**BASIC MAINTENANCE AND PERFORMANCE EVALUATION INFORMATION FOR GREEN ROOFS**

This section addresses green roof vegetation maintenance only. Consult with a roofing consultant or manufacturer for roof membrane maintenance requirements.

Green roof maintenance is particularly important during the first five years after green roof installation, to ensure vegetation becomes well established. It is recommended that the first five years of maintenance are included in the installation contract. Once the vegetation is well established - i.e. once most of the green roof surface is covered with desired plants, invasive species are minimal, and there are very few areas of bare ground - maintenance is still crucial, but maintenance needs typically decrease. Depending on the density, condition and species of vegetation planted, climate, and maintenance, a green roof is typically well established within two to five years after planting.

Level of maintenance needed is influenced by many factors, such as, for example, project goals, and project location (eg proximity to weed sources, views of the roof), rainfall and irrigation, and growing medium depth.

Because some maintenance will always be needed on a green roof (and also on a traditional roof), it is crucial to budget for maintenance and maintenance inspections during the project planning stages and identify responsibilities for that maintenance.

The plants and soil conditions that characterize green roofs are unfamiliar to most landscape service contractors. Therefore, it is always preferable to look for a contractor with experience in green roof services.

Typical green roof maintenance tasks include:

* + - 1. **Weeding**

While some weeding will always be necessary on a green roof, as green roofs will always be exposed to weed seeds, for example, via wind and birds, weeding is particularly important during the establishment phase, when the roof is not yet fully vegetated and there is more open ground in which weeds can germinate. If weeds are left to spread uncontrolled, they can choke out desirable plants and compete with desirable plants for nutrients and water. Since tree roots can damage roofing components, timely tree seedlings removal is especially crucial.

Weeds that are especially common on green roofs include, for example:

* Poplar seedlings, Populus species
* Clover species, Trifolium species
* Spotted Spurge, Euphorbia maculata
* Horseweed, Conyza Canadensis
* Dandelion, Taraxacum officinalis
* Foxtail, Setaria species

Do not use herbicide or pesticides or any other chemicals that could negatively affect the roofing membrane or warranty.

Vegetation free zones (hyperlink to definition) as well as vegetated areas will require weeding.

Maintenance specifications should state performance requirements (see example performance requirements at the end of this draft task 6 memo). Control invasive species to the required maintenance specifications.

Once the vegetation is established, a green roof typically needs to be weeded 2-3 times a year if done strategically at times just before weeds go to seed. Green roofs should be weeded more frequently if needed to prevent weeds from setting seed, or if tree seedlings or any other species threaten the integrity of the roofing assembly. Pulling weeds when they are small and before they set seed will maximize weeding efficiency. Weed cycles on the roof should be noted and weeding schedules adjusted to maximize effectiveness. If frequent observations of the roof condition are not practical, then more frequent weeding should be scheduled.

* + - 1. **Plant Replacement**

Some plant mortality is normal during the green roof establishment period. Good maintenance specifications will state how much plant mortality is acceptable, as well as required plant cover and diversity every year of the maintenance. Maintenance tasks need to include replacing plants as needed to meet project requirements.

In many instances, areas with disappointing or sparse plant coverage or diversity can be remedied by harvesting cuttings, seed, or healthy plants from other areas of the roof and transplanting. Micro-climatic factors can have dramatic effects on plant success. Over a space of years, it will become obvious which plant species are most stable on the various areas of the roof, and the green roof can be nudged toward the plant assemblages that perform best on the roof.

* + - 1. **Irrigation**

*During the establishment period*

* Almost all green roofs require irrigation during the establishment period (unless adequate rainfall occurs). Overhead watering is usually needed immediately after installing plugs, seed, or cuttings. Even green roofs with underground drip irrigation systems will need overhead watering until the roots have grown enough to reach water from the driplines.

*After the vegetation is well established*

* Irrigation requirements after establishment will depend on the plant species chosen, project goals, and the water holding capacity of the green roof growing medium and other components.
* Extensive green roofs planted with drought tolerant vegetation such as Sedums typically do not need irrigation once established if adequate growing medium depth is provided.
* See Task 5 for pros and cons of permanent irrigation of extensive green roofs.

During the establishment period and after vegetation is established, initial estimates of seasonal irrigation demand should be adjusted based on field observation. During each maintenance visit the moisture conditions should be investigated at the bottom of the profile (usually the level of the filter fabric). During dry weather conditions, media on irrigated roofs should be moist and cool to the touch, but not saturated. Fabrics exposed at drains should be wet, but little or no water should be escaping at the drain.

If plants are irrigated with harvested water, consult with an irrigation consultant or other professional to determine whether periodic testing of irrigation water may be recommended.

* + - 1. **Fertilization**

Green roofs may need periodic fertilization. To minimize leaching of fertilizer into stormwater runoff, fertilize (only) if/when soil tests or plant health indicates lack of nutrients. Fertilizing only when fertilizing is needed also lessens weed growth and maintenance needs. If fertilizing a green roof, use slow release, organic fertilizer in the spring. Avoid using compost derived from animal waste, which may leach excessive nitrogen and phosphorus (Hathaway et al., 2008). Generally, phosphorus-containing fertilizers can be avoided entirely. See soil tests below for guidance on determining whether or not fertilization is needed.

* + - 1. **Soil Tests**

Annual green roof soil tests are recommended to manage soil for maximum plant vigor while also minimizing nutrient leaching. Based on over 740 soil samples from Penn State, Berghage (no publication year given) recommends green roof maintenance aims for the following ranges for green roof media soil test results using the modified (DTPA)saturated paste extract (SME)test method:

**Table x. Recommended green roof growing medium parameter ranges:**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Recommended Range for Extensive Green Roofs** | **Recommended Range for Intensive Green Roofs** |
| pH | 6.5-7.8 | 6.5-7.8 |
| Nitrate (mg/L) | 1-4 | 2-32 |
| Ammonium (mg/L) | 0.1-0.8 | 0.1-0.8 |
| Nitrogen (mg/L) | 2-8 | 2-32 |
| Phosphorus (mg/L) | 2-10 | 2-15 |
| Potassium (mg/L) | 8-32 | 8-64 |
| Calcium (mg/L) | 100-300 | 100-300 |
| Magnesium (mg/L) | 10-80 | 10-80 |
| Iron (mg/L) | 8-32 | 8-32 |
| Manganese (mg/L) | 1-8 | 1-8 |
| Boron(mg/L) | 0.04-0.6 | 0.04-0.6 |
| Sodium (mg/L) | <20 | <20 |
| Zinc (mg/L) | 1-10 | 1-10 |
| Soluble Salts (mmhos/cm) | 0.4-1.2 | 0.4-1.2 |
| Sodium Absorption Ratio - SAR | <2 | <2 |

The above ranges are for mature green roofs. Higher nitrogen levels are recommended for green roofs during establishment.

* + - 1. **Spring Cleanup**

If dried vegetation from the previous season is thick or tall enough that it will negatively affect spring growth, remove dried vegetation using a scythe, trimmer, or weed-whip prior to spring growth flush.

**Other Factors to Consider during Green Roof Maintenance Period**Ensure that activities not directly related to green roof maintenance do not negatively impact green roof vegetation. Ensure, for example, that green roof vegetation is not damaged by activities such as power washing, any activities related to rooftop equipment, or use of any cleaning agents or other chemicals.

**Maintenance Inspections**

Maintenance inspections should monitor whether or not project requirements are being met. Inspections should be conducted at least once a year, and should be conducted more frequently during the establishment phase and should also be conducted more frequently as needed beyond the establishment phase, for example, if the roof is not meeting project requirements. Written reports of inspections should be reviewed prior to each subsequent inspection. A sample maintenance inspection checklist is included in appendix x.

**Photographical Record**

Photograph the green roof at each maintenance inspection for historical documentation of roof condition over time. Photos taken from the same location and view are recommended to track change over time. Photos of areas in need of maintenance are also recommended for a photographical record of effectiveness of maintenance practices (e.g. weeding, supplemental planting).

**Examples of Vegetation Performance Requirements**

1. **For acceptance of installation:**

**Set the following requirements for, for example, 30 days after Substantial Completion, for roofs established using cuttings, pre-grown modules, or mats:**

* Minimum percent cover of specified plant species required.
* Maximum percent cover and patch size of weed species (if any).
* Maximum square feet of bare area allowed.
* Minimum thickness of media.
* All areas that do not meet Performance Standards 30 days after installation shall be re-planted with original plant species and densities within 14 days of notification unless weather conditions are not suitable for planting as determined by Owner’s Representative.

**Set the following requirements for, for example, 30 days after Substantial Completion, for roofs established using plugs, or pots:**

* Minimum percent of plants that are healthy as determined by Owner’s Representative
	+ Crowns of plants level with top of media
	+ Vigorous foliage
* Root balls broken and integrated into the soil
* Maximum square feet of area of bare area allowed (excluding any areas that have been established from seed alone)
* Minimum thickness of media
* All areas that do not meet Performance Standards 30 days after installation shall be re-planted with original plant species and densities within 14 days of notification unless weather conditions are not suitable for planting as determined by Owner’s Representative.
1. **For acceptance of maintenance:**
* Minimum percent cover of specified plant species required for each year of the maintenance period.
* Minimum number of species present on the roof each year of the maintenance period, can also specify desired minimum percent cover needed to count as species diversity if desired.
* Maximum percent cover and patch size of weed species (if any).
* Maximum square foot of bare area allowed each year of the maintenance period.
* Vegetation will be replaced with species and densities acceptable by Owner’s Representative anytime vegetated cover requirements are not met during the maintenance period.

**Recommendations On The Utility Of Developing Maintenance Specifications**

Because exact maintenance requirements vary from roof to roof, we do not recommend developing maintenance specifications, but recommend developing example maintenance performance requirements, such as the ones above, instead. Alternatively, we can provide a SAMPLE maintenance specification. The danger with providing a SAMPLE maintenance specification though is that some designers may use the sample specification for roofs where the sample specification is not suitable.

**REFERENCES**

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