,000. The annual benefits however in energy savings and pollution reduction would be \$860,000, a net benefit of \$640,000. Going green improves the environment and saves money. For the average rowhome owner in Philadelphia it would cost about \$8,000 to install a green roof. In the long run, it's worth it – for your pocketbook and for our environment.”<sup>22</sup>

## **Green Roofs Around the World and at Home**

### **International**

Green roofs have gained popularity in a few places in particular that have folded them into building

standards and zoning restrictions at the municipal level and above. Germany is the clear leader in green roof technology, and estimates show that 10-12% of flat roofs in Germany are green.<sup>23,24</sup> By 2003, Tokyo had mandated that 20 percent of new construction incorporate a green roof.<sup>25</sup> The roof of the Schiphol International Airport in Amsterdam is softened by a pillowy layer of light purple flowering sedum, while an intensive green roof atop the Coast Plaza Hotel in Vancouver, BC, provides a woodland retreat rich with pines and rhododendron.<sup>26</sup>



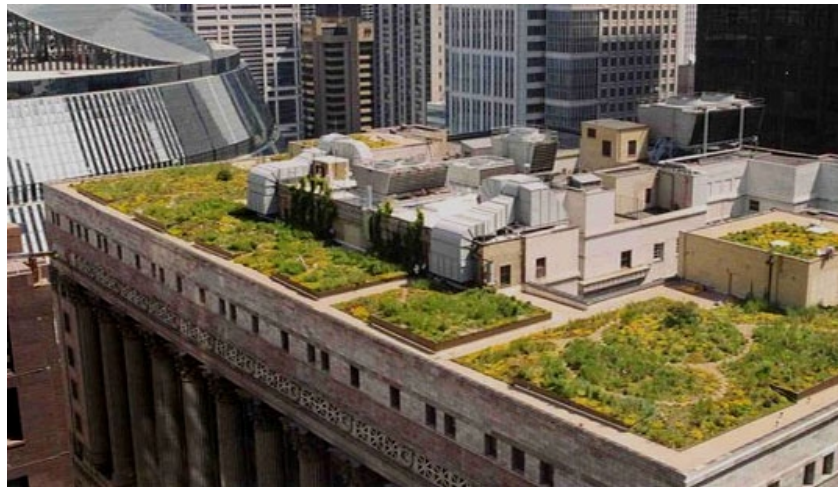
Schiphol International Airport, Amsterdam, Coast Plaza Hotel, Vancouver, BC. Source: [http://www.hrt.msu.edu/faculty/Rowe/Green\\_roof.htm](http://www.hrt.msu.edu/faculty/Rowe/Green_roof.htm)

## **Chicago**

Chicago is a leading city in greening efforts due in large part to long-term city planning and the strong, granular control that city government maintains over builders and developers through ordinances. The city enforces a landscape ordinance that requires developers to increase or improve the green space near any building project<sup>27</sup>, as well as a zoning ordinance requiring every roof over 10,000 square feet to be at least 50% green<sup>28</sup>. The first step in implementing such an ordinance was a 2001 test project carried out on no less than the roof of Chicago's 100-year old City Hall. The City Hall Rooftop Garden Pilot Project was carried out in conjunction with US-EPA's Urban Heat Island Initiative, and included test plots with four, six, and 18 inch growing beds, with ongoing monitoring of plants, birds, and insects that have made it their habitat. Temperature monitoring showed that during the summer, surface temperatures of green versus non-green areas was 70 degrees lower, while air temperature was 15 degrees lower<sup>29</sup>. Furthermore, the 20,000 square feet of green roof has saved the city around \$25,000, making a strong business argument for the efficacy of vegetated roofs.

Birder Jerry Garden described the return of wildlife to the oasis in the sky:

“During the first year, Garden saw a few sparrows each week and occasionally a flock of juncos. His list of visitors included a wren, a chickadee, a kinglet, a Cape May warbler, and an Empidonax flycatcher. The year 2003 brought 12 percent more birds and a greater variety: at least one of each species from the previous year, plus six types of sparrow, woodpeckers, thrushes, a robin, a thrasher, a starling, a Philadelphia vireo, and both a Cape May and a common yellowthroat warbler. But his biggest thrill came last October when Garden saw a rare olive-sided flycatcher determinedly push through the steel "Grand Canyon" of LaSalle Street and land on the roof. "It must have been compelled by its sense of direction to abandon a friendly route and take off into this inhospitable environment. The more green roofs we have," he says, "the more birds will get to know them."”<sup>30</sup>



Source: <http://www.inhabitat.com/2006/08/01/chicago-green-roof-program/>

## **Solar Decathlon, Washington, DC**

This year's solar decathlon, a DOE-sponsored competition where 20 universities are selected to build model solar homes for display and adjudication on the National Mall, showcased several homes with green roofs. The second place Leaf House from the University of Maryland and the Lumen/Essence

house from Team Montréal both incorporated green walls as well. Green walls are beyond the scope of this paper, but the talking point paper from Team Montréal cites temperature regulation and stormwater management as the main advantages.<sup>31</sup> The University of Maryland house takes a slightly different approach, funneling rainwater from the roof through the green wall for filtration, which is then collected to irrigate the garden.<sup>32</sup>



*“Vertical rain garden” or green wall on University of Maryland demo home entry in the DOE Solar Decathlon, 2007. Photo: Alarcón*

## **Green Roofs In Philadelphia**

### **Providers**

The major green roof provider in Philadelphia is Roofscapes, Inc., based in Germantown. They work across North America, and their portfolio includes the award-winning Chicago City Hall project, and the Heinz 57 corporate headquarters in Pittsburgh, PA.<sup>33</sup> Projects around Philadelphia include the Schuylkill Center for Environmental Education, the Papazian Building Expansion on the Swarthmore College campus, and the Temple University-Ambler Field House, and the Friends Center at 15<sup>th</sup> and

Cherry Sts.<sup>34</sup> The firm offers a many types of green cover, organized by plant community and day/wet weight. Their first project was completed ten years ago at the Fencing Academy of Philadelphia in Powelton Village, and since then they have done many residential and non-residential projects. I spoke with Nate Johnson from Roofscapes, and found that the company no longer works on projects smaller than 5000 square feet, but sometimes offload smaller projects to other contractors. The company does not offer structural engineering services, so property owners must complete separate studies to assess the strength of the building and the roof, and make a decision on the type of green roof based on that.<sup>35</sup>

For Philadelphia homeowners, a firm like BioNeighbors Sustainable Homes<sup>36</sup> might be a good option. Unfortunately, I was not able to contact the founder, Corey Suter, but his roofing work has been praised by members of the LAVA community center on Lancaster Avenue, for being affordable and reliable.

Outside Philadelphia, Lancaster county is focused on concentrating growth in already urban areas to preserve open space, and the local Creek Hill Nursery, which raises sedums and other green roofing plants, may be key to that goal. Dense growth means extra strain on municipal stormwater management systems, and county planner Mike Domin sees greening as a good solution: “You can either do it with physical improvements — digging up every street in Lancaster and installing new pipes — or you can try to control the stormwater by urban greening”. The county hopes to win \$500,000 from PA-DEP to help green 79,000 square feet of roofs, and plans to allow the earth sciences department at Millersville University to do monitoring.<sup>37</sup>

## **Implementations**

Most of the well publicized green roof implementations in Philadelphia were installed by Roofscapes, Inc. Their latest project is the Friends Center in Center City, which has a commitment to environmentally responsible renovations to the 34-year old office building, in keeping with Quaker principles of peace, equality, integrity and simplicity. Their “Quaker Gray into Quaker Green” campaign explains the link between sustainable renovations and peace:

“The wars of the 21st century are predicted to be over fossil fuel reserves and water resources. These wars have already begun in various parts of the world including the Middle East. Continued overconsumption of energy resources is a 'seed of war that finds nourishment' in our way of living. By creating a fossil fuel free building Friends Center will remove this seed of war from our way of living.”<sup>38</sup>

With help from a major PA-DEP grant, the Friends Center installed the \$300,000 roof which they believe “will be a major savings for our children and grandchildren” because of its longevity.

Furthermore, a cost-benefit analysis showed that a \$12.5 million green renovation would cost \$45 million dollars over 20 years, while a \$8.5 million dollar conventional rehab would come out to \$50 million dollars over the same period, taking into account utility and maintenance savings, as well as credits for reselling electricity generated by rooftop solar panels.



*Green roof atop Friends Center, 15th and Cherry, completed May 2007. Source: <http://friendscentercorp.org/>*

The oldest Philadelphia green roof implementation, according to Roofscapes, is the Fencing Academy of Philadelphia, at 3519 Lancaster Ave. Their profile on the Low Impact Development site states that the 3.4 inch, 17 pound/square foot (wet) retrofit was designed to restore the building's footprint to pre-development 2-year storms retention abilities. The roof has a saturated filtration capacity of 3.5 inches per hour, and reduces temperature variation to about 18 degrees.<sup>39</sup>



*Fencing Academy of Philadelphia. Source: Roofscapes, Inc.*

Other notable non-residential implementations are a living roof at Mill Creek Urban Farm in northwest Philadelphia, and Radnor Middle School, in Wayne, PA. The two projects are very different, with much of the natural building work at the farm done by staff and volunteers<sup>40</sup>, while the school is a new construction project with many green technologies<sup>41</sup>, and represent opposite end of the installation spectrum.



*"Jade, co-founder of Mill Creek Farm, standing on the living roof of their cobbed shed." (Source: Mac And Cheese Review-vegan food blog)*

### ***Residential Implementations***

In 2004, the City Paper featured local homeowners who had taken the green roof plunge, including the owner of The Khyber and his partner, a landscape architect. Society Hill homeowner Dale

Brazale had a two-tier system installed by Roofscapes, in the space of a day. The company was to return twice a year for minor maintenance, which would not be needed once the roof was established. "The last thing I would want to do is mow my roof," laughs Brazale.<sup>42</sup>

In spring 2008, a group of homes called Bancroft Green, where "luxury and green co-exist", are set to open in Point Breeze, with prices starting at \$560,000. The three bedroom, 2.5 bath units feature many luxury features, but hinge on a laundry list of green amenities: open floor plan for increased natural lighting, solar hot-water, partially vegetated roof and dual-flush toilets, paperstone countertops. bamboo or mesquite flooring with radiant floor heat, partial green roof, 1year free Philly Car Share(PCS), 2 new PCS spaces on the block," and a ten year tax abatement to top it off.<sup>43, 44</sup>

### **Before City Council**

Philadelphia Councilmember Jim Kenney introduced Bill No. 070072 on Feb 8, 2007, which would amend the tax code to provide a Green Roofs Tax Credit for up to 25% of the cost of green roof up to \$100,000, against an entity's Business Privilege tax. In his testimony to the City Council Finance Committee on March 19, 2007, City Controller Alan Butkovitz stated that heating and cooling cost savings are estimated to be 20%-30%.<sup>45</sup> According to Nate Johnson of Roofscapes, the bill could lead to green roof requirements for big box stores in the city. The rules committee hearing was scheduled for Oct 30, 2007, and at this time, results of the hearing are not available.<sup>46</sup>

### **Conclusion**

Philadelphia seems poised to be at the forefront of green roof development in the US. It is home to a major installer, several major projects that have been successful and cost effective, and both the mayor and governor are outwardly enthusiastic about green technology. On the other hand, it is also home to a sewage system that overflows during big rains, and a water department facing the need for expensive, ongoing water infrastructure improvements. The incentive for using green roofs, rain barrels, and other aids to the city's stormwater management system, certainly exists.

As a city filled with old architecture, it faces some challenges in getting rooftop improvements such as solar panels, solar hot water, and vegetated roofs, but the range of residential, commercial, and government building examples that are already here, are very encouraging. It is my hope that as large-scale installations become more common, that a more grassroots-accessible movement will get off the ground as well, with smaller roofers dedicated to residential applications, and neighbors teaching neighbors about how to green their roofs. Further, I hope that the city encourages both ends of the spectrum, by funding and incentivizing large projects, but also by choosing not to impose zoning restrictions that would hinder individuals homeowners' ability to consider the

possibility. I am eager to see how green roofs and other sustainable construction technologies fare since the city voted by referendum to reform the zoning board, and especially after the next mayoral election.

1 <http://www.schundler.com/greenroofs.htm>  
2 <http://www.wbdg.org/design/greenroofs.php>  
3 [http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement/BMP%20Manual/06\\_Chapter\\_Final\\_Draft.pdf](http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement/BMP%20Manual/06_Chapter_Final_Draft.pdf)  
4 <http://www.epa.gov/npdes/pubs/fact2-0.pdf>. Stormwater Phase II Final Rule, Small MS4 Stormwater Program Overview. USEPA Office of Water, Jan 2000. EPA 833-F-00-002 January 2000 (revised December 2005) Fact Sheet 2.0  
5 Phone conversation with Nate Johnson of Roofscapes, Inc., 10/22/2007  
6 <http://www.asla.org/meetings/awards/awds02/chicagocityhall.html>  
7 <http://www.apartmenttherapy.com/ny/green-ideas/water-not-required-green-roof-blocks--003045>  
8 <http://www.garlandco.com/green-roof-types.html>  
9 <http://www.asla.org/meetings/awards/awds02/chicagocityhall.html>  
10 <http://hortweb.cas.psu.edu/research/greenroofcenter/history.html>  
11 <http://www.roofmeadow.com/technical/astm.shtml>  
12 <http://www.nrca.net/>  
13 <http://www.f-l-l.de/>  
14 <http://www.wbdg.org/design/greenroofs.php>  
15 [http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement/BMP%20Manual/06\\_Chapter\\_Final\\_Draft.pdf](http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement/BMP%20Manual/06_Chapter_Final_Draft.pdf)  
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18 Wark, Christopher G. and Wark, Wendy W. Green Roof Specifications and Standards: Establishing an emerging technology. The Construction Specifier, August 2003. Vol. 56, No.8  
19 [http://www.ehow.com/how\\_110415\\_select-roofing.html](http://www.ehow.com/how_110415_select-roofing.html)  
20 <http://www.epa.gov/hiri/strategies/greenroofs.html>  
21 [http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement/BMP%20Manual/06\\_Chapter\\_Final\\_Draft.pdf](http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/stormwatermanagement/BMP%20Manual/06_Chapter_Final_Draft.pdf)  
22 <http://ework.phila.gov/philagov/radio/prelease.asp?id=197>  
23 [http://www.hrt.msu.edu/faculty/Rowe/Green\\_roof.htm](http://www.hrt.msu.edu/faculty/Rowe/Green_roof.htm)  
24 <http://www.hrt.msu.edu/greenroof/>  
25 Wark, Christopher G. and Wark, Wendy W. Green Roof Specifications and Standards: Establishing an emerging technology. The Construction Specifier, August 2003. Vol. 56, No.8  
26 [http://www.hrt.msu.edu/faculty/Rowe/Green\\_roof.htm](http://www.hrt.msu.edu/faculty/Rowe/Green_roof.htm)  
27 <http://www.newcityskyline.com/Theagelessartoflandscapedesign.html>  
28 Source: Amendment of Title 17 OF Municipal Code of Chicago (Chicago Zoning Ordinance) by Reclassification of Area Shown on Map Number 20-F. (As Amended) (Application Number 1 4 109)  
29 <http://www.asla.org/meetings/awards/awds02/chicagocityhall.html>  
30 <http://chicagowildernessmag.org/issues/summer2004/greenroof.html>  
31 [http://www.solardecathlon.org/pdfs/talking\\_points\\_07/2007\\_talking\\_points\\_montreal.pdf](http://www.solardecathlon.org/pdfs/talking_points_07/2007_talking_points_montreal.pdf)  
32 [http://www.solardecathlon.org/pdfs/talking\\_points\\_07/2007\\_talking\\_points\\_maryland.pdf](http://www.solardecathlon.org/pdfs/talking_points_07/2007_talking_points_maryland.pdf)  
33 <http://www.roofmeadow.com/projects/awards.shtml>  
34 <http://www.roofmeadow.com/projects/casestudies.shtml>  
35 Phone conversation with Nate Johnson of Roofscapes, Inc., 10/22/2007  
36 <http://www.bioneighbors.com/>  
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