

Green Roof Feasibility Review

King County Office Project
March 25, 2004

Overview

King County is working with Wright Runstad to develop a new 220,000 square foot office building. King County will be the tenant under a long-term lease. The County is interested in exploring a green roof as a sustainable design strategy. This study outlines green roof issues, benefits, costs and case studies for local, urban commercial projects.

In general, green roofs are applicable and feasible for commercial buildings in the Pacific Northwest. They are a proven strategy, with many local examples. As this technology is highly interactive with other building systems it should be reviewed in conjunction with other strategies to select those that are cost effective and that align with priorities set by the County.

What is a Green Roof?

A green roof is a lightweight, vegetated roof over a protective root barrier and a roof membrane. Green roofs are also known as 'Ecoroofs'. Green roofs offer many features not present in a conventional membrane roof. First, the vegetation and soil layers protect the waterproof membrane from solar exposure, prolonging roof membrane life. Second, the soil provides additional insulation and shades the roof from solar heat gain. Third, green roofs create many environmental benefits, including stormwater mitigation, oxygen transfer for increased air quality, and increased wildlife habitat in urban spaces.

Types of Green Roofs

There are two types of green roofs: Extensive and Intensive. Either type will need temporary irrigation or watering for establishment. The following descriptions highlight the main features of each green roof type.

1. **Extensive:** Extensive green roofs are typically not designed for foot traffic or occupancy except for maintenance. They are detailed to minimize the additional load on the roof structure, with only 2-6" of soil, have minimal plant diversity and require minimal maintenance. These features result in the lowest capital cost of the different green roof types. Extensive roofs may also be placed in special trays that rest on the membrane allowing for ease of replacement or access to the roof structure or membrane. Extensive roofs may 'brown-out' over dry summers, but dormant plants revive once the rainy season begins.
2. **Intensive:** Intensive green roofs may be accessible as a roof garden, similar to the landscaped areas at the King Street Center plaza above the parking garage. This type of green roof will have deeper soil, and therefore heavier

weight. The deeper soil allows more plant diversity, and will have higher maintenance than extensive green roofs. Soil depth is typically between 8-24". Intensive roofs typically are more attractive than extensive roofs during the dry season, and may be irrigated depending on soil depth, plant selection and location.

Extensive green roofs have recently been installed at the Seattle Justice Center and the Seattle City Hall. Over 10 extensive green roofs have been installed on Portland buildings, both commercial and residential. See Table 3 for non-residential examples. For an urban rooftop where regular access is not desired, an extensive green roof is the typical choice.

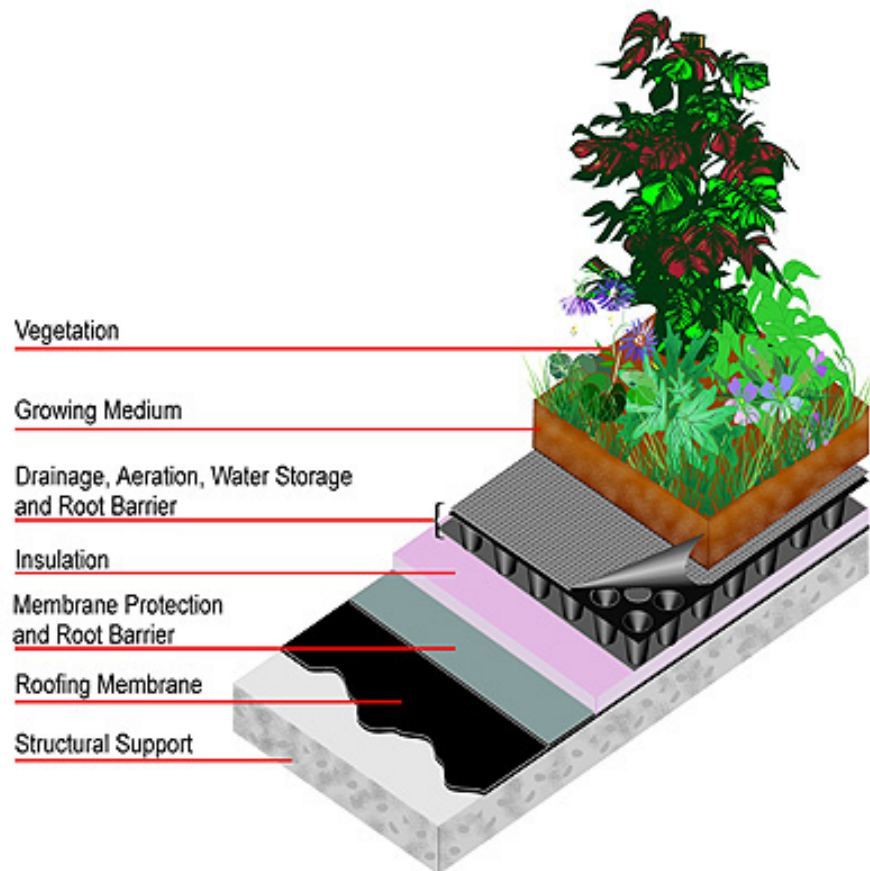


Figure 1: Typical Green Roof Cross-Section

Source: American Wick Drain Corp.

Benefits of Green Roofs

There are many benefits associated with green roofs (extensive or intensive) that accrue to different parties. Support for use of the system will vary depending on the beneficiary's perspective. A building owner's view may focus on costs, amenities and marketability. The County's focus is on the environment, the building occupants, public education and stewardship of taxpayer funds. Details of these benefits are outlined below.

Benefits to the Building Owner/Developer

Economic Benefits

- Protection of roof membrane extends roof life, up to twice as long as conventional roofs. Saves membrane maintenance and replacement costs, which will offset some of the maintenance associated with the green roof.
- Reduces heating and cooling energy costs due to shaded roof and increased insulation value.
- Energy savings create subsequent potential to downsize HVAC equipment.
- Offsets other roof insulation costs.
- Potential for Seattle City Light energy incentives for energy saving strategies, if located within Seattle limits.
- Green roofs can help slow the spread of fire. Just as firebreaks are provided in at-grade landscape areas, firebreaks should be included on the roof.
- Stormwater infrastructure or stormwater fees may be lowered due to reduced stormwater flows.

Community Benefits

- Roof garden may count toward open space requirements, if it is accessible to building occupants, or to the public in the case of green roofs over below grade parking garages.
- Lower story roofs are more attractive to upper story occupants.

Benefits to King County

Economic Benefits

- The economic benefits listed under Building Owner may also accrue to King County, if savings are passed through in the lease arrangement.
- Cost savings from decreased need to expand or rebuild related infrastructure, based on the increased stormwater retention capacity of the green roof.
- Productivity benefits associated with increased sound insulation and worker satisfaction.

Community Benefits

- Health, well being and worker satisfaction benefits if roof is accessible to occupants.
- Supports local economy and demand for recycled products including compost, mulch, local nursery plantings

Environmental Benefits

- Improved air quality due to filtration of air-born particulates & carbon dioxide/oxygen exchange by plants.
- Stormwater retention and water filtering: green roofs capture between 10-100 percent of impinging precipitation.
- Temperature regulation that moderates heat build-up, known as “urban heat island effect”. This impacts local environment, and society health care costs associated with air quality and ozone levels.
- Creation of microclimate increases green space used by birds.
- A green roof over 50% of the roof area earns 1 LEED point for Sustainable Sites (SS) credit 7.2 Urban Heat Island Reduction and contributes to Stormwater Management under SS credit 6.1 and Stormwater Treatment under SS credit 6.2.

Costs of Green Roofs

Green roofs have a higher initial construction cost almost twice that of a conventional roof installation or about \$10 to \$15 per square foot. However, a simple comparison of first costs does not consider the entire cost equation. A green roof has several features that add long-term value that are not present in a conventional roof. These features are typically overlooked in the standard “value-engineering” process. In addition to first cost, other costs related to insulation levels energy consumption, increased durability of the roof membrane, open space and maintenance issues.

Table 1: Green Roof & Conventional Roof Costs

| | Green Roof Cost per S.F. | Conventional Roof Cost per S.F. | Delta |
|-----------------------------|------------------------------------|---|--------------|
| First Cost | \$10 - \$15 | \$3 - \$9 | |
| Mean | 12.50 \$/SF | 6.00 \$/SF | 6.50 \$/SF |
| Re-Roofing | \$15 - \$25 | \$5 - \$20 | |
| Membrane Replacement | 0.00 \$/SF | 3.25 \$/SF | -3.25 \$/SF |
| Drainage | 0.013 \$/SF | 0.021 \$/SF | 0.008 \$/SF |

Source: City of Portland Ecoroof Program: Bureau of Environmental Services estimates based on City of Portland demonstration projects, and information obtained from roof contractors.

First cost includes structural support

Life Cycle Cost Analysis

Once project-specific details are available, a Life Cycle Cost Analysis of major sustainability features should be performed for King County’s office project if there is further interest in incorporating a green roof. A typical green roof has an expected life span of approximately 40 years. Many roof membranes typically only last 10 to 20 years before replacement; many may require patching or other repair as well. Exposed membranes are susceptible to ultra-violet radiation which degrades the membrane. These factors can result in a total cost of ownership for the green roof that is within 10% of a conventional roof design. Trade-offs in the initial construction budget can also be used to keep total project costs within established funds.

Table 2: Roof Comparative Life Cycle Analysis

| Green Roof | |
|--------------------------------|---------------------|
| Straightline Costs and Savings | |
| years | 40 |
| discount | 2.0% |
| First Cost | \$ (462,500) |
| Annual maintenance savings | \$ 500 |
| Annual drainage savings | \$ 206 |
| Annual energy savings | \$ 1,125 |
| Subtotal Annual Savings | \$ 1,831 |
| PV | \$ 50,094 |
| NPV | \$ (412,406) |

| Conventional Roof | |
|--------------------------------|---------------------|
| Straightline Costs and Savings | |
| years | 40 |
| discount | 2.0% |
| First Cost | \$ (300,000) |
| Annual Savings | \$ - |
| PV | \$ - |
| NPV | \$ (300,000) |

| Future Cost of Roof Replace 1 | |
|--------------------------------------|--------------------|
| years | 20 |
| discount | 2.0% |
| Future Cost | \$ (81,250) |
| PV | \$ (54,679) |
| NPV | \$ (54,679) |

| Future Cost of Roof Replace 1 | |
|--------------------------------------|---------------------|
| years | 20 |
| discount | 2.0% |
| Future Cost | \$ (162,500) |
| PV | \$ (109,358) |
| NPV | \$ (109,358) |

| Future Cost of Roof Replace 2 | |
|--------------------------------------|--------------------|
| years | 40 |
| discount | 2.0% |
| Future Cost | \$ (81,250) |
| PV | \$ (36,797) |
| NPV | \$ (36,797) |

| Future Cost of Roof Replace 2 | |
|--------------------------------------|--------------------|
| years | 40 |
| discount | 2.0% |
| Future Cost | \$ (162,500) |
| PV | \$ (73,595) |
| NPV | \$ (73,595) |

| Cost of Plant Maintenance | |
|----------------------------------|----------------|
| Year 1 | |
| years | 0.0% |
| discount | 0.02 |
| Future Cost | (\$ 15,000.00) |
| PV | (\$ 15,000.00) |
| NPV | (\$ 15,000.00) |

| | |
|-----------------------|------|
| Overall discount rate | 2.0% |
| Percent of Green Roof | 50% |

| Year 2 | |
|-------------|----------------|
| years | 1 |
| discount | 0.02 |
| Future Cost | (\$ 15,000.00) |
| PV | (\$ 14,705.88) |
| NPV | (\$ 14,705.88) |

| | |
|------------|--------------------|
| TCO | (\$533,588) |
|------------|--------------------|

| | |
|------------|--------------------|
| TCO | (\$482,953) |
|------------|--------------------|

Note:
PV = F/(1+d)t

Local Green Roof Projects

The environmental concerns associated with urban development and buildings include stormwater overflow into streams and water bodies, demand for water treatment infrastructure and overburdening of freshwater sources. In both the Seattle and Portland greater metro areas, this has meant particular focus on building issues related to regional water quality. That, in combination with the environmental mindset of the Pacific Northwest, has resulted in green roofs being incorporated in dozens of projects in this region. Table 3 lists a sampling of local projects, focusing on urban, commercial and commercial-scale projects in the Northwest.

Table 3: Pacific Northwest Case Studies

| Green Roof Project | Location | Type | Size | Owner/Developer |
|---|-----------------|-----------------------|-------------|--|
| B&O Building | Portland, OR | Extensive, Re-Roofing | – | – |
| Jean Vollum Natural Capital Center | Portland, OR | Extensive | 6,000 SF | Ecotrust |
| King County Airport | Seattle, WA | Intensive | 8,000 SF | King County |
| Mountain Equipment Co-op | Vancouver, B.C. | Extensive | – | Mountain Equipment Co-op |
| Multnomah County Building | Portland, OR | Extensive | 15,420 SF | Multnomah County |
| People's Food Co-op | Portland, OR | Extensive | 210 SF | People's Food Co-op |
| Seattle City Hall | Seattle, WA | Extensive | 8,000 SF | City of Seattle |
| Seattle Justice Center | Seattle, WA | Extensive | 7,300 SF | City of Seattle |
| Vancouver Public Library | Vancouver, B.C. | Intensive | > 20,000 SF | City of Vancouver |
| Waterfall Mixed-Use Building | Vancouver, B.C. | Intensive & Extensive | – | Hillside Developments Limited, Steven Hynes (604) 922-4722 |
| Fairmont Waterfront Hotel | Vancouver, B.C. | Intensive, Re-Roofing | 2,100 SF | Canadian Pacific Hotels |

The Jean Vollum Natural Capital Center



Figure 2: The Natural Capital Center

Green Roof Data

Type: Extensive

Size: 6,000 square feet

Cost: \$75,000 over conventional roof cost

Building Data

Location: 721 NW 9th Avenue, Portland, Oregon

Construction Cost: \$12.4 million (\$140/square foot)

Developer: Heritage Consulting Group

Owner: Ecotrust

The Jean Vollum Natural Capital Center is home to a community of non-profit and business tenants. The historic building in downtown Portland reopened in 2001 after renovation and addition of a third floor. The renovation included installation of a roof deck, rooftop fireplace and a green roof. The rooftop is an amenity to tenants and is a favored gathering space.

Viewable from the roof deck, the extensive green roof is accessible only for maintenance. The roof was designed using the German Famos system. This lightweight system includes a waterproof membrane, copper root barrier, drainage layer, 2" - 4" of soil and regional herbs, succulents and grasses. The drainage layer is white unwoven polyester, which holds packets of hydrogel crystals that swell up to store water. When it rains, the crystals swell with water, forming peaks. Overflow is directed to the narrow valleys in between peaks, which serve as drainage outlets.¹

The project incorporates many sustainable design features, including stormwater filtering by the green roof and bioswales in the parking lot. Additionally over 80% of the site's run-off is used to irrigate the landscaping. The project also recycled construction waste, installed low-emitting and recycled materials, and was designed to maximize access of natural light and views to building occupants. The project received a LEED Gold rating from the USGBC.



Figure 3: Plant Types Used at the Natural Capital Center

The Fairmont Waterfront Hotel Herb Garden



Figure 4: Waterfront Hotel Herb Garden in Spring

Green Roof Data

Type: Intensive

Size: 2,100 square feet

Cost: \$25,000 Canadian re-roofing/renovation cost

Building Data

Location: 900 Canada Place Way, Vancouver, British Columbia

Owner/Developer: Canadian Pacific Hotels

The Fairmont Waterfront Hotel restaurant boasts its own herb garden, in the midst of downtown Vancouver. The green roof garden supplies \$20,000-\$25,000 of herbs to the restaurant annually, easily paying back the initial \$25,000 construction cost.ⁱⁱ As the roof is accessible as landscaped open space used by the hotel and guests, it is thoroughly maintained, similar to any plaza or courtyard landscaping. Annual maintenance costs are approximately \$16,000. This intensive roof consists of a concrete slab with a waterproof 2-ply monolithic membrane by Hydrotech, 12 inches of foam insulation, a drain cloth, rocks and soil. The roof slab was minimally upsized to accommodate the weight of soil and plants.

In addition to herb production, the terraces also provide a desirable amenity to guests. Rooms that open onto the south terrace herb garden are special – having taller ceilings, more elaborate décor and private terrace areas, and rent for \$80 more per night than other rooms in the hotel.

ⁱ Roof anatomy from Rebuilt Green by Von Hagen, Bettina, Erin Kellogg, and Eugenie Frerichs, Editors.

ⁱⁱ Roof garden and hotel information from “Green Roof Herb Garden Case Study” by the Canada Mortgage and Housing Corporation (CMHC).