A Professional Guide to Green Roof Installations

George A. Irwin

Now available to the public!

A no nonsense guide to green roofs for the DYI and professional!

This is the only green roof book you will ever need!

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A Professional Reference

George A. Irwin
"The Green Wall Editor via www.greenroofs.com"

Your no-nonsense guide to installing green roofs

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Preface

After 13 years of research, industry involvement and multiple patents I am always amazed by the quality of green roofs around the world. I speak of quality from both ends of the spectrum--there have been some really great and functional green roofs and just as many of the not-so-great ones. There are some that the manufacturers literally made up as they went along. Since 1999, I have watched the industry undergo a transformation from heavy multilayered and time-consuming built-up systems with gravel drainage to plastic trays, sandbag-like socks, and rolled-up vegetation. Projects became more intense and parklike with thirty-foot trees, major water features, putting greens, sports fields, hills, farms and undulations, and amenity space that will made you forget you're on a rooftop.

The multilayered green roof technology introduced to the U.S. market provided increased material sales, an opportunity for higher budgeted waterproofing, and for geotextile and fabric recyclers to sell products while these extra layers were simply a means to increase profits and create an additional overburden. For every manufacturer, installer, designer, architect and engineer, there may be many opinions for materials, system buildups, plants, irrigation, etc. Since most working architects, engineers, and specifiers did not study green roof installations as part of their university education, and few had any authentic application or hands-on experience with green roofs, they were at the mercy of the media, landscaper or product representative to teach and explain how the product they sold was the best choice for their project. Unfortunately, these sales representatives have worked for multiple companies with varying degrees of similar products and services. Often the one they want to sell you is, in their opinion, the best one because it is their livelihood.

The intent of the book is to bring simplicity back to green roof building. Technology and modern materials have changed the way designers and installers can provide cost savings and product performance with simple applications. I hope you find this book informative, revealing and easy to understand.

"Just because green roofs, green walls, and agriculture are taught in a classroom does not guarantee students have the knowledge, skills, and ability to perform installation/maintenance duties in a safe, effective and successful manner. An authentic learning approach involves engaging and reflective experiential learning opportunities in addition to a classroom experience."

Respectfully,
George Irwin

Chapter 1: History of the Green Living Technologies International LLC and GLT Institute, LLC

Green Living Technologies Institute (GLTi) was born of curiosity more than anything else. In 1999, CEO & President George Irwin, a landscape contractor and teacher, was asked to consult for a roof garden. This was around the time some of the first green roofs were being built in the United States. Due to a lack of experience and knowledge this green roof project did not proceed but the green roof concept piqued George's interest. By working with European techniques, his existing landscape contracting business was transformed from doing only landscaping to designing and building Green Living Roofs. George devised ways to simplify the traditional green roof technologies and the changes in materials and techniques provided a whole system approach that allowed for cost savings and added technology benefits. Since then, his system of new green roof products has made them safer and easier to install, less expensive, and superior in performance to prior technologies.

The traditional built-up systems were too cumbersome and labor-intensive, so George's patented Green Living Roof combined all the key layers of a built-up green roof, increased the amount of stormwater retention, and made the system lighter and easier to install. The design improved traditional multilayered green roof systems into an easy "pick up and put down" method. Single system, modularity, plant health, water retention, and lower labor requirements were the end benefits.

In 2004, George recognized that not all roofs are flat and that there was a need for a system to accommodate sloped applications. The Green Living Wall was introduced as a sloped green roof application and after a few modifications was able to support pre-grown plants on extreme slopes and vertical planes. After five generations of product improvements the patented Green Living Wall has become the global benchmark of success for Living Walls.

2006 marked the year of the edible wall and roof farms. The Green Living Wall had evolved into edible walls or vertical farms growing produce. Now, there are larger scale "food factories" growing food vertically indoors throughout the year, without the use of hydroponics. With the addition to many other product applications involving vegetative technologies the demand for training and education was fueled by George's work in Los Angeles growing and installing 750 square feet of vertical farms to help feed the homeless population. The first training class was implemented Cal Poly and attended by a handful of the homeless population his company worked with. It was through these workshops and training classes that his company taught community members life changing skills and Green Living Wall technologies that have revolutionized urban farming around the world. Known as GLTi for short,

the GLT Institute is offically GLT Institute LLC, and the focus of the company was to provide advanced training, workshops, and an educational curriculum while continuing to develop new and improved products. The GLTi workshops and certification has attracted over 1,500 attendees from 9 countries including the United Arab Emerities, Qatar, Honduras, Chile, Canada, Turkey, Mexico and Ireland.

The no-nonsense methods have simplified green roof applications. In addition to the cognitive application, GLTi provides additional support, unlike any other company in the indusrty. Certified installers are supported with help quoting projects, job site supervision and authentic learning opportunities where attendees can participate in real project installations.

The best way to learn is to get certified and get to work! We assure you are not guessing at estimates, miscalculating labor hours, nor overlooking an important element to the project. We will continue to be here for you as long as you need us. We want to work with highly qualified and talented individuals and organizations. It is in our best interest to retain and continue to educate our partnerships and talented pool of installers and maintenance technicians.

Above – Teachers and staff members learn to install a green roof as part of a university-wide curriculum at Cal Poly.

Chapter 2: A History of Green Roofs

Humans have grown plants atop structures since antiquity. The ziggurats of ancient Mesopotamia had plantings of trees and shrubs on aboveground terraces. An example in Roman times was the Villa of the Mysteries in Pompeii, which had an elevated terrace where plants were grown. A roof garden has also been discovered around an audience hall in Roman-Byzantine Caesarea. The medieval Egyptian city of Fustat had a number of high-rise buildings that Nasir Khusraw in the early 11th century described as rising up to 14 stories, with roof gardens on the top story complete with ox-drawn water wheels for irrigating them.

Historical Periods

- The Stone Age
- Ancient history
- Mesopotamia (3500 BC - 559 BC) *King Nebuchadnezzar II, Hanging Gardens of Babylon*
- Ancient Rome (509 BC-AD 476)
- Roman-Byzantine (from approximately 306 AD to 1453 AD)
- Middle Ages (Europe, 4th century - 15th century)
- Early modern period (Europe, 16th century - 18th century)
    - Elizabethan period (United Kingdom 1558-1603)
- Modern era (18th century - 20th century)
    - Industrial Revolution (Europe, United States, elsewhere 18th and 19th centuries)
    - Machine Age (1900 - 1945)
    - Age of Oil (after 1901)
    - World War I (1914 - 1918)
    - The Great Depression (1929-WW2)
    - World War II (1937 or 1939 - 1945)

Icelandic Sod Roofs Photo by Leslie Larsen

Icelandic Sod Roofs Photo by Penguinatlaw

- *Rockefeller Center Green Roof*

Rockefeller Center Green Roof Garden
www.indiancinemafans.com

- Atomic Age (after 1945)
- Post-war era (1946-1962)
- The Sixties (1960-1969)
  - *Peace, Love and Environmental Awareness*
  - *German Green Roof Technology*
- The Seventies (1970-1979)
  - Modern Green Roof movement we know today starts in the late 60's early 70s in the German speaking countries of Europe.
  - US Introduction to IMRA Roofs Inverted Membrane Roof Assembly
  - Heavy, Costly and High Failure Rates
  - Now know as Protected Roof Membrane (PRM) with improved technology
- The Eighties (1980-1989)
  - Improved waterproofing technology
  - Additional green roof materials started to appear
  - Built-up green roof technology, multiple layers
- The Nineties (1990-1999)
  - Switzerland initiates federal law Green Roof policy
  - Additional policy implemented in UK, Tokyo
  - Green Roof installations dominate Chicago, Washington DC, as well as Atlanta & Portland
  - Other major cities recognize the benefits of Green Roofs
  - Green roofs are installed in New York, Philadelphia, Toronto, and Vancouver
- 2000 – Present
  - Policy and Incentives for North America
  - LEED Rating system for Green Buildings include Green Roofs
  - ASTM - In October, 2001, the American Society for the Testing of Materials (ASTM) established a Green Roof Standards Task Group, with a focus on providing national standards for Green Roof technologies.
  - Seattle Green Factor: As of January 21, 2007, requires 30% equivalent plant coverage on commercial developments in Neighborhood Commercial (NC) zones and this can be met in part through use of green roofs.
  - 2008 - Fireman's Fund Insurance Company is set to launch the first-ever green insurance for U.S. homeowners.
  - May 2009: The New York Buildings Department launched a new process for Green Roofs and Solar Electric Generating Systems tax abatements. This process will involve new job filing and abatement application filing procedures in the New York City boroughs for 2010 thru 2013. January 2010 update: City of Portland to offer Ecoroof Incentives grants that will pay up to $5 per square foot for new ecoroof projects.
  - May 26, 2009: Toronto City Council Adopts Mandatory Green Roof Requirements. The City of Toronto became the first City in North America to adopt a new Green

Roof by-law on new development with overwhelming support on May 26, 2009. The bylaw will apply to all new building permit applications made after January 31, 2010 (residential, commercial and institutional) and January 31, 2011 for all new industrial development.

- The details of the above information and additional policy / incentives can be found at: (http://www.greenroofs.com/Greenroofs101/industry_support.htm)

Products and System Developments:

1970's – German technology; Multilayered systems intended for the growth of vegetation. Green Roofs, prior to Ancient History originated in Germany as a decorative means to embellish houses. Today, modern German standards (FLL) are used to improve the conditions of urban environments and habitations, balancing the energy levels, as waterproof materials and to regulate the drainage and irrigation systems of a construction.

1980's – Introduction to plastic and high-density polyethylene, drainage, and protective fabric. Still using multiple layers of materials. Systems are heavy, pricy and labor intensive.

2004 - The era of modular systems, trays, panels

Today, green roof technologies have obtained a completely different recognition, owing to successful design and planning. The modern world views green roofs to be a healthy environmental design towards metropolitan design management and purpose.

2007 – Advanced sloped green roofs, and various materials including metal, plastic, and geotextiles.

2012 – Green roofs have become widely accepted and advanced research has shown the viability of green roofs in a myriad of applications. Improved waterproofing, technology, and reduced labor are critical factors that will continue to be addressed in order to drive price points down. The all-in-one solution from GLT Institute that includes training and certification, waterproofing, product and authentic support, is the first package of its kind available in the marketplace.

Chapter 3: Benefits of Green Roofs

Private Benefits

Increased Roof Life

The life expectancy of a "naked" flat roof is only 15 to 25 years, even with a professional installation. This is due to the physical and biological stress on the roof skin and waterproofing over the years. Temperature differences of more than 212 F (100 °C) during the year and 140 F (60 °C) over 24 hours are not unusual. UV-radiation and high Ozone ratios accelerate the ageing process of the waterproofing; which results in material fatigue, shrinking, crack formation, and leakage.

Green roofs provide protection for the waterproofing. The vegetation layer buffers the temperature stress during summer and winter, and temperature differences of, 95 F (35 °C) during the year and 60 F (15 °C) over 24 hours are not usually exceeded. In addition, the green roof creates a protection layer for the waterproofing in case of mechanical damage like hail, wind and vandalism.

Long-term studies have shown that a green roof can double and even triple the life expectancy of the waterproofing.

Reduced Noise Levels

Green roofs reduce sound reflection by up to 3 dB and improve sound insulation by up to 8 dB. This is important for people who live near airports, noisy discotheques, or industrial parks. Additionally, electromagnetic waves from transmitting stations can be effectively shielded by the vegetation layer.

Thermal Reflection/Insulation

Green roofs can be regarded as providing additional thermal reflection/insulation, thus, reducing the use of primary energy. This is a well-known economic benefit; however, in former times it was not possible to quantify this effect and integrate green roofs into the building energy balance. This gap was closed at the beginning of the nineties when special green roof build-ups were officially credited by the German Institute for Construction Engineering with thermal resistance values (R-Values). Depending on the original thermal insulation, an amount of 1-2 quarts per 10.72 square feet (1-2 L/m2) of oil can be saved with this additional thermal insulation.

Heat Shield

During the summer months green roofs reduce indoor temperatures through transpiration and shading. According to tests from Drefahl (1995), the microclimate of an apartment underneath a Green Roof is comparable with one on the base floor. The typical overheating of attics and upper level co-ops in summer can be avoided with vegetated roofs, therefore, decreasing the use of air conditioning and energy consumption through the retention of water and shading.

According to Liu (2002 & 2004)[3], when outdoor temperatures peaked at 95 F (35 C), unprotected waterproofing reached 158 F (70 C) while the waterproofing covered with a Green Roof absorbed significant amounts of solar radiation and remained at 77 F (25 C). The studies showed an overall reduction of 95% of heat gain.

Use of Space

Green roofs offer various possibilities for usage, including: natural refuges for insects and plants, recreational roof gardens, roof cafés, and sporting areas. If the technical and construction requirements of the building are met, there are virtually no limits for landscape designs with perennials, small trees, terraces, or gardens. Due to the utilization of the roof property, the building owner can save costs from purchasing additional land at ground level. A gorgeous view, fresh air, and privacy are also included in the price. Roof gardens increase the work environment enormously and offer nearby recreational areas, even in conurbations.

Public Benefits

Natural Habitat for Animals and Plants

The sealing of the landscape by human building activities has several negative effects on the ecosystem and the human habitat. This applies in particular for urban areas, where a large share of the total land area is sealed. Vegetated roofs can compensate for lost green areas. As "step-stone habitats", they create lively and vigorous places and connect isolated refuges for flora and fauna within sterile city centers. Low maintenance extensive green roofs especially promote biodiversity, as wild bees, butterflies, and beetles can find food and shelter there. Even rare and protected species can be found on green roofs. The natural cycle of plant growth, self-seeding and stress-selection lends to ecological systems with their unique character.

Storm water Retention

Green roofs are very important instruments in preventing local flooding. Depending on the green roof system and the depth of the growing medium, the immediate water run-off can be reduced by 50-90%. Most of this water returns directly into the natural water cycle through transpiration/evaporation and runoff from the green roof. The excess rainwater is filtered and drained off with a temporal delay. This leads to reduced stress on the sewer system during the year and at peak flow periods.

As a result of enough green roofs, some European municipalities require less or smaller dimensioned sewerage systems to be installed. In combination with other forms of modern rainwater management (for example, storage tanks or retaining trench-soaking hole-systems) the rainwater can be entirely infiltrated on the landowners ground. The benefits of green roofs for storm water management can lead to incentive programs for Green Roofs in various cities (European), such as, reduced storm water taxes.

Storm Water Quantity & Quality

Fig. 1

Fig. 2

The water in Figure 1 was collected from a control roof without vegetation. It contains high levels of heavy metals and sediments. Figure 2 shows the quality of the water collected from a Patented Green Living Roof in which the heavy sediment has been filtered and there is a reduction in metal content.

Urban Heat Island Effect

Global warming, an increasing number of sealed surfaces and excess heat from residential buildings, and industry and traffic are leading to continually rising temperatures within urban centers. The temperature difference between a city and the surrounding countryside is referred to as the urban heat island effect. In summer this effect can reach nearly 50 F (10 °C). The urban heat island effect drastically reduces the quality of life and impairs the health of the city's inhabitants. Natural "air conditioners" such as green areas and parks can absorb up to 80% of the thermal energy input; however, in densely populated districts, green areas are rare. Landscaped roof surfaces are an alternative, as they decrease the "urban heat island effect" through the process of transpiration, and they humidify dry air. This process lends to a better climate for the occupants of adjacent apartments and buildings.

The pictures on the left show what a street scene normally looks like and through an infrared camera that captures the “Hot Spots”. These “Hot Spots” are non-vegetated areas that continue to heat up throughout the day. When the sun goes down these areas continue to release heat well into the night, and do not cool down instantly, similar to a hot grill.

Bottom- The green roof on Chicago City Hall is usually 80 F (40 C) cooler than the adjacent roof.

Reduction of Dust and Smog Levels

Inner city air pollution can cause serious adverse health effects, and this has been shown by numerous studies in the past few years. In particular, nitrogen oxides, carbon monoxides, volatile organic compounds, and diesel exhaust gases are creating dangerous combinations of toxic substances for urban inhabitants. Plants are able to enhance the quality of the air; 10.72 ft^2 of green roof can filter approximately 0.5 lbs (0.2 kg) of aerosol dust and smog particles per year. In addition, nitrates and other harmful materials in the air and from rainfall are deposited in the growing medium.

Cities and Landscapes

Green roofs are visually enhancing the quality of life in the cities. Already a few blooming "islands" are able to interrupt the monotony of the grey, dismal city centers and improve people's mental and physical health. Additionally, in rural areas, green roofs allow industrial buildings to blend harmoniously with the natural scenery.

This rooftop park makes for a private area at a Portland Maine Co-Op. The media depth ranges from 6" to 56" atop the Patented Green Living Roof Panel.

Urban Agriculture

With widespread concerns about the quality and quantity of food city-dwellers can obtain, more and more attention is turning to urban agriculture. Like in rooftop gardens, the edible component can be blended in harmoniously with existing rooftop landscapes or as a standalone rooftop farm. Pending the crops, a few simple changes need to be addressed: additional weight loading to the roof to accommodate heavier organic-based media, and access to the roof, since edibles require much higher maintenance.

Scott Nyerges Eagle Street Rooftop Farm

GLTi – Philly Green Wall Roof Farm – Philadelphia

GLTi – Philly Green Wall Roof Farm – Philadelphia

Even a small rooftop farm in the heart of Philadelphia can be highly productive. Thousands of pounds of produce are grown in this small 500 square foot roof area. (Below – watermelon and zucchini grow abundant).

Chapter 4: Waterproofing

Waterproofing may be the single most important part of any vegetated roof, roof garden, eco-roof or the like. The waterproofing is what keeps the inside of the building dry! Green roof construction alone can be potentially invasive. Construction workers, equipment to move bulk materials, and unconventional tools like rakes and shovels all pose a potential breach hazard. Typically, inexperienced landscape contractors are not used to working in such environments and extreme caution needs to be applied when installing green roofs.

The second breach threat comes from the green roof itself. There are two main threats and circumstantial variables that may contribute to a breach situation. Typical extensive green roof media is high in aggregate that is abrasive. When media is lodged between the green roof components and the waterproofing there is a real potential for a breach. The second main breach is a result of root infestation during which roots migrate between the layers and enter the seams of the waterproofing.

The best advice is to start with the absolute best waterproofing money can buy. Cutting a budget here will result in failure and that equates to leaks.

Defintition:

“Waterproof” or “water-resistant” describes objects relatively unaffected by water or resisting the absorption of water under specified conditions. Such items may be used in wet environments or under water to specified depths. Waterproofing describes making an object waterproof or water-resistant (such as a camera or watch).

"Water-resistant" and "waterproof" often refer to the ***penetration of liquid***, unlike permeation of water vapor, which is reported as a water vapor transmission rate. Also, water from condensation is usually considered separately from "water resistant".

The hulls of boats and ships were once waterproofed by applying tar or pitch. Modern items may be waterproofed by applying water-repellent coatings and sprays, or by sealing seams with gaskets or O-rings.

In construction, a building or structure is waterproofed with the use of membranes and coatings to protect the contents underneath or within, and its structural integrity.

Waterproofing is used in reference to building structures (basements, decks, wet areas, etc.)

Waterproofing should not be confused with roofing, as roofing cannot withstand hydrostatic head, and waterproofing can. For example common shingles are considered roofing.

Key Terms for the Green Roof Industry:

Adhere:

To cause two surfaces to be held together by adhesion, typically with asphalt or roofing cements in built-up roofing and with contact cements in some single-ply membranes.

Adhesive Failure:

Loss of the bond of a coating or sealant from the surface to which it was applied.

Asphalt:

A bituminous compound, dark brown or black in color, used in the manufacture of asphalt roofing shingles.

Asphalt shingle:

A shingle manufactured by coating a reinforcing material (felt or fibrous glass mat) with asphalt and having mineral granules on the side exposed to the weather.

Ballast:

An anchoring material, such as aggregate or precast concrete pavers, which employs the force of gravity to hold (or assist in holding) single-ply roof membranes in place.

Bitumen:

Any of various mixtures of hydrocarbons occurring naturally or obtained through the distillation of coal or petroleum.

Built-up roof (BUR):

An outer covering of a comparatively flat roof, consisting of several layers of saturated felt. As they are laid, each layer is mopped with hot tar or asphalt. The top layer is finished with a mineral or rock covering and a special coating.

Cap Sheets:

In roofing, one to four plies of felt bonded and top-coated with bitumen that is laid over an existing roof as a treatment for defective roofs.

Class "A":

The highest fire-resistance rating for roofing as per ASTM E-108. Indicates roofing is able to withstand severe exposure to fire originating from sources outside the building.

Class "B":

Fire-resistance rating that indicates roofing materials are able to withstand moderate exposure to fire originating from sources outside the building.

Class "C":

Fire-resistance rating that indicates roofing materials are able to withstand light exposure to fire originating from sources outside the building.

Coal Tar Elastomeric Membrane (CTEM):

Composed of coal tar, PVC and DuPont™ Elvaloy®, a high molecular weight PVC plasticizer. This unique combination of materials produces a membrane that's unequaled for many waterproofing applications.

Concrete:

A construction material that consists, in its most common form, of Portland cement, aggregate (usually gravel and sand) and water. Concrete solidifies and hardens after mixing and placement due to a process known as hydration. The water reacts with the cement, which hardens, bonding the other components together and eventually creating a stone-like material.

Cool Roofing

A cool roof is defined as a roof surface that has both high reflectivity and high emissivity. High reflectivity requires the surfacing material to reflect solar energy away from the surface. High emissivity requires radiating heat energy away from the surface. Roofs undergo significant expansion and contraction as they heat and cool throughout the day. Heat absorbed by the roof can also accelerate degradation by ultraviolet rays and water. A reflective roof can reduce the amount of thermal shock that occurs on the roof surface and prolong the life of the roof.

Downspout:

A pipe for draining water from roof gutters. A downspout is also called a *leader*.

Drip Edge:

A metal flashing or other overhanging component, with an outward projecting lower edge, intended to control the direction of dripping water and help protect underlying building components. A drip edge also can be used to break the continuity of contact between the roof perimeter and wall components to help prevent capillary action.

Dry In:

To make a building waterproof.

EFVM – Electric Field Vector Mapping:

EFVM® is a low-voltage test method that creates an electrical difference between a non-conductive membrane surface and conductive structural deck or substrate, which is grounded. The technique is used to pinpoint membrane breaches.

EPDM:

Ethylene Propylene Diene Monomer. A single-ply membrane consisting of synthetic rubber; usually 45 or 60 mils. Application can be ballasted, fully adhered or mechanically attached. (see definition of mils)

Expansion Joint:

A structural separation between two building elements that allows free movement between the elements without damage to the roofing or waterproofing system.

Fasteners:

Any of a wide variety of mechanical devices and assemblies, including nails, screws, cleats, clips, and bolts, which may be used to secure various components of a roof assembly.

Food Test:

A method for testing the water tightness of waterproofing installations applied to horizontal surfaces having a slope not greater than 20 mm/m (2% slope)(2/4 in. per ft). Not always accurate and may not always detect small breach threats.

Fluid-Applied Elastomer:

A liquid Elastomeric material that cures after application to form a continuous waterproofing membrane.

Life-cycle cost:

The total lifetime cost of a roof. Calculated by adding maintenance costs to the installed price, then deducting the added value the roof provides when the home is resold.

Liquid Applied Membrane:

Generally applied to cast-in-place concrete surfaces in one or more coats to provide fully-adhered waterproof membranes which conform to all contours.

Loose-laid Membranes:

Membranes that are not attached to the substrate except at the perimeter of the road and at penetrations. Typically, loose-laid membranes are held in place with ballast, such as water worn stone, gravel pavers, etc.

Metal drip edge:

A narrow strip of non-corrodible metal used at the rake and eave to facilitate water runoff.

MIL:

Measurement often used to determine thickness of a roofing membrane. 1 mil = .001 inch (1/1000) or 25.400 microns. 1 millimetre approx equal to 40 mils.

Modified Bitumen:

A bitumen modified through the inclusion of one or more polymers (e.g., atactic polypropylene, styrene butadiene styrene, etc.); (2) composite sheets consisting of a polymer-modified bitumen often reinforced as sometimes surfaced with various types of mats, films, foils and mineral granules.

Peel Strength:

The average force (or force per unit width) required to peel a membrane or other material from the substrate to which it has been bonded.

Pitch:

Also known as "slope", pitch is the measure of how "steep" a roof is. For example, if a roof is "4 in 12", the roof rises 4 inches for every horizontal run of 12 inches. The pitch of the roof is a big factor in determining the kinds of materials that can be used and the longevity of the roof. Usually, a steeper roof (higher pitch) will last longer due to its better drainage capabilities.

SLOPE CONVERSION TABLE

Rise / Run (inches)	Slope (degrees)
0/12	Flat
1/12	5
2/12	10
3/12	14
4/12	18
5/12	23
6/12	27
7/12	30
8/12	34
9/12	37
10/12	40
11/12	42
12/12	45

Ponding:

Water that remains on a roof 48 hours after a rain.


Ponding Water

Positive Drainage:

The drainage condition of a roof where all water is gone from the roof surface within forty-eight hours of precipitation during normal drying conditions.

Primer:

A material of relatively thin consistency applied to a surface for the purpose of creating a more secure bonding surface and to form a barrier to prevent migration of components.

Re-roofing:

Installing a new roof system on a building that is not new.

Roof Slope:

Roof slope is the most important factor in roof design. The slope of a roof affects the interior volume of a building, drainage, style, and material used for the roof covering. If water collects on the roof (poor or nonexistent drainage), the cause is probably related to the slope. Slope is the angle made by the roof surface plane with the horizontal plane and expressed as the amount of vertical rise for every twelve-inch (12") horizontal run. For instance, a roof that rises four inches (4") for every twelve-inch (12") horizontal run, is expressed as having a "four in twelve" slope; often written as "4:12." Expressed as a percentage, the slope would be 33%, which is equal to 4 divided by 12. Also known as the Roof Pitch. Some common roof slopes and the terms that classify them are:

* Flat Roof: 2/12
* Low Slope: 2/12-4/12
* Conventional Slope Roof: 4/12-9/12
* Steep Slope: 9/12 and higher

Roofing tape:

An asphalt-saturated tape used with asphalt cements for flashing and patching asphalt roofing.

Screeding:

The wood or metal straightedge used to strike off or level newly placed concrete when doing cement work. Screeds can be the leveling device used or the form works used to level or establish the level of the concrete. Screeds can be manual or mechanical.

Single coverage:

Asphalt roofing that provides one layer of roofing material over the deck.

Single Ply:

A descriptive term signifying a roof membrane composed of only one layer of material such as Coal Tar Elastomeric Membrane, EPDM, Hypalon, TPO or PVC.

Single Source Provider:

Provide the waterproofing, green roof, and warranty.

Surface Temperature:

The temperature of the surface of the roof, wall, and other parts of the project.

Tear off:

A term used to describe the complete removal of the built-up roof membrane and insulation down to, and exposing, the roof deck.

Waterproofing:

A term that refers to the process where a building component is made totally resistant to the passage of water and/or water vapor.

Water Repellant (Coating):

Coating or sealer applied to the surface of concrete and masonry surfaces to repel water.

Water Vapor:

Moisture existing as a gas in air.

Wind Uplift:

The upward force exerted by wind traveling across a roof.

Types of Waterproofing

Waterproof membranes need to be 100% waterproof. There are several types of waterproof membranes available. Some are made of common construction materials in sheet or rolled forms, others are liquid applied.

Built-up Roofs (Multiple Layers)

The most traditional roofing system, the built-up version gets its name from the multiple layers of asphalt and roofing membranes laid on top of each other. The most common type of built-up roof is installed using a hot-mopped method. In this application, a thin layer of hot asphalt is spread over the roof with a mop, followed by rolling down a felt bituminous membrane reinforced by glass fiber or polyester on top of the asphalt.

A typical built-up roof configuration consists of four layers of asphalt and three layers of felt. The asphalt provides the waterproofing capabilities while the felt reinforces the asphalt.

To protect the roof from damaging ultraviolet rays, which cause it to dry, shrink, and eventually crack, the roof surfacing is usually treated in several ways. A common application is to spread gravel onto a layer of asphalt. This aggregate surfacing, as it is known, helps protect the roof not only from the elements but also from punctures and other penetrations.

Type I: Hot/Heat Applied Roofs

1. HOT MOP

This first type is also the oldest. Layers of roofing felt are placed in the desired area and each layer is coated with still molten tar. This process is called hot mopping, referring to the hot tar being mopped onto the paper. A certain number of successive layers are required for certain applications.

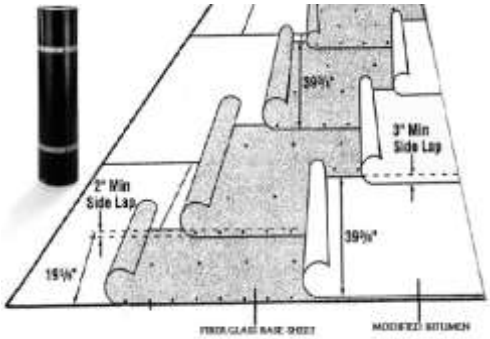
Hot Mop being applied to layers of felt and reinforced fiberglass

2. MODIFIED BITUMEN SYSTEMS

A second type of roofing system, modified bitumen, typically two layers of roofing membrane are laid down: the bottom one has a smooth surface while the top one is embedded with a mineral surface, creating an effect similar to the multiple layers of a built-up roof.

The layers in a modified bitumen system can be applied two ways: In the first method, known as APP (atactic propylene), a torch is used to heat the asphalt pre-applied to the bottom of the felt, adhering the membrane to the layer below aka “Torch Down”.

In the SBS (styrene butadiene styrene) method, the mineral cap sheet is usually hot mopped over the smooth-surfaced first layer, or in some cases, torched down as in an APP system.



Modified Bitumen Roof

Type II Built Up Cold-applied Systems

The APP and SBS will require a root barrier for use with green roof applications. These types of applications are susceptible to root penetration.

The third major type of roofing system also uses fiber-reinforced bituminous membranes. Instead of asphalt, however, a liquid adhesive and a catalyst are mixed in a cold solution and applied to the surface to promote adhesion.

An increasingly popular type of cold-applied system uses self-adhesive roofing membranes. As with the modified bitumen systems, a bottom layer with a smooth surface is used with a mineral cap sheet on top. Instead of hot mopping asphalt or torching the layers down, however, the self-adhesive membranes come with their own pre-applied adhesive elements and are directly applied to the substrate using primer.

Fig 1 Picture by National Roofing partners

Type III Single-Ply Systems

These membranes are manufactured and are available in small and large sheets, rolls, and liquid. Various manufacturers make these membranes in various thicknesses. Some are designed for waterproofing only. Still others have resistance as their primary goal. There are also liquid applied membranes that are designed to act as a waterproofing.

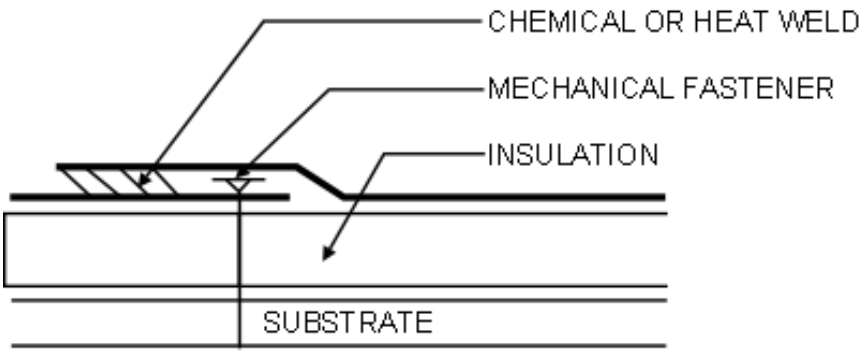
> **Definition:** Single-ply roofing systems—those with only one membrane instead of multiple layers usually in new commercial construction. Some types of membranes do not offer the durability of the built-up, modified bitumen, or cold-applied systems. *See CTEM

Type of Installation for Single-Ply Membranes

1. **Loose Laid** - The roof is "NOT glued" or secured to the substrate but held down with stones or pavers. (Below – a loose laid membrane is secured – ballasted with stones)

2. **Fully Adhered** - the roof is "glued" to the substrate using a special adhesive

3. **Mechanically Adhered** - Use a special screw-type fastener to secure it. The type of fastener will depend on the type of substrate but all fasteners are generally screw-type fasteners.



4. **Protected Membrane** - A closed-cell, extruded polystyrene insulation is placed on top of the waterproofing membrane.*

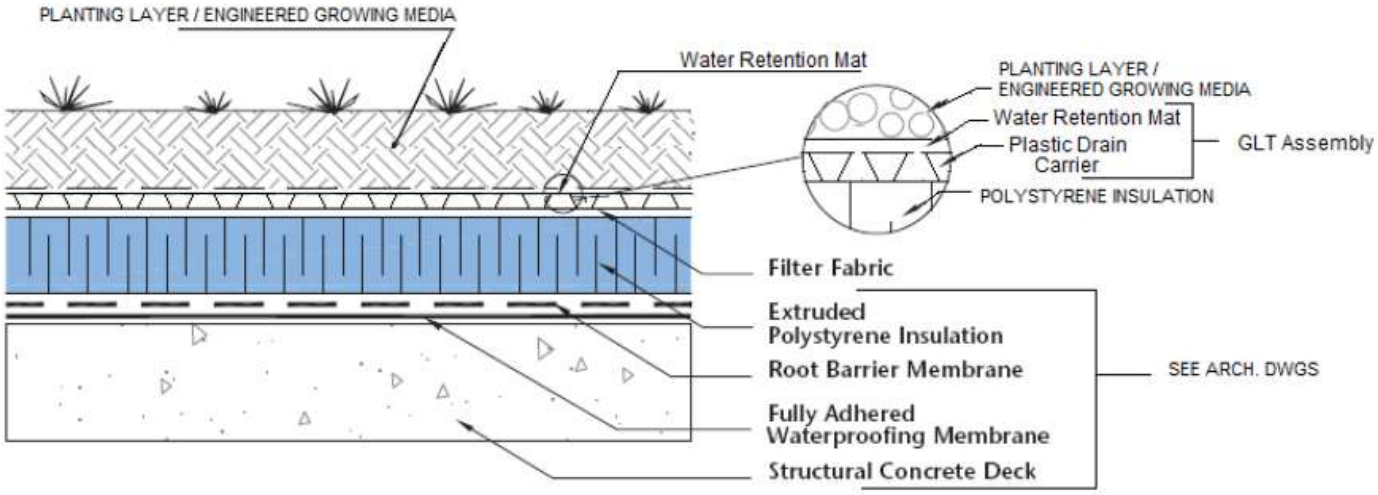


Fig. 1

Portland Oregon, Protected Assembly in Preparation to Accept the Pre-Grown Patented GLTI Green Living Roof Panels

1. Fully Adhered Membrane
2. Root Barrier (Loose Laid)
3. Styrofoam Ridged Insulation
4. Plywood protection (Temporary) to transport Green Living Roof into place as per Fig 1 on the previous page.

Utilizing the CTEM Self Adhered membrane by Hyload you can eliminate the root barrier and filter fabric when installing a GLTi Green Living Roof system. The two-year root barrier test done by Penn State showed no signs of root penetration. The complete waterproofing package includes a 25-year warranty with a no-dollar limit, a no-root barrier, and a GLTi Green Living Roof on top of the insulation.

Types of Single-Ply Membranes

a. EPDM

The ethylene propylene diene monomer (EPDM) creates a single-layer rubberized roof. It is a rubber sheet that is applied over a layer(s) of insulation. There is no heat involved in the installation and the seams are ly adhered. If there is a tear or bad seam and water gets under the membrane, the leak can travel under the membrane and throughout the insulation. Not only can it be very difficult to locate the leak, but wet insulation can also breed mold and algae.

Since the seams are ly adhered, they are subject to failure over time due to expansion and contraction. The seams are fastened with a pressure-sensitive butyl tape that will fail over time.

What is the life expectancy of EPDM that is properly installed and drains well?

- 45 Mil ballasted EPDM rubber - **12 years**
- 45 Mil mechanically attached roof - **12 years**
- 45 Mil adhered roof - **12+ years**
- 60 Mil ballasted EPDM rubber - **12+ years**
- 60 Mil mechanically attached roof **15 years**
- 60 Mil adhered roof - **15+ years**

SAMPLES OF EPDM

b. TPO: Thermoplastic Olefin or Polyolefin

TPO membranes are single-ply roof membranes constructed from ethylene propylene rubber. They are designed to combine the durability of EPDM rubber with hot-air welded seams. The material is sometimes advertised as a monolithic (seamless) roof.

Compared to EPDM, TPO is resistant to tears, impacts, and punctures, and has good flexibility to allow for building movement. TPOs are available in white, light gray, and black with thicknesses of either 45 mils (.045") or 60 mils (.060"). The width of the membrane depends on the manufacturer but they usually come in widths of six- to six-and-a-half feet and are 100 feet in length.

c. Self Adhered Cold-Applied CTEM Roofing

"150 mils of High Performance Coal Tar Elastomeric Membrane Self-Adhered Welded Seam CTEM Roofing System"

Hyload Self-Adhered (SA) CTEM is a self-adhered cold applied heat-welded seam. The elastomeric membrane is manufactured by blending coal tar pitch with DuPont's Elvaloy ® KEE and is reinforced with dispersed polyester fibers. The finished CTEM product is then coated with Styrene Butadiene Styrene (SBS) adhesive to provide a high performance self-adhered heat-welded seam roofing membrane. This unique formulation combines the time-proven characteristics of coal tar pitch with the advanced technology of DuPont's Elvaloy. Hyload SA CTEM is ideal for slope applications from dead level up to 3" per foot.

- 90 mil base sheet + 60 mil cap sheet = 150 mils of protection!
- Tough, durable and chemically resistant. The membrane will remain effective against environmental contaminants like UV light, acids, bases, petroleum products (including greases, oils and gas *including jet fuel), molds and algae
- Impervious to ponding water
- Hot-air welded membrane bonding
- Cloaks – pre-formed shapes for inside and outside corners that can be hot-air welded to the membrane
- Trowel-on Mastic — trowelable mastic that not only creates tight bonds, but also serves as an effective water and vapor barrier
- Can be applied over smooth, dry substrates such as cured concrete and wood
- Hyload Membrane Adhesive can be bead or trowel-applied to adhere the membrane to substrates where contamination or compatibility problems may exist, such as existing waterproofing systems (including coal tar) in retrofit applications

It is the only waterproofing that has a zero slope approval; it is designed to be underwater.
It has no VOCs and can be installed on public buildings during work and school hours.

Warranty Information (Including the Green Living Roof Package):

- 25-year warranty on the water proofing
- No dollar limit
- Still warranted under ponding water
- Every year there is a maintenance agreement for the vegetative roof; this will include periodic waterproofing inspections at no cost.
- Vegetation and Green Living Roof components are warranted as long as there is a maintenance agreement in place.

Fig 1

Fig 2

Fig 1 Coal Tar Peel and Stick with heat - welded seams (Fig 2) carries a 30-year warranty with the GLTI Green Roof System on top. The heat-welded seams are stronger than the actual waterproofing. This project was installed as a GLTI Single Source Provider by certified installers and trainer supervisors G-Space Design Build (Philadelphia) www.gspacedesign.com

d. Liquid Applied Membrane (LAM) Liquid Applied Membrane (LAM) is a low-viscosity, liquid-applied waterproofing membrane for use on horizontal or vertical surfaces. LAM is most commonly used for two-ply fiberglass reinforced applications.

The preferred Lam application of AlphaGuard MT system by Tremco is composed of a base coat, a glass mat for system strength, and a top coat. It's a single component, fully reinforced, aliphatic polyurethane, moisture-triggered roofing system, making it both very versatile and technologically advanced. The MT refers to its 'moisture triggered' curing mechanism, which is far more dependable than the 'moisture cured' mechanism of commodity coating systems. This helps contractors because the roof can be installed and operational quickly; projects are often shorter than with other systems, with even better results. This is an excellent choice for restoring almost any kind of aging but still functional roof that a contractor may face modified bitumen, built-up and single ply roofs, as well as roofs with exposed or buried membranes that were applied to concrete. Literally apply directly over the existing waterproofing.

Warranty Information (Including the Green Living Roof Package):

- 20 -year warranty on the water proofing
- No dollar limit
- Every year there is a maintenance agreement for the vegetative roof; this will include periodic waterproofing inspections at no cost.
- Vegetation and Green Living Roof components are warranted as long as there is a maintenance agreement in place.

Waterproofing Summary for Review and Discussion:

- Built-up roofs – Multiple layers
  - Hot Applied – Hot Mop, Modified Bitumen,
  - Cold Applied – self-adhesive roofing membranes, cold applied Modified Bitumen
    - Must have single ply root barrier prior to green roof

- Single-Ply Membranes
  - EPDM
  - TPO
  - CTEM

- Types of single-ply installations
  - Loose laid
  - Fully adhered
  - Mechanically adhered
  - Protected Roof Membrane (PRM)

- Liquid Applied Membrane (LAM

DISCUSSION:

1. What are the leading causes of environmental factors that could lead to waterproofing failure?

2. Discuss the pros and cons of built up vs. single-ply.

3. What are the benefits of a Protected Roof Membrane (PRM)?

4. Describe the means in which the seams of single ply membranes should influence what waterproofing to recommend.

5. What is a single source provider?

6. What type of waterproofing should you recommend? Why?

7. GLTi offers a full green roofing system. Provide the benefits of a CTEM SA with the GLTi Green Living Roof System.

Cons of the separate contractor warranty:

- Typically waterproofing manufacturers are not green roof experts and do not own a specific system.
- Other green roof companies are at the mercy of existing or others' proposed waterproofing systems.
- This situation causes warranty issues when the waterproofing company is blaming the green roof installer and vice versa.

Pros:

- Green Living Technologies with Hyload / Tremco can provide a min 20 -25-year warranty with the Green Living Roof systems on top.
- Waterproofing companies are not plant-oriented and usually cannot provide full service without long term sub-contracting. GLTI on the other hand can provide single source service or service from the waterproofing up.
- You don't have to be responsible for waterproofing and waterproofing warrantys.
- We offer many more green roof options than most membrane manufacturers, who do not own a patented green roof system.
- Most membrane manufacturers do not make a green roof system, instead they purchase componants to assemble vegetative roofs from others making the assembly a potential unknown with every vegetative roof. Our systems are consistant.
- Our systems can be pre-grown off site and are 100% mature.
- We have the option of applying our systems on most membranes.
- Our systems are backed by a single warranty.
- Installed by certified GLTi installers who are also waterproofing experts.

- We are also plant, irrigation, and maintenance specialists.

Chapter 5: Green Roof Nomenclature

Key Objective: Identify the three types of green roof systems:

Extensive, Intensive, and Hybrid

1. *Extensive green roofs:*
   - Typically low-growing plant material, usually 2" - 6" of growing media.
   - Traditionally planted with sedum genus or drought tolerant ground covers and alpine species.
   - Can be fitted with walking pavers, sitting areas, patios and other accessories.
   - Typically designed for its lightweight capabilities and lower maintenance requirments.
   - Ideal for use of pre-grown vegetation and pre-grown mats
   - The shallower the media the limited choices for plant material and the increased use of irrigation.
   - Historic weight loading can range from 18 to 30 pounds per square foot saturated
   - The average GLTi extensive green living roof weighs from 15 to 22 pounds per square foot and can be as light as 10 lbs per square foot. *
   - *Pending the media blends, a reduction in plant choices, and in addition to a necessary irrigation system.



Above: 3 Examples of extensive GLTI Green Living Roofs

2. *Intensive green roofs:*

- Deeper growing media that is usually 6”+ to several feet deep
- Can be a rooftop park or garden
- May include perennials, trees, bushes, shrubs, water features and hardscapes
- Rooftop agriculture
- Requires additional structural support
- Higher capital investment
- Usually defined by more “Intensive” maintenance

3. *Hybrid green roofs:*
    - A combination of extensive and intensive with pockets or areas of deeper intensive plantings.

Top: Lavender and Grasses added to the window ledge to allow for fragrance to enter the barn.

Right: Perennial plantings allow for an improved view from the office windows and sends a signal to the passer by advertising the green roof.

Bottom Right: Deeper-rooted grasses break up the roofline from the rear of the dwelling.

Common Green Roof Terminology

Drainage board - a component of a green roof system that allows water from rain events to move underneath the growing media/vegetation and exit the roof via roof drains.

Filter fabric - A layer of material that prevents growing media from eroding down through the drainage board or through retaining walls after a rain event.

FLL - The German Landscape Research, Development and Construction Society (FLL) is an independent non-profit organization, founded in 1975, that provides a guideline to green roof construction. The guidelines have come under scrutiny because of the inconsistency with which they are applied.

Growth Medium – Planting matrix consisting of organic and inorganic components. Green roof growth mediums are engineered to meet specific performance specifications and are produced or blended using components that have characteristics that promote drainage, are lightweight, and will sustain vegetation. Growing media will vary according to geographic location due to the availability of raw materials.

Inorganic material - Various aggregates like volcanic rock, expanded shale, recycled clay bricks, sand, and others can be used to provide drainage, aeration, and growth medium structure.

Live Load – Refers to a roof that must be engineered for movements on the roof. Examples of movements include those caused by roof installation equipment, maintenance people, visitors to the roof observation deck. Movements can also be caused by wind, snow, ice, or retained rainwater.

Organic matter - Plant or animal matter that is decomposing and providing nutrients, water retention, and beneficial microorganism activity. Compost is a common source of organic matter used in green roof growth mediums. When it has fully decomposed it is called humus. This humus is important for soil structure because it holds individual mineral particles together in clusters. Adding organic matter to the soil adds carbon, which promotes the growth of beneficial bacteria and increases the likelihood of hearty plants.

Pre-vegetated - Describes a green roof system where the vegetation is established into the panel, mat or tray at a growing facility prior to delivery, and to be installed in one or two steps.

Plant-in-place - Describes a green roof system where the installation process is to install the necessary components separately and establish the vegetation onsite over a period of time. Vegetation may be propagated from plugs, pots, cuttings, or in some cases, seed.

Root barriers – A layer of a green roof system that prevents root penetration into the waterproof membrane. Ideally used with traditional built-up roof systems. EPDM is a common root barrier.

Vegetation Free Zone - Usually an area near the perimeter of the roof or around a drain or protrusion that is void of vegetation. River rock or round stone is often used to facilitate this feature.

Vegetated Mat – A pre-grown green roof plant product consisting of a 1- to 2-inch layer of plant material rooted into a layer of mesh and growing medium. Vegetated mats are typically cut into rectangular sections and stacked or rolled up for transportation to the site. This product can work well for sloped roof applications, but may require a significant lead-time when ordering, requires special shipping arrangements, and takes extra care to establish.

Water Retention – A layer between the drain board and the filter fabric to aid in water retention.

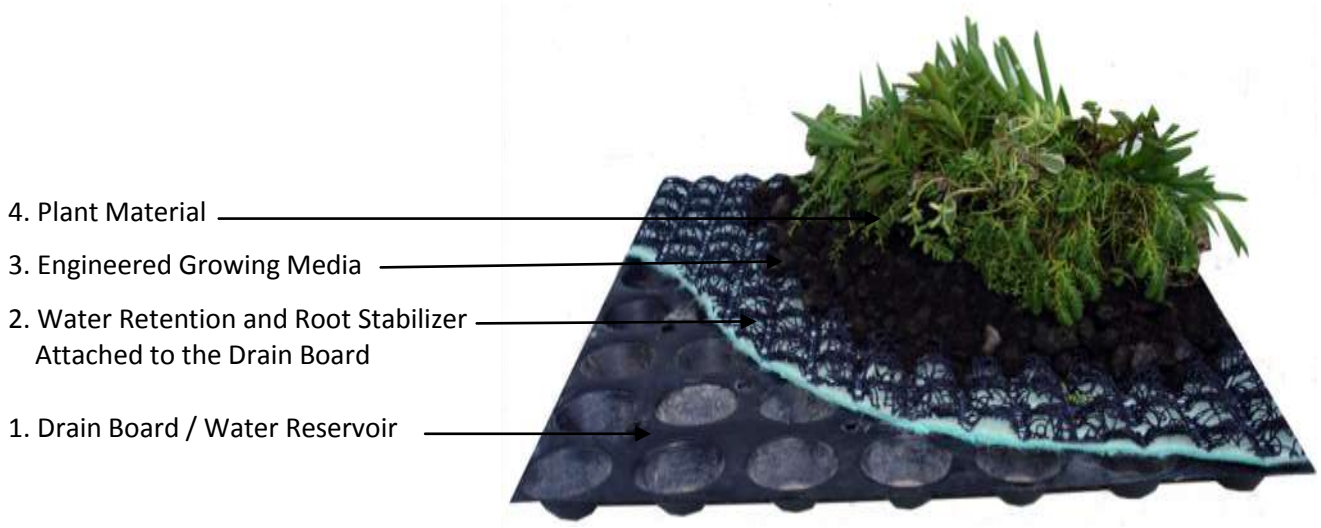
Notes:

Chapter 6 - Green Living Roof Panels

All the key layers are adhered to create an “easy to pick up and put down” system--one system for all three potential green roof applications.”

Green Living Roof Panels

Key layers from the bottom up include: a water reservoir / drain board, water retention and root stabilizer, growing media, and plant material.



1. Water Reservoir / Drain Board (Layer 1)

- Made of 90% post-consumer high density polyethlyne (HDPE), this structure provides the surface space between the green roof and its waterproofing. This allows for air movement and free drainage, and cups also provide the first layer of water retention
- Compressive strength of 3200psf (150 kN/m²)
- Drainage speed of 26 gallons per minute
- Class B fire rating
- Water retention (.55-.60 gal/sq ft) = 5.88 - 6.42 gal per 10.7 sf (Without vegetation)

Top Elevation Bottom Elevation

2. Water Retention and Root Stabilizer (Erosion Control Properties and Water Wicking)(Layer 2)

- Synthetic water retention mat sandwiched between
- 50% post-industrial ploypropylene + 100% post-consumer polyester
- Standard 16 oz weight can retain up to .30 gallons per f^2 (12 liters / m^2).
- Additional root stabilization and erosion control manufactured from high density polyethylene (HDPE) adds stability and retains its flexibility
- Extremely resistant to punctures and tears
- Inert to natural and biological degrading and unaffected by chemicals, alkalis and acids.
- Water Retention equals .15 gallon per square foot (10.72 x .15 gallons = 1.6 gallons per panel)
- Also acts as a filter fabric and prevents growing media fines from sifting through to the waterproofing.
- The water wicking capabilities provide full saturation and even moisture control prior to filling the drainage board below. Only then will the green roof drain to the waterproofing uninterrupted as excess water naturally finds the roof drains.

3. **Growing media (Layer 3)**

- Engineered and blended according to a specific recipe depending on the plant choices and geographic region
- Contains GLTi bioSoil (a trade secret of GLTi), which exceeds guidelines of the FLL
- Can retain up to an additional 1 gallon of water per panel

4. **Plant Material (Layer 4)**

- Will vary between geographic regions, as well as pre-vegetated, intensive & hybrid applications

Review

- *Intensive*
  - Bushes, Trees, Lawns, Agriculture, Ponds, Hardscapes
- *Extensive*
  - Pre-Grown
  - With Sedum Blankets
  - Planted in Place

The Patented green living roof panel is the only system in the world to provide all the benefits and flexibility of a traditional built-up green roof with the ease of modular applications, yet without sacrificing performance. The patented technology is designed to be flexible, water retaining, easy to cut curves and odd shapes in, and account for undulations and use on all types of green roof applications.

BENEFITS OF THE GREEN LIVING ROOF PANEL

- ***One system for all types of green roofs***
  - Extensive (2" – 6")
  - Intensive (6"+)
  - Hybrid (Combined areas of deeper rooted or garden areas)

- ***Designed around storm water retention***
  - By retaining water in multiple levels the plants do not sit in water, so this removes the threat of anaerobic conditions that benefit plant health.
  - Water retention can reduce irrigation needs by over 70% and *lower maintenance by 50%.*

- ***Flexibility***
  - Unlike other tray systems the flexibility of Green Living Roof Panels allow for undulations, contours and irregularities on the roof. There are NO corners that will break or penetrate the waterproofing.
  - The panels can be cut to fit exactly around odd angles and curves for a clean look. No cutting trays and wrapping them in fabric.
  - Lightweight and can be adjusted to accept 2" to 102" of growing media. With a crush weight of 3200 lbs per f^2 you can install live trees and build walks or patios directly on top of the panels.

- ***Multiple Planting Choices***
  - Pre-Grown 100% mature green living sedum blankets with over 15 varieties specific to the region complete with GLTi *bioSoil (scientifically advanced growing media)*.

- Plant in place with cuttings or plugs.

- ***Lifetime Warranty***
  - The Green Living Roof Panels are made of over 90% post-consumer materials and warranted for 15 years.
  - For every year a GLTi maintenance agreement is in place we will warranty the plant material and the non-organic materials.*Acts of God and vandalism not included
  - You have the added benefit of a single source warranty with the combination of the CTEM SA (pg 27 – 28)
  - Because our Certified Technicians are also waterproofing experts you are provided the added protection of periodic waterproofing inspections and preventative maintenance.

Plant Material

Engineered Media w GLTi bioSoil

Water Retention Mat

Drainage Board w/ Water Retention

100% Mature

100% Soil to Soil Contact

Water retention up to 8 gallons per meter and still only 15-18 lbs saturated.

*GLTi can meet a 10 lb per square foot specification for extreme lightweight needs!

GLTi bioSoil Scientifically Advanced Green Roof Growing Media

Typical green roof media is over 90% aggregate making it great for drainage but it is NOT ideal for holding nutrients, micronutrients, and water. The result of such a recipe is the important nutrients and growing media biology of the plant is literally washed away. Typically the following is the basic recipe for extensive green roofs:

- 70% lightweight aggregate such as expanded shale, recycled red brick and in some cases bark
- 10% coarse & fine sand and/or washed stone dust / screed
- 20% organic matter, high quality compost* (some recipes only contain 10% organic matter)

It is common that after a one- or two-year warranty period the green roof inevitably starts to decline. Planted in place or roofs planted with cuttings are at a higher risk and hardly ever reach 100% maturity after two years without heavy maintenance needs.

Even existing roofs that are heavily fertilized only utilize a small fraction of the chemical because of the known drainage ability of the media. The result is green roof runoff that is laced with synthetic chemicals. In essence, the fertilizer of the green roof is part of the problem and not a solution.

The combined application of the GLTi pre-grown vegetation and the GLTi bioSoil are advanced and scientifically proven to provide a healthier and more vibrant green roof. They also lower irrigation needs by over 50% when combined with the patented water retention technology and improved drought resistance.

The bioSoil is:

- **100% Natural / Organic YES we can say "organic"!**
- **NO growth inhibitors**
- **Manufactured in an EPA- and FDA- registered facility**
- **bioSoil is not a compost tea, manure tea, soil soup, or any other product**
- **bioSoil is biotechnology**
- **NO genetically modified organisms**
- **Unlike fertilizers, GLTi bioSoil will NOT leach**
- **Increases Brix levels (Increase in sugars and carbohydrates in plants)**
- **Improves drought resistance and lowers irrigation needs by 50%**
- **Improves Nutrient Storage**
- **Improves symbiotic relationship with plants to enhance nutrient uptake**

GLTi bioSoil Cont'd

(Left) Healthy root development in plants grown on the GLTi bioSoil. The bioSoil combines excellent drainage ability and encourages high nutrient and micronutrient uptake. It is also 100% organic.

(Below – LiveRoof Plastic Roof Tray) Root development is minimal; media alone is visually high in aggregate and lacks ability to hold nutrients. Erosion is evident with little to no ability to support water retention, therefore requiring intensive watering and fertilization to survive. This media will be stressed with weed development and will require a higher level of maintenance.

bioSoil is probiotics for plants, turf, agriculture, trees and golf course applications. bioSoil contains a wide consortium of living, natural, beneficial bacteria. Nitrogen-fixing bacteria convert nitrogen from the air into natural fertilizer right at the plant, reducing input and fertilizer runoff. Nitrifying bacteria convert higher nitrogen forms into nitrates, which are the principle form of nitrogen used by plants and turf. Phosphate solubilizing makes the

phosphorous in the growing media more available. The combination allows growers and maintenance technicians to greatly reduce their fertilizer inputs. The photosynthetic bacteria in bioSoil "feed" the plant as well as the entire growing media food web by producing sugars and adding carbon biomass. The multiple *Bacillus* strains in bioSoil increase plant and turf health thus increasing their natural resistance to pathogens and disease, and lowering the need for pesticides. Plant diseases are present when three variables join together:

- Host plant
- Pathogens and
- Favorable environmental conditions

Depending on their severity, root diseases can kill plants and can damage an entire crop. Less severe infections damage plant roots, which inhibits nutrient uptake, delays crop schedules and reduces plant quality. You can apply chemicals to prevent disease, however, over time pathogens become more chemical-resistant and your crop production costs go up. You have already incurred losses if you see plant disease. The GLTi bioSoil is already engineered with Subtilex® (active ingredient: Bacillus subtilis-MBI600), a high-performance ***biological fungicide*** that prevents root diseases. The ***beneficial Bacillus subtilis bacteria*** colonize developing root systems and combat disease-causing organisms that attack them. The bacteria also act as a bio-stimulant that enhances the establishment and the development of the root system, leading to stronger plant stands and increased yields. Unlike synthetic prevention, the GLTi bioSoil is 100% organic.

Bacillus subtilis is a naturally occurring strain of bacteria that combats harmful organisms, thus preventing the onset of root diseases and enhancing plant growth. When the plant's root system comes into contact with Subtilex®, the spores germinate and begin to colonize the roots within 48 hours. The bacteria grow around the root system to form a protective shield that serves as a physical barrier to common root rot pathogens. In return, the plant produces metabolites that serve as food for the organism. Subtilex® also produces an antibiotic and stimulates the plants immune response to ward off disease-causing organisms.

- Reduced Incidence of Root Diseases for all plant species – a broad spectrum of action against root pathogens (*Pythium*, *Rhizoctonia*, *Fusarium*).
- Enhanced Plant Vigor - better growth enhancement than Fungal Inoculants.
- Safe to use — No REI (restricted entry interval) or human toxicity

bioSoil is made with advanced science and biotechnology and it is an all-in-one agricultural product that will augment your compost, manure, humus, compost teas and other biologicals. It will also lower your use of fertilizers, water, fungicides and chemicals.

- Most other products contain spore-forming (inert) microorganisms. In contrast, the beneficial bacteria in bioSoil are vegetative (alive and actively growing) so they start working instantly—results are often seen in hours as opposed to days or weeks.

- bioSoil contains a wide variety of beneficial bacteria that perform various functions for the plant. Many competitor products contain 1 or just a few strains.
- We do not use growth inhibitors or other chemicals to keep our microbes alive.
- bioSoil is shelf stable for at least two years, a significant advancement in microbiology.
- bioSoil contains photosynthetic microorganisms that produce energy for plants.
- bioSoil is compatible with fertilizers and most chemicals.
- bioSoil can be mixed with dry or pelletized products.
- bioSoil can be applied by your normal watering equipment: Irrigation systems, watering cans, sprayers (end-hose, backpack, truck), etc.
- bioSoil can be applied as a foliar or a drench treatment.
- bioSoil can be used with hydroponics
- Reduces fertilizer use by 50%.
- Reduces water use by up to 50%.
- Reduces fungicide and chemical use significantly.
- Increases yields and Brix levels by 20% or more.
- Healthier and greener plants, trees and turfs.

The substance of the food we eat today is not the same as it was decades ago due to the way we grow our crops. Practices such as over-fertilization, and chemical and hormone use can greatly diminish the nutritional quality of our food. These techniques cause plants to grow very quickly, but they don't necessarily have the time to obtain nutrients from the soil or to produce the vitamins, anti-oxidants, and other vital nutrients that add value to our diet and health. This results in food that is deficient in nutrition and adds more empty calories to our diet.

bioSoil contains beneficial bacteria as well as organic humates, a combination that has proven very effective in producing nutrient-dense food. Our photosynthetic bacteria produce sugars by utilizing the energy in sunlight. This provides sugar to the plants - increasing the Brix (sugar) levels, taste and nutritional quality and density. The other beneficial bacteria in bioSoil help to break down and cycle organic compounds and to sequester minerals, thus providing plants with the raw materials they need to produce healthy substances and to store vital nutrients in their fruits and vegetables. Humates are known to bind over 50 elements from the periodic table, including vital minerals such as calcium and magnesium. The humates in bioSoil concentrate these substances near a plant, allowing the nutrients that are present to be better utilized by the plant and incorporated into the fruits and vegetables.

Data from field tests and from produce growers, including those for one of the largest food chains in the world, have demonstrated fruit and vegetables with higher Brix levels, as well as increased nutrient levels of magnesium, calcium and other micronutrients in plants grown with bioSoil.

Left: Potato Roots without bioSoil

Right: Potato Roots with bioSoil

Green Living Roof (Summer)

Green Living Roof (Winter)

Chapter 7 - Green Living Roof Panel Applications

Green Living Roof Panels - Extensive Green Roof Application

1. Pre-Grown Mats:

- Green Living Roof Panel
- GLTi bioSoil
- 100% mature sedum with over 15 varieties conducive to the geographic region
- Lead time – 1 to 3 Weeks

The pre-grown blankets are field or greenhouse grown to maturity and hardened off for a full season. Upon order, the panels are stacked, shipped the same day, brought to the roof, and literally installed within 12 hours from the field to the roof. They are 100% mature with the look of a monolithic roof and the ease of trays.

You can easily access the waterproofing without destroying the vegetative roof or having to cut through various layers of material.

Clean roof area

Install protection fabric / slip sheet as per specification *not required with CTEM

Growing media installation

Sedum blanket installation

Above: 3 months later with no irrigation

Above and Left: 1 year later – with no irrigation

Intensive Green Roof Application - Green Living Roof Panels

1. Roof Gardens – The SAME Patented System used for extensive

- Green Living Roof Panel
- GLTi bioSoil to specified depth
- Plant material, mulch and grass where applicable
- Lead time – 1 to 3 Weeks

The dynamic range of use for the Green Roof Panel is prevalent since it can be used for all types of green roof applications. With a **compression strength of 3200psf** (150 kN/m²), you can build patios directly on top of the panels, and trees, walkways and large planters are features that can be designed around the load capability of the roof.

Roof gardens are for experienced designers only. The details are NOT a one size fits all application, please consult with GLTi directly for roof garden design and assembly. Below are images of a 30,000 f^2 intensive green roof complete with trees and 56" of growing media.



(L) Prep the area and mark out the planting beds. (M) Stage pallets of materials (IMPORTANT! DO NOT EXCEED THE ROOF LOAD CAPABILITIES!) (R) Root barrier, wall construction, irrigation and lighting preparation.



(L) Lightweight retaining walls and lighting wire. (M) 2' caliper trees (IMPORTANT! DO NOT EXCEED THE ROOF LOAD CAPABILITIES!) (R) Root barrier and green living roof panels are installed in preparation for the trees and growing media.

Intensive Green Roof Application - Green Living Roof Panels Cont'd



(L) Custom blended/engineered growing media is blown into place at the specified depth. (M) 2" caliper trees are installed directly on top of the green living roof panels (IMPORTANT! DO NOT EXCEED THE ROOF LOAD CAPABILITIES!) (R) Lightweight insulation is installed along the perimeter to act as filler and to remove some of the excessive weight load created by the higher organic growing media. The planting areas will be filled to specification and a drip irrigation system will be installed with the sod to follow.



This private rooftop park provides aesthetic improvements, greenspace, amenity space, storm water retention. It also serves as a sitting and gathering area for the residence living in the mixed-use facility.

Intensive Green Roof Application - Green Living Roof Panels Cont'd

2. Rooftop Farms – The SAME Patented Panel System

- Green Living Roof Panel
- GLTi bioSoil to specified depth 12" – 18"
- Plant material
- Lead time – 1 to 3 Weeks

The success and ease of the Green Living Roof Panels are ideal for providing an easy installation and predicted performance. This is especially true if the application is for a rooftop farm. The Green Living Roof Panels are lightweight and tough! Your waterproofing under your rooftop farm is susceptible to damage from equipment not designed to be used on roofs. Shovels, spades, metal rakes, pitch forks all pose a real threat to the waterproofing protection. The Green Living Roof Panels are virtually impervious to accidental strikes with unforgiving tools, thus preventing the penetration of the waterproofing.

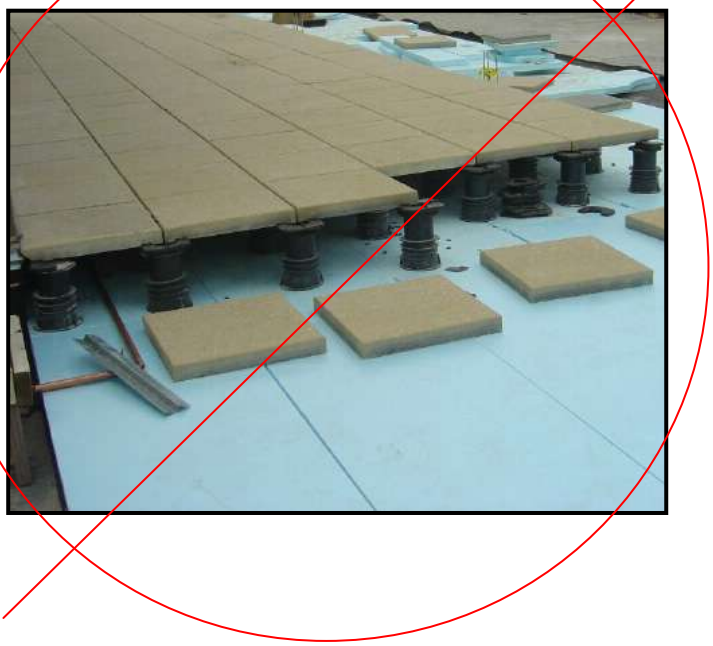
The reality is a roof farm worker might not even recognize that they hit the waterproofing. The result is a small leak that may travel under the waterproofing and the real location of the leak may never be found without an expensive removal or the green roof. The green living roof panels protect the roof in two ways; one, its durability and toughness; and two, its moveable sections because of the modular installation. You do not have to destroy all the key layers or remove unnecessary areas. *If the EFVM system was installed as part of the CTEM SA (pg 27 – 28) it would be easy to find the breach and repair the mistake under the single source warranty!

Hybrid Green Roof Application

Hybrid green roofs can be defined by combining both extensive and intensive green roofs. The flexibility of the green living roof panels allow for additional growing media to be added directly on top of the extensive areas. The built-up areas that accommodate deeper rooted perennials and shrubs need to be conducive to the structural load capabilities. DO NOT exceed the roof loading capabilities. As a designer or architect you can include berms and undulations and deeper areas of media blended into the extensive landscape.

Pavers, Patios, Walkways and Accessories

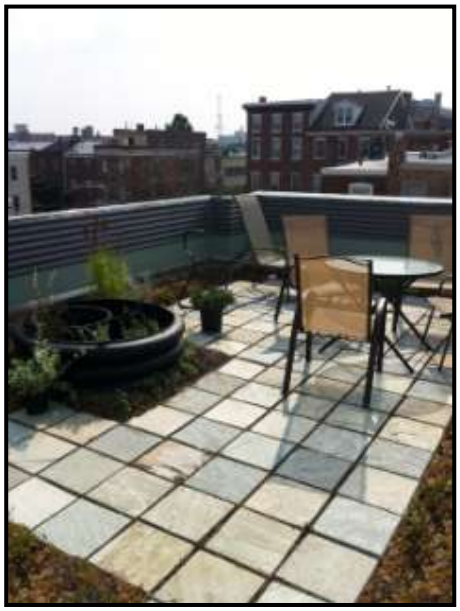
Vs.



(Left) The GLTi paver system is simple. Using the drainage board, fill the cups with coarse sand. Cover with a layer of landscape fabric and install your pavers.

(Bottom-left) In a traditional pedestal system each paver has to fit perfectly, be leveled, and the height has to be adjusted on every corner. The result is a very time consuming installation.

(Bottom) The GLTi paver system is part of our already durable Green Living Roof Panel allowing for curves, patterns and walkways that meander. You can design using a variety of materials as the transitions are clean when going from walkway/patio to green roof.



Pavers, Patios and Walkways Cont'd

Chapter 7: Sloped Green Living Roof Applications

0 – 20 degrees / 4:12 pitch – Green Living Roof Panels

The Pre-Grown GLTi Mats combined with the Green Living Roof Panels can accommodate slopes up to 20 degrees with zero erosion. Some precautionary measures must be applied in the form of finished edging details and irrigation. Please consult with GLTi for more information on specifying sloped green roof applications.








20 – 90 degrees - Green Living Wall Panels Cont'd

Utilizing the Green Living Wall in addition to the non-penetrating (two-sided) sloped roof and a minimal point penetration (single-sided) sloped green roof from 20 to 90 degrees, the bracket system allows for 3" of clearance, allowing water to flow freely between the green roof and the waterproofing. This design can be applied on top of shingles that are less than 10-years old! The design eliminates any chance of sitting water and allows for unrestricted airflow that lets the shingles breathe and dry out.

Because the green living wall system is 100% pre-grown there is no erosion. Custom designs and deeper-rooted perennials are a design option with the standard 4" and 6" depths. DO NOT EXCEED THE ROOF'S LOADING CAPACITY! Contact GLTi for consulting and design of your sloped green roof.

Above the GLTi Sloped Green Roof Brackets have only 4 penetrations on this single sided sloped green roof. The two sided sloped green roof application don't have a single penetration!

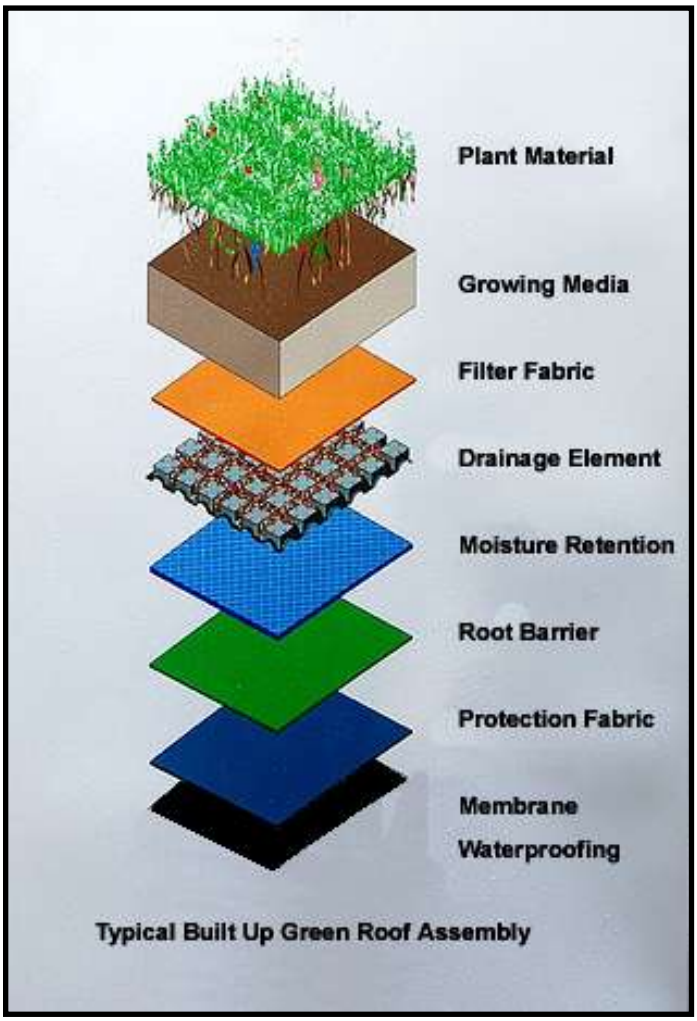
Notice the space between the waterproofing and the brackets that allow for any excess water to flow freely. Due to this air space, the waterproofing or shingles are allowed to remain dry.

20 to 90 degrees - Green Living Wall Panels Cont'd

ONE EASY-TO-USE SYSTEM FOR ALL TYPES OF GREEN ROOF APPLICATIONS

Chapter 9 - Green Roof Product Comparisons

Typical Built Up System



- Expensive
  - Multiple materials, rolls, sheets.
  - Labor
  - Lifting is 3 to 5 times more
  - Materials may not all arrive on time
- Difficult, time-consuming to install
  - Rolls have established memory and want to curl back
- Long establishment time and greater maintenance
  - Weeding, erosion control and irrigation
- Not very "green", requires multiple vendors for materials, excessive delivery
- Lacks consistency because of various vendors
- Pieced together on site
- Heavy – may require structural changes
- Up to 8 layers of material

This is a typical multilayer green roof assembly. Besides the waterproofing, which could also be an additional five layers pending the type of system, a multilayered green roof may contain seven additional layers of material.

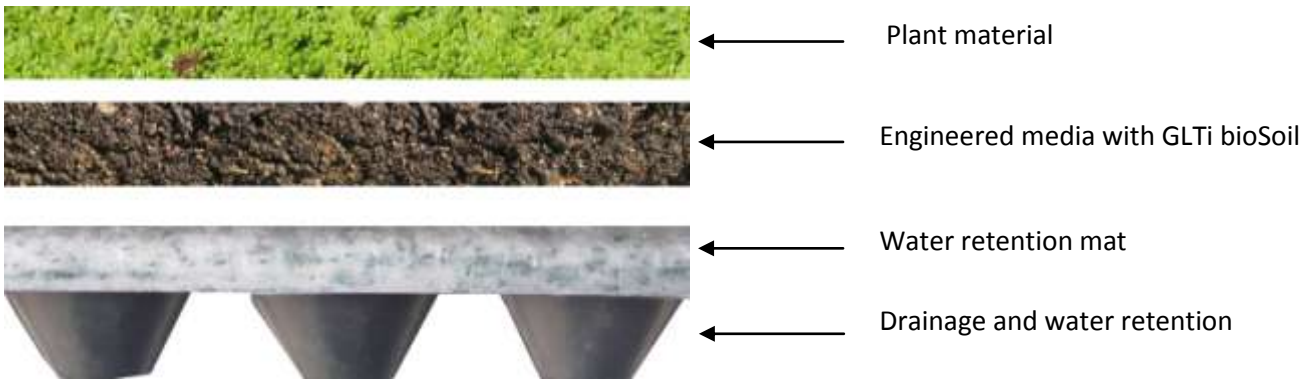
NOTE: It is a typical sales tactic to require or design such a system simply to increase the quantity of materials for higher sales margins when a simpler and more cost-effective method could be applied. Watch out for an abundance of unnecessary materials.

In some green roof applications the drain layer may still be comprised of gravel or drainage stone. On average, a cubic foot of gravel that is between ¼" and 2" thick will weigh 105 lbs. and

cover 8 square feet at 3”of depth. This is equivalent to 13 lbs per square foot, just for drainage. By adding stone as the drainage layer there is an increase of labor, machinery and the risk of penetrating the waterproofing with tools not designed for working on rooftops with. The gravel drain layer also presents a risk of breaching the waterproofing. Adding just 4” of growing media could equate to an additional 30 lbs per square foot, not including plant material.

Below (left) shows various layers of materials, and Below (right) shows the drainage layer being installed using a crane and typical metal rakes.

Versus:



Discussion:

What would be a more acceptable drainage layer and why?

Green Living Roof Panels

- One system for all types of green roofs--extensive, intensive, pre-grown, or planted in place
- Does not disturb the existing roof, is non-invasive, and rapidly installed.
- Installed in a neat and timely manner with no loose layers and no penetrations to the waterproofing.
- Pre-grown allows for immediate benefits
- Low maintenance when installed mature
- Superior water retention
- Flexible and easily shaped to fit around rooftop objects, can cut circular patterns and account for undulations
- Can be dismantled and reassembled in sections
- Can handle sloped (<20 degrees) or flat roof tops
- Lightweight suitable for commercial, industrial, residential and historic buildings.
- Locally grown for your region
- Because it is pre-grown it eliminates plant establishment costs and erosion fabrics that don't always breakdown in a timely manner
- 100% flexibility for any application
- Weighs approx. 12-15 lbs per sf saturated and as low as 10 lbs per sf saturated
- Ideal for roofs with a low load-bearing capacity
- The drainage carrier has a built-in water reservoir with overflow, preventing the plants and growing media from drying out, and preventing root rot
- The moisture retention mat/root stabilizer and growing media naturally wicks water horizontally and reaches full saturation before draining. The other systems simply let the water drain through. Retains up to 8 gallons per 10.5 f^2
- Unlike natural fiber mats the Green Living Roof moisture retention will not break down over time.
- 100% soil to soil contact

Other Roof Panels

- Requires multiple layers of material
- Installation is layered making roof repair a costly expense
- Increased installation cost due to nature of supplies and labor
- Increased maintenance cost due to immature plant material
- Increased labor to manually plant material
- Adds excess weight of materials to roof
- Can not be applied to some existing roofs
- Installation time is doubled and at times tripled because of materials and lifting time
- **DYK** that most of the other green roof companies are really waterproofing companies? They are not plant or media experts.
- Higher cost
- **DYK** that to fix your roof you would have to tear apart the entire green roof. With a Green Living Technologies system you simply remove the panels, fix your roof, and replace them! If you move, take us with you.
- Some don't have a drainage layer with the ability to hold water! This system requires consistent watering and irrigation.
- Some grid or tray systems will maintain the grid pattern and cannot be cut or shaped to odd angles.
- Tray systems must be on a flat slope and cannot account for undulations.
- Some tray systems have excessive plastic waste
- None of the trays have 100% soil to soil / root to root contact
- Exposed plastic will break down over time.
- Other trays do not have the water retention capabilities and promote root rot.

Product Comparisons

Plant in Place – Cuttings or Plugs

Planted-in-place green roofs are established with cuttings or plugs. Initially inexpensive to install, costs can range from $9 to $12 per square foot. Even though the techniques have an initial attractive price point, this technique will quickly dissolve the cost savings and increase the establishment costs through the maintenance required to establish the roof to maturity. These costs are well over the purchase price.

Below is an excerpt from a specification offering **NO warranty** and putting **ALL** the responsibility on the installer. "Company" has been inserted to protect the name of the firm that provided the quotation.

3.10 PROVIDE 2-YEAR MAINTENANCE SERVICE

The green roof installer shall offer a two-year maintenance service. This service will include:

A. Hand weeding and/or chemical weeding and fertilization, as required to maintain the health and vigor of the plants.

B. The installer shall guarantee an 80 percent cover rate at the end of 24 months.

C. As necessary, plants shall be replanted to achieve this requirement.

NOTICE

No warranty expressed or implied is offered for any work based on the information provided herein, unless

1) COMPANY, Inc. is providing a supervisory role in the construction of the vegetated roof cover, and

2) Installation and maintenance of the vegetated cover is provided by a contractor that is trained and licensed by COMPANY, Inc.

COMPANY, Inc. will not assume any responsibility for the inclusion of this material in specifications or documents published by others.

The specification clearly states: ***"PROVIDE 2-YEAR MAINTENANCE SERVICE"***

Ironically, ***this 24-month period is when green roofs start to decline.*** Historically, because of

the media types, the inability to retain water, lack of nutrients and susceptibility to weed infestation, the written specification includes the following requirements to establish the green roof in this manner.

A. Hand weeding and/or chemical weeding and fertilization, as required to maintain the health and vigor of the plants.

B. The installer shall guarantee an 80 percent cover rate at the end of 24 months. As necessary, plants shall be replanted to achieve this requirement.

Here is where the an inexperienced installer will become burdened with the amount of weeding, fertilizer and labor hours it will take to properly bring this project to 80% coverage as specified in letter B.

After the 2-year maintenance period, the contract is fulfilled. Rhetorically speaking, what will constitute 80% cover rate? This is going to be the first item in question upon the two-year close out. The weeding alone is an estimated gamble on how many hours one can spend weeding one project and for how long.

Typically the result over the two-year period is the maintenance contractor is actually losing money having to maintain the green roof and the attention to detail is abandoned.

Here is a letter pertaining to a quote directly from COMPANY also formally known as COMPANY: (The authors comments are seen in red after highlighted areas)

Hello Mr. xxxx,

You have asked us for a budget number for a 3" thick un-irrigated sedum green roof on the referenced building. The vegetated roof area is expected to be about 21,540 sf, installed on a steel roof deck about 30' above grade. Most likely, media would be placed onto the roof with pneumatic equipment. Non-union wage rates are assumed. Please note that this rough budget number only describes the installed cost of the vegetated roof (including pavers). The cost for installing the underlying waterproofing (and waterproofing protection layer) is NOT included in this estimate. Protection fabric is NOT included; this is the first added hidden cost to the base quote.

Given our limited understanding of your project, we would expect that the estimated installed cost of this green roof profile to be roughly about $11.00/sf – $13.00/sf. This is the base quote for 3" depth of media

Please note the additional following assumptions that underlie this estimate:

- The plants are established with plugs (one per square foot); however, use of cuttings to establish the sedums could reduce the installation cost by about 10%. If pre-grown vegetated mats are to be used, add about $6/sf to the cost above. One plug per square

foot is NOT sufficient. This is a tactic to lower costs on the materials sold to the installer. If you recall:

> ***A. Hand weeding and/or chemical weeding and fertilization, as required to maintain the health and vigor of the plants.***
>
> ***B. The installer shall guarantee an 80 percent cover rate at the end of 24 months.***
>
> ***C. As necessary, plants shall be replanted to achieve this requirement.***

This leaves the installer on the hook for a maintenance agreement that is not going to allow one plug to cover one square foot in less than 24 months. The result is an installer that is going to abandon the effort needed to bring the roof to the specified maturity. The result is a weed-infested green roof and an unhappy client.

- The weight of the saturated 4" thick green roof is about 27 lbs/sf. However we asked for 3" depth resulting in roughly 20 lbs per square foot.
- The pitch of the roof area does not exceed 2:12.
- A parapet is assumed and a 1-foot gravel perimeter around the green roof is assumed.
- A non-EPDM waterproofing was assumed. If EPDM is used, add about $0.50 to the cost above. Another up charge to the base price
- The waterproofing is not root resistant; a root barrier is assumed. This would be yet another up charge and notice the additional layers starting to add up. As mentioned on p.55 the increased use of unnecessary layers simply to sell product to increase profits.
- The waterproofing configuration is conventional (not PRM). Protected Roof Membrane, which is ideal for green roof applications and preferred. So why are they requesting a conventional roofing system?
- Two years of maintenance during the non-winter months (in addition to the standard Workmanship Warranty) is not included to insure the plants are weeded on a monthly basis and monitored to perform as specified. Yet another up charge to the standard base price.
- Six internal drains are assumed.
- The cost for permits is not included.
- Installation logistics are not complicated.

- The green roof is installed by a Company network green roof installer.*

*These costs are achievable in an environment in which smaller, specialized contractors skilled in these types of installations are permitted to bid and effectively compete. This estimate cannot account for potential markups often expected from contractors that are unaccustomed to installing these types of green roof assemblies.

These assumptions were made only to help us estimate the cost of your project but in no way illustrates the limits of our design capabilities or customer service. We can accommodate nearly any kind of architectural feature, including steep pitches on asymmetrical roofs. Finally, we work with a number of waterproofing manufacturers and can usually offer single source warranties if requested on conventional or PRM configurations.

END QUOTE

Comparison on a 21,450 square foot planted in place green roof:

Total SF = 21,450

COMPANY / COMPANY

- Base cost = \$13.00 per ft^2
- \$13.00 x 21,450 = \$278,850 base cost
- Waterproofing protection layer is not included. Assuming it is geotextile fabric add \$1.00 per ft^2.
- \$1.00 x 21,450 = \$21,450

To be fair, we will assume a TPO waterproofing (No EPDM so we don't mark the cost per ft^2 up anymore than it should be. The current total estimate is \$14.00 per square foot.

Total Cost to install the 21,450 ft^2 = \$ 300,300.00 or \$14.00 per ft^2 not including irrigation

This is for the installation ONLY for 3" of growing media and only 1 plug per square foot.

The additional long-term cost to establish the roof is to put back on the contracting installer:

A. The installer shall guarantee an 80 percent cover rate at the end of 24 months. As necessary, plants shall be replanted to achieve this requirement.

- 2 years of maintenance (2 man hours per 1,000 ft^2 = 42.9 man hours x \$35.00 per man hour = \$1501.50 per month for the next 2 years.
- Based on 9 months of the year x 2 years = 18 months x \$1501.50 = *\$27,027.00 additional maintenance*)

If maintenance costs are a generous \$1.25 per ft^2 the cost of plugs ranges from \$.50 to \$.75 each. The contractor is responsible for replacing plugs, and it is the conclusion that only one plug per ft^2 will eventually cost the contractor money on this account! The result is they will be forced to skip visits, not fertilize, and there will not be enough in the contract funds to pay labor for weeding and to replace plugs as needed. The result of the initial capital saved up front on the installation

will result in a failure to meet the 80% specification and a roof will struggle and become infested with weeds eventually overtaking the plugs that did survive.

The real cost has now climbed to $327,327.00 or $15.26 per ft^2
This is assumed that one plug per ft^2 will provide 80% coverage in 24 months using heavy fertilizers, and all without irrigation.

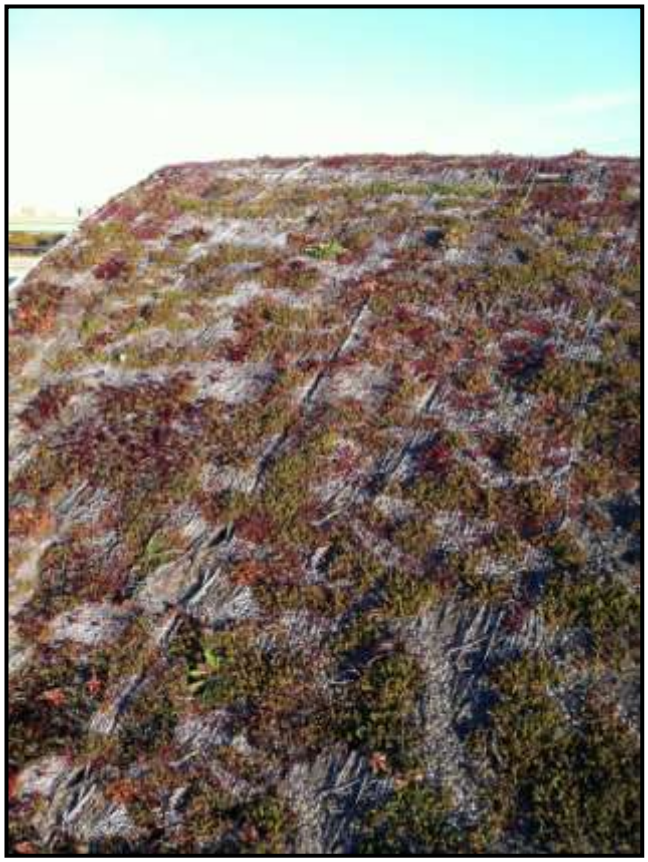
Authentic Documentation:

(LEFT) This project is moving into the 4th year (as of 2012). Planted with plugs, the sedum has been taken over by ground ivy, chickweed, spurge, clover, speedwell, plantain & dandelion.

Even though some of these weeds are annual, they die off seasonally, and they will re-seed themselves with vigor. Deep-rooted, these weeds also pose a potential issue for the waterproofing.

(RIGHT) The picture shows the result of minimal plant establishment. This is the same project of three years and the sedums have not been able to establish themselves. The result is erosion that exposed the irrigation lines buried under the media. These same areas are also prone to weed infestation.

Additional Results from Planted in Place cuttings or plugs:



This roof was planted with one plug per ft^2 recently photographed at the three-year interval.

The above project is also about 3-years old. Located in Syracuse, New York, this project is the result of poor maintenance practices. It is typical that the project was priced low enough to win the bid but lacked enough funding to keep up with the intensive maintenance needed. The general contractor was compensated; the installer was paid for their services and the first two years of maintenance. Because of the demands placed on the maintenance the installer could not keep up the needed hours to establish this roof placing the project in a spiraling decline.

It is clear that our analysis of the maintenance costs is accurate since we know this project well. If you recall the breakdown from p.62:

If maintenance costs are a generous \$1.25 per ft^2 the cost of plugs ranges from \$.50 to \$.75 each. The contractor is responsible for replacing plugs, and it is the conclusion that only one plug per ft^2 will eventually cost the contractor money on this account! The result is they will be forced to skip visits, not fertilize, and there will not be enough in the contract funds to pay labor for weeding and to replace plugs. The result of the initial capital saved up front on the installation will result in a failure to meet the 80% specification and a roof will struggle and become infested with weeds eventually overtaking the plugs that did survive.

(LEFT) Planted with cuttings this roof is fitted with a temporary irrigation system to keep cuttings moist. The irrigation may be turned on up to 6 times a day to keep the cuttings from drying out. The initial cost savings of the installation will **not** offset the intensive number of hours it will take to physically weed the roof during the establishment period.

(RIGHT) is a planted-in-place roof, planted with cuttings, that has been taken over by common weeds. The only way to remedy this green roof is to kill it off with harsh chemicals and salts and start over. These planted-in-place cuttings will also be subject to birds stealing the cuttings. In some projects yet another layer is applied in the form of jute fabric (p.64)

You can establish a roof with cuttings if you budget the labor hours and fertilizers to move it along. In the long run and for immediate impact, pre-grown sedum blankets is the method we recommend for the aesthetic value and the instant benefits while reducing the maintenance by 70%.

Product Comparisons Cont'd

Tray System

They typical tray system is just shy of a plastic box with holes; a formed box with holes in the bottom is also a fair evaluation. The series of negative attributes are long and overshadowed by a false sense of simplicity. The typical growing media is a major downfall for the performance of most tray systems. Since the introduction of trays, very little has been introduced in the way of proper water retention to prevent root rot in sedum species.

Above, a section of a Live Roof Tray is shown after being cut to display a plastic box with drain holes. The only water retention is in the media itself, recalling the exceptional draining ability of the engineered media, this system will require excessive irrigation. To make matters worse the Live Roof Tray has historically been difficult to design irrigation for.

Irrigation: It is exhausting to design or install irrigation systems for this tray. Because the tray lacks water retention and is unable to wick water a typical tray design will require overhead spray heads. Recalling p.41, green roof media is primarily aggregate that provides excellent drainage; the result is increased amounts of irrigation and wasted water. Water is wasted in multiple ways when using typical pop-up spray heads. Overspray and evaporation are common, and because the trays offer little means of securing the spray heads, the heads often move and shift every time the irrigation turns on and off. Because of the highly porous green roof media the irrigation is typically set to run every day. Excessive watering also promotes pathogens and fungal disease. The end result includes excessive water and wasted maintenance hours fixing irrigation spray heads. Because of the design flaws in trays the integrity and inconsistency of irrigation design may destroy the integrity of the box itself shown blow where the Live Roof Tray has to be cut in order to accommodate the irrigation and spray heads.

This Live Roof tray system shows a 6” pop up spray without support. Each time the irrigation is turned on the head will continue to loosen, over spraying irrigation, wasting water and irrigating areas NOT intended for water.

Live Roof tray system showing signs of alterations to account for irrigation line compromising the integrity of the tray.

Above & below poor design showing a 6” pop up connected to flexible piping. If the head was placed on a riser it would be subject to breakage.

Above & below 6” pop ups were poorly chosen to irrigate an area that is blocked by a larger grass. The 6” pop up will NOT provide proper coverage overwatering and wasting water.

Left: The flexibility of the Green Living Roof Panel allows for ridged PNC or flexible supply lines from ½" to 1-1/2" directly under the system. Designing the irrigation system is simple and the ability to stabilize the irrigation heads is built into the design feature. There are no holes to drill in the edging or sides of the trays. The Green Living Roof Panels make for a simple yet functional installation.

Structural: There are multiple tray systems available and most of them are manufactured from plastic. Plastic allows for an easy and cheap means to produce the box shapes that serve a single purpose. These box shapes hold the growing media for the plants and since they are plastic they are also susceptible to breaking due to the nature of the ridged structure.

Live Roof Tray

Metro Vision Plastic Tray with obvious attempt to glue the connector. (Greenbuild 2011)

The pictures above exemplify the susceptibility of the plastic tray. Sadly, during routine maintenance, the trays are walked on multiple times by multiple laborers during the year. This breaks the plastic, which then become sharp objects between the tray and the waterproofing.

Plastic boxes/trays do not flex and broken trays are always a threat to the waterproofing. Due to their rigidity, the plastic trays cannot account for the undulations and contours found on all roofs.

Many things happen:

- The trays' sharp plastic break and the maintenance technicians may not know until it is too late.
- Growing media falls between the trays. It has been documented on multiple occasions that the media erodes to the roof and eventually will hinder free drainage on the roof.
- The media eventually washes to the natural slope into the roof drain. With enough aggregate and fine particles, the drain will become clogged.
- The media, because it is 80% aggregate becomes a threat to breach the waterproofing especially when walked on.

Figure 1 displays the concept of tray installation. However, as shown in figure 2, rarely does a roof have a perfectly flat application. Even small undulations cannot be accounted for. Figure 3 depicts the reality of a ridged plastic tray. Figure 4 shows the broken connectors from Metro Green on p.36. If the tray does not sit perfectly, the tabs will break and walking on the roof for maintenance will eventually push the plastic tab into the waterproofing. (Fig. 5)

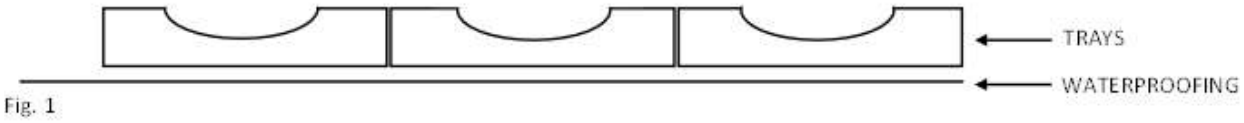


Fig. 1

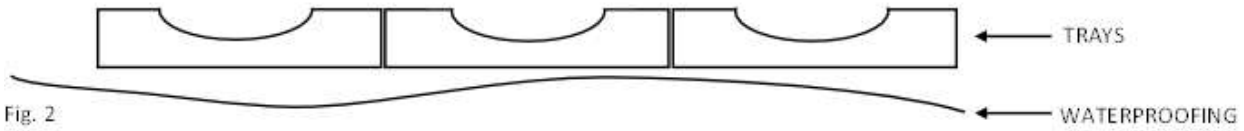


Fig. 2

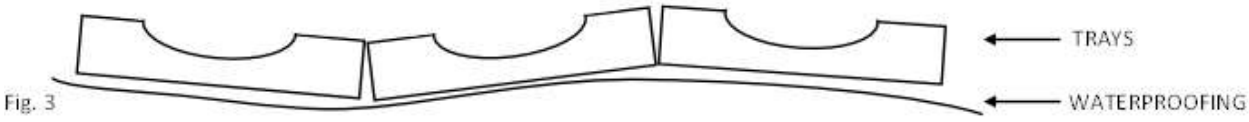
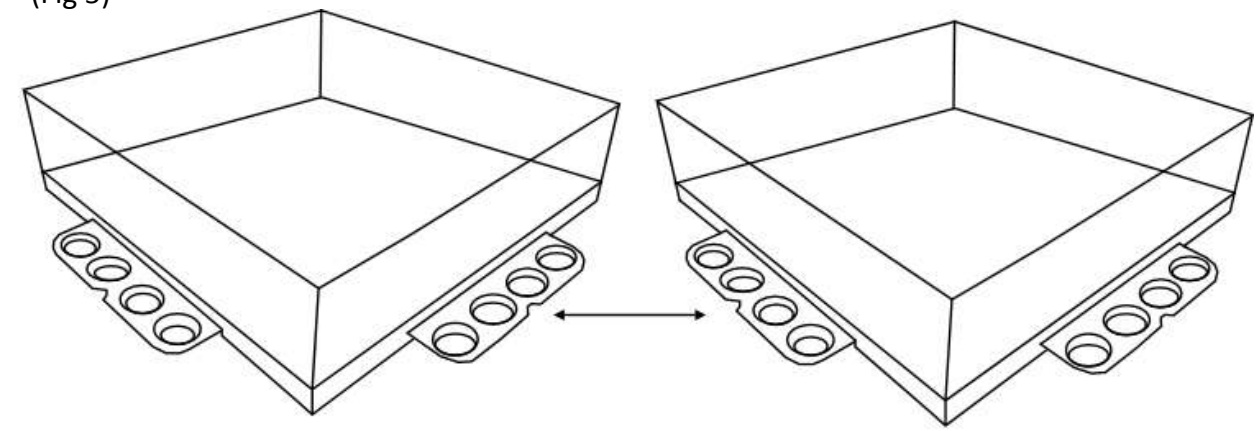
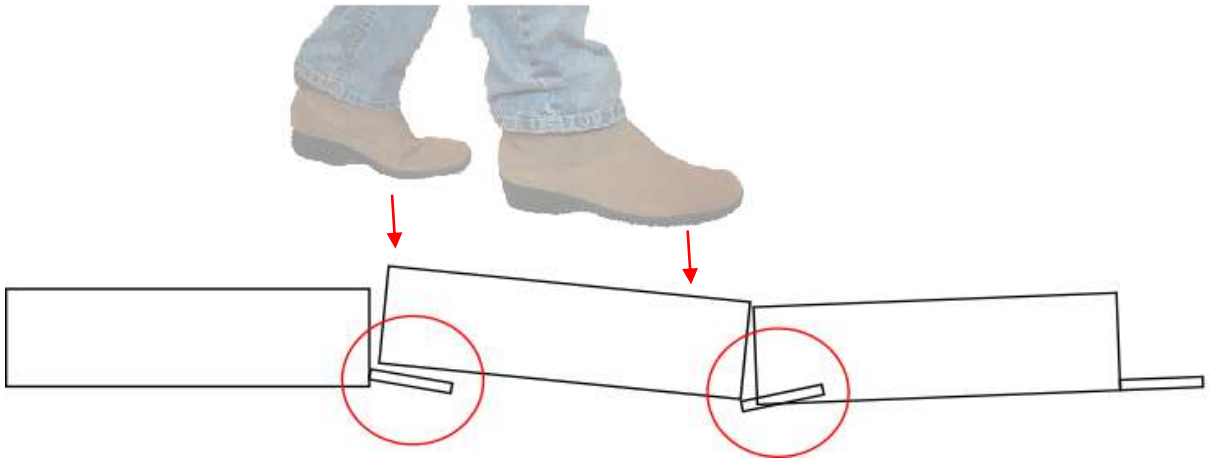


Fig. 3

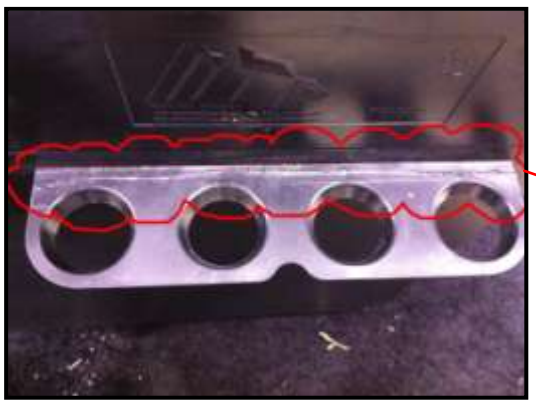

Fig. 4

(Fig 5)





(ABOVE) Broken tabs become sharp objects against the waterproofing. Once the tabs break it is too late. The maintenance tech walking on the roof will not know the tabs have broken and that a leak is developing. (BELOW) Documentation of the broken tabs.



Product Comparisons Cont'd

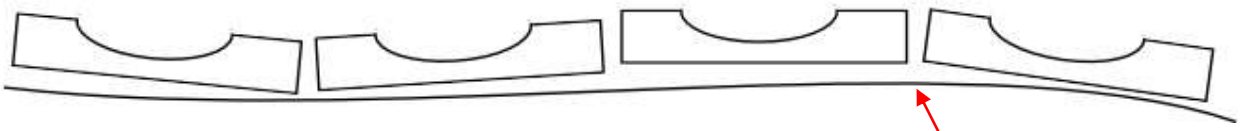
Trays - Product Materials

Exposed plastic will continue to expand and contract causing material deterioration. The inability to fully remove any seams will always cause media to fall between the trays.

Product Comparisons Cont'd

Trays – Installation and Design Flaws

The tray system inevitably has gaps between the trays allowing growing media to fall between the seams in which they sit next to each other.



TOP LEFT & BOTTOM RIGHT – Live Roof plastic tray shows growing media eroding under and between the trays. It is also noticeable that the roots of the plants have made their way to the waterproofing via the drain slots. *This project was less than a year old.

TOP RIGHT – Shows the gap created by the tray when the surface is not completely flat. Trays cannot account for undulations.

Product Comparisons Cont'd

Trays – Installation and Design Flaws

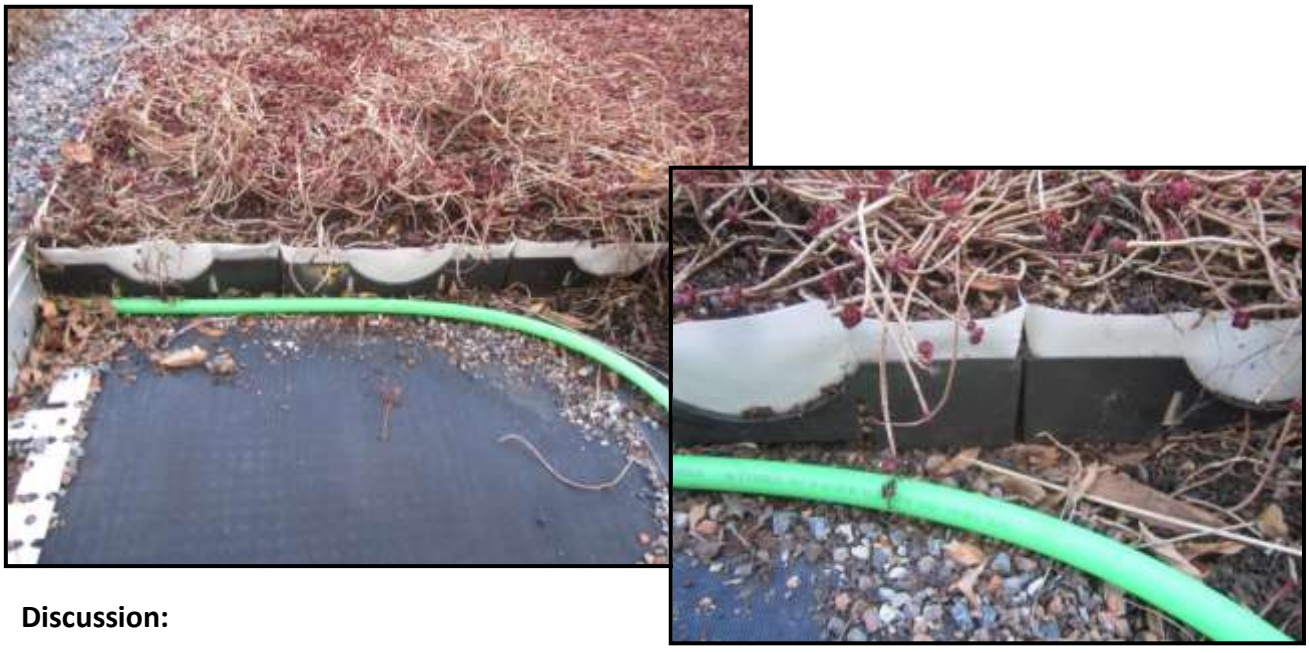
These two pictures clearly show the excessive growing media under this one tray alone. It also shows the root penetration between the drain slots.

Product Comparisons Continued

Trays – Installation and Design Flaws – Extra Parts, Pieces and Waste

Some of the tray systems developed recently over the years have "Lifts, Soil Elevators and Plastic Sides" to be removed upon installation. This allows a deeper depth of growing media without having to add a higher sidewall on the tray itself. This is a major reason for growing media eroding between the trays as shown on pages 72 and 73. These extra pieces also create additional waste.

A 3,000 ft^2 roof will require 1,500 x 2 ft^2 trays. If each tray has 4 soil elevators or other type of plastic riser that equates to 6000 sheets of corrugated plastic or other plastic material either being thrown away or shipped back to the manufacturer or grower. Rhetorically speaking, how many installing contractors are sending back the plastic? As demonstrated below some of the soil elevators are not removed because they are "ends" or terminating trays that have no ability to retain the media. Is this an acceptable way to terminate the edge of a green roof? Is this cosmetically acceptable?



Discussion:

What would be the proper way to terminate the edge?

View the pictures above. Describe existing and future problems. How can they of been prevented? Describe some of the GLTi applications to prevent this situation.

The Metro Tray (Below) has the same concerns and creates additional material waste. Notice the ridged plastic sides. Even as a display unit it appears to be sloppy and there is the risk of media falling under the tray.

Trays – Installation Flaws – A Square Peg in a Round Hole?

Does a square peg fit in a round hole? Obviously not, why would you design a curved placement with a square tray system? Cutting and fitting a square tray leaves very little room for flexibility and design. The world is littered with square buildings, straight lines and the ability to account for curves and odd angles is a key design element.

Unlike the GLTi Green Living Roof panels, the plastic tray systems are not designed to account for such features. According to a rep from a popular tray company, “After cutting the tray wrap it in filter fabric.” This is unacceptable; filter fabric is not going to hold the media on a curved or angled edge detail and the integrity of the tray has now been compromised.

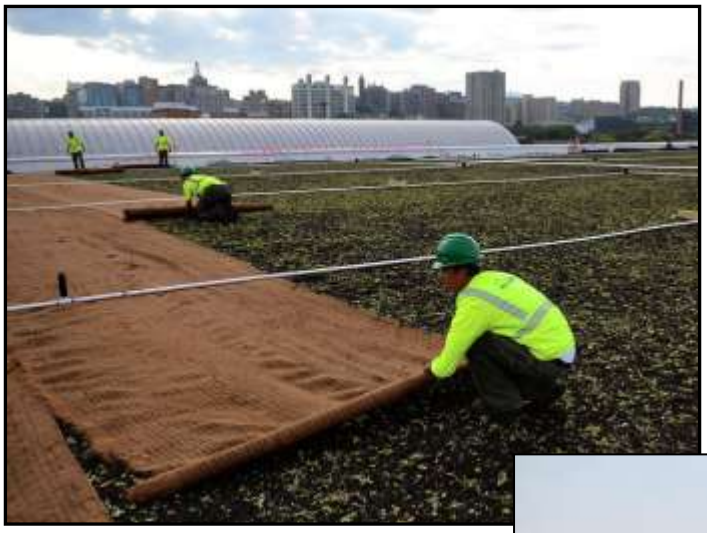
- Media falls between trays
- No Water Retention
- Roots grow through trays

Product Comparisons Cont'd

GLTi Pre-Vegetated Sedum Blankets

The GLTi sedum mats are the ideal application for instant gratification. Not only will the green roof be aesthetically pleasing but the roof will also be 100% mature. It will also require less maintenance, less water, less weeding, and the benefits are instantaneous!

Our price points for vegetation are extremely competitive and their quality is unmatched! The cost of pre-grown GLTi blankets will offset the extended cost of maintenance to weed, fertilize and irrigate the planted-in-place products.



TOP: Plant in Place with cuttings will require excessive irrigation and an additional layer of material, which adds to the overall cost

RIGHT: GLTi Pre-Grown Mats

You can save on the initial installation by using plugs and cuttings – but the overall cost will be up to three times that of the pre-grown sedum due to labor and maintenance!

Pre-Vegetated Sedum Mats -- Product Comparisons Cont'd

Below: GLTi mats in the field on March 12, 2012 (Dormant)

With over 500,000 square feet and two blends of sedum to choose from, the GLTi sedum blankets are always 100% mature and healthy. Delivered in a refrigerated truck, the blankets are ready for installation and can be installed in minutes!

BOTTOM: GLTi mats, close up, on 3-12-2012 (Dormant)

Pre-Vegetated Sedum Mats -- Product Comparisons Cont'd

GLTi Rolls and Mats, Quality unmatched!

Product Comparison Review

Media Quality & Termination Details
Left: GLTi Right: Live Roof

Root development and media quality
Left: GLTi Right: Live Roof

The GLTi system displays flexibility, easy to cut curves, angles and account for undulations. No media falls between the seams
Left: GLTi Right: Live Roof

Because of the GLTi flexibility, irrigation can be installed directly under the green living roof panels with NO need to modify the system to stabilize irrigation heads.

The tray displays an inability to properly irrigate vegetation without modifying the tray, and this compromises its integrity and function.

100% flexible can be cut to fit curves and angles. Patented technology allows for two layers of water retention with no threat of root rot, and requires less water and maintenance. The complete system allows the roof to breathe from below.

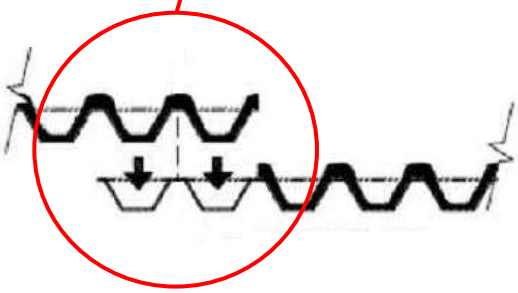
Cannot account for 100% design flexibility, curves or angles. Contractors have to cut and wrap the tray with cloth, which creates a point of eventual failure.

Inability to retain water requires constant irrigation and fertilizer. “Plastic tub with holes for drainage”.

Superior water retention! No sitting water at the root level, the roots and water are segregated unlike the tray systems that have no water retention capabilities.

Growing media is installed in a more natural state as the growth environment is more natural compared to boxes. Due to overlap in the panels, there is no media between the waterproofing and the panels, which eliminates any threat of a breach.

Growing media falls between the seams and under the trays, creating a threat of damming the drainage flow and breaching the waterproofing.



Due to the overlapping, there is no threat of media between the waterproofing and the GLTi Panel system. Even over time, the media will not fall between the seams.

Roots growing through the tray to the waterproofing, creating a threat of a waterproofing breach.

Clean installation without threat of media coming in between the system and the waterproofing either during or after the installation. The media will not migrate between the panels like it does with trays.

One system for all types of green roofs; extensive, intensive, roof farms, and hybrid. Compression strength of 3,200 lbs per ft^2 You can install trees, bushes, pavers and walks directly on top of the Green Living Roof Panels.

Chapter10 – Growing Media and Green Roof Plants

No media is created equal, and depending on which region you're located in, your media will have variations of key ingredients. It is much like baking a cake; you have certain mixtures that will provide a specific result, and the same is true with green roof media. Technically, because the media is blended, it is referenced to as "engineered" defined as "constructed".

The engineered media ingredients directly correlate to the media's quality and function. pH, oxygen exchange, water & nutrient holding, drainage and physical texture are considered characteristics of a quality recipe.

What's inside the media?

Organic material – High quality compost that initially supports biological activity, and pine, fir and hemlock bark.

Non-organic material – Expanded shale, sand, washed stone screenings, lava rock, and recycled clay brick.

Typical green roof media is a combination or a ratio of expanded clay, shale, bark chips, quality compost and sand. Depending the local and geographic region, the types of material will vary. For example the Hawaiian Islands are rich in lava rock, while the Pacific Northwest would be void of such material, or at least in bulk to suffice large-scale applications, while in the Northeast, expanded shale is abundant. The material ratios also vary specifically around the type of plant choices. More intensive or roof farms will require higher ratios of compost and still be able to provide sufficient drainage. On the other hand the typical extensive green roof with a common sedum genus will require a higher percentage of drainage material and aggregate and less compost.

Above, the author teaches the various ratios of engineered media in Honduras.

Expanded Shale

Recycled Red Brick

Black Lava Rock

Pine Bark Chips

Fir and Hemlock

Bulk Coco Husk

Stone Dust also known as Stone Screed

Coarse Sand (close view)

Fine Sand

Compost

The key factors to blending a successful engineered media can be classified by what is available and to what ratio it should be blended.

Geographic region – What ingredients are available? Previous attempts to import various media blends have resulted in vegetation failure. The single most important lesson here is to utilize what materials are available locally.

Ratios – What percentage will be needed to meet the needs of the plant choices, design intent, and the weight-loading restriction?

This is a typical extensive green roof media blend for project applications in the Northeast….

45% 3/8ths inch Red Lava Rock (no fines) or expanded shale or pine bark

20% Coarse and fine clean sand or washed stone dust and fine sand

15% Ground hemlock and fir bark

20% high quality compost

6 oz GLTi bioSoil (Probiotics for plants, turf, agriculture, trees and golf course applications.

bioSoil contains a wide consortium of living, natural, beneficial bacteria. (See p.49)

In the sample above we prefer higher compost content then a typical extensive blend which may only have 10% or less. However, typical extensive type media blends have increased drainage properties, which means that the media has very little nutrient holding power. It also means that when used with a system that has no water holding capability, such as a modular tray, there is an increased need for constant irrigation and fertilizing. Because the ratio of aggregate is high, the fertilizer and water are contributing and actually increasing runoff from the roof via excessive irrigation, except now, the runoff is coupled with fertilizer into the combine sewer or directly into other waste outlets. From a design perspective, a feature built into the Green Living Roof Panel is its ability to retain storm water and irrigation at the roof level and still be lightweight enough to accommodate a wide range of weight load restrictions.

A higher percentage of compost and bark will retain more water, increase microbiology and allow for nutrient retention resulting in healthier plants and a best management practice minimizing synthetic fertilizer use for extensive green roofs. (See p.195 Green Roof maintenance practices.)

The following is the baseline recipe in which you can adjust the ratios of available materials to meet a 20 lb per square foot specification at 4 inches deep, utilizing lava rock or expanded shale.

****Due to trade secrets we cannot disclose exact ratios and materials***

45% of the mix by Volume of 3/8" Red Lava Rock or Expanded Shale

Source:

Sizing

1/2".....100% Passing
1/4".....31% Passing
No. 16.....1% Passing

No. 200.....<1% Passing

Density

3/8" Lava Rock / Shale: 1 ton = 1.33 cubic yard

3/8" Lava Rock / Shale: 1 cy = 1500 lbs.

675 pounds of mix

20% of the mix by volume of Sand

Source:

A mix of clean, coarse, and fine sand.

Weight 2,500 pounds per cubic yard.

500 pounds of mix.

15% by Volume Fine Ground Hem-Fir Bark

Source:

Weight 750 pounds per cubic yard.

90.5 pounds per yard of mix.

20% by Volume GLTi Compost

Source: Compost Facility tested ½ inch minus compost product, using broiler litter, cow manure and woody clean yard debris as feedstocks composted aerobically for over 40 days and cured an additional 3 months.

Weight estimated at 1,000 lbs per cubic yard.

225 pounds per yard of mix.

GLT Lightweight Extensive Blend Weight

1,490.5 pounds per cubic yard delivered with average expected moistures during winter.

At three inches deep a cubic yard covers 100 square feet.

At four inches deep a cubic yard covers 80 square feet.

bioSoil – No factor in weight

The total weight of materials to meet the <20 pound / square foot (saturated) specification:

14.90 lbs = 3" of engineered growing media
2.00 lbs = 1" media with pre- grown sedum mats (lightweight by GLTi)
0.50 lbs = Non-organic materials / GLTi green roof panels
0.75 lbs = per square foot for water retention
18.25 lbs = saturated weight of a GLTi Green Living Roof with pre-grown sedum

In order to reduce the weight loading of the GLTi Green Living Roof system, the following is the baseline recipe in which you can adjust the ratios of available materials to meet a 12-15 lb per square foot specification at 3" – 4" inches deep.

****Due to trade secrets we cannot disclose exact ratios and materials***

50% of the mix by Volume of Pine or Hemlock Bark Chips

Source:

Density

Weight 500 pounds per cubic yard.

350 pounds of mix

20% of the mix by volume of Sand

Source:

A mix of clean coarse and fine sand

Weight 2,500 pounds per cubic yard

400 pounds of mix

10% by Volume Fine Ground Hem-Fir Bark

Source:

Weight 750 pounds per cubic yard.

60.5 pounds per yard of mix

20% by Volume GLT Compost

Source: Compost Facility tested ½ inch minus compost product using broiler litter, cow manure and woody clean yard debris as feedstocks composted aerobically for over 40 days and cured an additional 3 months

Weight estimated at 1,000 lbs per cubic yard

225 pounds per yard of mix

GLT Lightweight Extensive Blend Weight

1,035.5 pounds per cubic yard delivered with average expected moistures during winter.

At three inches deep a cubic yard covers 100 square feet

At four inches deep a cubic yard covers 80 square feet

The total weight of materials to meet the <20 pound / square foot (saturated) specification:

10.35 lbs = 3" of engineered growing media
2.00 lbs = 1" media with pre-grown sedum mats (lightweight by GLTi)
0.50 lbs = Non-organic materials / GLTi green roof panels
0.75 lbs = per square foot for water retention
13.25 lbs = saturated weight of a GLTi Green Living Roof with pre-grown sedum

GLTi is the only company in the United States that can meet a 10 lb. per square foot specification. Please note that irrigation is not an option and plant material is strictly limited!

Compost and Organic Content Controversy (COCC)

Pervious discussions depicted it was clear that "we prefer higher compost content than typical extensive media blends" and "a higher percentage of compost and bark will retain more water, increase microbiology and allow for nutrient retention resulting in healthier plants and a best management practice minimizing synthetic fertilizer use for extensive green roofs." As a reminder you also have to understand the needs of the plants!

With that said, in the industry as a whole there will be differing opinions and studies on how much organic material is ideal. The disagreement is not uncommon in the green roof world and in fact there are outright arguments. The one thing we can agree on is the fact organic material/compost will eventually break down, leaving the inorganic materials. In theory, speaking in terms of extensive green roofs with sedum, the thought process in the industry is that the dead leaves are to be left on the roof contributing to the organic material. What others

in the industry don't say is that it may take up to two years for the leaves to break down and become usable nitrogen or they may also become a feast for fungus and disease.

Understand that quality compost utilizes broiler litter, cow manure and woody clean yard debris composted aerobically. The key here is the heat and aerobic activity. Dead leaves on a green roof are hardly aerobic.

In the maintenance chapter we will address specific maintenance and best management practices for green roofs. The key to *this* chapter is to understand that the green roof is an artificial environment with organic and inorganic materials that make up a structure to support plants where natural organic material does not replenish itself like the forest and in fields where leaf litter, wood, and grasses become part of the living compost. Living compost is alive with bacteria, protozoa, nematodes, worms, arthropods and fungi. Contributing to the biology of the growing media, even if it is engineered, is critical to the success of all plants. Healthy roots equal healthy plants, less disease, less water, less fertilizer, less stress, less maintenance. Plants excrete exudates through the roots; this is a byproduct of photosynthesis, primarily in the form of carbohydrates (sugar) and protein. The excretion happens in the area known as the rhizosphere which is the immediate space between the root surface and the area surrounding it. The exudates are food for all the living organisms and competition is fierce, eat or be eaten. Protozoa and nematodes eat on the fungi, and bacteria also contribute nutrients to the compost as waste.

There is enough information on the living compost to fill a library. The point here is to realize that the living compost is a key contributor to the health of the plants. The organisms in the compost will do most of the work maintaining the plants. The plants will be less stressed, less prone to disease, well-fed, more resistant to insects and have increased oxygen and nutrient uptake.

Maintaining Living Compost in Green Roof Media

There are three key organic means in which we maintain the health of the media.

- bioSoil
- Compost tea
- Top dressing

It is typical that a planted-in-place green roof will rarely mature to specification and /or decline after about a year, and never reach its full potential without proper irrigation and fertilizer. Not to say all planted in place green roofs fail, my point is that they take too much care. The reason for the fertilizer is because the soil lacks living organisms! The synthetic fertilizer actually destroys living organisms. Fertilizers are salt and salt dehydrates living organisms, killing them. The same reaction is that of a plant treated with glyphosphate, the key ingredient in Round Up, a popular weed killer, in which the salt sucks moisture from the cells and roots and kills the plant. Fertilizer becomes a drug and once you start using it the soil becomes dependent on it.

Once fertilization stops the plants decline and become stressed, susceptible to disease, and require additional water.

This green roof shows clear signs of media decline. Once the media quality declines the plants die back and the voids lead to erosion and room for invasive weeds. This is a picture taken 3 years after the roof was installed; it never fully reached maturity primarily due to the inexperienced maintenance technician.

Getting rid of your fertilizer is much easier to maintain your living compost than it is to remediate it. The following is the natural means to maintain the living compost. Best management practice for the GLTi green living roof systems includes three key items:

- bioSoil
- Compost Tea
- Top Dressing

What is bioSoil? (review)

bioSoil is probiotics for plants, turf, agriculture, trees and golf course applications. bioSoil contains a wide consortium of living, natural, beneficial bacteria. Nitrogen-fixing bacteria

convert nitrogen from the air into natural fertilizer right at the plant, reducing input and fertilizer runoff. Nitrifying bacteria convert higher nitrogen forms into nitrates, the principle form of nitrogen used by plants and turf. Phosphate solubilizing makes the phosphorous in the growing media more available. The combination allows growers and maintenance technicians to greatly reduce their fertilizer inputs. The photosynthetic bacteria in bioSoil "feed" the plant as well as the entire growing media food web by producing sugars and adding carbon biomass. The multiple *Bacillus* strains in bioSoil increase plant and turf health thus increasing their natural resistance to pathogens and disease, and lowering the need for pesticides.

Plant diseases are present when three variables join together:

- Host plant
- Pathogen
- Favorable environmental conditions

Depending on their severity, root diseases can kill plants and damage an entire crop. Less severe infections damage plant roots, which inhibits nutrient uptake, delays crop schedules and reduces plant quality. You can apply chemicals to prevent disease, however at the same time that pathogen resistance is increased, your crop production costs go up. If you see plant disease, your plants have already experienced losses. The GLTi bioSoil is already engineered with Subtilex® (active ingredient: Bacillus subtilis-MBI600), a high-performance ***biological fungicide*** that prevents root diseases. The **beneficial *Bacillus subtilis* bacteria** colonize developing root systems, and combat disease-causing organisms that attack them. The bacteria also acts as a bio-stimulant that enhances the establishment and the development of the root system leading to stronger plant stands and increased yields. Unlike synthetic prevention, the GLTi bioSoil is 100% organic.

The *Bacillus subtilis* is a naturally occurring strain of bacteria. This bacterium combats harmful organisms preventing the onset of root diseases and enhances plant growth. When the plant's root system comes into contact with Subtilex®, the spores germinate and begin to colonize the roots within 48 hours. The bacteria grow around the root system to form a protective shield that serves as a physical barrier to common root rot pathogens. In return, the plant produces metabolites that serve as food for the organism. Subtilex® also produces an antibiotic and stimulates the plants immune response to ward off the disease organisms.

Reduced Incidence of Root Diseases for All Plant Species - broad spectrum of action against root pathogens (*Pythium, Rhizoctonia, Fusarium*).

Enhanced Plant Vigor - better growth enhancement than Fungal Inoculants.

Safe to use — No REI (Restricted Entry Interval) or human toxicity

bioSoil is an advanced science and biotechnology and an all-in-one agriculture product that will augment your compost, manure, humus, compost teas and other biologicals and lower your use of fertilizers, water, fungicides and chemicals.

- Similar products contain spore-forming (inert) microorganisms. In contrast, the beneficial bacteria in bioSoil are alive and actively growing so they start working instantly - results are often seen in hours as opposed to days or weeks.
- bioSoil contains a wide variety of beneficial bacteria that perform various functions for the plant. Many products contain 1 or just a few strains.
- We do not use growth inhibitors or other chemicals to keep our microbes alive.
- bioSoil is shelf stable for at least two years, which is a significant advancement in microbiology.
- bioSoil contains photosynthetic microorganisms that produce energy for plants.
- bioSoil is compatible with organic fertilizers.
- bioSoil can be applied with your normal watering equipment: Irrigation systems, watering cans, sprayers (end-hose, backpack, truck), etc.
- bioSoil can be applied as a foliar or a drench treatment.
- bioSoil can be used with Hydroponics
- Reduce fertilizer use by 50%.
- Reduce water use by up to 50%.
- Reduce fungicide and chemical use significantly.
- Increase yields and brix levels by 20% or more.
- Get healthier and greener plants, trees and turfs.

The substance of the food we eat today is not the same as it was decades ago due to the way we grow our crops. Practices such as over-fertilization, and chemical and hormone use can greatly diminish the nutritional quality in our food supply. These techniques cause plants to grow very quickly, but they don't necessarily have the time to obtain nutrients from the soil or to produce the vitamins, anti-oxidants, and other vital nutrients that add value to our diet and health. This results in food that is deficient in nutrition and adds more empty calories to our diet.

bioSoil contains beneficial bacteria as well as organic humates, a combination that has proven very effective in producing nutrient dense food. Our photosynthetic bacteria produce sugars by utilizing the energy in sunlight. This provides sugar to the plants - increasing the brix (sugar) levels, taste and nutritional quality and density. The other beneficial bacteria in bioSoil help to break down and cycle organic compounds and to sequester minerals, thus providing plants with the raw materials they need to produce healthy substances and to store vital nutrients in their fruits and vegetables. Humates are known to bind over 50 elements from the periodic table, including vital minerals such as calcium and magnesium. The humates in bioSoil concentrate these substances near a plant, allowing the nutrients that are present to be better utilized by the plant and incorporated into the fruits and vegetables.

Data from our field tests and from our many produce growers, including those for one of the largest food chains in the world, have demonstrated fruit and vegetables with higher brix levels, as well as increased nutrient levels of magnesium, calcium and other micronutrients in plants grown with bioSoil.

Left: Potato Roots without bioSoil Right: Potato Roots with bioSoil

Below – Green Living roof with bioSoil (Summer)

Below - Green Living roof with bioSoil (winter)

Below - Green Living roof (close up) with bioSoil (winter) showing no voids or erosion

Compost Tea

Compost tea is not liquid squeezed from a compost pile, nor a tea bag of manure hanging suspended in water or compost soaked in water. Using these types of soups invites pathogens and disease. The GLTi compost tea is aerobically enhanced through aeration. Aeration increases beneficial bacteria and microbes by four times. For example a good teaspoon of compost has a bacterial population of 1 billion in comparison to 4 billion bacteria in aerated compost. Because the microbes are glued to the compost the energy or aeration is used to separate them.

Part of the GLTi maintenance program includes the application of compost tea. There are multiple recipes and home brews available but we keep it simple. There are also just as many compost brewers. Keep it simple--you can make your own.

A new plastic garbage can (30 gallon) will produce enough compost tea to treat up to 3 acres where a 5 gallon bucket could treat a single acre or small garden or green roof less than 1000 square feet. No matter what if your tea is brewed properly you cannot over do it!

The second piece of equipment is an air source. Typically we use a pancake compressor with a gate valve on the hose to control the airflow. The water should be at a rolling boil--we want to use the energy to release the microbes, yet too much energy will kill them.

On the left a 100 psi pancake compressor ($69.00) and a 32-gallon plastic garbage can ($35.00), an easy investment for a commercial style compost tea brewer.

Compost Tea Recipe

Not to confuse you, but compost can be dominant in bacteria or fungi. It depends on the ingredients you use. Typically a bacterially dominant compost tea is applicable to the widest variety of plants, except for trees that prefer fungus-based compost.

For every 30 gallons:

1 lb of manure – Optional (cow, horse or chicken) *Dried and clean, pre bagged is usually best
3 - 5 lbs compost or Vermicastings
1 Cup Fish Emulsion
¼ Cup Liquid Kelp
¼ Cup of non-sulfured Molasses
2 oz. bioSoil

1. Aerate the 30 gallons of water for 2 hours. This will result in distilled water.
2. Blend manure, compost, fish emulsion, kelp and molasses
3. Let mixture brew for 24 hours
4. Add bioSoil at the end and allow brewing for another 15 minutes

Strain your brew through a paint strainer, a sock will be too fine and you will remove some of the bacteria you spend so much time separating from the compost and breeding.
The brew can be applied through a variety of applications; my favorite is to have a submersible pump attached to a garden hose with a coarse spray pattern. Submerse the pump into the tea and use the hose sprayer to apply directly to the vegetation.

Top Dressing vs. Fertilizer

Topdressing means adding a thin layer of material over the surface of ground cover or turf. Adding compost in very thin layers over the surface of the green roof makes it possible to add organic amendments and gradually maintain or change the soil without disturbing the actively growing plants. Use of compost is aligned with programs that seek to reduce use of fertilizer and pesticides.

The following benefits have been documented by topdressing with compost.

- Provide a natural source of nutrients
    - Numerous university studies have demonstrated that topdressing with compost improves turf quality equivalent to conventional fertilizer treatments (see Geisel et al., 2001 and Garling & Boehm, 2001)
- Increased organic material
- Improves soil structure
    - Increasing organic matter through compost topdressing has been shown to decrease soil bulk density and improve the ability of water to infiltrate into the soil (Johnson et al., 2006; Landschoot and McNitt, 1994).
- Reduce irrigation

        - "Higher soil organic matter content allows more moisture to be retained in the soil, which improves mineralization of nitrogen and, therefore, growth." (Kropp and Guillard, 2002)
- Reduce thatch layer of dead leaves and plants
- Contributes to beneficial microbes
    - Research has shown that certain of these microbes can play an important role in inhibiting plant pathogens and suppressing various diseases. (Nelson, 1996; Nelson and Boehm, 2002)
- Reduce winter damage
    - One effect of composting is to improve growth in early spring and promote recovery just because of their nitrogen content. (Hsiang et al., 1999)
- Reduce weeds
    - This is directly related to improvements in the density of vegetation providing a competitive advantage over the weeds.

Application

- Clean the vegetative area free from major leaves or debris.
- Spread compost over green roof to a depth of ¼ to ½ inch using a walk behind spreader.
- Lightly brush the vegetation with the backside of a rake. The object is to get as much top dressing touching the soil as possible.
- Water the compost in, washing off the leaves.

Application Rates and Coverage:

Broadcast ¼ inches to ½ inch of compost depending on sedum height.

Coverage:

1 cubic yard of compost at ¼" will cover 1290 square feet
1 cubic yard of compost at ½" will cover 645 square feet

CUBIC YARDS NEEDED TO COVER

1000 square feet at ¼ inch = 0.8 cy
1000 square feet at ½ inch = 1.6 cy

1 acre at ¼ inch = 35 cy
1 acre at ½ inch = 70 cy

Left – Typical drop spreader for compost. http://www.woodlanddirect.com

Right – A roller type spreader http://www.gemplers.com

Chapter 11 – Green Roof Plants

We can't list all plants for all conditions and all regions, however in order to simplify the classification, we have provided four groups of common plant taxonomy. *Succulents, Perennials, Grasses and Woody* plants make up the majority of plant material. When in doubt consult a professional horticulturist and do your own research!

Plant Terminology

- **Adapted** – A plant that is not native to a particular geographic area, but thrives in the ecological and climatic conditions of that area without being harmful (i.e. is not invasive). Adapted plants are highly effective on green roofs.
- **Annual –** A relative terms that describes a plant that produces vegetation, flowers, sets seeds, and dies in one growing season. Annuals can be a good choice as accent plants on a green roof; however they may not reappear after several growing seasons due to the lack of open ground for the seed to establish in. Plants that are considered perennials in warmer climates may be considered annuals in cooler climates.
- **Biennial –** A plant that produces vegetation the first growing season, and flowers, sets seeds, and dies during the second growing season. Biennials are not a good choice for green roofs because they leave gaps in the plant cover after the second season.
- **Cultivar –** A plant variety that has been created through intentional breeding and that has been deliberately selected specific desirable characteristics. A variety of plant selected for distribution.
- **Cuttings –** Un-rooted pieces literally cut from mature green roof plants. Sedums and some other species can be grown on green roofs from cuttings that are spread directly on top of the growing medium. Spreading cuttings around plugs is a technique sometimes used to decrease the amount of time it takes to achieve a fully covered green roof.
- **Deciduous –** A plant that drops its foliage during some portion of the year, between growing seasons. Deciduous plants add organic material to the green roof environment. Over time, an abundance of deciduous plants on a green roof may change the balance of the composition of the medium thereby affecting the plants or the functioning of the green roof.
- **Drainage / Positive Drainage –** Similar to directing water away from the foundation or basement of your home, water on a roof must have a way to drain away from the roots of the plants and also must be provided with a way to leave the roof. The structure of a green roof can be thought of as a large-scale container; as with any planted container (aside from ponds), the water must have a way out. There are several construction techniques that can achieve proper drainage for a green roof and these should be employed according to the specifications and needs of each project.
- **Drought Tolerant –** A plant that will tolerate periods of low rainfall or drier climates.

- **Evergreen –** *see Winter Interest*
- **Grass –** A herbaceous plant with narrow leaves generally growing outward in an array from the base. Sedges, rushes, bamboo, and turf grass are all examples of grasses. There are both native species and cultivated varieties of grasses. On green roofs, grasses typically need irrigation and at least 6 inches of media to thrive. Additional ongoing maintenance is usually required of these plants.
- **Groundcover –** A plant with significant horizontal growth that can be planted to cover large areas of soil. Groundcovers work exceptionally well on green roofs as they cover the growing media fairly quickly, limiting maintenance due to weeding.
- **Hardiness Zone –** A number assigned to a geographical location by the U.S. Department of Agriculture, based on average and low temperatures found in that area at ground level. Using the same numbers, Hardiness Ratings are assigned to plants based on their ability to survive in the geographic area of that temperature range. The zone number is a guideline, and complying with the zone may not ensure the success of a particular plant on a roof, which may experience different conditions than ground level.
- **Herb –** A seed-producing annual, biennial, or perennial that does not produce a woody stem, but dies back at the end of the growing season. Herbs require growing medium that is at least 6 inches in depth and irrigation to survive on extensive green roofs; these plants are generally short-lived in a green roof environment.
- **Herbaceous Perennial –** A plant that emerges from the ground at the beginning of each growing season and dies back to the roots at the onset of winter. Perennials offer a vast range of colors, textures, and seasonal variability; however, few perennials are able to withstand the low maintenance and harsh conditions of a green roof environment. Those that have proven to do well on green roofs generally require a layer of growing media layer at least 6 inches in depth, and must have some irrigation to continue to thrive. Perennials should be carefully chosen for use on green roofs based on the project location, environmental factors, and maintenance budget.
- **Invasive Plant –** A plant that has thrives and spreads aggressively in locations outside its native range of habitat.
- **Irrigation –** A system of watering plants on an occasional or daily basis; systems may be built-in or temporary. Irrigation may be necessary for plant establishment or for the long-term success of the green roof, depending on the geographical location of the project, the plant palette, and the time of year the plants are installed.
- **Light Requirement –** The amount of light a plant needs to thrive; typically broken into the following levels: sun, partial sun/partial shade, or shade.
- **Microclimate –** An area occurring on a roof that differs in some significant way from the environmental conditions of the surrounding area. For example, vents, walls, heating and air conditioning units, and drains are some examples of fixtures that can create a microclimate on a green roof. Architects and landscape architects may need to take these microclimates into consideration when designing a planting plan.

- **Moisture Tolerant –** A plant that will tolerate some moisture around its roots, including occasional irrigation and wetter climates.
- **Native Plant –** A plant that has evolved in response to the ecological and climatic conditions of a particular geographical location, allowing it to thrive in that location. Native plants are typically resistant to disease, insects, and animals found in the indigenous environment of an area, and are highly adapted to the soil conditions and nutrient levels found at ground level. However, almost never are the insects, animals, and soil conditions occurring naturally at ground level found on the roof of a building; exposure, load bearing considerations, and access are all factors that may limit the re-creation of these indigenous conditions on the roof. Because of this, native plants are not generally well suited to the conditions found in an extensive green roof environment.
- **Plant Establishment –** The time necessary to acclimatize plants to their new environment after installation; plants are generally considered established once they have rooted into the growing medium and are producing new growth. Generally, much care must be taken during this time, including proper watering to promote root growth, and weeding to eliminate root competition.
- **Plugs –** Sometimes referred to as landscape plugs; all of our plants are sold as plugs in trays of 72 plants per tray. Our plugs have a root mass that is approximately 1 inch across at the top, and 3 inches deep tapering slightly towards the bottom. Through testing, we have found this to be the optimal size for growing plants on a green roof. Even larger sized plants will not outperform plants started from plugs over the course of a growing season.
- **Protected or Preserved Habitat –** A natural area on a developed site that protects the existing ecosystem so that it may continue to function as habitat in conjunction with the developed portions of the site. Protected habitat should be able to support the variety of organisms native to the area. Under the LEED rating system, points may be earned for protecting habitat on a site. Protected habitat is not possible to achieve on green roofs due to their location on the roof of the building. Also see *Restored Habitat* and *Native Plants.*
- **Rain Garden –** A planted area, typically at ground level or in a low-lying area, which makes use of plants that tolerate flooding. Rain gardens use drainage pipes, reservoirs, landforms, and other storm water management techniques to manage rainfalls varying from small amounts to major storm events. Extensive green roofs do not typically support the installation of rain gardens due to the types of plants, soils depths and substructures required.
- **Restored Habitat –** An area on a developed site that is environmentally similar to the type of ecosystem that would have been present prior to the site being developed. Restored habitat should be able to support the variety of organisms native to the area. Under the LEED rating system, points may be earned for restoring habitat on a site.

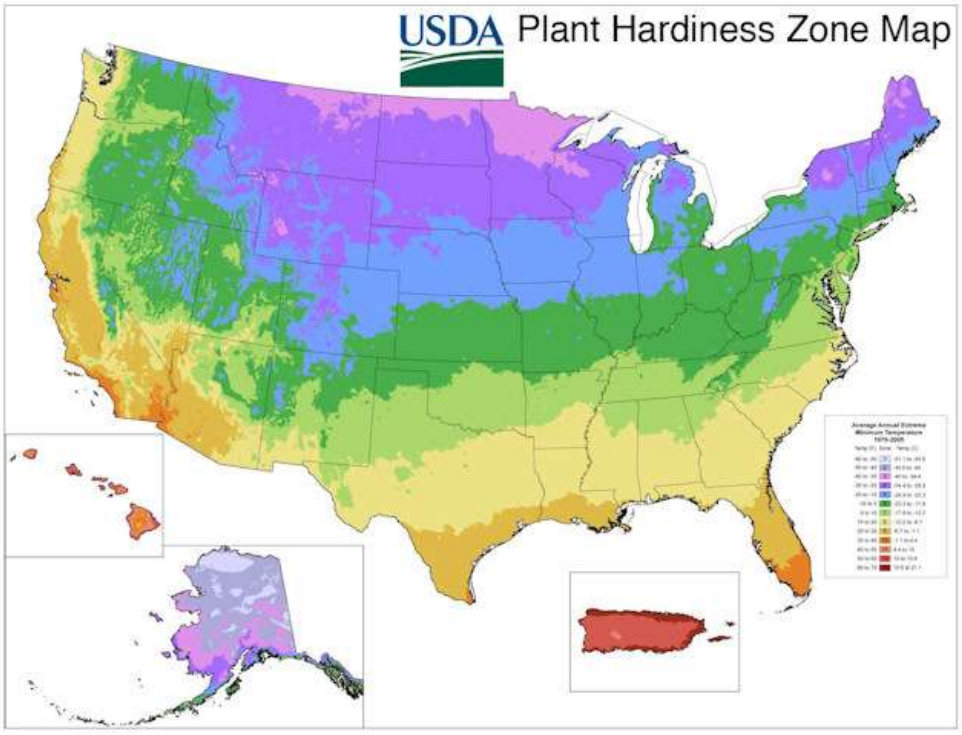
Restored habitat is difficult if not impossible to achieve on green roofs due to exposure, load bearing considerations, and access.

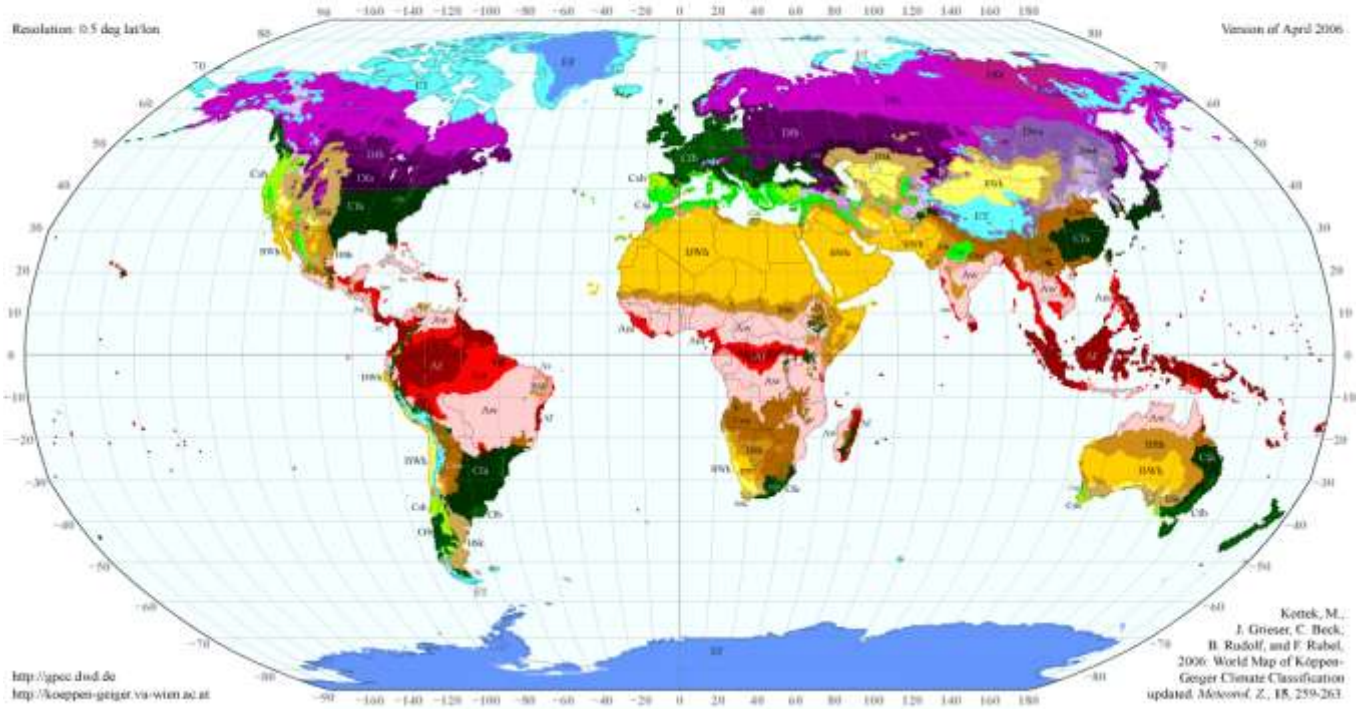
- **Self-sowing –** A plant that reproduces from viable seed; self-sowing plants will spread across a green roof as seasonal conditions favor that particular plant. Over time, self-sowing plants may impact the planting design or may reproduce at the ground level around the building from seed carried by the wind or by birds.
- **Species –** Biologically, a group of plants capable of interbreeding and producing fertile offspring and separated from other plant groups with which breeding does not normally occur. Species boundaries are constantly changing with increased scientific knowledge (i.e. botanical names often change as plants are re-classified). Sedums are one of the most commonly found species on green roofs.
- **Storm Water Management System –** An overall plan comprised of smaller systems that are designed to work together to capture, contain, transport, or disperse precipitation occurring on a site. With proper engineering and planning, a green roof can be one component of a storm water management system.
- **Tray –** A plastic container comprised of many individual cells in which plants are grown.
- **Weed –** A plant that is not intentionally planted and is not desired in the place it is found growing. Weeds are generally plants that spread by producing vast amounts of seeds during a growing season. They may be invasive plants, or simply a plant from someone else's garden that grows from a transported seed. Weeding is the most important maintenance procedure on a green roof during establishment; weeding should be done according to the seed cycles of weeds common to your project area. Note that some green roof plants may be grown from seed or may emerge as seedlings on a green roof; having personnel that are able to identify these plants is key to a successful maintenance program.
- **Winter Interest –** Many green roof plants have interesting attributes in colder or winter months. Some plants retain their green color through the winter months (some varieties of Jovibarba and sempervivum). More often, plant leaves change to a different color (Sedum hybridum 'Immergrunchen' turns orange in the fall and holds much of its foliage throughout the winter). Several plants drop most of their foliage but the plant stems or rosettes provide interest (for example, most varieties of Sedum spurium). Other plants die back to the roots completely, but leave behind a structure that lasts through the winter (grasses, for example, leave behind light brown stalks that some people consider sculptural).
- **Xeric –** A term describing a plant that has adapted a biological process for survival during periods of extremely low amounts of water, as in the desert. These plants typically have shallow root systems and can survive extreme temperatures (both hot and cold).

Seasonal Expectations: Roofs and walls go through normal plant cycles!

Plant Hardiness Zones:

According to Wikipedia, a hardiness zone (a subcategory of vertical zonation) is a geographically defined area in which a specific category of plant life is capable of growing, as defined by climatic conditions, including its ability to withstand the minimum temperatures of the zone (see the scale on the right or the table below). For example, a plant that is described as "hardy to zone 10" means that the plant can withstand a minimum temperature of -1°C. A more resilient plant that is "hardy to zone 9" can tolerate a minimum temperature of -7°C.




World Map of Köppen−Geiger Climate Classification
updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000
Af Am As Aw BWk BWh BSk BSh Cfa Cfb Cfc Csa Csb Csc Cwa
Cwb Cwc Dfa Dfb Dfc Dfd Dsa Dsb Dsc Dsd Dwa Dwb Dwc Dwd EF ET
Main climates
A: equatorial
B: arid
C: warm temperate
D: snow
E: polar
Precipitation
W: desert
S: steppe
f: fully humid
s: summer dry
w: winter dry
m: monsoonal
Temperature
h: hot arid
k: cold arid
a: hot summer
b: warm summer
c: cool summer
d: extremely continental
F: polar frost
T: polar tundra
Resolution: 0.5 deg lat/lon
Version of April 2006
http://gpcc.dwd.de
http://koeppen-geiger.vu-wien.ac.at
Kottek, M.,
J. Grieser, C. Beck,
B. Rudolf, and F. Rubel,
2006: World Map of Köppen-
Geiger Climate Classification
updated. Meteorol. Z., 15, 259-263.

Pictures below depict the seasonal changes that can be expected on a typical sedum roof in the Northeast.

Winter, Spring Summer & Fall

Citifield NY Mets MLB Stadium

Clockwise (from top left): Installation February, May, June Flowers, August

The GLTI superior water retention allows this roof to be naturally irrigated

Types of Green Roof Plants

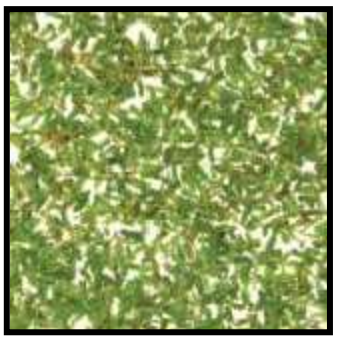
Succulents, *Perennials, Grasses and Woody Plants*

Succulents are often mentioned with cactus and all cacti are succulents, but not all succulents are cactus. Historically popular succulents have become the cornerstone of the extensive green roof market. GLTi green roofs are usually pre-grown off-site & delivered mature. This may not be the case on every project though! There is also the option to "plant-in-place" using plugs or cuttings. (Refer to p. 68) Sedum enjoys periods of drought; however, droughts longer than 6 weeks can be threatening. Sedums also are susceptible to heavy rain and fungi. It is critical to choose plant materials that are conducive to the region they'll be growing in.

Sedum Establishment Using Cuttings:

A. When cost pressures are a factor a rate of cuttings can be applied at 60 lbs per 1000 ft^2. Extreme care must be taken to prevent loss and coverage time will be much longer. Plan on higher maintenance visits, and we do not recommend a low ratio.
12" at 60 lbs per square foot.

B. An average rate of 100 lbs per 1000 ft^2 is typical. There is faster coverage and up to 80% coverage in a 10-week period. Irrigation, fertilizer and weeding determine the final product.
12" at 100 lbs per square foot.



C. Fully mature panels or mats will require up to 250 lbs per 1000 ft^2. This rate insures the fastest coverage in the shortest amount of time with the highest ratio of success.
12" at 250 lbs per square foot.

Common Sedum Genus Varieties Used in Green Living Roofs

Varieties *TOP 15 North East Variety	Zone	Height (Inches)	Spread (Inches)	Bloom Time	Bloom Color	Soil Depth (Inches)	Four Season	Shade Tolerant	Rugged
*Sedum acre 'Gold Moss'	3-8	3-6	12-15	Jul - Aug	Yellow	3-4			
Sedum acre 'Aurea'	4-7	1-2	12-15	May – June	Yellow	3-4	X	X	
*Sedum album 'Coral Carpet'	4-8	6-9	6-8	Jul - Aug	White	3-4	X		X
*Sedum album 'Murale	3-9	2-4	4-8	May - June	White	3-4			
Sedum album 'Orange Ice'	4-8	1-2	6-8	Jul - Aug	White	3-4			X
*Sedum floriferum 'Weihenstephaner Gold'	3-7	3-5	8-12	May - June	Yellow	3-4	X		
*Sedum hybridum 'Immergrunchen'	4-7	5-6	6-8	June - Sept	Yellow	3-4	X	X	
Sedum hybridum 'Czars Gold'	4-7	5-6	6-8	July – Aug	Yellow	3-4			X
*Sedum kamtschaticum	4-7	56	6-8	June – July	Yellow	3-4			X
Sedum kamtschticum 'Variegatum'	4-7	56	6-8	June – July	Yellow	3-4		X	X
*Sedum reflexum 'Blue Spruce'	5-7	4-6	8-12	May – June	Yellow	3-4	X		
*Sedum rupestre 'Angelina'	4-7	4-6	8-12	July – Aug	Yellow	3-4			
Sedum rupestre	4-7	4-6	8-12	July – Aug	Yellow	3-4			X
*Sedum sexangulare	4-7	3-4	6-8	July - Aug	Yellow	3-4		X	X
*Sedum spurium 'Fuldaglut'	5-8	4-6	6-8	June – July	Red	3-4		X	
Sedum spurium 'Album Superbum'	5-8	4-6	6-8	June – July	White	3-4		X	

*Sedum spurium 'Coccineum'	3-7	2-3	6-8	July – Aug	Red	3-4	X		
*Sedum spurium 'Eco Mt Emei'	4-7	3-4	8-10	June – July	Yellow	3-4		X	
*Sedum spurium 'John Creech"	3-8	4-6	6-8	July - Aug	Pink	3-4	X	X	
*Sedum spurium 'Red Carpet'	3-7	3-4	8-10	July - Aug	Red	3-4	X		
Sedum spurium 'Roseum'	4-7	4-6	6-8	June - July	Pink	3-4	X		X
Sedum spurium 'Summer Glory'	4-7	4-6	6-8	June - July	Pink	3-4	X		
*Sedum spurium 'Tricolor'	4-7	3-4	6-8	June – July	Pink	3-4			
Sedum spurium 'Voodoo'	4-8	4-6	6-8	June – Sept	Pink	3-4			X
*Sedum takesimensis 'Golden Carpet'	4-8	4-6	8-10	July - Aug	Yellow	3-4			
Sedum middendorffianum diffusum	5-8	3-4	6-8	July – Aug	Yellow	3-4	X		X
Sedum pachyclados	4-7	2-3	5-6	July – Aug	White	3-4		X	
Sedum cauticolum	3-7	3-6	10-12	Jul – Aug	Pink	3-4			X
Sedum ellacombianum	3-7	3-5	12-15	Jun – July	Yellow	3-4			X
Sedum ternatum	4-7	2-3	6-8	Jun – July	White	3-4		X	
Sedum stefco	5-8	1-2	6-8	July – Sept	White	3-4			X
Sedum tetractinum 'Coral Reef'	6-9	3-4	8-10	May – June	Yellow	3-4	X		



Sedum acre ‘Gold Moss’



Sedum acre ‘Aurea’

Fast grower, good for quick fill-in, bright color both in flowers and with chartreuse foliage, and can be aggressive.



Sedum album ‘Coral Carpet’


Sedum album ‘Murale’


Sedum album ‘Orange Ice’


Sedum floriferum ‘Weihenstephaner Gold’



Sedum hybridum ‘Immergrunchen’

Similar to kamtschaticum in form and toughness, but with the added bonus of being more evergreen in winter.



Sedum hybridum ‘Czars Gold’



Sedum kamtschaticum

Sedum kamtschaticum ‘Variegatum’

Sedum reflexum ‘Blue Spruce’

Sedum rupestre ‘Angelina’

Sedum rupestre

Sedum sexangulare

Showing winter red

Similar in appearance to Sedum acre, but much tougher and longer-lived, basic, recommended, good for fill.

Sedum spurium ‘Fuldaglut’ (More tolerant of tropical conditions) Winter

Sedum spurium ‘Album Superbum’ (Most commonly seen white-flowered form of spurium)

Sedum spurium ‘Coccineum’

Sedum spurium ‘Eco Mt Emei’


Sedum spurium ‘John Creech” (Widely adapted one of the more widely used green roof sedums)


Sedum spurium ‘Red Carpet’

Sedum spurium ‘Roseum’


Sedum spurium ‘Summer Glory’


Sedum spurium ‘Tricolor’


Sedum spurium ‘Voodoo’


Sedum takesimence ‘Golden Carpet’

Sedum middendorffianum diffusum


Sedum pachyclados

(Slower growing sedum that is often used for shade and moisture tolerance. Good for Pacific Northwest)



Sedum cauticolum


Sedum kamtschaticum ellacombianum



Sedum ternatum (Native in eastern United States)


Sedum stefco


Sedum tetractinum ‘Coral Reef’

NOTES:

Suggested Sunny and Shade Locations

It is not uncommon that there will be different lighting conditions for each project. Some roofs will be predominantly shaded, some full sun and yet a combination of both. Here are some plant suggestions for various lighting conditions.

Shade Tolerant Sedum

Sedum pachyclados

Sedum acre ‘Aurea’

Sedum reflexum 'Green Spruce'

Sedum sexangulare

Sedum spurium ‘Album Superbum’

Sedum divergens

Sedum spurium ‘Fuldaglut’

Sedum album ‘Green Ice’

Sedum, Sedum spurium ‘John Creech’

Sedum ternatum

Sedum tetractinum ‘Coral Reef’

Sunny Locations

Sedum Euphorbia myrsinites, Myrtle Spurge

Sedum aizoon ‘Euphorbioides’, Euphorbia Leaved Sedum

Sedum middendorffianum var. diffusum, ‘Middendorf’s Sedum

Sedum ellacombianum, Ellacombe’s Sedum

Sedum cautacola ‘Sunset Cloud’, ‘Sunset Cloud’ Sedum

Sedum hybridum ‘Immergrunchen’, Evergreen Sedum

Sedum kamtschaticum ‘Takahira Dake’, ‘Takahira Dake’ Sedum

Sedum floriferum ‘Weihenstephaner Gold’, ‘Weihenstephaner Gold’ Sedum

Sedum spectabile ‘Brilliant’, ‘Brilliant’ Sedum

Sedum spectabile ‘Pink Chablis’, ‘Pink Chablis’

Sedum x ‘Vera Jameson’, ‘Vera Jameson’ Sedum

Sedum takesimense ‘Gold Carpet’, ‘Gold Carpet’ Sedum

Sedum spectabile ‘Neon’, ‘Neon’ Sedum

Sedums and Succulents for Cold Winter Locations

Pending on the region you are located the plant choices for the Northeast will not suffice for the deeper south and into the tropics of Central and South America.

Warm Sub-Tropic Regions


Aeonium, Pinwheel


Anacampseros rufescens


Anacampseros Aptenia cordifolia, Aptenia

Cephalophyllum, Ice Plant

Chlorophytum, Spider Plant

Authors Green Roof (Honduras)

Crassula (Large variety of choices)

Drosanthemum, Dewflower

Echeveria species, Echeveria (over 150 varieties)

(http://en.wikipedia.org/wiki/Haworthia)

Haworthia, Window Plant (Each variety has a different flower)

Lampranthus, Vygie

(Shown here with orange flowers, these succulent plants flower during the spring and summer. They come in red, crimson, orange, and yellow and the leaves are short and blue-green in color. These plants are drought-tolerant and grow well in sunny areas.)

Portulaca, Moss Rose (Authors Green Roof Honduras)

Sedum morganianum, Burro's Tail Sedum

Sedum rubrotinctum, Pork and Beans or Jelly Bean Sedum

*Sedum References:

http://crassulaceae.net/sedummenu/90-lists/237-genus-sedum-in-the-americas

Perennials, *Succulents, Grasses and Woody Plants*

Perennials are typically known to come back year after year. Use caution with the term, some plants may only live for two years. Typically perennials will require a deeper depth of growing media except for the shallow requirements of some drought tolerant bulbs, corms and tubers.

The links provided here are for reference only, so be sure to consult with your landscape architect or horticultural expert to determine appropriate selections for the roof type, planting zone, and microclimate.

http://www.finegardening.com/PlantGuide/PlantFinder.aspx?274=2052&270=4
http://www.intrinsicperennialgardens.com

Common Perennial Plantings:

(Partial List for the Northeast United States for roofs between 4 inches and deeper)

Chives (Allium schoenoprasum)

Chives Garlic (Allium tuberosum)

Achillea millefolium (yarrow) Multiple varieties and color variations

Antennaria dioica (pussy toes)

Cerastium tomentosum (snow-in-summer)

Common Perennial Plantings:

(Partial List for the Northeast United States for roofs between 8 inches and deeper) List provided by http://www.bbg.org/

Sea Holly *Eryngium bourgatii*—This plant has a wonderful structure and is exceedingly tough. Its leaves are stiff and marked by white veins that complement the spiny, silvery white flower bracts. It is hardy to Zone 7 and grows to 24 inches tall.

Perennial Flax *Linum perenne*—The flowers of perennial flax are a deep, clear, and true blue. They open in the heat of day and close again by evening. This easy-to-grow plant does best in full sun and well-drained soil. It's hardy to Zone 7 and reaches 1 to 2 feet in height.

Coneflower *Echinacea purpurea*—This drought-tolerant North American native grows best in sandy soil and full sun. The white cultivars are especially attractive and grow to 24 inches tall. This makes them somewhat shorter than their more common pink cousin. All *Echinacea* bloom from July through August and are hardy to Zone 6.

Globe Thistle *Echinops bannaticus*—This thistle has long-lasting, pale blue, globe-shaped flowers that make excellent cut and dried displays. Foliage and growth habit are also very attractive. Globe thistle is hardy to Zone 6 and reaches 2 to 3 feet tall (depending on the cultivar).

Butterfly Weed *Asclepias tuberosa*—Its taproot makes this North American native an especially drought-tolerant choice, and its flowers attract bees and butterflies to your garden in abundance. Cultivars range from 1 to 3 feet in height, with flowers available in yellow, orange, vermilion, or white. It is hardy to Zone 6.

Grasses, *Succulents, Perennials, and Woody Plants*

CAUTION: Some grasses and woody plants have very extensive root systems. Insuring proper media depth and blend is detrimental to the success of the plant and to the protection of the waterproofing.

Festuca glauca 'Elijah Blue' - Blue coloration to this clumping ornamental grass is maintained through the heat of summer. Perfectly suited for edging borders or mass planting as a groundcover. Evergreen.

Blue Hair Grass *(Koeleria Glauca)* - Both the foliage and flowers of Blue Hair Grass are attractive and enhancing. This ornamental grass will only grow to 12" tall, producing dense tufts of blue leaves. Blue Hair grass is well-behaved and non-spreading. This ornamental grass is short-lived, and may only live for 2-3 years, particularly if planted in the moist, fertile environment of a typical border. Easily grown in average, dry to medium, well-drained soil in full sun, and best in infertile, sandy and well-drained soils. Drought tolerant. Intolerant of heavy clay soils, wet soils and shade. One of the few low-growing ornamental grasses. (http://www.outsidepride.com/seed/ornamental-grass/blue-hair-ornamental-grass-seed.html)

Due to the diversity of grasses, it is critical that you address each project specifically for the common variables. Consult with your horticultural expert or landscape architect.

For more information on grasses visit http://www.bluestem.ca/grass-scapes/index.htm

Woody Plants, *Succulents*, Perennials, *and Grasses*

According to http://www.thefreedictionary.com/woody+plant**,**

a **woody plant** is a plant that has hard lignified tissues or woody parts, especially stems

Also reference http://en.wikipedia.org/wiki/Woody_plant

There are hundreds and thousands of classified woody plants that include everything from trees, to shrubs and bushes and ground cover. We must disclose that the design intention and the variables that contribute to the plant choices must address roof loading, design intent, and hardiness zones among a myriad of other considerations. This book is only a guide--please consult your horticulturist, or landscape architect.

The link below provided by Cornell will lead you through a questionnaire that allows you to search for woody plants by name or characteristics.

http://woodyplants.mannlib.cornell.edu/

Chapter 12: Logistics & the installation of a Green Living Roof

Disclosure: In this chapter we will explain the process in which a green living roof goes from contract to installation to final closing submittals. Not all processes are suitable for each situation, so this is only a guide.

- Planning and Timelines
- Safety
- Preparing the Job Site Section A
- Equipment

  Product Inspection upon Delivery
- Storing the Green Roof Panels
- Handle Material for Transport
- Preparing the Job Site Section B
- Protection Fabric Installation
- Adding Edge Details or Root Free Zones
- Panel Installation Cut the Panels to Fit
- Adding Growing Media and Additional Plantings
- Irrigation
- Basic Maintenance

Planning and Timelines

KEEP YOURSELF ORGANIZED!

Each successful installation starts with organization. Each company has a standard operating proceedure or SOP for short. This book is only a guide. Our system will be different than yours, so we start by creating a file for each inquiry we receive. In that file, anyone at anytime can find the clients contacts, drawings, notes, quote, etc. Once the project is signed and a date is set for installation, you should start to prepare immediately. Here is a sample six-month lead time; however, due to the pre-production of our sedum mats, an extensive green roof can be installed with a 2 – 4 week lead time:

6 Months out: -Place an order for a green roof or green walls (Even if the product is not pre-grown, order it anyways)

4 Months out: Prepare heavy equipment checklist (E.g. Lifts, cranes, skid steers etc.)
Call the client and keep them informed

2 Months out: Prepare mobilization checklist
Prepare materials checklist and order as needed
Prepare tools checklist
Call the client and keep them informed

1 Month out: Check on growing process
Finalize all delivery means and methods
Finalize personnel and mobilization
Finalize materials
Finalize tools
Call the client and keep them informed

Include multiple meets with the project manager, general contractor, and client to review all plans as things rapidly change and you may be at the mercy of additional sub-trades such as the plumber and the waterproofing installer. In addition to timelines, task hierarchy is also an important tool. Plan your installation right down to the day. Have a plan for every task and try and stick to it. Remember! You are not going to be the only trade on the project site. You will need to work with the General Contractor (GC) to get your work done. The easier you are to work with the more likely the GC is willing to help out with changes and getting other sub-contractors to adjust to your needs.

On the next page is a simple sample timeline also known as the construction schedule. Notice some key areas, number one is communication. This schedule should contain all key contact information for the architect, general contractor, project manager and any one who may impact the final outcome.

Company Name					Cpmpany name			
TBD	Site Inspection							
TBD	Pre- Construction Meeting on Site							
TBD	Installation Date				Office Mailing Address:			
Project Address								
					Phone			
					Fax			
Task Analysis			**Date**		**June 25-July 1**			
NOTES:								
Enter Task		Sat	June 25, 2011					
Lift gets delivered and left on site		Sat	June 25, 2011					
Tools (see tool List Sheet 3)		Sat	June 25, 2011					
Protection material to set pallets on		Sat	June 25, 2011					
NOTE: SHADED BOXES MEANS LIFTING MATERIALS TO ROOF								
Sun.Morning meeting with team for a walk through, last min planning, safety check and precautionary flags set up.		Mon	June 27, 2011					
Green Wall / Roof Brackets installed by ___		Mon	June 27, 2011					
The Following Pallets should be lifted as follows: Green Living Wall Brackets installed via _____.		Mon	June 27, 2011					
NOTE: SHADED BOXES MEANS LIFTING MATERIALS TO ROOF								
Morning meeting 7:30 am		Tue	June 28, 2011					
Safety Check List		Tue	June 28, 2011					
Sweep the waterproofing area for initial loading		Tue	June 28, 2011					
Lift tools, irrigation and protection material to roof deck		Tue	June 28, 2011					
Protection material installed to protect the waterproofing, assemble tools to be accountable and organized		Tue	June 28, 2011					
Roof Preparation		Wed	June 29, 2011					
Prepare edge detail for Pink, Yellow and Orange Zones		Wed	June 29, 2011					

Here is a more advanced **task analysis** built into the construction schedule.

Enter all information here Client, Project, Address, Drawings	Installer Contact	Enter all information here Grower, Installer, Foreman etc

Task Analysis		Date	Sept 5-11	Sept 12-18	Sept 19-25
			S M T W T F S	S M T W T F S	S M T W T F S
g sine late March		Aug. 5, 2010			
	Fri	Sept. 10	X		
Sat.Morning meeting walk through	Sat	Sept. 11	X		
First Day e lifting insulation late afternoon, GLT will piggyback off the crane Start Time 3 PM - 10 PM	Sat	Sept. 11	X		
GLT Materials being lifted:	Sat	Sept. 11			
Tools (see tool List Sheet 3)	Sat	Sept. 11	X		
Protection material to set pallets on	Sat	Sept. 11	X		
The Following Green Roof Pallets should be lifted as follows: the 14 pallets of Main Green Roof 1st since it will be used after the Penthouse Panels. Staging the Penthouse panels for immediate use.					
10 Pallets of Green Roof (2.0" Depth Main Roof)	Sat	Sept. 11	X		
14 Pallets of Green Roof (2.5" depth Penthouse Panels)	Sat	Sept. 11	X		
2 pallets of bagged stone	Sat	Sept. 11	X		
1 sac of growing media	Sat	Sept. 11	X		
Edging, seam tape, Primer, primer brusnes	Sat	Sept. 11	X		
*GLT will require one person from Sat. for ground work /					
				Sept 12-18	
				S M T W T F S	
FIRST INSTALLATION AREA = ZONE 1 PENTHOUSE Labor 5-6				X	
Sweep Penthouse Deck	Sun	Sept. 12		X	
Confirm paver measurment via L - 101	Sun	Sept. 12		X	
Prepare Edge Detail as per L-101 - 4	Sun	Sept. 12		X	
Prepare Edge Detail around any protrusions as per L-101-4	Sun	Sept. 12		X	
Install Green Living Roof panels (126 for Penthouse) L-101	Sun	Sept. 12		X	
Remove one transfer shovel width of media and plants to create root free zone and to prepare for 1/2" irrigation supply L-101-5	Sun	Sept. 12		X	
Install 1/2" Supply for irrigation *Tape off end to protect from contamination, to be connected at a later date L-103-2	Sun /Mon	Sept. 12 - 13		X X	
Install Lateral runs of 1/4" drip tubing 18" on center L-102	Sun /Mon	Sept. 12 - 13		X X	
Cover 1/2" supply with 3" stone ballast as per L-101-5	Sun /Mon	Sept. 12 - 13		X X	
Minimally add additional growing media to cover seams of the Green Roof panels	Sun /Mon	Sept. 12 - 13		X X	
Final cosmetic / functional inspection / clean area	Sun /Mon	Sept. 12 - 13		X X	
PENTHOUSE COMPLETE *Connect Irrigation at a later Date	Sun /Mon	Sept. 12 - 13		X X	
				Sept 12-18	
				S M T W T F S	
Second INSTALLATION AREA = ZONE 5 L-102 Labor 5-6					
Sweep Deck	Mon	Sept. 13		X	
Confirm paver measurment via L - 101	Mon	Sept. 13		X	
Prepare Edge Detail as per L-101 - 4	Mon	Sept. 13		X	
Prepare Edge Detail around any protrusions as per L-101-4	Mon	Sept. 13		X	
Install Green Living Roof panels (61 for Zone 1) L-101	Mon	Sept. 13		X	
Remove one transfer shovel width of media and plants to create root free zone and to prepare for 1/2" irrigation supply L-105 / L-101-5	Mon	Sept. 13		X	
Install 1/2" Supply for irrigation *Tape off end to protect from contamination, to be connected at a later date L-103-2	Mon	Sept. 13		X	
Install Lateral runs of 1/4" drip tubing 18" on center L-102	Mon	Sept. 13		X	
Cover 1/2" supply with 3" stone ballast as per L-101-5	Mon	Sept. 13		X	

Minimally add additional growing media to cover seams of the Green Roof panels	Mon	Sept. 13	X
Final cosmetic / functional inspection / clean area	Mon	Sept. 13	X
Zone 1 Complete *Connect Irrigation at a later Date	Mon	Sept. 13	X
Third INSTALLATION AREA = ZONE 2 & 3 L-102 Labor 5-6	Mon	Sept. 13	X
Working from L-101-2/L4.1 Corner Sweep Deck	Mon	Sept. 13	X
Confirm paver measurment via L - 101	Mon	Sept. 13	X
Prepare Edge Detail as per L-101 - 4	Mon	Sept. 13	X
Prepare Edge Detail around any protrusions as per L-101-4	Mon	Sept. 13	X
Install Green Living Roof panels (218 for Zone 2 & 3) L-101 working along the East Wall first row by row to the West.	Mon / Tue	Sept. 13 - 14	X X
			Sept 12-18
			S M T W T F S
LIFTING DAY GLT Materials being lifted: AM			X
The remainder of the 28 pallets of Main Green Roof will be delivered	Tue	Sept. 14	X
28 Pallets of Green Roof (2.0" Depth Main Roof) 335 Panels	Tue	Sept. 14	X
2 pallets of bagged stone	Tue	Sept. 14	X
1 sac of growing media*If needed	Tue	Sept. 14	X
CONTINUE WITH INSTALLATION OF ZONES 2 & 3	Tue	Sept. 14	X
Remove one transfer shovel width of media and plants to create root free zone and to prepare for 1/2" irrigation supply L-101-5	Tue	Sept. 14	X
Install 1/2" Supply for irrigation *Tape off end to protect from contamination, to be connected at a later date L-103-2	Tue	Sept. 14	X
Install Lateral runs of 1/4" drip tubing 18" on center L-102	Tue	Sept. 14	X
Cover 1/2" supply with 3" stone ballast as per L-101-5	Tue	Sept. 14	X
Minimally add additional growing media to cover seams of the Green Roof panels	Tue	Sept. 14	X
Final cosmetic / functional inspection / clean area	Tue	Sept. 14	X
Zones 2&3 Complete *Connect Irrigation at a later Date	Tue	Sept. 14	X
			Sept 12-18
			S M T W T F S
Fourth INSTALLATION AREA = ZONE 4 L-102 Labor 5-6	Wed	Sept. 15	X
Sweep Deck	Wed	Sept. 15	X
Confirm paver measurment via L - 101	Wed	Sept. 15	X
Prepare Edge Detail as per L-101 - 4	Wed	Sept. 15	X
Prepare Edge Detail around any protrusions as per L-101-4	Wed	Sept. 15	X
Install Green Living Roof panels (61 for Zone 1) L-101	Wed	Sept. 15	X
Remove one transfer shovel width of media and plants to create root free zone and to prepare for 1/2" irrigation supply L-105 / L-101-5	Wed	Sept. 15	X
Install 1/2" Supply for irrigation *Tape off end to protect from contamination, to be connected at a later date L-103-2	Wed	Sept. 15	X
Install Lateral runs of 1/4" drip tubing 18" on center L-102	Wed / Thur	Sept. 15-16	X X
Cover 1/2" supply with 3" stone ballast as per L-101-5	Wed / Thur	Sept. 15-16	X X
Minimally add additional growing media to cover seams of the Green Roof panels	Wed / Thur	Sept. 15-16	X X
Final cosmetic / functional inspection / clean area	Wed / Thur	Sept. 15-16	X X
Zone 4 Complete *Connect Irrigation at a later Date	Wed / Thur	Sept. 15-16	X X
			X X
At this time all Green Roof Panels are in place, Irrigation is in place, Ballast is in place			
			Sept 12-18
			S M T W T F S
IRRIGATION MANIFOLD AND POC (POINT OF CONNECTIONS)			
See L-102 L-103 (1 experienced Irrigation Tech from Tuefal)	Fri	Sept. 17	X
Any Overflow of work from above to be done here	Fri	Sept. 17	X
FINAL CLEAN UP AND DEMO / TRASH / TOOL REMOVAL VIA CRANE	Sat	Sept. 18	X

Reading through the schedule notice that each task is listed, identified, detailed and mentally noted is called **a task analysis**. The more detail you can include the better prepared you will be. The task analysis will never be in perfect relation to the timeline. However, mentally preparing the project from start to finish on paper will ease any changes that may occur, especially the ones that are out of your control like the weather. The schedule also presents a plan of action to the other members of the immediate installation team and the other supporting roles such as administrative, sub-contractor trades and the general contractor. When you don't plan there

will be mass confusion and frustration from those who are part of the project. For example, last minute ordering may prevent materials from arriving on time and not preparing a tool list will cause delays when a key tool is missing.

This is only the beginning. The other parts of the planning are just as important. The task analysis allows you to mentally vision how the project will be assembled while trying to decipher any potential delays or unforeseen circumstances. Delivery, tools, heavy machinery, mobilization, personal planning, and labour are also part of this planning process. One unforeseen situation or mistake could cause delays and potential hazards at the end costing money that impacts the bottom line.

Delivery Schedule

GREEN LIVING TECHNOLOGIES PROJECT PLAN Installer
9/7/2010 Pre- Construction Meeting

for:

Enter all information here
Client, Project, Address, Drawings

Contact

Enter all information here

Grower, Installer, Foreman etc

DELIVERY 1
When

Sept. 11 Sat Between 3 pm - 6 pm or TBD by GC

What

10 Pallets of Green Roof (2.0" Depth Main Roof) 100 panels
14 Pallets of Green Roof (2.5" depth Penthouse Panels) 140 panels
1 sac of growing media

By Who

Enter all information here

Grower, Delivery Company, Contacts

DELIVERY 2
When

Sept. 14 Tue Between 6 am - 9 am or TBD by GC

What

28 Pallets of Green Roof (2.0" Depth Main Roof) 335 Panels
1 sac of growing media* If needed

By Who

Enter all information here

Grower, Delivery Company, Contacts

As you continue reading notice the additional planning sections that support the actual installation. The delivery schedule will allow you to time the arrival of key materials especially those that are time sensitive like plants. You won't want to have all the plant material delivered in a single day if they are going to be staged for long periods of time. Here you run the risk of the plants being ruined, damaged or subject to disease or pests.

The tool list is another important planning tool. As you prepare the task analysis it is easy to determine the tools needed to accomplish the task. This is also an opportunity to

prepare any rental equipment, lifting means, street closures etcetera allowing ample time to prepare the larger items needed.

Tool List

Installer

Office Mailing Address:

Contact

Tool List

2-3 Brooms
Optional hand held blower
2-3 Transfer shovel, flat wide shovel
Hax saw w multiple blades
Tape Measures
5- Sharpie Markers
5- utility knifes with 10 blades each
2 - standard metal rakes (12"-18", not a lawn rake)
4 - 5 gallon buckets
utility shears
circular saw with abrasive blade
2 - Cordless drill(s) w/ one set of bits
Cordless or AC shop vac
Exensions if tools need to be plugged in
Irrigation Tools

Hardware, edging, protection for pallets, irrigation etc....
GC will provide the use of roof top carts, pnumatic tire
pallet jack, lifting means from the main roof deck to the

SAFETY materials PPE (Personal Protection Equipment)

Hard Hats
gloves
eye protection
safety harnesses *everyone will be tied off on the penthouse roof
Please no aggressive tread boots
High Vis Vest or Clothing
Traffic Flags

PLAN, PLAN & PLAN AGAIN….As the project develops things change. Utilizing a simple spreadsheet will allow you to make changes much easier.

Safety

According to the OSHA (Occupation Safety and Health Administration), 4,609 workers were killed on the job in 2011 [BLS revised 2011 workplace fatality data*] (3.5 per 100,000 full-time equivalent workers) — which means almost 90 persons a week or nearly 13 deaths every day. (This is a slight increase from the 4,551 fatal work injuries in 2009, and the second lowest annual total since the fatal injury census was first conducted in 1992).

Out of 4,114* worker fatalities in private industry in calendar year 2011, 721 or 17.5% were in construction. The leading causes of worker deaths on construction sites were falls, followed by electrocution, being struck by an object, and being caught-in/between. These "Fatal Four" were responsible for nearly three out of five (57%) construction worker deaths in 2011*, BLS reports.

Four Categories defined by OSHA

- Falls – 251 out of 721 total deaths in construction in CY 2011 (35%)
- Electrocutions – 67 (9%)
- Struck by Object – 73 (10%)
- Caught-in/between – 19 (3%)

Top 3 most frequently cited OSHA standards violated in FY2011

1. Scaffolding, general requirements, construction (29 CFR 1926.451)
2. Fall protection, construction (29 CFR 1926.501)
3. Hazard communication standard, general industry (29 CFR 1910.1200)

In our field of work it is very common to include moderate elevations. Whether it is on a folding ladder or on top of a high rise there is extreme risk to our profession. There is no room for the lack of safety and safety education! Not being informed and trained can and will endanger not only you but also those around you.

It is recommended that installers obtain the minimum **OSHA 10** certification. At http://www.clicksafety.com you can obtain the certification online for a minimal fee. The course will prepare you and your employees to not only protect themselves and others but will also depict your rights and mandates for the right to a safe work place.

Disclaimer: The author makes claims to certifying installers or maintenance technicians to be OSHA 10 or 30 ready. We do not accept responsibility for any actions by readers or purchasers of this material. It is strongly suggested that the reader obtain OSHA Certification through the references provided above.

Each project site is different. There are ever-changing conditions throughout a construction project, so be aware of the working conditions, the sub-trades around you, and your own personal space. Tread with caution and always be alert. There is no excuse for the use of illegal drugs, alcohol and over the counter and prescription drugs that will hinder your ability to stay focused and react to variable and complex work environments.

Safety is everyone's responsibility, and personal safety is your responsibility. However, there are action items that can be implemented to protect everyone.

1. All projects sites operated by a general contractor usually require a safety orientation prior to starting work or being allowed on a project site. The orientation will include the dos and don'ts, emergency plan of action, accident reporting procedure, safety reminders and mandatory equipment. Each orientation will vary with each individual contractor.
2. If the project is not part of a larger scope or includes a general contractor then you should prepare a safety orientation for your team.
3. Dedicate a single person to be responsible for the overall environment for your operation. It is always a good idea to have a single point person who is deemed safety coordinator. On a large project it may require more than one person.
4. Prepare a safety action and preventative plan.

NOTES:

Sample Safety Action Plan

JOB SITE SAFETY PLAN

Name of Project

1.0 General Information

Developed for: Name of Project **Date:** _____

Location: _____ _____ _____

Job ID: _____ **Project Number** _____

Job Description:

	Name	Telephone	Cell Phone
Owner Contact	**Enter Contact info**	**Phone:** **Fax:**	
General Contractor Foreman	**Enter Contact info**	**Phone:** **Fax:**	
General Contractor Project Manager	**Enter Contact info**	**Phone:** **Fax:**	
GLTi Safety Representative	**Enter Contact info**	**Phone:** **Fax:**	
Subcontractors			
Third-Party Contacts	**Enter Contact info**	**Phone:** **Fax:**	
Regulatory Agency Contacts	**Enter Contact info**	**Phone:** **Fax:**	

Non-Governmental Organizations (NGO) Contacts	**Enter Contact info**	**Phone:** **Fax:**	
Hotline Number	This number is to be used to report Safety or Environmental concerns that you feel have not been addressed. • Calls can be made anonymously. (You do not have to leave your name.) • Calls go directly to an independent third party consultant who is authorized to take your call and convey your concerns to the right people.		
Additional Contacts			

2.0 Safety Principles

Here at _____, we believe all incidents are preventable:

- ✓ Do it safely or not at all.
- ✓ There is always time to do it right.
- ✓ When in doubt, find out.

Always:

1. Operate within design or environmental limits.
2. Operate in a safe and controlled condition.
3. Ensure safety devices are in place and functioning.
4. Follow safe work practices and procedures.
5. Meet or exceed customers' requirements.
6. Maintain integrity of dedicated systems.
7. Comply with all applicable rules and regulations.
8. Address abnormal conditions.
9. Follow written procedures for high risk or unusual situations.
10. Involve the right people in decisions that affect procedures and equipment.

3.0 Responsibilities

Employees, Contractors and/or Visitors:

1. Be familiar with and abide by the:
   - tenet principles for _____;
   - rules and practices contained in the _____Safety Handbook;
   - posted safety regulations in the workplace;
   - written and oral company instructions to perform their jobs safely;
2. Comply with all applicable rules, regulations, codes, covenants, restrictions, etc. (e.g. country, federal, state, and local regulations).
3. Comply with provisions set forth in this Job Site Safety Plan (JSSP).

Contractor Management:

1. Develop and keep an up-to-date statement of the contractor's policy for Health, Environment, and Safety (HES), and ensure that it is brought to the notice of all employees. Communicate philosophy and commitment that set levels of expectations for safety performance.
2. Maintain overall control for safety.
3. Ensure established safety policies are properly administered and enforced.
4. Arrange for adequate resources (e.g. funds, facilities, and personnel) to meet the requirements of the contractor's policy.
5. Ensure that field operations personnel are aware of and implement policy and associated processes, programs, procedures, and safe work practices established to safely control the work.
6. Prepare instructions for the organization and methods for carrying out the contractor policy, to make each person aware of their responsibilities, and the means by which they will carry them out.
7. Know the appropriate statutory requirements affecting the contractor's operations for whatever locale the work is being carried out.
8. Ensure that appropriate walk through & training is given to all staff prior to arriving at job site.
9. Ensure that there is liaison on GLTi matters between the contractor and others working on the site.
10. Institute incident reporting and investigation process to eliminate hazards and implement appropriate corrective actions.
11. Discipline, re-educate/train, or replace (or a combination thereof) any member of staff failing to satisfactorily discharge responsibilities for _____.
12. Set a personal example when visiting sites by wearing appropriate Personal Protection Equipment (PPE), and following applicable rules.
13. Arrange for regular reports to be reviewed to analyze safety performance, incident statistics, losses, and training standards. Metrics tracked and analyzed in reporting should include both leading and lagging indicators.
14. Conduct periodic job site visits to validate effectiveness of contractor's policy and JSSP implementation.
15. Identify trends as they develop and modify plans and procedures accordingly.

Supervisors/Foreman Must:

1. Verify all personnel are fit for duty.
2. Know and apply the contractor's Safety Policy, and relevant occupational health and safety rules and regulations that are brought to the attention of personnel under your control. Ensure that all employees work in a safe manner and use all protective devices and procedures required by the contractor, in accordance with legislation, to protect their health and safety.
3. Advise all employees of any potential or actual dangers and how to isolate, prevent, or remove them.
4. Arrange for medical treatment as required, in the case of injury or illness including transportation to a doctor or hospital as detailed in this JSSP.
5. Report all incidents immediately, investigate all incidents fully, and advise management on how to prevent similar incidents in the future.
6. Carry out regular inspections of the work place to ensure a safe and healthy work environment, and establish provisions for equipment/tool inspection and ongoing maintenance to confirm safety and integrity.
7. Evaluate an employee's performance to determine whether the employee is competent at the required work task. Direct supervision should be given to an employee unfamiliar with certain tasks.
8. Know the regulations applicable to the work and insist that these regulations are followed.
9. Incorporate safety instructions in routine orders and see that they are obeyed.
10. Not allow personnel to take unnecessary risks.
11. Ensure that new and short service employees (SSE) are shown the correct method of working and are advised of all safety precautions applicable to their work.
12. Ensure that any special rules applying on the site are being implemented correctly and check that Safe Work Permits are being complied with.
13. Commend personnel who, by action or initiative, eliminate hazards.
14. Not allow "horse-play" or practical jokes, and discipline those who consistently fail to consider their own safety or that of others around them.
15. Report immediately any defects of plant or equipment.
16. Respond appropriately to incidents reported by employees, however minor, and report incidents as delineated in the JSSP and through the chain of command.
17. Set a personal example by wearing protective clothing and by carrying out all work in a safe manner.

18. Look for and suggest ways to eliminate hazards and encourage employees to do the same. Bring to the notice of supervision any improvement or addition to the Company Safety Policy that you feel should be made.
19. Suggest to Supervision ways of improving safety and eliminating hazards.
20. Mentor new employees and warn them of known hazards and safe work practices.
21. Report any incident or damage, however minor, to Supervision.
22. Take all personal hygiene measures necessary to prevent job related health effects (e.g. dermatitis).

All Personnel Must:

1. Perform assessment for personal safety before beginning any activity/task/job.
2. Read, understand, and comply with the contractor's Safety Policy, safe work practices, procedures, and rules.
3. Develop and/or review Job Safety Analysis (JSA) prior to commencing work.
4. Wear the safety equipment, personal protective devices, and clothing required by regulations and Chevron.
5. Complete pre-use inspection on all tools and equipment prior to commencing work.
6. Immediately notify supervisor of any unsafe conditions or acts that may be of danger to workers or others.
7. Take all reasonable precautions to protect the safety of workers and others.
8. Report all incidents and injuries to supervisor immediately.
9. Attend all scheduled safety meetings.
10. Openly communicate on issues related to safety. Use Stop Work Authority as necessary to ensure each individual's personal safety and all co-workers.
11. Notify supervisor of prescription and non-prescription medication use prior to coming on job site.

4.0 Job Scope Overview

Describe the major elements or tasks for the project or job.

Task#	Activity
1	**TO BE FILLED OUT AFTER INITIAL INSPECTION—Refer to Task Analysis**
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	

5.0 Risk Assessment and Hazard Identification

Risk/Hazard	Applicable Task # (N/A, Y, N, Potential)	Mitigation
Access/Egress		
Allergic Reactions		
Animals and Insects		
- Snakes		
- Spiders		
- Bees and Wasps		
- Endangered Species		
- Other		
- Other		
Blasting (Hydro, Abrasive, etc.)		
Crossings		
Cables		
- Railroads		
- Road		
- Water		
- Pipeline		
Electrical		
- Overhead Power Lines		
Emergency		
- Hurricane		
- Tornado		
- Flood		
- Explosion		
- Fire		
- Earthquake		
- Pipeline Leak		
- Community Disaster		
- Toxic Gas Release		
- Spill		
- Medical		
- Loss Of Power		
Hot Work/Fire		
Human Factors		
- Fatigue		
- Illness		

- Fitness		
- Lighting		
Air Quality		
Confined Space		
Risk/Hazard	**Applicable Task #** (N/A, All, 1, etc.)	**Mitigation**
Earthwork		
- Excavation		
- Blasting		
- Trenches		
- Cave-In		
- Fall-In		
- Buried Hazards		
+ Sewers		
+ Cables		
+ Power Lines		
+ Grounding Systems		
+ Pipe		
Ergonomics		
Existing Facilities Hazards		
Fabrication, Laydown Areas		
Falling Objects		
Fumes		
Hazardous Material		
- Asbestos		
- Benzene		
- TMA		
- Silica Dust		
- Cement Dust		
- Lead		
- H_2S		
Language/Communication		
Lifting		
- Crane		
- Manual		
- Come Along		
- Tuggers		
- Spreader Bar		
- Winches		
- Lines		

- Chains		
Lifting Near Live Equipment		
Location Safety Culture		
Material Handling and Storage		
Medications (prescription and non-prescription)		
Moving and Transportation Equipment		
Moving/Rotating Equipment		
Noise		
Risk/Hazard	**Applicable Task #** (N/A, All, 1, etc.)	**Mitigation**
Overhead Obstruction		
Political Security		
Power Tools		
Radiation		
Sanitation (Port-A-Potty and Hand Washing Facilities, etc.)		
Security Incident		
Startup Considerations		
- Combustibles		
- Burns		
- Hazardous Material		
- Spills and Releases		
- Pressure (Hydraulic, Pneumatic)		
- Equipment Heat		
- Equipment Cold		
- Mechanical Integrity (NDE Testing)		
- Control Systems		
- Hazardous Waste		
- Scaffolding Hazard		
Shutdown Considerations		
- Spills and Releases		
- Isolation (Elec., Process, Line Breaking, etc.)		
- Hazardous Waste		
- Fall Hazards		
- Burns (Thermal,)		
- Hazardous Material		

- Confined Space		
- Scaffolding Hazards		
- Process Safety Hazards		
Toxic s		
Traffic Safety		
- Control Onsite Vehicular Traffic		
- Local Traffic Safety Control		
- Construction Traffic		
- Permitted Loads		
- Detours		
Tripping, Slipping, Collision		
Vegetation (e.g. poison ivy)		
Visibility		
Waste Disposal		
Risk/Hazard	**Applicable Task #** (N/A, All, 1, etc.)	**Mitigation**
Weather		
- Ice		
- Mud		
- Storm (Hurricane/Typhoons)		
- Heat		
- Cold		
- Seas		
- Fog		
- Wind		
- Lightning		
Other		
Other		
Other		
Other		
Other		

6.0 Relevant Safety Programs and Procedures

Check (✓) Safety Programs directly involved in job, and provide a brief narrative to describe how they will be effectively applied

Programs/Procedures	Narrative (Describe applicable program/procedure and provide documentation onsite)
☐ Asbestos	
☐ Abrasive Blasting	
☐ BBS	
☐ Boat Safety	
☐ Change Management Review and Approval	
☐ Confined Space	
☐ Cranes/Hoists	
☐ Electrical Safety	
☐ Excavation	
☐ Equipment Inspection	
☐ Fall Protection	
☐ Hand/Power Tools	
☐ Haz Com	
☐ HAZWOPER	
☐ Hearing	
☐ Heat/Cold Stress	
☐ Hot Work	
☐ H_2S	
☐ Lead	
☐ Lifting/Rigging	
☐ LOTO	
☐ Pipeline Repair	
☐ Pipeline Locate	
☐ Radiation	
☐ Respiratory	
☐ Safe Work Permit	
☐ Safety Meetings	
☐ Site Inspections	
☐ Tank Cleaning	
☐ Vehicle Safety	
☐ Other	
☐ Other	

7.0 Education and Training

Description	Applicable	Narrative (Describe applicable training and provide documentation onsite)
Abrasive Blasting	☐	
Back Injury Prevention	X	Manufacturer Certification – OSHA 10
Basic New Employee Orientation	X	Manufacturer Certification – OSHA 10
Basic Principles of Safety	X	Manufacturer Certification – OSHA 10
Behavior Based Safety	X	Manufacturer Certification – OSHA 10
Benzene, Asbestos, Lead, and H_2S Awareness	☐	
Bloodborne Pathogens	☐	
Body Positioning Training	X	Manufacturer Certification – OSHA 10
Commercial Diving	☐	
Confined Space Entry	☐	
Cranes and Material Handling	X	Manufacturer Certification – OSHA 10
Defensive Driving/Driving Safety	☐	
Electrical Lock-Out/Tag-Out	X	Manufacturer Certification – OSHA 10
Electrical Safety	X	Manufacturer Certification – OSHA 10
Emergency Evacuation (Drills, Muster Points)	X	Manufacturer Certification – OSHA 10
Emergency Marine Evacuation	☐	
Emergency Response Plan	X	Manufacturer Certification – OSHA 10
Excavation and Trenching	X	Manufacturer Certification – OSHA 10
Explosives and Ordinance	☐	
Fall Protection	X	Manufacturer Certification – OSHA 10
Fire Safety	X	Manufacturer Certification – OSHA 10
Fire Watch	X	Manufacturer Certification – OSHA 10
First Aid (CPR, EMS)	X	First Responder
Flammable and Toxic Material Handling	☐	
Floor and Wall Opening	X	Manufacturer Certification – OSHA 10
Hazard Communication (MSDS), Labeling, etc.	X	Manufacturer Certification – OSHA 10
Hazard Identification and Awareness	X	Manufacturer Certification – OSHA 10
Hazardous Energy Lock-Out	X	Manufacturer Certification – OSHA 10
Hazmat Training	☐	
HAZWOPER Training	☐	
Hearing Conservation Program	☐	
Heat and Cold Stress Prevention	X	Manufacturer Certification – OSHA 10

Helicopter Safety	☐	
Description	**✓Applicable**	**Narrative** (Describe applicable training and provide documentation onsite)
Hot Taps	☐	
Hot Work	☐	
Incident Investigation and Reporting	☐	
Industrial Hygiene Exposure Monitoring	☐	
Job Safety Analysis	X	Manufacturer Certification – OSHA 10
Land Transportation Safety	X	Manufacturer Certification – OSHA 10
Lifeboat Safety	☐	
Line Breaking/Opening Process	☐	
Marine Drilling Safety	☐	
Near Miss Reporting	X	Manufacturer Certification – OSHA 10
Offshore Diving	☐	
Personal Protective Equipment	X	Manufacturer Certification – OSHA 10
Power Actuated Tools	X	Manufacturer Certification – OSHA 10
Radiation Control	☐	
Respiratory Control	X	Manufacturer Certification – OSHA 10
Respiratory Protection Program	X	Manufacturer Certification – OSHA 10
Roofing Work Procedure	X	Manufacturer Certification – OSHA 10
Safety Culture/Commitment Training	X	Manufacturer Certification – OSHA 10
Safety Equipment Usage	X	Manufacturer Certification – OSHA 10
Safety Observation/Audit	X	Manufacturer Certification – OSHA 10
Scaffolding Safety	X	Manufacturer Certification – OSHA 10
Signs and Barricades	X	Manufacturer Certification – OSHA 10
Start-up Safety Workshop	X	Manufacturer Certification – OSHA 10
Water Survival	☐	
Welding/Cutting	☐	
Other	☐	
Other	☐	
Other	☐	

8.0 Hazard Communication

s Brought on Site

(By generic use name. List here or append a separate Inventory List.)

1. NONE

2.

3.

4.

5.

Special PPE (Personal Protection Equipment) or Handling Requirements

(List the PPE requirements for each listed above)

1.

2.

3.

4.

5.

MSDS's are to be supplied for each brought on site. MSDS's for these s will be reviewed during the pre-job hazard review. There must be a MSDS to correspond with each item on the Inventory List. These are to be reviewed with all employees prior to commencing work and made readily available for easy reference. ***Contractor to identify where all MSDS's associated with the project can be found at the job site.***

9.0 Personal Protective Equipment (PPE)

In accordance with OSHA 29CFR 1910.132-140, a completed CPL 731 form must be attached.

Minimum PPE Required Throughout the Job at All Times:

1. Gloves
2. Hard Hats
3. Safety Glasses
4. Steel-Toed Boots (Optional/ Pending General Contractor Requirements)
5. Fall Restraint as Required
6. Hi Vis Clothing / Vest
7.
8.
9.
10.

Additional PPE Considerations:

10.0 Safe Work Permits

Describe contractor's plan detailing how permits will be issued and received (e.g. hot work, confined space, LOTO, excavation/trenching, etc.)

NONE for this specific project

11.0 Environmental

Wastes Generated:

None predicted

Waste Management Procedure:

As per General Contractors written specification

Permit Compliance:

NA

Spill Prevention and Containment:

NA

Sensitive Area Protection:

NA

12.0 Managing Subcontractors

All workers will be Certified GLTi Installers and Maintenance Technicians in collaboration with GLTi project manager to insure safety compliance as per GLTi and General Contractor in addition complete OSHA 10 training.

13.0 Audits, Inspections, and Planned Observations

(Facility Audits, Onsite Inspections, Planned Task Observations)

1. Preliminary site meeting(s)

2. General Contractors safety review / meeting

3. Walk through and pre determined hazards

4. Ongoing evaluation and documentation

14.0 Motor Vehicle Safety

All vehicles will be parked in designated space provided by General Contractor.

15.0 Security Measures

_____ will secure tools and materials as needed…..etc….

16.0 Stop Work Authority

Every employee and contractor for _____ **is responsible and authorized** to stop any work that does not comply with _____operations. There will be no repercussions for exercising Stop Work Authority; it is a right and a responsibility.

17.0 Short-Service Employee (SSE) Identification and Mentoring

NA

18.0 Communication

Direct dialogue

Cell Phone

Radios

19.0 Incident, Injury, and Illness Management

First Aid/Minor Treatment Facility (Clinic or other treatment center)	**Phone**
Contact (Doctor or professional medical provider's name)	**Phone**
Emergency Medical Treatment Facility (Local Hospital/Regional Trauma Center)	**Phone**
Emergency Transportation Provider (Attach driving route to this plan)	**Phone**
Medical Management Plan Provider **Contact**	**Phone**
Local Law Enforcement	**Phone**
Local Fire Department	**Phone**
Alternate Medical Management Plan Provider	**Phone**

Incident Response:
HAZWOPER Emergency Plan: (Refer to instructions for requirements. This section should be discussed in detail. Append additional documents as appropriate.)
Incident Reporting and Investigation: (Describe requirements and process)

- Insert driving directions/maps/satellite photos as necessary to identify routes of travel to and from work site(s).

- Provide briefing with local emergency responders so that they are aware of driving directions to work site (e.g. local municipal fire department/volunteer fire department /sheriff's department/state police/city police).

END EMERGENCY PLAN

SAFETY & Personal Protection Equipment

1. **Prepare and wear your personal protection equipment (PPE), harnesses and attachment points first!**

2. **Prepare and wear your personal protection equipment (PPE), harnesses and attachment points first!**

DO YOU GET IT?

Everything involves safety and safety is everyones responsibility!

Always check with your project safety supervisor for the local regulations.

What is Personal Protection Equipment (PPE)?

PPE is defined by the minimal equipment that is required to prevent the worker from injury. Each job will require specific equipment for each task, consult your Safety supervisor for more details. Typical PPE will include: Steel toe boots, Hard hats, Safety glasses, High visability vests or clothing and gloves as a minimal requirment to work at a project site. Additional specialty equipment may include fall restraint harnesses and retractable fall arrest cables.

Typical Safety Equipment:

Fall Arrest Harness

Hi-Visibility Vest and Hard Hat

Gloves, Non-Aggressive Tread Steel Toe Boots, Safety Glasses, Long Pants, Hearing Protection are all additional options/ needs for job site safety.

Obey the signs. They are there for your safety.

*These are only a sample few signs that may be posted at any one project site, please review with the safety coordinator and / or the general contractor.

Preparing the Job Site Section A

The truly wonderful thing about our choice of work is that no two projects are ever the same. Each project has similarities but all are in need of preliminary preparation. The preparation starts with planning and the task analysis.

Here is a sample task analysis to the preparation of the project area:

1. Set up your safety plan and prepare your PPE
2. Prepare the staging area.
    - The general contractor should provide an area for you to stage tools and materials, designated parking and delivery areas.

The staging area for materials and lifting was designated along the side of the building.

3. Always start with a clean work area.
    - Insure the work area is clean and free of any debris or any additional hardware by other trades. It is not uncommon to find screws,wood and other debris left behind.

- On smaller projects and confined areas it is preferable to sweep versus the use of a blower, being careful not to blow any debris off the building; using a shop vacuum will contain the debris.
- On a larger project a hand held or back pack blower may be feasible.
- Do not remove anything sealed into the roof.
- Tread lightly on any roof, a simple stone compressed by someone walking on it may cause a leak.
- Secure staging areas for materials and equipment both on the roof and on the ground.

4. Prepare the staging area on the roof.
    - NOTE! DO NOT place all the materials on the roof in one location! The roof has a maximum load capability per square foot, overloading will cause the roof to collaspe. Only stage materials if in fact that space is structurally capable to accept the load.
    - There may be areas designated by the structural engineer that can be “Point Loaded”. These are certain areas of the roof that can handle extra loading. These areas may be found on top of colume supports within the building.

5. Using the task analysis prepare the sections of the roof to be installed first.
    - Install plywood at the staging area and as a pathway to an from the sections that will be installed according to the plan.
    - Careful not to drag or slide the plywood along the waterproofing.
    - *THE NUMBER ONE CONCERN BESIDES SAFETY IS THE PROTECTION OF THE WATERPROOFING.*


Left – Materials staged on top of plywood in preparation for installation. **Right** – Plywood is used to create travel lanes for material transport. The plywood protects the waterproofing.

6. Keep the work area clean at all times. This will prevent any accidental breached and a lot is said about a contractor who keeps a neat job site.
    - Tools that are organized and neatly assembeled are less likely to be a hazard.
    - Consistently sweeping and vacuuming will also prevent accidents and accidental breaches. Remember typical green roof media is high in aggregate and if stepped on may cause a breach and the installer may never know it. *This is typical of tray systems.
    - It is important that the green roof is installed with no media between the waterproofing and the green roof system.


Left – GLTi Green Living Roof Panel showing the clean installation. Due to the overlap in the panel there will never be growing media between the membrane and the green roof. **Right** – Live Roof tray system clearly showing how media can easily become a hazard eroding between the trays pressured between the tray and the waterproofing.

Equipment

- Each project is a puzzle, pending on the materials, environment and other variables there is specified equipment for each task.
- As mentioned earlier prepare your heavy equipment 4 months out and finalize your tools one month out from the projected project date. Make a list of these tools to complete the task.
- When in doubt that a tool is required, list and bring it anyway. More times then enough we have been on a job only to have to go rent or worse yet buy a piece of equipment that is sitting on the floor in the shop.
- Below is a list of common equipment use to install.

Types of Equipment:

- **Hand Tools:** Hammers, pliers, long handled screw driver, tape measure, utility knife w/ plenty of new blades, seam tape roller, rags, brooms, flat shovel, hack saw.
- **Power Tools:** Heavy Duty Shop Vacuum, circular saw with abrasive blade, cut off saw / grinder extension cords.
- **Heavy Equipment:** Cranes, blower trucks, sky jacks, scissors lifts and hoists.

Sample List of Tools from the Task Analysis

- 3 brooms
- Handheld blower
- 3 wide transfer shovels
- Hack Saw
- 3 Tape Measures
- 5 Sharpie Markers, Black
- 5 Utility knives
- 25 new utility knife blades
- 3 metal grading rakes
- 3 plastic fan rakes
- 3 Five gallon buckets
- Utility shears
- Circular saw w/ abrasive blade
- 2 cordless drills
- 1 set of drill bits
- 10 concrete drill bits for anchors
- 2 shop vacuums
- 3 one hundred foot extension cords with build in GFI
- Irrigation tools
- Cart with pneumatic wheels
- Pallet jac

Materials Lifting

- Anything that needs to be on the roof has to get there. You can walk them up stairs, elevators, and crane or lift them from the outside of the building.
- Lifting can be one of the highest expenses of a project & it's not just the cost of the lift
- Lane closures, traffic directing, police presents, permits, safety personal are all part of the overall cost to bring materials to the roof.
- Be creative, sometimes you have to utilize a stairwell and not a crane, this may mean walking tools many flights to the roof or using a service elevator.

A Pallet Jack had to be removed from the roof 8 stories high via a staircase because it was forgotten after the crane was disassembled.

Lifting Means

Scissors Lift:

These machines have a platform which is built on top of a criss-cross base that may enlarge and contract per height. They are obtainable in a selection of diverse sizes.

http://www.squidoo.com/scissorliftstypes

Extended boom lifts:

A cherry picker (also known as a boom lift, man lift, basket crane or hydraladder), is a type of aerial work platform that consists of a platform or bucket at the end of a hydraulic lifting system.

Mast lifts:

Blower trucks:

Blower trucks are a viable option to blow soils and small river rock; they are also expensive to rent but the trade off is the savings in man-

Crane:

Costly and must be operated by a trained professional. Takes multiple people to operate.

Materials Mover:

One person operation, pending the work site this machine can lift up to 4000 lbs 4 stories high.

Product Inspection upon Delivery:

- The materials should arrive with packing slip. Make sure that everything on the packing slip is included in your order and that everything is in good condition.

Storing the Pre-Vegetated Green Roof Panels

- If you are not able to install the green roof upon arrival ***first and immediately remove the wrapping,*** the vegetation must be stored in cool dark place out of the sunlight. Preferably in a refrigerated truck. If the vegetation is not going to be installed within 24 hours un stack the mats or rolls and lay them out. The pre-grown rolls or mats cannot be stacked for more than 24 hours pending the heat. Please refer to the written specification. (See Below)
- If the rolls or mats are not used in 24 hours lay them flat and saturate them with water. Plan on letting them dry out for a few days since the excess water will make them extremely heavy.
- If the outside temperature is above 25°C (77°F) the modules must be installed within one (1) day after being palletized to prevent damage to the vegetation. If the outside temperature is between 15°C (59°F) and 25°C (77°F) the modules must be installed two (2) days after being palletized to prevent damage to the vegetation.
- If the outside temperature is between 5°C (41° F) and 15°C (59°F) the modules must be installed four (4) days after being palletized to pre-vent damage to vegetation.
- Palletized vegetated material must be stored in a secure, cool shady environment out of direct sunlight prior to installation. Vegetated panels must be protected from rapid temperature changes of more than 15°C (59°F)/hour.
- All other materials (non-living) should be stored in a dry location out of direct sunlight with origi- nal packaging and documentation left intact prior to installation.

With large projects you cannot have all your panels delivered at the same time if you cannot install them within two days. Stagger your deliveries! Plan, plan and plan again.

Fungus developed because the panels were left stacked too long.

Mature sedum rolls preparing to be lifted to the roof. Notice the air flow mesh that keeps the rolls securely on the pallet. The vegetative material should never be delivered in plastic wrap. In some cases if extra security is needed temporarily wrap the pallet in plastic until it is secured on the roof.

Sedum rolls stored in the shade in preparation for installation.

Moving Materials in Bulk on the Roof

- Protect the waterproofing
- When bringing up materials in bulk if on a pallet or in bags a means to move the material is a must.
- If you are using a pallet jack use plywood that is clean and not broken.
- In the event the pallet jack stops short it could cause damage to the waterproofing below.
- Alwalys keep the plywood runway clean with a broom or shop vacuum.


Left: Plywood is prepared to stage green roof pallets. Right: Pallets are staged on top of the plywood to protect the insulation and waterproofing

Handle Materials for Transport

Communicate with co-works to prevent injury and improve the flow of work. Above project managers and co-workers review the plan to move vegetation.

Preparing the Job Site Section B

As in Preparing the Job Site Section "A", clean roof of all debris. Although single-ply membranes also act as a root barrier, it is recommended that all roof membranes be covered with at least a geo-textile fabric or manufacturer's slip sheet in order to maintain the warranty of the manufacturer.* When in doubt about any action that involves the waterproofing contact the architect, client and/or the waterproofing manufacturer's representative. *Except with partner Hyload.

Root Barrier Installation

1. Broom and or shop vacuum the entire surface. Continue to broom and vacuum as you progress with the work. Remove all small stones and excess media from the surface prior to installing the root barrier and or protection fabric.

Left: Inspections to the waterproofing prior to the protection fabric being installed on top of a single ply TPO. GLTI Sysco Foods, Vancouver BC, 68,000 ft^2

   - Pending the size of the project we recommend that 2 to 3 laborers are best for installations less than 1,500 square feet.

2. Waterproofing = Single-ply: in most cases, the manufacturers' geo-textile fabric will be recommend.
   - If the waterproofing is a built-up hot or cold appied the first layer should be a root barrier. A common root barrier is a loose laid EPDM overlapped by 16"-24"
   - The green roof has a minimum life expectancy of 50 years plus. During this time the plants spread and roots will try and make their way to the membrane. The root barrier will protect the membrane from any root penetration.

Root Barrier Installation Cont.

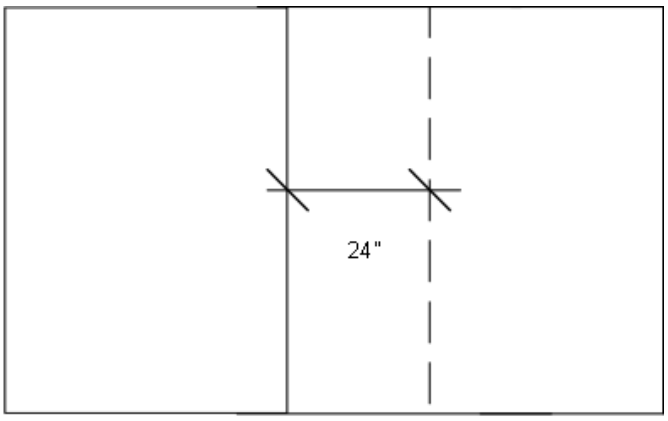
3. Roll out the protection fabric to allow enough excess to be folded over the edge of the roof up the side of an existing parapet. Make sure the protection fabric is above the finished height of the green roof. In addition each seam will need to have a 16” – 24” overlaps see Fig 1.

Left: Protection fabric being installed on top of a single ply TPO. GLTI Pittsburgh PA.

Left: Protection fabric being installed on top of a single ply TPO. GLTI Orange NY.

Bottom Left: Root barrier installed on top of a built up roof. Portland OR.

Bottom Right: Root barrier overlap



(Fig. 1 Root Barrier Overlap)

Adding Edge Details or Root Free Zones

- Some projects may call for root free zones or details also known as vegetation-free.
- Other projects may not have a parapet and you have to create an edge detail to terminate the vegetative roof.
- Root free zones are typically incorporated around the buildings perimeter edge,at drains and other penetrations.
- These areas typically consist of a 6”to 18” wide path of round stone, concrete paving stones and most recently a recycled rubber paver or porous paver to take the place of stone ballast.
- These root free zones protect the roof flashings as well as providing ease of access to flashings, fire breaks and wind up lift protection. (*High wind areas on taller buildings need to be designed to accommodate root free zones, the higher the project the larger the root free zone for wind uplift, consult structural or wind uplift engineer.)
- The edging detail can be used to neutralize any round ballast stone (*The stone has to be round, any pointed type of crusher run or other decorative stone will damage the roof membrane)
- The edging can be cut to fit and bent into shape.
- Theses zones should all be consructed using non – penetrating techniques.

Left: Ballast edge detail

Right: Roof protrusion prepared for edge detail and ballast. Root free zone

Adding Edge Detail to Roof Termination Cont.

Materials List:

- Edging (The height of the edging will be determined on the depth of the media, it is suggested that the edging is at least 1" or at the final grade of the vegetation)
- Double Sided EPDM Seam Tape
- 6" Single Sided EPDM Seam Tape
- Waterproofing manufactuers Primer, Applicators Pad, Seam Tape Roller

1. Prepare surface clean with broom.Using seam tape primer, apply the primer directly to the waterproofing area and the edging surface needing to be secured.

2. Apply one side of the double sided seam tape directly to the waterproofing and roll it with a hand held seam roller (below) removing air gaps.

3. Once the double sided seam tape is secure remove enough of the top tape cover to install one section of edging at a time.

4. Press the bottom of the “L” edging into the top of the double sided seam tape making sure to keep the tape clean.

5. Remove the tape cover from the 6” cover tape and apply it to the top of the inner “L” bracket and the waterproofing, using a seam roller to insure the security and move on to the next section.

6. Work as a team and communicate to insure that the tape is not compromised with foreign debris. Once the tape is secure it is virtually impossible to remove!

Adding Edge Detail to Roof Termination Cont.

Finished Common Edge Details:

Adding Edge Detail to Roof Termination Cont.

Finished Custom Edge Details: IT'S ALL ABOUT THE DETAILS!

Left: Powder coated edging to match trim on the building.

Middle Left: Copper wrap applied to match the copper gutters

Middle Right: Trim 3 years after installation

Bottom: Custom edging to tie in pavers and green roof

Irrigation Installation

Because of the flexibility of the Green Living Roof Panel, solid or flexible irrigation supply lines can be installed directly under the panels. Depending on the design feature and type of green roof (extensive, intensive or a hybrid), the irrigation system is 100% design friendly and can accommodate various zones and irrigation emitter types including:

- Drip zones for sensative watering situations
- Pop-up spray and rotors
- Impact heads for large coverage areas.

The irrigation head stabilizer prevents the spray or pop-up rotor from being misaligned. Unlike trays the ease of irrigation is a built-in feature that can deliver water, fertilizer, fungicide and biological enhancers right through the irrigation.

REVIEW: Top & Right the GLTi flexibility to install irrigation

Bottom: Typical tray system

Because the Green Living Roof system is modular accessing the irrigation and waterproofing is easy!

Because of the patented water wicking capabilities of the GLTi Green Roof Panels the roof reaches full saturation prior to any run off. This also allows for more accurate watering without the use of sprays and evaporation. Irrigating at the root level without wetting the foliage or creating sitting water is ideal.

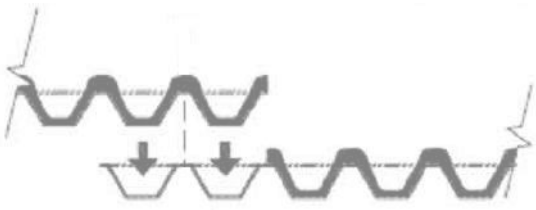
Installation

- Install the Green Living Roof Panels directly on top of the irrigation.

Green Living Roof Panels

1. Start with the longest straight edge.
2. Create the system / pattern for the next rows (9-10 Fig 2)
3. As the rows are installed, place media ontop of the panels keeping the underside 100% spotless with NO media between the waterproofing and the green roof.
4. Continue with steps 2 and 3 until the entire area is prepared with media.

1	2	3	4	5	6		
7	8	9	10	11	12		Install Cut Panels Last
13	14						
		Install Cut Panels Last					



2 Rows of interlocking cups

Green Roof Panel Installation Cont'd

Green Living Roof Panels - GLTi Sedum Blankets / Rolls

1. Install the non-vegetated Green Living Roof Panels
2. Screed the engineered green roof media to the specified depth. *Do not apply additional media unless specified. Overloading the roof could cause structural failure.
3. Install sedum mats and pull the seams tight to avoid any weed germination

Protection Fabric, Edging and the Green Living Roof Panels in Place

Protection Boards to Maneuver Engineered Growing Media

Engineered Growing Media

Engineered Growing Media, Screed to Depth

Green Roof Panel Installation Cont.

Top – Green Living Roof Panel Install is 100% clean with no threat of growing media to breach the waterproofing.

Right – The tray system is not only an immediate breach threat to the waterproofing but also a future threat because of the space between the trays. Refer to pages 67-76

Sedum Mats Ready for Install

Sedum Mats Installation

ALL PICTURES TAKEN THE DAY OF INSTALLATION

Basic Maintenance

- Upon installation it will take 2-4 weeks for your extensive pre-grown green roof to "bounce back" from travel, installation, and stress.

Plant in Place or Pre-Vegetated Extensive Sedum Green Roof:

- Sedum is drought-tolerant, and not a desert plant. They will need water every 3-4 weeks to thrive and every 4-6 weeks to survive. *If they are planted in place they will need water weekly during the first year.
- Once established, the plants will not require high doses of fertilizers. The plants feed from the pollutants in rain water. If the plants survive on potable water a light fertilizer of 10-10-10 is recommended in the spring. If the green roof is planted in place, provide the 10-10-10 upon planting. GLTi preferes to use a top dressing of the GLTi bioSoil and high quality compost. (p.97) Applied at an 1⁄8 to ¼ of an inch the compost base will replace the nutients and micro nutrients without the runoff of synthetic fertilizers.
- Greenroofs require weeding, especially if they are planted in place where there is open space between the plants. Like a thick lawn, the green roof once established will need less weeding due to its maturity and the weed seeds will burn out due to the lack of water. Weeding for newly planted greenroofs should be done bi-weekly for the first year
- Fungus is the only major disease of the sedum genus. Spores are always present and only present a problem after the plant is stressed by very high temperatures or a lack of water. If the plant shows signs of off brown and tan spray with a recommend dose of Chlorothalonil better known as Daconil or Ortho Garden Disease Control. **Follow the recommended rate of application which is usually 2.0 -3.0 oz per gallon and 1 gallon covers 250 square feet. The Chlorothalonil can cure existing disease and used as a preventative measure for historical fungus problems*
- Also check the drains during these visits, remove debris to allow water to easily flow.
- Keep good records. Each project should have a specific maintenacne checklist prescribed for each client.

Sample Maintenance Checklist:

_____ PROJECT NAME – Maintenance and Plant Guarantee Agreement

Maintenance and ____% Plant Replacement Guarantee Agreement

This agreement dated this _____day of _____, 20_____is made, between **Client**

(Insert Client / Customer information in full)

Contact Name:_____

Business Name:_____

Address:_____

City:_____

State/ Province:_____

Country:_____

Contact Number:_____ Cellular Number:_____ Emergency Number:_____

Fax Number:_____

Email:_____

and Maintenance Technician

Contact Name:_____

Business Name:_____

Address:_____

City:_____

State/ Province:_____

Country:_____

Contact Number:_____,

Cellular Number:_____ Emergency Number:_____

Fax Number:_____

Email:_____

The Customers and _____ agree to the following terms and conditions regarding the maintenance, replacement and related services (collectively “Services”) of the following green wall panels:

Service Address: (If different from Client/Customer above)

Address:_____

City:_____

State/ Province:_____ Country:_____

(Enter authorized maintenance technician here) an authorized agent will furnish all supervision, labor, material, equipment and transportation for _____ visits per month during the months of April, May, June, July, August, September and October and for ___ *(__)* visit(s) per month during the months of November, December, January, February, March to maintain the _____ Green Living Roof to start from, _____ (or actual installation date). GLTI Authorized Maintenance Technician *(enter technician here)* will provide the following services outlined below and will submit to the client a completed Maintenance Task Chart that will also outline any additional recommendations. Any questions can be directed to _____.

The initial warranty for the non-organic materials (green roof panels), not including irrigation, states that for a minimum of 2 years the green living roof panels will perform as specified and will not degrade due to or environmental exposure. The warranty includes materials only and is subject to removal and reinstallation costs by a certified _____agent. Installation workmanship provided by a _____ agent is warranted for a period of one year upon installation. Every year there is a maintenance agreement in place by a _____agent; _____ will continue to warranty the non-organic materials (green roof panels) not including irrigation, for the period of the maintenance agreement. If the maintenance agreement is terminated or if the agreement is not renewed, for any reason, the warranty is void.

In order to retain all warranties, a copy of the maintenance agreement needs to be registered with_____by the installer; a copy of the maintenance log shall be on file at the location of the project, with the maintenance technician and electronically with _____ and if combined with a Hyload waterproofing, a copy will be on file with Hyload.

List Plant Types:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

Grower / Nursery Owner Information

Contact Name:_____
Business Name:_____
Address:_____
City:_____
State/ Province:_____
Country:_____
Contact Number:_____
Fax Number:_____
Email:_____

Agent RESPONSIBILITIES

Agent will provide Services consisting of:

A) **Plant Health Waterproofing, Inspection, and Maintenance**

1. Provide a perimeter inspection looking for adverse conditions including but not limited to: Parapet, Waterproofing, Root Free areas, Drains, protrusions. Structural Methodology:

    a. Visual inspection of green roof perimeter, checking for abnormalities
    b. View waterproofing in areas susceptible to breech, e.g. Penetrations, termination bars, drains…etc. Visually inspect for adverse plant growth in these areas that may affect the performance of the waterproofing.
    c. Trim and clean foliage as needed, remove vegetation from “vegetation free areas”.
    d. Provide replacement of dead and unsightly plants subject to the conditions set out in Section 4 (Replacement Guarantee) of this Agreement.
    e. Apply an Integrated Pest and Disease Management Program which will inspect for foliar pests to control pests and diseases and take preventative measures to attempt to prevent as necessary and as noted below according to local regulations;
    f. The implementations of control measures for pest and disease management shall be in strict compliance with all Federal, State, and Local regulations: All implementation shall be performed by a state licensed pesticide applicator. A copy of the license of such applicator shall be placed on file and is available upon request. MSDS sheets of all products used for pest control shall be placed on file and is available upon request.
    g. Apply antiperspirants as needed in the Fall and Winter.
    h. Apply GLTi bioSoil as part of the regular maintenance program.
    i. Clean drains / scuppers as needed.
    j. Periodically remove sections of GLTi Green Roof panels to inspect waterprooing below.
    k. Inspect noted areas of waterproofing that were difficult and concerns during the waterproofing installation.

B) **Irrigation and Drainage Inspection and Maintenance**

    a. Inspect moisture levels and adjust the irrigation system as necessary;
    b. Deliver fertilization / GLTi bioSoil as required through the irrigation system; via foliar or other injection means.
    c. Inspect and test all components and zones in the irrigation system monthly; reset zone periods according to seasonal changes; adjust, repair or clean valves, emitters, filters, timers, sensors and control systems for small leaks,

and other minor repairs and adjustments with labor and parts supplied by Agent;

d. Keep all surfaces after each maintenance operation clean.
e. Provide the customer with a monthly maintenance summary attached to the monthly invoice.

2. Irrigation Methodology:
   a. Manually operate irrigation
   b. Thoroughly check all zones and water distribution of each zone
   c. Insure proper water distribution and timing.
   d. Visually inspect emitters for clogging
   e. Clean screens within drip irrigation filters
   f. Visually inspect zone valves for leaks

Botanical Name	Common Name	Interior (Y/N)	Req. Foot-candles'	Potential Diseases	Potential Pests

NOTES:

Maintenance Task
Perimeter – Structural – Waterproofing
• Visual inspection of green wall perimeter/trim • Root free zones and drains.
Irrigation
• Manually operate irrigation • Adjust Timer (Seasonal) • Visually inspect emitters for clogging • Clean filter screens on zone valves
Plant Material
Fertilizers, Fungicides, Pesticides

Fertilizer Applied
Brand:
Type:
Rate:

Fungicide
Brand:
Type:
Rate:

Pesticide
Brand:
Type:
Rate:

GLTi bioSoil
Other:

Other Observations

- Dry plants / panels
- Missing plants
- Excessive Moisture
- Mold
- Other (List):

- Trim and prune as needed
- Weed if any
- Replacement
- Retain shape logo if applicable
- Fall Antiperspirant / Winter Antiperspirant

Add drawings, plant legend and any other original documentation from architect or other.

END BASIC MAINTENANCE

Notes:

To simplify the process, here is a common list of installation tasks for the extensive green living roof:

1. Inspect the work area.
2. Prepare and implement safety plan and personal protection equipment.
3. Stage materials.
4. Broom, sweep or vacuum the roof area. (ongoing)
5. Visually inspect the waterproofing and continue to do so as the green roof is installed.
6. Prepare and lift materials.
7. Measure the edging details.
8. Prime edging and waterproofing.
9. Install edging.
10. Install protection fabric.
11. Install sub-surface irrigation. (If required)
12. Install green living roof panels.
13. Install growing media to specified depth.
14. Install vegetation.
15. Clean up.
16. Provide the client with maintenance agreement and owner's manual.

Chapter 13: Logistics and the Installation of a Green Living Roof

Intensive Green Roof Applications and Techniques

Intensive green roofs will require a more complex task analysis. Intensive green roofs may also be known as roof gardens that can include trees, bushes and shrubs, grass, water features and hardscapes like pavers, patios and walls.

The single most important factor will always be the roof loading capability. A formal structural engineers report will be the first requirement to determine the design outcome. There really is no reason to start the design phase or concept until you know what type of weight load you can design for.

Each component of the roof needs to be assigned a weight. If the weight is not available, you may have to physically weigh the material to determine how much of it can be implemented. Here is a simple guide that will help determine a base line load for design and concept phase only. Do not use this guide as a final load determination!

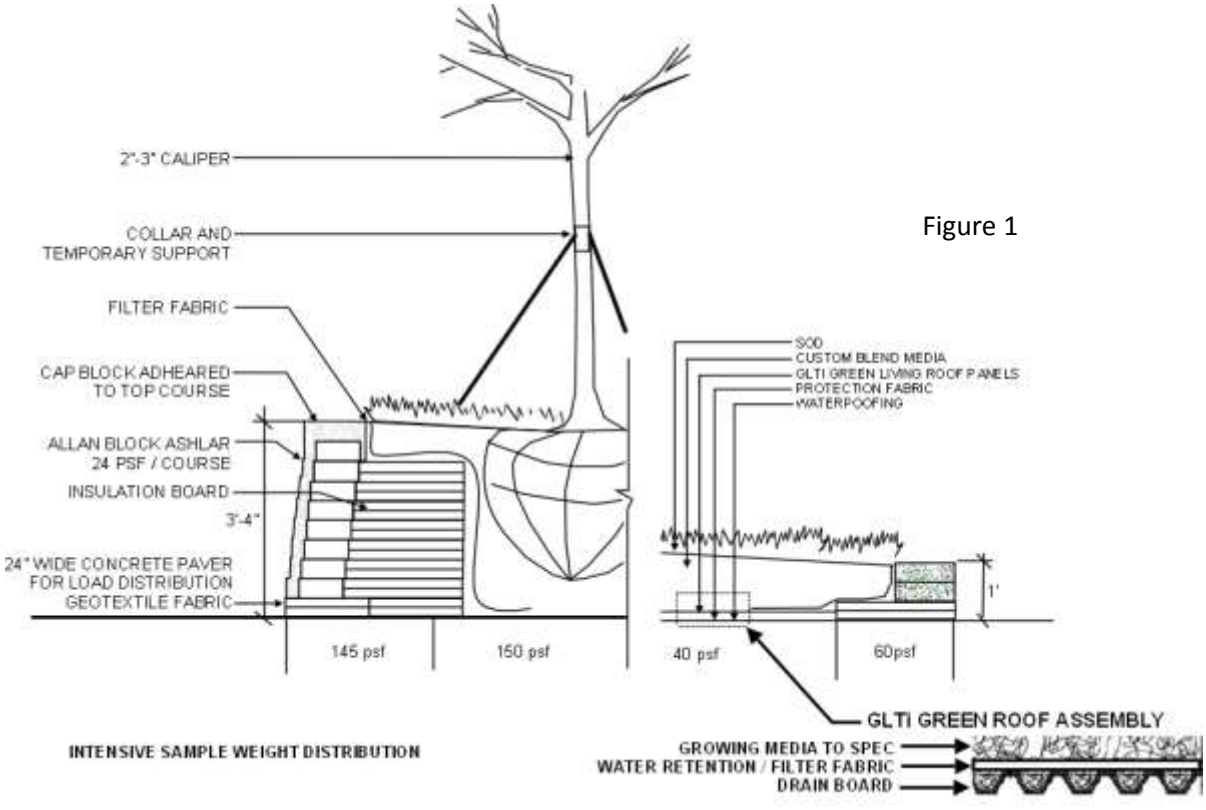


Figure 1

Intensive roofs take on a broad spectrum of applications. Intensive can be trees, bushes, grass, water features and it may take on the look of a private oasis, a backyard or a public park. In 2007 we had the opportunity to provide a quote for the High Line in New York City. The winning bid went to a European company and has been received as a highly successful public space.

Zucchini grows atop a roof farm courtesy of GLTi partner Philly Green Wall

Inexpensive green roofs also can be combined with extensive taking on a combination or hybrid application. The desires to add undulations, various depths, or a deeper planting area are design features applicable to increasing aesthetics, diverse plant choices and specific outcomes like butterfly gardens. Intensive also qualifies as roof top farming or agriculture.

Intensive Techniques and Details

1. Deeper Pockets of Growing Media to Accommodate Grasses, Perennials, Edibles and Annuals

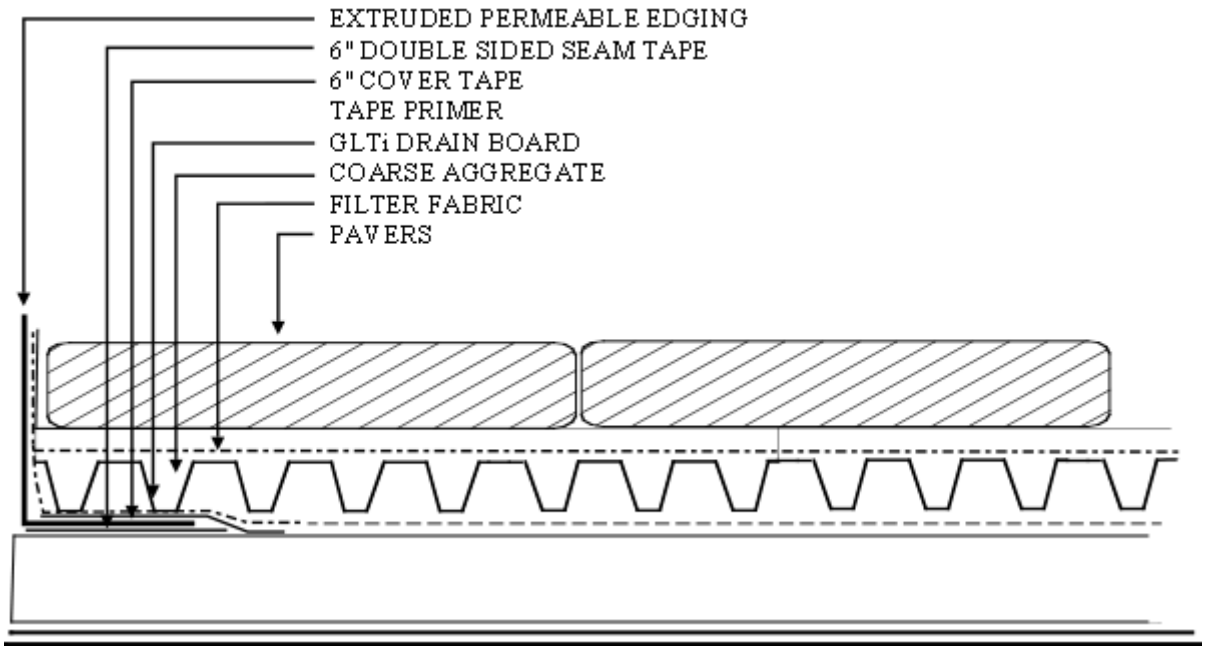
The simplest technique is adding deeper pockets of growing media to an extensive green roof in order to grow deeper-rooted plants. This technique is easy because of the loading capability of the Green Living Roof Panel. Recall p.39 the system has a compression strength of 3,200 pounds per square foot. Relative to Figure 1 on p.197 the weight of a mature specimen tree accounts for 150 pounds per square foot. The system is rated for 10 of those trees in one space, of course we have to account for roof loading and realistically we would not plant that many trees in that space. The easiest way to install the additional media is before you install the extensive vegetation. Install the media to the specified depth for the extensive areas and build up the areas with additional media to accommodate the additional intensive plants. WARNING! Do not exceed the roof load capacity. This technique will allow you to add interest to your design. In Figure 2 you can see the media that was installed and the “build up” of additional media to account for decorative grasses.

Figure 1: Intensive area was planted prior to the installation of extensive sedum.

Figure

2. Paver Walks & Patios

Adding a simple walkway or patio is another easy application for the green living roof panels. Unlike pedestal paving systems where each pedestal has to be leveled with the one adjacent to it, pavers can be placed directly on top of the panels. Many times on an extensive roof the walkway or spaced paver blocks are used for maintenance however you can also build patios and lager areas for amenity use.



3. Patios and Larger Walkways

The detail on page 199 establishes a standard for larger paver applications. It allows for a nice transition from the paved area to the vegetation.

Left: patio application using the Green Roof panels courtesy of GLTi partner Philly Green Wall

Below: Nice transition between pavers and green roof while still retaining the water retention built in to the green roof panels.

George Irwin, CEO

George Irwin is the founder and CEO of GLT Institute (GLTI), a privately held company that manufactures Green Living Walls, Green Living Roofs. It is also the global pioneer in vertical agriculture with a focus on education & training. A published author and featured “Green Wall Editor”, George is also a leading resource and authority for green wall and roof technologies around the world. TIME, Fortune & Profit magazine, CNN, NBC, ABC, National Geographic, Newsweek, the Los Angeles Times and the New York Times are among the major media to feature stories about George and GLTi.

Prior to founding GLTi, George was a landscape contractor for over two decades. He holds a degree in education and maintains his passion for out-of-the-box learning, combining his love for the environment and zest for learning into a growing global business. George personally oversees all green wall and roof education, integrating his state-of-the-art technology and ideas into a continuously evolving educational and training curriculum. Annually, he teaches hundreds of new green technology experts in green roof manufacturing, installation, growth, and maintenance. His efforts have earned him recognition as an educational partner for the New York City Department of Education and an association with multiple higher education facilities and universities, resulting in the development of a dedicated degree track in "Green Tech" and STEM (Science Technology Engineering and Math) education at the middle and secondary school levels. George is poised to become the *de facto* leader in Green Education with anticipated long-term commitments from leading colleges and graduate programs coast-to-coast.

George's vision extends well beyond achieving his own entrepreneurial aspirations: His mission is to help create sustainable solutions to the challenges of food insecurity and the dearth of job opportunities for at-risk youth in America's inner cities. His technology is quickly replacing complex mechanical systems and hydroponics with simple growing techniques that can be replicated on any scale. Research studies are now underway to measurably prove just how economically viable and productive his state-of-the-art systems are for maximizing small plots, parking areas, brownfields, and interior spaces within buildings to facilitate the growth of food year-round.

George Irwin may be contacted by e-mail at george@agreenroof.com or george@gltinstitute.com for speaking engagements, classes, and keynotes.