

# GREEN ROOF MANUAL

## How to Replace your Dead Roof with a Living Landscape

### GREEN ROOFS – A Sustainable Solution

Green roofs, otherwise known as living roofs or eco-roofs, are the wave of the future in sustainable design. Environmentally-sensitive roofing systems allow plants to grow on the surface of what would otherwise be just a protective covering for houses and commercial buildings. The long-term aesthetic and ecological benefits of green roofs far outnumber those of traditional roofs.

Since the eco-building movement gained momentum in Germany fifty years ago, living roof technology has advanced significantly. The German government fully supports the installation of green roofs and has offered builder incentives to continue with this tradition. It's estimated that over thirteen million green roofs have already been installed in Germany as a result of these efforts. While Germany is still the leader in green roof technology, as well as the manufacturing of systems and materials, over the past five years green roofs have started to sprout on the top of public and private buildings across the United States.

Currently, cities like Chicago, IL, and Portland, OR are making a strong push to utilize green roofs in the construction of new buildings, and are retrofitting old ones so green roofs can be added in the near future. In the city of Seattle, many of the new civic buildings are being constructed with green roofs.



Seattle City Hall in July, 2004. Photo by Linda S. Velazquez  
[www.greenroofs.com](http://www.greenroofs.com)

## How to use this Green Roof Manual

This guide will cover the costs and benefits of green roof construction and provide a list of resources and materials available to homeowners in the Pacific Northwest. The following chapters will aid the reader in asking questions and getting started on planning their green roof. Most importantly, each green roof is different, and professional guidance is necessary when installing a green roof over your own head.



Dave Logan's pitched Seattle garage was one of the first Northwest EcoBuilding Guild greenroofs, finished in 2002, and has served as testing grounds for different plants. This Photo by Linda S. Velazquez [www.greenroofs.com](http://www.greenroofs.com)

At the ground level, our cities and communities are often lively and vibrant spaces, while our roofs lay desolate and lifeless. Every square foot of barren rooftop is an opportunity to add back habitat missing from the ground. Surprisingly, replenishing this life requires little to no reengineering of the existing roof. Pomegranate Center had the opportunity to demonstrate green roof construction through the creation of the Pickering Farm Community Teaching Garden in Issaquah, WA. Since 2001, Pomegranate Center has been working with the City of Issaquah and local residents to design and build a garden that will demonstrate for its visitors a variety of sustainable landscaping methods that they could try at home. Green roofs are one of the methods showcased within this garden. Examples and pictures from our hands-on experience with planting green roofs are included in this manual and we invite readers to visit the garden in order to see the living rooftops for themselves. For more information on Pomegranate Center and directions to the Pickering Farm Community Teaching Garden please visit [www.pomegranate.org/garden](http://www.pomegranate.org/garden).





## Why green roofs are good for the homeowner and the environment

### Green roofs...

#### Reduce the volume of storm water runoff

Green roofs are known to retain 50-60 percent of the total annual runoff volume of a roof. Most importantly, the soil retains 90-100% of the critical first hour of heavy rainfall that can overwhelm storm water management systems. In urban and suburban centers, this could aid in alleviating the cost of storm water management and help in flood control.

#### Improve the quality of the water going into streams and waterways

Green roofs trap and filter dust particles and other pollutants from entering our storm water, thereby allowing cleaner water to enter into Puget Sound. Overall, adding plants and soil on rooftops will help maintain the quality of our water systems around the area and provide a healthier marine environment.



Dunnett and Kingsbury p. 43.

#### Reduce the effects of 'urban heat Island effect'

Due to all the hard paved surfaces and traditional roofs, cities are retaining heat and maintaining temperatures 10 degrees higher than the surrounding area. In the summer heat, the temperature on green roofs can be 20-60 degrees cooler than conventional roofing.



#### Cut back on the amount of dust and other pollutants in the air

It is widely known that more native plant life improves respiratory conditions in humans. On the [www.greenroofs.org](http://www.greenroofs.org) website it states, "1 square meter of grass roof can remove 0.2 kg of airborne particulate from the air every year."



### Control building temperature

For hundreds of years, living roofs were used in various countries to prevent heat from escaping or penetrating during different seasons. Controlling a building's interior is possible by replacing the asphalt surface of the roof with plants and soil, which act as insulators to keep buildings cooler in summer and warmer in winter.



### Reduce noise and glare

The noises produced by traffic, including automobiles, trucks, and airplanes are greatly reduced in the vicinity of a green roof, as are other human and mechanical sounds.

### Provide soothing and calming spaces to look down upon

With improvements being made in every aspect of green roof technology, we should see more green roofs offering a greater diversity of plants as well as more human access. Either way green roofs are more aesthetically pleasing, giving the viewer a soothing vista to gaze upon.



The recently completed Evergreen State College Seminar II Building. Photo Courtesy Tom Regney of the Garland Company. [www.greenroofs.org](http://www.greenroofs.org)

### Create wildlife corridors for migrating species

Many migrating species pass through urban centers. Green roofs offer these creatures the food, shelter, and respite they need to successfully finish their journey.



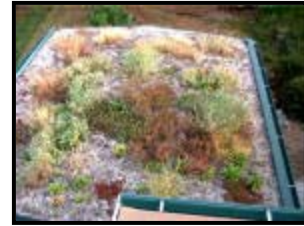
2004 ASLA Design Award of Merit winner Cedar River Watershed Education Center. Photo Right: Nancy Rottle; Left: Lara Swimmer Source: [ASLA.org](http://ASLA.org)



## The costs of going green

### Long-term financial benefits

Green roofs will lower the cost of storm water management in urban areas. Once a green roof is in full operation, it should cut down on the amount of heating and air conditioning a building needs to maintain comfortable temperatures. These reductions should be seen in the monthly costs of electricity and natural gas.



### Savings for the Homeowner

The average green roof lasts for an average of 40 years as opposed to the 17-year life expectancy of roofs installed with standard roofing materials, like cedar shake. Living roofs come with lower maintenance, repair and replacement expenditures than “dead” roofs. A reduction should also be noted in waste water charges.



### The initial cost of a green roof can be high depending on:

- 1) Type of system installed
- 2) Size of the roof
- 3) Thickness of Growth Media
- 4) Types of plants used
- 5) Use of Irrigation system



Green roofs vary considerably in cost according to what kind of green roof is installed. Please contact any of the green roof experts included in the back of this guide and compare quotes before making a final decision. Remember, the waterproof membrane will be the most expensive cost on a green roof. Care should be used when selecting this layer for your roof.



### Financial Incentives

A living garden will extend the life of your roof 20-40 years because it absorbs destructive UV rays and prevents extremely high temperatures from breaking down the waterproof membrane.

The storm water management and water quality benefits of green roofs make them an important tool to developers for responding to water quality and salmon habitat listing.



Market-based green building rating systems like LEED and Master Builders Association of King and Snohomish Counties, and BuiltGreen are making an effort to build, quantify and categorize buildings with environmental features such as green roofs. Green roofs address multiple categories used by these systems.



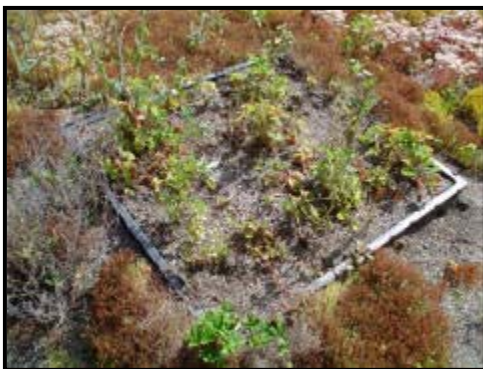
## Do your research - What to consider before installing a green roof system

**Slope** - the slope of roof is a major factor when considering a green roof. Roofs with pitches greater than 7:12 (30 degrees) do not do well as green roofs. They suffer from slippage and slumping of materials as well as swift release of runoff water. However, flat roofs are not always the best for green roofs either. Actually, it is possible to have a roof that is too flat. On flat surfaces, poor drainage can lead to roof damage, root rot and damage to plants. The ideal slope is about 1:12. Although, in special cases it can be as flat as  $\frac{1}{2}$ ":12" and as steep as 7.5":12" In Switzerland green roofs can be as steep as 60 degrees from the horizontal but it is important to consider the climate where the roof is being installed. Drought-resistant plants need very good drainage or else they can drown in puddles. The steeper the slope the more care should be taken to make sure the plants near the top are the most drought-tolerant because they will get less water.



(Left) The green roof on Tom Balderston's home studio office has a slope of 6.5:12. The slope of this roof posed some challenges for the Northwest EcoBuilding Guild design team in 2003. Photo by Patrick Carey, June 14, 2004. (Above) Those problems were solved by using circular drainage units. Photo by LSV, July 16, 2004.

**Climate** - local climatic factors like wind, sunlight, shade and temperature, need to be taken into consideration before building a green roof. Plants can struggle in extreme climates or in windy areas and green roofs have not been overly successful in sub-tropical or tropical environments. Tropical conditions support plant growth immediately and on any type of substrate, therefore weeds become a big problem.



Tomatoes and flowers grow on the roof of John Alexander's garage in Seattle. Photo by LSV.

**Insurance** - check with your insurance company to see if they will cover green roofs under your policy.

**Zoning** - ask your city officials if any zoning laws permit the building of green roofs. Many cities might offer incentives for this type of environmentally-sustainable construction also. It is recommended that you first try planting a living roof on your shed or garage before you plant over your head.

**Structure** – check with an architect to make sure that the structure of your roof can support the extra weight of a green roof. (The weight of a roof with a thin layer of soil and sedums is approximately the same as a roof of clay tiles).

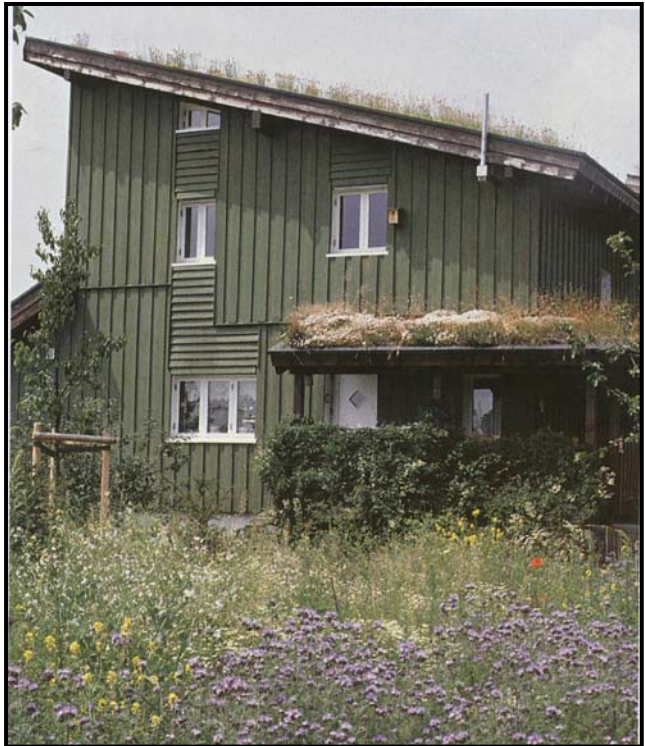
**Conditions, Covenants, and Restrictions (CC and Rs)** - many subdivisions have C,C, and Rs that restrict the homeowner from changing the look of the neighborhood. Please check with your neighborhood association for any C,C, and Rs regarding green roofs.

### **Mistakes to Avoid – brought to you by the experts at [www.roofmeadow.com](http://www.roofmeadow.com)**

**Avoid any design that is not properly drained** - Inadequate drainage can result in dead plants and dead weight that the roof may not be able to sustain.

**Avoid using herbicides to prevent root growth** - Herbicides will eventually leach out of materials, escaping into the environment and diminishing the root-inhibiting function of the root-barrier.

**Avoid using surface irrigation, if at all possible** - Surface drip and spray systems are expensive to maintain, do not deliver water efficiently to the roots, where it is most needed — and waste enormous amounts of water through evaporation. Also, on surface-irrigated green roofs plant roots tend to develop nearer the surface. This makes the covers increasingly dependent on irrigation and vulnerable to lapses in the watering schedule.

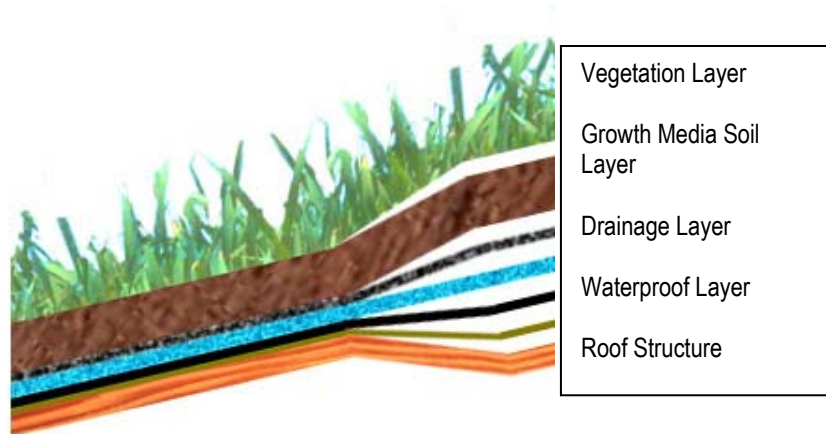


Dunnett and Kingsbury, pg.91

**Finally, avoid false economies** - Your green roof is a long-range investment. The highest return will come from thoughtful, responsive design engineering and stringent standards of installation and maintenance, giving you a trouble-free green roof for years to come.

## Materials - Let's start with a roof!

**All green roofs are comprised of the same basic components:** a waterproof layer, a drainage layer, the growth media (soil) layer and the vegetation layer. As mentioned earlier, check the pitch of your roof to see if it is suited for a green roof. (It may be wise to consult with a builder or architect to be sure your structure can support a green roof.) There are several green roof systems available on the market and choosing the right one for you will require some research.



### Waterproof Layer

The most expensive and important layer on a green roof is the waterproof layer. As its name suggests, it will prevent water from leaking through your roof as well as protect it from root penetration. There are a variety of waterproof membranes commercially available ranging from single-ply, heavy duty rubber sheets to roll-on liquid layers.

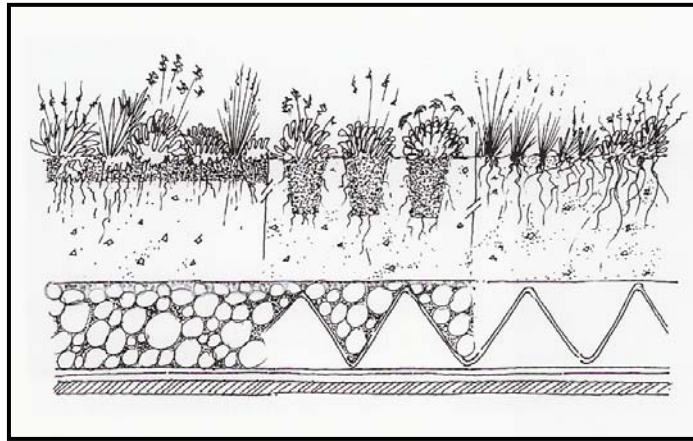
### Drainage Layer

The drainage layer can also vary from simple fabrics to systems that channel water through v-shaped troughs; once again you will have to select a product that works best with your roof and its pitch. A drainage layer is necessary for roofs with a pitch less than 5 percent.

Types of drainage material:

- 1) Coarse material like gravel, pumice, lava rocks, expanded shale or similar substances. This style of drainage is heavier in weight and allows air pockets to form providing plants better aeration.
- 2) Porous mats, such as Enka Drain, create paths for the water to drain easier. Over-retention of water can cause plants to drown.
- 3) Products such as Zinco's Floradrain has troughs that provide up to 1.5' of water storage. There is a system of channels on the underside for drainage of excess water below. Special holes allow aeration to the roots.





Shows the variety of drainage layers available (Dunnett and Kingsbury, pg.65)

### Growth Media

The growth media layer is the soil layer. Soil for green roofs must be lightweight and meet required saturated weights. The ideal soil mix will:

- Retain moisture
- Drain Excess Water
- Provide and absorb nutrients
- Anchor the plants

According to Dunnett and Kingsbury, "German research indicated that the ideal growing medium will comprise 30-40 per cent substrate and 60-70 percent pore space." Because the soil must meet so many requirements, artificial soils are often used. Most commercial green roof substrates are based upon non-organic mineral components that have moisture holding capacity, mimicking the function that organic material may achieve in conventional soils. Artificial soils include:

- Perlite
- Vermiculite
- LECA (Light expanded clay granules)

They are often mixed with other naturally occurring soils (sand, lava, pumice, gravel) to provide the best mixture for growing needs and structural requirements.

Substrate materials	Weight of a 1-cm layer (kg per square metre)	Weight of a 1-in layer (lb per square foot)
Gravel	16-19	3.3-3.9
Pebbles	19	3.9
Pumice	6.5	1.3
Brick (solid with mortar)	18	3.7
Sand	18-22	3.7-4.5
Sand and gravel mixed	18	3.7
Topsoil	17-20	3.5-4.1
Water	10	2.1
Lava	8	1.6
Perlite	5	1.0
Vermiculite	1	0.2
Light expanded clay granules (LECA)	3-4	0.6-0.8

Shows the variety of green roof materials at their saturated weight (Dunnett and Kingsbury, page 60)

The website [www.greenroofs.com](http://www.greenroofs.com) supports the idea of using organic material. They recommend that, "...using a mixture of native soil upgraded with organic or mineral additives (peat, humus, wood chips, sand, lava or expanded clay), it is possible to achieve optimum...

- Water retention
- Permeability
- Density
- Erosion Control

Soil Mix	Dry Weight	Saturated Weight	Formula
#1			30% organic matter (15% organic compost, 14% coconut husk) 1% decayed leaf matter or live ground soil, 70% aggregate (30% pumice, 40% perlite)
#2			10% organic compost, 1% decayed leaf matter, 30% fine bark, 15% coarse bark, 15% coarse perlite, 10% pumice, 20% coir
#3			15% compost, 35% fine bark, 25% coconut fiber, 25% perlite; added fertilizer, bloodmeal, bonemeal, regular and dolomitic limes
#4	40lbs./cu. ft.		60% pumice, 20% perlite, 10% lava rock, 10% compost

Shows the soils mixes being tested by the Northwest Ecobuilders Guild.

Some ambitiously green experiments are tested the use of soil mixtures comprised from recycled building materials, clay tiles, crushed concrete and sub-soils from building foundations.

## Plants

In the vegetation layer, the plants used on green roofs are Sedums, Delosperma, and Sempervivum. These species are hardy, drought-tolerant, grow well in sunny areas, have non-woody roots and require little maintenance. These plants are self-sustaining and look good throughout most of the year and also tolerate shallow substrates. Moreover, these plants work well in substrates ranging 1.6" up to 4". With a substrate of 4", other low growing plants, such as Dianthus, Thymus, Alyssum, to name a few, can be used to provide more color. Certain grasses and sedges, especially Festuca, can be effective in substrates with depths of 4"-6". There are several species that can grow on green roofs but the success depends on the depth of the substrate as well as their ability to deal with invasion from other plants. The plant list for green roofs is long and growing longer.



Roof garden covered with flowering Sedums (Dunnett & Kingsbury, page 107)

However, in many areas, people have been advocating for the use of native species only, claiming they are in sync with the local natural habitat. Here are some of the arguments for using native plants:

- Non-native plant species with invasive tendencies are a major problem in some regions. The use of non-natives avoids the danger of introducing potential “problem plants.”
- Native plants support local wildlife. In some cases insect larvae will only eat a particular species and no other.
- The use of regionally native vegetation replaces lost habitat.

There have been arguments against this, mainly stating, that local species may not do well on the roofs or are simply not hardy enough for roof-type environments.



A spontaneous green roof in Bellevue, WA

### **Pomegranate Center and Green Roofs**

At Pomegranate Center, we recognize that the physical environments of our cities, towns, and neighborhoods mirror the psychological landscapes of our mind. Therefore, we are trying to influence the way our society thinks about and designs communities. Our work is both practical and educational, spanning the hands-on construction of gathering places and public artworks with the ongoing education of what makes healthy communities and responsible community conduct.

Designed by Pomegranate Center, Landscape Architect J.T. Atkins and many dedicated community volunteers, the Pickering Farm Community Teaching Garden in Issaquah is an active garden that illustrates ways to minimize the effects of urban landscaping on the natural environment and the solid waste stream while also providing an inviting space for the community. It is a living classroom that can be used to educate residents and visitors on landscaping techniques that save water, improve water quality, improve natural habitat and reduce the amount of garbage Issaquah generates.



Pickering Farm Community Teaching Garden





Volunteers place waterproof membrane on the rooftops, the base layers to the green roofs.



A volunteer covers the roof with soil.

Pomegranate Center's involvement with the Pickering Farm Community Teaching Garden has gone beyond design. From the fall of 2002 to the fall of 2004, Pomegranate Center worked with the EcoBuilding Guild and close to 100 volunteers to build four kiosks, an outdoor classroom, two benches, and a fence. Green roofs were constructed on three of the kiosks on April 26th and 27th, 2003. The roofs were planted with strawberries and sedums.



A volunteer plants the roof with sedums and moss.



The roof is thoroughly watered.





Thanks to a grant from WaterWorks, the King County Water Quality Block Grant awarded by the King County Department of Natural Resources and Parks, and a donation from the Issaquah Rotary Club, Pomegranate Center built an outdoor classroom featuring a green roof in October of 2004. Pomegranate Center worked with Duncan Chalmers, Patrick Carey, and John Bacon to design and build the green roof, then held a one-day hands-on workshop to explain the details and benefits of green roofs and to plant the outdoor classroom.

### Materials Used by Pomegranate Center at the Pickering Farm Community Teaching Garden



#### Soil Mix:

- 10% Diatomaceous Earth
- 15% Red Lava Rock
- 60% Large Pumice Rock (3/8)
- 15% Organic Compost (Cedar Grove)



Drainage Mat and Filter Fabric  
Delta Drain 9000 or Miradrain 9900  
Westside Concrete Supply  
Phone: 253-804-9439  
Fax: 253-833-8392  
Address: 3705 W. Valley Hwy. N.  
Auburn, WA 98001

Drainage Mat & Filter Fabric  
 Enkadrain 3611R or 9120 Dependable  
 Construction Supply  
 206-362-3005  
 206-362-1618  
 10920 Whitman Ave North  
 Seattle WA 98177



Waterproof Membrane and Roofing  
 TPO 60mil & Ice and Water Shield 200  
 Intermountain Supply  
 206-624-8881  
 206-624-1771  
 3700 6th Avenue South  
 Seattle WA 98134  
[www.intermountainsupply.com](http://www.intermountainsupply.com)

Metal Cap Flashing  
 Custom Metal Bending and Supply  
 Pacific Sheetmetal  
 206-682-5354  
 111 South Spokane Street  
 Seattle WA 98134



Plants  
 Delosperma congestum  
 Delosperma nubigenum 'basutoland'  
 Sedum album 'Murale'  
 Sedum 'Angelina'  
 Sedum Angelicum 'Valle De Al'



Sedum 'Button'/Stonecrop Button  
 Sedum hispanicum 'Blue Carpet'  
 Sedum kamaschaticum 'Variegatum'  
 Sedum stefco  
 Sempervivum tectorum 'Hen and Chickens'  
 Thymus serpyllum 'Albus'  
 Thymus serpyllum 'Elfin'





Hayes Nursery  
12504 Iss-Hobart Rd SE  
Issaquah, WA 980275  
(425) 391-4166  
[www.hayesnurdery.com](http://www.hayesnurdery.com)

Squak Mt. Nursery  
7600 Renton-Issaquah Rd SE  
Issaquah, WA 98027  
(425) 392-1025  
[www.squakmtnursery.com](http://www.squakmtnursery.com)

*This manual was written by Alyssa Martin, as part of her AmeriCorps Community Action Project. If you have any questions please email [alyssalmartin@gmail.com](mailto:alyssalmartin@gmail.com)*

*Special Thanks to:*

*Laura Cacho, Carolyne Orazi, John Bacon, Chrys Bertolotto, Issaquah Rotary Club, King County Waterworks, Christie O'Brien, Duncan Chalmers, Patrick Carey*

## Additional Resources

**Duncan Chalmers – Project Manager at Pomegranate Center 425.557.6412**  
**[Duncan@pomegranate.org](mailto:Duncan@pomegranate.org)**

**Patrick Carey – Residential Green Roof Expert at NW EcoBuilding Guild**  
**[pkc@hadj.net](mailto:pkc@hadj.net)**

## Websites

[www.pomegranate.org](http://www.pomegranate.org)  
[www.hadj.net/green-roofs](http://www.hadj.net/green-roofs)  
[www.ecobuildingguild.org](http://www.ecobuildingguild.org)  
[www.roofmeadow.com](http://www.roofmeadow.com)  
[www.greenroofs.com](http://www.greenroofs.com)  
[www.zinco.de](http://www.zinco.de)  
[www.hydrotechusa.com](http://www.hydrotechusa.com)  
[www.garlandco.com](http://www.garlandco.com)  
[www.esw.org](http://www.esw.org)

## Books and Articles

Alexander, Ron. Biocycle. "Green Roofs Grow...With Brown Compost," Sep 2004. Vol. 45, Iss. 9; pg. 55

Cowie, Denise. Knight Ridder/Tribune News Service. "Green roof technology beginning to catch on in U.S." march 14, 2002

Daniels, Elizabeth. Seattle Daily Journal of Commerce Online Edition. "Green Building starts at top." September 14, 2000

DeLorenzo, Josephine. Environmental Design + Construction. "Garden Roof: Enlisted in Fight for Environment." May 2004, Vol. 7, Iss. 4; pg. S6

Dunnet, Nigel and Kingsbury, Noel. Planting Green Roofs and Living Walls. Portland; Timber Press, 2004

Dr. Stephen Kellert. The Green Roof Infrastructure Monitor. "Beyond LEED: From Low Environmental Impact to Restorative Design," Spring 2004, Vol. 6, No.1

Velazquez, Linda S. "Sky Gardens – Travels in Landscape Architecture". August 2004. [http://www.greenroofs.com/archives/sg\\_aug-sep04.htm](http://www.greenroofs.com/archives/sg_aug-sep04.htm)

Wingate, Mary. Seattle Post-Intelligencer. "Raising the Roof; How green is your roof? Landscaping is rising to a new level," September 2, 2004, pg. F.8

*WaterWorks*



King County

Department of  
Natural Resources and Parks  
Water and Land Resources Division

POMEGRANATE  CENTER



**GETTING THINGS DONE**



The creation of this manual was made possible through WaterWorks, the King County Water Quality Block Grant awarded by the King County Department of Natural Resources and Parks.